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COAL RESOURCE CHARACTERIZATION USING THE THEORY OF COREGIONALIZED VARIABLES

by

Ahmet Unal

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APPROVED:

Christopher Haycocks, Chairman

J. Richard Lucas

Gregory T. Adel

Michael Karmis

Turgay Dabak

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Blacksburg, Virginia

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(ABSTRACT)

A typical coal resource characterization study calls for estimating thickness, density, and quality parameters over a block or node simultaneously. Traditionally, estimation has been done for each variable independent of the other variables. The methods range from the well known polygonal and distance weighting methods to the geostatistical method of kriging. None of these methods takes the correlations between the variables into account explicitly. A comprehensive study has been undertaken to determine whether the joint estimation technique of cokriging may be used to utilize intervariable correlations in increasing the accuracy of estimation.

Seam thickness, density, ash, calorific value, and sulphur have been studied to determine whether they are cross-correlated. Significant cross-correlations have been found to exist between ash content, density, and calorific value, where the rank of the coal is stable. A survey and a case study indicated that seam thickness may also be cross-correlated with ash content and density. Subsequently, separate kriging and cokriging results have been subjected to comparison via a cross-validation procedure. After normalization, cokriging has provided substantial improvements over kriging in estimating thickness, density, and ash content. Moreover, cokriging performed well in replicating the correlation schemes where kriging occasionally failed.

In this study, geostatistical methods have been found to produce results in compliance with their probabilistic premises.

A general purpose geostatistics software package has been written to carry out modeling and part of the research on a personal computer. This package has been designed to provide many advantages over the existing costly and black-box type software.

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CHAPTER 1

INTRODUCTION

From the contemporary coal resource characterization point of view, coal beds present a number of variables of interest that need to be estimated. For example, in tonnage calculations, seam thickness and density need to be determined. In order to develop scheduling and blending plans, or to design processing plants and boilers to meet environmental constraints, such as restrictions on sulphur dioxide, nitrogen oxides, and particulate emmisions, we need to estimate the quality parameters, such as ash content, calorific value (Btu content), and sulphur content.

Until now, each variable has been modeled and estimated independent of the others, irrespective of which method of estimation has been selected. For example, if Btu content is one of the variables to be determined, it has been estimated from the Btu samples, even though ash content has also been sampled. However, it is an established fact that calorific value is indirectly proportional to ash content (Knudsen, 1981; p. 56.) Thus, a valuable source of information has probably been wasted due to separate estimation. It is also intuitive that there is a direct relationship between density and ash content. The change in the rank of the coal, however, is one of the major factors in defining how strong these relationships are in both cases. In general, rank gradually changes laterally over many miles or stratigraphically over hundreds to thousands of feet (Wood,1983.) It is not expected to change throughout a mining tract.

If it is hypothesized that the point to point correlation that exists between some of the variables of interest also extends spatially, two major questions await answers. The first question is whether spatially cross-correlated variables should be jointly estimated so that more accurate estimates can be obtained and the prevalent inter-relationships are better represented. The implicit assumption is that the spatial cross-correlations may not be duplicated as well in the case of independent estimations. The second question is closely related to the answer to the first. Even if the independent estimations are not significantly different from the joint estimations, under what circumstances can the information contained in the inter-variable correlations be utilized? This question refers to the possibility of obtaining more accurate estimates for under-sampled variables by using the correlation between more completely sampled variables. This is a common case in coal resource characterization with regard to non-cored reconnaissance drill holes, for which only very few variables, such as thickness, are recorded.

1.1 Research Objectives

The research undertaken for this dissertation aims at finding the answers to the following questions:

- In a typical coal resource characterization study, which major variables are cross-correlated, and for which of these do cross-correlations extend spatially?

- Is joint estimation of cross-correlated variables relevant?

- Under what circumstances can the information contained in the cross-correlations between variables be utilized?

In order to find answers to the questions above, the following questions have to be answered first:

- How should the variables be estimated jointly?

- How should the results of independent and joint estimations be compared?

As far as the techniques for joint estimations are concerned, there is only one method available, and it is this method which will be used for comparisions with independent estimations. This estimation method is called cokriging and is the counterpart of kriging, which is utilized for making independent estimations. Both methods have been developed within the realm of geostatistics. Comparisons will be implemented in the form of a cross-validation by case study. That is, each drill hole will be individually deleted from the data, and estimated by both kriging and cokriging as if the values for thickness, ash, and density are not known. The estimated values from both techniques will then be compared. On the other hand, comparison with the actual values will make it possible to evaluate geostatistics as a modeling and estimation tool in coal resource characterization.

To carry out the described research, computer programs will be required for:

- Univariate statistical analysis.

- Bi-variate statistical analysis.

- Modeling of the spatial correlations and cross-correlations.

- Kriging and cokriging.

Writing the necessary computer programs complements the research objectives.

CHAPTER 2

ESTIMATION METHODS

2.1 Chronological Perspective

Today, coal resource characterization requires much more than determination of the rank and the ability to roughly predict the tonnage of minable coal. The energy and steel markets are more competitive than ever, compelling the management of mining operations to desire more precise reserve evaluations before undertaking any risks beyond drilling. High risks involved in the form of intensive capital investment are associated with not knowing with certainty the amount and quality of the available resources. The uncertainty can be defined in many ways, but the most natural is through a probabilistic interpretation of the unavoidable error of estimation.

Environmental considerations impose the stringent restictions on the emission of particulates, sulphur dioxide, and nitrogen oxides, which in turn necessitate the development of optimum production schedules and blending strategies that will yield production of specified quantity and quality of coal from beds which do not necessarily contain compliance coal throughout. Production scheduling and blending require local estimations in addition to the statement of global reserves.

Progression from the earliest to the most recent methods has focused upon the adoption of estimators, as well as upon the incorporation of approaches that quantify the estimation error. Local estimation is what is used by sophisticated computer software in the numerical modeling of coal resources for reserve estimation and mine planning (Barua, 1985; Drake, 1983; Haycocks, 1981; Olson, 1977; Ramani, 1974)

One of the earliest estimation methods is the polygonal method. It is designed for global estimation using uniform but random sampling. Unless the sample is uniform and random with a small spacing, the polygonal method is not an efficient local estimation method. In response, distance weighting methods were developed. The simplest is known as the inverse distance method, which weights the neighboring samples within the range of influence with the inverse of the distance to the center of estimation. The most sophisticated version is called weighted moving average, and allows for weighting the inverse of the distance to an emprically determined constant together with a regionality constant. Even though it is a better local estimator, weighted moving average does not perform optimally in the case of clustered data, nor does it quantify the error of estimation.

The compelling idea of assessing the risk in terms of quantifying the estimation error, which occurs regardless of the estimation method used, resulted in the adoptation of statistical techniques. The classical statistical theory was abandoned shortly after the independent and identically distributed random variable assumption was proven to be unfruitful. Evidently, the variables within the range of influence are not independent. The correlation between them is a function of the separation vector, and may be captured in either the correlogram, covariogram or variogram. Subsequently, the variance of the estimation error can be derived for any sampling configuration, once the correlation function is deduced. This approach reflects the philosophy behind the geostatistical estimation methods. For a weighted estimator, then, the estimation variance can be expressed in terms of the correlation function. Furthermore, the weights can be chosen such that the variance of the estimation error can be minimized. This procedure is given the name kriging to honor D.G. Krige, who developed the basis of this approach. In summary, the phenomenon of coal (ore) deposition has been based on the concept of regionalized variables, and formulated using the theory of random functions under the name of geostatistics. The theory of random functions may be considered as an extension of the theory of stochastic processes (Azun, 1983.)

The extension of the concept of regionalized variables represented by a single random function is that of coregionalized variables represented by multiple random functions. The procedure of selecting the weights for the estimator, so that the estimation variance is minimized in the presence of more than one regionalized variable is called cokriging, and is the counterpart of kriging. There are two aspects of joint estimation with coexisting variables. First, the estimation is expected to honor the intervariable correlations. Second, the information contained in the intervariable correlations may be used to increase the accuracy of estimations. The early applications of and enhancements to the concept of coregionalized variables have focused on the second aspect. In particular, cokriging has been used to improve the accuracy of estimation for a variable, which is undersampled with respect to a more completely sampled one. Journel (1978) gives examples for iron-copper content in a copper deposit, chemical and radiometric measurements of U_3O_8 in an uranium deposit; and lead, zinc, and silver content in a lead-zinc deposit. An application outside mining has been given by Aboufirassi (1984.)

Myers (1982) emphasized the need for cokriging even if a variable is not undersampled. He formulated the cokriging problem in the general matrix form, for which one variable being undersampled is a special case. Carr (1985) used this matrix formulation to enhance modeling and estimation of relevant parameters of earthquake response spectra.

In mining literature, the only joint estimation example for coal resource characterization has been given by Davis and Green (1983.) They have modified principal component analysis, which is a standard multivariate statistical analysis technique for solving the cokriging problem. Principal component analysis alone cannot handle the spatial dependency without modification. Actually, there are no standard methods in statistics to account for the locations of the sample points. The method of Davis and Green depends upon the assumption that the data can be transformed by principal component decomposition into another coordinate system of dimension equal to the number of variables, where dependency in location disappears. This idea was originally proposed by Borgman and Frahme (1976) to study the multivariate characteristics of bentonite. The assumption of independence may not always be verified. Besides, no way of deriving the parameters of the error of estimation has been suggested. For a statistical method, this is a contradictory handicap.

In the rest of this chapter, the concept of regionalized and coregionalized variables will be discussed. Also, kriging and cokriging formulation will be presented.

2.2 Geostatistical Methods

Among a broad spectrum of methods that have been used for estimation, the geostatistical approach is unique in the sense that an attempt is made to statistically quantify the error of estimation. This is achieved by conceptualizing the spatial distribution of each measurable quantity of interest, such as seam thickness, as a random function. Formulation through random functions allows consideration of measurable quantity as a random variable at every location, structured according to the correlation scheme dictated by the geological phenomena. The correlation structure may change from one deposit to another, but it is always dependent on the distance and direction, previously parameterized as zone of influence and anisotropy. Such an interpretation of geological or other variables, dictated by the nature, stems from the concept of the regionalized variable. Selecting the weights for an estimator, constructed as the linear combination of nearby samples so that the estimation variance is minimized, is called kriging.

Extension of kriging to spatially cross-correlated coexisting variables is cokriging. The concept of coregionalized variables that underlies cokriging has been adapted from the concept of regionalized variables underlying kriging. The variables of interest that are spatially cross-correlated should be estimated jointly rather than separately. Cokriging is an alternative method for joint estimation.

2.2.1 Kriging Formulation

Let Z denote a random function representing the variable of interest.[1] Z(x), the RF at point x, is a random variable. The variance of Z(x) is

$$Var\{Z(x)\} = E\left\{[Z(x) - E\{Z(x)\}]^2\right\} \qquad [2.1]$$

[1] Random Function will be abbreviated by RF.

where E and Var denote the expectation operator and variance, respectively. The covariance between the two RFs, $Z(x_1)$ and $Z(x_2)$ is

$$C(x_1, x_2) = CoVar\{Z(x_1), Z(x_2)\} = E\{[Z(x_1) - E\{Z(x_1)\}][Z(x_2) - E\{Z(x_2)\}]\} \quad [2.2]$$

where CoVar denotes the covariance. Similarly,

$$2\gamma(x_1, x_2) = Var\{Z(x_1) - Z(x_2)\} \quad [2.3]$$

is the variogram between the two RFs, where $\gamma(x_1, x_2)$ is the semi-variogram.

A RF is called a stationary RF, if

$$(i)\ E\{Z(x)\} = m \quad [2.4a]$$

$$(ii)\ C(h) = CoVar\{Z(x + h), Z(x)\} = E\{Z(x + h).Z(x)\} - m^2. \quad [2.4b]$$

On the other hand, a RF is called an intrinsic RF, if

$$(i)\ E\{Z(x + h) - Z(x)\} = 0 \quad [2.5a]$$

$$(ii)\ 2\gamma(h) = Var\{Z(x + h) - Z(x)\} = E\{[Z(x + h) - Z(x)]^2\}. \quad [2.5b]$$

It should be noted that a stationary RF is also an intrinsic function, but the converse is not necessarily true. That is, the existence of the variogram does not imply the existance of covariogram unconditionally. For a sationary RF, the variogram is a function of the covariogram, and vice versa.

Let $\{x_1, \ldots\ldots, x_k, \ldots\ldots, x_n\}$ represent the set of drill hole locations, and $z(x_k)$, the realization of the random function Z at x_k. The kriging estimator is constructed as the linear combination of $Z(x_k)$, from the n available drill holes, as follows:

$$Z^*(x_0) = \sum_{k=1}^{n} \lambda_k . z(x_k) \qquad [2.6]$$

For the stationarity RFs defined by [2.4a] and [2.4b], the sufficient condition for unbiasedness is

$$\sum_{k=1}^{n} \lambda_k = 1 \qquad [2.7]$$

and the variance of the estimation error is

$$\sigma_k^2 = Var\{Z(x_0) - Z^*(x_0)\} = C(0) - 2\sum_{k=1}^{n} \lambda_k . C(x_0, x_k) + \sum_{j=1}^{n}\sum_{k=1}^{n} \lambda_j \lambda_k \qquad [2.8]$$

The kriging solution is thus, to minimize the estimation variance in [2.8], subject to the unbiasedness condition in [2.7]. This minimization problem can be solved by the Lagrange method for constrained optimization, which results in the following system of n+1 linear equations:

$$\sum_{k=1}^{n} \lambda_k C(x_i, x_k) - \mu = C(x_i, x_0), \qquad for \quad k = 1,....,n \qquad [2.9]$$

$$\sum_{k=1}^{n} \lambda_k = 1. \qquad [2.10]$$

$n + 1$ unknowns, λ_k and μ, which can be found by solving these simultaneous linear equations, yield the minimum estimation variance which is defined as

$$\sigma_k^2 = C(0) + \mu - \sum_{k=1}^{n} \lambda_k C(x_k, x_0). \qquad [2.11]$$

By the assumption of stationary RFs, the existence of the covariance function C(h) is assured. In the case of intrinsic RFs, however, only the existence of the variogram function is assured. [2.9] and [2.10] can be expressed in terms of the variogram function as:

$$\sum_{k=1}^{n} \lambda_k \gamma(x_i, x_k) + \mu = \gamma(x_i, x_0), \quad for \quad k = 1,....,n. \qquad [2.12]$$

$$\sum_{k=1}^{n} \lambda_k = 1. \qquad [2.13]$$

The kriging variance is then

$$\sigma_k^2 = \sum_{k=1}^{n} \lambda_k \gamma(x_k, x_0) + \mu - \gamma(0). \qquad [2.14]$$

2.2.2 Cokriging Formulation

The stationary RF in regionalized variables and kriging is extended to coregionalized variables and cokriging as:

$$(i)\ E\{Z_i(x)\} = m_i, \quad for \quad i = 1,....,m \qquad [2.15a]$$

$$(ii)\ C_{ij}(h) = CoVar\{Z_i(x), Z_j(x+h)\} = E\{Z_i(x).Z_j(x+h)\} - m_i m_j, \quad for \quad i,j = 1,....,m \qquad [2.15b]$$

Similarly, the intinsic RF in coregionalization is defined as:

$$(i)\ E\{Z_i(x+h) - Z_i(x)\} = 0, \quad for \ i = 1,...,m \qquad [2.16a]$$

$$(ii)\ 2\gamma_{ij}(h) = CoVar\{Z_i(x+h) - Z_i(x), Z_j(x+h) - Z_j(x)\} \quad for \ i,j = 1,...,m \qquad [2.16b]$$

With the intrinsic coregionalized RF, the existence of the cross-variograms are assured without any provision for the existence of the cross-covariograms.

Using the notation of Myers (1982), let $Z_1,....,Z_i,....,Z_m$ denote cross-correlated RFs representing the variables of interest, such as, thickness, density, ash content, calorific value, and the like; $x_1,....,x_k,....,x_n$ the set of drill hole locations and

$$\bar{z}(x_k) = [z_1(x_k),...., z_i(x_k),...., z_m(x_k)]$$

the realization of the RFs expressed in the form of a vector. The linear cokriging estimator is then written as

$$\bar{Z}^*(x) = \sum_{k=1}^{n} \bar{z}(x_k)\Lambda_k \qquad [2.17]$$

where Λ_k is analogous to λ_k in kriging, but is an $m \times m$ matrix instead of a scalar. In nonmatrix form, the cokriging estimator is written as:

$$Z_j^*(x) = \sum_{k=1}^{n} \sum_{i=1}^{m} z_i(x_k)\lambda_{ij}^k, \quad for \quad j = 1,...,m \qquad [2.18]$$

where λ_{ij}^k is the ith row and jth column of Λ_k, and corresponds to the weight of the ith variable at location x_k in estimating the jth variable. Under the stationarity hypothesis, the condition

$$\sum_{k=1}^{n} \Lambda_k = I \qquad [2.19]$$

is sufficient for $\bar{Z}^*$ to be unbiased, where I is the identity matrix. Equation 13 can be expressed in nonmatrix form as follows:

$$\sum_{k=1}^{n} \lambda_{ii}^k = 1, \quad for \quad i = 1,...,m \qquad [2.20a]$$

$$\sum_{k=1}^{n} \lambda_{ij}^k = 0, \quad for \quad i,j = 1,...,m; \quad and \quad i \neq j. \qquad [2.20b]$$

If the joint estimation variance is expressed as

$$\sum_{i=1}^{m} Var\left\{Z_i(x) - Z_i^*(x)\right\}, \qquad [2.21]$$

then the estimation problem is in minimizing the cumulative variance in [2.21], which is expressed in terms of the covariance as defined in [2.15b], subject to Equation [2.19]. The solution to this optimization problem, and formulae for decomposition of the joint estimation variance into separate variances has been given by Myers(1982.)

Covariance, described in [2.15b], is a function of the separation vector, h, and called the cross-covariogram when i and j define two different RFs. Otherwise, it is called the cross-variogram. Unlike the cross-variograms, cross-covariograms may not be symmetrical with respect to the separation vector (Journel, 1978; p. 41.) The nonsymmetry of the cross-covariance may be expressed by the inequality in [2.22] and equality [2.23] below:

$$C_{ij}(h) \neq C_{ij}(-h) \qquad [2.22]$$

$$C_{ij}(h) = C_{ji}(-h) \qquad [2.23]$$

Nevertheless, the difficulty in estimating cross-covariograms is not a possible nonsymmetry, but it is necessary to form an estimator, which is bound to include the estimators of the expected values for the variables involved, simultaneously. Cross-variogram defined in [2.16b] eliminates this difficulty. That is, for stationary RFs,

$$\gamma_{ij}(h) = C_{ij}(0) - \frac{1}{2}\left[C_{ij}(h) + C_{ji}(h)\right], \qquad [2.24]$$

and cross-covariogram and cross-semivariogram are equivalent tools of expressing the spatial correlation between the variables to represent the joint estimation variance in [2.22].

An unbiased estimator of the cross-semivariogram function may be formed as

$$\gamma_{ij}^{*}(h) = \frac{1}{2N(h)} \sum_{i=1}^{n} \sum_{j=i+1}^{n} \left[z_i(x+h) - z_i(x)\right]\left[z_j(x+h) - z_j(x)\right] \qquad [2.25]$$

where $N(h)$ denotes the number of pairs at lag h.

Another way of estimating the cross-semivariogram function, which would replace [2.25], may be established defining the new variable, $Z_{i+j}(x) = Z_i(x) + Z_j(x)$. For stationary RFs, it can be shown that

$$CoVar\left\{Z_{i+j}(x), Z_{i+j}(x+h)\right\} = C_i(h) + C_j(h) + 2C_{ij}(h) \qquad [2.26]$$

and

$$\gamma_{ij}(h) = \frac{1}{2}\left[\gamma_{i+j}(h) - \gamma_i(h) + \gamma_j(h)\right]. \qquad [2.27]$$

Thus, it is possible to select the semi-variogram models for $Z_{i+j}, Z_i, and\ Z_j$, separately in order to obtain the cross-semivariogram. Nonetheless, it is necessary to verify that

$$|\gamma_{ij}(h)| \leq \sqrt{\gamma_i(h)\ \gamma_j(h)}\,. \qquad [2.28]$$

Evidently, if the inequality relationship in [2.22] is true, variograms and cross-variograms cannot be replaced by the covariograms and the cross-covariograms in the cokriging solution.

CHAPTER 3

VARIABLES OF INTEREST AND CROSS-CORRELATIONS

The major variables incorporated into a typical coal resource characterization study depend mainly on whether the coal be used as steam or metallurgical coal. Other than the parameters which determine the quality of coal, seam thickness and density have to be estimated in order to calculate tonnage.

For steam coal, one of the most important quality parameters is undoubtedly the heat content of the coal. It is the dominant factor in determining the capacity of the power generation plant. Higher calorific value means a smaller plant, requiring less capital investment. The desirable properties for metallurgical coal are expressed as high carbon and low volatile matter content, rather than calorific value. The higher the carbon content and/or the lower the volatile matter content, the more iron ore is reduced in the furnace. Ash plays an important role, not only because it more or less defines the heat content, but also because it affects the operation of the boiler, causing slagging, fouling, and corrosion. Sulfur content is important in terms of cleaning costs. Coals with high sulphur content have to be cleaned before, during, or after the burning to comply with the environmental restrictions regarding permissable levels of sulphur dioxide emmision. In the metallurgical coal, sulphur present in the feedstock is carried to the pig iron, causing undesirable properties. Undoubtedly, moisture decreases the efficiency of steam generation by using a part of the heat generated for evaporation.

These variables comprise only a part of a long list, but will not be taken into consideration in this study. It will be assumed that carbon content, volatile matter, and moisture do not represent significant variations in mine tract level. This assumption is based on the fact that all three of the variables are the result of large scale geological processes, such as coalification and maturation, which do not show large scale variations locally. Consequently, the study will be limited to seam thickness, density, ash content, sulphur content, and calorific value.

3.1 Variables of Interest

3.1.1 Seam Thickness

In this study, seam thickness is defined as the total thickness of coal, partings, and coaly material between a predefined roof and a floor strata, that are correlatable to a considerable extent throughout the study area. No selective exclusion is allowed according to any criteria, such as high parting thickness or high ash. This definition should not be confused with the coal thickness definition of the U.S. Geological Survey for reserve calculations (Wood, 1983):

> **thickness of coal for resource calculations**-The thickness of coal used for resource calculations is the net thickness of coal in a bed excluding all partings more than 3/8 inch thick. Beds and parts of beds

made up of alternating layers of thin coal and partings are omitted from calculations if the partings comprise more than one-half of the total thickness. Also, benches of anthracite and bituminous coal less than 14 inches thick and benches of subbituminous coal and lignite less than 30 inches thick are omitted from calculations if they lie above or below partings that may deter their mining. Coal and coaly material containing more than 33 percent ash is excluded from resource and reserve estimates unless the ash is largely in associated partings so that the coal is cleanable to less than 33 percent ash.

A regionalized variable must be such that all linear combinations of its values retain the same meaning (Journel, 1978; p.199.) The coal thickness as defined by the U.S. Geological Survey is not necessarily an additive variable. It may happen that the variable sampled at one location is only one bench, while it represents the cumulative thickness of all the benches at another location. This precludes its use with linear estimators like kriging and cokriging. If selective exclusion of structural or lithological units are required, each unit should be studied separately first, and then classified.

3.1.1.1 Compositing

Frequently, the seam will encompass more than one lithological unit in the vertical direction, each having different physical and chemical properties that may be persistent over a large aereal extent. In such cases, the quality parameters should be composited. Thus, a single quality value will be obtained at any location in two dimensional space that spans the coal seam. Seam composite is obtained by calculating the weighted average of the quality parameter with respect to the thickness of the lithological units. The importance of recognition of the lithological units of different characteristics to establishing the correlations cannot be overemphasized.

3.1.2 Density

Density is defined as the mass per unit volume, and is usually expressed as short tons per acre-foot for tonnage calculations. Hence, density is multiplied by the product of acreage and thickness in calculations of tonnage.

Laboratory measurements are usually reported as specific gravity, which is unitless. Specific gravity, sometimes called relative density, is the ratio of the mass of unit volume of coal to the mass of an equal volume of water at standard temperature and pressure. Conversion from specific gravity to density can be done through multiplication by the density of water.

The specific gravity of coal varies considerably with rank and with differences in ash content (Wood, 1983.) If the rank can be assumed to be constant in the mine tract level, then the specific gravity depends highly on the ash content. The higher the ash content, the higher the density should be.

3.1.3 Ash

Ash may be defined as the inorganic residue remaining after the complete incineration of coal. Ash content is determined by following the procedures described under section D 2795-84 of the Annual Book of ASTM Standards. It is the percentage of a laboratory sample of coal remaining after incineration to constant mass. It virtually comprises the oxides remaining after the coal has burnt and all the volatile mineral constituents have been driven off (Sanders, 1977.) Therefore, ash may not be identical, in composition and quantity, with the original mineral matter existing in coal.

3.1.4 Calorific Value

Gross calorific value is defined as the heat produced by combustion of a unit quantity of coal, at constant volume, in an oxygen bomb calorimeter under specified conditions defined by section D 121-78 of the Annual Book of ASTM standards. The common unit for the calorific value is British Thermal Units per pound.

3.2 Cross-correlations

The point to point correlation coefficient between calorific value, density, and ash content are known to be high (Unal, 1986.) There is, of course, a natural explanation for this strong relationship. The relative density of ash is higher than that of coal; therefore, the higher the ash content, the higher the density. Likewise, the calorific value of coal with less ash will be higher than that of a similar rank and volume of coal for which the ash content, percentagewise, is higher. This is the direct consequence of the relatively high specific energy of coal with respect to almost no calorific value of ash material. For these reasons, density, ash, and calorific value are expected to be spatially cross-correlated.

On the other hand, the cross-correlation between seam thickness, and the above properties is not readily evident. The occurrence of sulphur, which is of great concern, may come about either through deposition in the already existing fissures, cracks, and cavities locally in the later stages of coalification, or through intimate intergrowth with the coal to a wide lateral extent in the initial stages of coalification. In neither case is the amount of sulphur high enough to significantly affect density, ash, specific energy, or to inflate seam thickness. One exception is the case where a sizable ash band, particularly rich in sulphur, is intermingled with coal in such a way that it cannot be mined selectively. The regions where the ash band exists will therefore be rich in both ash and sulphur content. Sulphur nodules, for example, are frequently associated with such ash bands.

The seam thickness may be affected by the amount of ash forming mineral matter transported to the depositional basin in large quantities. If, for example, extensive mineral matter is introduced with or without coal forming material being deposited at the same time, the seam thickness may increase, resulting in an increase in ash content and density, but a drop in calorific value. A similar association between seam thickness and quality parameters such as ash and sulphur content has been encountered in a case study by Ferm (1985.) This is not the only scenario, although it is, in the mine tract level, the most likely. Seam thickness may, for example, be high in a specific localized area because the surface of deposition is in the shape of a pot, thus collecting more coal forming material. This, in turn, results in higher seam thickness, but not necessarily in higher density and ash levels.. Therefore, the existence of different origins does not contribute any useful information as far as cross-correlations are concerned.

CHAPTER 4

METHOD OF ANALYSIS

If the existing point to point correlation between the variables of interest extends spatially, then joint estimation should become relevant. Hence, it should be possible to construct an estimator that would incorporate extra information due to the spatial cross-correlations between the variables. The cokriging estimator discussed in Chapter 2 is as yet the only estimator constructed for this purpose. Although this estimator is the direct extension of the kriging estimator to more than one variable, it should not be considered as the sole alternative for restoring and utilizing cross-correlations. Even if joint estimation turns out to be relevant, the question of how well this particular estimator performs over independent krigings has yet to be investigated. Before attempting to compare the performance of the cokriging estimator with that of separate kriging using real data, it is necessary to demonstrate theoretically that there is a basis for the hypothesis that the cokriging estimator will perform better.

4.1 Theoretical Basis for the Cokriging Estimator

The general cokriging formulation described in Chapter 2 depends on minimizing the sum of the estimation variances for each variable included in joint estimation. The unbiasedness constraints for cokriging, in nonmatrix form, are given in Equations [2.20a] and [2.20b]. The unbiasedness conditions for separate krigings correspond to the following:

$$\sum_{k=1}^{n} \lambda_{ii}^{k} = 1, \qquad for \quad i = 1,...,m \qquad [4.1a]$$

$$\lambda_{ij}^{k} = 0, \qquad for \quad i,j = 1,...,m; \quad and \quad i \neq j. \qquad [4.1b]$$

Equation [2.20a] and [4.1a] are exactly the same. On the other hand, [4.1b] of kriging is only a special case of [2.20b], and restricts the domain for feasible solutions. In the language of projections, separate kriging results in projecting into a smaller subspace and hence, the estimation variance, in general, will be larger (Myers, 1982.)

4.1.1 Normalization

The objective function to be minimized in cokriging formulation as described in [2.21] is the summation of the variance of estimation for each variable involved in joint estimation. The estimation variance for each variable is expressed in terms of the variogram function for that variable and of the cross-variogram function between that variable and all other variables, depending upon the configuration of the observations with respect to the location and domain of estimation. The numerical solution of the minimization problem; that is, selection of the weights so that the unbiasedness constraints are satisfied and the cumulative variance is minimized, will unavoidably be affected by a large variance differential between the variables. The emphasis will be on those component variances that are higher, whereas the smaller variances will be numerically insignificant during iterative solution. Indeed, ash content, specific energy, density, sulphur content, and seam thickness depict variation in very different scales, mainly because they express different characteristics defined on different scales.

One way to alleviate this problem is to eliminate any variation differential between the variables. This can be achieved by a data normalization procedure. Carr (1985) divided each major variable by its maximum value, reducing the range to an interval between 0 and 1, inclusive. However, the normalization was employed as an aid to cross-variogram calculations rather than for providing stability to the numerical solution.[2] Division by the maximum value transforms each sample to the same range, but not necessarily to the same variance scale. The normalization procedure that will be employed herein involves a transformation to reach a population with zero mean and unit variance. This can be done by subtracting the mean and then dividing the result by the standard deviation. Even though population mean and standard deviation will not be known, they can be replaced by the sample mean and standard deviation, respectively. This will result in a normalized variogram with the sill value practically equal to unity for each variable. In general, the normalized experimental semivariogram value will be equal to the quotient of the regular experimental semivariogram value divided by the sample variance. The variables require finite variances in order to utilize this transformation. The normalization procedure discussed above will not only solve the numerical stability problem, but

[2] To obtain the experimental cross-variogram between two variables, a new variable is formed by summing the two variables and then obtaining the variogram of the sum as discussed in Chapter 2. Yet, if a large magnitude differential exists between two variables, the new variable will be practically equal to the variable having the larger magnitude.

also solve the resolution problem in the calculation of the experimental cross-sum semivariograms.

4.2 Practical Considerations for Comparison

In the previous section, the theoretical basis for expecting the cokriging estimator to yield an error with smaller variance in comparison to that of separate krigings was discussed. Additionally, the cokriging estimator is expected to honor cross-correlations between the variables. In order to justify the extra effort involved in modeling the cross-variograms and cokriging, the cokriging error should be smaller; and cokriging estimates should replicate the cross-correlations, where separate krigings would fail to do so. If the cokriging estimator does not perform significantly better, then either another estimator should be constructed for joint estimation, or separate kriging should be accepted as sufficient. The comparison will be made by a cross-validation type procedure. The overall test will not only render comparison between cokriging and kriging possible, but also test the feasibility of their use as estimation tools in coal resource characterization.

4.2.1 Verification of Kriging and Cokriging

Feasibility of using geostatistical methodology by either kriging or cokriging should be determined by the extent to which they fulfill the underlying probabilistic premises. That is, it should be possible to model the distance dependent variability within and between the variables, and to obtain meaningful confidence intervals for the estimated parameters. Cross-validation results can be a good test for this purpose. If kriging errors are approximated by a normal distribution, the actual values should be contained by the interval of length twice the kriging standard deviation on both sides of the kriged estimate by a probability of 95%. The same argument is also valid as regards cokriging. The capability of choosing variogram models so that the calculated confidence intervals are not violated will be taken as an indication of the soundness of each method.

If each variable is normally distributed, kriging and cokriging estimators are also normally distributed as being linear combinations of normally distributed variables. However, they are not independent. Therefore, derivation of confidence intervals can be made only if binormality can be assumed. Hence, the method described above is only an approximation of the actual case of binormal distribution.

4.2.2 Cross-validation

Assuming that theoretical variogram and cross-variogram models can be obtained without any significant error, an estimate can be obtained at every drill hole location using kriging and cokriging as if the actual values were not known. Since kriging and cokriging are exact interpolators, the sample at the location of estimation should temporarily be excluded. The difference between the actual and estimated value is the error of estimation for each variable for both kriging and cokriging, and therefore a comparison is possible.

Ideally, a subset of the drill core measurements should be randomly selected as the control group for cross-validation. The variogram models should be obtained from the remaining observations. Otherwise, the estimates obtained for cross-validation will be biased, because they are obtained using the variograms that have been calculated from their actual values. Unfortunately, the number of observations in a typical coal drilling program in mine tract level is not always sufficient for reserving a control group and a variogram modeling group.

4.2.3 Comparison of Kriging and Cokriging Results

Comparison of the variance of the error of estimation within the framework of classical parametric hypothesis testing is fairly difficult, because the underlying assumptions are not likely to be met. In general, neither the cokriging nor the kriging estimator will constitute an independent sample. Some of the drill holes included in estimation in one location will also be used in estimation in another location. Cokriging and kriging errors would be identically distributed only if calculated on a regular grid. Since the underlying assumptions for standard hypothesis testing methods are not likely to be satisfied, other techniques should be resorted to. In the meantime, it should be noted that the comparison method to be used should take advantage of the fact that the variation due to location may be minimized by considering the errors as pairs. Sample configuration may be different at each drill hole location, but the same configuration will be used at each location for kriging and cokriging. The squared cokriging and kriging error at each location for the control group is an unbiased estimator of the cokriging and kriging variances. If squared errors are not significantly different, their scatter plot should be concentrated around the regression line with a 45 degree slope. A lower slope in the plot of squared cokriging errors versus squared kriging errors is an indication of the superiority of cokriging over kriging. The absolute value of the errors may also be used instead of the squared errors.

A measure called *percent variance explained*, which is analogous to the coefficient of determination in regression analysis, has been used to compare alternative semivariogram models according to the error each model produces in kriging (Knudsen, 1978; pp.174-176; and Pauncz, 1980.) *Percent variance explained* is defined in terms of a statistic called weighted squared error, which is a weighted average of the squared errors. Weighting is implemented according to the variance produced by kriging at every drill hole location, eliminating the variation due to location. If the total variation is expressed as the sample variance, then the ratio of the weighted squared error to the sample variance corresponds to the percent variation not accounted for by kriging. This procedure may also be used to compare cokriging and kriging. *Percent variance explained*, calculated for cokriging and kriging, provides a base for comparison. Cokriging is expected to account for a higher percent of the total variance for each variable.

The last two techniques discussed in this study will be used to compare cokriging and kriging.

CHAPTER 5

COMPUTER PROGRAMS

A detailed geostatistical analysis encompasses many steps which rely heavily upon computer usage. In general, the following tasks constitute the framework of a thorough study:

- Creating a data base management system for drill core information
- Statistical analysis
- Modeling the variability (variogram modeling)
- Estimation
- Plotting
  - drill hole locations
  - experimental and theoretical variogram

- histograms and box-plots

An integrated geostatistical software package has been written to implement the foregoing steps, which are also required for the research described in this dissertation. This package, originally named GEOSTAT and discussed by Unal (1985), was later updated and its name changed to GPPC to prevent a controversy with a consulting firm bearing the same name. GPPC is the acronym for **Geostatistics Package for Personal Computers.**

Even though GPPC was mainly written to implement a portion of the research discussed herein, an equally great effort has gone into an innovative design to eliminate the impracticalities of the existing computer software for geostatistics. In the interest of sharing GPPC with the practitioners of geostatistics, and to disclose the innovations incorporated, a large portion of the rest of this chapter is devoted to GPPC.

While most of the available geostatistical programs require mainframe computers, GPPC runs on a small personal computer. A help option has been incorporated to eliminate the need for a lengthy users' manual. The whole package is integrated and interactive; therefore, the inconvenience of batch processing peculiar to the existing software is avoided. Color graphics are utilized at every phase for facilitating the analysis.

Despite numerous unique advantages, GPPC does not cover all of the tools of geostatistics. It is restricted to two-dimensional analysis and linear geostatistics. However, this is sufficient for many of the coal seams being mined today, with the exception of the very thick coal seams characteristic of the Western United States. Three-dimensional analysis would be necessary only if the height of the estimation block has to be taken smaller than the thickness of the coal seam.

Unfortunately, estimation through cokriging had to be omitted, due to the memory and speed limitations of personal computers available today. The cokriging program of Carr (1985b,) COKRIG, has instead been utilized for this purpose.

5.1 Existing Geostatistics Software

A few textbooks and research reports have been the source of algorithms and computer programs in geostatistics. David (1977), in his textbook, presents FORTRAN programs for computing experimental semivariograms and implementing kriging. Likewise, Journel and Huijbregts (1978) also provide FORTRAN routines for the same purpose. The treatise of geostatistical material and the required algorithms, such as calculation of mean semivariogram values and solution of linear equations by Journel and Huijbregts, is more comprehensive than any other source.

Kim and Knudsen (1977) have included FORTRAN programs for variogram computation (UGAMM) and kriging (UKRIG) in their research report. Furthermore, they have incorporated two computer programs as visual aids to an analysis. The program VARPLOT is written to display variograms, and MAP to display kriged block values. VARPLOT is written using Calcomp subroutines, and is capable of plotting various experimental variograms and a spherical variogram model. MAP creates a plan map of the block values, which may chosen to express the estimated value of a parameter, estimation variance thereof, and confidence interval. MAP uses the line printer to create the plots.

The programs mentioned above implement ordinary kriging only, that is, kriging under the stationarity or intrinsic hypothesis. This amounts to assuming an expectation equal to a constant, regardless of location, as was discussed in Chapter 2. Any hypothesis other than the stationarity and intrinsic hypothesis is left out of the treatise of regionalized variables in this dissertation. However, other assumptions have been suggested in the context of geostatistics, and a corresponding kriging procedure has been developed accordingly. One such assumption considers expectation at a location as the summation of monomials, which are functions of the coordinates. The resulting kriging is called universal kriging. Skrivan and Karlinger (1980) have written a FORTRAN program to estimate the variogram of the residuals and to implement universal kriging. The entire program is referred to as the kriging package, and the user has been given four options to choose from. These options are variogram calculation, cross-validation, kriging, and estimation of the coefficient of the drift. In cases where the drift is a constant, universal kriging is equivalent to ordinary kriging with known mean.

The theory of intrinsic random functions of order k, and the accompanying kriging procedure, has been programmed by Kafritsas and Bras (1981) in a package of FORTRAN subroutines called AKRIP, a kriging program. The theory of intrinsic random functions of order k is the generalization of the intrinsic hypothesis discussed in Chapter 2, which corresponds to an intrinsic function of order 0 (Matheron, 1973.) Originally, the first computer program to utilize the intrinsic random functions is BLUEPACK, but this program is not available to the general public (Delfiner, 1976.) Of these few available programs, AKRIP is the only interactive program. The user has five options to choose from in identifying the correlation structure and obtaining point and block estimates. One of the options is comprised of a cross-validation procedure for deciding upon the best covariance model given various possible choices. In AKRIP, the automatic estimation algorithm discussed by Delfiner (1976) has been adopted rather than the traditional approach of incorporating qualitative geological information through plotting of experimental semivariograms.

Publicly available geostatistical software lacks many desirable functions that would save time and effort in carrying out a geostatistical study. For example, none incorporate a statistical analysis option, even though this is an indispensable part of a geostatistical analysis. As a consequence, one must use a statistical package and subsequently reenter data in the format required by the package. None of the programs, except for AKRIP, are interactive and menu-driven. Therefore, each time a parameter is changed, the data file has to be modified and the program rerun. Only VARPLOT plots the experimental and theoretical semivaroigrams, which is an essential step in variogram modeling. In addition, no existing geostatistical software takes advantage of widely available personal computers and the advances in hardware and software that have accompanied them.

5.2 GPPC - A Geostatistics Package for PC's

Before initiating the project of writing geostatistical software a few objectives were set, one of which was to make use of widespread and low-cost personal computers. Another objective was to create integrated software. This meant incorporating every fundamental function necessary to carry out a basic geostatistical analysis based on a simple data base. The result was in menu-driven software with a modular structure.

Color graphics capabilities have been utilized to the fullest extent for a comprehensive reserve analysis using geostatistics.

The user is accomodated with an on-line help option, which is intended to eliminate the users' manual and to serve as a geostatistics reference text.

While it may be best to use GPPC in its full capacity for point and block estimation, it may also be used as a data base management, statistical and graphics system for drill hole data alone. The gridding option may be interfaced with a contouring and surface plotting software package as well. The variogram model chosen may be used in another program to choose the additional drill hole locations if needed.

5.2.1 Hardware Requirements

At the time that the task of writing a software package was undertaken, one stated objective was to restrict the hardware requirements so that the package would be within the reach of as many users as possible. Thus, a personal computer with a single disk drive, preferably but not necessarily a hard disk, 64 Kilobytes of random access memory, a dot matrix printer, and a color graphics monitor were projected to be the components of what would be the optimum setup for reasonable period of time to come.

Practice with GPPC has indicated that a pen plotter would have been extremely useful in regard to the creation of hard copies of the graphs generated on the terminal. Presently, hard copies can only be obtained by a screen dump into the dot matrix printer.

5.2.2 Software Characteristics

GPPC is written in Basic programming language, to be run on a personal computer system that supports the IBM Personal Computer Basic Version A2.00 or higher. This is an interpreter and is different than the compiler in numerous ways. First, interpreter Basic is more versatile in the sense that it contains certain commands that the compiler does not.[3] Second, not every command that is common to both has the same syntax. There are also structural differences between the interpreter and compiler with regard to the allocation of registers. For example, the list of common variables in each chaining program should be identical for the compiler. This is not required in the interpreter, which generally increases the free memory available. All the other publicly available geostatistical software is written in FORTRAN language, which is not as suitable as Basic language to control input functions and generate graphics as will be discussed in the rest of this section.

In the program development stage, it is always advantageous to work with the interpreter Basic, not only because of the reasons stated in the foregoing paragraph, but also because of the convenience in debugging and validating the programs. With the compiler, every time an error is detected, the code has to be recompiled. In addition, printing out the values of the variables requires either special debugging macros or explicit write statements. With the interpreter Basic, however, it is always possible to interrupt execution, examine the values of the variables, and then continue the execution from any point in the program. Once all the programs are free of errors, they can be compiled in order to run faster. GPPC, as listed in Appendix A, can in the presented form be run only by the interpreter. For this reason, several minor changes have to be made to eradicate the discrepancies between the interpreter and the compiler before attempting to compile GPPC as listed.

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[3] Each new version and/or brand of the compiler Basic narrows the gap between the interpreter Basic Version A2.00.

An uninterrupted analysis is very desirable in a lengthy reserve analysis session. One should be able to retrieve or edit the data file, process it, and obtain the estimated values after a software package is loaded. Trying to figure out how and which program to load, which data file to choose, and what is wrong when an error occurs is frustrating and results in an unnecessary loss of time. Batch processing is avoided in GPPC, unless interface with another computer program is desired. For example, gridded data may be used in contouring and surface plotting software. In such a case, the user must leave the GPPC environment and load that software. The continuity in the flow is maintained by a menu-driven and modular, but integrated, architecture.

GPPC is driven by a module containing the main menu. In general, each item in the main menu is a module driven by a menu of its own. Any desired task may be selected by choosing the relevant options in the main menu and the submenu consecutively. Thus, all irrelevant questions and input requirements are bypassed, ensuring that the shortest path to implementation of a desired task will be taken while the sequence of loading and running the modules will remain transparent to the user.

GPPC is interactive, but not in an accustomed fashion. The user is not expected to answer a question immediately after the question is asked. Instead, all the relevant questions, whether they require a yes/no or more complex answer, are collected on screen pages in the form of questionnaire sheets. Thus, a repeated question-answer-error message sequence has been avoided. Moreover, the user has the flexibility of being able to go back and check what information has been supplied, and to change it, if desired, before the run command is issued using a function key on the keyboard. Upon the implementation of the run command, every entry is checked with regard to type and default or imposed range. Consequently, the probability of program interruption due to an entry error is minimized. In fact, the program may be run by a single keystroke if the default values provided are accepted.

The input statements available in the Basic language are not suitable for creating a controlled input and page editing environment. The major reasons are:

1. Total control over the location of the cursor is not possible.
2. Immediate trapping of the function and special purpose keys is not possible.
3. Certain errors cannot be trapped, and the running of the program is terminated with error messages.

To overcome these difficulties, a subroutine was written which required:

1. Developing editing algorithms to:
   - Type a character
   - Delete a character
   - Insert a character
   - Backspace
2. Manipulating the cursor movements on every screen page using:
   - Cursor up

- Cursor down
- Cursor right
- Cursor left
- Tab
- Shift + Tab

3. Keeping track of the location of the cursor and the input fields on every page at all times.

4. Assigning specific tasks to the function keys and special purpose keys, which are:

   - F1-Help
   - F2-Run
   - F3-Load a file
   - F4-Save a file
   - F7/Pg Up-Previous page
   - F8/Pg Dn-Next page
   - F10/Home-Menu

Each variable, whether it be a character or numeric variable, is inputted as a character variable. At the start, each variable is initialized by a character string equivalent to the default value padded with blank characters. Afterwards, the required changes may be made by locating the cursor at the position of the character to be changed and typing in the new character. When editing is finished, the numeric variables are converted to their actual values from their character equivalents. This aids in the detection of syntax errors while entering numbers.

The controlled input and page editing philosophy that has been incorporated into GPPC was originally developed for GEOSTAT (Unal, 1985.) This approach later evolved into the short subroutine, called EDITOR.BAS, which has been used in various other computer software packages developed in the Department of Mining and Minerals Engineering Department at Virginia Polytechnic Institute and State University, such as U-SEAMS (Grenoble, 1985) and FRAPS (Haycocks, 1984.) While EDITOR.BAS has been used in some of the modules in GPPC as given in Appendix A, the original version has not been replaced in all modules.

The on-line help option is one of the most useful aspects of GPPC, especially for the first time users. It serves not only as the user's manual, but also as a reference for the relevant geostatistical topics. The user enters the help environment by pressing the F1 key, independent of what module is being executed. This takes the user to the relevant section of the help file, where detailed instructions are given and geostatistical concepts are discussed. Once the help option has been accessed, it is possible to move to any section of it.

On-line help option is an independent module rather than a subroutine, which may be chained to from any of the modules. Upon the request of help, the control is passed to the help module, called HLP.BAS, together with the corresponding page number in the help file. The help information is stored in a random access file. HLP.BAS retrieves the relevant page and displays it. In the meantime, one preceeding and two succeeding pages are also retrieved and loaded into the buffer of the video display for possible subsequent requests.

All of the graphics and plots are designed for four color execution in extended high resolution mode, if the graphics card is capable of supporting that.[4] Hence, it has been possible to present more information in a display without sacrificing clarity. A character set has been added which has the ability to print special characters and labels in the vertical direction.

5.2.2.1 Modules of GPPC.

GPPC is comprised of six principal modules. Their names and functions briefly are:

1. MAINMENU - Interfacing and Utilities

2. INPUT - Data Base Management

3. PLOTS - Drill Hole Plotting

4. STAT - Statistical Analysis

5. VARGRAM - Variogram Calculation and Modeling

---

[4] Extended high resolution mode in GPPC is written according to the Frederick Electronics Corp. colorgraphics board COLORPLUS. If this mode is bypassed, two colors in high resolution (640 by 200 pixels) are available.

6. KRIG - Estimation

In fact, there are two more modules in the software package, namely HLP and GPPC. HLP maintains the interface with the help file, and has been discussed in the previous section. GPPC bears the same name as the package itself, and serves as a starter. Initially, it displays the GPPC logo on the screen and then passes the control to MAINMENU; this sequence will not to be visited again unless the package is restarted.

Each of these modules are individual programs written in the Basic language, and have been given the extension **.BAS** . The listing for all modules are given in Appendix A. Nevertheless, these modules may terminate prematurely if run independently. They have been written to be driven by MAINMENU, and this process is transparent to the user. MAINMENU loads the module required by the user and takes the control when finished. The organization of the modules in the package is illustrated in Figure 1 on page 42.

Executive Module: MAINMENU is the executive of the package. Any specific task starts and ends here. All of the options in the package are summarized in this display, and the user is asked to make a choice as shown in Figure 2 on page 43. MAINMENU loads the module corresponding to the option chosen, and takes control back when this option has finished running. If an option is chosen before a visit to the prerequisite option(s), a warning is issued. The first five options in the main menu correspond to the modules INPUT, PLOTS, STAT, VARGRAM, and KRIG, respectively. The last two items in the main menu and the main menu itself are implemented by the module MAINMENU.

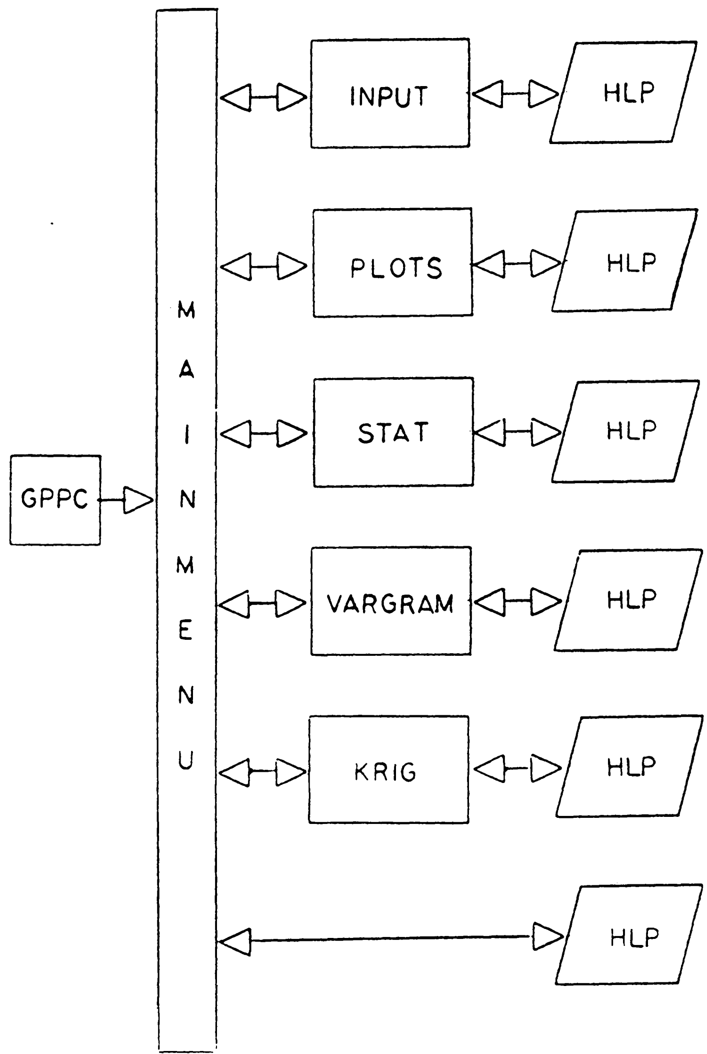


Figure 1. Organization of the modules in GPPC

```
                              MAIN MENU

        1   Input of Drill Hole Data and Boundary Points
        2   Plot of Drill Holes and Boundary Lines
        3   Statistical Analysis
        4   Spatial Analysis-Semivariogram Modeling
        5   Estimation (Ordinary Kriging)
        6   Exit to DOS
        7   Utility Functions
              * GPPC Instructions
              * File List
              * Printout of Data Files
              * Set Color Attributes

Your Choice : I



-----------------------------------------------------------------------------
            F1/F10Help-Detailed/Quick Ref.   F2/F3Page Down/up
Invalid entry! Enter the number of your choice from the menu between 1 and 7.
```

Figure 2. Main menu of GPPC

INPUT is the prerequisite for all the remaining modules. Statistical analysis should always be the prerequisite of variogram analysis, which is in turn the prerequisite for estimation. Even though no provisions have been made to prevent visiting VARGRAM before STAT, or KRIG before VARGRAM, the necessary parameters are passed to the subsequent module if the correct sequence of INPUT, PLOTS, STAT, VARGRAM, and KRIG is followed. For example, the variance is passed to VARGRAM from STAT to be displayed in the experimental variogram plot for use in modeling the sill value. Likewise, the latest variogram model studied in VARGRAM is passed to KRIG for use in estimation.

MAINMENU is the only means of exit from GPPC and entry into the DOS environment. This is accomplished by choosing Option 6 in the main menu. Option 7 provides various utility functions. Among them are the options of displaying the starter instructions, listing the files, obtaining printouts for the data files created by GPPC, and setting the color attributes. The user is allowed to choose the foreground and background colors in which to display the data fields. The data files created by GPPC are random access files with record lengths of greater than 132 characters, which does not allow a neatly formatted printout. Therefore, an option has been provided with which to print data files on a dot matrix printer. The file list option eliminates the need to exit to DOS in order to view a list of the files on the disk. Although very simple, file list has proven to be a very useful option.

Data Base Management Module: Data base management module is composed of four submodules, namely INPUT, INPUTR, INPUTE, and INPUTE1. INPUT may be thought as the executive of this module. After being loaded into memory by way of MAINMENU, it loads one of the other submodules according to the choice of the user.

In oder to read a file that has previously been created and to return to the main menu afterwards, INPUTR is loaded. Editing a new or a previously created file, requires the loading of INPUTE. INPUTE1 follows INPUTE, if there is a desire to input or modify more than one variable. In the software's present form, up to 129 drill holes with up to eight variables for each drill hole can be handled by retrieving one variable at a time. In addition, data fields are reserved for drill hole labels and coordinates for each hole. Extra information may be entered in the drill hole label field. Figure 3 on page 46 shows the layout of the screen for INPUTE or INPUTE1.
Drill hole labels and coordinates, as well as the variable, may be edited in INPUTE, but only the variable may be edited in INPUTE1.

The data file created is a random access file. This provides flexibility in retrieving and manipulating the records.

The built-in page editor and the controlled input environment greatly facilitate input and alterations. As seen in Figure 3 on page 46, information for seventeen drill holes is displayed simultaneously, and a change may be made at any position in any of the input fields. Cursor and function keys have been programmed to skip the cursor from one field to another, both horizontally and vertically, providing faster access to the target field.

Provisions have been made to allow drill holes for which no values have been recorded to be excluded from the analysis, instead of being included as zeros. All the inputted values may be checked for possible errors with regard to user-defined ranges before being saved. If a value is found to be out of range, the cursor is located at that field and a warning issued.

1.3.DRILL HOLE DATA

No value at a drill hole => ? in the first column of that Seam Thick.(m) field.

	Drill Hole Label	E-Coordinate	N/S-Coordinate	Seam Thick.(m)
1	1014	8016.58	17196.53	1.32
2	1021	8598.13	18599.31	1.66
3	1022	7941.36	17450.59	1.34
4	1023 Sep. Pop.	8865.45	18599.87	?3.09
5	1028 + 1319/2	7945.80	17699.39	1.715
6	1029	8215.81	17699.89	2.27
7	1061	7532.91	17991.	1.59
8	1062 *	7633.50	17992.76	1.39
9	1063	7758.98	18300.09	1.57
10	1091	8090.51	16798.32	1.21
11	1123	7264.01	18910.59	1.79
12	1213 *********	9335.00	14549.	?.67
13	1214 *********	9750.54	14549.71	?.67
14	1217 *********	10206.27	21193.34	?.43
15	1240 Sep. Pop.	7881.55	19298.97	?3.89
16	1241	7166.16	18599.7	.99
17	1242	7463.80	18300.47	1.53

F1 (Help)   F2 (Done;proceed)   F3 (Previous Menu)   Shift+PrtSc (Print Screen)
F7/F8 (Page up/down)   F9/F10 (Move left/right between fields)
/ (Move up/down between fields)   /(Move right/left within a field)
This value is not in the range you have specified ! Please correct it.

Figure 3. Screen layout for data editing in GPPC

Drill Hole Plotting Module: The graphics module which displays drill holes and property boundary lines is PLOTS. The user has been provided with many useful options with which to overcome the problem of low resolution, characteristic of inexpensive color monitors. Two such tools are the dual capabilities of zooming and panning. The plot is composed of dril hole identifiers, drill hole labels, and property boundary lines. Zooming to any section of the plot renders a clear view, not plauged by overlapping characters and lines. On the other hand, it is possible to fit more information onto the screen by panning. For example, more drill holes may be marked upon a plot by panning, if the option for plotting drill hole labels is foregone.

Statistics Module: The satistics module, STAT, implements basic statistical analysis techniques to be used in modeling regionalized variables. STAT's menu is comprised of four options:

1. Statistical summary

2. Histogram and box-plot

3. Kolmogorov Simirnov Goodness of Fit test for normality

4. Logarithmic transformation

Statistics such as median, mean, variance, standard deviation, coefficient of variation, minimum, maximum, and range are presented in the statistical summary. Additionally, the non-outlier range is calculated, and the drill holes which are outside this range are classified as mild and extreme outliers (Tukey, 1977.) The results are also summarized as box-plots, together with the histograms in the following option. These exploratory data analysis tools provide sufficient insight for determining whether the data is normally distributed, which has important implications in geostatistics. If normality does not hold true, lognormality may be investigated by a logarithmic transformation using the fourth option in this module. For a formal test of normality, the Kolmogorov-Simirnov 2-sided Goodness of Fit test has been offered as an option (Stephens, 1977.)

Variogram Modeling Module.: The variogram modeling module, VARGRAM, offers three options to choose from:

1. Experimental semivariogram calculation,

2. Semivariogram modeling, and

3. Anisotropy analysis.

Up to eight experimental semivariograms can be calculated at one time. Direction, direction tolerance, lag distance, and lag distance tolerance may be requested for each. If required, weighted semivariogram is calculated instead of the average semivariogram. Weighted semivariogram is the weighted average of the squared differences, calculated with respect to the separation distance of the pairs that go into calculation. The user has also the option of requesting the relative semivariogram, which is the semivariogram divided by the square of the mean of the data values that have been included in the semivariogram calculation. All semivariograms calculated may be saved in a data file and retrieved later. The screen page for the experimental semivariogram calculation option is shown in Figure 4 on page 50. Any combination of the experimental semivariograms that are currently in effect, that is, either calculated or retreived, may be depicted on one plot. For example, the calculating and plotting of semivariograms at different angles helps in detection of anisotropies.

Up to eight different theoretical models may be superimposed on the plot of the experimental semivariograms. Each model may comprise up to two submodels, and a nugget value. Submodels may be chosen to be spherical, exponential, gaussian, or linear. The greatest advantage in being able to display more than one model is the resulting ability to compare the fit of the competing models visually. These models may be of the same type with different parameters, of different types with the same parameters, or of different types with different parameters. Visual inspection will help to decrease the alternatives for cross-validation.

If a geometric anisotropy is prevalent, an appropriate model may be fitted using the third option of VARGRAM. The required input for plotting the anisotropy ellipse to represent the geometric anisotropy consists of the angle of anisotropy, the anisotropy factor, and the range at the major axis of the ellipse. For an isotropic model, the angle of anisotropy is zero and the anisotropy factor is unity. The directions considered in the semivariogram modeling option are automatically included in the anisotropy analysis. For all the directions, nugget values should be equal, and the semivariogram types and the sills thereof should be identical for both the first and the second model. Otherwise, the anisotropy will be zonal rather than geometrical. The output consists of a plot of the directional ranges and the anisotropy ellipse. Thus, the user can choose the best fitting anisotropy ellipse by changing the angle of anisotropy and the anisotropy factor.

Estimation Module: The ordinary kriging procedure, as described in section 2.2.1, is performed by the module KRIG. For the solution of the system of linear equations

```
                    4.1.EXPERIMENTAL SEMIVARIOGRAM

          Experimental semivariogram file retrieved : o-tv.dat
          Logarithmic transformation [ (y)es,(n)o ] :  no

          Weighted semivariogram [ (y)es,(n)o ] : n  [n/N => plot ave. semivar.]
          Relative semivariogram [ (y)es,(n)o ] : n

      Remarks  [blank => Do not] Direction  Direction     Lag     Lag Distance
      Relative Calcu- Print Plot [degrees]  Tolerance   Distance    Tolerance
      Semivar.  late                          [+/-]                   [+/-]
  1      n                 yes     90.0        15         500          250
  2      n                 yes     67.5        15         500          250
  3      n                 yes     45.0        15         500          250
  4      n                 yes     22.5        15         500          250
  5      n                 yes      0.0        15         500          250
  6      n                 yes    -22.5        15         500          250
  7      n                 yes    -45.0        15         500          250
  8      n                 yes    -67.5        15         500          250

           Orion Seam  (Outliers Eliminated)       * Seam Thick.(m)

--------------------------------------------------------------------------------
   F1/F10Help-Detailed/Quick Ref.  F2/F9Page down/up  F3/F4Load/Save  Home
*SAVE*Type file name and hit RETURN
```

Figure 4. Screen layout for semivariogram calculation in.GPPC

given in [2.9] and [2.10], the method of Gauss Triangulation with Back Substitution is used. The output is comprised of the kriging estimate and the kriging variance. The input requirements may be classified into three main categories as variogram, block, and search parameters.

The variogram parameters include the range (A) and the sill value (C) of the submodels. The parameters selected in the anisotropy analysis option of the module VARGRAM are kept and constitute the default values. Up to two submodels and a nugget value (C_0) may be nested. A different geometric anisotropy may be imposed on each submodel, and each submodel may be chosen to be spherical, exponential, gaussian, and linear.

Search parameters are the maximum search distance and maximum number of points to be included in weighting. There is no limit to the maximum search distance, but the maximum number of points has been limited to 15.

Krig may perform either point or block kriging depending on what the user defines as the block configuration. Each estimation block is defined by the coordinates of its center and the length of the two adjacent sides. If the sides are elected to be zero, the estimation becomes the point estimation. An array of blocks (or points) may be estimated in one single run by defining the number of blocks in the North and the East directions and the coordinates of the center point for the lower left-most block. The option of the point estimation is incorporated for the purpose of better variogram modeling. The capability of choosing the variogram model which preforms better according to some certain criteria (usually related with the estimation errors) is very helpful especially when there is not much geological information to determine the type of the model and its parameters. Coincidentally, the cross-validation procedure used in this study has been implemented using the point estimation option of KRIG.

5.3 COKRIG - A Cokriging Program

The attempts to include a cokriging module into GPPC failed for two major reasons. First, the memory required was estimated to be directly proportional with the number of variables jointly estimated. Second, the execution time was projected to be impractically high on a personal computer. For these reasons, the cokriging program, COKRIG, was used instead of writing a new program. The listing of the computer program and the necessary instructions to use it have been published by its author James R. Carr (1985b.) COKRIG is written in FORTRAN language to be run on a mainframe in batch environment.

CHAPTER 6

A CASE STUDY

This case study has been conducted to test the hypotheses made with regard to cokriging and the prerequisites thereof in coal resource characterization. It has been asserted that cokriging should provide better results than kriging, and this has been based on the assumption that some of the variables of interest are spatially cross-correlated. This case study will make it possible to see which of the variables are cross-correlated and how strong this correlation is, spatially or otherwise. Checking will also be done to ascertain to what extent the correlation scheme depicted by the data can be duplicated by kriging and cokriging. Finally, kriging and cokriging estimators will be compared.

6.1 The Data

The data used in this case study is taken from a report which investigates the application of kriging to coal reserve estimation (Pauncz, 1980.) It was chosen despite a limited number of drill holes. The variability structure has already been determined, so that ordinary kriging used in cross-validation yields the minimum weighted squared errors possible. Although the variogram models selected and the significance of the criteria used for cross-validation in this report are debatable, they provide a good setting in which to test the performance of cokriging over separate krigings. In addition, the data file has been freed from systematic errors, which is essential when modeling and discerning cross-correlations. Biases or other types of errors in sampling, laboratory analysis, and compositing may easily conceal the existing spatial structures.

The area of interest is located in the eastern portion of Queensland in Australia. The data comes from the fully or partially cored drill holes intersecting the Orion seam, which lies within the Rangal Coal Measures in the Bowen basin. A complete listing of the data comprising 41 drill holes has been provided in Appendix B. Drill holes 1213, 1214, 740, 1217, and 238 were too far away to be included in the estimation, and therefore have been discarded. Holes 1319 and 818 have also been discarded after being averaged with 1028 and 1317, respectively, due to duplicate sampling. This reduced the number of available drill holes to 34, covering an area of interest which is approximately 11 sq km. The map of the drill holes given in Figure 5 on page 55 illustrates the distribution of the drill holes in the area of interest.

While thickness has been recorded for all of the drill holes, density and ash content have not been recorded at 4 locations, leaving a full sample size of 30. There are only a total of 5 observations regarding sulphur content and calorific value, and these have therefore been left out of the analysis despite a possible correlation with ash content.

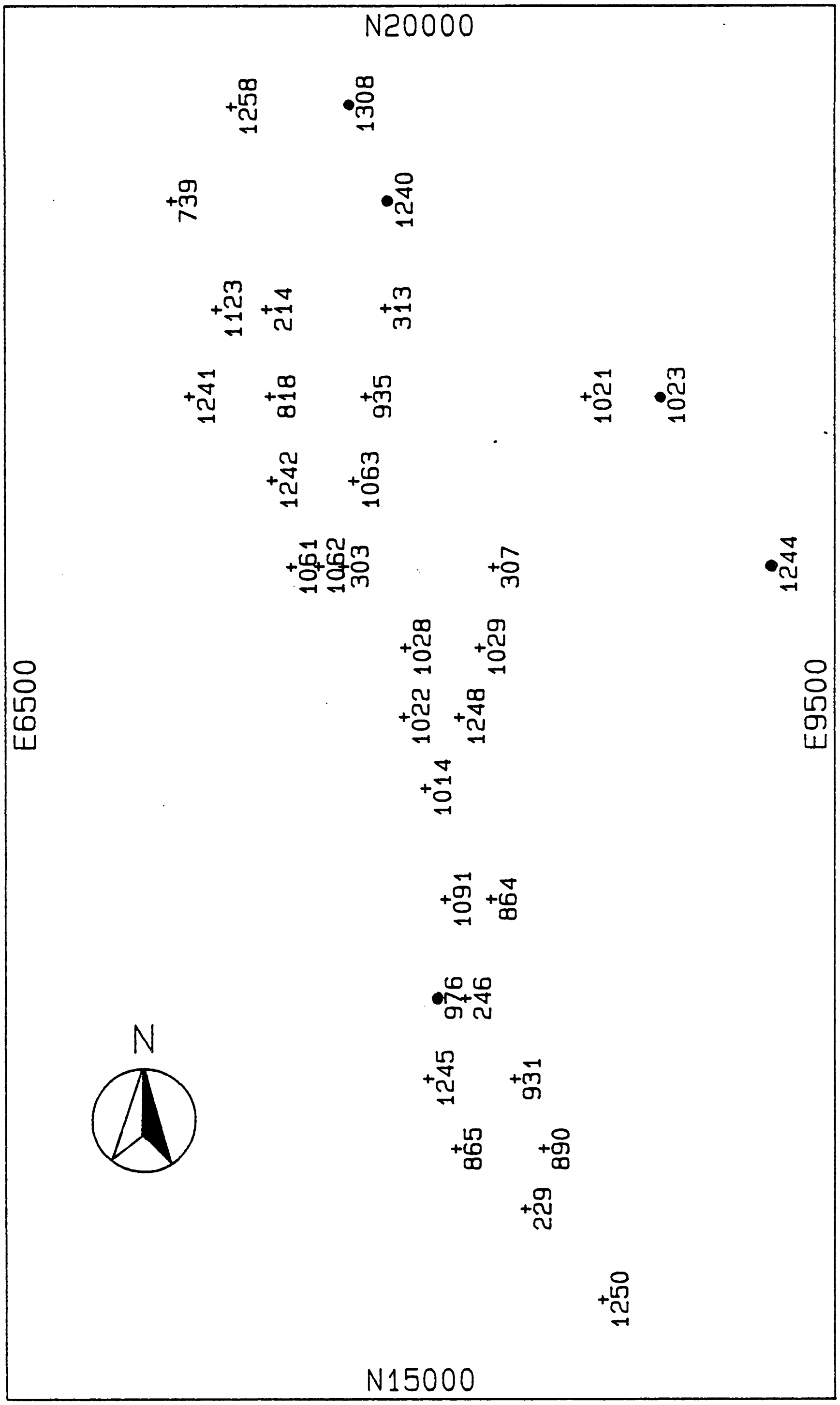


Figure 5. Drill Hole Location Map: The drill holes indicated by circles have different statistical properties than do the rest.

6.2 Statistical and Geostatistical Analysis

The data has been subjected to univariate and bivariate statistical analysis, which has been followed by variogram and cross-variogram modeling.

The results, as will be discussed in greater detail in the rest of this chapter, indicated the possibility of the existence of at least three distinct zones with different univariate and bivariate properties. The first zone includes the drill holes 1308, 1240, 1023, 976, while the second zone includes drill hole 1244, as shown in Figure 5 on page 55. The third zone is defined by the remaining drill holes.

In the presence of more than one homogeneous zones, modeling and estimation is carried out within each zone separately (Haycocks, 1983.) Nonetheless, the number of drill holes in the first zone is insufficient for accurate modeling and estimation. Therefore, the drill holes contained in the first and second zones will be excluded, leaving only those in the third zone for modeling, estimation, and cross-validation.

6.2.1 Univariate Statistical Analysis

Univariate statistical analysis includes the calculation of mean, median, minimum, maximum, and variance; plotting histograms and box-plots; and applying the Kolmogorov-Simirnov test for normality. The purpose is to determine the distribution charactristics of the variables without any spatial considerations. A summary of the basic statistics are given in Table 1 on page 57.

Figure 6 on page 58 illustrates the histograms and box-plots for the 34 thickness, 30 ash content, and 30 density observations.

Table 1. Summary of the statistics for the complete data

	Seam Thickness (m)	Ash (%)	Density (t/cu m)
Sample Size	34	30	30
Mean	1.74	19.07	1.46
Median	1.595	15.75	1.43
Minimum	.83	10.30	1.37
Maximum	3.89	41.50	1.69
Range	3.06	31.20	.32
Variance	.41	71.91	.007
Standard Dev.	.64	8.48	.08
Skewness	1.12	1.08	1.22
Kurtosis	4.72	3.13	3.69

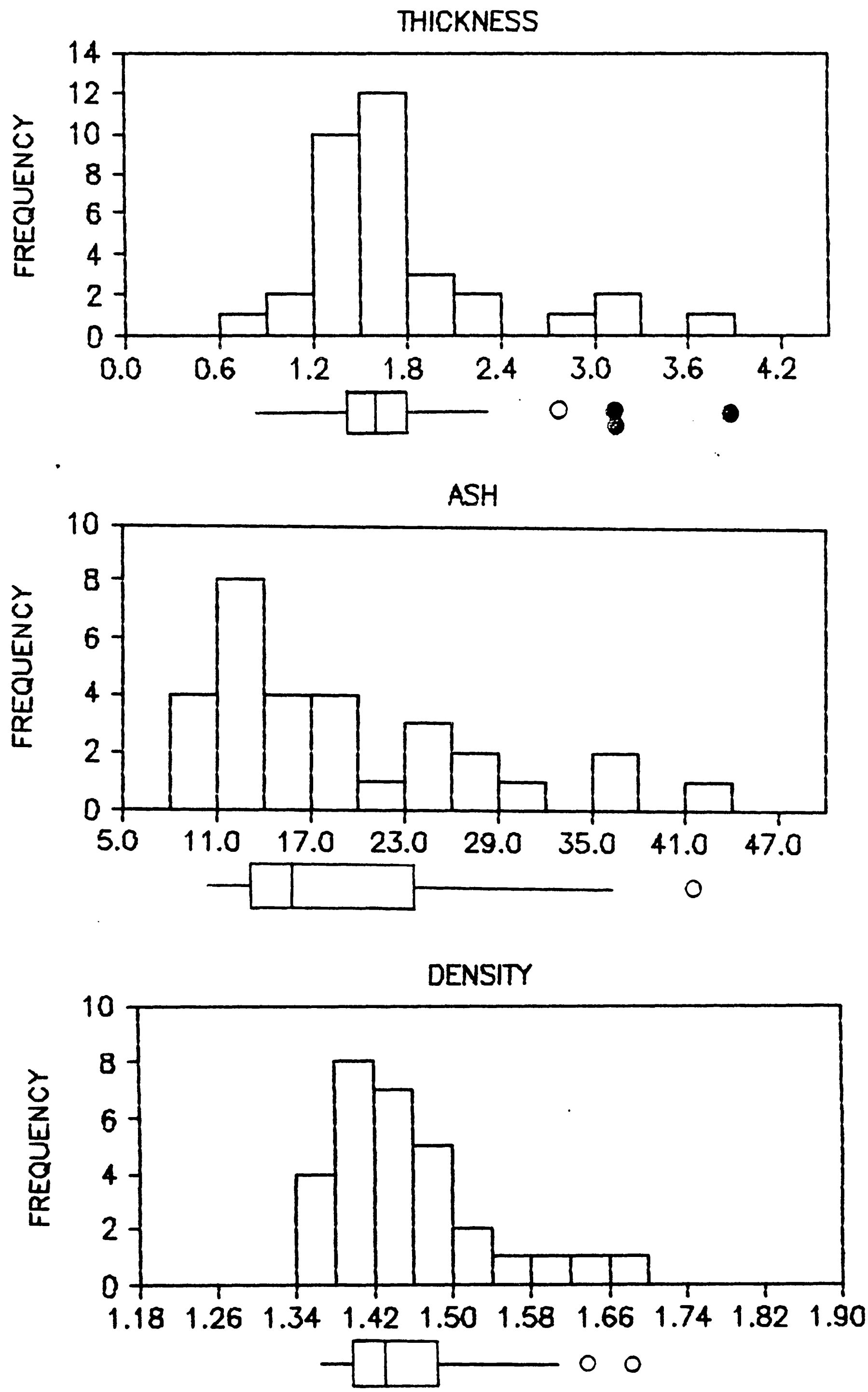


Figure 6. Histograms and box-plots of seam thickness, ash content, and density

An obvious multimodality can be observed for all three variables from the histograms. The thickness appears to be bimodal, the modes occurring around 1.6 and 3.1. Drill holes 1308, 1023, and 1240 are extreme outliers and 976 is a mild outlier for seam thickness, as shown in Figure 6 on page 58. These four holes signify a different population. The first three are zoned in the extreme northeastern flank of the study area, as can be seen in Figure 5 on page 55. It is probable that drill hole 976 comes from the same population as do the other three, but it is separated from them by a band of coal body with different thickness and quality properties. Density also shows bimodality with modes around 1.45 and 1.60. Drill holes 1244 and 307 appear as mild outliers. The distribution is skewed to the right. The distribution of the percent ash is also skewed to the right. There is only one mild outlier, hole 1244, and there are no other outliers. At least four modes can be detected from the histogram at approximately 13, 19, 29, and 37 percent ash. The test statistic for the Kolmogorov-Simirnov Goodness of Fit test for normality corresponds to a risk level of between .025 and .01. The rejection level is much less than .01 for both thickness and density . The high probability for rejecting normality is possibly due to multimodality. However, the possibility of skewness should not be discounted.

The summary of the univariate analysis with drill holes 1308, 1240, 1023, 976, and 1244 deleted is given in Table 2 on page 60.

The histograms and box-plots for the 29 thickness, 25 ash content, and 25 density observations are illustrated in Figure 7 on page 61.

Multimodality has been reduced to unimodality for thickness. For ash and density, the histograms and box-plots, as shown in Figure 7 on page 61, display a very similar distribution pattern with bimodality and skewness to the right. The drill holes which appear to cause the multimodality and skewness are 307, 1021, 1029, 313, and 1258. These

Table 2. Summary of the statistics for the reduced data

	Seam Thickness (m)	Ash (%)	Density (t/cu m)
Sample Size	29	25	25
Mean	1.565	18.368	1.452
Median	1.57	14.90	1.43
Minimum	.93	10.30	1.37
Maximum	2.29	36.20	1.64
Range	1.36	25.90	.27
Variance	.089	61.708	.0056
Standard Dev.	.299	7.855	.075
Skewness	1.01	1.09	1.27
Kurtosis	4.13	3.25	3.74

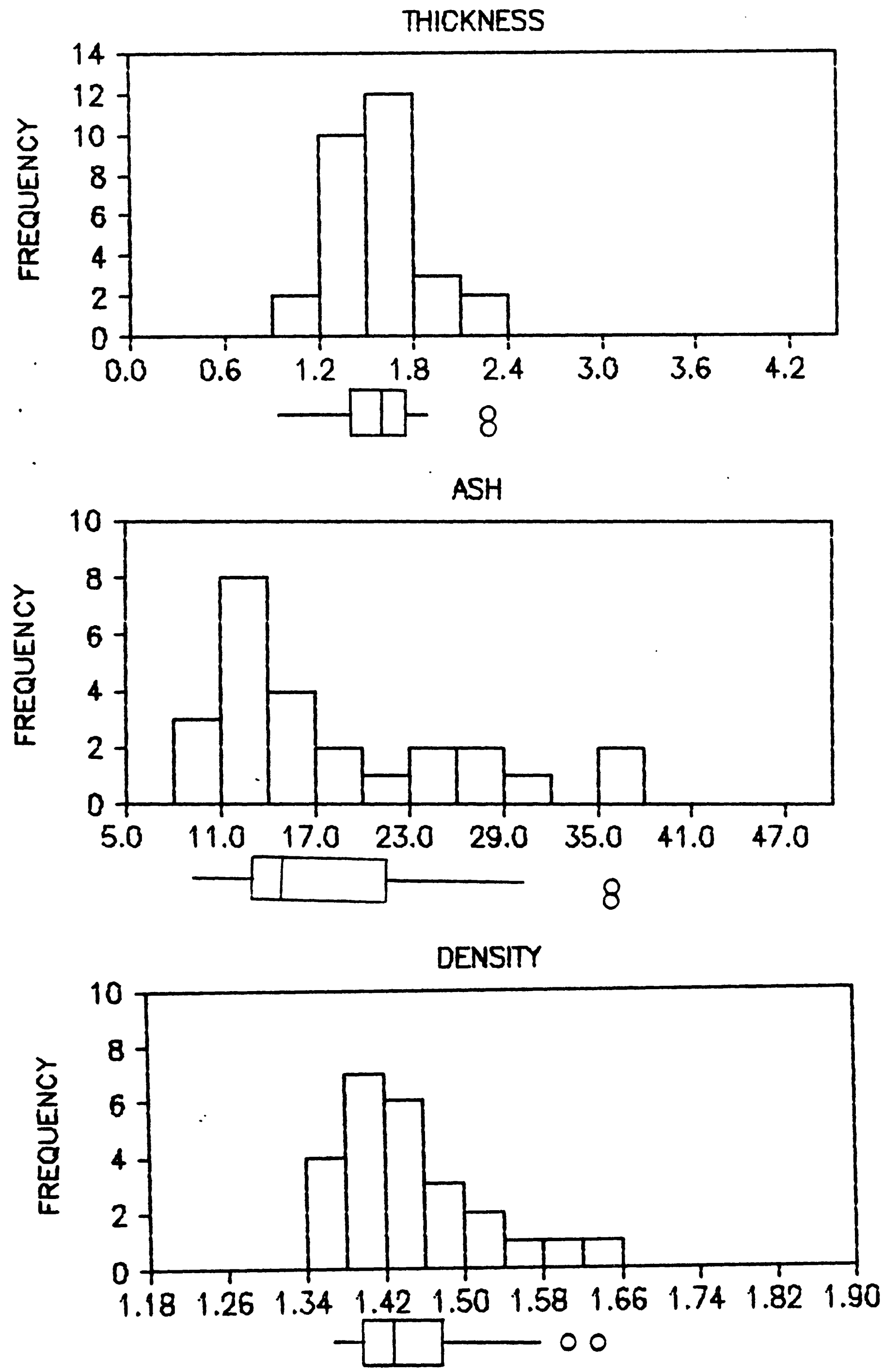


Figure 7. Histograms and box-plots of seam thickness, ash content, and density of the reduced data

constitute the northwestern border of the remaining body of drill holes. The spacing between any of these drill holes is two to three times that of the average interhole spacing. For this reason, it will be assumed that the underlying distribution for ash and density is unimodal and symmetric, contrary to the bimodal and skewed histograms and box-plots. This has been attributed to nonuniform and scarce sampling in the northeastern flank.

6.2.2 Bivariate Statistical Analysis

Correlation is covariance between two variables divided by the product of their standard deviations. Covariance is also a measure of intervariable relationship, but is not by itself very informative. Correlation coefficient is the most widely known estimator of the degree of correlation between two variables. It is unitless, and takes on a value between +1 and -1. Both +1 and -1 are inclusive and correspond to a perfect direct and indirect linear relationship, respectively.

The correlation between ash and density, as illustrated in Figure 8 on page 63, is very high and corresponds to a correlation coefficient of 0.94, indicating a very strong direct linear relationship.
This confirms with the hypothesis asserted in chapter 3. In the presence of such a strong relationship, it would not be difficult to estimate the most likely value of ash, if density were known, using the equation of the regression line in Figure 8 on page 63. However, this is only a special case of the general estimation problem encounterd in coal resource characterization. The general problem, as implied in kriging and cokriging formulation, may be stated as extending the value of an RF at any location in order to estimate the most likely value at another location. If, for example, there is an ash sample a few

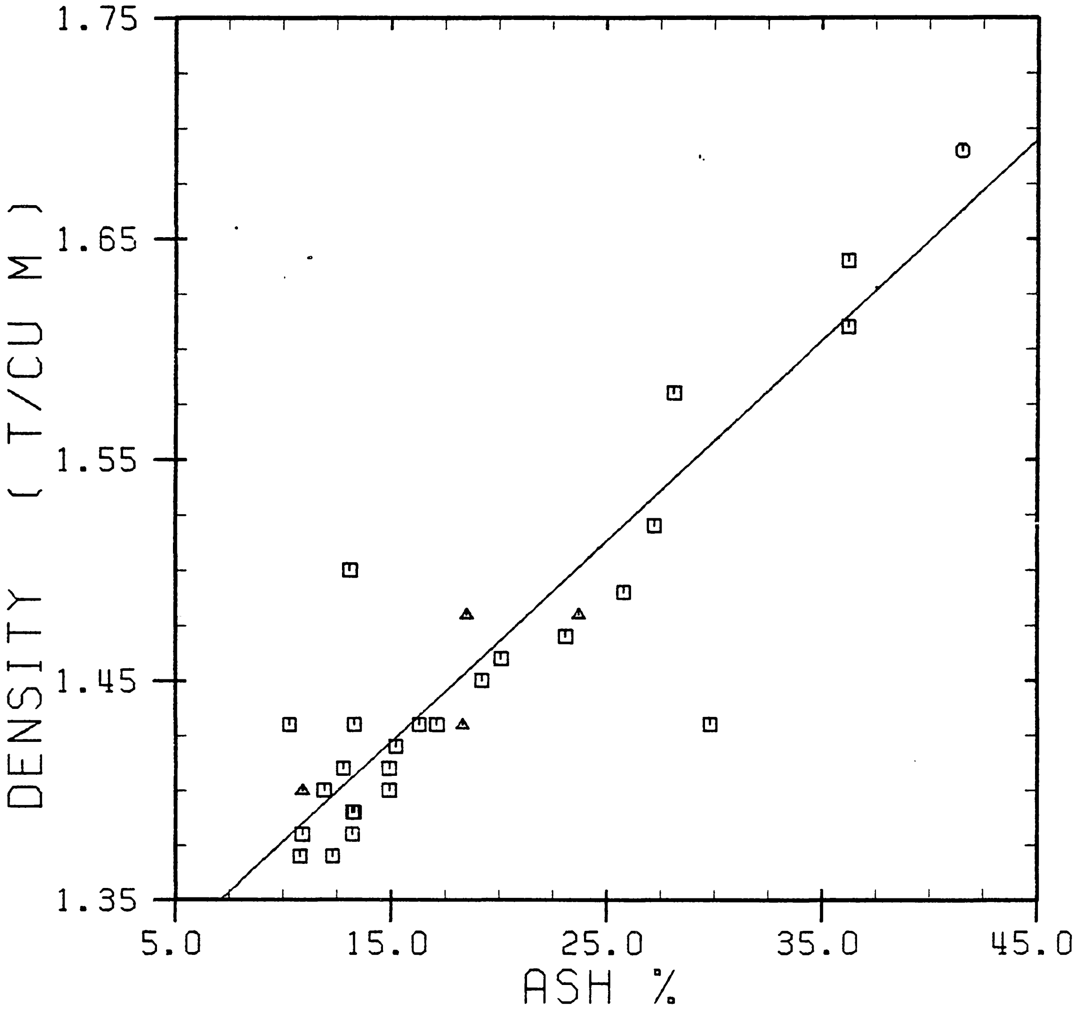


Figure 8. Scatter plot of density versus ash percent: Drill holes 1023, 1240, 1308, and 976 are indicated by triangles, and drill hole 1244 is indicated by a circle.

hundreds of yards away and a density sample very far away from the point at which density is to be estimated, how should an estimator be formed out of these two pieces of information? In order to answer this question, the degree of spatial cross-correlation between ash and density, indicated in the cross-variogram, and the degree of spatial cross-correlation within density, indicated by the density variogram, should be utilized in cokriging. Both the cross-variograms and the variograms will be given in the following sections.

The scatter plot of ash content versus seam thickness, as illustrated in Figure 9 on page 65, does not indicate a strong linear relationship, compared to which is found between ash content and density. The overall correlation coefficient is equal to .125. However, if the major homogeneous zone is isolated from the other distinct zones by deleting holes 1308, 1023, 1240, 976, and 1244, the correlation coefficient jumps to .66, revealing the direct relationship. Although not a rule, this usually is the case. A gradual or abrupt increase in the ash content, when a constant amount of coal is being deposited, will inflate the seam thickness, which would otherwise remain rather constant. Such a relationship will reveal itself either in a portion of the study area in the mine tract level, or in the entire area.

The same type of a relationship should prevail between density and thickness, because ash and density are strongly correlated, as shown in Figure 8 on page 63. Indeed, the correlation coefficient between seam thickness and density increases from .11 to .69 as shown in Figure 10 on page 66, when the same five drill holes are deleted.

This study has proven that bivariate analysis is useful in detecting zones with different statistical and geological properties.

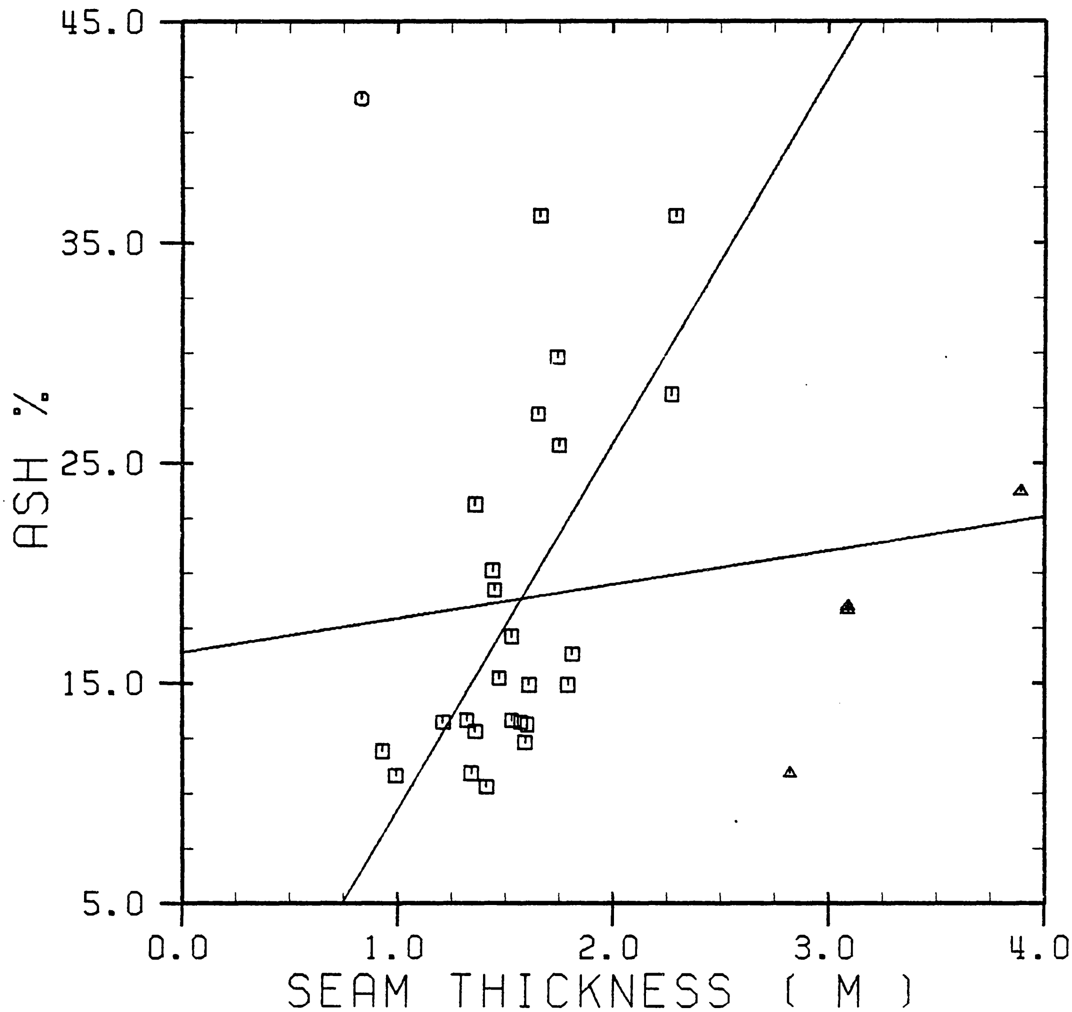


Figure 9. Scatter plot of ash % versus seam thickness: The regression line with the smaller slope corresponds to the case in which all drill holes are included, whereas the other corresponds to the case in which holes 1023, 1240, 1308, 976, and 1244, indicated by triangles and a circle, respectively, are deleted.

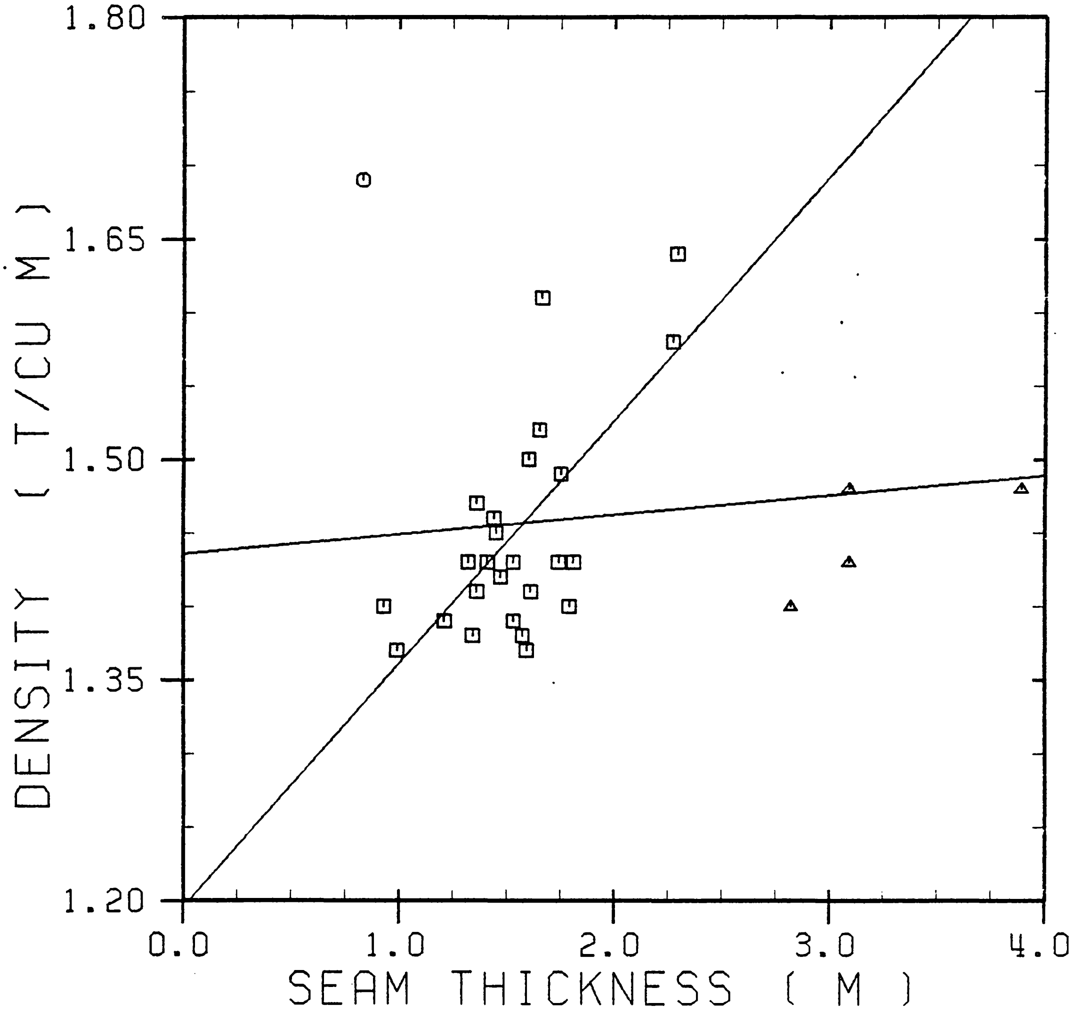


Figure 10. Scatter plot of density versus seam thickness: The regression line with the smaller slope corresponds to the case in which all drill holes are included, whereas the other corresponds to the case in which holes 1023, 1240, 1308, 976, and 1244, indicated by triangles and a circle, respectively, are deleted.

6.2.3 Spatial Correlations

The scatter plots and the correlation coefficient, as given in the previous section, are not sufficient for representing the spatial correlations. Nonetheless, they may be thought as the estimators of the spatial correlation or cross-correlation at zero lag, that is, a null separation vector. Capturing and illustrating the spatial correlations and cross-correlations with experimental variograms and cross-variograms is a very important step in a geostatistical estimation.

In calculating the experimental variograms and cross-variograms, drill holes 1023, 1240, 1308, 976, and 1244 have not been taken into consideration. In general, the variogram values calculated using less than 20 pairs have not been shown in the figures.

6.2.3.1 Variograms

The average experimental semi-variogram

$$\gamma^{*}(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [z(x) - z(x + h)]^2 \qquad [6.1]$$

where $N(h)$ represents the number of pairs at lag distance h, is an unbiased estimator of the semi-variogram given in [2.5b]. [6.1] has been used in calculating the semi-variograms below.

The experimental semi-variogram and the fitted theoretical models for seam thickness, ash, and density are illustrated in Figure 11 on page 68, Figure 12 on page 69, and Figure 13 on page 70, respectively.

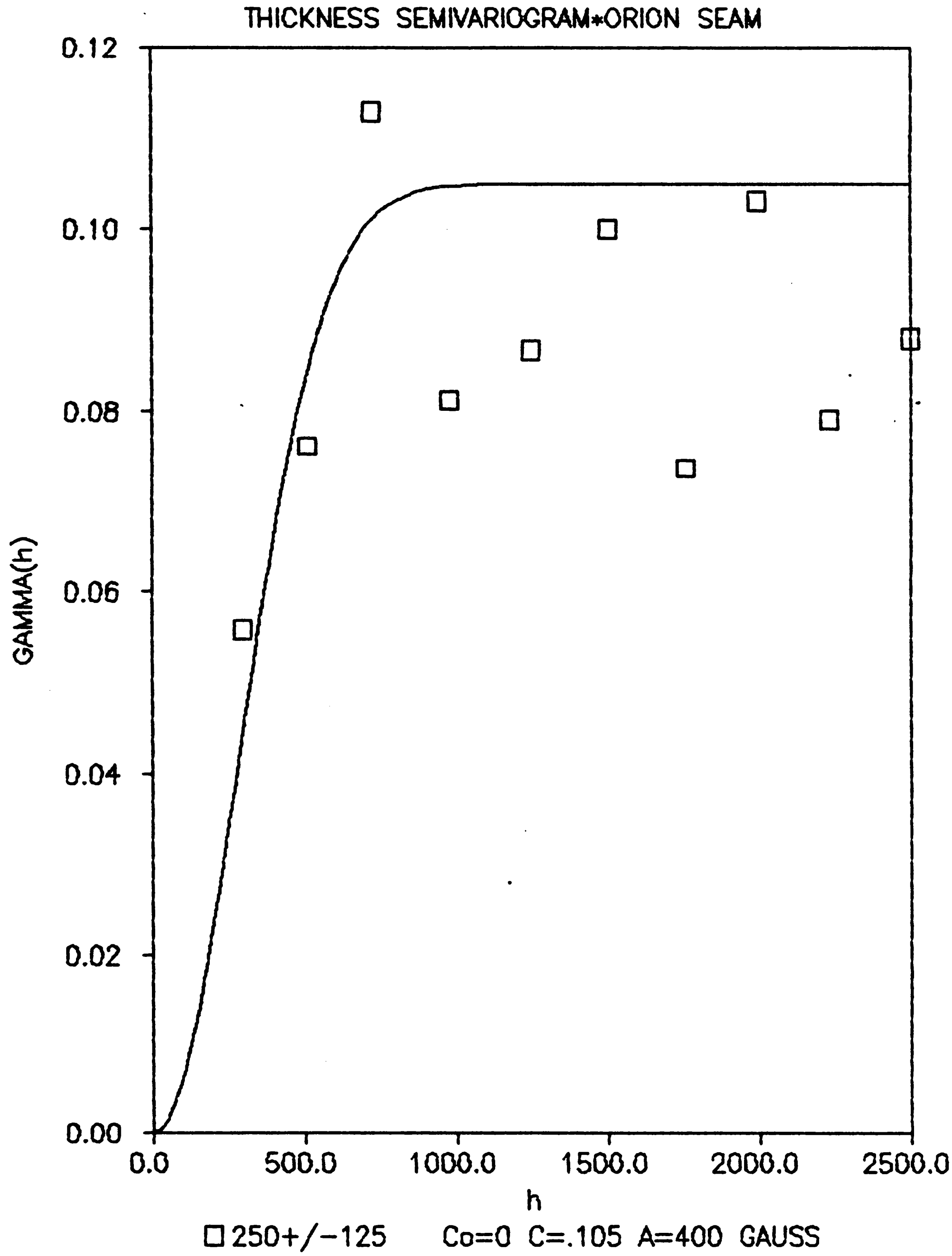


Figure 11. Experimental semi-variogram and the fitted model for seam thickness

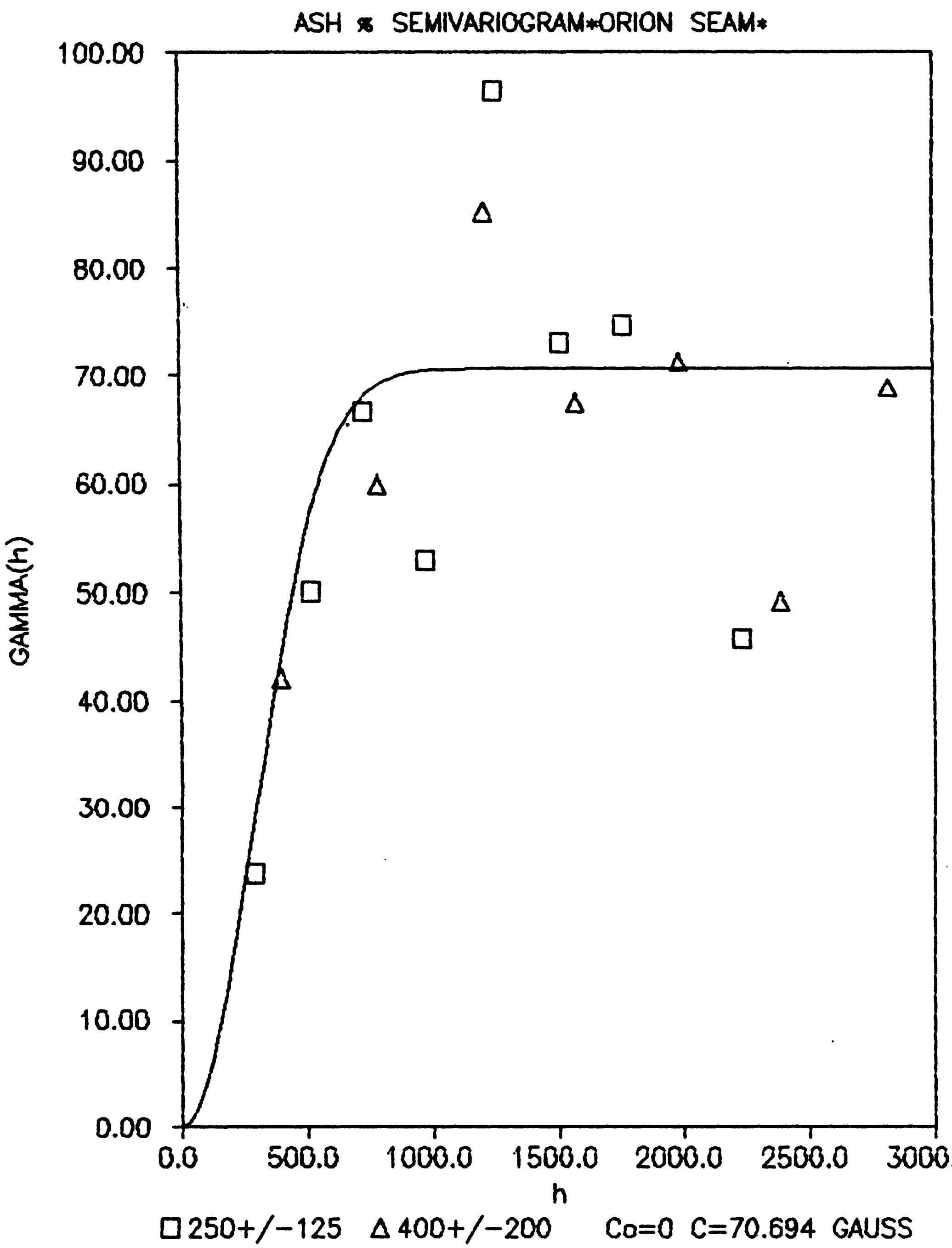


Figure 12. Experimental semi-variogram and the fitted model for percent ash

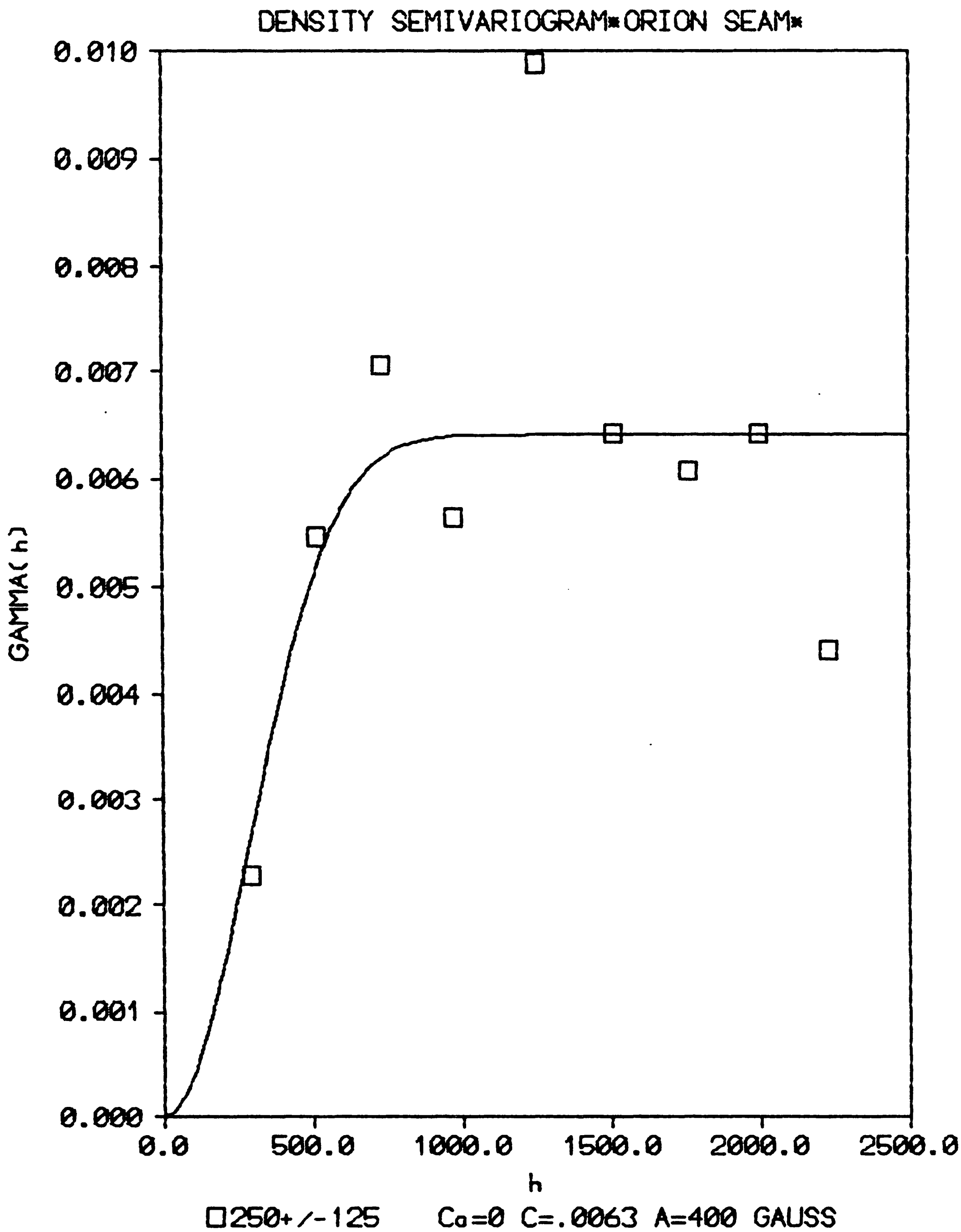


Figure 13. Experimental semi-variogram and the fitted model for density

6.2.3.2 Cross-variograms

For intrinsic RFs, the experimental cross-semivariogram

$$\gamma_{ij}^*(h) = 1/2\left[\gamma_{i+j}(h)^* - \gamma_i^*(h) - \gamma_j^*(h)\right] \qquad [6.2]$$

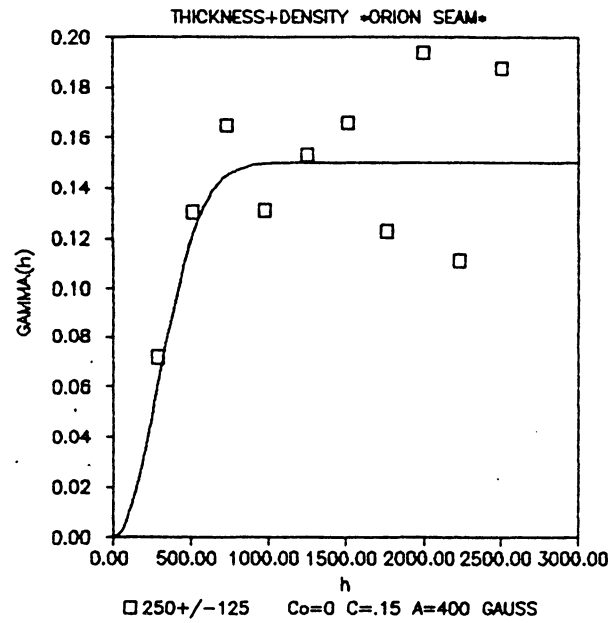
is an unbiased estimator of the underlying cross-semivariogram given in [2.27], and has been used in calculating experimental cross-variograms to be used in cokriging. For each possible pair of variables to be incorporated into cokriging, the above formula implies forming a new variable by adding the two variables first. Afterwards, the cross-variogram may be calculated according to [6.2].

The cross-sum experimental semi-variogram, the resulting cross-semivariogram, and the fitted models for thickness and density, as illustrated in Figure 14 on page 72, indicate a nontrivial spatial cross-correlation.

Therefore, an efficient joint-estimation procedure is expected to provide more accurate estimates for both variables. Also, the estimation variance for joint-estimation are expected to be smaller than those of independent estimations. The spatial cross-correlation for ash and density, as illustrated in Figure 15 on page 73, is not as significant as is it is in the case of thickness and density.

Likewise, the spatial cross-correlation, as illustrated in Figure 16 on page 74, is quite trivial.

All of the fitted theoretical semi-variograms, cross-sum semi-variograms, and resulting cross-semivariograms are summarized in Table 3 on page 75.



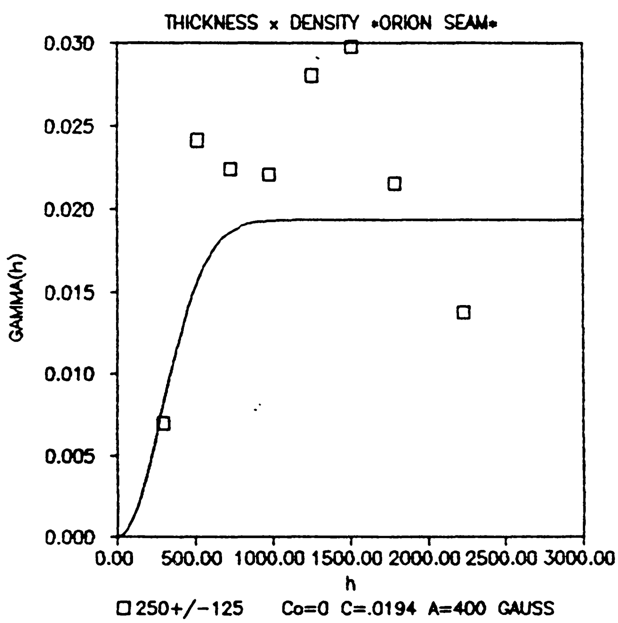
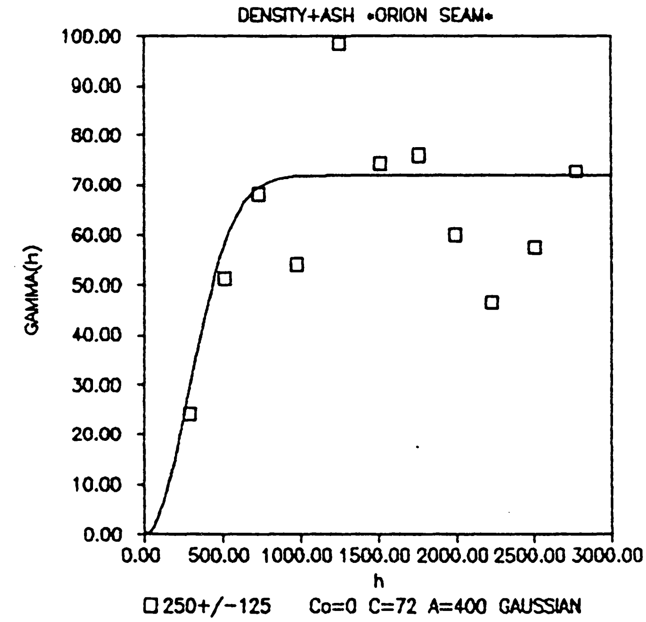


Figure 14. Experimental cross-sum variogram, cross-semivariogram, and the fitted models for thickness and density



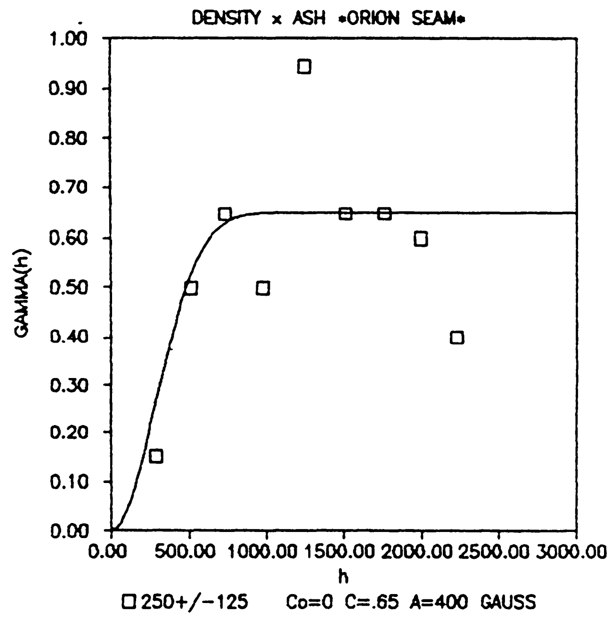
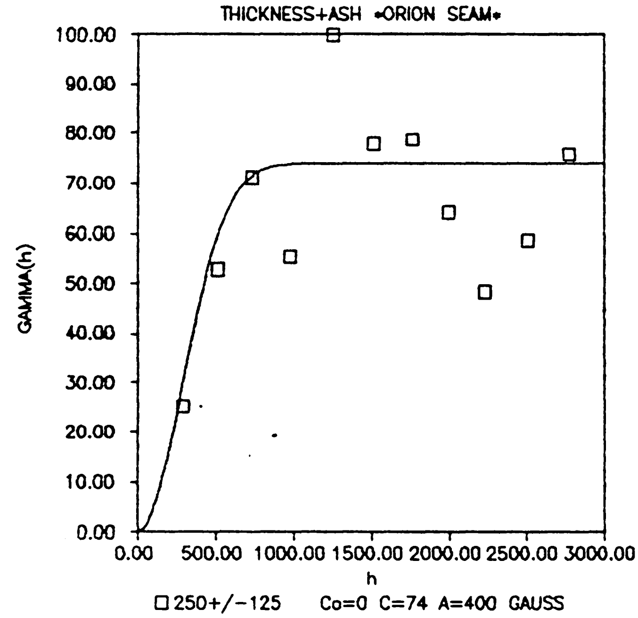


Figure 15. Experimental cross-sum variogram, cross-semivariogram, and the fitted models for density and ash



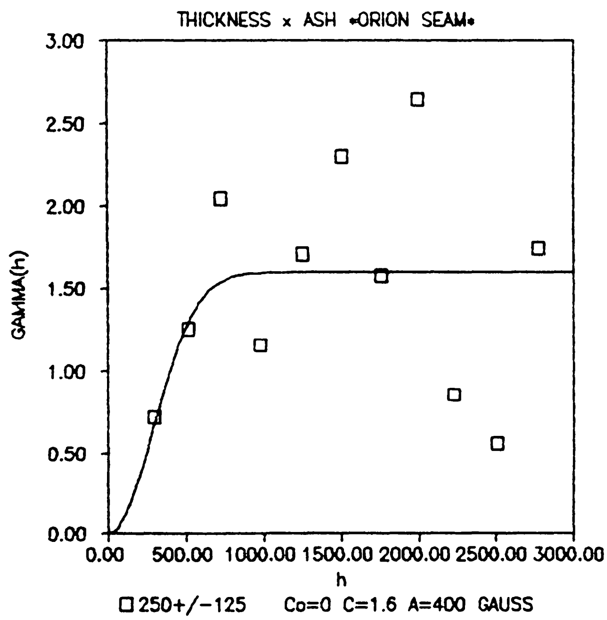


Figure 16. Experimental cross-sum variogram, cross-semivariogram, and the fitted models for thickness and ash

Table 3. Summary of the fitted semi-variograms, cross-sum semi-variograms and cross-semivariograms

	Model	Nugget	Range	Sill	Anisotropy Angle	Anisotropy Ratio
Thickness (m)	Gaussian	.0	400	.105	0	1
Ash (%)	Gaussian	.0	400	70.694	0	1
Density (t/cu m)	Gaussian	.0	400	.00625	0	1
Thick. + Ash	Gaussian	.0	400	74.0	0	1
Thick. + Density	Gaussian	.0	400	.15	0	1
Ash + Density	Gaussian	.0	400	72.0	0	1
Thick. x Ash	Gaussian	.0	400	1.6005	0	1
Thick. x Density	Gaussian	.0	400	.019375	0	1
Ash x Density	Gaussian	.0	400	.65	0	1

Models Selected by Pauncz and Nixon (1980)

	Model	Nugget	Range	Sill	Anisotropy Angle	Anisotropy Ratio
Thickness (m)	Spherical	.05	1750	.45	0	1
Ash (%)	Spherical	.0	1600	92.0	0	1
Density (t/cu m)	Spherical	.0	1700	.0095	0	1

6.3 Results and Discussion

6.3.1 Comparision of Kriging and Cokriging

The most straightforward way of comparing kriging and cokriging is to use the same variogram models and to compare resultant errors at the same location. In addition to the variogram models required in kriging, cross-variogram models must be fitted for cokriging. Thickness, density, and ash have been estimated jointly by cokriging and separately by kriging according to the cross-validation procedure discussed in Chapter 4. The semi-variogram and cross-semivariogram models, given in Table 3 on page 75, have been used. The semi-variogram models fitted by Pauncz and Nixon (1980) have also been given in Table 3 on page 75. Their semi-variogram models have not been adopted for two major reasons. First, an error would be committed by assuming the whole study area as a statistically homogeneous zone. Indeed, they later realized that thickness values for drill holes 1240 and 1308 have been incorrectly recorded. Second, the cross-variogram models have to be greatly modified not to violate the Schwartz's inequality given in [2.28].

The results of the comparison between cokriging and kriging has been presented in Table 4 on page 77. Percent variance explained for thickness is calculated to be 17.48 for cokriging, in comparision to 17.51 for kriging, and 12.27 for kriging with the models of Pauncz.

Percent variance explained for density turned out to be 92.05 for cokriging, whereas it is 89.97 for kriging. Only 64.29% of the variance has been explained by the models of Pauncz. The variance accounted by cokriging for density is the highest representation found in the literature. High performance may be explained by the relatively higher

Table 4. Comparision of the cokriging and kriging before normalization

	KRIGING		COKRIGING	
	Weighted Squared Error	Percent Variance Explained	Weighted Squared Error	Percent Variance Explained
Thickness (m)	.0734	17.51	.0734	17.48
Ash (%)	23.36	62.15	22.89	62.91
Density (t/cu m)	.00056	89.97	.000445	92.05

	KRIGING of PAUNCZ (1980)	
	Weighted Squared Error	Percent Variance Explained
Thickness (m)	.363	12.27
Ash (%)	31.04	56.84
Density (t/cu m)	.0025	64.29

spatial cross-correlation found between density and other variables. Percent variance explained for ash content is around 62 for both kriging and cokriging, where it is 56.84 with the models selected in the Pauncz report.

One striking observation is that the results of separate krigings, in which the variogram models selected by Pauncz are pluged in, are consistently worse than those of cokriging and separate krigings calculated following the modeling adopted in this study. Exclusion of the two nonhomogenous zones is the primary reason of obtaining much better results.

Using cokriging, however, did not produce any significant improvements in increasing the accuracy of estimation over separate krigings. In fact, kriging and cokriging resulted in extremely close estimated values and estimation variances for most of the 25 drill holes. This dilemma may be explained in one of two ways. Either the spatial cross-correlations are not significantly high, or cokriging is not a more accurate estimator for joint-estimation.

Cross-variograms in Figure 14 on page 72, Figure 15 on page 73, and Figure 14 on page 72 do indicate spatial cross-correlations, but not in significantly high scales. Even the covariances at zero lag are not restored to their original values indicated by the correlation coefficients. To the contrary of what is expected, the cross-correlation between ash and density is relatively small. The highest cross-correlation is observed for thickness and density in which the magnitude differential is the smallest. Actually, these are all indicators of poor representation of spatial cross-correlations. Consequently, variography modeling and kriging have been implemented after applying the normalization procedure discussed in Chapter 4. The selected theoretical semi-variogram models, cross-sum semi-variogram models, and resulting cross-semivariogram models are sum-

marized on Table 5 on page 80. As can be seen from Table 5, the spatial cross-correlations are approximately a quarter of the total variance now.
Also, the correlation coefficient that may be calculated by dividing the sill value of the cross-semivariogram (represents the covariance) by the product of the square root of the sill of the individual variograms (represents the standard deviation,) matches their original values. The estimates are backtranformed after estimation. The estmation variances are converted into their nominal scales by multiplying the normalized estimation variance by the original variance, that is, the sill value.

The results of the comparision of kriging and cokriging has been summarized in Table 6 on page 81.
This time, percent variance accounted for by cokriging is consistently higher than that of kriging for all three variables. Percent variance explained by cokriging formulation increased by 8.9% for thickness. Percent variance explained totaled to almost 95% for density. Although the improvement over kriging is around 3%, a great portion of the variance has already been explained. For this reason, even 3% should be considered as significant. With an increase of 8.33%, percent variance accounted for ash by kriging has increased to 70.27%.

Percent variance explained is a rather abstract measure. A more comprehensive way of comparing kriging and cokriging is to plot the squared kriging errors versus the squared cokriging errors, as shown in Figure 17 on page 82, Figure 18 on page 83, and Figure 19 on page 84 for thickness, density, and ash, respectively.
The 45 degree lines indicate no difference between cokriging and kriging in these plots. If the points, however, tend to cluster below this line, it is an indication of the superiority of cokriging. Cokriging provides better results than kriging throughout the entire range

Table 5. Summary of the fitted semi-variograms, cross-sum semi-variograms and cross-semivariograms for the normalized data

	Model	Nugget	Range	Sill	Anisotropy Angle	Anisotropy Ratio
Thickness (m)	Gaussian	.3	400	.7	0	1
Ash (%)	Gaussian	.0	400	1.0	0	1
Density (t/cu m)	Gaussian	.0	400	1.18	0	1
Thick. + Ash	Gaussian	.3	400	3.4	0	1
Thick. + Density	Gaussian	.3	400	3.05	0	1
Ash + Density	Gaussian	.0	400	3.72	0	1
Thick. x Ash	Gaussian	.0	400	.85	0	1
Thick. x Density	Gaussian	.0	400	.585	0	1
Ash x Density	Gaussian	.0	400	.77	0	1

Table 6. Comparision of the Cokriging and Kriging for the Normalized Variables

	KRIGING		COKRIGING	
	Weighted Squared Error	Percent Variance Explained	Weighted Squared Error	Percent Variance Explained
Thickness (m)	.7637	23.63	.6747	32.53
Ash (%)	.3806	61.94	.2973	70.27
Density (t/cu m)	.0983	91.67	.0605	94.87

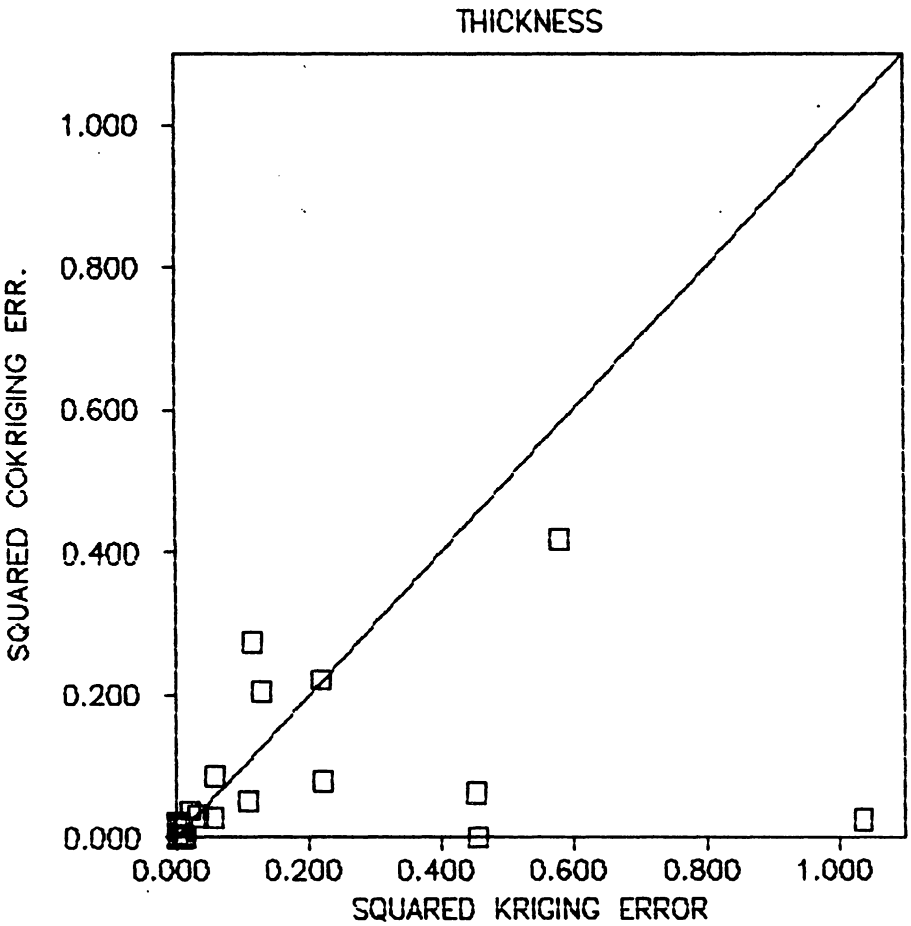


Figure 17. Plot of squared kriging errors versus squared cokriging errors for thickness

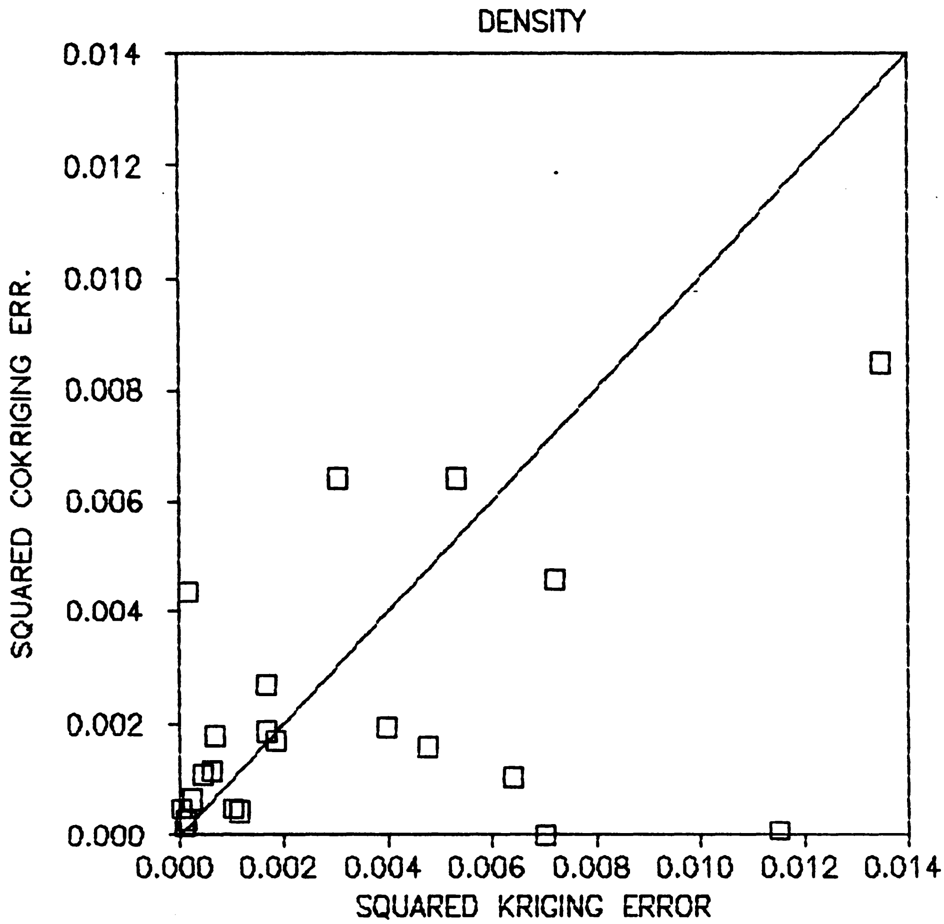


Figure 18. Plot of squared kriging errors versus squared cokriging errors for density

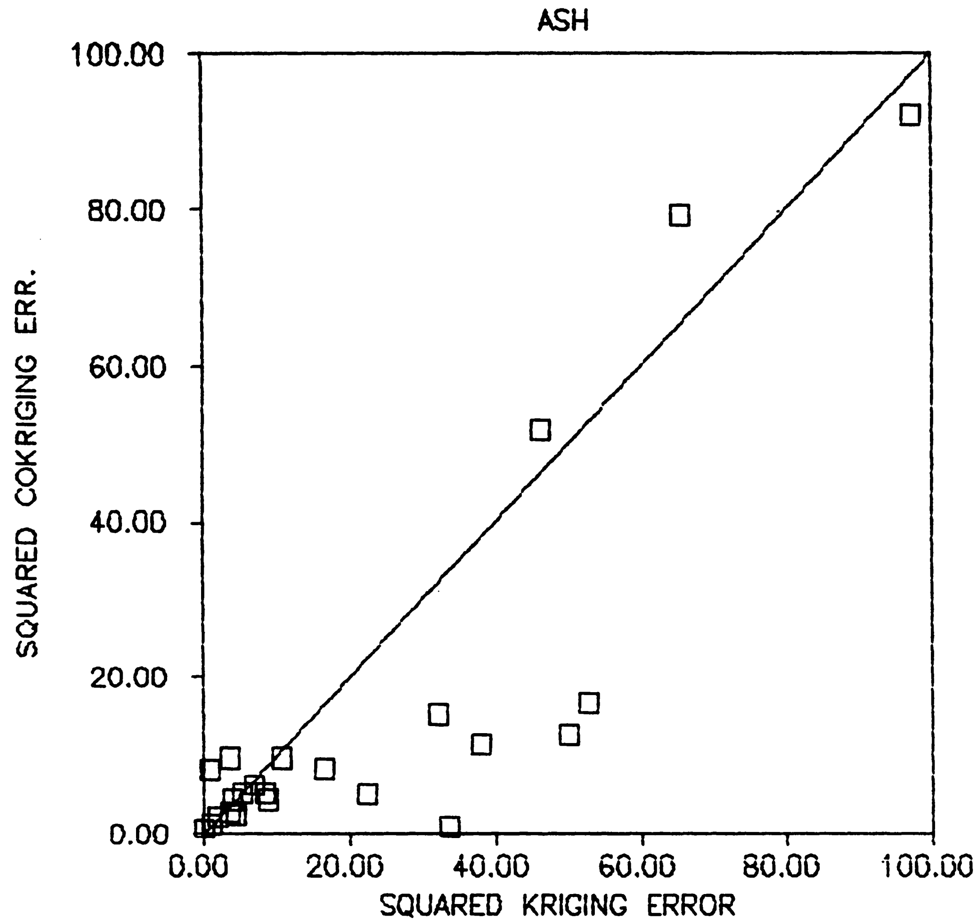


Figure 19. Plot of squared kriging errors versus squared cokriging errors for ash

of errors in the estimation of thickness, density, and ash. It should be noted that almost no improvements were achieved without normalization.

6.3.2 Verification of the Probabilistic Premises of Cokriging and Kriging

In order to determine whether cokriging and kriging comply with the probabilistic premises underlying them, it is sufficient to check if the estimation errors are contained within the confidence intervals. The results of this test has been illustrated in X-Y plots for thickness, density, and ash. The X-axis denotes the absolute value of the estimation error and is calculated by taking the absolute value of the difference between the actual and estimated value. The approximate 95% confidence interval marked on the Y-axis is 1.96 times the standard deviation of cokriging or kriging. The probability that an observed error value lies outside the confidence limits is thus 5%. That is, not more than one observation should lie outside the 95% confidence interval on the average.[5] Hence, a 45 degree line would serve as a delimeter. The points below the delimiting line indicate the error values that lie outside the 95% confidence limits.

For thickness, as illustrated in Figure 20 on page 86, the points that lie outside the 95% confidence limits belong to kriging.

Because their number is not greater than 2, it is concluded that there is not enough evidence to prove that kriging performed unsatisfactorily. Cokriging did not generate any points outside the 95% confidence interval and this proves that the results are well within the acclaimed probabilistic premises. The verification of the probabilistic prem-

[5] The total number of error observations available for ash and density is 24. The total number for thickness is 29, and it corresponds to 1.5 errors allowable outside the 95% confidence interval.

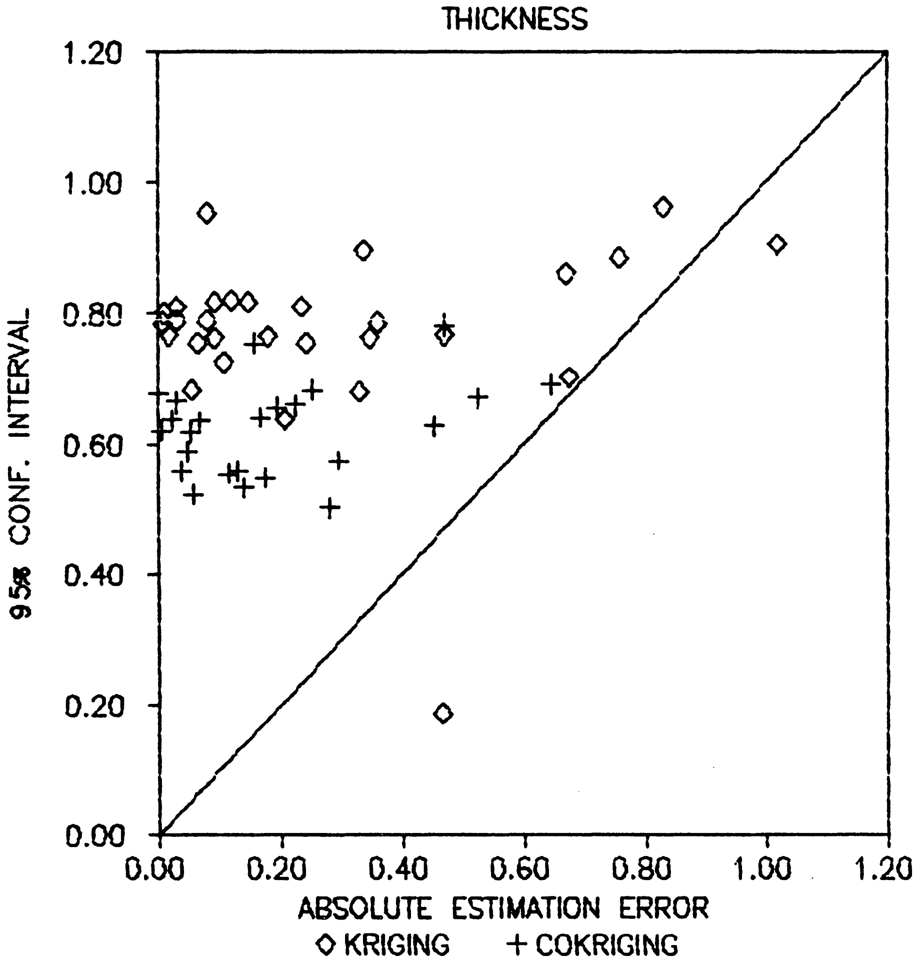


Figure 20. Plot of estimation error versus 95% confidence interval for thickness

ises underlying kriging and cokriging, as shown in Figure 21 on page 88 and Figure 22 on page 89, yield similar results for density and ash.
Therefore, it has been concluded that both cokriging and kriging comply with the probabilistic premises imbedded in them.

6.3.3 Reconstruction of the Cross-correlations

In order to determine the extent of success with which the correlations present in the data are represented by the cokriging and kriging estimates, the correlation coefficients have been estimated. In addition, the discrepancy between the actual and estimated slopes and intercepts has been compared.

The results, as summarized in Table 7 on page 90, demonstrate that kriging has failed to reconstruct the moderately high linear correlation between thickness and density. Likewise, kriging was inable to reconstruct the correlation between thickness and ash. Nonetheless, the high linear correlation between ash and density was well represented by both kriging and cokriging. Cokriging did well in representing the correlations thickness depicts between ash and density, as can be deduced from the closeness of the correlation coefficients,the slope and intercept for the actual and estimated regresion lines. Therefore, it has been concluded that cokriging reconstructs the inherent cross-correlations where kriging fails to do so unless the correlation is exceptionally high.

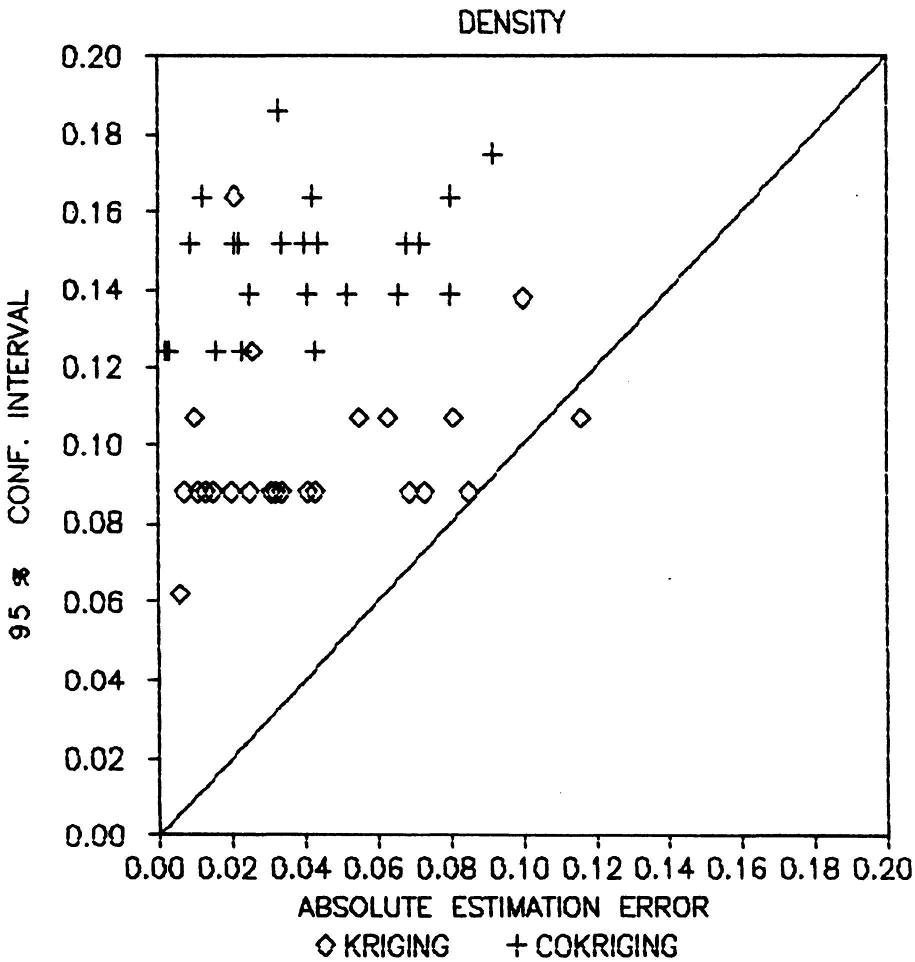


Figure 21. Plot of estimation error versus 95% confidence interval for density

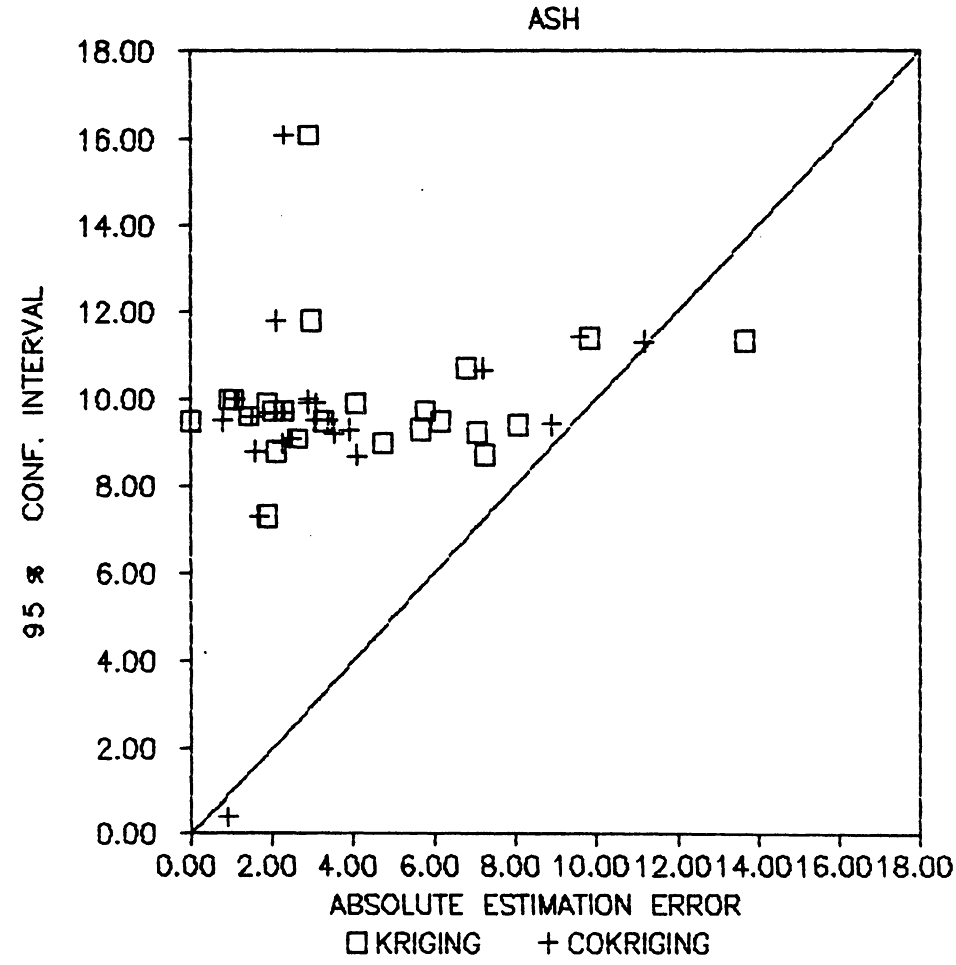


Figure 22. Plot of estimation error versus 95% confidence interval for ash

Table 7. Summary of the regression parameters between the cokriging and kriging estimates

	ACTUAL DATA	KRIGING	COKRIGING
Thickness and Density			
Correlation coefficient	.69	.38	.51
Slope	.165	.04	.103
Intercept	1.19	1.37	1.28
Ash and Density			
Correlation coefficient	.92	.87	.90
Slope	.00817	.00862	.00841
Intercept	1.28	1.29	1.28
Thickness and Ash			
Correlation coefficient	.66	.35	.71
Slope	16.60	1.63	16.12
Intercept	-7.30	12.19	-7.63

CHAPTER 7

CONCLUSIONS

The major contributions of this research to the field of coal resource estimation may be summarized as follows:

- The types and the extent of the cross-correlations between ash content, density, calorific value, seam thickness, and sulphur content have been delineated.
- It has been shown that the cross-correlations are significantly high and extend spatially.
- The additional information contained in the spatial cross-correlations can be utilized to improve the accuracy of estimation.
- It has been demonstrated that the theory of coregionalized variables and the joint-estimation technique of cokriging
  - reconstructs the prevalent correlation schemes more realistically, and

- increases the accuracy of estimation substantially over the existing methods.

- The efficient use of cokriging depends on eliminating the magnitude and variance differential between the variables prior to estimation.

The cross-correlations between ash content, density, and calorific value were determined to be very high. The typical correlation coefficients changed between .90 and .99. Such correlations were persistent with the only condition that the rank of coal was stable. Besides, cross-correlations have been identified between thickness and ash, but in smaller scales. The correlation coefficient was found to be closer to .70. Small scale cross-correlations between sulphur and ash have also been encountered in the literature. However, it has been discovered that the latter two types of weaker correlations are not universal, and exist only under specific depositional conditions and settings. In the case where such correlations exist, the estimation method should honor them.

The hypothesis that the major variables of interest in coal resource characterization are also spatially cross-correlated was verified. The experimental cross-semivariograms between seam thickness, density, and ash content turned out to be very continuous with ranges extending to 1200 m. Cross-semivariograms, however, proved unsatisfactory to represent the spatial cross-correlations in the presence of a magnitude differential between the variables. For example, the difference in magnitude between ash content and density has masked the actually high spatial cross-correlation and undermined cokriging. Due to the same reason, it would not be unrealistic to predict that the spatial cross-correlation between calorific value and any other variable will appear much lower than it actually is because the magnitude differential will always be high. Normalization of the data prior to calculation of the cross-variogram has been proven to alleviate the problem of scaling down of the cross-correlations in cokriging.

The joint-estimation method of cokriging has been chosen to detect and quantify the improvements that can be achieved over separate krigings by incorporating the extra information contained in the cross-correlations. Substantial improvements have been obtained due to cokriging after normalization. The increase in the percent variance explained has been close to 10% for ash content and seam thickness. Even though 3% more has been accounted for density by cokriging over kriging, the total variance accounted was close to 95%.

Cokriging performed well in replicating all types and magnitudes of correlations that exist between the variables. On the other hand, kriging failed to reconstruct the smaller scale cross-correlations as well as cokriging did. For this reason, it has been concluded that joint-estimation is relevant and should be preferred over kriging, especially where intricate intervariable correlations are detected.

Summarized below are the conclusions derived from the experience gained in using the geostatistical estimation techniques:

- Kriging and cokriging comply with the underlying probabilistic premises.

- Recognition of zones with distinct statistical properties and identification of errors in recording the drill hole information enhance modeling and estimation.

- Bivariate statistical analysis is very instrumental in detecting erroneous data points and discerning statistically distinct subzones.

It has been demonstrated by case study that geostatistical methodology works well for coal resource characterization. In particular, kriging and cokriging have been found to be satisfactory estimation techniques with regard to the confidence intervals that can be constructed using the estimation variances.

Bivariate statistical analysis has been found to be extremely useful in discerning sub-zones with similar statistical properties. In fact, the improvement in the accuracy of estimations due to the recognition of such zones has been greater than the improvement due to cokriging over kriging in the case study presented.

7.1 Suggested Research Areas

- In this study, cross-correlations only between the most common variables of interest has been investigated. The type and extent of cross-correlations between less common variables of interest, such as the petrographic constituents of the coal should also be investigated.

- Only the cross-correlations between continuous variables can be incorporated in the joint estimation technique of cokriging. However, high cross-correlations are known to exist between continuous and categorical variables. One such example is the highly acclaimed relation between the roof lithology and the sulphur content. Roof lithology is a categorical variable and cannot be handled by the existing techniques. Therefore, development of new estimation techniques to utilize the spatial cross-correlations between continuous and categorical variables is highly recommended.

- The cross-correlation between different variables of interest is not the only type of cross-correlation encountered in a typical coal resource characterization study. The same variable may be sampled by two different techniques as in the case of drill hole logging and drill core analysis. Geophysical logging is less expensive and also less reliable than core drilling. The intrinsic correlation between geophysical logs and drill core analysis may be utilized in cokriging to minimize the exploration budget and maximize the accuracy of estimations at the same time. Case studies are needed to delineate the approximate gain in accuracy that might be expected for different variables.

- Despite the fact that cokriging has provided substantial improvements over kriging, it should not be accepted as the ultimate alternative of incorporating cross-correlations. It is believed that a more efficient estimator may be constructed if the spatial cross-correlations can be expressed as distance dependent regressions. This approach would require reformulation of the estimation problem in terms of *regression variograms*, yet undiscovered.

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APPENDIX A

LISTING FOR GPPC

```
1000 REM*****A GEOSTATISTICS PACKAGE FOR PC'S
1010 REM*****MODULE NAME = GPPC.BAS
1020 REM*****GPPC VERSION 1.0 REQUIRES IBM ADVANCED BASIC VERSION 2.0
                                 October 1985
1030 REM*****Programmed by AHMET UNAL
1040 OPTION BASE 1
1050 DIM CLR%(4),ACD$(2),AOA$(2),AF$(2),AC$(2),AA$(2)
1060 COMMON MS,CLR%(),CO$,ACD$(),AOA$(),AF$(),AC$(),AA$()
1070 CLR%(1)=4:CLR%(2)=1:CLR%(3)=7:CLR%(4)=7:B1$=SPACE$(8):B2$=SPACE$(6):CO$=B1$
:FOR I=1 TO 2:ACD$(I)="  ":AOA$(I)=B2$:AF$(I)=B2$:AC$(I)=B1$:AA$(I)=B1$:NEXT
1080 DIM  A1%(1298),A2%(1298)
1090 OPEN "r",3,"help",1912
1100 KEY OFF: SCREEN 1,0: COLOR 1,0: CLS
1110 KEY 1,"":KEY 2,"":KEY 3,"":KEY 4,"":KEY 5,"":KEY 6,"":KEY 7,"":KEY 8,"":
     KEY 9,"":KEY 10,""
1120 A$="GPPC"
1130 R%=25: I%=0
1140 FOR C%=48 TO 48+32*(LEN(A$)-1) STEP 32 'for every letter
1150 DEF SEG=&HF000 'Video Characters
1160 I%=I%+1
1170 ADDR=&HFA6E + 8*ASC(MID$(A$,I%,1))
1180   FOR Y%=0 TO 7
1190   ROW%=PEEK(ADDR+Y%) 'starting address of the rows of each letter
1200     FOR X%=0 TO 7 'every bit of each row
1210     LTR%=2^(7-X%)
1220     IF (LTR% AND ROW%)=0 THEN 1310 'the bit peeked by ROW%=0(off)
1230     PSET(C%+  X%*4,R%+  Y%*4),1   'the bit peeked by ROW%=1(on)
1240     PSET(C%+  X%*4,R%+2+Y%*4),1
1250     PSET(C%+1+X%*4,R%+  Y%*4),1
1260     PSET(C%+1+X%*4,R%+2+Y%*4),1
1270     PSET(C%+2+X%*4,R%+  Y%*4),1
1280     PSET(C%+2+X%*4,R%+2+Y%*4),1
1290     PSET(C%+3+X%*4,R%+  Y%*4),1
1300     PSET(C%+3+X%*4,R%+2+Y%*4),1
1310 NEXT X%,Y%,C%
1320 GET (0,25)-(223,56),A1%
1330 R%=57: I%=0
1340 FOR C%=143 TO 143+32*(LEN(A$)-1) STEP 32
1350 I%=I%+1
1360 ADDR=&HFA6E + 8*ASC(MID$(A$,I%,1))
1370   FOR Y%=0 TO 7
1380   ROW%=PEEK(ADDR+Y%)
1390     FOR X%=0 TO 7
1400     LTR%=2^(7-X%)
1410     IF (LTR% AND ROW%) =0 THEN 1500
1420     PSET(C%+  X%*4,R%+1+Y%*4),2
1430     PSET(C%+  X%*4,R%+3+Y%*4),2
1440     PSET(C%+1+X%*4,R%+1+Y%*4),2
1450     PSET(C%+1+X%*4,R%+3+Y%*4),2
1460     PSET(C%+2+X%*4,R%+1+Y%*4),2
1470     PSET(C%+2+X%*4,R%+3+Y%*4),2
1480     PSET(C%+3+X%*4,R%+1+Y%*4),2
1490     PSET(C%+3+X%*4,R%+3+Y%*4),2
1500 NEXT X%,Y%,C%
1510 GET (95,57)-(319,88),A2%: CLS
1520 FOR I%=46 TO 48 STEP 1
1530 PUT(95-I%,25),A2%,XOR
1540   FOR J%=1 TO 1000: NEXT J%
1550   PUT(95-I%,25),A2%,PSET
1560   FOR J%=1 TO 1000: NEXT J%
1570    PUT (I%,25),A1%,XOR
1580   FOR J%=1 TO 1000: NEXT J%
1590    IF I%>46 THEN 1630
1600    PUT(I%,25),A1%,PSET
```

```
1610   FOR J%=1 TO 1000: NEXT J%
1620 NEXT I%
1630 LOCATE 10,5: PRINT "A Geostatistics Package for PC's": LOCATE 14,20:     PR
INT TAB(20) "by"
1640 A$="Ahmet UNAL"
1650 R%=112: I%=0
1660 FOR C%=81 TO 81+16*(LEN(A$)-1) STEP 16
1670 I%=I%+1
1680 ADDR=&HFA6E + 8*ASC(MID$(A$,I%,1))
1690   FOR Y%=0 TO 7
1700   ROW%=PEEK(ADDR+Y%)
1710     FOR X%=0 TO 7
1720     LTR%=2^(7-X%)
1730     IF (LTR% AND ROW%)=0 THEN 1760
1740     PSET(C%+  X%*2,R%+1+Y%*2),2
1750     PSET(C%+1+X%*2,R%+1+Y%*2),2
1760 NEXT X%,Y%,C%
1770 LOCATE 18,4: PRINT "Department of Mining Engineering":PRINT "    Virginia P
olytechnic Institute     ";"          and State University         ";
1780 LOCATE 25,9: PRINT "Press any key to start";
1790 GOSUB 1940
1800 K$=INKEY$: IF K$<>"" THEN 1800
1810 I$=INKEY$: IF I$="" THEN 1810
1820 LOCATE 25,9: PRINT SPACE$(22);
1830 ' load chracter table
1840 DEF SEG=0: M=PEEK(1043)+PEEK(1044)*256 'total memory size in Kbytes
1850 M=M*1024-1024 'physical address for alternate character table
1860 MS=INT(M/16): MO=M-MS*16 'segment and offset for table
1870 POKE &H7C,MO-INT(MO/256)*256:POKE &H7D,INT(MO/256)'lower half of EXT-PTR
1880 POKE &H7E,MS-INT(MS/256)*256:POKE &H7F,INT(MS/256)'upper half of EXT-PTR
1890 DEF SEG=MS
1900 BLOAD "galtchro.bas",0
1910 DEF SEG
1920 SCREEN 0,1: COLOR 0: WIDTH 80: CLS
1930 CHAIN"mainmenu"
1940 REM*****SUBROUTINE PLAYS NBC
1950 SOUND 650,7: FOR I%=1 TO 100: NEXT I%
1960 SOUND 1100,7: FOR I%=1 TO 100: NEXT I%
1970 SOUND 880,8: FOR I%=1 TO 100: NEXT I%
1980 RETURN
```

```
1000 ON ERROR GOTO 60000:MODULE$="mainmenu"
1005 DIM G$(16),E$(11)
1100 COMMON MS,CLR%(),D#(),E#(),N#(),R$(),DHL$(),BE#(),BN#(),DS$,PLS%,B%,V%,MN#,
VR#,CO$,ACD$(),AOA$(),AF$(),AC$(),AA$()
1110 IF B% THEN FILE$=R$(4)+SPACE$(10) ELSE FILE$=SPACE$(24)
1120 IF CLR%(3)>9 THEN FG1$=RIGHT$(STR$(CLR%(3)),2) ELSE FG1$=RIGHT$(STR$(CLR%(3
)),1)+" "
1130 BG1$=RIGHT$(STR$(CLR%(1)),1)
1140 IF CLR%(4)>9 THEN FG2$=RIGHT$(STR$(CLR%(4)),2) ELSE FG2$=RIGHT$(STR$(CLR%(4
)),1)+" "
1150 BG2$=RIGHT$(STR$(CLR%(2)),1)
1200 FOR J%=1 TO 2:IF J%=1 THEN SCREEN 0,1,3,0 ELSE SCREEN ,,0,3
1400 COLOR 6,0:CLS:LOCATE 4,35,0,6,7:PRINT "MAIN MENU":PRINT
1500 PRINT TAB(15) "1  Input of Drill Hole Data and Boundary Points"
1600 PRINT TAB(15) "2  Plot of Drill Holes and Boundary Lines"
1700 PRINT TAB(15) "3  Statistical Analysis"
1800 PRINT TAB(15) "4  Spatial Analysis-Semivariogram Modeling"
1900 PRINT TAB(15) "5  Estimation (Ordinary Kriging)"
2200 PRINT TAB(15) "6  Exit to DOS"
2300 PRINT TAB(15) "7  Utility Functions"
2400 PRINT TAB(20) "* GPPC Instructions"
2500 PRINT TAB(20) "* File List"
2600 PRINT TAB(20) "* Printout of Data Files"
2700 PRINT TAB(20) "* Set Color Attributes":PRINT
2800 PRINT "Your Choice : ";:COLOR CLR%(4),CLR%(2):PRINT" "
2900 GOSUB 7000:NEXT J%:SCREEN ,,0
3000 R%=18:C%=15:K$=" "
3100 COLOR CLR%(4),CLR%(2):LOCATE R%,C%,1
3200 I$=INKEY$: IF I$<>"" THEN 3200
3300 I$=INKEY$: IF I$="" THEN 3300
3400 COLOR 0,0:LOCATE 25,1,0:IF SCREEN(25,1)<>32 THEN PRINT SPACE$(79);
3500 COLOR CLR%(4),CLR%(2):LOCATE R%,C%,1
3600 IF LEN(I$)=2 THEN I$=RIGHT$(I$,1):GOTO 3700 ELSE IF ASC(I$)<32 THEN 3300 EL
SE LOCATE ,,0:PRINT I$;:LOCATE R%,C%,1:K$=I$:GOTO 3300
3700 IF ASC(I$)=59 THEN GOSUB 6800:HPAGE%=5:L%=3100:CHAIN"hlp",,ALL
3800 IF ASC(I$)=60 OR ASC(I$)=81 THEN 3900 ELSE 3300'F2/PgDn
3900 IF ASC(K$)<49 OR ASC(K$)>55 THEN GOSUB 6000
4000 ON VAL(K$) GOTO 5100,5200,5300,5400,5500,5800
4002 FOR J%=1 TO 2:IF J%=1 THEN SCREEN 0,1,3,0 ELSE SCREEN ,,0,3
4004 COLOR 6,0:CLS:LOCATE 5,31,0:PRINT"9.UTILITY FUNCTIONS":LOCATE 7,21:PRINT"1
GPPC Instructions":PRINT TAB(21)"2 File List":PRINT TAB(21)"3 Printout of Data F
iles":PRINT TAB(21)"4 Set Color Attributes"
4006 LOCATE 12,7:PRINT"Your Choice : ";:COLOR CLR%(4),CLR%(2):PRINT" ":GOSUB 710
0
4007 NEXT J%:SCREEN ,,0
4008 R%=12:C%=21:K$=" "
4010 COLOR CLR%(4),CLR%(2):LOCATE R%,C%,1
4012 I$=INKEY$: IF I$<>"" THEN 4012
4014 I$=INKEY$: IF I$="" THEN 4014
4016 COLOR 0,0:LOCATE 25,1,0:IF SCREEN(25,1)<>32 THEN PRINT SPACE$(79);
4018 COLOR CLR%(4),CLR%(2):LOCATE R%,C%,1
4020 IF LEN(I$)=2 THEN I$=RIGHT$(I$,1):GOTO 4022 ELSE IF ASC(I$)<32 THEN 4014 EL
SE LOCATE ,,0:PRINT I$;:LOCATE R%,C%,1:K$=I$:GOTO 4014
4022 IF I$=CHR$(59) THEN GOSUB 6800:HPAGE%=5:L%=4010:CHAIN"hlp",,ALL
4023 IF ASC(I$)=61 OR ASC(I$)=73 OR ASC(I$)=71 THEN 1200 'F3/PgUp/Home
4024 IF ASC(I$)=60 OR ASC(I$)=81 THEN 4026 ELSE 4014'F2/PgDn
4026 IF ASC(K$)<49 OR ASC(K$)>52 THEN BEEP:LOCATE 25,1,0:COLOR 27,0:PRINT"Invali
d entry!";:COLOR 3,0:PRINT" Enter the number of your choice from the menu betwee
n 1 and 4."TAB(78);:GOTO 4010
4028 ON VAL(K$) GOTO 5000,4990,4200
4030 FOR J%=1 TO 2:IF J%=1 THEN SCREEN ,,3,0 ELSE SCREEN ,,0,3
4040 COLOR 6,0:CLS:LOCATE 1,30,0:PRINT"9.4.COLOR ATTRIBUTES":LOCATE 4,33:PRINT"F
oreground      Background":PRINT TAB(33)"Color Code      Color Code":PRINT TAB(3
4)"[ 0-15 ]"TAB(51)"[ 0-7 ]"
```

```
4042 PRINT TAB(20)"Field #1 :";:LOCATE ,37:COLOR CLR%(4),CLR%(2):PRINT FG1$;:LOC
ATE ,54:PRINT BG1$:COLOR 6,0:PRINT TAB(20)"Field #2 :";:LOCATE ,37:COLOR CLR%(3)
,CLR%(1):PRINT FG2$;:LOCATE ,54:PRINT BG2$
4043 COLOR 6,0:LOCATE 12,27:PRINT"Color Code Reference Table"
4044 LOCATE 14,3:COLOR 0,7:PRINT"0 => ";CHR$(254);" Black";:COLOR 4,0:LOCATE ,22
:PRINT"4 => ";CHR$(254);" Red";TAB(41);:COLOR 0,7:PRINT"8 => ";CHR$(254);" HI-Bl
ack";:COLOR 12,0:PRINT TAB(61)"12 => ";CHR$(254);" HI-Red"
4046 LOCATE ,3:COLOR 1:PRINT"1 => ";CHR$(254);" Blue";:COLOR 5:PRINT TAB(22)"5 =
> ";CHR$(254);" Magenta";TAB(41);:COLOR 9:PRINT"9 => ";CHR$(254);" HI-Blue";:COL
OR 13,0:PRINT TAB(61)"13 => ";CHR$(254);" HI-Magenta"
4048 LOCATE ,3:COLOR 2:PRINT"2 => ";CHR$(254);" Green";:COLOR 6:PRINT TAB(22)"6
=> ";CHR$(254);" Yellow";TAB(40);:COLOR 10:PRINT"10 => ";CHR$(254);" HI-Green";:
COLOR 14,0:PRINT TAB(61)"14 => ";CHR$(254);" HI-Yellow"
4050 LOCATE ,3:COLOR 3:PRINT"3 => ";CHR$(254);" Cyan";:COLOR 7:PRINT TAB(22)"7 =
> ";CHR$(254);" White";TAB(40);:COLOR 11:PRINT"11 => ";CHR$(254);" HI-Cyan";:COL
OR 15,0:PRINT TAB(61)"15 => ";CHR$(254);" HI-White":GOSUB 7100
4051 NEXT J%:SCREEN ,,0
4052 R%=7:CMIN%=37:CMAX%=38:COLOR CLR%(4),CLR%(2):FLD$=FG1$:GOSUB 50000:FG1$=FLD
$:ON NXT GOTO 4056,4056,4054,4058,4060,4002,4002,4059
4054 R%=7:CMIN%=54:CMAX%=54:COLOR CLR%(4),CLR%(2):FLD$=BG1$:GOSUB 50000:BG1$=FLD
$:ON NXT GOTO 4058,4058,4056,4052,4060,4002,4002,4059
4056 R%=8:CMIN%=37:CMAX%=38:COLOR CLR%(3),CLR%(1):FLD$=FG2$:GOSUB 50000:FG2$=FLD
$:ON NXT GOTO 4052,4052,4058,4054,4060,4002,4002,4059
4058 R%=8:CMIN%=54:CMAX%=54:COLOR CLR%(3),CLR%(1):FLD$=BG2$:GOSUB 50000:BG2$=FLD
$:ON NXT GOTO 4054,4054,4052,4056,4060,4002,4002,4059
4059 IF ASC(I$)=60 THEN 4060 ELSE 4100'F2
4060 I%=VAL(FG1$):IF I%>15 OR I%<0 THEN BEEP:LOCATE 25,1,0:COLOR 27,0:PRINT"Inva
lid entry!";:COLOR 3:PRINT" Enter a number between 0 and 15."TAB(78);:GOTO 4052
ELSE CLR%(3)=I%
4062 I%=VAL(FG2$):IF I%>15 OR I%<0 THEN BEEP:LOCATE 25,1,0:COLOR 27,0:PRINT"Inva
lid entry!";:COLOR 3:PRINT" Enter a number between 0 and 15."TAB(78);:GOTO 4056
ELSE CLR%(4)=I%
4064 I%=VAL(BG1$):IF I%>7 OR I%<0 THEN BEEP:LOCATE 25,1,0:COLOR 27,0:PRINT"Inval
id entry!";:COLOR 3:PRINT" Enter a number between 0 and 7."TAB(78);:GOTO 4054 EL
SE CLR%(1)=I%
4066 I%=VAL(BG2$):IF I%>7 OR I%<0 THEN BEEP:LOCATE 25,1,0:COLOR 27,0:PRINT"Inval
id entry!";:COLOR 3:PRINT" Enter a number between 0 and 7."TAB(78);:GOTO 4058 EL
SE CLR%(2)=I%
4078 GOTO 4002
4100 IF ASC(I$)=59 THEN GOSUB 6800:HPAGE%=3:L%=4052:CHAIN"hlp",,ALL
4110 IF ASC(I$)=61 THEN 4002 ELSE 4052 'F3
4200 B$=STRING$(66,205)
4202 FOR J%=1 TO 2:IF J%=1 THEN SCREEN 0,1,3,0 ELSE SCREEN ,,0,3
4203 COLOR 6,0:LOCATE ,,0:CLS:PRINT TAB(7)"/" B$ ";":PRINT TAB(7)":"TAB(29)"9.3.
GPPC PRINT UTILITY"TAB(74)":":PRINT TAB(7)"L" B$ "9":PRINT TAB(7)": File specifi
cation of data : ";:COLOR CLR%(4),CLR%(2):PRINT FILE$;:COLOR 6,0:PRINT TAB(74)":
"
4206 PRINT TAB(7)"L" B$ "9":PRINT TAB(7)": Project Title"TAB(31)":"TAB(74)":":PR
INT TAB(7)": Quadrant chosen"TAB(31)":"TAB(74)":":PRINT TAB(7)": Number of drill
 holes :"TAB(74)":":PRINT TAB(7)": Drill hole labels      :"TAB(74)":"
4209 PRINT TAB(7)": Number of data sets   :"TAB(74)":":PRINT TAB(7)"L" B$ TAB(74
) "9":PRINT TAB(7)":"TAB(25)"Sequence and Names of Data Sets"TAB(74)":":PRINT TA
B(7)":"TAB(74)":"
4212 FOR I=1 TO 4:PRINT TAB(7)":"TAB(16);I;"."TAB(46);I+4;"."TAB(74)":":NEXT:PRI
NT TAB(7)":"TAB(74)":":PRINT TAB(7)"L" B$ TAB(74)"9":PRINT TAB(7)": Boundary poi
nts"TAB(35)":"TAB(74)":":PRINT TAB(7)": Number of boundary points :"TAB(74)":"
4215 PRINT" IMMMMJ" B$ "JMMMM;":PRINT" : ";:COLOR 2:PRINT"F1/F10";:COLOR 6:PRINT
" Help-Detailed/Quick Reference";:COLOR 2:PRINT "  F2/F3";:COLOR 6:PRINT" Page d
own/up";:COLOR 2:PRINT"  Home";:COLOR 6:PRINT TAB(79)":":PRINT" HMMMMM" B$ "MMMM
M<";
4216 NEXT J%:SCREEN ,,0
4218 R%=4:CMIN%=38:CMAX%=61:COLOR CLR%(4),CLR%(2):FLD$=FILE$:GOSUB 50000:FILE$=F
LD$:ON NXT GOTO 4218,4218,4218,4218,4230,4002,4002
4221 IF ASC(I$)=59 THEN GOSUB 6800:HPAGE%=3:L%=4218:CHAIN"hlp",,ALL
```

```
4224 IF ASC(I$)=61 THEN 4002 'F3
4227 IF ASC(I$)=60 THEN 4230 ELSE 4218 'F2
4230 OPEN "r",1,FILE$,177
4232 FIELD 1, 14 AS G$(1),40 AS G$(2),3 AS G$(3),1 AS G$(4),1 AS G$(5),14 AS G$(
6),14 AS G$(7),14 AS G$(8),14 AS G$(9),2 AS G$(10),1 AS G$(11),3 AS G$(12),14 AS
 G$(13),14 AS G$(14),14 AS G$(15),14 AS G$(16)
4234 GET 1,1:IF INSTR(FILE$,G$(1))>0 OR INSTR(G$(1),FILE$)>0 THEN 4254
4236 COLOR 3,0:LOCATE 25,1,0:GOSUB 61100:CLOSE #1:GOTO 4218
4254 GD$(1)=G$(6):GD$(2)=G$(7):GD$(3)=G$(8):GD$(4)=G$(9)
4258 GD$(5)=G$(13):GD$(6)=G$(14):GD$(7)=G$(15):GD$(8)=G$(16)
4263 COLOR 14,0:LOCATE 6,33:PRINT G$(2):LOCATE ,33:PRINT G$(10):LOCATE ,33:PRINT
 G$(3):LOCATE ,33:PRINT G$(4):LOCATE ,33:PRINT G$(5)
4264 LOCATE 14:FOR I%=6 TO 9:LOCATE ,21:PRINT G$(I%);:LOCATE ,51:PRINT G$(I%+7):
NEXT:LOCATE 20,37:PRINT G$(11):LOCATE ,37:PRINT G$(12):COLOR 3
4265 NNDH%=VAL(G$(3))
4266 BEEP:COLOR 3,0:LOCATE 25,1,0:PRINT"Printer head on the first line? Hit any
key when ready."TAB(78);:GOSUB 62100
4267 LPRINT CHR$(10);CHR$(10) 'skip to the 5th line (the printer head should be
     in the first column)
4268 LPRINT CHR$(27);CHR$(67);CHR$(66);CHR$(27);CHR$(78);CHR$(8) 'set TOF where
     the printer head is (the fifth line), set the page length to 66 lines, and
     skip 4 lines at the bottom and top of consequtive pages
4269 LPRINT DATE$: LPRINT TIME$: FOR I%=1 TO 15: LPRINT :NEXT
4270 LPRINT "Name of the Data File";TAB(30);"= ";FILE$:LPRINT :LPRINT "Project n
ame";TAB(30);"= ";CHR$(27);CHR$(71);G$(2);CHR$(27);CHR$(72)
4274 LPRINT "Number of Drill Holes";TAB(30);"= ";G$(3)
4278 LPRINT "Drill Hole Labels";TAB(30);"= ";G$(4)
4282 LPRINT "Number of Data Sets";TAB(30);"= ";G$(5)
4286 LPRINT:LPRINT "Sequence and Names of Data Sets :"
4290 NNDS%=VAL(G$(5))
4294 IF NNDS%<5 THEN J%=NNDS% ELSE J%=4
4298 FOR I%=1 TO J%:LPRINT TAB(10);I%;". ";G$(I%+5):NEXT I%
4302 IF NNDS%<5 THEN 4310
4306 FOR I%=5 TO NNDS%:LPRINT TAB(10);I%;". ";G$(I%+8):NEXT I%
4310 LPRINT:LPRINT "Quadrant Chosen";TAB(30);"= ";G$(10)
4314 LPRINT "Boundary Points";TAB(30);"= ";G$(11)
4318 LPRINT " Number of boundary points";TAB(30);"= ";G$(12)
4322 WIDTH "lpt1:",132
4326 LPRINT CHR$(15) '17 CPI
4330 FIELD 1,14 AS E$(1),14 AS E$(2),14 AS E$(3),14 AS E$(4),14 AS E$(5),14 AS E
$(6),14 AS E$(7)
4334 LPRINT CHR$(27);CHR$(68),CHR$(0) 'cancel the default tabs
4338 LPRINT CHR$(27);CHR$(68);CHR$(5);CHR$(12);CHR$(29);CHR$(46);CHR$(63);CHR$(8
0);CHR$(97);CHR$(114);CHR$(0) 'set the new tabs
4342 LPRINT CHR$(12); 'form feed
4346 GOSUB 4414
4350 FOR I%=2 TO NNDH%+1
4354 GET 1,I%
4358 LPRINT CHR$(9);I%-1;CHR$(9);E$(1);CHR$(9);E$(2);CHR$(9);E$(3);CHR$(9);E$(4)
;CHR$(9);E$(5);CHR$(9);E$(6);CHR$(9);E$(7):LPRINT
4362 IF (I%-1) MOD 28 THEN 4366 ELSE GOSUB 4414
4366 NEXT I%
4370 IF NNDS%<5 THEN 4406
4374 LPRINT CHR$(12); 'form feed
4378 FIELD 1,14 AS E$(1),14 AS E$(2),14 AS E$(3),56 AS E$(4),14 AS E$(5),14 AS E
$(6),14 AS E$(7),14 AS E$(8)
4382 GOSUB 4434
4386 FOR I%=2 TO NNDH%+1
4390 GET 1,I%
4394 LPRINT CHR$(9);I%-1;CHR$(9);E$(1);CHR$(9);E$(2);CHR$(9);E$(3);CHR$(9);E$(5)
;CHR$(9);E$(6);CHR$(9);E$(7);CHR$(9);E$(8):LPRINT
4398 IF (I%-1) MOD 28 THEN 4402 ELSE GOSUB 4434
4402 NEXT I%
4406 LPRINT CHR$(18);CHR$(12) 'cancel 17 CPI/FF
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4410 WIDTH "lpt1:",80:CLOSE #1:BEEP:COLOR 3,0:LOCATE 25,1:PRINT"Printing is comp
lete !"TAB(78);:GOTO 4218
4414 LPRINT CHR$(27);CHR$(71);'will be auto form feed and then enhanced printing

4418 LPRINT CHR$(9);"No.";CHR$(9);"Drill Hole Code";CHR$(9);" E-Coordinate";CHR$
(9);"N/S-Coordinate";CHR$(9);GD$(1);CHR$(9);GD$(2);CHR$(9);GD$(3);CHR$(9);GD$(4)

4422 LPRINT CHR$(10);
4426 LPRINT CHR$(27);CHR$(72); 'cancel enhanced printing
4430 RETURN
4434 LPRINT CHR$(27);CHR$(71);'will be auto form feed and then enhanced printing

4438 LPRINT CHR$(9);"No.";CHR$(9);"Drill Hole Code";CHR$(9);" E-Coordinate";CHR$
(9);"N/S-Coordinate";CHR$(9);GD$(5);CHR$(9);GD$(6);CHR$(9);GD$(7);CHR$(9);GD$(8)

4442 LPRINT CHR$(10);
4446 LPRINT CHR$(27);CHR$(72); 'cancel enhanced printing
4450 RETURN
4990 FOR J%=1 TO 2:IF J%=1 THEN SCREEN ,,3,0 ELSE SCREEN ,,0,3 'file list
4991 COLOR 6,0:CLS:LOCATE 1,1,0:FILES:LOCATE ,,0
4992 GOSUB 7100:NEXT J%:SCREEN ,,0
4993 I$=INKEY$:IF I$<>"" THEN 4993
4994 I$=INKEY$:IF I$="" THEN 4994
4995 IF LEN(I$)=1 THEN 4994 ELSE I$=RIGHT$(I$,1)
4996 IF I$=CHR$(59) THEN COLOR 3:LOCATE 22,1:PRINT"Please ignore the 'Wait until
 the cursor appears' msg after returning from HELP";:GOSUB 6800:HPAGE%=3:L%=4993
:CHAIN"hlp",,ALL
4997 IF ASC(I$)=60 OR ASC(I$)=61 OR ASC(I$)=81 OR ASC(I$)=73 OR ASC(I$)=71 THEN
4002 ELSE 4994'F2/F3/PgDn/PgUp/Home
5000 GOSUB 6800:HPAGE%=1:L%=4010:CHAIN "hlp",,ALL 'GPPC instructions
5100 GOSUB 6200: IF B% THEN CHAIN "input",1030 ELSE CHAIN "input"
5200 IF V% THEN GOSUB 6200:CHAIN "plots" ELSE GOSUB 6400
5300 IF V% THEN GOSUB 6200:CHAIN "stat" ELSE GOSUB 6400
5400 IF V% THEN GOSUB 6200:CHAIN "vargram" ELSE GOSUB 6400
5500 IF V% THEN GOSUB 6600:CHAIN "krig" ELSE GOSUB 6400
5800 COLOR 7,0:CLS:SYSTEM
5900 REM*****SUBROUTINE GIVES INVALID ENTRY MESSAGE
6000 BEEP:LOCATE 25,1,0:COLOR 27,0:PRINT"Invalid entry!";:COLOR 3:PRINT" Enter t
he number of your choice from the menu between ";:COLOR 11:PRINT"1";:COLOR 3:PRI
NT" and ";:COLOR 11:PRINT"7."TAB(79);:RETURN 3100
6100 REM*****SUBROUTINE GIVES WAIT MSG
6200 COLOR 27,0:LOCATE 25,1,0:PRINT"Please wait!";:COLOR 3:PRINT" This will not
take more than a few seconds."TAB(78);:RETURN
6300 REM*****SUBROUTINE GIVES FIRST 'OPTION 2' MSG
6400 BEEP:COLOR 3,0:LOCATE 25,1,0:PRINT"You have to go all the way through 'opti
on 1' first to choose this option!"TAB(78);:RETURN 3100
6500 REM*SUBROUTINE GIVES UNDER DEVELOPMENT MSG
6600 BEEP:LOCATE 25,1,0:COLOR 14,4:PRINT "This option is in the development stag
e! It will be ready soon."TAB(79);:RETURN 3100
6700 REM*****SUBROUTINE GIVES WAIT FOR HELP MSG
6800 COLOR 27,0:LOCATE 25,1,0:PRINT"Please hold on!";:COLOR 3:PRINT" Help file i
s being searched."TAB(79);:RETURN
6900 REM*****SUBROUTINE PRINTS THE LAST LINE
7000 LOCATE 23,1,0:COLOR 6,0:PRINT STRING$(79,95):COLOR 2:PRINT TAB(14)"F1/F10";
:COLOR 6:PRINT"Help-Detailed/Quick Ref.  ";:COLOR 2:PRINT"F2/F3";:COLOR 6:PRINT"
Page Down/up  ";:RETURN
7100 LOCATE 23,1,0:COLOR 6,0:PRINT STRING$(79,95):COLOR 2:PRINT TAB(11)"F1/F10";
:COLOR 6:PRINT"Help-Detailed/Quick Ref.  ";:COLOR 2:PRINT"F2/F3";:COLOR 6:PRINT"
Page Down/up  ";:COLOR 2,0:PRINT"Home";:RETURN
50000 C%=CMIN%:LOCATE R%,C%,1  'EDITOR-------------------------------------
50010 DEF SEG=0:POKE 1050,PEEK(1052)
50020 I$=INKEY$:IF I$="" THEN 50020
50030 IF LEN(I$)=2 THEN I$=RIGHT$(I$,1):I=ASC(I$):GOTO 50220
50040 I=ASC(I$):IF I=9 OR I=13 THEN GOSUB 50430:NXT=3:RETURN 'Tab/Return
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```
50050 IF I<>8 THEN 50080 'Backspace
50060 IF C%>CMIN% THEN B$=MID$(FLD$,C%-CMIN%+1,CMAX%-C%+1)+" ":FLD$=MID$(FLD$,1,
C%-CMIN%-1)+B$:C%=C%-1:LOCATE ,C%:PRINT B$;:LOCATE ,C% ELSE FLD$=MID$(FLD$,2,CMA
X%-C%+1)+" ":PRINT FLD$;:LOCATE ,CMIN%
50070 GOTO 50020
50080 IF I=27 THEN GOSUB 50430:FLD$=SPACE$(CMAX%-CMIN%+1):LOCATE ,CMIN%:PRINT FL
D$;:LOCATE ,CMIN%:C%=CMIN%'Esc
50090 IF I<32 THEN 50020  'Unprintable character
50100 IF INS THEN 50140   'Branch for insert mode
50110 '----Non insert mode data entry--------------------------------------------
50120 PRINT I$:C%=C%+1:IF C%<CMAX%+1 THEN LOCATE R%,C%:CI%=C%-1 ELSE LOCATE R%,C
%-1:CI%=C%-1:C%=C%-1
50130 MID$(FLD$,CI%+1-CMIN%,1)=I$:GOTO 50020
50140 '----Insert mode data entry-----------------------------------------------
50150 IF ASC(RIGHT$(FLD$,1))<>32 THEN BEEP:GOTO 50020
50160 B$=MID$(FLD$,C%-CMIN%+1,CMAX%-C%)
50170 FLD$=LEFT$(FLD$,C%-CMIN%)+I$+B$
50180 PRINT I$;:C%=C%+1:LOCATE ,C%:PRINT B$;:IF C%>CMAX% THEN C%=C%-1
50190 LOCATE ,C%:GOTO 50020
50200 '----Process special function key---------------------------------------
50210 I$=RIGHT$(I$,1)
50220 IF I=77 THEN 50230 ELSE 50240         'CR
50230 IF C%<CMAX% THEN C%=C%+1:LOCATE ,C%:GOTO 50020 ELSE BEEP:GOTO 50020
50240 IF I=75 THEN 50250 ELSE 50260         'CL
50250 IF C%>CMIN% THEN C%=C%-1:LOCATE ,C%:GOTO 50020 ELSE BEEP:GOTO 50020
50260 IF I=72 THEN GOSUB 50430:NXT=2:RETURN 'CU
50270 IF I=15 THEN GOSUB 50430:NXT=4:RETURN 'Shift+Tab
50280 IF I=80 THEN GOSUB 50430:NXT=1:RETURN 'CD
50290 IF I=71 THEN GOSUB 50430:NXT=7:RETURN 'Home
50300 IF I<69 AND I>58 THEN GOSUB 50430:NXT=8:RETURN 'F-keys
50310 IF I=73 THEN GOSUB 50430:NXT=6:RETURN 'PgUp
50320 IF I=81 THEN GOSUB 50430:NXT=5:RETURN 'PgDn
50330 IF I=115 THEN C%=CMIN%:LOCATE ,C%:GOTO 50020 'Ctrl+CL
50340 IF I=116 THEN GOSUB 50430:LF=CMAX%-CMIN%+1 ELSE 50380 'Ctrl+CR
50350 FOR L=0 TO LF-1:B$=MID$(FLD$,LF-L,1):IF ASC(B$)<>32 THEN 50360 ELSE NEXT L

50360 C%=CMAX%-L+1:IF C%>CMAX% THEN LOCATE ,CMAX% ELSE LOCATE ,C%
50370 GOTO 50020
50380 IF I=82 THEN 50390 ELSE 50410     'Insert
50390 IF INS THEN INS=0:LOCATE ,,,6,7 ELSE INS=1:LOCATE ,,,4,7
50400 GOTO 50020
50410 IF I=83 THEN B$=MID$(FLD$,C%-CMIN%+2,CMAX%-C%)+" ":FLD$=MID$(FLD$,1,C%-CMI
N%)+B$:PRINT B$;:LOCATE ,C%:GOTO 50020 'Delete
50420 GOTO 50020                         'Undefined key
50430 IF INS THEN INS=0:LOCATE ,,,6,7
50440 RETURN '--------------------------------------------------------------
60000 IF ERR=52 OR ERR=64 OR ERR=66 OR ERR=68 OR ERR=75 OR ERR=76 THEN GOSUB 610
00 ELSE 60100
60010 IF ERL=4242 THEN RESUME 4218 ELSE 60900
60100 IF ERR=54 THEN GOSUB 61100 ELSE 60200
60110 IF ERL=4246 OR ERL=4330 OR ERL=4378 THEN CLOSE #1:RESUME 4218 ELSE 60900
60200 IF ERR=67 THEN GOSUB 61200:GOTO 60010 ELSE 60300
60300 IF ERR=61 THEN GOSUB 61300:GOTO 60010 ELSE 60400
60400 IF ERR=70 THEN GOSUB 61400:RESUME
60500 IF ERR=71 THEN GOSUB 61500:RESUME
60600 IF ERR=72 THEN GOSUB 61600:RESUME
60700 IF ERR=27 THEN GOSUB 61700:RESUME
60800 IF ERR=24 OR ERR=25 OR ERR=51 OR ERR=57 THEN GOSUB 61800 ELSE 60900
60900 LOCATE 25,1:PRINT"Programming error. ERR=";ERR;"ERL=";ERL;"Try again to re
create the problem!";TAB(78);:ON ERROR GOTO 0:STOP
61000 LOCATE 25,1:PRINT"Invalid file specification!";:GOTO 62000
61100 LOCATE 25,1:PRINT "Not the right file. Created by GPPC?";:GOTO 62000
61200 LOCATE 25,1:PRINT"Invalid file specification or too many files!";:GOTO 620
00
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61300 LOCATE 25,1:PRINT"Invalid file specification or disk full!";:GOTO 62000
61400 LOCATE 25,1:PRINT"If the diskette is write-protected, change it!";:GOTO 62
000
61500 LOCATE 25,1:PRINT"If the diskette drive door is open, close it!";:GOTO 620
00
61600 LOCATE 25,1:PRINT"Diskette has gone bad, please replace it!";:GOTO 62000
61700 LOCATE 25,1:PRINT"Either printer has to be switched on or out of paper!";:
GOTO 62000
61800 LOCATE 25,1:PRINT"Unexpected error!";:GOTO 62000
62000 BEEP:PRINT" Hit any key and retry.";TAB(78);
62100 B$=INKEY$:IF B$<>"" THEN 62100
62200 B$=INKEY$:IF B$="" THEN 62200 ELSE RETURN
```

```
1000 REM*****MODULE NAME = INPUT.BAS
1010 ON ERROR GOTO 2080
1020 DIM R$(24),BE#(129),BN#(129),DHL$(129),D#(129),E#(129),N#(129)
1030 R$(3)=" ":R$(4)=SPACE$(14)
1040 DIM N%(24),X%(24),F$(16)
1050 FOR I%=1 TO 24: READ N%(I%):NEXT
1060 DATA 81,81,40,30,81,17,35,36,49,81,81,3,3,3,3,25,71,27,49,48,23,23,23,23
1070 FOR I%=1 TO 24: READ X%(I%):NEXT
1080 DATA 0,0,40,43,0,56,37,36,49,0,0,16,16,16,16,25,71,28,49,50,36,36,36,36
1090 R$(16)=" ":R$(17)=" "
1100 DIM R1$(16),N1%(16),X1%(16)
1110 FOR I%=1 TO 16:READ N1%(I%):NEXT
1120 FOR I%=1 TO 16: READ X1%(I%):NEXT
1130 DATA 81,81,79,81,81,24,24,81,81,49,81,81,24,40,40,40
1140 DATA 0,0,79,0,0,37,37,0,0,49,0,0,37,53,53,53
1150 B$=SPACE$(14):D$="10000000000000":R1$(3)="y":R1$(6)=B$:R1$(7)=B$:R1$(10)="y
":R1$(13)=B$:R1$(14)=D$:R1$(15)=D$:R1$(16)=D$
1160 DIM P%(9)
1170 FOR I%=1 TO 9:READ P%(I%):NEXT:DATA 1,18,34,50,66,82,98,114,130
1180 DIM N3%(4),X3%(4)
1190 N3%(1)=6:N3%(2)=26:N3%(3)=46:N3%(4)=66:X3%(1)=19:X3%(2)=39:X3%(3)=59:X3%(4)
=79
1200 SAY%=-1:SAYDH%=-1:SAYBP%=-1:C1$="n":C2$="n":BPF%=1:DHF%=1
1210 DHFF%=0:BPFF%=0:PF%=1
1220 FOR J%=1 TO 2:IF J%=1 THEN SCREEN ,,3,0 ELSE SCREEN ,,0,3
1230 COLOR 6,0:CLS:LOCATE 1,15,0:PRINT"2.INPUT OF DRILL HOLE DATA AND BOUNDARY P
OINTS":PRINT
1240 PRINT"Source of data [ (e)dit,(r)etrieve ] : ";:COLOR 7,4:PRINT R$(3)
1250 COLOR 6,0:PRINT"File specification of data : ";:COLOR 7,1:PRINT R$(4)
1260 COLOR 2,0:LOCATE 6,1,0:PRINT"      You may type in  (r)  as the source of d
ata and  (warcreek.dat) for      ":PRINT"      the  file  specification to retri
eve the  demonstration  datafile.     "
1270 LOCATE 22,1,0:COLOR 6,0:PRINT STRING$(79,95)
1280 COLOR 2,0:PRINT"F1 ";:COLOR 6:PRINT"(Help)  ";:COLOR 2:PRINT" F2 ";:COLOR 6
:PRINT"(Done;proceed)  ";:COLOR 2:PRINT" F3 ";:COLOR 6:PRINT"(Previous Menu)   "
;:COLOR 2:PRINT"Shift+PrtSc ";:COLOR 6:PRINT"(Print Screen)"
1290 COLOR 2:PRINT CHR$(24);"/";CHR$(25);:COLOR 6:PRINT" (Move up/down between f
ields)  ";:NEXT J%:SCREEN ,,0:MODULE$="input"
1300 LRF%=0:CLRF%=0:R%=3:C%=40
1310 COLOR 7,CLR%(CLRF%+1):LOCATE R%,C%,1
1320 I$=INKEY$:IF I$<>"" THEN 1320
1330 I$=INKEY$:IF I$="" THEN 1330
1340 COLOR 0,0:LOCATE 25,1,0:IF SCREEN(25,1)<>32 THEN PRINT SPACE$(79);
1350 COLOR 7,CLR%(CLRF%+1): LOCATE R%,C%,1
1360 IF LEN(I$)=2 THEN I$=RIGHT$(I$,1):GOTO 1380 ELSE IF ASC(I$)<32 THEN 1330 EL
SE LOCATE ,,0:PRINT I$;:I%=C%:IF C%<X%(R%) THEN C%=C%+1:LOCATE ,,1 ELSE LOCATE ,
C%,1
1370 MID$(R$(R%),I%+1-N%(R%),1)=I$:GOTO 1330
1380 IF I$=CHR$(80) OR I$=CHR$(72) THEN 1390 ELSE 1420'CD/CU
1390 IF R%=3 THEN R%=4:C%=30 ELSE R%=3:C%=40
1400 IF CLRF% THEN CLRF%=0 ELSE CLRF%=1
1410 COLOR ,CLR%(CLRF%+1):LOCATE R%,C%:GOTO 1330
1420 IF I$=CHR$(77) THEN 1430 ELSE 1450'CR
1430 IF C%<X%(R%) THEN C%=C%+1:LOCATE R%,C%
1440 GOTO 1330
1450 IF I$=CHR$(75) THEN 1460 ELSE 1480'CL
1460 IF C%>N%(R%) THEN C%=C%-1:LOCATE R%,C%
1470 GOTO 1330
1480 IF I$=CHR$(61) THEN GOSUB 1830:B%=1:V%=0:CLOSE 1,2:CHAIN"mainmenu",,ALL'F3
1490 IF I$=CHR$(60) THEN LOCATE ,,0:GOTO 1520'F2
1500 IF I$=CHR$(59) THEN 1510 ELSE 1330'F1
1510 LOCATE 25,1,0:COLOR 27,0:PRINT"Please hold on!";:COLOR 3:PRINT" Help file i
s being searched.";:HPAGE%=8:L%=1310:CHAIN "hlp",,ALL
1520 IF R$(3)="e" OR R$(3)="E" OR R$(3)="r" OR R$(3)="R" THEN 1550
```

```
1530 BEEP:LOCATE 25,1,0:COLOR 3,0:PRINT"Enter ";:COLOR 11:PRINT"e or E";:COLOR 3
:PRINT" to edit an old or a new file and ";:COLOR 11:PRINT"r or R";:COLOR 3:PRIN
T" to retrieve an old file.";
1540 R%=3:C%=40:CLRF%=0:GOTO 1310
1550 R1$(4)=R$(4):GOSUB 1850
1560 ON ERROR GOTO 0:ON ERROR GOTO 2030
1570 NAME R$(4) AS R$(4)
1580 DHFF%=1
1590 OPEN "r",1,R$(4),177
1600 FIELD 1,14 AS F$(1),40 AS F$(2),3 AS F$(3),1 AS F$(4),1 AS F$(5),14 AS F$(6
),14 AS F$(7),14 AS F$(8),14 AS F$(9),2 AS F$(10),1 AS F$(11),3 AS F$(12),14 AS
F$(13),14 AS F$(14),14 AS F$(15),14 AS F$(16)
1610 GET 1,1
1620 R$(4)=F$(1):R$(6)=F$(2):R$(7)=F$(3):R$(8)=F$(4):R$(9)=F$(5):R$(12)=F$(6):R$
(13)=F$(7):R$(14)=F$(8):R$(15)=F$(9):R$(18)=F$(10):R$(19)=F$(11):R$(20)=F$(12):R
$(21)=F$(13):R$(22)=F$(14):R$(23)=F$(15):R$(24)=F$(16)
1630 ON ERROR GOTO 0:ON ERROR GOTO 2210
1640 NAME R$(1) AS R$(1)
1650 BPFF%=1
1660 OPEN "r",2,R$(1),28
1670 FIELD 2,28 AS F$(1)
1680 B%=1
1690 IF R$(3)="r" OR R$(3)="R" THEN 1730
1700 GOSUB 1830:IF R$(9)<>CHR$(0) THEN 1720
1710 R$(6)=SPACE$(40): R$(7)="   ":R$(8)="y":R$(9)="8": R$(18)="ne": R$(19)="y":
     R$(20)="   ": FOR I%=12 TO 15: R$(I%)=B$: R$(I%+9)=B$: NEXT
1720 R$(4)=R1$(4): CHAIN"Inpute",,ALL
1730 IF DHFF%=1 AND LOF(1)>0 THEN 1750
1740 BEEP:LOCATE 25,1,0:COLOR 27,0:PRINT R1$(4);:COLOR 19:PRINT" has not been cr
eated yet !";:COLOR 3:PRINT" Why don't you choose ";:COLOR 11:PRINT"option e";:C
OLOR 3:PRINT" ?";:GOSUB 1950:CLRF%=0:R%=3:C%=40:GOTO 1310
1750 IF R$(4)=R1$(4) THEN 1770
1760 BEEP:LOCATE 25,1,0:COLOR 11,0:PRINT R1$(4);:COLOR 3:PRINT"was created as ";
:COLOR 11:PRINT R$(4);:COLOR 3:PRINT".Pls. choose ";:COLOR 11:PRINT"option e";:C
OLOR 3:PRINT" to correct it.";:GOSUB 1950:CLRF%=0:R%=3:C%=40:GOTO 1310
1770 IF R$(19)="n" OR R$(19)="N" THEN 1800
1780 IF BPFF%=1 AND LOF(2)>0 THEN 1810
1790 BEEP:LOCATE 25,1,0:COLOR 11,0:PRINT R$(1);:COLOR 3:PRINT" not found! Copy i
t or choose ";:COLOR 11:PRINT"option e";:COLOR 3:PRINT" to create or nullify it.
";:GOSUB 1950:CLRF%=0:R%=3:C%=40:GOTO 1310
1800 IF LOF(2) THEN CLOSE 2:GOTO 1810 ELSE CLOSE 2:KILL R$(1)
1810 GOSUB 1830:CHAIN"Inputr",,ALL
1820 REM*****SUBROUTINE GIVES WAIT MSG
1830 LOCATE 25,1,0: COLOR 27,0: PRINT "Please wait!";: COLOR 3: PRINT" This will
 not take more than a few seconds.";SPACE$(23);:RETURN
1840 REM*****SUBROUTINE DETERMINES THE BOUNDARY POINT FILE NAME
1850 FOR I%=14 TO 1 STEP-1:IF MID$(R$(4),I%,1)="\" THEN 1860 ELSE NEXT
1860 J%=I%:FOR I%=14 TO J%+1 STEP-1:IF MID$(R$(4),I%,1)="." THEN 1870 ELSE NEXT
1870 K%=I%:IF K%>J% THEN I%=K%-1 ELSE I%=J%+8
1880 GOSUB 1900:IF ERC% THEN R$(1)=LEFT$(R$(4),I%)+".bdp":RETURN ELSE RETURN 131
0
1890 REM*****SUBROUTINE DETECTS DEVICE NAME ERROR
1900 FOR L%=1 TO 14:IF MID$(R$(4),L%,1)=":" THEN 1910 ELSE NEXT
1910 IF L%=15 THEN L%=0
1920 IF L%=1 OR L%>2 THEN 1930 ELSE ERC%=1:RETURN
1930 BEEP:COLOR 27,0:LOCATE 25,1,0:PRINT "Invalid device name!";:COLOR 3:PRINT"O
nly existing disk(ette) drives may be referred as devices!";:CLOSE 1,2:CLRF%=1:R
%=4:C%=30:ERC%=0:RETURN
1940 REM*****SUBROUTINE INITIALIZES FILES
1950 R$(4)=R1$(4): DHFF%=0: BPFF%=0
1960 IF LOF(1) THEN I%=0 ELSE I%=1
1970 IF LOF(2) THEN J%=0 ELSE J%=1
1980 CLOSE 1,2
1990 IF I% THEN KILL R$(4)
```

```
2000 IF J% THEN KILL R$(1)
2010 RETURN
2020 REM*****ROUTINE TRAPS FILE ERRORS
2030 IF ERL=1570 THEN IF ERR=58 THEN RESUME NEXT ELSE RESUME 1590 ELSE 2040
2040 IF ERL=1600 AND ERR=54 THEN 2050 ELSE 2060
2050 BEEP: LOCATE 25,1,0: COLOR 27,0: PRINT "File wasn't created by GEOSTAT!";:C
OLOR 3:PRINT"You can only work with files created by GEOSTAT!";:CLRF%=0:R%=3:C%=
40:GOSUB 1950:RESUME 1310
2060 IF ERR=52 OR ERR=64 OR ERR=66 OR ERR=76 THEN 2070 ELSE 2080
2070 BEEP:LOCATE 25,1,0:COLOR 27,0:PRINT"Invalid file spec. !";:COLOR 3:PRINT" E
rror code is";ERR;". Check the appendix of HELP for detail.";:CLRF%=1:R%=4:C%=30
:RESUME 1310
2080 IF ERR<>67 THEN 2100
2090 BEEP:LOCATE 25,1,0:COLOR 3,0:PRINT"Either the file spec. is invalid or # fi
les exceeds the max. allowable number.";:CLRF%=1:R%=4:C%=30:RESUME 1310
2100 IF ERR<>61 THEN 2120
2110 BEEP:LOCATE 24,1,0: COLOR 27,0: PRINT "Disk full or invalid file spec.!";:C
OLOR 3:PRINT" Erase unneeded files or correct file spec.";:CLRF%=1:R%=4:C%=30:RE
SUME 1310
2120 IF ERR<>70 THEN 2140
2130 BEEP:LOCATE 25,1,0:COLOR 3,0:PRINT "Is the diskette write-protected? If not
, too bad! This => a hardware problem!";:RESUME 1310
2140 IF ERR<>71 THEN 2160
2150 BEEP:LOCATE 25,1,0:COLOR 3,0:PRINT "Is the diskette drive door open? If not
 please insert the work diskette!";:RESUME 1310
2160 IF ERR<>72 THEN 2180
2170 BEEP:LOCATE 25,1,0:COLOR 3,0:PRINT"It seems as if the diskette has gone bad
! Hopefully you've made a backup copy!";:RESUME 1310
2180 IF ERR=24 OR ERR=25 OR ERR=51 OR ERR=57 THEN ON ERROR GOTO 0
2190 BEEP:LOCATE 25,1,0:COLOR 27,0:PRINT"Unpredicted program error!";:COLOR 3:PR
INT" Error code is";ERR;". See Ahmet if HELP doesn't help!";:GOSUB 1950:RESUME 1
310
2200 'for boundary points file=r$(1)
2210 IF ERL=1640 THEN IF ERR=58 THEN RESUME NEXT ELSE RESUME 1660 ELSE 2220
2220 IF ERL=1670 AND ERR=54 THEN 2230 ELSE 2080
2230 BEEP:LOCATE 25,1,0:COLOR 27,0:PRINT"A very rare case!";:COLOR 3:PRINT" Plea
se give another name instead of ";:COLOR 11:PRINT R1$(4);:COLOR 3:PRINT"to proce
ed.";:GOSUB 1950:CLRF%=1:R%=4:C%=30:RESUME 1310
```

```
100 MODULE$="Inputr"
110 COMMON MS,CLR%(),D#(),E#(),N#(),R$(),DHL$(),BE#(),BN#(),DS$,PLS%,B%,V%,MN#,V
R#,CO$,ACD$(),AOA$(),AF$(),AC$(),AA$()
120 NBP%=VAL(R$(20)): NDH%=VAL(R$(7))
130 DIM E$(NDH%),N$(NDH%),DS$(NDH%)
140 FOR J%=1 TO 2: IF J%=1 THEN SCREEN ,,3,0 ELSE SCREEN ,,0,3
150 COLOR 6,0: CLS: LOCATE 1,15,0: PRINT
    "1.INPUT OF DRILL HOLE DATA AND BOUNDARY POINTS": PRINT
160 PRINT "Source of data [ (e)dit,(r)etrieve ] : ";:COLOR CLR%(1),CLR%(3): PRIN
T R$(3)
170 COLOR 6,0:PRINT"File specification of data : ";:COLOR CLR%(2),CLR%(4):PRINT
R$(4):PRINT
180 COLOR 6,0: COLOR 6,0: PRINT "Project label : ";:COLOR CLR%(2),CLR%(4): PRINT
 R$(6)
190 COLOR 6,0:PRINT "Number of drill holes [ 1-129 ] : ";:COLOR CLR%(2),CLR%(4):
PRINT R$(7)
200 COLOR 6,0:PRINT"Drill hole labels [ (y)es,(n)o ] : ";:COLOR CLR%(2),CLR%(4):
PRINT R$(8)
210 COLOR 6,0: PRINT "Number of data sets for each borehole [ 1-8 ] : ";:
   COLOR CLR%(2),CLR%(4): PRINT R$(9): PRINT
220 COLOR 6,0: PRINT "Sequence and names of data sets :"
230 COLOR CLR%(1),CLR%(3): PRINT "1";: LOCATE 12,3: PRINT R$(12);:COLOR CLR%(2),
CLR%(4):LOCATE ,21:        PRINT "5";: LOCATE ,23: PRINT R$(21)
240 PRINT "2";: LOCATE 13,3: PRINT R$(13);:COLOR CLR%(1),CLR%(3): LOCATE ,21: PR
INT "6";:      LOCATE ,23: PRINT R$(22)
250 PRINT "3";: LOCATE 14,3: PRINT R$(14);:COLOR CLR%(2),CLR%(4): LOCATE ,21: PR
INT "7";:      LOCATE ,23: PRINT R$(23)
260 PRINT "4";: LOCATE 15,3: PRINT R$(15);:COLOR CLR%(1),CLR%(3): LOCATE ,21: PR
INT "8";:      LOCATE ,23: PRINT R$(24)
270 LOCATE 16,1: COLOR 6,0: PRINT "Data set chosen [1-8] : ";:COLOR CLR%(4),CLR%
(2):           R$(16)=" ": PRINT R$(16): PRINT
280 COLOR 6,0: PRINT "Quadrant chosen [ne,se] : ";:COLOR CLR%(2),CLR%(4): PRINT
R$(18)
290 COLOR 6,0:PRINT "Boundary points for the property [(y)es,(n)o] : ";:
   COLOR CLR%(2),CLR%(4): PRINT R$(19)
300 COLOR 6,0: PRINT " If yes; number of boundary points [ 1-129 ] : ";:
   COLOR CLR%(2),CLR%(4): B$=STRING$(3,32): PRINT R$(20)
310 LOCATE 23,1,0: COLOR 6,0: PRINT STRING$(79,95)
320 COLOR 2,0:PRINT "F1 ";:COLOR 6:PRINT "(Help)   ";:COLOR 2: PRINT " F2 ";:
   COLOR 6:PRINT "(Done;proceed)   ";:COLOR 2: PRINT " F3 ";:COLOR 6:PRINT "(Pre
vious Menu)    ";:COLOR 2:PRINT "Shift+PrtSc ";:COLOR 6:PRINT "(Print Screen)";
330 NEXT J%: SCREEN ,,0
340 R%=16: C%=25: CLRF%=1
350 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1): LOCATE R%,C%,1
360 I$=INKEY$: IF I$<>"" THEN 360
370 I$=INKEY$: IF I$="" THEN 370
380 COLOR 0,0: LOCATE 25,1,0: IF SCREEN (25,1)<>32 THEN PRINT SPACE$(79);
390 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1): LOCATE R%,C%,1
400 IF LEN(I$)=2 THEN I$=RIGHT$(I$,1): GOTO 420 ELSE IF ASC(I$)<32 THEN 370 ELSE
    LOCATE ,,0: PRINT I$;: I%=C%: IF C%<X%(R%) THEN C%=C%+1: LOCATE ,,1 ELSE
    LOCATE ,C%,1
410 MID$(R$(R%),I%+1-N%(R%),1)=I$: GOTO 370
420 IF I$=CHR$(61) THEN 430 ELSE 460 'F3
430 LOCATE 25,1,0: COLOR 27,0: PRINT "Please hold on!";: COLOR 3: PRINT
    " This will not take more than a couple of seconds.";
440 ERASE E$,N$,DS$
450 CLOSE 1,2: V%=0: CHAIN "Input",1220,ALL
460 IF I$=CHR$(59) THEN 470 ELSE 480 'F1
470 LOCATE 25,1,0: COLOR 27,0: PRINT "Please hold on!";: COLOR 3: PRINT
    " Help file is being searched.";: HPAGE%=10: L%=350: CHAIN"hlp",,ALL
480 IF I$<>CHR$(60) THEN 370 'F2
490 LOCATE ,,0:IF ASC(R$(16))>48 AND ASC(R$(16))=<ASC(R$(9)) THEN 510
500 BEEP: COLOR 3,0: LOCATE 25,1,0: PRINT"Entry is out of range or a non-numeric
 character. Enter a number between";: COLOR 11: PRINT" 1 & ";R$(9);: COLOR 3:
```

```
    PRINT".";:GOTO 350
510 SAY%=SAY%+1
520 IF SAY%=0 THEN 540
530 IF DSC%=VAL(R$(16)) THEN 750
540 DSC%=VAL(R$(16))
550 IF DSC%>4 THEN DS$=R$(DSC%+16) ELSE DS$=R$(DSC%+11)
560 IF R$(19)="n" OR R$(19)="N" THEN 600
570 COLOR 27,0: LOCATE 25,1,0: PRINT "Please wait!";: COLOR 3: PRINT
    " GEOSTAT is reading ";: COLOR 11: PRINT "boundary points";: COLOR 3: PRINT
    " and ";: COLOR 11: PRINT DS$;: COLOR 3: PRINT " data.";
580 FIELD 2,14 AS F$(1),14 AS F$(2)
590 FOR I%=1 TO NBP%:GET 2,I%:BE#(I%)=VAL(F$(1)):BN#(I%)=VAL(F$(2)):NEXT:
    GOTO 610
600 COLOR 27,0: LOCATE 25,1,0: PRINT "Please wait!";: COLOR 3: PRINT
    " GEOSTAT is reading ";: COLOR 11: PRINT DS$;: COLOR 3: PRINT
    " data from the file.";SPACE$(11);
610 FCTRB%=(DSC%-1)*14
620 FIELD 1,14 AS F$(1),14 AS F$(2),14 AS F$(3),FCTRB% AS F$(4),14 AS F$(5)
630 FOR I%=2 TO NDH%+1: GET 1,I%: J%=I%-1: DHL$(J%)=F$(1): E$(J%)=F$(2):
    N$(J%)=F$(3): DS$(J%)=F$(5): NEXT
640 CLOSE 1,2: I%=0
650 FOR J%=1 TO NDH%: E#(J%)=VAL(E$(J%)): N#(J%)=VAL(N$(J%))
660 IF LEFT$(DS$(J%),1)="?" THEN D#(J%)=-100000000000000#: I%=I%+1
     ELSE D#(J%)=VAL(DS$(J%))
670 NEXT
680 PLS%=NDH%-I%: IF I%=0 THEN 750
690 FOR J%=1 TO NDH%-1
700 IF D#(J%)<>-100000000000000# THEN 740
710  FOR K%=J%+1 TO NDH%
720  IF D#(K%)<>-100000000000000# THEN SWAP E#(J%),E#(K%): SWAP N#(J%),N#(K%):
     SWAP D#(J%),D#(K%): SWAP DHL$(J%),DHL$(K%): GOTO 740
730  NEXT K%
740 NEXT J%
750 V%=1: CHAIN "mainmenu"
```

```
1000 MODULE$="Inpute"
1010 COMMON MS,CLR%(),D#(),E#(),N#(),R$(),DHL$(),BE#(),BN#(),DS$,PLS%,B%,V%,MN#,
VR#,CO$,ACD$(),AOA$(),AF$(),AC$(),AA$()
1020 FOR J%=1 TO 2:IF J%=1 THEN SCREEN ,,3,0 ELSE SCREEN ,,0,3
1030 COLOR 6,0:CLS:LOCATE 1,15,0:PRINT"1.INPUT OF DRILL HOLE DATA AND BOUNDARY P
OINTS":PRINT
1040 PRINT"Source of data [ (e)dit,(r)etrieve ] : ";:COLOR CLR%(1),CLR%(3):PRINT
 R$(3):COLOR 6,0:PRINT"File specification of data : ";:COLOR CLR%(2),CLR%(4):PRI
NT R$(4):PRINT:COLOR 6,0:PRINT"Project label : ";:COLOR CLR%(4),CLR%(2):PRINT R$
(6)
1050 COLOR 6,0:PRINT"Number of drill holes [ 1-129 ] : ";:COLOR CLR%(4),CLR%(2):
PRINT R$(7):COLOR 6,0:PRINT"Drill hole labels [ (y)es,(n)o ] : ";:COLOR CLR%(4),
CLR%(2):PRINT R$(8)
1060 COLOR 6,0:PRINT"Number of data sets for each borehole [ 1-8 ] : ";:COLOR CL
R%(4),CLR%(2):PRINT R$(9):PRINT:COLOR 6,0:PRINT"Sequence and names of data sets
:"
1070 COLOR CLR%(3),CLR%(1):PRINT"1";:LOCATE ,3:PRINT R$(12);:COLOR CLR%(4),CLR%(
2):LOCATE ,21:PRINT"5";:LOCATE ,23:PRINT R$(21):PRINT"2";:LOCATE ,3:PRINT R$(13)
;:COLOR CLR%(3),CLR%(1):LOCATE ,21:PRINT"6";:LOCATE ,23:PRINT R$(22)
1080 PRINT"3";:LOCATE ,3:PRINT R$(14);:COLOR CLR%(4),CLR%(2):LOCATE ,21:PRINT"7"
;:LOCATE ,23:PRINT R$(23):PRINT"4";:LOCATE ,3:PRINT R$(15);:COLOR CLR%(3),CLR%(1
):LOCATE ,21:PRINT"8";:LOCATE ,23:PRINT R$(24)
1090 LOCATE 16,1:COLOR 6,0:PRINT"Data set chosen [1-8] : ";:COLOR CLR%(4),CLR%(2
):PRINT R$(16):COLOR 6,0:PRINT"Edit another data set after editing the data set
above [(y)es,(n)o] : ";:COLOR CLR%(4),CLR%(2):PRINT R$(17)
1100 COLOR 6,0:PRINT"Quadrant chosen [ne,se] : ";:COLOR CLR%(4),CLR%(2):PRINT R$
(18):COLOR 6,0:PRINT"Boundary points for the property [(y)es,(n)o] : ";:COLOR CL
R%(4),CLR%(2):PRINT R$(19):COLOR 6,0:PRINT" If yes; number of boundary points [
1-129 ] : ";
1105 COLOR CLR%(4),CLR%(2):PRINT R$(20):GOSUB 4070:NEXT J%:SCREEN ,,0
1110 LRF%=0:CLRF%=1:R%=6:C%=17
1120 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE R%,C%,1
1130 I$=INKEY$:IF I$<>"" THEN 1130
1140 I$=INKEY$:IF I$="" THEN 1140
1150 COLOR 0,0:LOCATE 25,1,0:IF SCREEN(25,1)<>32 THEN PRINT SPACE$(79);
1160 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE R%,C%,1
1170 IF LEN(I$)=2 THEN I$=RIGHT$(I$,1):GOTO 1200 ELSE IF ASC(I$)<32 THEN 1140 EL
SE LOCATE ,,0:PRINT I$;:I%=C%
1180 GOSUB 4170:IF C%<X%(J%) THEN C%=C%+1:LOCATE ,,1 ELSE LOCATE ,C%,1
1190 MID$(R$(J%),I%+1-N%(J%),1)=I$:GOTO 1140
1200 IF I$=CHR$(59) THEN GOSUB 4520:HPAGE%=9:L%=1120:CHAIN"hlp",,ALL
1210 IF I$=CHR$(61) THEN 1220 ELSE 1280'F3
1220 IF C2$="n" THEN BEEP:COLOR 27,0:LOCATE 25,1,0:PRINT"Warning!";:COLOR 3:PRIN
T" You must continue with F2 to save all the editing you have made!";:C2$="y":GO
TO 1120
1230 GOSUB 4310:IF LOF(1) THEN I%=0 ELSE I%=1
1240 IF LOF(2) THEN J%=0 ELSE J%=1
1250 CLOSE 1,2:IF I% THEN KILL R$(4)
1260 IF J% THEN KILL R$(1)
1270 V%=0:CHAIN"Input",1040
1280 IF I$=CHR$(80) THEN 1290 ELSE 1350'CD
1290 IF R%=20 THEN R%=6:GOTO 1340 ELSE 1300
1300 IF R%=9 THEN R%=R%+3 ELSE R%=R%+1
1310 IF R%<12 OR R%>16 THEN 1340
1320 IF R%=16 AND LRF%=0 THEN 1340 ELSE GOSUB 4150
1330 IF R%=16 AND LRF% THEN LRF%=0
1340 GOSUB 4170:C%=N%(J%):LOCATE R%,C%:GOTO 1140
1350 IF I$=CHR$(77) THEN 1360 ELSE 1380'CR
1360 GOSUB 4170:IF C%<X%(J%) THEN C%=C%+1:LOCATE R%,C%
1370 GOTO 1140
1380 IF I$=CHR$(75) THEN 1390 ELSE 1410'CL
1390 GOSUB 4170:IF C%>N%(J%) THEN C%=C%-1:LOCATE R%,C%
1400 GOTO 1140
1410 IF I$=CHR$(72) THEN 1420 ELSE 1470'CU
```

```
1420 IF R%=6 THEN R%=20:GOTO 1460 ELSE 1430
1430 IF R%=12 THEN R%=R%-3 ELSE R%=R%-1
1440 IF R%>14 OR R%<9 THEN 1460
1450 IF R%=9 AND LRF% THEN LRF%=0:GOTO 1460 ELSE GOSUB 4150
1460 GOSUB 4170:C%=N%(J%):LOCATE R%,C%:GOTO 1140
1470 IF I$=CHR$(67) OR I$=CHR$(68) THEN 1480 ELSE 1500'F9L/F10R
1480 IF R%<12 OR R%>15 THEN 1140
1490 GOSUB 4130:GOSUB 4150:GOSUB 4170:C%=N%(J%):LOCATE R%,C%:GOTO 1140
1500 IF I$<>CHR$(60) THEN 1140'F2
1510 LOCATE ,,0:I$=R$(7):CLRF%=1:R%=7:C%=34:LRF%=0:GOSUB 4220
1520 IF VAL(R$(7))>0 AND VAL(R$(7))<130 THEN 1540
1530 GOSUB 4260:COLOR CLR%(4),CLR%(2):CLRF%=1:R%=7:C%=35:LRF%=0:LOCATE 7,35,1:GO
TO 1130
1540 IF R$(8)="y" OR R$(8)="Y" OR R$(8)="n" OR R$(8)="N" THEN 1560
1550 D$="to enter drill hole labels":GOSUB 4270:CLRF%=1:R%=8:C%=36:LRF%=0:GOTO 1
120
1560 IF ASC(R$(9))>48 AND ASC(R$(9))<57 THEN 1590
1570 BEEP:COLOR 27,0:LOCATE 25,1,0:PRINT"Entry is out of range or a non-numeric
character!";:COLOR 3:PRINT" Enter a number between ";:COLOR 11:PRINT"1 & 8.";
1580 CLRF%=1:R%=9:C%=49:LRF%=0:GOTO 1120
1590 IF ASC(R$(16))>48 AND ASC(R$(16))<57 THEN 1600 ELSE 1720
1600 IF R$(17)="y" OR R$(17)="Y" OR R$(17)="n" OR R$(17)="N" THEN 1620
1610 D$="to edit another data set next":GOSUB 4270:CLRF%=1:R%=17:C%=71:LRF%=0:GO
TO 1120
1620 IF R$(18)="ne" OR R$(18)="NE" OR R$(18)="se" OR R$(18)="SE" THEN 1650
1630 BEEP:COLOR 3,0:LOCATE 25,1,0:COLOR 11:PRINT"se";:COLOR 3:PRINT" or ";:COLOR
 11:PRINT"SE";:COLOR 3:PRINT" to choose South-East quadrant and ";:COLOR 11:PRIN
T"ne";:COLOR 3:PRINT" or ";:COLOR 11:PRINT"NE";:COLOR 3:PRINT" for North-East qu
adrant.";
1640 COLOR CLR%(4),CLR%(2):CLRF%=1:R%=18:C%=27:LRF%=0:GOTO 1120
1650 IF R$(19)="y" OR R$(19)="Y" OR R$(19)="n" OR R$(19)="N" THEN 1670
1660 D$="to enter boundary points":GOSUB 4270:CLRF%=1:R%=19:C%=49:LRF%=0:GOTO 11
20
1670 IF R$(19)="n" OR R$(19)="N" THEN 1710
1680 I$=R$(20):CLRF%=1:R%=20:C%=47:LRF%=0:GOSUB 4220
1690 IF VAL(R$(20))>0 AND VAL(R$(20))<130 THEN 1710
1700 GOSUB 4260:CLRF%=1:R%=20:C%=48:LRF%=0:GOTO 1120
1710 IF VAL(R$(9))=>VAL(R$(16)) THEN 1730
1720 BEEP:COLOR 3,0:LOCATE 25,1,0:PRINT"Either enter a number between ";:COLOR 1
1:PRINT"1";:COLOR 3:PRINT" and ";:COLOR 11:PRINT R$(9);:COLOR 3:PRINT" or increa
se number of data sets.";:CLRF%=1:R%=16:C%=25:LRF%=0:GOTO 1120
1730 SAY%=SAY%+1
1740 IF SAY% THEN 1780
1750 NBP%=VAL(R$(20)):NBPB%=NBP%:NDH%=VAL(R$(7)):NDHB%=NDH%
1760 DSC%=VAL(R$(16)):IF DSC%>4 THEN DS$=R$(DSC%+16) ELSE DS$=R$(DSC%+11)
1770 GOTO 1870
1780 IF DSC%=VAL(R$(16)) THEN DSCF%=0:GOTO 1800
1790 DSCF%=1:C2$="n":R1$(10)="y":R1$(13)=B$:R1$(16)="1000000000000"
1800 IF R$(19)="n" OR R$(19)="N" THEN 1820
1810 IF NBP%=VAL(R$(20)) THEN BPF%=0 ELSE BPF%=1
1820 IF NDH%=VAL(R$(7)) THEN DHF%=0 ELSE DHF%=1
1830 IF DSCF% THEN 1840 ELSE 1850
1840 DSC%=VAL(R$(16)):IF DSC%>4 THEN DS$=R$(DSC%+16) ELSE DS$=R$(DSC%+11)
1850 IF BPF% THEN NBPB%=NBP%:NBP%=VAL(R$(20))
1860 IF DHF% THEN NDHB%=NDH%:NDH%=VAL(R$(7))
1870 FIELD 1,177 AS F$(1):D$=R$(4)+R$(6)+R$(7)+R$(8)+R$(9)+R$(12)+R$(13)+R$(14)+
R$(15)+R$(18)+R$(19)+R$(20)+R$(21)+R$(22)+R$(23)+R$(24):LSET F$(1)=D$:PUT 1,1
1880 FOR J%=1 TO 2:IF J%=1 THEN SCREEN ,,3,0 ELSE SCREEN ,,0,3
1890 COLOR 6,0:CLS:LOCATE 1,12,0:PRINT"1.1.ERROR CHECK FOR DRILL HOLE DATA AND B
OUNDARY POINTS":PRINT
1900 PRINT"Error check for the ";:COLOR 0,6:PRINT"drill hole(and boundary point)
 coordinates";:COLOR 6,0:PRINT" [(y)es,(n)o] : ";:COLOR CLR%(4),CLR%(2):PRINT R1
$(3);:LOCATE 5,27:COLOR 6,0:PRINT"Minimum";TAB(43);"Maximum"
1910 COLOR 6,0:PRINT TAB(5)"East Coordinate :  ";:COLOR CLR%(3),CLR%(1):PRINT R1
```

```
$(6);:COLOR ,0:PRINT"  ";:COLOR ,CLR%(1):PRINT R1$(14):COLOR 6,0:PRINT TAB(5);"N
/S Coordinate  :  ";:COLOR CLR%(4),CLR%(2):PRINT R1$(7);:COLOR ,0:PRINT"  ";:COL
OR ,CLR%(2)
1920 PRINT R1$(15):PRINT:PRINT:COLOR 6,0:PRINT"Error check for ";:COLOR 0,6:PRIN
T DS$;:COLOR 6,0:PRINT" [ (y)es,(n)o ] : ";:COLOR CLR%(4),CLR%(2):PRINT R1$(10):
PRINT:COLOR 6,0:PRINT TAB(27);"Minimum";TAB(43);"Maximum"
1930 PRINT TAB(5);DS$;" :";TAB(24);:COLOR CLR%(4),CLR%(2):PRINT R1$(13);:COLOR ,
0:PRINT"  ";:COLOR ,CLR%(2):PRINT R1$(16):GOSUB 4070:NEXT J%:SCREEN ,,0
1940 LRF%=0:CLRF%=1:R%=3:C%=79:CM%=N1%(R%)
1950 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE R%,C%,1
1960 I$=INKEY$:IF I$<>"" THEN 1960
1970 I$=INKEY$:IF I$="" THEN 1970
1980 COLOR 0,0:LOCATE 25,1,0:IF SCREEN(25,1)<>32 THEN PRINT SPACE$(79);
1990 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE R%,C%,1
2000 IF LEN(I$)=2 THEN I$=RIGHT$(I$,1):GOTO 2030 ELSE IF ASC(I$)<32 THEN 1970 EL
SE LOCATE ,,0:PRINT I$;:I%=C%
2010 GOSUB 4190:IF C%<X1%(J%) THEN C%=C%+1:LOCATE ,,1 ELSE LOCATE ,C%,1
2020 MID$(R1$(J%),I%+1-N1%(J%),1)=I$:GOTO 1970
2030 IF I$=CHR$(59) THEN GOSUB 4520:HPAGE%=12:L%=1950:CHAIN"hlp",,ALL
2040 IF I$=CHR$(61) THEN 1020'F3
2050 IF I$=CHR$(80) THEN 2060 ELSE 2110'CD
2060 IF R%=13 THEN R%=3:LRF%=0:GOTO 2100
2070 IF R%=6 THEN R%=R%+1 ELSE R%=R%+3
2080 IF R%=6 OR R%=7 THEN GOSUB 4150
2090 IF R%=10 THEN LRF%=0
2100 GOSUB 4190:C%=N1%(J%):LOCATE R%,C%:GOTO 1970
2110 IF I$=CHR$(77) THEN 2120 ELSE 2140'CR
2120 GOSUB 4190:IF C%<X1%(J%) THEN C%=C%+1:LOCATE R%,C%
2130 GOTO 1970
2140 IF I$=CHR$(75) THEN 2150 ELSE 2170'CL
2150 GOSUB 4190:IF C%>N1%(J%) THEN C%=C%-1:LOCATE R%,C%
2160 GOTO 1970
2170 IF I$=CHR$(72) THEN 2180 ELSE 2230'CU
2180 IF R%=3 THEN R%=13:GOTO 2220
2190 IF R%=7 THEN R%=R%-1 ELSE R%=R%-3
2200 IF R%=3 OR R%=6 THEN GOSUB 4150
2210 IF R%=3 OR R%=10 THEN LRF%=0
2220 GOSUB 4190:C%=N1%(J%):LOCATE R%,C%:GOTO 1970
2230 IF I$=CHR$(67) OR I$=CHR$(68) THEN 2240 ELSE 2250'F9L/F10R
2240 IF R%=3 OR R%=10 THEN 1970 ELSE GOSUB 4130:GOSUB 4190:C%=N1%(J%):LOCATE R%,
C%:GOTO 1970
2250 IF I$<>CHR$(60) THEN 1970'F2
2260 LOCATE ,,0:IF R1$(10)="y" OR R1$(10)="Y" OR R1$(10)="n" OR R1$(10)="N" THEN
 2280
2270 D$="to check "+DS$+" values":GOSUB 4270:CLRF%=1:R%=10:C%=49:LRF%=0:GOTO 195
0
2280 IF R1$(10)="n" OR R1$(10)="N" THEN 2310
2290 J%=13:R%=13:C%=22:LRF%=0:CLRF%=1:GOSUB 4440
2300 J%=16:C%=38:LRF%=1:GOSUB 4440
2310 IF R1$(3)="y" OR R1$(3)="Y" OR R1$(3)="n" OR R1$(3)="N" THEN 2330
2320 D$="to check coordinate values":GOSUB 4270:CLRF%=1:R%=3:C%=79:LRF%=0:GOTO 1
950
2330 IF R1$(3)="n" OR R1$(3)="N" THEN 2380
2340 J%=6:R%=6:C%=22:LRF%=0:CLRF%=0:GOSUB 4440
2350 J%=14:C%=38:LRF%=1:GOSUB 4440
2360 J%=7:R%=7:C%=22:LRF%=0:CLRF%=1:GOSUB 4440
2370 J%=15:C%=38:LRF%=1:GOSUB 4440
2380 IF R$(19)="n" OR R$(19)="N" OR BPF%=0 THEN 3090 ELSE SAYBP%=SAYBP%+1
2390 IF SAYBP% THEN 2450
2400 DIM N2%(2),X2%(2),BE$(129),BN$(129)
2410 N2%(1)=25:N2%(2)=45:X2%(1)=38:X2%(2)=58
2420 I%=17:D$="boundary points":GOSUB 4340
2430 FIELD 2,14 AS F$(1),14 AS F$(2)
2440 FOR I%=1 TO NBP%:GET 2,I%:BE$(I%)=F$(1):BN$(I%)=F$(2):NEXT:GOTO 2460
```

```
2450 FOR I%=NBPB%+1 TO NBP%:BE$(I%)=B$:BN$(I%)=B$:NEXT
2460 FOR I%=1 TO 8:IF NBP%>P%(I%)-1 AND NBP%<P%(I%+1) THEN 2470 ELSE NEXT
2470 NP%=I%:LP%=NBP%-(P%(I%)-2):IF NP%=1 THEN LP%=LP%-1
2480 COLOR 6,0:CLS
2490 LOCATE 1,31,0:PRINT"1.1.BOUNDARY POINTS":COLOR 2:LOCATE ,10:PRINT"Please en
ter boundary point coordinates in clockwise order!":COLOR 6:LOCATE ,26:PRINT"E-C
oordinate       N/S-Coordinate":GOSUB 4090:ERC%=0:VF%=1
2500 R%=4:C%=N2%(VF%)
2510 CLRF%=1:COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE ,,0
2520 IF PF%>NP% OR PF%<2 THEN PF%=1
2530 IF PF%=1 THEN SLN%=1 ELSE SLN%=P%(PF%)-1
2540 IF PF%=NP% THEN PL%=LP% ELSE PL%=17
2550 FOR K%=1 TO PL%:D$=STR$(SLN%):GOSUB 4290
2560 LOCATE K%+3,20:PRINT D$;:LOCATE ,25:PRINT BE$(SLN%);:LOCATE ,45:PRINT BN$(S
LN%)
2570 SLN%=SLN%+1:IF CLRF% THEN CLRF%=0 ELSE CLRF%=1
2580 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):NEXT
2590 IF PF%<NP% THEN 2620
2600 COLOR ,0
2610 FOR K%=PL%+4 TO 20:LOCATE K%,20:PRINT SPACE$(39);:NEXT
2620 IF ERC% THEN CLRF%=CLRF1%:VF%=VF1%:SLN%=SLN1%:ERC%=0 ELSE CLRF%=1:IF PF%=1
THEN SLN%=1 ELSE SLN%=P%(PF%)-1
2630 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE R%,C%,1
2640 I$=INKEY$:IF I$<>"" THEN 2640
2650 I$=INKEY$:IF I$="" THEN 2650
2660 COLOR 0,0:LOCATE 25,1,0:IF SCREEN(25,1)<>32 THEN PRINT SPACE$(79);
2670 IF ERC% THEN ERC%=0:CLRF%=CLRF1% ELSE 2680
2680 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE R%,C%,1:IF LEN(I$)=2 THEN I$=RIGHT
$(I$,1):GOTO 2710 ELSE IF ASC(I$)<32 THEN 2650  ELSE LOCATE ,,0:PRINT I$;:I%=C%:
IF C%<X2%(VF%) THEN C%=C%+1:LOCATE ,,1 ELSE LOCATE ,C%,1
2690 IF VF%=1 THEN MID$(BE$(SLN%),I%+1-N2%(VF%),1)=I$ ELSE MID$(BN$(SLN%),I%+1-N
2%(VF%),1)=I$
2700 GOTO 2650
2710 IF I$=CHR$(77) THEN 2720 ELSE 2740'CR
2720 IF C%<X2%(VF%) THEN C%=C%+1:LOCATE R%,C%
2730 GOTO 2650
2740 IF I$=CHR$(67) OR I$=CHR$(68) THEN 2750 ELSE 2770'F9L/F10R
2750 IF VF%=1 THEN VF%=2 ELSE VF%=1
2760 C%=N2%(VF%):LOCATE R%,C%:GOTO 2650
2770 IF I$=CHR$(80) THEN 2780 ELSE 2820'CD
2780 IF PF%=NP% THEN L%=PL%+3 ELSE L%=20
2790 IF R%<L% THEN R%=R%+1:SLN%=SLN%+1:GOSUB 4150:GOTO 2810 ELSE R%=4:IF PF%=1 T
HEN SLN%=1 ELSE SLN%=P%(PF%)-1
2800 IF PL% MOD 2 THEN 2810 ELSE GOSUB 4150
2810 C%=N2%(VF%):LOCATE R%,C%:GOTO 2640
2820 IF I$=CHR$(66) THEN PF%=PF%+1: GOTO 2500'F8PD
2830 IF I$=CHR$(75) THEN 2840 ELSE 2860'CL
2840 IF C%>N2%(VF%) THEN C%=C%-1:LOCATE R%,C%
2850 GOTO 2650
2860 IF I$=CHR$(72) THEN 2870 ELSE 2910'CU
2870 IF PF%=NP% THEN L%=PL%+3:K%=NBP% ELSE L%=20:K%=P%(PF%+1)-1
2880 IF R%>4 THEN R%=R%-1:SLN%=SLN%-1:GOSUB 4150:GOTO 2900 ELSE R%=L%:SLN%=K%
2890 IF PL% MOD 2 THEN 2900 ELSE GOSUB 4150
2900 C%=N2%(VF%):LOCATE R%,C%:GOTO 2640
2910 IF I$=CHR$(65) THEN 2920 ELSE 2930'F7PU
2920 PF%=PF%-1:IF PF% THEN 2500 ELSE PF%=NP%:R%=4:C%=N2%(VF%):CLRF%=1:COLOR CLR%
(CLRF%+3),CLR%(CLRF%+1):LOCATE ,,0:GOTO 2530
2930 IF I$=CHR$(60) THEN 2960'F2
2940 IF I$=CHR$(59) THEN GOSUB 4520:HPAGE%=13:L%=2630:CHAIN"hlp",,ALL
2950 IF I$=CHR$(61)THEN 1880 ELSE 2650'F3
2960 LOCATE ,,0:FOR I%=1 TO NBP%:BE#(I%)=VAL(BE$(I%)):BN#(I%)=VAL(BN$(I%)):NEXT
2970 D$="boundary point coordinates":IF R1$(3)="n" OR R1$(3)="N" THEN 3040
2980 EN#=VAL(R1$(6)):EX#=VAL(R1$(14)):NN#=VAL(R1$(7)):NX#=VAL(R1$(15))
2990 I%=2:GOSUB 4500:K%=0
```

```
3000 FOR I%=1 TO NBP%
3010 IF BE#(I%)=>EN# AND BE#(I%)=<EX# THEN 3020 ELSE VF%=1:GOSUB 4350
3020 IF BN#(I%)=>NN# AND BN#(I%)=<NX# THEN 3030 ELSE VF%=2:GOSUB 4350
3030 NEXT
3040 I%=6:GOSUB 4510
3050 FIELD 2,14 AS F$(1),14 AS F$(2)
3060 FOR I%=1 TO NBP%:LSET F$(1)=BE$(I%):LSET F$(2)=BN$(I%):PUT 2,I%:NEXT
3070 FOR I%=1 TO NBP%:BE#(I%)=VAL(BE$(I%)):BN#(I%)=VAL(BN$(I%)):NEXT
3080 ERASE N2%,X2%,BE$,BN$:SAYBP%=-1
3090 SAYDH%=SAYDH%+1
3100 IF SAYDH%=0 THEN 3140
3110 IF DSCF% THEN 3150
3120 IF DHF%=0 THEN 3200
3130 FOR I%=NDHB%+1 TO NDH%:E$(I%)=B$:N$(I%)=B$:DS$(I%)=B$:DHL$(I%)=B$:NEXT:GOTO
 3200
3140 DIM E$(129),N$(129),DS$(129)
3150 PF%=1
3160 I%=13:D$=DS$+" data":GOSUB 4340
3170 FCTRB%=(DSC%-1)*14
3180 FIELD 1,14 AS F$(1),14 AS F$(2),14 AS F$(3),FCTRB% AS F$(4),14 AS F$(5)
3190 FOR I%=2 TO NDH%+1:GET 1,I%:DHL$(I%-1)=F$(1):E$(I%-1)=F$(2):N$(I%-1)=F$(3):
DS$(I%-1)=F$(5):NEXT
3200 FOR I%=1 TO 8:IF NDH%>P%(I%)-1 AND NDH%<P%(I%+1) THEN 3210 ELSE NEXT
3210 NP%=I%:LP%=NDH%-(P%(I%)-2):IF NP%=1 THEN LP%=LP%-1
3220 COLOR 6,0:CLS
3230 LOCATE 1,31,0:PRINT"1.3.DRILL HOLE DATA":COLOR 2:PRINT"No value at a drill
hole => ? in the first column of that ";DS$;" field.":COLOR 6:LOCATE 3,5:PRINT"D
rill Hole Label       E-Coordinate          N/S-Coordinate        ";DS$;:GOSUB 4090:ER
C%=0:VF%=1
3240 R%=4:C%=N3%(VF%)
3250 CLRF%=1:COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE ,,0
3260 IF PF%>NP% OR PF%<1 THEN PF%=1
3270 IF PF%=1 THEN SLN%=1 ELSE SLN%=P%(PF%)-1
3280 IF PF%=NP% THEN PL%=LP% ELSE PL%=17
3290 FOR K%=1 TO PL%:D$=STR$(SLN%):GOSUB 4290
3300 LOCATE K%+3,1:PRINT D$;:LOCATE ,6:PRINT DHL$(SLN%);:LOCATE ,26:PRINT E$(SLN
%);:LOCATE ,46:PRINT N$(SLN%);:LOCATE ,66:PRINT DS$(SLN%);
3310 SLN%=SLN%+1:IF CLRF% THEN CLRF%=0 ELSE CLRF%=1
3320 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):NEXT
3330 IF PF%<NP% THEN 3350
3340 COLOR ,0:FOR K%=PL%+4 TO 20:LOCATE K%,1:PRINT SPACE$(79);:NEXT K%
3350 IF ERC% THEN CLRF%=CLRF1%:VF%=VF1%:SLN%=SLN1%:ERC%=0 ELSE CLRF%=1:IF PF%=1
THEN SLN%=1 ELSE SLN%=P%(PF%)-1
3360 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE R%,C%,1
3370 I$=INKEY$:IF I$<>"" THEN 3370
3380 I$=INKEY$:IF I$="" THEN 3380
3390 COLOR 0,0:LOCATE 25,1,0:IF SCREEN(25,1)<>32 THEN PRINT SPACE$(79);
3400 IF ERC% THEN ERC%=0:CLRF%=CLRF1% ELSE 3410
3410 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE R%,C%,1:IF LEN(I$)=2 THEN I$=RIGHT
$(I$,1):GOTO 3470 ELSE IF ASC(I$)<32 THEN 3380  ELSE LOCATE ,,0:PRINT I$;:I%=C%:
IF C%<X3%(VF%) THEN C%=C%+1:LOCATE ,,1 ELSE LOCATE ,C%,1
3420 ON VF% GOTO 3430,3440,3450,3460
3430 MID$(DHL$(SLN%),I%+1-N3%(VF%),1)=I$:GOTO 3380
3440 MID$(E$(SLN%),I%+1-N3%(VF%),1)=I$:GOTO 3380
3450 MID$(N$(SLN%),I%+1-N3%(VF%),1)=I$:GOTO 3380
3460 MID$(DS$(SLN%),I%+1-N3%(VF%),1)=I$:GOTO 3380
3470 IF I$=CHR$(77) THEN 3480 ELSE 3500'CR
3480 IF C%<X3%(VF%) THEN C%=C%+1:LOCATE R%,C%
3490 GOTO 3380
3500 IF I$=CHR$(68) THEN 3510 ELSE 3530'F10R
3510 IF VF%=4 THEN VF%=1 ELSE VF%=VF%+1
3520 C%=N3%(VF%):LOCATE R%,C%:GOTO 3380
3530 IF I$=CHR$(80) THEN 3540 ELSE 3580'CD
3540 IF PF%=NP% THEN L%=PL%+3 ELSE L%=20
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3550 IF R%<L% THEN R%=R%+1:SLN%=SLN%+1:GOSUB 4150:GOTO 3570 ELSE R%=4:IF PF%=1 T
HEN SLN%=1 ELSE SLN%=P%(PF%)-1
3560 IF PL% MOD 2 THEN 3570 ELSE GOSUB 4150
3570 C%=N3%(VF%):LOCATE R%,C%:GOTO 3380
3580 IF I$=CHR$(66) THEN PF%=PF%+1:GOTO 3240'F8PD
3590 IF I$=CHR$(75) THEN 3600 ELSE 3620'CL
3600 IF C%>N3%(VF%) THEN C%=C%-1:LOCATE R%,C%
3610 GOTO 3380
3620 IF I$=CHR$(67) THEN 3630 ELSE 3650'F9L
3630 IF VF%=1 THEN VF%=4 ELSE VF%=VF%-1
3640 C%=N3%(VF%):LOCATE R%,C%:GOTO 3380
3650 IF I$=CHR$(72) THEN 3660 ELSE 3700'CU
3660 IF PF%=NP% THEN L%=PL%+3:K%=NDH% ELSE L%=20:K%=P%(PF%+1)-1
3670 IF R%>4 THEN R%=R%-1:SLN%=SLN%-1:GOSUB 4150:GOTO 3690 ELSE R%=L%:SLN%=K%
3680 IF PL% MOD 2 THEN 3690 ELSE GOSUB 4150
3690 C%=N3%(VF%):LOCATE R%,C%:GOTO 3380
3700 IF I$=CHR$(65) THEN 3710 ELSE 3720'F7PU
3710 PF%=PF%-1:IF PF% THEN 3240 ELSE PF%=NP%:R%=4:C%=N3%(VF%):CLRF%=1:COLOR CLR%
(CLRF%+3),CLR%(CLRF%+1):LOCATE ,,0:GOTO 3270
3720 IF I$=CHR$(60) THEN 3760'F2
3730 IF I$=CHR$(59) THEN GOSUB 4520:HPAGE%=14:L%=3360:CHAIN"hlp",,ALL
3740 IF I$=CHR$(61) THEN 3750 ELSE 3380'F3
3750 V%=0:SAYBP%=-1:BPF%=0:DSCF%=0:DHF%=0:GOTO 1880
3760 LOCATE ,,0:I%=0
3770 FOR J%=1 TO NDH%:E#(J%)=VAL(E$(J%)):N#(J%)=VAL(N$(J%))
3780 IF LEFT$(DS$(J%),1)="?" THEN D#(J%)=-100000000000000#:I%=I%+1 ELSE D#(J%)=V
AL(DS$(J%))
3790 NEXT:PLS%=NDH%-I%:K%=1
3800 IF R1$(3)="n" OR R1$(3)="N" THEN 3870
3810 EN#=VAL(R1$(6)):EX#=VAL(R1$(14)):NN#=VAL(R1$(7)):NX#=VAL(R1$(15))
3820 D$="drill hole coordinates":I%=6:GOSUB 4500
3830 FOR I%=1 TO NDH%
3840 IF E#(I%)=>EN# AND E#(I%)=<EX# THEN 3850 ELSE VF%=2:GOSUB 4350
3850 IF N#(I%)=>NN# AND N#(I%)=<NX# THEN 3860 ELSE VF%=3:GOSUB 4350
3860 NEXT
3870 IF R1$(10)="n" OR R1$(10)="N" THEN 3940
3880 D$=DS$+" data":I%=9:GOSUB 4500
3890 DN#=VAL(R1$(13)): DX#=VAL(R1$(16))
3900 FOR I%=1 TO NDH%
3910 IF D#(I%)=-100000000000000# THEN 3930
3920 IF D#(I%)=>DN# AND D#(I%)=<DX# THEN 3930 ELSE VF%=4:GOSUB 4350
3930 NEXT
3940 D$=DS$+" data":I%=13:GOSUB 4510
3950 FIELD 1,14 AS F$(1),14 AS F$(2),14 AS F$(3),FCTRB% AS F$(4),14 AS F$(5)
3960 FOR I%=2 TO NDH%+1:GET 1,I%:LSET F$(1)=DHL$(I%-1):LSET F$(2)=E$(I%-1):LSET
F$(3)=N$(I%-1):LSET F$(5)=DS$(I%-1):PUT 1,I%:NEXT
3970 IF LOF(2) THEN K%=0 ELSE K%=1
3980 CLOSE 2:IF K% THEN KILL R$(1)
3990 IF R$(17)="y" OR R$(17)="Y" THEN CHAIN"Inpute1",,ALL
4000 FOR J%=1 TO NDH%-1
4010 IF D#(J%)<>-100000000000000# THEN 4050
4020 FOR K%=J%+1 TO NDH%
4030 IF D#(K%)<>-100000000000000# THEN SWAP E#(J%),E#(K%):SWAP N#(J%),N#(K%):SWA
P D#(J%),D#(K%):SWAP DHL$(J%),DHL$(K%):GOTO 4050
4040 NEXT K%
4050 NEXT J%
4060 V%=1:CLOSE 1:CHAIN"mainmenu"
4070 GOSUB 4110:PRINT"F9/F10 ";:COLOR 6:PRINT"(Move left/right between fields)":
COLOR 2:PRINT CHR$(24);"/";CHR$(25);:COLOR 6:PRINT" (Move up/down between fields
)   ";:COLOR 2:PRINT CHR$(26);"/";CHR$(27);:COLOR 6:PRINT" (Move right/left with
in a field)";
4080 RETURN
4090 GOSUB 4110:PRINT"F7/F8 ";:COLOR 6:PRINT"(Page up/down)    ";:COLOR 2:PRINT"F
9/F10 ";:COLOR 6:PRINT "(Move left/right between fields)"
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4100 COLOR 2:PRINT CHR$(24);"/";CHR$(25);:COLOR 6:PRINT" (Move up/down between f
ields)   ";:COLOR 2:PRINT CHR$(26);"/";CHR$(27);:COLOR 6:PRINT" (Move right/left
 within a field)";: RETURN
4110 LOCATE 21,1,0:COLOR 6,0:PRINT STRING$(79,95)
4120 COLOR 2,0:PRINT"F1 ";:COLOR 6:PRINT"(Help)   ";:COLOR 2: PRINT" F2 ";:COLOR
6:PRINT"(Done;proceed)  ";:COLOR 2: PRINT" F3 ";:COLOR 6: PRINT"(Previous Menu)
  ";:COLOR 2:PRINT"Shift+PrtSc ";:COLOR 6:PRINT"(Print Screen)":COLOR 2:RETURN
4130 IF LRF% THEN LRF%=0 ELSE LRF%=1
4140 RETURN
4150 IF CLRF% THEN CLRF%=0 ELSE CLRF%=1
4160 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):RETURN
4170 IF LRF% THEN J%=R%+9 ELSE J%=R%
4180 RETURN
4190 IF LRF%=0 THEN J%=R% ELSE IF R%=13 THEN J%=R%+3 ELSE J%=R%+8
4200 RETURN
4210 COLOR 27,0:LOCATE 25,1,0:PRINT"Please wait! ";:COLOR 3:RETURN
4220 FOR I%=1 TO 3:D$=MID$(I$,I%,1):IF (ASC(D$)<48 OR ASC(D$)>57) AND ASC(D$)<>3
2 THEN GOSUB 4250:GOTO 4240 ELSE NEXT
4230 RETURN
4240 C%=C%+I%:RETURN 1120
4250 GOSUB 4330:PRINT"Non-numeric characters except for blanks are not allowed."
;:RETURN
4260 BEEP:COLOR 27,0:LOCATE 25,1,0:PRINT"Entry out of range!";:COLOR 3:PRINT" En
ter a value between ";:COLOR 11:PRINT"1";:COLOR 3:PRINT" and ";:COLOR 11:PRINT"1
29.";:RETURN
4270 GOSUB 4330:PRINT"Type ";:COLOR 11:PRINT"y";:COLOR 3:PRINT" or ";:COLOR 11:P
RINT"Y ";:COLOR 3:PRINT D$;" and ";:COLOR 11:PRINT"n";:COLOR 3:PRINT" or ";:COLO
R 11:PRINT"N";:COLOR 3:PRINT" otherwise.";:RETURN
4290 IF SLN%>99 THEN D$=RIGHT$(D$,3):RETURN
4300 IF SLN%>9 THEN D$=RIGHT$(D$,2)+" ":RETURN ELSE D$=RIGHT$(D$,1)+"  ":RETURN
4310 GOSUB 4210:PRINT"This will not take more than a few seconds.";:RETURN
4320 GOSUB 4330:PRINT"Enter an ";:COLOR 11:PRINT "integer";:COLOR 3:PRINT" or a
";:COLOR 11:PRINT"decimal number.";:RETURN
4330 BEEP:COLOR 27,0:LOCATE 25,1,0:PRINT"Invalid entry! ";:COLOR 3:RETURN
4340 GOSUB 4210:PRINT"GEOSTAT is reading ";:COLOR 11:PRINT D$;:COLOR 3:PRINT" fr
om the file.";SPACE$(I%);:RETURN
4350 GOSUB 4530:FOR J%=1 TO 8:IF I%>P%(J%)-1 AND I%<P%(J%+1) THEN 4360 ELSE NEXT

4360 L%=PF%:VF1%=VF%:SLN%=I%:SLN1%=I%
4370 IF K% THEN C%=N3%(VF%) ELSE C%=N2%(VF%)
4380 PF%=J%:IF PF%=1 THEN R%=I%-P%(J%)+4 ELSE R%=I%-P%(J%)+5
4390 ERC%=1
4400 IF I% MOD 2=0 THEN CLRF1%=0 ELSE CLRF1%=1
4410 IF K% THEN 4430
4420 IF L%=J% THEN LOCATE R%,C%,1:RETURN 2640 ELSE RETURN 2510
4430 IF L%=J% THEN LOCATE R%,C%,1:RETURN 3370 ELSE RETURN 3250
4440 L%=0
4450 FOR I%=1 TO 14:D$=MID$(R1$(J%),I%,1)
4460 IF D$="." THEN L%=L%+1: IF L%>1 THEN GOSUB 4320:GOTO 4490 ELSE 4470
4470 IF (ASC(D$)<48 OR ASC(D$)>57) AND D$<>" " AND D$<>"." THEN GOSUB 4320: GOTO
 4490 ELSE NEXT I%
4480 RETURN
4490 C%=C%+I%+1:COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE R%,C%,1:RETURN 1960
4500 GOSUB 4210:PRINT"GEOSTAT is performing error check on ";:COLOR 11:PRINT D$;
".";SPACE$(I%);:RETURN
4510 GOSUB 4210:PRINT"GEOSTAT is writing ";:COLOR 11:PRINT D$;:COLOR 3:PRINT" in
to the file.";SPACE$(I%);:RETURN
4520 GOSUB 4210:PRINT"Help file is being searched.";:RETURN
4530 BEEP:COLOR 3,0:LOCATE 25,1,0:PRINT"This value is not in the range you have
specified ! ";:COLOR 27:PRINT"Please correct it.";SPACE$(9);:RETURN
```

```
1000 MODULE$="Inputel"
1010 COMMON MS,CLR%(),D#(),E#(),N#(),R$(),DHL$(),BE#(),BN#(),DS$,PLS%,B%,V%,MN#,
VR#,CO$,ACD$(),AOA$(),AF$(),AC$(),AA$()
1020 C2$="n" '=>give msg at F3
1030 V%=0: PF%=1: R$(16)=" ": R$(17)=" "
1040 R1$(10)="y": R1$(13)=B$: R1$(16)="10000000000000"
1050 FOR J%=1 TO 2: IF J%=1 THEN SCREEN ,,3,0 ELSE SCREEN ,,0,3
1060 COLOR 6,0:CLS:LOCATE 1,15,0:PRINT "1.INPUT OF DRILL HOLE DATA AND BOUNDARY
POINTS": PRINT
1070 PRINT "Source of data [ (e)dit,(r)etrieve ] : ";: COLOR CLR%(1),CLR%(3): PR
INT R$(3)
1080 COLOR 6,0: PRINT "File specification of data : ";: COLOR CLR%(2),CLR%(4): P
RINT R$(4)
1090 PRINT: COLOR 6,0: PRINT "Project label : ";: COLOR CLR%(2),CLR%(4): PRINT R
$(6)
1100 COLOR 6,0:PRINT"Number of drill holes [ 1-129 ] : ";:COLOR CLR%(2),CLR%(4):
PRINT R$(7)
1110 COLOR 6,0: PRINT "Drill hole labels [ (y)es,(n)o ] : ";: COLOR CLR%(2),CLR%
(4): PRINT      R$(8)
1120 COLOR 6,0: PRINT "Number of data sets for each borehole [ 1-8 ] : ";:
     COLOR CLR%(2),CLR%(4): PRINT R$(9): PRINT
1130 COLOR 6,0: PRINT "Sequence and names of data sets :"
1140 COLOR CLR%(1),CLR%(3): PRINT "1";: LOCATE 12,3: PRINT R$(12);: COLOR CLR%(2
),CLR%(4): LOCATE ,21:       PRINT "5";: LOCATE ,23: PRINT R$(21)
1150 PRINT "2";: LOCATE 13,3: PRINT R$(13);: COLOR CLR%(1),CLR%(3): LOCATE ,21:
PRINT "6";:      LOCATE ,23: PRINT R$(22)
1160 PRINT "3";: LOCATE 14,3: PRINT R$(14);: COLOR CLR%(2),CLR%(4): LOCATE ,21:
PRINT "7";:      LOCATE ,23: PRINT R$(23)
1170 PRINT "4";: LOCATE 15,3: PRINT R$(15);: COLOR CLR%(1),CLR%(3): LOCATE ,21:
PRINT "8";:      LOCATE ,23: PRINT R$(24)
1180 LOCATE 16,1: COLOR 6,0: PRINT "Data set chosen [1-8] : ";: COLOR CLR%(4),CL
R%(2): PRINT     R$(16)
1190 COLOR 6,0: PRINT "Edit another data set after editing the data set above ";
     "[(y)es,(n)o] : ";: COLOR CLR%(4),CLR%(2): PRINT R$(17)
1200 COLOR 6,0: PRINT "Quadrant chosen [ne,se] : ";: COLOR CLR%(2),CLR%(4): PRIN
T R$(18)
1210 COLOR 6,0:PRINT "Boundary points for the property [(y)es,(n)o] : ";:
     COLOR CLR%(2),CLR%(4): PRINT R$(19)
1220 COLOR 6,0: PRINT " If yes; number of boundary points [ 1-129 ] : ";:
     COLOR CLR%(2),CLR%(4): PRINT R$(20)
1230 GOSUB 2680: NEXT J%: SCREEN ,,0
1240 LRF%=0: CLRF%=1: R%=16: C%=25
1250 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1): LOCATE R%,C%,1
1260 I$=INKEY$: IF I$<>"" THEN 1260
1270 I$=INKEY$: IF I$="" THEN 1270
1280 COLOR 0,0:LOCATE 25,1,0:IF SCREEN(25,1)<>32 THEN PRINT SPACE$(79);
1290 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1): LOCATE R%,C%,1
1300 IF LEN(I$)=2 THEN I$=RIGHT$(I$,1): GOTO 1320 ELSE IF ASC(I$)<32 THEN 1270
     ELSE LOCATE ,,0: PRINT I$;: I%=C%: IF C%<X%(R%) THEN C%=C%+1: LOCATE ,,1
     ELSE LOCATE ,C%,1
1310 MID$(R$(R%),I%+1-N%(R%),1)=I$: GOTO 1270
1320 IF I$=CHR$(80) OR I$=CHR$(72) THEN 1330 ELSE 1350'CD/CU
1330 IF R%=16 THEN R%=17: C%=71 ELSE R%=16: C%=25
1340 LOCATE R%,C%,1: GOTO 1270
1350 IF I$=CHR$(77) THEN 1360 ELSE 1380'CR
1360 IF C%<X%(R%) THEN C%=C%+1: LOCATE R%,C%
1370 GOTO 1270
1380 IF I$=CHR$(75) THEN 1390 ELSE 1410'CL
1390 IF C%>N%(R%) THEN C%=C%-1: LOCATE R%,C%
1400 GOTO 1270
1410 IF I$=CHR$(61) THEN 1420 ELSE 1440'F3
1420 IF C2$="y" THEN GOSUB 2820: CLOSE 1: V%=0: CHAIN "mainmenu"
1430 BEEP: COLOR 27,0: LOCATE 25,1,0: PRINT "Warning!";: COLOR 3: PRINT " If you
 want to leave ";: COLOR 11: PRINT DS$;: COLOR 3: PRINT " data as it was, hit F3
```

```
once again.";: C2$="y": COLOR CLR%(CLRF%+3),CLR%(CLRF%+1): LOCATE R%,C%,1: GOTO
 1260
1440 IF I$=CHR$(59) THEN GOSUB 3020:HPAGE%=10:L%=1250:CHAIN"hlp",,ALL
1450 IF I$<>CHR$(60) THEN 1270'F2
1460 LOCATE ,,0: IF ASC(R$(16))>48 AND ASC(R$(16))<57 THEN 1480
1470 GOSUB 2800: CLRF%=1: R%=16: C%=25: LRF%=0: GOTO 1250
1480 IF VAL(R$(9))<VAL(R$(16)) THEN 1470
1490 IF R$(17)="y" OR R$(17)="Y" OR R$(17)="n" OR R$(17)="N" THEN 1510
1500 D$="to edit another data set next":GOSUB 2780:LRF%=0:CLRF%=1:R%=17:C%=71:
     GOTO 1250
1510 IF DSC%=VAL(R$(16)) THEN 1600
1520 C2$="n"
1530 DSC%=VAL(R$(16))
1540 IF DSC%>4 THEN DS$=R$(DSC%+16) ELSE DS$=R$(DSC%+11)
1550 GOSUB 2740: COLOR 3: PRINT "GEOSTAT is reading ";: COLOR 11: PRINT DS$;" da
ta";: COLOR 3: PRINT " from the file.";
1560 FCTRB%=(DSC%-1)*14+42
1570 FIELD 1,FCTRB% AS F$(1),14 AS F$(2)
1580 FOR I%=2 TO NDH%+1: GET 1,I%: DS$(I%-1)=F$(2): NEXT
1590 R1$(10)="y": R1$(13)=B$: R1$(16)="10000000000000": PF%=1
1600 FOR J%=1 TO 2: IF J%=1 THEN SCREEN ,,3,0 ELSE SCREEN ,,0,3
1610 COLOR 6,0: CLS: LOCATE 1,12,0: PRINT
     "1.1.ERROR CHECK FOR DRILL HOLE DATA AND BOUNDARY POINTS": PRINT
1620 PRINT "Error check for coordinates of drill holes and boundary points [(y)e
s,(n)o] : ";: COLOR CLR%(2),CLR%(4): PRINT R1$(3);
1630 LOCATE 5,27: COLOR 6,0: PRINT "Minimum";TAB(43);"Maximum"
1640 COLOR 6,0: PRINT TAB(5);"East Coordinate :  ";: COLOR CLR%(1),CLR%(3): PRIN
T R1$(6);: COLOR ,0: PRINT "  ";: COLOR ,CLR%(3): PRINT R1$(14)
1650 COLOR 6,0: PRINT TAB(5);"N/S Coordinate  :  ";: COLOR CLR%(2),CLR%(4): PRIN
T R1$(7);: COLOR ,0: PRINT "  ";: COLOR ,CLR%(4): PRINT R1$(15): PRINT : PRINT
1660 COLOR 6,0: PRINT "Error check for ";:COLOR 0,6: PRINT DS$;: COLOR 6,0:
     PRINT " [ (y)es,(n)o ] : ";: COLOR CLR%(4),CLR%(2): PRINT R1$(10): PRINT
1670 COLOR 6,0:PRINT TAB(27);"Minimum";TAB(43);"Maximum"
1680 PRINT TAB(5);DS$;" :";TAB(24);: COLOR CLR%(4),CLR%(2): PRINT R1$(13);: COLO
R ,0: PRINT      "  ";: COLOR ,CLR%(2): PRINT R1$(16)
1690 GOSUB 2680: NEXT J%: SCREEN ,,0
1700 LRF%=0: CLRF%=1: R%=10: C%=49
1710 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1): LOCATE R%,C%,1
1720 I$=INKEY$: IF I$<>"" THEN 1720
1730 I$=INKEY$: IF I$="" THEN 1730
1740 COLOR 0,0:LOCATE 25,1,0:IF SCREEN(25,1)<>32 THEN PRINT SPACE$(79);
1750 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1): LOCATE R%,C%,1
1760 IF LEN(I$)=2 THEN I$=RIGHT$(I$,1): GOTO 1790 ELSE IF ASC(I$)<32 THEN 1730
     ELSE LOCATE ,,0: PRINT I$;:I%=C%: IF LRF% THEN J%=R%+3 ELSE J%=R%
1770 IF C%<X1%(J%) THEN C%=C%+1: LOCATE ,,1 ELSE LOCATE ,C%,1
1780 MID$(R1$(J%),I%+1-N1%(J%),1)=I$: GOTO 1730
1790 IF I$=CHR$(59) THEN GOSUB 3020:HPAGE%=12:L%=1710:CHAIN"hlp",,ALL
1800 IF I$=CHR$(61) THEN 1050'F3
1810 IF I$=CHR$(80) OR I$=CHR$(72) THEN 1820 ELSE 1840'CD/CU
1820 IF R%=13 THEN R%=10: C%=49 ELSE R%=13: C%=24
1830 LRF%=0: LOCATE R%,C%: GOTO 1730
1840 IF I$=CHR$(77) THEN 1850 ELSE 1880'CR
1850 IF LRF% THEN J%=R%+3 ELSE J%=R%
1860 IF C%<X1%(J%) THEN C%=C%+1: LOCATE R%,C%
1870 GOTO 1730
1880 IF I$=CHR$(75) THEN 1890 ELSE 1920'CL
1890 IF LRF% THEN J%=R%+3 ELSE J%=R%
1900 IF C%>N1%(J%) THEN C%=C%-1: LOCATE R%,C%
1910 GOTO 1730
1920 IF I$=CHR$(67) OR I$=CHR$(68) THEN 1930 ELSE 1970'F9L/F10R
1930 IF R%=10 THEN 1730
1940 IF LRF% THEN LRF%=0 ELSE LRF%=1
1950 IF LRF% THEN J%=R%+3 ELSE J%=R%
1960 C%=N1%(J%): LOCATE R%,C%: GOTO 1730
```

```
1970 IF I$<>CHR$(60) THEN 1730'F2
1980 IF R1$(10)="y" OR R1$(10)="Y" OR R1$(10)="n" OR R1$(10)="N" THEN 2000
1990 D$="to check "+DS$+" values": GOSUB 2780: GOTO 1700
2000 IF R1$(10)="n" OR R1$(10)="N" THEN 2030
2010 J%=13:R%=13:C%=22:LRF%=0:CLRF%=1:GOSUB 2850
2020 J%=16:C%=38:LRF%=1:GOSUB 2850
2030 COLOR 6,0: CLS
2040 LOCATE 1,31,0:PRINT"1.3.DRILL HOLE DATA":COLOR 2:PRINT"No value at a drill
hole => ? in the first column of that ";DS$;" field.":COLOR 6:LOCATE 3,5:PRINT"D
rill Hole Label       E-Coordinate          N/S-Coordinate        ";DS$;:GOSUB 2690:ER
C%=0:VF%=4
2050 R%=4: C%=N3%(VF%)
2060 CLRF%=1: COLOR CLR%(CLRF%+3),CLR%(CLRF%+1): LOCATE ,,0
2070 IF PF%>NP% OR PF%<1 THEN PF%=1
2080 IF PF%=1 THEN SLN%=1 ELSE SLN%=P%(PF%)-1
2090 IF PF%=NP% THEN PL%=LP% ELSE PL%=17 '# times the data rows are written
2100 FOR K%=1 TO PL%:D$=STR$(SLN%):GOSUB 2910
2110 LOCATE K%+3,1:PRINT D$;:LOCATE ,6:COLOR CLR%(CLRF%+1),CLR%(CLRF%+3):PRINT D
HL$(SLN%);:          LOCATE ,26:PRINT E$(SLN%);:LOCATE ,46:PRINT N$(SLN%);:LOCATE ,6
6:                   COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):PRINT DS$(SLN%);
2120 SLN%=SLN%+1:IF CLRF% THEN CLRF%=0 ELSE CLRF%=1
2130 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):NEXT
2140 IF PF%<NP% THEN 2160
2150 COLOR ,0: FOR K%=PL%+4 TO 20: LOCATE K%,1: PRINT SPACE$(79);: NEXT K%
2160 IF ERC% THEN CLRF%=CLRF1%: VF%=VF1%: SLN%=SLN1%: ERC%=0 ELSE CLRF%=1:
     IF PF%=1 THEN SLN%=1 ELSE SLN%=P%(PF%)-1
2170 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1): LOCATE R%,C%,1
2180 I$=INKEY$: IF I$<>"" THEN 2180
2190 I$=INKEY$: IF I$="" THEN 2190
2200 COLOR 0,0:LOCATE 25,1,0:IF SCREEN(25,1)<>32 THEN PRINT SPACE$(79);
2210 IF ERC% THEN ERC%=0: CLRF%=CLRF1% ELSE 2220
2220 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1): LOCATE R%,C%,1: IF LEN(I$)=2 THEN I$=RIG
HT$(I$,1):          GOTO 2240 ELSE IF ASC(I$)<32 THEN 2190 ELSE LOCATE ,,0: PRINT I
$;: I%=C%:          IF C%<X3%(VF%) THEN C%=C%+1: LOCATE ,,1 ELSE LOCATE ,C%,1
2230 MID$(DS$(SLN%),I%+1-N3%(VF%),1)=I$: GOTO 2190
2240 IF I$=CHR$(77) THEN 2250 ELSE 2270'CR
2250 IF C%<X3%(VF%) THEN C%=C%+1: LOCATE R%,C%
2260 GOTO 2190
2270 IF I$=CHR$(80) THEN 2280 ELSE 2320'CD
2280 IF PF%=NP% THEN L%=PL%+3 ELSE L%=20
2290 IF R%<L% THEN R%=R%+1:SLN%=SLN%+1:GOSUB 2930:GOTO 2310 ELSE R%=4:IF PF%=1 T
HEN SLN%=1 ELSE SLN%=P%(PF%)-1
2300 IF PL% MOD 2 THEN 2310 ELSE GOSUB 2930
2310 C%=N3%(VF%):LOCATE R%,C%:GOTO 2190
2320 IF I$=CHR$(66) THEN PF%=PF%+1: GOTO 2050'F8PD
2330 IF I$=CHR$(75) THEN 2340 ELSE 2360'CL
2340 IF C%>N3%(VF%) THEN C%=C%-1: LOCATE R%,C%
2350 GOTO 2190
2360 IF I$=CHR$(72) THEN 2370 ELSE 2410'CU
2370 IF PF%=NP% THEN L%=PL%+3:K%=NDH% ELSE L%=20:K%=P%(PF%+1)-1
2380 IF R%>4 THEN R%=R%-1:SLN%=SLN%-1:GOSUB 2930:GOTO 2400 ELSE R%=L%:SLN%=K%
2390 IF PL% MOD 2 THEN 2400 ELSE GOSUB 2930
2400 C%=N3%(VF%):LOCATE R%,C%:GOTO 2190
2410 IF I$=CHR$(65) THEN 2420 ELSE 2430'F7PU
2420 PF%=PF%-1: IF PF% THEN 2050 ELSE PF%=NP%: R%=4: C%=N3%(VF%): CLRF%=1: COLOR
     7,CLR%(CLRF%+1): LOCATE ,,0: GOTO 2080
2430 IF I$=CHR$(59) THEN GOSUB 3020:HPAGE%=14:L%=2170:CHAIN"hlp",,ALL
2440 IF I$=CHR$(61) THEN V%=0: GOTO 1600'F3
2450 IF I$<>CHR$(60) THEN 2190'F2
2460 LOCATE ,,0: I%=0
2470 FOR J%=1 TO NDH%
2480  IF LEFT$(DS$(J%),1)="?" THEN D#(J%)=-100000000000000#: I%=I%+1
      ELSE D#(J%)=VAL(DS$(J%))
2490 NEXT J%
```

```
2500 PLS%=NDH%-I%
2510 IF R1$(10)="y" OR R1$(10)="Y" THEN 2520 ELSE 2580
2520 GOSUB 2740: PRINT "GEOSTAT is performing error check on ";: COLOR 11: PRINT
     DS$;: COLOR 3: PRINT " data.";SPACE$(9);
2530 DN#=VAL(R1$(13)): DX#=VAL(R1$(16))
2540 FOR I%=1 TO NDH%
2550  IF D#(I%)=-100000000000000# THEN 2570
2560  IF D#(I%)=>DN# AND D#(I%)=<DX# THEN 2570 ELSE GOSUB 2950
2570 NEXT I%
2580 GOSUB 2740: PRINT "GEOSTAT is writing ";: COLOR 11: PRINT DS$;: COLOR 3:
     PRINT " data into the file.";SPACE$(13);
2590 FOR I%=2 TO NDH%+1: GET 1,I%: LSET F$(2)=DS$(I%-1): PUT 1,I%: NEXT
2600 IF R$(17)="y" OR R$(17)="Y" THEN 1020
2610 FOR J%=1 TO NDH%-1
2620 IF D#(J%)<>-100000000000000# THEN 2660
2630  FOR K%=J%+1 TO NDH%
2640  IF D#(K%)<>-100000000000000# THEN SWAP E#(J%),E#(K%): SWAP N#(J%),N#(K%):
      SWAP D#(J%),D#(K%): SWAP DHL$(J%),DHL$(K%): GOTO 2660
2650  NEXT K%
2660 NEXT J%
2670 V%=1: CLOSE 1: CHAIN "mainmenu"
2680 LOCATE 23,1,0: GOSUB 2720: RETURN
2690 LOCATE 21,1,0: GOSUB 2720
2700 COLOR 2: PRINT "F7/F8 ";: COLOR 6: PRINT "(Page up/down)   ";: COLOR 2:
     PRINT "F9/F10 ";:COLOR 6:PRINT "(Move left/right between fields)"
2710 COLOR 2:PRINT CHR$(24);"/";CHR$(25);:COLOR 6:PRINT
     " (Move up/down between fields)   ";:COLOR 2:PRINT CHR$(26);"/";CHR$(27);:
     COLOR 6:PRINT " (Move right/left within a field)";:RETURN
2720 COLOR 6,0: PRINT STRING$(79,95): COLOR 2,0: PRINT "F1 ";: COLOR 6: PRINT
     "(Help)  ";: COLOR 2: PRINT " F2 ";: COLOR 6: PRINT "(Done;proceed)  ";:
     COLOR 2: PRINT " F3 ";: COLOR 6: PRINT "(Previous Menu)   ";: COLOR 2
2730 PRINT "Shift+PrtSc ";: COLOR 6: PRINT "(Print Screen)";: RETURN
2740 COLOR 27,0: LOCATE 25,1,0: PRINT "Please wait! ";: COLOR 3: RETURN
2750 BEEP: COLOR 27,0: LOCATE 25,1,0: PRINT "Invalid entry!";: COLOR 3: PRINT
     " Non-numeric characters are not allowed.";SPACE$(25);: RETURN
2760 BEEP:COLOR 27,0: LOCATE 25,1,0: PRINT "Entry out of range!": COLOR 3: PRINT
     " Enter a value between ";: COLOR 11: PRINT "1";: COLOR 3: PRINT " and ";:
     COLOR 11:PRINT "129";:COLOR 3:PRINT ".";SPACE$(27);
2770 RETURN
2780 BEEP:COLOR 27,0:LOCATE 25,1,0:PRINT"Invalid entry!";:COLOR 3:PRINT" Type";:
     COLOR 11:PRINT" y";:COLOR 3:PRINT" or ";:COLOR 11:PRINT"Y ";:COLOR 3:PRINT
     D$;" and ";:COLOR 11:PRINT"n";:COLOR 3:PRINT" or ";:COLOR 11:PRINT"N";
2790 COLOR 3:PRINT" otherwise.";: RETURN
2800 BEEP: COLOR 3,0: LOCATE 25,1,0: PRINT "Either enter a number between ";:
     COLOR 11: PRINT "1";: COLOR 3: PRINT " and ";: COLOR 11: PRINT R$(9);:
     COLOR 3: PRINT " or increase number of data sets.";
2810 RETURN
2820 COLOR 27,0: LOCATE 25,1,0: PRINT "Please hold on!";: COLOR 3: PRINT " This
will not take more than a couple of seconds.";: RETURN
2830 BEEP: COLOR 27,0: LOCATE 25,1,0: PRINT "Invalid entry!";: COLOR 3: PRINT
     " Enter an ";:COLOR 11: PRINT "integer";: COLOR 3:PRINT" or a ";: COLOR 11:
     PRINT "decimal number.";
2840 RETURN
2850 L%=0
2860 FOR I%=1 TO 14: D$=MID$(R1$(J%),I%,1)
2870 IF D$="." THEN L%=L%+1: IF L%>1 THEN GOSUB 2830: GOTO 2900 ELSE 2880
2880 IF (ASC(D$)<48 OR ASC(D$)>57) AND D$<>" " AND D$<>"." THEN GOSUB 2830: GOTO
 2900 ELSE NEXT I%
2890 RETURN
2900 C%=C%+I%+1:COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE R%,C%,1:RETURN 1720
2910 IF SLN%>99 THEN D$=RIGHT$(D$,3):RETURN ELSE 2920
2920 IF SLN%>9 THEN D$=RIGHT$(D$,2)+" ":RETURN ELSE D$=RIGHT$(D$,1)+"  ":RETURN
2930 IF CLRF% THEN CLRF%=0 ELSE CLRF%=1
2940 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1): RETURN
```

```
2950 BEEP:COLOR 3,0:LOCATE 25,1,0:PRINT"This value is not in the range you have
specified ! ";: COLOR 27: PRINT "Please correct it.";SPACE$(9);
2960 FOR J%=1 TO 8: IF I%>P%(J%)-1 AND I%<P%(J%+1) THEN 2970 ELSE NEXT
2970 L%=PF%: VF1%=VF%: SLN%=I%: SLN1%=I%
2980 PF%=J%: C%=N3%(VF%): IF PF%=1 THEN R%=I%-P%(J%)+4 ELSE R%=I%-P%(J%)+5
2990 ERC%=1 'not to interfere with display of 1.1.
3000 IF I% MOD 2=0 THEN CLRF1%=0 ELSE CLRF1%=1
3010 IF L%=J% THEN LOCATE R%,C%,1: RETURN 2180 ELSE RETURN 2060
3020 GOSUB 2740: PRINT"Help file is being searched.";: RETURN
```

```
1000 REM*****GEOSTAT PACKAGE
1010 REM*****MODULE NAME = PLOTS.BAS
1020 REM*****GEOSTAT VERSION 1.0 REQUIRES IBM ADVANCED BASIC VERSION 2.00
                                  October 1984
1030 REM*****Programmed by AHMET UNAL
1040 REM
1050 REM  A plot graph in high resoltion mode is drawn for Color+. Each point
1060 REM  plotted is scaled for a screen area of 160x555 points with an axis
1070 REM  intercept of minimum boundary point abscissa and ordinate.
1080 REM
1090 MODULE$="plots"
1100 COMMON MS,CLR%(),D#(),E#(),N#(),R$(),DHL$(),BE#(),BN#(),DS$,PLS%,B%,V%,MN#,
VR#,CO$,ACD$(),AOA$(),AF$(),AC$(),AA$()
1110 DEF SEG=MS
1120 DSC%=VAL(R$(16)):NBP%=VAL(R$(20)):NDH%=VAL(R$(7)):B%=1:V%=1
1130 IF R$(19)="y" OR R$(19)="Y" THEN 1160
1140 DIM EC(NDH%),NC(NDH%),RP$(21),N%(21),X%(21)
1150 NBP%=0: GOTO 1210
1160 DIM BEC(NBP%),BNC(NBP%),EC(NDH%),NC(NDH%),RP$(21),N%(21),X%(21)
1170 FOR I%=1 TO NBP%
1180 BNC(I%)=CSNG(BN#(I%)): BEC(I%)=CSNG(BE#(I%))
1190 NEXT I%
1210 N%(12)=31:N%(13)=31:N%(15)=31:N%(16)=31:N%(18)=65:N%(19)=39:N%(20)=38:
     N%(21)=12
1220 X%(12)=44:X%(13)=44:X%(15)=44:X%(16)=44:X%(18)=65:X%(19)=39:X%(20)=40:
     X%(21)=13
1230 RP$(18)="y": RP$(19)="y": RP$(20)="3  ": RP$(21)="5 "
1240 FOR I%=1 TO NDH%
1250 EC(I%)=CSNG(E#(I%)): NC(I%)=CSNG(N#(I%))
1260 NEXT I%
1270 IF R$(18)="ne" OR R$(18)="NE" THEN YLABEL$="Northing" ELSE YLABEL$="Southin
g"
1280 XLABEL$="Easting"
1290 IF R$(19)="n" OR R$(19)="N" THEN T$=R$(6)+" * Drill Holes *": TC%=13
ELSE T$=R$(6)+" * Drill Holes and Boundary Lines *": TC%=4
1300 IF R$(19)="n" OR R$(19)="N" THEN 1620
1320 ' find max/min north/east coordinate of boundary points
1340 YMAXB=BNC(1):YMINB=BNC(1):XMAXB=BEC(1):XMINB=BEC(1)
1350 FOR J%=2 TO NBP%
1352   IF BNC(J%)>YMAXB THEN YMAXB=BNC(J%)
1354   IF BNC(J%)<YMINB THEN YMINB=BNC(J%)
1356   IF BEC(J%)>XMAXB THEN XMAXB=BEC(J%)
1358   IF BEC(J%)<XMINB THEN XMINB=BEC(J%)
1370 NEXT J%
1600 ' find max/min north/south coordinate of drill holes
1620 YMAXD=NC(1):YMIND=NC(1):XMAXD=EC(1):XMIND=EC(1)
1630 FOR J%=2 TO NDH%
1632   IF NC(J%)>YMAXD THEN YMAXD=NC(J%)
1634   IF NC(J%)<YMIND THEN YMIND=NC(J%)
1636   IF EC(J%)>XMAXD THEN XMAXD=EC(J%)
1638   IF EC(J%)<XMIND THEN XMIND=EC(J%)
1650 NEXT J%
1880 IF R$(19)="n" OR R$(19)="N" THEN XMAX=XMAXD: XMIN=XMIND: YMAX=YMAXD:
     YMIN=YMIND: GOTO 1930 ELSE 1890
1890 IF YMAXB>YMAXD THEN YMAX=YMAXB ELSE YMAX=YMAXD
1900 IF XMAXB>XMAXD THEN XMAX=XMAXB ELSE XMAX=XMAXD
1910 IF YMINB<YMIND THEN YMIN=YMINB ELSE YMIN=YMIND
1920 IF XMINB<XMIND THEN XMIN=XMINB ELSE XMIN=XMIND
1930 RP$(12)=RIGHT$(STR$(XMAX),LEN(STR$(XMAX))-1): RP$(13)=RIGHT$(STR$(XMIN),LEN
(STR$(XMIN))-1): RP$(15)=RIGHT$(STR$(YMAX),LEN(STR$(YMAX))-1)
1940 RP$(16)=RIGHT$(STR$(YMIN),LEN(STR$(YMIN))-1)
1950 RP$(12)=RP$(12)+SPACE$(14-LEN(RP$(12))):XMAX$=RP$(12):
     RP$(13)=RP$(13)+SPACE$(14-LEN(RP$(13))):XMIN$=RP$(13)
1960 RP$(15)=RP$(15)+SPACE$(14-LEN(RP$(15))):YMAX$=RP$(15):
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```
    RP$(16)=RP$(16)+SPACE$(14-LEN(RP$(16))):YMIN$=RP$(16)
1970 FOR J%=1 TO 2
1980 IF J%=1 THEN SCREEN 0,1,3,0 ELSE SCREEN ,,0,3
1990 COLOR 6,0: CLS
2000 LOCATE 1,21,0,6,7: PRINT "2.PLOT OF DRILL HOLES AND BOUNDARY LINES"
2010 LOCATE 3,4: COLOR 2: PRINT "Automatic Plotting Specifications :"
2020 LOCATE 4,3: PRINT "*The viewing window corners are set to the minimum and m
aximum of the East"
2030 LOCATE ,4: PRINT "and North/South coordinates of all boundary points and dr
ill holes."
2040 LOCATE ,3: PRINT "*If property boundary points are provided, boundary lines
 are drawn."
2050 LOCATE ,3: PRINT "*Drill holes with and without ";: PRINT DS$;: PRINT
    " values are plotted."
2060 LOCATE ,4: PRINT "If drill hole labels have been provided :"
2070 LOCATE ,3: PRINT "*One for every 3 drill hole labels (starting with first)
are put on the plot."
2080 LOCATE ,3: PRINT "*Left-most 5 characters are put on the plot."
2090 PRINT "If you want custom designed plotting , change the parameters below :
"
2100 IF R$(18)="se" OR R$(18)="SE" THEN 2170
2110 COLOR 7: LOCATE 12,6: PRINT "N";CHR$(24);:COLOR 6:PRINT TAB(24);"EMAX : ";:
    COLOR CLR%(4),CLR%(2): PRINT RP$(12);:LOCATE ,49:COLOR CLR%(2),CLR%(4):PRIN
T XMAX$
2120 COLOR 5,0: PRINT TAB(3);"NMAX";: COLOR 7: PRINT "CDDDDDBDDDD?";: COLOR 6:
    PRINT TAB(24);"EMIN : ";: COLOR CLR%(3),CLR%(1): PRINT RP$(13);:LOCATE ,49:
            COLOR CLR%(1),CLR%(3):PRINT XMIN$
2130 COLOR 7,0:PRINT TAB(7);"3";TAB(13);"3";:COLOR 5:PRINT "PLOT";:COLOR 7:
    PRINT "3"
2140 COLOR 5: PRINT "  NMIN";: COLOR 7: PRINT "CDDDDDEDDDD4";: COLOR 6: PRINT
    TAB(24);"NMAX : ";: COLOR CLR%(4),CLR%(2): PRINT RP$(15);:LOCATE ,49:COLOR
CLR%(2),CLR%(4):       PRINT YMAX$
2150 COLOR 7,0: PRINT TAB(7);"@DDDDDADDDDADD";CHR$(26);: COLOR 6: PRINT TAB(24);
    "NMIN : ";:COLOR CLR%(3),CLR%(1):PRINT RP$(16);:LOCATE ,49:COLOR CLR%(1),CL
R%(3):PRINT YMIN$
2160 COLOR 5,0: PRINT TAB(5);"(0,0) EMIN EMAX";: COLOR 7: PRINT " E": GOTO 2230
2170 COLOR 5: PRINT TAB(5);"(0,0) EMIN EMAX ";: COLOR 7: PRINT "E  ";: COLOR 6:
    PRINT "EMAX : ";: COLOR CLR%(4),CLR%(2): PRINT RP$(12);:LOCATE ,49:COLOR CL
R%(2),CLR%(4):         PRINT XMAX$
2180 COLOR 7,0:PRINT TAB(7);"ZDDDDDBDDDDBDD";CHR$(26);:COLOR 6:
    PRINT"  EMIN : ";:COLOR CLR%(3),CLR%(1):PRINT RP$(13);:LOCATE ,49:COLOR CLR
%(1),CLR%(3):          PRINT XMIN$
2190 COLOR 5,0: PRINT TAB(3);"SMIN";: COLOR 7: PRINT "CDDDDDEDDDD4"
2200 COLOR 7: PRINT TAB(7);"3";TAB(13);"3";: COLOR 5: PRINT "PLOT";: COLOR 7:
    PRINT "3";: COLOR 6: PRINT TAB(24);"SMAX : ";: COLOR CLR%(4),CLR%(2): PRINT
 RP$(15);:        LOCATE ,49:COLOR CLR%(1),CLR%(3):PRINT YMAX$
2210 COLOR 5,0: PRINT TAB(3);"SMAX";: COLOR 7: PRINT "CDDDDDADDDDY";: COLOR 6:
    PRINT TAB(24);"SMIN : ";:COLOR CLR%(3),CLR%(1):PRINT RP$(16);:LOCATE ,49:CO
LOR CLR%(1),CLR%(3):     PRINT YMIN$
2220 COLOR 7,0: PRINT TAB(6);"S";CHR$(25)
2230 COLOR 6:PRINT "Plot drill holes without ";DS$;" values [ (y)es,(n)o ] : ";:
    COLOR CLR%(4),CLR%(2):PRINT RP$(18)
2240 IF R$(19)="n" OR R$(19)="N" THEN 2260
2250 LOCATE 19,1:COLOR 6,0: PRINT "Put : Boundary lines [ (y)es,(n)o ] : ";:
    COLOR CLR%(4),CLR%(2): PRINT RP$(19)
2260 IF R$(8)="n" OR R$(8)="N" THEN 2290
2270 LOCATE 20,1: COLOR 6,0: PRINT TAB(7);"One drill hole label for every ";:
    COLOR CLR%(3),CLR%(1): PRINT RP$(20);: COLOR 6,0: PRINT " drill holes (star
ting with the first)."
2280 PRINT TAB(7);"Only ";: COLOR CLR%(4),CLR%(2): PRINT RP$(21);: COLOR 6,0: PR
INT            " left-most character(s) of the drill holes on the plot [ 0-14 ].
"
2290 LOCATE 22,1: COLOR 6,0: PRINT STRING$(79,95)
2300 COLOR 2: PRINT "F1 ";: COLOR 6: PRINT "(Help)  ";: COLOR 2: PRINT " F2 ";:
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COLOR 6: PRINT "(Done;proceed)  ";: COLOR 2: PRINT " F3 ";: COLOR 6: PRINT
"(Previous menu)   ";: COLOR 2: PRINT "Shift+PrtSc ";: COLOR 6
2310 PRINT "(Print Screen)": COLOR 2: PRINT CHR$(24);"/";CHR$(25);: COLOR 6:
PRINT "(Move up/down between fields)   ";:COLOR 2: PRINT CHR$(26);"/";
CHR$(27);: COLOR 6: PRINT " (Move right/left within a field)";
2320 NEXT J%: SCREEN ,,0
2330 LRF%=0: CLRF%=1: R%=12: C%=31
2340 LOCATE R%,C%,1: COLOR CLR%(CLRF%+3),CLR%(CLRF%+1)
2350 I$=INKEY$: IF I$<>"" THEN 2350
2360 I$=INKEY$: IF I$="" THEN 2360
2370 COLOR 0,0:LOCATE 25,1,0:IF SCREEN(25,1)<>32 THEN PRINT SPACE$(79);
2380 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1): LOCATE R%,C%,1
2390 IF LEN(I$)=2 THEN I$=RIGHT$(I$,1): GOTO 2410 ELSE IF ASC(I$)<32 THEN 2360
ELSE LOCATE ,,0:PRINT I$;: I%=C%: IF C%<X%(R%) THEN C%=C%+1: LOCATE ,,1
ELSE LOCATE ,C%,1
2400 MID$(RP$(R%),I%+1-N%(R%),1)=I$: GOTO 2360
2410 IF I$=CHR$(80) THEN 2420 ELSE 2550'CD
2420 IF (R$(19)="y" OR R$(19)="Y") AND (R$(8)="y" OR R$(8)="Y") THEN 2500
2430 IF (R$(19)="n" OR R$(19)="N") AND (R$(8)="n" OR R$(8)="N") THEN 2440
ELSE 2450
2440 IF R%=18 THEN R%=12: C%=31: GOSUB 4540 ELSE 2510
2450 IF R$(19)="y" OR R$(19)="Y" THEN 2490
2460 IF R%=21 THEN R%=12: C%=31: GOSUB 4540 ELSE 2470
2470 IF R%=13 OR R%=16 OR R%=18 THEN R%=R%+2 ELSE R%=R%+1
2480 GOTO 2530
2490 IF R%=19 THEN R%=12: C%=31: GOSUB 4540 ELSE 2510
2500 IF R%=21 THEN R%=12: C%=31: GOSUB 4540 ELSE 2510
2510 IF R%=13 OR R%=16 THEN R%=R%+2 ELSE R%=R%+1
2520 IF R%=19 THEN 2540
2530 IF CLRF% THEN CLRF%=0 ELSE CLRF%=1
2540 C%=N%(R%): GOSUB 4540
2550 IF I$=CHR$(77) THEN 2560 ELSE 2580'CR
2560 IF C%<X%(R%) THEN C%=C%+1: LOCATE R%,C%
2570 GOTO 2360
2580 IF I$=CHR$(75) THEN 2590 ELSE 2610'CL
2590 IF C%>N%(R%) THEN C%=C%-1: LOCATE R%,C%
2600 GOTO 2360
2610 IF I$=CHR$(72) THEN 2620 ELSE 2770'CU
2620 IF (R$(19)="y" OR R$(19)="Y") AND (R$(8)="y" OR R$(8)="Y") THEN 2720
2630 IF (R$(19)="n" OR R$(19)="N") AND (R$(8)="n" OR R$(8)="N") THEN 2640
ELSE 2670
2640 IF R%=12 THEN R%=18: C%=65: GOSUB 4540 ELSE 2650
2650 IF R%=15 OR R%=18 THEN R%=R%-2 ELSE R%=R%-1
2660 GOTO 2750
2670 IF R$(19)="y" OR R$(19)="Y" THEN 2710
2680 IF R%=12 THEN R%=21: C%=12: GOSUB 4540 ELSE 2690
2690 IF R%=20 OR R%=18 OR R%=15 THEN R%=R%-2 ELSE R%=R%-1
2700 GOTO 2750
2710 IF R%=12 THEN R%=19: C%=39: GOSUB 4540 ELSE 2730
2720 IF R%=12 THEN R%=21: C%=12: GOSUB 4540 ELSE 2730
2730 IF R%=18 OR R%=15 THEN R%=R%-2 ELSE R%=R%-1
2740 IF R%=18 THEN 2760
2750 IF CLRF% THEN CLRF%=0 ELSE CLRF%=1
2760 C%=N%(R%): GOSUB 4540
2770 IF I$=CHR$(61) THEN DEF SEG:LOCATE 25,1,0:COLOR 27,0:PRINT "Please stand by
!";:COLOR 3:PRINT" This will not take more than a few seconds.";:CHAIN"mainmenu"
'F3
2780 IF I$=CHR$(59) THEN LOCATE 25,1,0:COLOR 27,0:PRINT"Please hold on! ";:COLOR
 3:PRINT"Help file is being searched.";:HPAGE%=15:L%=2340:CHAIN"hlp",,ALL
2790 IF I$<>CHR$(60) THEN 2360'F2
2800 LOCATE ,,0
2810 XMAX=VAL(RP$(12)): XMIN=VAL(RP$(13)): YMAX=VAL(RP$(15)): YMIN=VAL(RP$(16))
2820 DHLMOD%=VAL(RP$(20)): DHLEFT%=VAL(RP$(21))
2830 FOR J%=12 TO 16
```

```
2840 IF J%=14 THEN 2910
2850 DCP%=0
2860 FOR I%=1 TO 14
2870 D$=MID$(RP$(J%),I%,1)
2880 IF D$="." THEN DCP%=DCP%+1
2890 IF DCP%>1 THEN GOSUB 4520: GOTO 2950
2900 IF (ASC(D$)<48 OR ASC(D$)>57) AND D$<>" " AND D$<>"." THEN GOSUB 4520:
     GOTO 2930 ELSE NEXT I%
2910 NEXT J%
2920 GOTO 2970
2930 IF J%=12 OR J%=15 THEN CLRF%=1 ELSE CLRF%=0
2940 R%=J%: C%=30+I%: GOTO 2340
2950 IF J%=12 OR J%=15 THEN CLRF%=1 ELSE CLRF%=0
2960 R%=J%: C%=29+I%: GOTO 2340
2970 IF XMAX=<XMIN THEN BEEP: COLOR 3,0: LOCATE 25,1,0: PRINT "EMAX cannot be eq
ual to or less than EMIN!";: COLOR 27: PRINT " Please change one of them.";:
     R%=12: C%=31: CLRF%=1: GOTO 2340
2980 IF YMAX=<YMIN THEN 2990 ELSE 3020
2990 IF R$(18)="se" OR R$(18)="SE" THEN 3000 ELSE 3010
3000 BEEP: COLOR 3,0: LOCATE 25,1,0: PRINT "SMAX cannot be equal to or less than
 SMIN!";: COLOR 27: PRINT " Please change one of them.";: R%=15: C%=31: CLRF%=1:
 GOTO 2340
3010 BEEP: COLOR 3,0: LOCATE 25,1,0: PRINT "NMAX cannot be equal to or less than
 NMIN!";: COLOR 27: PRINT " Please change one of them.";: R%=15: C%=31: CLRF%=1:
 GOTO 2340
3020 IF RP$(18)="y" OR RP$(18)="Y" OR RP$(18)="n" OR RP$(18)="N" THEN 3040
3030 BEEP: COLOR 3,0: LOCATE 25,1,0: PRINT "Enter y or Y to plot drill holes wit
hout ";DS$;" data; n or N otherwise.";: CLRF%=1: R%=18: C%=65: GOTO 2340
3040 IF R$(19)="n" OR R$(19)="N" THEN 3070
3050 IF RP$(19)="y" OR RP$(19)="Y" OR RP$(19)="n" OR RP$(19)="N" THEN 3070
3060 BEEP: COLOR 3,0: LOCATE 25,1,0: PRINT "Enter y or Y to plot boundary lines
and n or N otherwise.";: CLRF%=1: R%=19: C%=39: GOTO 2340
3070 IF R$(8)="n" OR R$(8)="N" THEN 3120
3080 IF DHLMOD%>0 THEN 3100
3090 BEEP: COLOR 27,0: LOCATE 25,1,0: PRINT "Invalid entry!";: COLOR 3: PRINT
     " Enter a number greater than 0.";: CLRF%=0: R%=20: C%=38: GOTO 2340
3100 IF DHLEFT%=>0 AND DHLEFT%<15 THEN 3120
3110 BEEP: COLOR 27,0: LOCATE 25,1,0: PRINT "Invalid entry!";: COLOR 3: PRINT
     " Enter a number between 0 and 14.";: CLRF%=1: R%=21: C%=12: GOTO 2340
3120 SX=553/(XMAX-XMIN): SY=161/(YMAX-YMIN) 'x and y scales are based on max.
     and min. values of drill hole and boundary point coordinates
3130 RENK%=0
3140 SCREEN 2,0: OUT &H3DD,&H20: CLS: OUT &H3DD,&H60: CLS: OUT &H3D9,&H0
     ' blue background
3150 IF RENK% THEN 3160 ELSE 3380
3160 LOCATE 1,TC%: PRINT T$ ' print title
3170 '
3180 '  print y-axis label
3190 '
3200 IR%=(22-LEN(YLABEL$))\2+1
3210 ICNT%=LEN(YLABEL$)+1
3220 FOR R%=IR% TO IR%+LEN(YLABEL$)-1
3230 ICNT%=ICNT%-1
3240 IF ASC(MID$(YLABEL$,ICNT%,1))<128 THEN 3250 ELSE 3260
3250 LOCATE R%,1: PRINT CHR$(ASC(MID$(YLABEL$,ICNT%,1))+128): GOTO 3270
3260 LOCATE R%,1: PRINT CHR$(ASC(MID$(YLABEL$,ICNT%,1)))
3270 NEXT R%
3280 '
3290 '  print x-axis label
3300 '
3310  IC%=(69-LEN(XLABEL$))\2+11
3320 ICNT%=0
3330 FOR C%=IC% TO IC%+LEN(XLABEL$)-1
3340 ICNT%=ICNT%+1
```

```
3350 LOCATE 24,C%: PRINT CHR$(ASC(MID$(XLABEL$,ICNT%,1)));
3360 NEXT C%
3370 LOCATE 25,13,0: PRINT "F2";: LOCATE ,33: PRINT "F3";: LOCATE ,54:
     PRINT "Shift+Prtsc";
3380 LINE(74,8)-(639,174),1,B ' boxing of the plot
3390 '
3400 '  y-axis values, every 3rd row for NE quadrant
3410 '
3420 IF R$(18)="se" OR R$(18)="SE" THEN 3520
3430 FOR I%=0 TO 10
3440   LOCATE 22-I%*2,2 ' position for y value
3450   PRINT USING".###^^^^";I%*16/SY+YMIN; ' 16 points per 2 rows
3460   LINE (75,171-I%*16)-(79,171-I%*16),1 ' tic marks for y-axis
3470   IF RENK%=0 THEN LINE (80,171-I%*16)-(639,171-I%*16),1,,&HCCCC
        'tic marks for y-axis
3480 NEXT I%: GOTO 3610
3490 '
3500 '  y-axis values, every 3rd row for SE quadrant
3510 '
3520 FOR I%=10 TO 0 STEP -1
3530   LOCATE 2+I%*2,2 ' position for y value
3540   PRINT USING".###^^^^";I%*16/SY+YMIN; ' 16 points per 2 rows
3550   LINE (75,171-I%*16)-(79,171-I%*16),1 ' tic marks for y-axis
3560   IF RENK%=0 THEN LINE (80,171-I%*16)-(639,171-I%*16),1,,&HCCCC
        'tic marks for y-axis
3570 NEXT I%
3580 '
3590 '  x-axis values, every 9 columns
3600 '
3610 FOR I%=0 TO 7
3620   LOCATE 23,7+I%*9 ' position for x value
3630   PRINT USING".###^^^^";I%*72/SX+XMIN; ' 72 points per 9 columns
3640   LINE (80+I%*72,173)-(80+I%*72,172),1 ' tic marks for x-axis
3650   IF RENK%=0 THEN LINE (80+I%*72,171)-(80+I%*72,9),1,,&HAAAA
        'tic marks for y-axis
3660 NEXT I%
3670 LOCATE 25,1,0: PRINT "PRESS :";: LOCATE ,16: PRINT "(Done;proceed)";:
     LOCATE ,36: PRINT "(Previous Menu)";: LOCATE ,66: PRINT "(Print Screen)";
3680 RENK%=RENK%+1
3690 IF RENK%=1 THEN OUT &H3DD,&H20: GOTO 3150
3700 XMI=XMIN-2/SX: XMA=XMAX+2/SX: YMI=YMIN-2/SY: YMA=YMAX+2/SY
3710 IF R$(18)="se" OR R$(18)="SE" THEN 3750
3720 WINDOW (XMI,YMI)-(XMA,YMA)
3730 VIEW (78,9)-(634,173)
3740 GOTO 3800
3750 WINDOW SCREEN (XMI,YMI)-(XMA,YMA)
3760 VIEW (78,9)-(634,173)
3770 '
3780 '  plot drill holes only
3790 '
3800 IF R$(8)="y" OR R$(8)="Y" THEN 3920
3810 FOR I%=1 TO PLS%
3820 PSET(EC(I%),NC(I%))
3830 CIRCLE(EC(I%),NC(I%)),2/SX,1,,,2/3
3840 NEXT I%
3850 IF RP$(18)="n" OR RP$(18)="N" THEN 4370
3860 RENK%=0: OUT &H3DD,&H60
3870 FOR I%=PLS%+1 TO NDH%
3880 PSET(EC(I%),NC(I%))
3890 CIRCLE(EC(I%),NC(I%)),2/SX,1,,,2/3
3900 NEXT I%
3910 RENK%=RENK%+1: IF RENK%=1 THEN OUT &H3DD,&H20: GOTO 3870 ELSE 4370
3920 J%=DHLEFT%\2
3930 IF R$(18)="se" OR R$(18)="SE" THEN 4170
```

```
3940 '
3950 'put drill holes and put labels for NE quadrant
3960 '
3970 FOR I%=1 TO PLS%
3980 PSET(EC(I%),NC(I%))
3990 CIRCLE(EC(I%),NC(I%)),2/SX,1,,,2/3
4000 C%=(80+(EC(I%)-XMIN)*SX)/8-J%: IF C%<11 OR C%+DHLEFT%>78 THEN 4030
4010 R%=(169-(NC(I%)-YMIN)*SY)\8: IF R%<3 OR R%>22 THEN 4030
4020 IF I% MOD DHLMOD%=0 THEN LOCATE R%,C%: PRINT LEFT$(DHL$(I%),DHLEFT%)
4030 NEXT I%
4040 IF RP$(18)="y" OR RP$(18)="Y" THEN 4050 ELSE 4370
4050 RENK%=0: OUT &H3DD,&H60
4060 FOR I%=PLS%+1 TO NDH%
4070 PSET(EC(I%),NC(I%))
4080 CIRCLE(EC(I%),NC(I%)),2/SX,1,,,2/3
4090 C%=(80+(EC(I%)-XMIN)*SX)/8-J%: IF C%<11 OR C%+DHLEFT%>78 THEN 4120
4100 R%=(169-(NC(I%)-YMIN)*SY)\8: IF R%<3 OR R%>22 THEN 4120
4110 IF I% MOD DHLMOD%=0 THEN LOCATE R%,C%: PRINT LEFT$(DHL$(I%),DHLEFT%)
4120 NEXT I%
4130 RENK%=RENK%+1: IF RENK%=1 THEN OUT &H3DD,&H20: GOTO 4060
      ELSE OUT &H3DD,&H20: GOTO 4370
4140 '
4150 'put drill holes and put labels for SE quadrant
4160 '
4170 FOR I%=1 TO PLS%
4180 PSET(EC(I%),NC(I%))
4190 CIRCLE(EC(I%),NC(I%)),2/SX,1,,,2/3
4200 C%=(80+(EC(I%)-XMIN)*SX)/8-J%: IF C%<11 OR C%+DHLEFT%>78 THEN 4230
4210 R%=(8+(NC(I%)-YMIN)*SY)\8: IF R%<3 OR R%>22 THEN 4230
4220 IF I% MOD DHLMOD%=0 THEN LOCATE R%,C%: PRINT LEFT$(DHL$(I%),DHLEFT%)
4230 NEXT I%
4240 IF RP$(18)="y" OR RP$(18)="Y" THEN 4250 ELSE 4370
4250 RENK%=0: OUT &H3DD,&H60
4260 FOR I%=PLS%+1 TO NDH%
4270 PSET(EC(I%),NC(I%))
4280 CIRCLE(EC(I%),NC(I%)),2/SX,1,,,2/3
4290 C%=(80+(EC(I%)-XMIN)*SX)/8-J%: IF C%<11 OR C%+DHLEFT%>78 THEN 4320
4300 R%=(8+(NC(I%)-YMIN)*SY)\8: IF R%<3 OR R%>22 THEN 4320
4310 IF I% MOD DHLMOD%=0 THEN LOCATE R%,C%: PRINT LEFT$(DHL$(I%),DHLEFT%)
4320 NEXT I%
4330 RENK%=RENK%+1: IF RENK%=1 THEN OUT &H3DD,&H20: GOTO 4260
4340 '
4350 'plot boundary lines
4360 '
4370 IF R$(19)="n" OR R$(19)="N" THEN 4450
4380 RENK%=0: OUT &H3DD,&H60
4390 PSET(BEC(1),BNC(1))
4400 FOR I%=2 TO NBP%
4410 LINE -(BEC(I%),BNC(I%))
4420 NEXT I%
4430 LINE -(BEC(1),BNC(1))
4440 RENK%=RENK%+1: IF RENK%=1 THEN OUT &H3DD,&H20: GOTO 4390
4450 I$=INKEY$: IF I$<>"" THEN 4450
4460 I$=INKEY$: IF I$="" THEN 4460
4470 IF LEN(I$)=1 THEN 4460
4480 I$=RIGHT$(I$,1)
4490 IF I$=CHR$(61) THEN SCREEN 0,1: COLOR 0: WIDTH 80: CLS: GOTO 1970'F3
4500 IF I$=CHR$(60) THEN SCREEN 0,1:COLOR 0:WIDTH 80:CLS:DEF SEG:CHAIN"mainmenu"
     ELSE 4450'F2
4510 REM*****SUBROUTINE GIVES INTEGER OR DECIMAL NUMBER MSG
4520 BEEP: COLOR 27,0: LOCATE 25,1,0: PRINT "Invalid entry!";: COLOR 3: PRINT
     " Enter a positive integer or decimal number.";: RETURN
4530 REM*****SUBROUTINE ROUTS TO INKEY$ INSTEAD OF POKE
4540 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1): LOCATE R%,C%,1: RETURN 2360
```

```
1000 MODULE$="stat"
1020 DEF SEG=MS
1040 COMMON MS,CLR%(),D#(),E#(),N#(),R$(),DHL$(),BE#(),BN#(),DS$,PLS%,B%,V%,MN#,
VR#,CO$,ACD$(),AOA$(),AF$(),AC$(),AA$()
1060 DIM N%(19),X%(19),RS$(19),ALPHA(5),CVL(5),DN(2*PLS%),F%(31)
1080 FOR I%=1 TO 5:READ ALPHA(I%):NEXT
1100 DATA .15,.1,.05,.025,.01
1120 FOR I%=1 TO 5:READ CVL(I%):NEXT
1140 DATA .775,.819,.895,.955,1.035
1160 FOR I%=1 TO 5:READ N%(I%):NEXT
1180 DATA 27,37,45,54,62
1200 A1#=.4361836:A2#=-.1201676:A3#=.937298:Q=1/SQR(2*3.14159)
1220 DSC%=VAL(R$(16))
1240 IF DSC%>4 THEN DS$=R$(DSC%+16) ELSE DS$=R$(DSC%+11)
1260 N%(9)=47:N%(10)=56:N%(11)=41:N%(13)=57:N%(16)=14:N%(19)=55:X%(9)=49:X%(10)=
69:X%(11)=54:X%(13)=57:X%(16)=14:X%(19)=55:SF%=0
1280 RS$(16)=" ":RS$(19)=" "
1300 FOR J%=1 TO 2:IF J%=1 THEN SCREEN 0,1,3,0 ELSE SCREEN ,,0,3
1320 COLOR 6,0:CLS
1340 LOCATE 1,29,0:PRINT "3.STATISTICAL ANALYSIS":PRINT
1360 PRINT TAB(20)"Variable being studied is ";:COLOR 14:PRINT DS$:COLOR 6:PRINT

1380 PRINT TAB(17)"Logarithmic transformation (base e) status =";:COLOR 14:PRINT
 TSF%:COLOR 6
1400 PRINT TAB(25)"0 => not transformed;"
1420 PRINT TAB(25)"1 => transformed.":PRINT:PRINT:PRINT
1440 PRINT TAB(15) "1  Statistical Summary"
1460 PRINT TAB(15) "2  Histogram and Box-Plot"
1480 PRINT TAB(15) "3  Kolmogorov-Simirnov Goodness of Fit Test for Normality"
1500 PRINT TAB(15) "4  Logarithmic or Anti-Logarithmic Transformation":PRINT
1520 PRINT"Your Choice: ";:COLOR CLR%(4),CLR%(2):PRINT RS$(16)
1540 GOSUB 8060:NEXT J%:SCREEN ,,0
1560 CLRF%=1:R%=16:C%=14
1580 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE R%,C%,1
1600 I$=INKEY$: IF I$<>"" THEN 1600
1620 I$=INKEY$: IF I$="" THEN 1620
1640 COLOR 0,0:LOCATE 25,1,0:IF SCREEN(25,1)<>32 THEN PRINT SPACE$(79);
1660 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE R%,C%,1
1680 IF LEN(I$)=2 THEN I$=RIGHT$(I$,1):GOTO 1700 ELSE IF ASC(I$)<32 THEN 1620 EL
SE LOCATE ,,0:PRINT I$;:LOCATE R%,C%,1:RS$(16)=I$:GOTO 1620
1700 IF I$=CHR$(59) THEN GOSUB 8020:HPAGE%=5:L%=3200:CHAIN"hlp",,ALL
1720 IF I$=CHR$(61) THEN LOCATE ,,0:B%=1:GOSUB 7980:DEF SEG:CHAIN"mainmenu"'F3
1740 IF I$<>CHR$(60) THEN 1620 'F2
1760 IF ASC(RS$(16))>48 AND ASC(RS$(16))<53 THEN 1800
1780 BEEP:LOCATE 25,1,0:COLOR 27,0:PRINT"Invalid entry!";:COLOR 3:PRINT" Enter t
he number of your choice from the menu between ";:COLOR 11:PRINT"1";:COLOR 3:PRI
NT" and ";:COLOR 11:PRINT"4.";SPACE$(2);:GOTO 1580
1800 ON VAL(RS$(16)) GOTO 2340,4080,6840,1820
1820 COLOR 6,0:LOCATE 19,1:PRINT "Transformation [ (l)ogarithmic,(a)nti-logarith
mic ] : ";:IF TSF% THEN RS$(19)="a" ELSE RS$(19)="l"
1840 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):PRINT RS$(19);
1860 R%=19:C%=55
1880 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE R%,C%,1
1900 I$=INKEY$: IF I$<>"" THEN 1900
1920 I$=INKEY$: IF I$="" THEN 1920
1940 COLOR 0,0:LOCATE 25,1,0:IF SCREEN(25,1)<>32 THEN PRINT SPACE$(79);
1960 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE R%,C%,1
1980 IF LEN(I$)=2 THEN I$=RIGHT$(I$,1):GOTO 2000 ELSE IF ASC(I$)<32 THEN 1920 EL
SE LOCATE ,,0:PRINT I$;:LOCATE R%,C%,1:RS$(19)=I$:GOTO 1920
2000 IF I$=CHR$(59) THEN GOSUB 8020:HPAGE%=5:L%=4500:CHAIN"hlp",,ALL
2020 IF I$=CHR$(61) THEN RS$(16)=" ":GOTO 1300 'F3
2040 IF I$<>CHR$(60) THEN 1920 'F2
2060 IF RS$(19)="a" OR RS$(19)="A" OR RS$(19)="l" OR RS$(19)="L" THEN 2120
2080 BEEP:LOCATE 25,1,0:COLOR 27,0:PRINT"Invalid entry!";:COLOR 3:PRINT"Enter ";
```

```
:COLOR 11:PRINT"a or A";:COLOR 3:PRINT" for anti- and ";:COLOR 11:PRINT"l or L";
:COLOR 3:PRINT" for logarithmic transformation.";
2100 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1):LOCATE R%,C%,1:GOTO 1920
2120 IF TSF% AND (RS$(19)="l" OR RS$(19)="L") THEN BEEP:COLOR 27,0:LOCATE 25,1:P
RINT"Request denied!";:COLOR 3:PRINT" Natural logarithms of the data has already
 been taken!";:GOTO 1880
2140 IF TSF%=0 AND (RS$(19)="a" OR RS$(19)="A") THEN BEEP:COLOR 27,0:LOCATE 25,1
:PRINT"Request denied!";:COLOR 3:PRINT" Natural logarithms of the data has not b
een taken yet!";:GOTO 1880
2160 IF RS$(19)="a" OR RS$(19)="A" THEN 2300
2180 COLOR 27,0:LOCATE 25,1,0:PRINT"Please wait !";:COLOR 3:PRINT" Natural logar
ithms of the data is being taken.";
2200 ON ERROR GOTO 8200
2220 FOR I%=1 TO PLS%
2240 D#(I%)=LOG(D#(I%))
2260 NEXT I%
2280 ON ERROR GOTO 0:TSF%=1:SF%=0:GOTO 1280
2300 COLOR 27,0:LOCATE 25,1,0:PRINT"Please wait!";:COLOR 3:PRINT" Anti-logarithm
s of the previously transformed data is being taken.";
2320 FOR I%=1 TO PLS%:D#(I%)=EXP(D#(I%)):NEXT:TSF%=0:SF%=0:GOTO 1280
2340 FOR J%=1 TO 2:IF J%=1 THEN SCREEN 0,1,3,0 ELSE SCREEN ,,0,3
2360 COLOR 6,0:CLS
2380 LOCATE 1,29,0:PRINT "3.1.STATISTICAL SUMMARY"
2400 PRINT TAB(17)"Logarithmic transformation (base e) status =";:COLOR 14:PRINT
 TSF%:COLOR 6
2420 PRINT TAB(13)"Sample size in the master file"TAB(50)"="
2440 PRINT TAB(13)"Sample size"TAB(50)"="
2460 PRINT TAB(13)"Mean"TAB(50)"="
2480 PRINT TAB(13)"Variance"TAB(50)"="
2500 PRINT TAB(13)"Standart deviation"TAB(50)"="
2520 PRINT TAB(13)"Coefficient of variation"TAB(50)"="
2540 PRINT TAB(13)"Median"TAB(50)"="
2560 PRINT TAB(13)"Minimum"TAB(50)"="
2580 PRINT TAB(13)"Maximum"TAB(50)"="
2600 PRINT TAB(13)"Range"TAB(50)"="
2620 PRINT TAB(13)"Non-outlier range (after J.W.Tukey)"TAB(50)"="
2640 COLOR 2:PRINT"   ZDDDDDDDD Mild Outliers DDDDDDDDDD?   ";:COLOR 10:PRINT"ZD
DDDDDD Extreme Outliers DDDDDDDD?"
2660 COLOR 2:PRINT"   3";:COLOR 6:PRINT"Drill Hole Label"TAB(24)DS$;:COLOR 2:PRI
NT"3";:COLOR 10:PRINT"   3";:COLOR 6:PRINT"Drill Hole Label"TAB(62);DS$;:COLOR 1
0:PRINT "3"
2680 FOR K%=1 TO 6
2700 COLOR 2:PRINT TAB(4)"3"TAB(38)"3";:COLOR 10:PRINT TAB(42)"3"TAB(76)"3"
2720 NEXT K%
2740 COLOR 2:PRINT"   @DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDY   ";:COLOR 10:PRINT"@D
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDY"
2760 GOSUB 8040:GOSUB 8160:NEXT J%:SCREEN ,,0
2780 COLOR 14:LOCATE 3,53:PRINT R$(7)
2800 LOCATE ,52:PRINT PLS%
2820 SUM#=0#:SUM2#=0#
2840 FOR I%=1 TO PLS%:SUM#=SUM#+D#(I%):SUM2#=SUM2#+D#(I%)*D#(I%):NEXT
2860 MN#=SUM#/PLS%
2880 VR#=(PLS%*SUM2#-SUM#*SUM#)/(PLS%*(PLS%-1))
2900 SD#=SQR(VR#)
2920 CV#=SD#/MN#
2940 LOCATE ,52:PRINT CSNG(MN#):LOCATE ,52:PRINT CSNG(VR#):LOCATE ,52:PRINT CSNG
(SD#):LOCATE ,52:PRINT CSNG(CV#)
2960 'sort +ve data values by incresing order
2980 FOR J%=1 TO PLS%-1
3000  FOR K%=J%+1 TO PLS%
3020  IF D#(J%)>D#(K%) THEN SWAP D#(J%),D#(K%):SWAP E#(J%),E#(K%):
      SWAP N#(J%),N#(K%):SWAP DHL$(J%),DHL$(K%)
3040  NEXT K%
3060 NEXT J%
```

```
3080 RANGE#=D#(PLS%)-D#(1)
3100 LOCATE 10,52:PRINT CSNG(D#(1)):LOCATE ,52:PRINT CSNG(D#(PLS%)):LOCATE ,52:P
RINT CSNG(RANGE#)
3120 DMD=(PLS%+1)/2:LDMD%=INT(DMD)
3140 IF PLS% MOD 2 THEN MD#=D#(LDMD%) ELSE MD#=(D#(LDMD%)+D#(LDMD%+1))/2
3160 LOCATE 9,52:PRINT CSNG(MD#)
3180 DQ=(LDMD%+1)/2:LDQ%=INT(DQ)
3200 IF LDMD% MOD 2 THEN LQ#=(D#(LDQ%)+D#(LDQ%+1))/2:RG%=PLS%-LDQ%:UQ#=(D#(RG%)+
D#(RG%+1))/2 ELSE LQ#=D#(LDQ%):UQ#=D#(PLS%-LDQ%)
3220 IQR#=UQ#-LQ#:STP#=IQR#*1.5
3240 LIMI1#=LQ#-STP#:LIMO1#=UQ#+STP#:LIMI2#=LIMI1#-STP#:LIMO2#=LIMO1#+STP#
3260 'lower end
3280 IF D#(1)>=LIMI1# THEN DLA%=1:DLA2%=1:GOTO 3540 'no outliers
3300 'mild outliers only or mild outliers and extreme outliers
3320 FOR I%=1 TO LDQ%
3340 IF D#(I%)>=LIMI1# THEN 3380
3360 NEXT
3380 DLA%=I%
3400 IF D#(1)<LIMI1# AND D#(1)>=LIMI2# THEN DLA2%=1:GOTO 3540 'mo only
3420 'both mild and extreme outliers
3440 FOR I%=1 TO DLA%
3460 IF D#(I%)>=LIMI2# THEN 3500
3480 NEXT
3500 DLA2%=I%
3520 'upper end
3540 IF D#(PLS%)<=LIMO1# THEN DUA%=PLS%:DUA2%=PLS%:GOTO 3800 'no outliers
3560 'mild outliers only or mild and exreme outliers
3580 FOR I%=PLS% TO PLS%-LDQ% STEP-1
3600 IF D#(I%)<=LIMO1# THEN 3640
3620 NEXT
3640 DUA%=I%
3660 IF D#(PLS%)>LIMO1# AND D#(PLS%)<=LIMO2# THEN DUA2%=PLS%:GOTO 3800 'mo only
3680 'both mild and extreme outliers
3700 FOR I%=PLS% TO PLS%-DUA% STEP-1
3720 IF D#(I%)<=LIMO2# THEN 3760
3740 NEXT
3760 DUA2%=I%
3780 'print out the results
3800 LOCATE 13,53:PRINT"[";CSNG(D#(DLA%));"-";CSNG(D#(DUA%));"]";:LOCATE 16
3820 'mild outliers
3840 FOR I%=DLA2% TO DLA%-1:LOCATE ,6:PRINT DHL$(I%)TAB(24)CSNG(D#(I%)):NEXT
3860 FOR I%=DUA%+1 TO DUA2%:LOCATE ,6:PRINT DHL$(I%)TAB(24)CSNG(D#(I%)):NEXT
3880 LOCATE 16
3900 'extreme outliers
3920 FOR I%=1 TO DLA2%-1:LOCATE ,44:PRINT DHL$(I%)TAB(62)CSNG(D#(I%)):NEXT
3940 FOR I%=DUA2%+1 TO PLS%:LOCATE ,44:PRINT DHL$(I%)TAB(63)CSNG(D#(I%)):NEXT
3960 LOCATE 25,1:PRINT SPACE$(79);
3980 I$=INKEY$: IF I$<>"" THEN 3980
4000 I$=INKEY$: IF I$="" THEN 4000
4020 IF LEN(I$)=1 THEN 4000 ELSE I$=RIGHT$(I$,1)
4040 IF I$=CHR$(59) THEN COLOR 3:LOCATE 22,1:PRINT "Please ignore the 'Wait unti
l the cursor appears' msg after returning from HELP";:GOSUB 8020:HPAGE%=5:L%=666
8:CHAIN"hlp",,ALL
4060 IF I$=CHR$(60) OR I$=CHR$(61) THEN SF%=1:GOTO 1280 ELSE 4000 'F2/F3
4080 IF SF%=0 THEN GOSUB 8320'Histogram and Box-Plot
4100 RS$(13)="0":YLABEL$="Frequency":XLABEL$=DS$:T$=R$(6)+" * Histogram & Box-Pl
ot *":TC%=6
4120 CIW#=RANGE#/30:NCI%=RANGE#/CIW#+1
4140 SP#=D#(1)-RANGE#/60:IF D#(1)=0 THEN SP#=0
4160 GOSUB 8360 'calculate the frequencies in the histogram
4180 RS$(9)=RIGHT$(STR$(NCI%),LEN(STR$(NCI%))-1): RS$(10)=STR$(CSNG(SP#)): RS$(1
1)=RIGHT$(STR$(CSNG(CIW#)),LEN(STR$(CSNG(CIW#)))-1)
4200 RS$(9)=RS$(9)+SPACE$(3-LEN(RS$(9))):RS$(10)=RS$(10)+SPACE$(14-LEN(RS$(10)))
:RS$(11)=RS$(11)+SPACE$(14-LEN(RS$(11)))
```

```
4220 'FOR J%=1 TO 2
4240 'IF J%=1 THEN SCREEN 0,1,3,0 ELSE SCREEN ,,0,3
4260 COLOR 6,0: CLS
4280 LOCATE 1,27,0: PRINT "3.2.HISTOGRAM AND BOX-PLOT":PRINT
4300 PRINT TAB(20)"Variable being studied is ";:COLOR 14:PRINT DS$:COLOR 6:PRINT

4320 PRINT TAB(18)"Sample size in the master file"TAB(52)"=  ";:COLOR 14:PRINT R
$(7):COLOR 6
4340 PRINT TAB(18)"Sample size"TAB(52)"= ";:COLOR 14:PRINT PLS%:COLOR 6
4360 PRINT TAB(18)"Range"TAB(52)"= ";:COLOR 14:PRINT CSNG(RANGE#):COLOR 6:PRINT
4380 PRINT TAB(10)"Number of class intervals [ 5-31 ] : ";:COLOR CLR%(4),CLR%(2)
:PRINT RS$(9):COLOR 6,0
4400 PRINT TAB(10)"Starting value for the first class interval : ";:COLOR CLR%(4
),CLR%(2):PRINT RS$(10):COLOR 6,0
4420 PRINT TAB(10)"Class interval width ( 0-   ] : ";:COLOR CLR%(4),CLR%(2):PRINT
 RS$(11):COLOR 6,0:PRINT
4440 PRINT TAB(10)"Results of the calculations on the [ 0,1,2 ] : ";:COLOR CLR%(
4),CLR%(2):PRINT RS$(13);:COLOR 6,0
4460 PRINT TAB(23)"1 => screen":PRINT TAB(23)"2 => printer":PRINT TAB(23)"0 => n
either (go to the plot)
4480 LOCATE 22,1: COLOR 6,0: PRINT STRING$(79,95)
4500 COLOR 2: PRINT "F1 ";: COLOR 6: PRINT "(Help)   ";: COLOR 2: PRINT " F2 ";:
     COLOR 6: PRINT "(Done;proceed)  ";: COLOR 2: PRINT " F3 ";: COLOR 6: PRINT
     "(Previous menu)   ";: COLOR 2: PRINT "Shift+PrtSc ";: COLOR 6
4520 PRINT "(Print Screen)": COLOR 2: PRINT CHR$(24);"/";CHR$(25);: COLOR 6:
     PRINT "(Move up/down between fields)"TAB(79)
4540 'NEXT J%: SCREEN ,,0
4560 R%=9:C%=47:CLRF%=1
4580 LOCATE R%,C%,1: COLOR CLR%(CLRF%+3),CLR%(CLRF%+1)
4600 I$=INKEY$: IF I$<>"" THEN 4600
4620 I$=INKEY$: IF I$="" THEN 4620
4640 COLOR 0,0:LOCATE 25,1,0:IF SCREEN(25,1)<>32 THEN PRINT SPACE$(79);
4660 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1): LOCATE R%,C%,1
4680 IF LEN(I$)=2 THEN I$=RIGHT$(I$,1): GOTO 4720 ELSE IF ASC(I$)<32 THEN 4620
     ELSE LOCATE ,,0:PRINT I$;: I%=C%: IF C%<X%(R%) THEN C%=C%+1: LOCATE ,,1
     ELSE LOCATE ,C%,1
4700 MID$(RS$(R%),I%+1-N%(R%),1)=I$: GOTO 4620
4720 IF I$=CHR$(80) THEN 4740 ELSE 4820'CD
4740 IF R%=13 THEN R%=9:GOTO 4780
4760 IF R%=11 THEN R%=13 ELSE R%=R%+1
4780 IF R%=10 THEN C%=N%(R%)+1 ELSE C%=N%(R%)
4800 LOCATE R%,C%:GOTO 4620
4820 IF I$=CHR$(77) THEN 4840 ELSE 4880'CR
4840 IF C%<X%(R%) THEN C%=C%+1: LOCATE R%,C%
4860 GOTO 4620
4880 IF I$=CHR$(75) THEN 4900 ELSE 4940'CL
4900 IF C%>N%(R%) THEN C%=C%-1: LOCATE R%,C%
4920 GOTO 4620
4940 IF I$=CHR$(72) THEN 4960 ELSE 5040'CU
4960 IF R%=9 THEN R%=13:GOTO 4780
4980 IF R%=13 THEN R%=11 ELSE R%=R%-1
5000 IF R%=10 THEN C%=N%(R%)+1 ELSE C%=N%(R%)
5020 LOCATE R%,C%:GOTO 4620
5040 IF I$=CHR$(61) THEN LOCATE 25,1,0:COLOR 27,0:PRINT "Please stand by!";:COLO
R 3:PRINT" This will not take more than a few seconds.";:GOTO 1280 'F3
5060 IF I$=CHR$(59) THEN GOSUB 8020:HPAGE%=15:L%=2340:CHAIN"hlp",,ALL
5080 IF I$<>CHR$(60) THEN 4620'F2
5100 LOCATE ,,0
5120 'CHECK THE ENTRIES AND CONVERT THEM INTO THEIR NUMERIC VALUES
5140 NCI%=VAL(RS$(9)):SP#=VAL(RS$(10)):CIW#=VAL(RS$(11))
5160 SX=486/(CIW#*NCI%)
5180 GOSUB 8360 'calculate the frequencies in the histogram
5200 FMAX%=F%(1)
5220 FOR I%=2 TO NCI%
```

```
5240 IF F%(I%)>FMAX% THEN FMAX%=F%(I%)
5260 NEXT I%
5280 FOR I%=0 TO 7
5300 IF (FMAX%+I%) MOD 9=0 THEN 5340
5320 NEXT I%
5340 BAS%=(FMAX%+I%)/9
5360 YMIN%=0:YMAX%=BAS%*9:SY=145/YMAX%
5380 RENK%=0
5400 SCREEN 2,0: OUT &H3DD,&H20: CLS: OUT &H3DD,&H60: CLS: OUT &H3D9,&HO
     ' blue back & red foreground
5420 LOCATE 1,TC%: PRINT T$ ' print title
5440 '
5460 '  print y-axis label
5480 '
5500 IR%=(20-LEN(YLABEL$))\2+1
5520 ICNT%=LEN(YLABEL$)+1
5540 FOR R%=IR% TO IR%+LEN(YLABEL$)-1
5560 ICNT%=ICNT%-1
5580  IF ASC(MID$(YLABEL$,ICNT%,1))<128 THEN 5600 ELSE 5620
5600  LOCATE R%,1: PRINT CHR$(ASC(MID$(YLABEL$,ICNT%,1))+128): GOTO 5640
5620 LOCATE R%,1: PRINT CHR$(ASC(MID$(YLABEL$,ICNT%,1)))
5640 NEXT R%
5660 '
5680 '  print x-axis label
5700 '
5720  IC%=(61-LEN(XLABEL$))\2+11
5740 ICNT%=0
5760 FOR C%=IC% TO IC%+LEN(XLABEL$)-1
5780 ICNT%=ICNT%+1
5800 LOCATE 25,C%: PRINT CHR$(ASC(MID$(XLABEL$,ICNT%,1)));
5820 NEXT C%
5840 FRMT$="##.####^^^^":LOCATE 4,69:PRINT USING FRMT$;CSNG(MN#):LOCATE 7,69:PRI
NT USING FRMT$;CSNG(SD#):LOCATE 10,69:PRINT USING FRMT$;CSNG(CIW#):LOCATE 13,72:
PRINT PLS%:LOCATE 17,70:PRINT "Proceed":LOCATE 20,68:PRINT "Previous Menu":LOCAT
E 23,68
5860 PRINT "Print Screen"
5880 IF RENK% THEN 5960
5900 FOR I%=0 TO 7
5920   LINE (49,27+I%*16)-(531,27+I%*16),1,,&HCCCC 'lines for y-axis
5940 NEXT I%
5960 RENK%=RENK%+1
5980 IF RENK%=1 THEN OUT &H3DD,&H20: GOTO 5420
6000 LINE(47,11)-(532,155),1,B ' boxing of the plot
6020 '
6040 '  y-axis values, every 3rd row for SE quadrant
6060 '
6080 FOR I%=0 TO 18 STEP 2
6100   LOCATE 2+I%,2:PRINT YMAX%-I%*BAS%/2
6120 NEXT I%
6140 '
6160 '  x-axis values every k% class interval
6180 '
6200 K%=72/(CIW#*SX):LOCATE 21
6220 FOR I%=0 TO NCI%-1 STEP K%
6240   L%=47+I%*CIW#*SX
6260   LINE (L%,157)-(L%,156)
6280   LOCATE ,(L%-46)/8+3:PRINT USING"##.#^^^^";CSNG(I%*CIW#+SP#);
6300 NEXT I%
6320 LOCATE 3,72:PRINT "Mean":LOCATE 6,68:PRINT "Standard Dev.":LOCATE 9,69:PRIN
T "Class Width":LOCATE 12,68:PRINT "No of Samples":LOCATE 16,73:PRINT "F2":LOCAT
E 19,73:PRINT "F3":LOCATE 22,69:PRINT "Shift+PrtSc"
6340 'draw the histogram
6360 FOR I%=0 TO NCI%-1
6380 LINE (47+I%*CIW#*SX,155)-(47+(I%+1)*CIW#*SX,155-F%(I%+1)*SY),1,B
```

```
6400 NEXT I%
6420 'draw the box-plot
6440 LINE (47+(LQ#-SP#)*SX,186)-(47+(UQ#-SP#)*SX,172),1,B 'main box
6460 LINE (47+(MD#-SP#)*SX,172)-(47+(MD#-SP#)*SX,186),1 'median
6480 LINE (47+(D#(DLA%)-SP#)*SX,179)-(47+(LQ#-SP#)*SX,179) 'lower non-outlier
6500 LINE (47+(D#(DUA%)-SP#)*SX,179)-(47+(UQ#-SP#)*SX,179) 'upper non-outlier
6520 'mild outliers
6540 FOR I%=DLA2% TO DLA%-1:CIRCLE(47+(D#(I%)-SP#)*SX,179),3,1,,,.6667:NEXT
6560 FOR I%=DUA%+1 TO DUA2%:CIRCLE(47+(D#(I%)-SP#)*SX,179),3,1,,,.6667:NEXT
6580 'extreme outliers
6600 FOR I%=1 TO DLA2%-1:PRESET(47+(D#(I%)-SP#)*SX,179):CIRCLE STEP(0,0),3,1,,,.
6667:PAINT STEP(0,0),1:NEXT
6620 FOR I%=DUA2%+1 TO PLS%:PRESET(47+(D#(I%)-SP#)*SX,179):CIRCLE STEP(0,0),3,1,
,,.6667:PAINT STEP(0,0),1:NEXT
6640 I$=INKEY$: IF I$<>"" THEN 6640
6660 I$=INKEY$: IF I$="" THEN 6660
6680 IF LEN(I$)=1 THEN 6660
6700 I$=RIGHT$(I$,1)
6720 IF I$=CHR$(61) THEN SCREEN 0,1: COLOR 0: WIDTH 80: CLS: GOTO 4220'F3
6740 IF I$=CHR$(60) THEN SCREEN 0,1:COLOR 0:WIDTH 80:CLS:GOTO 1280 ELSE 6640'F2
6760 REM*****SUBROUTINE GIVES INTEGER OR DECIMAL NUMBER MSG
6780 BEEP: COLOR 27,0: LOCATE 25,1,0: PRINT "Invalid entry!";: COLOR 3: PRINT
     " Enter a positive integer or decimal number.";: RETURN
6800 REM*****SUBROUTINE ROUTS TO INKEY$ INSTEAD OF POKE
6820 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1): LOCATE R%,C%,1: RETURN 4620
6840 IF SF%=0 THEN GOSUB 8320 'K-S
6860 FOR J%=1 TO 2:IF J%=1 THEN SCREEN 0,1,3,0 ELSE SCREEN ,,0,3
6880 COLOR 6,0:CLS
6900 LOCATE 1,12,0:PRINT "3.3.KOLMOGOROV-SIMIRNOV GOODNESS OF FIT TEST FOR NORMA
LITY":PRINT:PRINT
6920 COLOR 2:PRINT"Null Hypothesis : ";:COLOR 6:PRINT DS$;" values are normally
distributed with :"
6940 PRINT TAB(19)"Population Mean (=sample mean)          =";CSNG(MN#)
6960 PRINT TAB(19)"Population Variance (=sample variance) =";CSNG(VR#):PRINT
6980 COLOR 2:PRINT"Alternative Hypothesis : ";:COLOR 6:PRINT DS$;"are not from t
he above distribution."
7000 PRINT"NOTE: This includes any combination of the following possibilities:"
7020 PRINT TAB(15)"1. The distribution is not normal,":PRINT TAB(15)"2. The popu
lation mean is not equal to";CSNG(MN#);", and":PRINT TAB(15)"3. Population varia
nce is not equal to";CSNG(VR#);".":PRINT
7040 COLOR 2:PRINT" Z";STRING$(18,196);" Critical Values for the Test Statistic
";STRING$(18,196);"?"
7060 PRINT " 3";:COLOR 0,2:PRINT"  '-Risk Level  ";:COLOR 6,0:PRINT TAB(38)".10"
TAB(46)".05"TAB(55)".025"TAB(63)".01";:COLOR 2:PRINT TAB(79)"3";
7080 PRINT " 3";:COLOR 0,2:PRINT" Critical Value ";:COLOR 6,0:PRINT TAB(28)".775
"TAB(38)".819"TAB(46)".895"TAB(55)".955"TAB(62)"1.035";:COLOR 2:PRINT TAB(79)"3"
;" @";STRING$(76,196);"Y";:GOSUB 8040
7100 LOCATE 25,1:COLOR 3:PRINT"Use the arow keys to choose the decision level, a
nd then hit F2 to proceed.";:NEXT J%:SCREEN ,,0
7120 C%=1:R%=15:LOCATE 15,28:COLOR 0,6:PRINT".15";
7140 I$=INKEY$: IF I$<>"" THEN 7140
7160 I$=INKEY$: IF I$="" THEN 7160
7180 IF LEN(I$)=1 THEN 7140 ELSE I$=RIGHT$(I$,1)
7200 IF I$=CHR$(59) THEN COLOR 3:LOCATE 22,1:PRINT "Please ignore the 'Wait unti
l the cursor appears' msg after returning from HELP";:GOSUB 8020:HPAGE%=5:L%=155
13:CHAIN"hlp",,ALL
7220 IF I$=CHR$(77) THEN 7240 ELSE 7300 'CR
7240 LOCATE R%,N%(C%):COLOR 6,0:PRINT ALPHA(C%);:COLOR 0,6
7260 IF C%=5 THEN C%=1 ELSE C%=C%+1
7280 LOCATE ,N%(C%):PRINT ALPHA(C%);:GOTO 7160
7300 IF I$=CHR$(75) THEN 7320 ELSE 7380 'CL
7320 LOCATE R%,N%(C%):COLOR 6,0:PRINT ALPHA(C%);:COLOR 0,6
7340 IF C%=1 THEN C%=5 ELSE C%=C%-1
7360 LOCATE ,N%(C%):PRINT ALPHA(C%);:GOTO 7160
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7380 IF I$=CHR$(61) THEN 1280 'F3
7400 IF I$=CHR$(60) THEN 7420 ELSE 7160' F2
7420 GOSUB 8160
7440 'K-S gof test
7460 FOR I%=1 TO PLS%
7480 'calculate F(z)
7500 Z#=(D#(I%)-MN#)/SD#
7520 T#=1/(1+.33267*ABS(Z#))
7540 H#=(A1#*T#+A2#*T#*T#+A3#*T#*T#*T#)*Q*EXP(Z#*Z#*-.5)
7560 IF Z#>0 THEN FZ#=1-H# ELSE FZ#=H#
7580 'find DN+ and DN-
7600 DN(I%)=I%/PLS%-FZ#
7620 DN(I%+PLS%)=FZ#-(I%-1)/PLS%
7640 NEXT I%
7660 'find the test statistic DNt
7680 DNT=0
7700 FOR I%=1 TO 2*PLS%:IF DN(I%)>=DNT THEN DNT=DN(I%)
7720 NEXT I%
7740 DNT=DNT*(SQR(PLS%)-.01+.85/SQR(PLS%))
7760 COLOR 6,0:LOCATE 19,30:PRINT"Test Statistic = ";:COLOR 14:PRINT DNT
7780 IF DNT>CVL(C%) THEN 7820 'reject HO
7800 LOCATE 21,1:PRINT"We fail to reject the null hypothesis at";ALPHA(C%);" ris
k level and conclude that ";DS$;" is normally distributed with the above paramet
ers.";:GOTO 7840
7820 LOCATE 21,1:PRINT"We reject the null hypothesis at";ALPHA(C%);" risk level.
 Please see the note for the":PRINT"alternative hypothesis.";:GOTO 7840
7840 LOCATE 25,1:PRINT SPACE$(79);
7860 I$=INKEY$:IF I$<>"" THEN 7860
7880 I$=INKEY$:IF I$="" THEN 7880
7900 IF LEN(I$)=1 THEN 7880 ELSE I$=RIGHT$(I$,1)
7920 IF I$=CHR$(59) THEN COLOR 3:LOCATE 22,1:PRINT "Please ignore the 'Wait unti
l the cursor appears' msg after returning from HELP";:GOSUB 8020:HPAGE%=5:L%=666
8:CHAIN"hlp",,ALL
7940 IF I$=CHR$(60) OR I$=CHR$(61) THEN 1280 ELSE 7860 'F2/F3
7960 REM*****SUBROUTINE GIVES WAIT MSG
7980 COLOR 27,0:LOCATE 25,1,0:PRINT"Please wait!";:COLOR 3:PRINT" This will not
take more than a few seconds."TAB(79):RETURN
8000 REM*****SUBROUTINE GIVES WAIT FOR HELP MSG
8020 COLOR 27,0:LOCATE 25,1,0:PRINT"Please hold on!";:COLOR 3:PRINT" Help file i
s being searched."TAB(79):RETURN
8040 REM*****SUBROUTINE PRINTS THE LAST LINE
8060 LOCATE 23,1,0:COLOR 6,0:PRINT STRING$(79,95):PRINT"PRESS:";:COLOR 2:PRINT"
 F1 ";:COLOR 6:PRINT"(Help)  ";:COLOR 2:PRINT"F2 ";:COLOR 6:PRINT"(Proceed)  ";:
COLOR 2:PRINT"F3 ";:COLOR 6:PRINT "(Previous Menu)  ";:COLOR 2:PRINT"Shift+PrtSc
 ";:COLOR 6
8080 PRINT"(Print Screen)";:RETURN
8100 REM*SUBROUTINE GIVES UNDER DEVELOPMENT MSG
8120 BEEP:LOCATE 25,1,0:COLOR 14,4:PRINT "THIS OPTION IS IN THE DEVELOPMENT STAG
E! IT WILL BE READY SOON."TAB(79):RETURN 1580
8140 REM*****SUBROUTINE GIVES WAIT MSG
8160 COLOR 27,0:LOCATE 25,1,0:PRINT"Please wait!";:COLOR 3:PRINT" Calculations a
re in progress."TAB(79):RETURN
8180 REM*ROUTINE TRAPS LOG(0) ERROR
8200 COLOR 27,0:LOCATE 23,1,0:PRINT"ERROR! ";:COLOR 3:PRINT DS$;" value which is
 equal to 0 at drill hole ";DHL$(I%);"   ";:PRINT"will temporarily be set to 2.9
E-39 if you will. Press 'y' or 'Y' to continue   ";
8220 LOCATE 25,1:PRINT"execution or any other key to return to ";:COLOR 11:PRINT
 "MAIN MENU :"TAB(79):COLOR 3:LOCATE ,53,1
8240 I$=INKEY$:IF I$<>"" THEN 8240 ELSE 8260
8260 I$=INKEY$:IF I$="" THEN 8260 ELSE 8280
8280 IF I$="y" OR I$="Y" THEN PRINT I$;:COLOR 6,0:LOCATE 25,1,0:PRINT SPACE$(79)
;:GOSUB 8060:D#(I%)=0#:RESUME NEXT ELSE B%=1:V%=0:GOSUB 7980:CHAIN "mainmenu"
8300 REM*****SUBROUTINE GIVES FIRST STATTITICAL ANALYSIS MESSAGE
8320 BEEP:COLOR 3,0:LOCATE 25,1,0:PRINT"You have to choose ";:COLOR 11:PRINT"Sta
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tistical Summary";:COLOR 3:PRINT" first to choose this option."TAB(79):RS$(16)="
1":LOCATE 16,14:COLOR CLR%(4),CLR%(2):PRINT"1";:RETURN 1560
8340 REM*SUBROUTINE CALCULATES THE FREQUENCIES FOR THE HISTOGRAM
8360 K%=0:EP#=SP#
8380 FOR I%=1 TO NCI%-1
8400 EP#=EP#+CIW#
8420 FOR J%=K%+1 TO PLS%
8440 IF D#(J%)>=EP# THEN 8480
8460 NEXT J%
8480 F%(I%)=J%-1-K%:K%=J%-1
8500 NEXT I%
8520 FOR I%=PLS% TO 1 STEP-1:IF D#(I%)<EP# THEN 8560 'freq. in last interval
8540 NEXT I%
8560 F%(NCI%)=PLS%-I%
8580 RETURN
```

```
1000 ON ERROR GOTO 60000:DEFINT I-N:MODULE$="vargram"
1100 COMMON MS,CLR%(),D#(),E#(),N#(),R$(),DHL$(),BE#(),BN#(),DS$,PLS%,B%,V%,MN#,
VR#,CO$,ACD$(),AOA$(),AF$(),AC$(),AA$()
1150 F1$="varexp1.scr":F2$="varexp2.scr":FMT1$="##.###^^^^":FMT2$="#.###^^^^":FM
T3$=".###^^^^":RADC#=.017453292519943#
1200 DIM CAL$(8),PRN$(8),PLT$(8),RMRK$(8),ALP$(8),DALP$(8),LAG$(8),DLAG$(8)
1400 FOR I=1 TO 8:READ ALP$(I):NEXT
1500 DATA " 90.0"," 67.5"," 45.0"," 22.5","  0.0","-22.5","-45.5","-67.5"
1600 FOR I=1 TO 8:CAL$(I)="   ":PRN$(I)="   ":PLT$(I)="   ":RMRK$(I)=SPACE$(3):D
ALP$(I)=SPACE$(4):LAG$(I)=SPACE$(8):DLAG$(I)=SPACE$(7):NEXT:MC$="n":RS$="n"
1910 DIM CH#(8,21),DRIFT#(8,21),G#(8,21),MC#(8,21),MCG#(8,21),NC(8,21),LAG#(8),D
LAG#(8),ALP#(8),DALP#(8),CTHETA#(8),SIGMA#(8),SIGMASQ#(8),N(8),CALP#(8),SALP#(8)
,STF%(8,129),CALF%(8),PRNF%(8),PLTF%(8)
1922 DIM PLTM$(8),CO$(8),CD$(8,2),C$(8,2),A$(8,2),PMF%(8),CO(8),C(8,2),A(8,2)
1924 B$=SPACE$(8):FOR I=1 TO 8:PLTM$(I)="   ":CO$(I)=B$:FOR J=1 TO 2:CD$(I,J)="
"::C$(I,J)=B$:A$(I,J)=B$:NEXT J,I:MNC$=" "
1930 DIM AOA(2),AF(2),AC(2),AA(2),S(8,2)
1935 CO$=CO$(1):ACD$(1)=CD$(1,1):ACD$(2)=CD$(1,2):AOA$(1)="0.0    ":AOA$(2)="0.0
  ":AF$(1)="1.0    ":AF$(2)="1.0    ":AC$(1)=C$(1,1):AC$(2)=C$(1,2):AA$(1)=A$(1,1)
:AA$(2)=A$(1,2)
2100 FOR J=1 TO 2:IF J=1 THEN SCREEN 0,1,3,0 ELSE SCREEN ,,0,3
2200 COLOR 6,0:CLS:LOCATE 5,19,0:PRINT"4.SPATIAL ANALYSIS-VARIOGRAM MODELING":LO
CATE 7,21:PRINT"1 Experimental Semivariogram":PRINT TAB(21)"2 Semivariogram Mode
ling":PRINT TAB(21)"3 Anisotropy Analysis"
2500 LOCATE 11,7:PRINT "Your Choice : ";:COLOR CLR%(4),CLR%(2):PRINT" ":GOSUB 11
502
2700 NEXT J:SCREEN ,,0:FLD$=" "
2900 R%=11:CMIN%=21:CMAX%=21:COLOR CLR%(4),CLR%(2):GOSUB 50000:ON NXT GOTO 2900,
2900,2900,2900,3100,2940,2900,2950
2940 GOSUB 57000:CHAIN"mainmenu"
2950 IF ASC(I$)=59 OR ASC(I$)=68 THEN LOCATE 25,1:COLOR 3,0:PRINT "Help option o
f this module is incomplete. Sorry for the inconvinience.";TAB(79);:GOTO 2900 'F
1-F10-help
2960 IF ASC(I$)=67 THEN 2940 'F9
3000 IF ASC(I$)<>60 THEN 2900 'F2
3100 IF ASC(FLD$)<49 OR ASC(FLD$)>51 THEN BEEP:LOCATE 25,1,0:COLOR 27,0:PRINT"In
valid entry!";:COLOR 3:PRINT" Enter the number of your choice from the menu betw
een 1 and 3.";TAB(79);:GOTO 2900
3900 ON VAL(FLD$) GOTO 4100,4000
3940 IF KF THEN 47000 ELSE T$="Options 1 & 2 have to be visited before anisotrop
y analysis!":GOSUB 54500:GOTO 2900
4000 IF JF THEN 35000 ELSE T$="Experimental semivariogram(s) have to be plotted
before modeling!":GOSUB 54500:GOTO 2900
4100 FOR J=1 TO 2:IF J=1 THEN SCREEN ,,3,0 ELSE SCREEN ,,0,3
4200 COLOR 6,0:CLS:LOCATE 1,25,0:PRINT"4.1.EXPERIMENTAL SEMIVARIOGRAM"
4250 LOCATE 3,10:PRINT"Experimental semivariogram file retrieved : ";:COLOR CLR%
(2),CLR%(4):PRINT FR$:COLOR 6,0:LOCATE 4,10:PRINT"Logarithmic transformation [ (
y)es,(n)o ] : ";:COLOR CLR%(1),CLR%(3):IF TSF% THEN PRINT" yes " ELSE PRINT " no
"
4400 LOCATE 6,10:COLOR 6,0:PRINT"Weighted semivariogram [ (y)es,(n)o ] : ";:COLO
R CLR%(4),CLR%(2):PRINT MC$;:COLOR 6,0:PRINT"  [n/N => plot ave. semivar.]":LOCA
TE 7,10:PRINT"Relative semivariogram [ (y)es,(n)o ] : ";:COLOR CLR%(3),CLR%(1):P
RINT RS$;
4600 LOCATE 9,5:COLOR 6,0:PRINT"Remarks  [blank => Do not]  Direction  Direction
      Lag      Lag Distance":PRINT TAB(5)"Relative Calcu- Print Plot  [degrees]
Tolerance    Distance    Tolerance":PRINT TAB(5)"Semivar.  late"TAB(46)"[+/-]"TA
B(71)"[+/-]"
4700 LOCATE 12,1:FOR I=1 TO 8:IF I MOD 2 THEN COLOR CLR%(4),CLR%(2) ELSE COLOR C
LR%(3),CLR%(1)
4900 PRINT I;:LOCATE ,7:PRINT RMRK$(I);:LOCATE ,16:PRINT CAL$(I);:LOCATE ,22:PRI
NT PRN$(I);:LOCATE ,28:PRINT PLT$(I);:LOCATE ,35:PRINT ALP$(I);:LOCATE ,47:PRINT
 DALP$(I);:LOCATE ,57:PRINT LAG$(I);:LOCATE ,70:PRINT DLAG$(I):NEXT I
5000 COLOR 0,6:LOCATE 22,10:PRINT R$(6)+" * "+DS$:GOSUB 11502:NEXT J:SCREEN ,,0
5050 M=1:VF%=1:CLRF%=1:R%=6
```

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5100 CMIN%=50:CMAX%=50:FLD$=MC$:COLOR CLR%(4),CLR%(2):GOSUB 50000:MC$=FLD$:GOSUB
 15000:GOTO 10000
5200 CMIN%=50:CMAX%=50:FLD$=RS$:COLOR CLR%(3),CLR%(1):GOSUB 50000:RS$=FLD$:GOSUB
 15000:GOTO 10000
5300 GOSUB 11550:FLD$=CAL$(M):GOSUB 50000:CAL$(M)=FLD$:GOSUB 15000:GOTO 10000
5400 GOSUB 11550:FLD$=PRN$(M):GOSUB 50000:PRN$(M)=FLD$:GOSUB 15000:GOTO 10000
5500 GOSUB 11550:FLD$=PLT$(M):GOSUB 50000:PLT$(M)=FLD$:GOSUB 15000:GOTO 10000
5600 GOSUB 11550:FLD$=ALP$(M):GOSUB 50000:ALP$(M)=FLD$:GOSUB 15000:GOTO 10000
5700 GOSUB 11550:FLD$=DALP$(M):GOSUB 50000:DALP$(M)=FLD$:GOSUB 15000:GOTO 10000
5800 GOSUB 11550:FLD$=LAG$(M):GOSUB 50000:LAG$(M)=FLD$:GOSUB 15000:GOTO 10000
5900 GOSUB 11550:FLD$=DLAG$(M):GOSUB 50000:DLAG$(M)=FLD$:GOSUB 15000
10000 ON VF% GOTO 5300,5400,5500,5600,5700,5800,5900
11202 IF ASC(I$)=59 OR ASC(I$)=68 THEN LOCATE 25,1:COLOR 3,0:PRINT "Help option
of this module is incomplete. Sorry for the inconvinience.";TAB(79);:GOTO 5300 '
F1/F10
11204 IF ASC(I$)=61 THEN 11206 ELSE 11250 'F3-load
11206 GOSUB 54000
11210 OPEN FILE$ FOR INPUT AS 1
11212 INPUT #1,B$,I$,M
11213 IF B$<>R$(6) THEN T$="Project titles":GOSUB 17500:R$(6)=B$
11214 IF I$<>DS$ THEN T$="Variable names":GOSUB 17500:DS$=I$
11216 IF M<>TSF% THEN T$="Log trans. status":GOSUB 17500:TSF%=M
11218 FOR I=1 TO 8:IF EOF(1) THEN 11228
11220 INPUT #1,RMRK$(I),N(I),SIGMA#(I),SIGMASQ#(I):INPUT #1,ALP$(I),DALP$(I),LAG
$(I),LAG#(I),DLAG$(I)
11222 FOR J=1 TO 21:INPUT #1,NC(I,J),DRIFT#(I,J),G#(I,J),MC#(I,J),CH#(I,J):NEXT
J:LOCATE I+11,7:IF I MOD 2 THEN COLOR CLR%(4),CLR%(2) ELSE COLOR CLR%(3),CLR%(1)

11224 PRINT RMRK$(I);:LOCATE ,16:PRINT CAL$(I);:LOCATE ,22:PRINT PRN$(I);:LOCATE
 ,28:PRINT PLT$(I);:LOCATE ,35:PRINT ALP$(I);:LOCATE ,47:PRINT DALP$(I);:LOCATE
,57:PRINT LAG$(I);:LOCATE ,70:PRINT DLAG$(I)
11226 NEXT I
11228 CLOSE 1:FR$=FILE$:COLOR CLR%(2),CLR%(4):LOCATE 3,54,0:PRINT FR$:JF=0
11230 IF I=9 THEN 5050
11232 GOSUB 51000:BEEP:LOCATE ,1:PRINT"Erase fields";I;:INPUT;"to 8";B$:IF B$=""
 THEN 5050
11235 B$=LEFT$(B$,1):IF B$="y" OR B$="Y" THEN B$="    ":FOR J=I TO 8:CAL$(J)=B$:P
RN$(J)=B$:PLT$(J)=B$:RMRK$(J)=B$:DALP$(J)=B$+" ":LAG$(J)=SPACE$(8):DLAG$(J)=SPAC
E$(7):NEXT J:GOTO 4100 ELSE 5050
11250 IF ASC(I$)=62 THEN 11252 ELSE 11282 'F4-save
11252 GOSUB 17400:GOSUB 51000:LOCATE ,1:PRINT"*SAVE*";:GOSUB 52000:GOSUB 51000
11256 L=0:FOR I=1 TO 8:IF MID$(RMRK$(I),2,1)=" " THEN 11258 ELSE L=L+1
11258 NEXT:IF L THEN 11264 ELSE T$="No values have been calculated so that can b
e saved !":GOSUB 54500:GOTO 5050
11264 OPEN FILE$ FOR OUTPUT AS 1
11266 WRITE #1,R$(6),DS$,TSF%:FOR I=1 TO 8:IF MID$(RMRK$(I),2,1)=" " THEN 11278
11268 WRITE #1,RMRK$(I),N(I),SIGMA#(I),SIGMASQ#(I)
11270 WRITE #1,ALP$(I),DALP$(I),LAG$(I),LAG#(I),DLAG$(I)
11272 FOR J=1 TO 21
11274 WRITE #1,NC(I,J),DRIFT#(I,J),G#(I,J),MC#(I,J),CH#(I,J)
11276 NEXT J
11278 NEXT I
11280 CLOSE 1:GOTO 5050
11282 IF ASC(I$)=67 THEN 2100 'F9
11284 IF ASC(I$)=60 THEN GOSUB 17400:GOTO 20000 ELSE 5050 'F2
11502 LOCATE 23,1,0:COLOR 6,0:PRINT STRING$(79,95):COLOR 2:PRINT TAB(4)"F1/F10";
:COLOR 6:PRINT"Help-Detailed/Quick Ref.  ";:COLOR 2:PRINT"F2/F9";:COLOR 6:PRINT"
Page down/up  ";:COLOR 2:PRINT"F3/F4";:COLOR 6:PRINT"Load/Save  ";:COLOR 2:PRINT
"Home";:RETURN
11550 ON VF% GOTO 11600,11700,11800,11900,12000,12100,12200
11600 CMIN%=16:CMAX%=18:RETURN
11700 CMIN%=22:CMAX%=24:RETURN
11800 CMIN%=28:CMAX%=30:RETURN
11900 CMIN%=35:CMAX%=39:RETURN
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12000 CMIN%=47:CMAX%=50:RETURN
12100 CMIN%=57:CMAX%=64:RETURN
12200 CMIN%=70:CMAX%=76:RETURN
15000 ON NXT GOTO 15100,15200,15300,15400,15500,15550,15600,15700
15100 IF R%=19 THEN R%=6:GOSUB 17000:RETURN 5100
15110 IF R%=7 THEN R%=12:GOSUB 17000:RETURN
15120 IF R%=6 THEN R%=7:GOSUB 17000:RETURN 5200 ELSE R%=R%+1:GOSUB 17000:RETURN
15200 IF R%=6 THEN R%=19:GOSUB 17000:RETURN
15210 IF R%=12 THEN R%=7:GOSUB 17000:RETURN 5200
15220 IF R%=7 THEN R%=6:GOSUB 17000:RETURN 5100 ELSE R%=R%-1:GOSUB 17000:RETURN
15300 IF R%=6 THEN R%=7:GOSUB 17000:RETURN 5200
15310 IF R%=7 THEN R%=12:GOSUB 17000:RETURN
15320 IF R%=19 AND VF%=7 THEN R%=6:GOSUB 17000:RETURN 5100
15330 IF VF%=7 THEN VF%=1:R%=R%+1:GOSUB 17000:RETURN ELSE VF%=VF%+1:RETURN
15400 IF R%=7 THEN R%=6:GOSUB 17000:RETURN 5100
15410 IF R%=6 THEN R%=19:GOSUB 17000:RETURN
15420 IF R%=12 AND VF%=1 THEN R%=7:GOSUB 17000:RETURN 5200
15430 IF VF%=1 THEN VF%=7:R%=R%-1:GOSUB 17000:RETURN ELSE VF%=VF%-1:RETURN
15500 RETURN 20000
15550 RETURN 2100
15600 RETURN 2100
15700 RETURN 11202
17000 IF CLRF% THEN CLRF%=0 ELSE CLRF%=1
17100 COLOR CLR%(CLRF%+3),CLR%(CLRF%+1)
17200 IF R%=6 OR R%=7 THEN VF%=1:M=1:RETURN
17300 M=R%-11:RETURN
17400 IF RS$="y" OR RS$="Y" OR RS$="n" OR RS$="N" THEN RETURN ELSE T$="Invalid e
ntry! Enter y/Y to denote relative semivariogram and n/N otherwise.":GOSUB 54500
:M=1:VF%=1:CLRF%=0:R%=7:RETURN 5200
17500 GOSUB 51000:LOCATE ,1:BEEP:PRINT T$;:INPUT;" do not match! Do you want to
continue";FLD$:FLD$=LEFT$(FLD$,1):IF FLD$="y" OR FLD$="Y" THEN RETURN ELSE CLOSE
 1:RETURN 5050
20000 LOCATE ,,0:L=0:FOR I=1 TO 8:IF CAL$(I)="    " THEN CALF%(I)=1 ELSE CALF%(I)
=0:L=L+1
20030 ALPR#=VAL(ALP$(I))*RADC#:IF R$(18)="se" OR R$(18)="SE" THEN ALPR#=-ALPR#
20040 CALP#(I)=COS(ALPR#):SALP#(I)=SIN(ALPR#):CTHETA#(I)=COS(VAL(DALP$(I))*RADC#
):LAG#(I)=VAL(LAG$(I)):DLAG#(I)=VAL(DLAG$(I))
20100 NEXT:IF L=0 THEN 25390
20300 COLOR 27,0:LOCATE 25,1,0:PRINT"Please wait!";:COLOR 3:PRINT" Calculations
are in progress.";TAB(78);
25000 FOR I=1 TO 8
25025 IF CALF%(I) THEN 25070
25030 FOR J=1 TO 21
25040 CH#(I,J)=0!:DRIFT#(I,J)=0!:G#(I,J)=0!:MC#(I,J)=0!:NC(I,J)=0
25050 NEXT J
25060 FOR K=1 TO PLS%:STF%(I,K)=0:NEXT K
25070 NEXT I
25080 FOR I=1 TO PLS%-1
25085 LOCATE 25,45:PRINT I;
25090 FOR J=I+1 TO PLS%
25095 LOCATE 25,55:PRINT J;
25100 DE#=E#(J)-E#(I):DN#=N#(J)-N#(I):H#=SQR(DE#*DE#+DN#*DN#)
25110 IF H#<.001 THEN COLOR 27,0:LOCATE 25,1,0:PRINT"Warning!";:COLOR 3:PRINT"Dr
ill holes";DHL$(I);" and ";DHL$(J);" have the same coordinates.";:GOTO 25180
25120 FOR K=1 TO 8
25130 IF CALF%(K) THEN 25170
25140 M=INT(H#/LAG#(K)+.5#)+1:H1#=ABS(H#-(M-1)*LAG#(K))
25150 IF M>21 OR H1#>DLAG#(K) THEN 25170
25153 COSD#=(DE#*CALP#(K)+DN#*SALP#(K))/(H#+.0001)
25154 IF ABS(COSD#)<CTHETA#(K) THEN 25170
25155 STF%(K,I)=1:STF%(K,J)=1:DD#=D#(J)-D#(I):DD#=ABS(DD#)*SGN(COSD#):DDSQ#=DD#*
DD#:HDDSQ#=H#*DDSQ#:CH#(K,M)=CH#(K,M)+H#:DRIFT#(K,M)=DRIFT#(K,M)+DD#:G#(K,M)=G#(
K,M)+DDSQ#:MC#(K,M)=MC#(K,M)+HDDSQ#:NC(K,M)=NC(K,M)+1
25170 NEXT K
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25180 NEXT J
25190 NEXT I
25210 FOR I=1 TO 8
25220 IF CALF%(I) THEN 25380
25230 N(I)=0:SIGMA#(I)=0!:SIGMASQ#(I)=0!
25240 FOR J=1 TO PLS%
25250 IF STF%(I,J) THEN N(I)=N(I)+1:SIGMA#(I)=SIGMA#(I)+D#(J):SIGMASQ#(I)=SIGMAS
Q#(I)+D#(J)*D#(J)
25260 NEXT J
25265 IF N(I)=0 THEN 25380
25270 SIGMASQ#(I)=(N(I)*SIGMASQ#(I)-SIGMA#(I)*SIGMA#(I))/(N(I)*(N(I)-1)):SIGMA#(
I)=SIGMA#(I)/N(I)
25280 FOR J=1 TO 21
25290 NCJ=NC(I,J):IF NCJ=0 THEN 25370
25310 DRIFT#(I,J)=DRIFT#(I,J)/NCJ
25330 IF RS$="y" OR RS$="Y" THEN G#(I,J)=G#(I,J)/(SIGMA#(I)*SIGMA#(I)):MC#(I,J)=
MC#(I,J)/(SIGMA#(I)*SIGMA#(I))
25350 G#(I,J)=G#(I,J)/(NCJ*2#)
25355 IF MC#(I,J)=0! THEN 25370
25360 MC#(I,J)=MC#(I,J)/(CH#(I,J)*2#):CH#(I,J)=CH#(I,J)/NCJ
25370 NEXT J
25372 MID$(RMRK$(I),2,1)=RS$:CAL$(I)="    ":LOCATE I+11,8:IF I MOD 2 THEN COLOR C
LR%(4),CLR%(2) ELSE COLOR CLR%(3),CLR%(1)
25374 PRINT RS$;:LOCATE ,16:PRINT CAL$(I)
25380 NEXT I
25390 L=0:FOR I=1 TO 8:IF PRN$(I)="    " THEN PRNF%(I)=1 ELSE PRNF%(I)=0:L=L+1
25395 NEXT:IF L=0 THEN 30000
25400 WIDTH "lpt1:",132:LPRINT CHR$(15);
25410 FOR I=1 TO 8
25420 IF PRNF%(I) OR MID$(RMRK$(I),2,1)=" " THEN 25630
25430 LPRINT:LPRINT:LPRINT TAB(47);R$(6):LPRINT:LPRINT TAB(44);"EXPERIMENTAL SEM
IVARIOGRAM FOR ";DS$:LPRINT:LPRINT"DIRECTION [degrees]";TAB(30);"= ";ALP$(I);TAB
(77);"S T A T I S T I C A L   S U M M A R Y"
25460 LPRINT"DIRECTION TOLERANCE [+/-]    = ";DALP$(I);TAB(67);"DATA USED IN CAL
CULATIONS";TAB(104);"COMPLETE DATA SET":LPRINT"LAG DISTANCE";TAB(30);"= ";LAG$(I
)
25480 LPRINT"LAG DISTANCE TOLERANCE [+/-] = ";DLAG$(I);TAB(67);"NO. OF SAMPLES =
";N(I);TAB(100);"NO. OF SAMPLES =";PLS%
25490 LPRINT"MAXIMUM DISTANCE";TAB(30)"=";CSNG(20*LAG#(I)+DLAG#(I)/2!);TAB(67)"M
EAN";TAB(82)"=";CSNG(SIGMA#(I));TAB(100);"MEAN";TAB(115);"=";CSNG(MN#)
25500 LPRINT"LOGARITHMIC TRANSFORMATION   = ";:IF TSF% THEN LPRINT "yes"; ELSE L
PRINT "no";
25510 LPRINT TAB(67);"VARIANCE";TAB(82);"=";CSNG(SIGMASQ#(I));TAB(100);"VARIANCE
";TAB(115);"=";CSNG(VR#)
25520 LPRINT"RELATIVE SEMIVARIOGRAM";TAB(30);"=";:IF RS$="N" OR RS$="n" THEN LPR
INT" no"; ELSE LPRINT" yes";
25530 LPRINT TAB(67);"STD. DEVIATION =";CSNG(SQR(SIGMASQ#(I)));TAB(100);"STD. DE
VIATION =";CSNG(SQR(VR#)):LPRINT
25540 LPRINT:LPRINT TAB(79);"S E M I V A R I G R A M":LPRINT TAB(9);"LAG DISTANC
E";TAB(31);"AVERAGE DISTANCE";TAB(59);"DRIFT";TAB(78);"AVERAGE";TAB(97);"WEIGHTE
D";TAB(114);"NO. OF COUPLES"
25550 FOR J=1 TO 21
25560 IF G#(I,J)<>0! THEN 25570 ELSE 25610
25570 LPRINT TAB(9);:LPRINT USING FMT1$;LAG#(I)*(J-1);:LPRINT TAB(34);:LPRINT US
ING FMT1$;CH#(I,J);
25590 LPRINT TAB(57);:LPRINT USING FMT2$;DRIFT#(I,J);:LPRINT TAB(77);:LPRINT USI
NG FMT2$;G#(I,J);:LPRINT TAB(97);:LPRINT USING FMT2$;MC#(I,J);:LPRINT TAB(119);N
C(I,J)
25610 NEXT J:LPRINT CHR$(12); 'FF
25620 PRN$(I)="    ":LOCATE I+11,22:IF I MOD 2 THEN COLOR CLR%(4),CLR%(2) ELSE CO
LOR CLR%(3),CLR%(1)
25625 PRINT PRN$(I)
25630 NEXT I:LPRINT CHR$(18);:WIDTH "LPT1:",80
30000 L=0:FOR I=1 TO 8:IF PLT$(I)="    " THEN PLTF%(I)=1 ELSE PLTF%(I)=0:L=L+1
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30020 NEXT:IF L=0 THEN 35000
30050 XMAX=0!:YMAX=0!:IF MC$="y" OR MC$="Y" THEN MCGF=1 ELSE MCGF=0
30051 FOR I=1 TO 8:FOR J=1 TO 21:IF MCGF THEN MCG#(I,J)=MC#(I,J) ELSE MCG#(I,J)=
G#(I,J)
30052 NEXT J,I
30055 FOR I=1 TO 8:IF PLTF%(I) THEN 30080
30060 FOR J=1 TO 21
30065 IF CH#(I,J)>XMAX THEN XMAX=CH#(I,J)
30070 IF MCG#(I,J)>YMAX THEN YMAX=MCG#(I,J)
30075 NEXT J
30080 NEXT I
30090 IF XMAX=0! OR YMAX=0! THEN T$="Max. value for neither lag dist. nor variog
ram may be zero. Plotting denied!":GOSUB 54500:GOTO 5050
30110 DEF SEG=MS:SCREEN 2,0:OUT &H3DD,&H20:CLS:OUT &H3DD,&H60:CLS:OUT &H3D9,&H0
30120 YLABEL$=CHR$(142)+"(LAG DISTANCE)":XLABEL$="LAG DISTANCE":T$=R$(6)+"  * "+
DS$+" Semivariogram *":SX=504/XMAX:SY=144/YMAX:RENK%=0
30170 LOCATE 1,1:PRINT TAB((80-LEN(T$))\2);T$;:LINE (74,8)-(590,158),1,B:IF RENK
%=0 THEN J=155-VR#*SY:LINE(80,J)-(584,J)
30220 IR=(19-LEN(YLABEL$))\2+1:IK=LEN(YLABEL$)+1
30240 FOR R%=IR TO IR+LEN(YLABEL$)-1
30260 IK=IK-1:LOCATE R%,1:IF ASC(MID$(YLABEL$,IK,1))<128 THEN PRINT CHR$(ASC(MID
$(YLABEL$,IK,1))+128) ELSE PRINT CHR$(ASC(MID$(YLABEL$,IK,1)))
30290 NEXT
30330 IC=(62-LEN(XLABEL$))\2+11:IK=0:FOR C%=IC TO IC+LEN(XLABEL$)-1:IK=IK+1:LOCA
TE 22,C%:PRINT CHR$(ASC(MID$(XLABEL$,IK,1)));:NEXT
30420 FOR I=0 TO 9:LOCATE 20-I*2,2:PRINT USING FMT3$;I*16/SY;:LINE(75,155-I*16)-
(79,155-I*16),1:LINE(80,155-I*16)-(589,155-I*16),1,,&H8888:NEXT
30520 FOR I=0 TO 7:LOCATE 21,7+I*9:PRINT USING FMT3$;I*72/SX;:LINE(80+I*72,157)-
(80+I*72,156),1:LINE(80+I*72,155)-(80+I*72,9),1,,&HAAAA:NEXT
30600 IF RENK%=0 THEN DEF SEG=&HB800:BSAVE F1$,0,&H4000:OUT &H3DD,&H20
30610 RENK%=RENK%+1:IF RENK%<2 THEN DEF SEG=MS:GOTO 30170 ELSE DEF SEG=&HB800
30620 LOCATE 5,77:PRINT"F2":LOCATE ,76:PRINT"PgDn":LOCATE 10,77:PRINT"F9":LOCATE
 ,76:PRINT"PgUp":LOCATE 15,76:PRINT"Home":LOCATE ,76:PRINT"Menu"
30730 FOR NN=1 TO 8:IF PLTF%(NN) OR MID$(RMRK$(NN),2,1)=" " THEN 31100
30735 LL=NN*10-8
30740 ON NN GOTO 30780,30860,30900,30940,30980,31011,31016,31021
30780 FOR I=1 TO 21:IF MCG#(NN,I)=0! OR NC(NN,I)<21 THEN 30805 'rec
30790 X=80+CH#(NN,I)*SX :Y=155-MCG#(NN,I)*SY:LINE(X+2,Y+2)-(X-2,Y-2),,B
30805 NEXT:GOSUB 32000:J=51:K=176:GOSUB 32400:J=35:K=184:GOSUB 32400:LINE(2,177)
-(6,181),,B:PSET(4,179):GOTO 31050
30860 FOR I=1 TO 21:IF MCG#(NN,I)=0! OR NC(NN,I)<21 THEN 30885 'cir
30870 X=80+CH#(NN,I)*SX:Y=155-MCG#(NN,I)*SY:CIRCLE (X,Y),3,,,,.67
30885 NEXT:GOSUB 32000:J=131:K=176:GOSUB 32400:J=115:K=184:GOSUB 32400:CIRCLE(84
,179),3,,,,.67:PSET(84,179),1:GOTO 31050
30900 FOR I=1 TO 21:IF MCG#(NN,I)=0! OR NC(NN,I)<21 THEN 30925 'tri
30910 X=76+CH#(NN,I)*SX:Y=157-MCG#(NN,I)*SY:DRAW"bm="+VARPTR$(X)+",="+VARPTR$(Y)
+"E4 F4 L8"
30925 NEXT:GOSUB 32000:J=211:K=176:GOSUB 32400:J=195:K=184:GOSUB 32400:DRAW"bm 1
64,181 e4 f4 l8":PSET(168,179):GOTO 31050
30940 FOR I=1 TO 21:IF MCG#(NN,I)=0! OR NC(NN,I)<21 THEN 30965 'utri
30950 X=76+CH#(NN,I)*SX:Y=153-MCG#(NN,I)*SY:DRAW"bm="+VARPTR$(X)+",="+VARPTR$(Y)
+"r8 g4 h4"
30965 NEXT:GOSUB 32000:J=291:K=176:GOSUB 32400:J=275:K=184:GOSUB 32400:DRAW"bm 2
38,177 r8 g4 h4":PSET(242,179):GOTO 31050
30980 FOR I=1 TO 21:IF MCG#(NN,I)=0! OR NC(NN,I)<21 THEN 31005 'rho
30990 X=77+CH#(NN,I)*SX:Y=155-MCG#(NN,I)*SY:DRAW"bm="+VARPTR$(X)+",="+VARPTR$(Y)
+"e3 f3 g3 h3"
31005 NEXT:GOSUB 32000:J=371:K=176:GOSUB 32400:J=355:K=184:GOSUB 32400:DRAW"bm 3
20,179 e3 f3 g3 h3":PSET(324,179):GOTO 31050
31011 FOR I=1 TO 21:IF MCG#(NN,I)=0! OR NC(NN,I)<21 THEN 31014 'squ
31012 X=80+CH#(NN,I)*SX:Y=155-MCG#(NN,I)*SY:LINE(X+3,Y+2)-(X-3,Y-2),,B
31014 NEXT:GOSUB 32000:J=451:K=176:GOSUB 32400:J=435:K=184:GOSUB 32400:LINE(400,
177)-(406,181),,B:PSET(403,179):GOTO 31050
31016 FOR I=1 TO 21:IF MCG#(NN,I)=0! OR NC(NN,I)<21 THEN 31019 'utrif
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31017 X=76+CH#(NN,I)*SX:Y=153-MCG#(NN,I)*SY:DRAW"bm="+VARPTR$(X)+",="+VARPTR$(Y)
+"r8 g4 h4":PAINT(X+4,Y+1),1
31019 NEXT:GOSUB 32000:J=531:K=176:GOSUB 32400:J=515:K=184:GOSUB 32400:DRAW"bm 4
79,177 r8 g4 h4":PAINT(483,178),1:GOTO 31050
31021 FOR I=1 TO 21:IF MCG#(NN,I)=0! OR NC(NN,I)<21 THEN 31024 'rhf
31022 X=77+CH#(NN,I)*SX:Y=155-MCG#(NN,I)*SY:DRAW"bm="+VARPTR$(X)+",="+VARPTR$(Y)
+"e3 f3 g3 h3":PAINT(X+1,Y),1
31024 NEXT:GOSUB 32000:J=611:K=176:GOSUB 32400:J=595:K=184:GOSUB 32400:DRAW"bm 5
60,179 e3 f3 g3 h3":PAINT(564,179),1:GOTO 31050
31050 FOR N=1 TO 21:IF MCG#(NN,N)=0! THEN NEXT N ELSE 31058
31056 N=21
31058 X=80+CH#(NN,N)*SX:Y=155-(MCG#(NN,N)*SY):PSET(X,Y)
31060 FOR I=N TO 21:IF MCG#(NN,I)=0! THEN 31090
31070 X=80+CH#(NN,I)*SX:Y=155-(MCG#(NN,I)*SY):LINE-(X,Y)
31090 NEXT I
31100 NEXT NN
31200 BSAVE F2$,0,&H4000:JF=1
31570 GOSUB 46980
31578 IF ASC(I$)=73 OR ASC(I$)=67 THEN SCREEN 0,0,0:GOTO 4100 'PgUp/F9
31580 IF ASC(I$)=81 OR ASC(I$)=60 THEN SCREEN 0,0,0:GOTO 35000 'PgDn/F2
31582 IF ASC(I$)=71 THEN SCREEN 0,0,0:GOTO 2100 ELSE 31570'Home
32000 LOCATE 23,LL:PRINT ALP$(NN);" ";LEFT$(DALP$(NN),2);:LOCATE 24,LL-1:PRINT L
EFT$(LAG$(NN),4);:LOCATE ,LL+4:PRINT LEFT$(DLAG$(NN),4);:RETURN
32400 LINE(J,K)-(J,K+4):LINE(J-2,K+2)-(J+2,K+2):LINE(J-2,K+6)-(J+2,K+6):RETURN
35000 FOR J=1 TO 2:IF J=1 THEN SCREEN ,,3,0 ELSE SCREEN ,,0,3
35010 COLOR 6,0:CLS:LOCATE 1,19,0:PRINT"4.2.EXPERIMENTAL SEMIVARIOGRAM MODELING"
:COLOR 2:PRINT"Codes for semivariogram submodels : ";:COLOR 10:PRINT"s";:COLOR 2
:PRINT" =Spherical; ";
35020 COLOR 10:PRINT"e";:COLOR 2:PRINT" =Exponential; ";:COLOR 10:PRINT"g";:COLO
R 2:PRINT" =Gaussian;":COLOR 10:PRINT"[l";:COLOR 2:PRINT" =Linear (A=max. distan
ce to be considered; C=semivariogram value at A)]"
35030 COLOR 6:LOCATE ,2:PRINT"Model No.      Plot"TAB(32)"CO"TAB(43)"Code"TAB(56)
"C"TAB(72)"A":PRINT TAB(12)"[blank =>no]   Nugget Value"TAB(55)"Sill"TAB(70)"Ran
ge"
35040 LOCATE 6:FOR I=1 TO 8:COLOR CLR%(4),CLR%(2):LOCATE ,4:PRINT I;:LOCATE ,16:
PRINT PLTM$(I);:LOCATE ,29:PRINT CO$(I);:FOR K=1 TO 2:LOCATE ,44:PRINT CD$(I,K);
:LOCATE ,53:PRINT C$(I,K);:LOCATE ,69:PRINT A$(I,K):COLOR CLR%(3),CLR%(1):NEXT K
,I
35050 COLOR 6,0:LOCATE ,1:PRINT"Model no. chosen for validation/estimation : ";:
COLOR CLR%(4),CLR%(2):PRINT MNC$;:COLOR 6,0:PRINT"  [ blank => anisotropy ]";:GO
SUB 11502:GOSUB 11502
35060 NEXT J:SCREEN ,,0
35100 M=1:VF%=1:R%=6:N=1
35105 GOSUB 41000:FLD$=PLTM$(M):GOSUB 50000:PLTM$(M)=FLD$:GOSUB 46000:GOTO 35700

35110 GOSUB 41000:FLD$=CO$(M):GOSUB 50000:CO$(M)=FLD$:GOSUB 46000:GOTO 35700
35115 GOSUB 41000:FLD$=CD$(M,N):GOSUB 50000:CD$(M,N)=FLD$:GOSUB 46000:GOTO 35700

35120 GOSUB 41000:FLD$=C$(M,N):GOSUB 50000:C$(M,N)=FLD$:GOSUB 46000:GOTO 35700
35125 GOSUB 41000:FLD$=A$(M,N):GOSUB 50000:A$(M,N)=FLD$:GOSUB 46000:GOTO 35700
35145 R%=22:VF%=1:M=1:N=1:FLD$=MNC$:CMIN%=46:CMAX%=46:COLOR CLR%(4),CLR%(2):GOSU
B 50000:MNC$=FLD$:GOSUB 46000
35700 ON VF% GOTO 35105,35110,35115,35120,35125
35800 IF ASC(I$)=59 OR ASC(I$)=68 THEN LOCATE 25,1:COLOR 3,0:PRINT "Help option
of this module is incomplete. Sorry for the inconvinience.";TAB(79);:GOTO 35100
'F1-F10-help
35802 IF ASC(I$)=67 THEN 4100 'F9
35808 IF ASC(I$)<>60 THEN 35100 'F2
35810 SCREEN 2,0:DEF SEG=&HB800:OUT &H3D9,&H0:OUT &H3DD,&H60:CLS:OUT &H3DD,&H20:
CLS:BLOAD F2$,0:OUT &H3DD,&H60:BLOAD F1$,0
36000 FOR I=1 TO 8:PMF%(I)=1:CO(I)=VAL(CO$(I)):FOR J=1 TO 2
36100 IF PLTM$(I)="  " THEN PMF%(I)=0:GOTO 36700
36200 IF CD$(I,J)="s" OR CD$(I,J)="S" OR CD$(I,J)="e" OR CD$(I,J)="E" OR CD$(I,J
)="g" OR CD$(I,J)="G" OR CD$(I,J)="l" OR CD$(I,J)="L" THEN 36700 ELSE PMF%(I)=PM
```

```
F%(I)+J
36700 A(I,J)=VAL(A$(I,J)):C(I,J)=VAL(C$(I,J))
36800 IF A(I,J)>0! OR PMF%(I)=3 OR PMF%(I)=4 THEN 37400
37100 IF PMF%(I)=1 THEN IF J=1 THEN PMF%(I)=2 ELSE PMF%=3 ELSE PMF%(I)=4
37400 NEXT J,I
37500 FOR I=1 TO 8
37600 IF PMF%(I)=0 OR PMF%(I)=4 AND CO$(I)=SPACE$(8) THEN 39700
37700 GOSUB 46900:LOCATE 25,1,0:PRINT"Model";I;";CO=";CO$(I);";";" "I$;" A=";A$(
I,1);",C=";C$(I,1);" ";B$;" A=";A$(I,2);",C=";C$(I,2);
37800 YO=155-CO(I)*SY:PSET(80,YO):IF PMF%(I)=4 THEN LINE-(584,YO):GOTO 39700
37820 IF PMF%(I)=2 THEN N=2:M=2:GOTO 38100
37840 IF PMF%(I)=3 THEN N=1:M=1 ELSE N=1:M=2
38100 FOR J=81 TO 584:Y=0:FOR L=N TO M
38200 Q=(J-80)/SX:HOA=Q/A(I,L)
38500 IF CD$(I,L)="s" OR CD$(I,L)="S" THEN 38530 ELSE 38600
38530 IF Q=>A(I,L) THEN Y=Y+C(I,L) ELSE Y=Y+C(I,L)*(1.5*HOA-.5*HOA*HOA*HOA)
38560 GOTO 39300
38600 IF CD$(I,L)="e" OR CD$(I,L)="E" THEN Y=Y+C(I,L)*(1-EXP(-HOA)):GOTO 39300
38700 IF CD$(I,L)="g" OR CD$(I,L)="G" THEN Y=Y+C(I,L)*(1-EXP(-HOA*HOA)):GOTO 393
00
38800 Y=Y+C(I,L)*HOA
39300 NEXT L
39400 Y=YO-Y*SY:IF Y<11 THEN LOCATE Y/8+1,(J+4)/8:GOTO 39650
39600 PSET(J,Y):NEXT J:LOCATE Y/8,73-(I-1)*2
39650 PRINT RIGHT$(STR$(I),1)
39700 NEXT I:KF=1
39800 GOSUB 46980
40300 IF ASC(I$)=71 THEN SCREEN 0,0,0:GOTO 2100 'Home
40400 IF ASC(I$)=73 OR ASC(I$)=67 THEN SCREEN 0,0,0:GOTO 35000 'PgUp/F9
40500 IF ASC(I$)=81 OR ASC(I$)=60 THEN 40501 ELSE 39800
40501 SCREEN 0,0,0:GOTO 47000 'PgDn/F2
41000 ON VF% GOTO 45000,45010,45020,45030,45040
45000 CMIN%=16:CMAX%=18:COLOR CLR%(4),CLR%(2):RETURN
45010 CMIN%=29:CMAX%=36:COLOR CLR%(4),CLR%(2):RETURN
45020 CMIN%=44:CMAX%=44:GOTO 45050
45030 CMIN%=53:CMAX%=60:GOTO 45050
45040 CMIN%=69:CMAX%=76
45050 IF N=1 THEN COLOR CLR%(4),CLR%(2) ELSE COLOR CLR%(3),CLR%(1)
45060 RETURN
46000 ON NXT GOTO 46100,46200,46300,46400,46500,46600,46700,46800
46100 IF R%=22 THEN R%=6:VF%=1:M=1:N=1:RETURN
46110 IF R%=21 OR R%=20 AND VF%<3 THEN RETURN 35145
46120 IF VF%<3 THEN R%=R%+2:M=M+1:RETURN
46130 R%=R%+1:IF N=2 THEN N=1:M=M+1 ELSE N=2
46140 RETURN
46200 IF R%=6 THEN RETURN 35145
46210 IF R%=22 THEN R%=21:VF%=5:M=8:N=2:RETURN
46220 IF VF%<3 THEN R%=R%-2:M=M-1:RETURN
46230 R%=R%-1:IF N=2 THEN N=1 ELSE N=2:M=M-1
46240 RETURN
46300 IF R%=22 THEN R%=6:VF%=1:M=1:N=1:RETURN
46310 IF R%=21 AND VF%=5 THEN RETURN 35145
46320 IF N=2 AND VF%=5 THEN VF%=1:R%=R%+1:M=M+1:N=1:RETURN
46330 IF N=1 AND VF%=5 THEN N=2:VF%=3:R%=R%+1:RETURN
46340 VF%=VF%+1:RETURN
46400 IF R%=22 THEN R%=21:VF%=5:M=8:N=2:RETURN
46410 IF R%=6 AND VF%=1 THEN RETURN 35145
46420 IF VF%=1 THEN N=2:VF%=5:R%=R%-1:M=M-1:RETURN
46430 IF N=2 AND VF%=3 THEN N=1:VF%=5:R%=R%-1:RETURN
46440 VF%=VF%-1:RETURN
46500 RETURN 35810
46600 RETURN 4100
46700 RETURN 2100
46800 RETURN 35800
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```
46900 IF CD$(I,1)=" " THEN I$="" ELSE FLD$=CD$(I,1):GOSUB 46950:I$=FLD$
46910 IF CD$(I,2)=" " THEN B$="" ELSE FLD$=CD$(I,2):GOSUB 46950:B$=FLD$
46920 RETURN
46950 IF FLD$="s" OR FLD$="S" THEN FLD$="SPHER.":RETURN
46955 IF FLD$="e" OR FLD$="E" THEN FLD$="EXPON.":RETURN
46960 IF FLD$="g" OR FLD$="G" THEN FLD$="GAUS." ELSE FLD$="LINEAR"
46970 RETURN
46980 DEF SEG=0:POKE 1050,PEEK(1052)
46981 I$=INKEY$:IF I$="" THEN 46981
46982 IF LEN(I$)=1 THEN 46981
46983 I$=RIGHT$(I$,1):RETURN
47000 DEF SEG=&HB800:SCREEN 0,1,0,3:LOCATE ,,0:BLOAD"var43.scr",0
47005 COLOR 6,0:LOCATE 19,6:PRINT"CO"TAB(15)"Semivar.   Angle of"TAB(41)"Anisotr
opy"TAB(60)"C"TAB(74)"A":PRINT"Nugget Value    Code    Anisotropy"TAB(43)"Factor
"TAB(59)"Sill"TAB(72)"Range"
47010 COLOR CLR%(4),CLR%(2):LOCATE ,3:PRINT CO$;:LOCATE ,18:PRINT ACD$(1);:LOCAT
E ,27:PRINT AOA$(1);:LOCATE ,43:PRINT AF$(1);:LOCATE ,57:PRINT AC$(1);:LOCATE ,7
1:PRINT AA$(1)
47015 COLOR CLR%(3),CLR%(1):LOCATE ,18:PRINT ACD$(2);:LOCATE ,27:PRINT AOA$(2);:
LOCATE ,43:PRINT AF$(2);:LOCATE ,57:PRINT AC$(2);:LOCATE ,71:PRINT AA$(2):GOSUB
11502:SCREEN ,,0
47020 R%=21:COLOR CLR%(4),CLR%(2):FLD$=CO$:CMIN%=3:CMAX%=10:GOSUB 50000:CO$=FLD$
:ON NXT GOTO 47050,47050,47025,47070,47090,35000,2100,47075
47025 R%=21:COLOR CLR%(4),CLR%(2):FLD$=ACD$(1):CMIN%=18:CMAX%=18:GOSUB 50000:ACD
$(1)=FLD$:ON NXT GOTO 47050,47050,47030,47020,47090,35000,2100,47075
47030 R%=21:COLOR CLR%(4),CLR%(2):FLD$=AOA$(1):CMIN%=27:CMAX%=32:GOSUB 50000:AOA
$(1)=FLD$:ON NXT GOTO 47055,47055,47035,47025,47090,35000,2100,47075
47035 R%=21:COLOR CLR%(4),CLR%(2):FLD$=AF$(1):CMIN%=43:CMAX%=48:GOSUB 50000:AF$(
1)=FLD$:ON NXT GOTO 47060,47060,47040,47030,47090,35000,2100,47075
47040 R%=21:COLOR CLR%(4),CLR%(2):FLD$=AC$(1):CMIN%=57:CMAX%=64:GOSUB 50000:AC$(
1)=FLD$:ON NXT GOTO 47065,47065,47045,47035,47090,35000,2100,47075
47045 R%=21:COLOR CLR%(4),CLR%(2):FLD$=AA$(1):CMIN%=71:CMAX%=78:GOSUB 50000:AA$(
1)=FLD$:ON NXT GOTO 47070,47070,47050,47040,47090,35000,2100,47075
47050 R%=22:COLOR CLR%(3),CLR%(1):FLD$=ACD$(2):CMIN%=18:CMAX%=18:GOSUB 50000:ACD
$(2)=FLD$:ON NXT GOTO 47025,47025,47055,47045,47090,35000,2100,47075
47055 R%=22:COLOR CLR%(3),CLR%(1):FLD$=AOA$(2):CMIN%=27:CMAX%=32:GOSUB 50000:AOA
$(2)=FLD$:ON NXT GOTO 47030,47030,47060,47050,47090,35000,2100,47075
47060 R%=22:COLOR CLR%(3),CLR%(1):FLD$=AF$(2):CMIN%=43:CMAX%=48:GOSUB 50000:AF$(
2)=FLD$:ON NXT GOTO 47035,47035,47065,47055,47090,35000,2100,47075
47065 R%=22:COLOR CLR%(3),CLR%(1):FLD$=AC$(2):CMIN%=57:CMAX%=64:GOSUB 50000:AC$(
2)=FLD$:ON NXT GOTO 47040,47040,47070,47060,47090,35000,2100,47075
47070 R%=22:COLOR CLR%(3),CLR%(1):FLD$=AA$(2):CMIN%=71:CMAX%=78:GOSUB 50000:AA$(
2)=FLD$:ON NXT GOTO 47045,47045,47020,47065,47090,35000,2100
47075 IF ASC(I$)=59 OR ASC(I$)=68 THEN LOCATE 25,1:COLOR 3,0:PRINT "Help option
of this module is incomplete. Sorry for the inconvinience.";TAB(79);:GOTO 47020
'F1-F10-help
47080 IF ASC(I$)=67 THEN 35000 'F9
47085 IF ASC(I$)<>60 THEN 47020 'F2
47090 FOR I=1 TO 2:AF(I)=VAL(AF$(I)):IF AF(I)<1 THEN BEEP:LOCATE 25,1,0:COLOR 3,
0:PRINT"Anisotropy factor should be equal to or greater than one!"TAB(78);:GOTO
47100
47095 NEXT I:GOTO 47105
47100 IF I=1 THEN 47035 ELSE 47060
47105 SCREEN 2,0:OUT &H3DD,&H60:CLS:OUT &H3DD,&H20:CLS:OUT &H3D9,&H0
47110 RENK%=0:K=&H1010
47115 LINE(0,18)-(301,146),,B:LINE(150,16)-(150,17):LINE(150,148)-(150,147):LINE
(303,82)-(302,82):LINE(320,18)-(622,146),,B:LINE(471,16)-(471,17):LINE(471,148)-
(471,147):LINE(624,82)-(623,82):RENK%=RENK%+1:IF RENK%=1 THEN OUT &H3DD,&H60:GOT
O 47115
47120 FOR J=1 TO 2:IF ACD$(J)="s" OR ACD$(J)="S" OR ACD$(J)="g" OR ACD$(J)="G" O
R ACD$(J)="e" OR ACD$(J)="E" OR ACD$(J)="l" OR ACD$(J)="L" THEN XMAX=0:GOTO 4712
5 ELSE 47235
47125 IF ACD$(J)="l" OR ACD$(J)="L" THEN 47130 ELSE 47155
47130 FOR I=1 TO 8
```

```
47135 IF C(I,J)=0! THEN S(I,J)=0!:GOTO 47150 ELSE S(I,J)=A(I,J)/C(I,J):X=ABS(CAL
P#(I)*S(I,J)):Y=ABS(SALP#(I)*S(I,J))
47140 IF X>XMAX THEN XMAX=X
47145 IF Y>XMAX THEN XMAX=Y
47150 NEXT I:GOTO 47180
47155 FOR I=1 TO 8:X=ABS(CALP#(I)*A(I,J)):Y=ABS(SALP#(I)*A(I,J))
47160 IF X>XMAX THEN XMAX=X
47165 IF Y>XMAX THEN XMAX=Y
47170 NEXT I
47175 IF XMAX=0 THEN LOCATE 25,1:PRINT"Range of semivariogram models can't all b
e zero in 4.2. Hit any key to resume.";:GOSUB 62100:SCREEN 0,0,0:GOTO 47000
47180 SXA=150/XMAX:SYA=63/XMAX:Y2=82:IF J=1 THEN N=3:X2=150 ELSE N=43:X2=471
47185 LOCATE 1,N:PRINT"Anisotropy Ellipse * Submodel";J;"*":LOCATE ,N+17:PRINT"N
"TAB(N+35)"NE":LOCATE 11,N+36:PRINT"E":LOCATE 20,N+17:PRINT"S"TAB(N+35)"SE"
47190 FOR I=1 TO 8:IF CALP#(I)=0 THEN X=0:Y=63:GOTO 47205
47195 IF SALP#(I)=0 THEN X=150:Y=0:GOTO 47205
47200 X1=ABS(SALP#(I)/CALP#(I)):IF X1<.5 THEN X=SGN(CALP#(I))*150:Y=ABS(X)*X1*SG
N(SALP#(I))*5/12 ELSE Y=SGN(SALP#(I))*63:X=SGN(CALP#(I))*ABS(Y)/X1*2.4
47205 LINE(X2+X,Y2-Y)-(X2-X,Y2+Y),,,K
47210 IF ACD$(J)="I" OR ACD$(J)="L" THEN X=CALP#(I)*S(I,J)*SXA:Y=SALP#(I)*S(I,J)
*SYA ELSE X=CALP#(I)*A(I,J)*SXA:Y=SALP#(I)*A(I,J)*SYA
47215 LINE(X2+X,Y2-Y)-(X2-X,Y2+Y):NEXT I:OUT &H3DD,&H20
47220 AOA(J)=VAL(AOA$(J)):AC(J)=VAL(AC$(J)):AA(J)=VAL(AA$(J)):B=AA(J)/AF(J):AOA(
J)=RADC#*AOA(J):SALP#=SIN(AOA(J)):CALP#=COS(AOA(J))
47225 LOCATE 22,N:PRINT"Angle of Anisotropy = ";AOA$(J):LOCATE ,N:PRINT"Anisotro
py Factor   =";AF(J):LOCATE ,N:PRINT"Major Axis         =";2*AA(J);
47230 FOR C=0 TO 6.3 STEP .015:X=AA(J)*COS(C):Y=B*SIN(C):X1=(X*CALP#-Y*SALP#)*SX
A:Y1=(X*SALP#+Y*CALP#)*SYA:PSET(X2+X1,Y2-Y1),1:NEXT C
47235 OUT &H3DD,&H60:NEXT J
47240 GOSUB 46980
47605 IF ASC(I$)=71 THEN SCREEN 0,0,0:GOTO 2100 'Home
47610 IF ASC(I$)=73 OR ASC(I$)=67 THEN SCREEN 0,0,0:GOTO 47000 'PgUp/F9
47620 IF ASC(I$)=81 OR ASC(I$)=60 THEN SCREEN 0,0,0:GOTO 2100 ELSE 47240'PgDn/F2

50000 C%=CMIN%:LOCATE R%,C%,1  'EDITOR----------------------------------------
50010 DEF SEG=0:POKE 1050,PEEK(1052)
50020 I$=INKEY$:IF I$="" THEN 50020
50030 IF LEN(I$)=2 THEN I$=RIGHT$(I$,1):I=ASC(I$):GOTO 50220
50040 I=ASC(I$):IF I=9 OR I=13 THEN GOSUB 50430:NXT=3:RETURN 'Tab/Return
50050 IF I<>8 THEN 50080 'Backspace
50060 IF C%>CMIN% THEN B$=MID$(FLD$,C%-CMIN%+1,CMAX%-C%+1)+" ":FLD$=MID$(FLD$,1,
C%-CMIN%-1)+B$:C%=C%-1:LOCATE ,C%:PRINT B$;:LOCATE ,C% ELSE FLD$=MID$(FLD$,2,CMA
X%-C%+1)+" ":PRINT FLD$;:LOCATE ,CMIN%
50070 GOTO 50020
50080 IF I=27 THEN GOSUB 50430:FLD$=SPACE$(CMAX%-CMIN%+1):LOCATE ,CMIN%:PRINT FL
D$;:LOCATE ,CMIN%:C%=CMIN%'Esc
50090 IF I<32 THEN 50020  'Unprintable character
50100 IF INS THEN 50140   'Branch for insert mode
50110 '----Non insert mode data entry----------------------------------------
50120 PRINT I$:C%=C%+1:IF C%<CMAX%+1 THEN LOCATE R%,C%:CI%=C%-1 ELSE LOCATE R%,C
%-1:CI%=C%-1:C%=C%-1
50130 MID$(FLD$,CI%+1-CMIN%,1)=I$:GOTO 50020
50140 '----Insert mode data entry---------------------------------------------
50150 IF ASC(RIGHT$(FLD$,1))<>32 THEN BEEP:GOTO 50020
50160 B$=MID$(FLD$,C%-CMIN%+1,CMAX%-C%)
50170 FLD$=LEFT$(FLD$,C%-CMIN%)+I$+B$
50180 PRINT I$;:C%=C%+1:LOCATE ,C%:PRINT B$;:IF C%>CMAX% THEN C%=C%-1
50190 LOCATE ,C%:GOTO 50020
50200 '----Process special function key--------------------------------------
50210 I$=RIGHT$(I$,1)
50220 IF I=77 THEN 50230 ELSE 50240        'CR
50230 IF C%<CMAX% THEN C%=C%+1:LOCATE ,C%:GOTO 50020 ELSE BEEP:GOTO 50020
50240 IF I=75 THEN 50250 ELSE 50260        'CL
50250 IF C%>CMIN% THEN C%=C%-1:LOCATE ,C%:GOTO 50020 ELSE BEEP:GOTO 50020
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50260 IF I=72 THEN GOSUB 50430:NXT=2:RETURN 'CU
50270 IF I=15 THEN GOSUB 50430:NXT=4:RETURN 'Shift+Tab
50280 IF I=80 THEN GOSUB 50430:NXT=1:RETURN 'CD
50290 IF I=71 THEN GOSUB 50430:NXT=7:RETURN 'Home
50300 IF I<69 AND I>58 THEN GOSUB 50430:NXT=8:RETURN 'F-keys
50310 IF I=73 THEN GOSUB 50430:NXT=6:RETURN 'PgUp
50320 IF I=81 THEN GOSUB 50430:NXT=5:RETURN 'PgDn
50330 IF I=115 THEN C%=CMIN%:LOCATE ,C%:GOTO 50020 'Ctrl+CL
50340 IF I=116 THEN GOSUB 50430:LF=CMAX%-CMIN%+1 ELSE 50380 'Ctrl+CR
50350 FOR L=0 TO LF-1:B$=MID$(FLD$,LF-L,1):IF ASC(B$)<>32 THEN 50360 ELSE NEXT L

50360 C%=CMAX%-L+1:IF C%>CMAX% THEN LOCATE ,CMAX% ELSE LOCATE ,C%
50370 GOTO 50020
50380 IF I=82 THEN 50390 ELSE 50410    'Insert
50390 IF INS THEN INS=0:LOCATE ,,,6,7 ELSE INS=1:LOCATE ,,,4,7
50400 GOTO 50020
50410 IF I=83 THEN B$=MID$(FLD$,C%-CMIN%+2,CMAX%-C%)+" ":FLD$=MID$(FLD$,1,C%-CMI
N%)+B$:PRINT B$;:LOCATE ,C%:GOTO 50020 'Delete
50420 GOTO 50020                        'Undefined key
50430 IF INS THEN INS=0:LOCATE ,,,6,7
50440 RETURN '------------------------------------------------------------------
51000 COLOR 3,0:LOCATE 25,1,0:PRINT TAB(78);:RETURN
52000 BEEP:INPUT;"Type file name and hit RETURN ",FILE$:RETURN
53000 COLOR 0,0:LOCATE 25,1,0:IF SCREEN(25,1)<>32 THEN PRINT TAB(78);:RETURN
54000 GOSUB 51000:LOCATE ,1:PRINT"*LOAD*";:GOSUB 52000:GOSUB 51000:RETURN
54500 BEEP:LOCATE 25,1,0:COLOR 3,0:PRINT T$;TAB(78);:RETURN
57000 COLOR 27,0:LOCATE 25,1,0:PRINT"Please wait!";:COLOR 3:PRINT" This will not
 take more than a few seconds."TAB(78):RETURN
60000 IF ERR=52 OR ERR=64 OR ERR=66 OR ERR=68 OR ERR=75 OR ERR=76 THEN GOSUB 610
00 ELSE 60100
60010 IF ERL=11210 THEN RESUME 11206
60020 IF ERL=11264 THEN RESUME 11252 ELSE 60900
60100 IF ERR=53 THEN GOSUB 61100 ELSE 60150
60110 IF ERL=11210 THEN RESUME 11206 ELSE 60900
60150 IF ERR=62 THEN GOSUB 61150:CLOSE 1:RESUME 5050
60200 IF ERR=67 THEN GOSUB 61200:GOTO 60010 ELSE 60300
60300 IF ERR=61 THEN GOSUB 61300:GOTO 60010 ELSE 60400
60400 IF ERR=70 THEN GOSUB 61400:RESUME
60500 IF ERR=71 THEN GOSUB 61500:RESUME
60600 IF ERR=72 THEN GOSUB 61600:RESUME
60700 IF ERR=27 THEN GOSUB 61700:RESUME
60750 IF ERR><6 THEN 60800
60760 IF ERL=11212 THEN GOSUB 61150:CLOSE 1:RESUME 5050 ELSE 60900
60800 IF ERR=24 OR ERR=25 OR ERR=51 OR ERR=57 THEN GOSUB 61800 ELSE 60900
60900 LOCATE 25,1:PRINT"Programming error. ERR=";ERR;"ERL=";ERL;"Try again to re
create the problem!";TAB(78);:ON ERROR GOTO 0:STOP
61000 LOCATE 25,1:PRINT"Invalid file specification!";:GOTO 62000
61100 LOCATE 25,1:PRINT"File not found!";:GOTO 62000
61150 LOCATE 25,1:PRINT "Not the right file. Empty?";:GOTO 62000
61200 LOCATE 25,1:PRINT"Invalid file specification or too many files!";:GOTO 620
00
61300 LOCATE 25,1:PRINT"Invalid file specification or disk full!";:GOTO 62000
61400 LOCATE 25,1:PRINT"If the diskette is write-protected, change it!";:GOTO 62
000
61500 LOCATE 25,1:PRINT"If the diskette drive door is open, close it!";:GOTO 620
00
61600 LOCATE 25,1:PRINT"Diskette has gone bad, please replace it!";:GOTO 62000
61700 LOCATE 25,1:PRINT"Either printer has to be switched on or out of paper!";:
GOTO 62000
61800 LOCATE 25,1:PRINT"Unexpected error!";:GOTO 62000
62000 BEEP:PRINT" Hit any key and retry.";TAB(78);
62100 B$=INKEY$:IF B$<>"" THEN 62100
62200 B$=INKEY$:IF B$="" THEN 62200 ELSE RETURN
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```
1000 ON ERROR GOTO 2720:DEFINT I-N:MODULE$="krig"
1010 COMMON MS,CLR%(),D#(),E#(),N#(),R$(),DHL$(),BE#(),BN#(),DS$,PLS%,B%,V%,MN#,
VR#,CO$,ACD$(),AOA$(),AF$(),AC$(),AA$()
1020 DIM AOA(2),AF(2),AC(2),AA(2),TMX(2,3),CA(2),SA(2),DELH(2),IND(17),DIST(17),
CMX(17,17),RHS(17),WT(17)
1030 RADC#=.01745329251994З#:VL=1.7E+38
1040 CDF%=1:BL$=SPACE$(14):SR$=BL$:DP$="  ":PO$="y":XL$=BL$:YL$=BL$:XNUM$="    ":
YNUM$="    ":XO$=BL$:YO$=BL$
1050 FOR J=1 TO 2:IF J=1 THEN SCREEN 0,1,3,0 ELSE SCREEN ,,0,3
1060 COLOR 6,0:CLS:LOCATE 1,30,0:PRINT"5.ORDINARY KRIGING":PRINT:PRINT"Data file
 retreived : ";:COLOR CLR%(2),CLR%(4):PRINT R$(4):COLOR 6,0:PRINT"Project Title
     : ";:COLOR CLR%(1),CLR%(3):PRINT R$(6)
1070 COLOR 6,0:PRINT"Variable chosen      : ";:COLOR CLR%(2),CLR%(4):PRINT DS$
1080 LOCATE 7,6:COLOR 6,0:PRINT"CO"TAB(15)"Semivar.   Angle of"TAB(41)"Anisotrop
y"TAB(60)"C"TAB(74)"A":PRINT"Nugget Value     Code     Anisotropy"TAB(43)"Factor"T
AB(59)"Sill"TAB(72)"Range"
1090 COLOR CLR%(4),CLR%(2):LOCATE ,3:PRINT CO$;:LOCATE ,18:PRINT ACD$(1);:LOCATE
 ,27:PRINT AOA$(1);:LOCATE ,43:PRINT AF$(1);:LOCATE ,57:PRINT AC$(1);:LOCATE ,71
:PRINT AA$(1)
1100 COLOR CLR%(3),CLR%(1):LOCATE ,18:PRINT ACD$(2);:LOCATE ,27:PRINT AOA$(2);:L
OCATE ,43:PRINT AF$(2);:LOCATE ,57:PRINT AC$(2);:LOCATE ,71:PRINT AA$(2)
1110 PRINT:COLOR 6,0:PRINT"Search radius for the kriging estimator";TAB(57);": "
;:COLOR CLR%(4),CLR%(2):PRINT SR$
1120 COLOR 6,0:PRINT"Number of data points for the kriging estimator [ ≤15 ] : "
;:COLOR CLR%(3),CLR%(1):PRINT DP$:LOCATE 15:COLOR 6,0
1130 COLOR 6,0:LOCATE 15,51:PRINT"East           North/South":PRINT "Block dimens
ions";TAB(44);": ";:COLOR CLR%(4),CLR%(2):PRINT XL$;:LOCATE ,63:PRINT YL$
1140 COLOR 6,0:PRINT"Number of blocks";TAB(44);": ";:COLOR CLR%(3),CLR%(1):PRINT
 XNUM$;:LOCATE ,63:PRINT YNUM$
1150 COLOR 6,0:PRINT"Coordinates of the lower left-most block's":PRINT" center (
upper left-most in SE-Quadrant)";TAB(44)": ";:COLOR CLR%(4),CLR%(2):PRINT XO$;:L
OCATE ,63:PRINT YO$
1160 PRINT:COLOR 6,0:PRINT"Print out the estimated values [ (y)es,(n)o ] : ";:CO
LOR CLR%(3),CLR%(1):PRINT PO$
1170 LOCATE 23,1,0:COLOR 6,0:PRINT STRING$(79,95):COLOR 2:PRINT TAB(4)"F1/F10";:
COLOR 6:PRINT"Help-Detailed/Quick Ref.  ";:COLOR 2:PRINT"F2/PgDn";:COLOR 6:PRINT
"Proceed  ";:COLOR 2:PRINT"F9";:COLOR 6:PRINT"Previous Menu  ";TAB(78);
1180 NEXT J:SCREEN ,,0
1190 R%=9:COLOR CLR%(4),CLR%(2):FLD$=CO$:CMIN%=3:CMAX%=10:GOSUB 2220:CO$=FLD$:ON
 NXT GOTO 1200,1290,1200,1380,1200,1390,1200,1390        NORTH/SOUTH
1200 R%=9:COLOR CLR%(4),CLR%(2):FLD$=ACD$(1):CMIN%=18:CMAX%=18:GOSUB 2220:ACD$(1
)=FLD$:ON NXT GOTO 1250,1380,1210,1190,1200,1200,1200,1390
1210 R%=9:COLOR CLR%(4),CLR%(2):FLD$=AOA$(1):CMIN%=27:CMAX%=32:GOSUB 2220:AOA$(1
)=FLD$:ON NXT GOTO 1260,1380,1220,1200,1210,1210,1210,1390
1220 R%=9:COLOR CLR%(4),CLR%(2):FLD$=AF$(1):CMIN%=43:CMAX%=48:GOSUB 2220:AF$(1)=
FLD$:ON NXT GOTO 1270,1380,1230,1210,1220,1220,1220,1390
1230 R%=9:COLOR CLR%(4),CLR%(2):FLD$=AC$(1):CMIN%=57:CMAX%=64:GOSUB 2220:AC$(1)=
FLD$:ON NXT GOTO 1280,1380,1240,1220,1230,1230,1230,1390
1240 R%=9:COLOR CLR%(4),CLR%(2):FLD$=AA$(1):CMIN%=71:CMAX%=78:GOSUB 2220:AA$(1)=
FLD$:ON NXT GOTO 1290,1380,1250,1230,1240,1240,1240,1390
1250 R%=10:COLOR CLR%(3),CLR%(1):FLD$=ACD$(2):CMIN%=18:CMAX%=18:GOSUB 2220:ACD$(
2)=FLD$:ON NXT GOTO 1300,1200,1260,1240,1250,1250,1250,1390
1260 R%=10:COLOR CLR%(3),CLR%(1):FLD$=AOA$(2):CMIN%=27:CMAX%=32:GOSUB 2220:AOA$(
2)=FLD$:ON NXT GOTO 1300,1210,1270,1250,1260,1260,1260,1390
1270 R%=10:COLOR CLR%(3),CLR%(1):FLD$=AF$(2):CMIN%=43:CMAX%=48:GOSUB 2220:AF$(2)
=FLD$:ON NXT GOTO 1300,1220,1280,1260,1270,1270,1270,1390
1280 R%=10:COLOR CLR%(3),CLR%(1):FLD$=AC$(2):CMIN%=57:CMAX%=64:GOSUB 2220:AC$(2)
=FLD$:ON NXT GOTO 1300,1230,1290,1270,1280,1280,1280,1390
1290 R%=10:COLOR CLR%(3),CLR%(1):FLD$=AA$(2):CMIN%=71:CMAX%=78:GOSUB 2220:AA$(2)
=FLD$:ON NXT GOTO 1300,1240,1300,1280,1290,1290,1290,1390
1300 R%=12:COLOR CLR%(4),CLR%(2):FLD$=SR$:CMIN%=59:CMAX%=72:GOSUB 2220:SR$=FLD$:
ON NXT GOTO 1310,1290,1310,1290,1300,1300,1300,1390
1310 R%=13:COLOR CLR%(3),CLR%(1):FLD$=DP$:CMIN%=59:CMAX%=60:GOSUB 2220:DP$=FLD$:
ON NXT GOTO 1320,1300,1320,1300,1310,1310,1310,1390
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1320 R%=16:COLOR CLR%(4),CLR%(2):FLD$=XL$:CMIN%=46:CMAX%=59:GOSUB 2220:XL$=FLD$:
ON NXT GOTO 1340,1310,1330,1310,1320,1320,1330,1390
1330 R%=16:COLOR CLR%(4),CLR%(2):FLD$=YL$:CMIN%=63:CMAX%=76:GOSUB 2220:YL$=FLD$:
ON NXT GOTO 1350,1310,1340,1320,1330,1330,1330,1390
1340 R%=17:COLOR CLR%(3),CLR%(1):FLD$=XNUM$:CMIN%=46:CMAX%=48:GOSUB 2220:XNUM$=F
LD$:ON NXT GOTO 1360,1320,1350,1330,1340,1340,1340,1390
1350 R%=17:COLOR CLR%(3),CLR%(1):FLD$=YNUM$:CMIN%=63:CMAX%=65:GOSUB 2220:YNUM$=F
LD$:ON NXT GOTO 1370,1330,1360,1340,1350,1350,1350,1390
1360 R%=19:COLOR CLR%(4),CLR%(2):FLD$=XO$:CMIN%=46:CMAX%=59:GOSUB 2220:XO$=FLD$:
ON NXT GOTO 1380,1340,1370,1350,1360,1360,1360,1390
1370 R%=19:COLOR CLR%(4),CLR%(2):FLD$=YO$:CMIN%=63:CMAX%=76:GOSUB 2220:YO$=FLD$:
ON NXT GOTO 1380,1350,1380,1360,1370,1370,1370,1390
1380 R%=21:COLOR CLR%(3),CLR%(1):FLD$=PO$:CMIN%=49:CMAX%=49:GOSUB 2220:PO$=FLD$:
ON NXT GOTO 1190,1370,1190,1370,1380,1380,1380,1390
1390 IF ASC(I$)=59 OR ASC(I$)=68 THEN 1190 'F1-F10
1400 IF ASC(I$)=67 THEN GOSUB 2700:CHAIN"mainmenu" 'F9
1410 IF ASC(I$)=60 OR ASC(I$)=81 THEN 1420 ELSE 1190 'F2/PgDn
1420 COLOR 6,0:CLS:LOCATE 25,1,0:COLOR 27:PRINT"Please wait!";:COLOR 3:PRINT" Ca
lculations are in progress.";TAB(78);
1430 COLOR 6,0:LOCATE 1,24,0:PRINT"5.ORDINARY KRIGING (Results)":PRINT
1440 PRINT "Row";TAB(6);"Column";TAB(15);"East";TAB(30);"North";TAB(45);"Kriging
";TAB(60);"Kriging":PRINT TAB(45);"Estimate";TAB(60);"Variance":PRINT "---";TAB(
6);"------";TAB(15);"----";TAB(30);"-----";TAB(45);"--------";TAB(60);" -------"

1450 IFNI=1:IFNF=1
1460 FOR J=1 TO 2:AOA(J)=VAL(AOA$(J)):AF(J)=VAL(AF$(J)):AC(J)=VAL(AC$(J)):AA(J)=
VAL(AA$(J)):NEXT:CO=VAL(CO$):XL=VAL(XL$):YL=VAL(YL$):NX=VAL(XNUM$):NY=VAL(YNUM$)
:XO=VAL(XO$):YO=VAL(YO$):SR=VAL(SR$):NKP=VAL(DP$)
1470 FOR I=IFNI TO IFNF:CA(I)=COS(AOA(I)*RADC#):SA(I)=SIN(AOA(I)*RADC#):TMX(I,1)
=CA(I)*CA(I)+AF(I)*SA(I)*SA(I):TMX(I,2)=SA(I)*CA(I)*(1!-AF(I)):TMX(I,3)=SA(I)*SA
(I)+AF(I)*CA(I)*CA(I):NEXT
1480 'Calculate block variance
1490 CVV=0!
1500 IF XL=0! AND YL=0! THEN CVV=CO+AC(1)+AC(2):GOTO 1590
1510 FOR I=-2 TO 2:X1=I*XL/5!
1520 FOR K=-2 TO 2:Y1=K*YL/5!
1530 FOR II=-2 TO 2:X2=II*XL/5!
1540 FOR KK=-2 TO 2:Y2=KK*YL/5!
1550 GOSUB 2770
1560 CVV=CVV+C12
1570 NEXT KK:NEXT II:NEXT K:NEXT I
1580 CVV=CVV/625!
1590 IF PO$="y" OR PO$="Y" THEN 1600 ELSE 1630
1600 LPRINT "ROW";TAB(6);"COLUMN";TAB(15);"EAST";TAB(30);"NORTH";TAB(45);"KRIGIN
G";TAB(60);"KRIGING"
1610 LPRINT TAB(45);"ESTIMATE";TAB(60);"VARIANCE"
1620 LPRINT "---";TAB(6);"------";TAB(15);"----";TAB(30);"-----";TAB(45);"------
--";TAB(60);"--------"
1630 FOR II=1 TO NX:XOB=XO+(II-1)*XL
1640 FOR JJ=1 TO NY:YOB=YO+(JJ-1)*YL
1650 VKE=0!:VKV=0!
1660 'Find the NKP closest observations to (XOB,YOB) and place them in the
      pointer array IND
1670 FOR I=1 TO NKP+1:DIST(I)=VL:NEXT
1680 FOR I=1 TO PLS%
1690 DELX=XOB-E#(I):DELY=YOB-N#(I):DELH=(DELX*TMX(1,1)+DELY*TMX(1,2))^2+(DELX*TM
X(1,2)+DELY*TMX(1,3))^2
1700 FOR J=1 TO NKP:IF DELH<DIST(J) THEN 1720
1710 NEXT J:GOTO 1740
1720 FOR K=NKP TO J+1 STEP -1:SWAP IND(K),IND(K-1):SWAP DIST(K),DIST(K-1):NEXT K

1730 IND(J)=I:DIST(J)=DELH
1740 NEXT I
1750 FOR I=NKP TO 1 STEP -1
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1760 IF DIST(I)<=SR*SR THEN 1780
1770 NEXT I
1780 KP=I
1790 IF KP<1 THEN VKE=0!:VKV=-1!:KP=0:GOTO 2150
1800 'Form the C(v,v) matrix CMX
1810 FOR IJ=1 TO KP-1:LOC1=IND(IJ):CMX(IJ,KP+1)=1!
1820 FOR JI=IJ+1 TO KP:LOC2=IND(JI):X1=E#(LOC1):Y1=N#(LOC1):X2=E#(LOC2):Y2=N#(LO
C2)
1830 GOSUB 2780:CMX(IJ,JI)=C12
1840 NEXT JI:NEXT IJ
1850 FOR IJ=1 TO KP
1860 X1=0!:Y1=0!:X2=0!:Y2=0!
1870 GOSUB 2780:CMX(IJ,IJ)=C12
1880 NEXT IJ
1890 CMX(KP,KP+1)=1!:CMX(KP+1,KP+1)=0!
1900 'calculate C(v,V)
1910 FOR I=1 TO KP
1920 INDX=IND(I):X1=E#(INDX):Y1=N#(INDX):RHS(I)=0!
1930 FOR IJ=-2 TO 2:X2=XOB+IJ*XL/5!
1940 FOR K=-2 TO 2:Y2=YOB+K*YL/5!
1950 GOSUB 2780:RHS(I)=RHS(I)+C12
1960 NEXT K:NEXT IJ
1970 RHS(I)=RHS(I)/25!
1980 NEXT I
1990 RHS(KP+1)=1!
2000 'solve the system of linear equations using the Gaussian method
2010 FOR I=1 TO KP+1:WT(I)=RHS(I):NEXT I
2020 FOR I=1 TO KP
2030 FOR J=I+1 TO KP+1:T=CMX(I,J)/CMX(I,I):WT(J)=WT(J)-WT(I)*T
2040 FOR K=J TO KP+1:CMX(J,K)=CMX(J,K)-CMX(I,K)*T
2050 NEXT K:NEXT J:NEXT I
2060 FOR J=KP+1 TO 2 STEP -1:WT(J)=WT(J)/CMX(J,J)
2070 FOR I=1 TO J-1:WT(I)=WT(I)-WT(J)*CMX(I,J):NEXT I
2080 NEXT J:WT(1)=WT(1)/CMX(1,1)
2090 'Calculate the kriging estimate and variance
2100 VKE=0!:VKV=0!:XMU=WT(KP+1)
2120 FOR I=1 TO KP:VKE=VKE+WT(I)*D#(IND(I)):VKV=VKV+WT(I)*RHS(I):NEXT I
2130 VKV=CVV-VKV-XMU
2140 'Print out the result
2150 IF PO$="y" OR PO$="Y" THEN 2160 ELSE 2170
2160 LPRINT II;TAB(8);JJ;TAB(15);XOB;TAB(30);YOB;TAB(45);VKE;TAB(60);VKV:LPRINT
2170 PRINT II;TAB(8);JJ;TAB(15);XOB;TAB(30);YOB;TAB(45);VKE;TAB(60);VKV:PRINT
2180 NEXT JJ:NEXT II
2190 COLOR 3,0:LOCATE 25,1,0:PRINT"Calculations are over! Hit any key to continu
e";TAB(78);
2200 DEF SEG=0:POKE 1050,PEEK(1052)
2210 I$=INKEY$:IF I$="" THEN 2210 ELSE 1050
2220 C%=CMIN%: LOCATE R%,C%,1  'EDITOR---------------------------------------
2230 DEF SEG=0:POKE 1050,PEEK(1052)
2240 I$=INKEY$:IF I$="" THEN 2240
2250 IF LEN(I$)=2 THEN 2440
2260 IF ASC(I$)=9 THEN GOSUB 2660:NXT=3:RETURN  'Tab to next horiz. field
2270 IF ASC(I$)=13 THEN GOSUB 2660:NXT=3:RETURN 'Return key
2280 IF ASC(I$)=8 THEN 2290 ELSE 2310          'Backspace
2290 IF C%>CMIN% THEN B$=MID$(FLD$,C%-CMIN%+1,CMAX%-C%+1)+" ":FLD$=MID$(FLD$,1,C
%-CMIN%-1)+B$:C%=C%-1:LOCATE ,C%:PRINT B$;:LOCATE ,C% ELSE FLD$=MID$(FLD$,2,CMAX
%-C%+1)+" ":PRINT FLD$;:LOCATE ,CMIN%
2300 GOTO 2240
2310 IF ASC(I$)=27 THEN FLD$=SPACE$(CMAX%-CMIN%+1):LOCATE ,CMIN%:PRINT FLD$;:LOC
ATE ,CMIN%:C%=CMIN%             'ESC(clear field)
2320 IF ASC(I$)<32 THEN 2240  'Unprintable character
2330 IF INS%=1 THEN 2370      'Branch for insert mode
2340 '----Non insert mode data entry-----------------------------------------
2350 PRINT I$:C%=C%+1:IF C%<CMAX%+1 THEN LOCATE R%,C%:CI%=C%-1 ELSE LOCATE R%,C%
```

```
-1:CI%=C%-1:C%=C%-1
2360 MID$(FLD$,CI%+1-CMIN%,1)=I$:GOTO 2240
2370 '----Insert mode data entry-------------------------------------------
2380 IF ASC(RIGHT$(FLD$,1))<>32 THEN BEEP:GOTO 2240
2390 B$=MID$(FLD$,C%-CMIN%+1,CMAX%-C%)
2400 FLD$=LEFT$(FLD$,C%-CMIN%)+I$+B$
2410 PRINT I$;:C%=C%+1:LOCATE ,C%:PRINT B$;:IF C%>CMAX% THEN C%=C%-1
2420 LOCATE ,C%:GOTO 2240
2430 '----Process special function key--------------------------------------
2440 I$=RIGHT$(I$,1)
2450 IF I$=CHR$(77) THEN 2460 ELSE 2470          'CR
2460 IF C%<CMAX% THEN C%=C%+1:LOCATE ,C%:GOTO 2240 ELSE BEEP:GOTO 2240
2470 IF I$=CHR$(75) THEN 2480 ELSE 2490          'CL
2480 IF C%>CMIN% THEN C%=C%-1:LOCATE ,C%:GOTO 2240 ELSE BEEP:GOTO 2240
2490 IF I$=CHR$(72) THEN GOSUB 2660:NXT=2:RETURN 'CU
2500 IF I$=CHR$(15) THEN GOSUB 2660:NXT=4:RETURN 'Shift+Tab
2510 IF I$=CHR$(80) THEN GOSUB 2660:NXT=1:RETURN 'CD
2520 IF I$=CHR$(71) THEN GOSUB 2660:NXT=7:RETURN 'Home
2530 IF ASC(I$)<69 AND ASC(I$)>58 THEN GOSUB 2660:NXT=8:RETURN 'F-keys
2540 IF I$=CHR$(73) THEN GOSUB 2660:NXT=6:RETURN 'PgUp
2550 IF I$=CHR$(81) THEN LOCATE ,,0:GOSUB 2660:NXT=5:RETURN 'PgDn
2560 IF I$=CHR$(115) THEN C%=CMIN%:LOCATE ,C%:GOTO 2240 'Tab to beginning of
     field (Ctrl+CL)
2570 IF I$=CHR$(116) THEN GOSUB 2660:FL%=CMAX%-CMIN%+1 ELSE 2610 'Tab to end
 of field (Ctrl+CR)
2580 FOR L=0 TO FL%-1:B$=MID$(FLD$,FL%-L,1):IF ASC(B$)<>32 THEN 2590 ELSE NEXT L

2590 C%=CMAX%-L+1:IF C%>CMAX% THEN LOCATE ,CMAX% ELSE LOCATE ,C%
2600 GOTO 2240
2610 IF I$=CHR$(82) THEN 2620 ELSE 2640   'Insert-----------------------
2620 IF INS%=0 THEN INS%=1:LOCATE R%,C%,,4,7 ELSE INS%=0:LOCATE ,,,6,7
2630 GOTO 2240
2640 IF I$=CHR$(83) THEN B$=MID$(FLD$,C%-CMIN%+2,CMAX%-C%)+" ":FLD$=MID$(FLD$,1,
C%-CMIN%)+B$:PRINT B$;:LOCATE ,C%:GOTO 2240 'Delete
2650 GOTO 2240                                    'Undefined key
2660 IF INS%=1 THEN INS%=0:LOCATE ,,,6,7: '-----Cancel Insert--------------
2670 RETURN '-------------------------------------------------------------
2680 COLOR 3,0:LOCATE 25,1,0:PRINT TAB(78);:RETURN
2690 COLOR 0,0:LOCATE 25,1,0:IF SCREEN(25,1)<>32 THEN PRINT TAB(78);:RETURN
2700 COLOR 27,0:LOCATE 25,1,0:PRINT"Please wait!";:COLOR 3:PRINT" This will not
take more than a few seconds."TAB(78);:RETURN
2710 'Error routine
2720 IF ERR=27 THEN LOCATE 25,1:PRINT"Either printer has to be switched on or ou
t of paper!";:GOSUB 2740:RESUME
2730 LOCATE 25,1:PRINT"Unexpected error! Change the parameters to avoid it.";:GO
SUB 2740:RESUME
2740 BEEP:PRINT" Hit any key and retry.";TAB(78);
2750 B$=INKEY$:IF B$<>"" THEN 2750
2760 B$=INKEY$:IF B$="" THEN 2760 ELSE RETURN
2770 'This subroutine calculates the covariance between two points (X1,Y1) and (
X2,Y2) as c12.
2780 C12=0!:DELX=X1-X2:DELY=Y1-Y2
2790 FOR J=IFNI TO IFNF
2800 DELH(J)=SQR((DELX*TMX(J,1)+DELY*TMX(J,2))^2+(DELX*TMX(J,2)+DELY*TMX(J,3))^2
)
2810 IF DELH(J)=>AA(J) THEN 2880
2820 IF DELH(J)=0! THEN C12=C12+C0+AC(J):GOTO 2880
2830 HOA=DELH(J)/AA(J)
2840 IF ACD$(J)="l" OR ACD$(J)="L" THEN C12=C12+AC(J)*(1!-HOA):GOTO 2880
2850 IF ACD$(J)="s" OR ACD$(J)="S" THEN C12=C12+AC(J)*(1!-1.5*HOA+.5*HOA*HOA*HOA
):GOTO 2880
2860 IF ACD$(J)="e" OR ACD$(J)="E" THEN C12=C12+AC(J)*EXP(-HOA):GOTO 2880
2870 C12=C12+AC(J)*EXP(-HOA*HOA)
2880 NEXT J:RETURN
```

```
1000 REM*MODULE NAME = HLP.BAS
1010 DIM SCN%(4),ST%(3),PGNO%(3),PGNO$(3),S%(7),SP%(7,4)
1020 FOR I%=1 TO 7:READ S%(I%):NEXT:DATA 0,3,0,0,0,0,0
1030 FOR I%=1 TO 7:FOR J%=1 TO 4:READ SP%(I%,J%):NEXT J%:NEXT I%
1040 DATA 7,0,0,0,4,1,1,1,3,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
1050 PGL%=17:PN$=SPACE$(6):CH%=25:SCN%(1)=0:SCN%(2)=0:SCN%(3)=0
1060 FIELD 3,239 AS F$(1),239 AS F$(2),239 AS F$(3),239 AS F$(4),239 AS F$(5),23
9 AS F$(6),239 AS F$(7),239 AS F$(8)
1070 IF HPAGE%>1 THEN 1250
1080 SCN%(1)=HPAGE%:SCN%(2)=HPAGE%+1:SCN%(3)=HPAGE%+2:CH%=25:LOCATE ,,0:K%=0
1090 FOR I%=1 TO 3:SCREEN ,,I%,1:COLOR 2,0:CLS:GET 3,I%:FOR J%=1 TO 8:PRINT F$(J
%);:NEXT J%:GOSUB 1840:NEXT I%
1100 SCREEN ,,1:STATE%=1
1110 COLOR 7,1:LOCATE 25,CH%,1
1120 GOSUB 1850
1130 IF I$=CHR$(77) THEN 1140 ELSE 1160'CR.
1140 IF CH%<30 THEN CH%=CH%+1:LOCATE ,CH%
1150 GOTO 1120
1160 IF I$=CHR$(75) THEN 1170 ELSE 1190'CL
1170 IF CH%>25 THEN CH%=CH%-1:LOCATE ,CH%
1180 GOTO 1120
1190 IF I$=CHR$(71) THEN 1800'Home
1200 IF I$=CHR$(81) THEN STATE%=2:CH%=25:K%=2:GOTO 1480'PgDn
1210 IF I$=CHR$(73) THEN CH%=25:I$="This is the first page!":GOSUB 2110:GOTO 112
0'PgUp
1220 IF I$<>CHR$(60) THEN 1120'F2
1230 GOSUB 1900:IF HPAGE%>PGL% OR HPAGE%<1 THEN 1240 ELSE 1070
1240 CH%=25:I$="Sorry! This page has not been edited yet.":GOSUB 2110:GOTO 1120
1250 IF HPAGE%<PGL% THEN 1430
1260 SCN%(3)=HPAGE%:SCN%(2)=HPAGE%-1:SCN%(1)=HPAGE%-2:CH%=25:LOCATE ,,0:K%=1
1270 FOR I%=3 TO 1 STEP -1:SCREEN ,,I%,3:COLOR 2,0:CLS:GET 3,HPAGE%:FOR J%=1 TO
8:PRINT F$(J%);:NEXT J%:GOSUB 1840:HPAGE%=HPAGE%-1:NEXT I%
1280 SCREEN ,,3:STATE%=3
1290 COLOR 7,1:LOCATE 25,CH%,1
1300 GOSUB 1850
1310 IF I$=CHR$(77) THEN 1320 ELSE 1340'CR
1320 IF CH%<30 THEN CH%=CH%+1:LOCATE ,CH%
1330 GOTO 1500
1340 IF I$=CHR$(75) THEN 1350 ELSE 1370'CL
1350 IF CH%>25 THEN CH%=CH%-1:LOCATE ,CH%
1360 GOTO 1500
1370 IF I$=CHR$(71) THEN 1800'Home
1380 IF I$=CHR$(81) THEN CH%=25:I$="This is the last page!":GOSUB 2110:GOTO 1300
'PgDn
1390 IF I$=CHR$(73) THEN STATE%=2:CH%=25:K%=2:GOTO 1480'PgUp
1400 IF I$<>CHR$(60) THEN 1500 ELSE GOSUB 1900'F2
1410 IF HPAGE%>PGL% OR HPAGE%<1 THEN 1420 ELSE 1070
1420 CH%=25:I$="Sorry! This page has not been edited yet.":GOSUB 2110:GOTO 1300
1430 LOCATE ,,0:CH%=25:K%=2
1440 SCN%(1)=HPAGE%-1:SCN%(2)=HPAGE%:SCN%(3)=HPAGE%+1
1450 SCREEN ,,2,2:COLOR 2,0:CLS:STATE%=2:GET 3,HPAGE%:FOR J%=1 TO 8:PRINT F$(J%)
;:NEXT:GOSUB 1840
1460 SCREEN ,,1,2:COLOR 2,0:CLS:GET 3,HPAGE%-1:FOR J%=1 TO 8:PRINT F$(J%);:NEXT:
GOSUB 1840
1470 SCREEN ,,3,2:COLOR 2,0:CLS:GET 3,HPAGE%+1:FOR J%=1 TO 8:PRINT F$(J%);:NEXT:
GOSUB 1840
1480 SCREEN ,,2
1490 COLOR 7,1:LOCATE ,CH%,1
1500 GOSUB 1850
1510 IF I$=CHR$(71) THEN 1800'Home
1520 IF I$=CHR$(81) THEN 1530 ELSE 1620'PgDn
1530 HPAGE%=SCN%(STATE%)+1
1540 IF HPAGE%=PGL% THEN 1260 ELSE ST%(1)=STATE%
1550 FOR I%=1 TO 3
```

```
1560 IF I%=STATE% THEN 1580
1570 IF SCN%(I%)=HPAGE% THEN ST%(2)=I% ELSE IF SCN%(I%)=HPAGE%-2 THEN ST%(3)=I%
1580 NEXT
1590 SCREEN ,,ST%(3),ST%(2):COLOR 2,0:CLS:LOCATE ,,0:GET 3,HPAGE%+1:FOR J%=1 TO
8:PRINT F$(J%);:NEXT:GOSUB 1840
1600 SCREEN ,,ST%(2):CH%=25:COLOR 7,1:LOCATE ,CH%,1
1610 SCN%(ST%(1))=HPAGE%-1:SCN%(ST%(2))=HPAGE%:SCN%(ST%(3))=HPAGE%+1:STATE%=ST%(
2):GOTO 1500
1620 IF I$=CHR$(73) THEN 1630 ELSE 1710'PgUp
1630 HPAGE%=SCN%(STATE%)-1:IF HPAGE%=1 THEN 1080
1640 ST%(3)=STATE%
1650 FOR I%=1 TO 3
1660 IF I%=STATE% THEN 1670 ELSE IF SCN%(I%)=HPAGE% THEN ST%(2)=I% ELSE IF SCN%(
I%)=HPAGE%+2 THEN ST%(1)=I%
1670 NEXT
1680 SCREEN ,,ST%(1),ST%(2):COLOR 2,0:CLS:LOCATE ,,0:GET 3,HPAGE%-1:FOR J%=1 TO
8:PRINT F$(J%);:NEXT:GOSUB 1840
1690 SCREEN ,,ST%(2):CH%=25:COLOR 7,1:LOCATE ,CH%,1
1700 SCN%(ST%(1))=HPAGE%-1:SCN%(ST%(2))=HPAGE%:SCN%(ST%(3))=HPAGE%+1:STATE%=ST%(
2):GOTO 1500
1710 IF I$=CHR$(77) THEN 1720 ELSE 1740'CR
1720 IF CH%<30 THEN CH%=CH%+1:LOCATE ,CH%
1730 GOTO 1500
1740 IF I$=CHR$(75) THEN 1750 ELSE 1770'CL
1750 IF CH%>25 THEN CH%=CH%-1:LOCATE ,CH%
1760 GOTO 1500
1770 IF I$<>CHR$(60) THEN 1500'F2
1780 GOSUB 1900:IF HPAGE%>PGL% OR HPAGE%<1 THEN 1790 ELSE 1070
1790 CH%=25:I$="Sorry! This page has not been edited yet.":GOSUB 2110:GOTO 1500
1800 ERASE SCN%,ST%,PGNO%,PGNO$,S%,SP%
1810 SCREEN ,,0:COLOR 27,0:LOCATE 25,1,0:PRINT"Please wait";:COLOR 3:PRINT" unti
l the cursor appears on the screen!";SPACE$(28);
1820 CHAIN MODULE$,L%,ALL
1830 REM*PRINT 25th LINE FOR HELP
1840 PN$=SPACE$(6):COLOR 0,6:LOCATE 25,1,0:PRINT"PgDn";:COLOR ,0:PRINT"  ";:COLO
R ,6:PRINT"PgUp";:COLOR ,0:PRINT"  ";:COLOR ,6:PRINT"Home";:COLOR ,0:PRINT"  ";:
COLOR ,6:PRINT"Page #";:COLOR 7,1:PRINT PN$;:COLOR 0,6:PRINT"+F2";:RETURN
1850 I$=INKEY$:IF I$="" THEN 1850
1860 COLOR 0,0:LOCATE 25,36,0:IF SCREEN(25,36)<>32 THEN PRINT SPACE$(44);
1870 COLOR 7,1:LOCATE ,CH%,1:IF LEN(I$)=2 THEN I$=RIGHT$(I$,1):RETURN ELSE IF AS
C(I$)<32 THEN 1850 ELSE LOCATE ,,0:PRINT I$;:I%=CH%:IF CH%<30 THEN CH%=CH%+1:LOC
ATE ,,1 ELSE LOCATE ,CH%,1
1880 MID$(PN$,I%-24,1)=I$:GOTO 1850
1890 REM*CONVERT PAGE CODE TO RECORD NUMBER
1900 IF MID$(PN$,2,1)="." THEN 1910 ELSE CH%=26:GOTO 1920
1910 IF MID$(PN$,4,1)="." THEN 1930 ELSE CH%=28
1920 I$="Invalid page # format! Need a period.":GOSUB 2110:GOTO 2100
1930 FOR I%=1 TO 5 STEP 2:D$=MID$(PN$,I%,1)
1940 IF ASC(D$)>47 AND ASC(D$)<58 THEN 1950 ELSE CH%=24+I%:I$="Invalid character
 in page # field!":GOSUB 2110:GOTO 2100
1950 NEXT
1960 PGNO$(1)=MID$(PN$,1,1):PGNO$(2)=MID$(PN$,3,1):PGNO$(3)=MID$(PN$,5,2)
1970 PGNO%(1)=VAL(PGNO$(1)):PGNO%(2)=VAL(PGNO$(2)):PGNO%(3)=VAL(PGNO$(3))
1980 IF PGNO%(1)<8 AND PGNO%(1)>0 THEN 2000
1990 CH%=25:I$="Page # starts with a number between 1 and 7!":GOSUB 2110:GOTO 21
00
2000 IF PGNO%(2)<S%(PGNO%(1))+1 AND PGNO%(2)=>0 THEN 2020
2010 CH%=27:I$="There are"+STR$(S%(PGNO%(1)))+" submenus in menu "+PGNO$(1)+"!":
GOSUB 2110:GOTO 2100
2020 IF (PGNO%(3)<SP%(PGNO%(1),PGNO%(2)+1)+1) AND PGNO%(3)>0 THEN 2060
2030 D$=STR$(SP%(PGNO%(1),PGNO%(2)+1)):I$=PGNO$(1)+"."+PGNO$(2)+"."
2040 IF LEN(D$)=2 THEN D$=RIGHT$(D$,1) ELSE D$=RIGHT$(D$,2)
2050 CH%=29:I$="Valid page #s are between "+I$+"1 and "+I$+D$+"!":GOSUB 2110:GOT
O 2100
```

```
2060 IF PGNO%(1)=1 THEN HPAGE%=PGNO%(3):RETURN
2070 HPAGE%=0:FOR I%=1 TO PGNO%(1)-1:FOR J%=1 TO S%(I%)+1:HPAGE%=HPAGE%+SP%(I%,J
%):NEXT J%:NEXT I%:IF PGNO%(2)=0 THEN 2090
2080 FOR J%=1 TO PGNO%(2):HPAGE%=HPAGE%+SP%(PGNO%(1),J%):NEXT
2090 HPAGE%=HPAGE%+PGNO%(3):RETURN
2100 IF K%=0 THEN RETURN 1120 ELSE IF K%=1 THEN RETURN 1300 ELSE RETURN 1500
2110 BEEP:LOCATE ,36,0:COLOR 3,0:PRINT I$;:COLOR 7,1:LOCATE ,CH%,1:RETURN
```

APPENDIX B

DATA FOR THE CASE STUDY

No.	Drill Hole Code	E-Coordinate	N/S-Coordinate	Seam Thick.(m)	Top of Seam(m)	Seam Depth(m)	R.D.(t/cu.m.)
1	1014	8016.58	17196.53	1.32	138.68	15.1	1.43
2	1021	8598.13	18599.31	1.66	90.86	69.8	1.61
3	1022	7941.36	17450.59	1.34	140.45	13.02	1.38
4	1023	8865.45	18599.87	3.09	114.96	43.3	1.48
5	1028avd w/1319	7945.80	17699.39	1.715	130.56	25.73	?
6	1029	8215.81	17699.89	2.27	111.7	45.37	1.58
7	1061	7532.91	17991.	1.59	145.52	15.51	1.37
8	1062	7633.50	17992.76	1.39	142.17	18.02	?
9	1063	7758.98	18300.09	1.57	128.16	35.08	1.38
10	1091	8090.51	16798.32	1.21	141.68	20.37	1.39
11	1123	7264.01	18910.59	1.79	144.62	23.09	1.4
12	1213	9335.	14549.	?.67	124.8	?28.2	?1.42
13	1214	9750.54	14549.71	?.67	93.1	?55.59	?1.44
14	1217	10206.27	21193.34	?.43	127.08	?35.27	?1.51
15	1240	7881.55	19298.97	3.89	110.48	46.05	1.48
16	1241	7166.16	18599.7	.99	146.59	16.61	1.37
17	1242	7463.80	18300.47	1.53	147.13	16.62	1.39
18	1244	9271.51	17996.42	.83	86.22	65.10	1.69
19	1245	8028.15	16150.69	1.6	150.35	18.22	1.5
20	1248	8141.54	17451.08	1.75	122.88	29.74	1.49
21	1250	8656.73	15350.62	.93	135.78	23.69	1.4
22	1258	7317.66	19634.2	1.65	126.24	32.4	1.52
23	1308	7739.97	19642.46	3.09	128.47	27.9	1.43
24	1317avd w/818	7456.97	18600.94	1.805	135.41	28.45	?
25	1319avd w/1028	7945.80	17699.39	?1.7	?130.7	?25.59	?
26	214	7444.57	18910.82	1.81	135.47	28.7	1.43
27	229	8379.2	15677.79	1.36	136.83	27.3	1.41
28	238	10187.30	21565.35	?2.44	122.42	35.8	?1.41

No.	Drill Hole Code	E-Coordinate	N/S-Coordinate	Seam Thick. (m)	Top of Seam(m)	Seam Depth(m)	R.D. (t/cu.m.)
29	246	8163.56	16444.56	1.47	142.31	23.9	1.42
30	303	7721.3	17992.83	1.61	136.48	23.72	1.41
31	307	8264.92	17990.84	2.29	103.75	56.32	1.64
32	313	7874.11	18915.44	1.74	111.18	48.6	1.53
33	739	7102.1	19299.06	1.8	140.11	23.11	?
34	740	11175.18	15619.78	?.95	110.43	43.	?
35	818avd w/1317	7456.97	18600.94	?1.68	?135.26	?28.60	?
36	864	8256.77	16799.35	1.45	127.08	35.88	1.45
37	865	8128.26	15895.11	1.41	148.51	20.92	1.43
38	890	8444.92	15896.76	1.44	125.71	40.89	1.46
39	931	8341.27	16151.75	1.53	133.16	33.87	1.43
40	935	7803.03	18600.2	1.36	119.06	42.14	1.47
41	976	8059.88	16446.81	2.82	143.23	24.19	1.4

No.	Drill Hole Code	E-Coordinate	N/S-Coordinate	Ash(%)	Sulfur(%)	S.Ener.(MJ/kg)	Seam Accumltn.
1	1014	8016.58	17196.53	13.3	.37	28.21	1.8876
2	1021	8598.13	18599.31	36.2	?	?	2.6725
3	1022	7941.36	17450.59	10.9	.39	30.2	1.8492
4	1023	8865.45	18599.87	18.5	?	?	4.5732
5	1028avd w/1319	7945.80	17699.39	?	?	?	?
6	1029	8215.81	17699.89	28.1	?	?	3.5866
7	1061	7532.91	17991.	12.3	?	?	2.1783
8	1062	7633.50	17992.76	?	?	?	?
9	1063	7758.98	18300.09	13.2	?	?	2.1666
10	1091	8090.51	16798.32	13.2	?	?	1.6819
11	1123	7264.01	18910.59	14.9	?	?	2.506
12	1213	9335.	14549.	?16.5	?	?	?
13	1214	9750.54	14549.71	?21.5	?	?	?
14	1217	10206.27	21193.34	?22.1	?	?	?
15	1240	7881.55	19298.97	23.7	?	?	5.7572
16	1241	7166.16	18599.7	10.8	?	?	1.3563
17	1242	7463.80	18300.47	13.3	?	?	2.1267
18	1244	9271.51	17996.42	41.5	?	?	1.4027
19	1245	8028.15	16150.69	13.1	.33	22.46	2.4
20	1248	8141.54	17451.08	25.8	?	?	2.6075
21	1250	8656.73	15350.62	11.9	?	?	1.302
22	1258	7317.66	19634.2	27.2	?	?	2.508
23	1308	7739.97	19642.46	18.3	?	?	4.4187
24	1317avd w/818	7456.97	18600.94	?	?	?	?
25	1319avd w/1028	7945.80	17699.39	?	?	?	?
26	214	7444.57	18910.82	16.3	?	?	2.5883
27	229	8379.2	15677.79	12.8	?	?	1.3176
28	238	10187.30	21565.35	?11.9	?	?	?

No.	Drill Hole Code	E-Coordinate	N/S-Coordinate	Ash(%)	Sulfur(%)	S.Ener.(MJ/kg)	Seam Accumltn.
29	246	8163.56	16444.56	15.2	?	?	2.0874
30	303	7721.3	17992.83	14.9	?	?	2.2701
31	307	8264.92	17990.84	36.2	.89	21.41	3.7556
32	313	7874.11	18915.44	29.8	?	?	2.6622
33	739	7102.1	19299.06	?	?	?	?
34	740	11175.18	15619.78	?	?	?	?
35	818avd w/1317	7456.97	18600.94	?	?	?	?
36	864	8256.77	16799.35	19.2	?	?	2.1025
37	865	8128.26	15895.11	10.3	.36	27.62	2.0163
38	890	8444.92	15896.76	20.1	?	?	2.1024
39	931	8341.27	16151.75	17.1	?	?	2.1879
40	935	7803.03	18600.2	23.1	?	?	1.9992
41	976	8059.88	16446.81	10.9	?	?	3.948

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