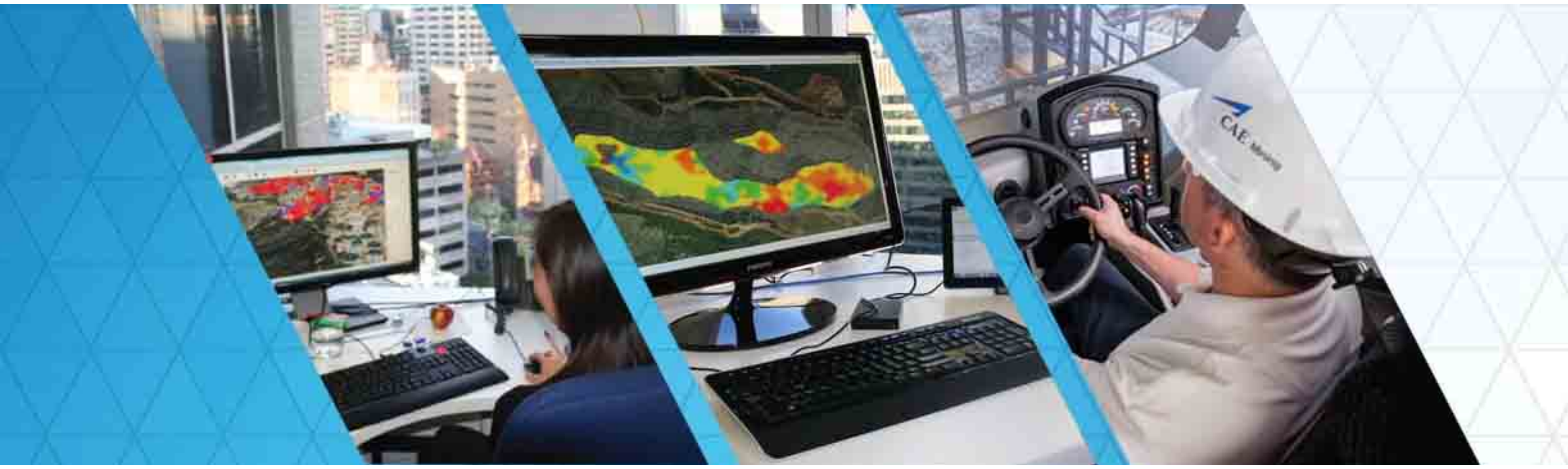
Studio 3

CAE Mining

Grade Estimation User Guide



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Studio 3 Grade Estimation User Guide

This tutorial introduces you to the key **Studio 3** features used for grade estimation. Typically 'grades' are estimated into the cells of a geological block model in order to generate a resource block model, which would then be used as input into the ore reserve optimisation or generation process of a mine planning cycle. Alternatively, 'grades' can estimated using panel (mining block) outlines and results saved to a results table, without creating a block model.

> 'Grades' are typically concentrations of the minerals or elements of interest. The use of the grade estimation techniques is not restricted to mineral or element concentrations but can also be used to estimate other numerical properties or attributes of interest e.g. layer, rock mass or material properties; geochemical, geomechanical or metallurgical properties.

This tutorial covers techniques for both 2- and 3-dimensional estimation exercises. The input for a grade estimation exercise typically uses the results from a geostatistical analysis in order to define mineralization zones and their associated grade estimation parameters.

This tutorial includes introductory sections, procedures and exercises covering the following topics:

- Defining grade estimation parameters (in both 2D and 3D)
- Basic estimation tools and techniques
- Advanced estimation tools and techniques
- Evaluation and reporting (generation of summary tonnes and grades)
- Presentation of grade estimation data e.g. as plan plots

The Main Grade Estimation Processes

Grades are typically estimated for individual block model cells, although grades can also be estimated directly for panels (mining blocks) defined by closed strings or perimeters. The following **Studio 3** processes are used to estimate grades:

- **GRADE** - basic grade estimation process, with the following key features:
    - estimation into block model cells
    - search, variogram model and estimation parameters input as process parameters
    - single grade estimates
    - a subset of estimation methods
- **ESTIMA** - advanced grade estimation process, with the following features:

    - estimation into block model cells
    - search, variogram model and estimation parameters input as process parameters or parameter files
    - can be recorded into a macro or script
    - the full set of estimation methods

- **ESTIMATE** - dialog controlled, advanced grade estimation process, with the following key features:
    - estimation into block model cells
    - controlled via interactive dialogs
    - calculation of multiple simultaneous grade estimates
    - search, variogram and estimation parameters stored in tables
    - the full set of estimation methods
    - advanced features
- **PANELEST** - panel grade estimation process, with the following key features:
    - estimation of panel outlines (strings) output to a results table
    - can be recorded into a macro or script
    - panels defined by input closed strings or perimeters file

Grade Estimation Methods

The following grade estimation methods are available in **Studio 3**:

- Nearest neighbour
- Inverse Power Distance
- Ordinary Kriging
- Simple Kriging
- Indicator Estimation
- Sichel's T.

Grade Estimation Inputs

The inputs to the above **Studio 3** process typically include a sample file, block model, search volume parameters, variogram model parameters (if a kriging estimation method is used), estimation parameters and panels (if the panel grade estimation process is used). Parameters are stored in parameter files or as parameters within each process. These are summarized below:

Samples

Sample grades can be point data or drillholes.

Block Model

All the block model grade estimation methods require a prototype block model to interpolate the sample grades into.

If the specified prototype model already contains cells and subcells, e.g. a geological block model, then grade values will be interpolated into the existing cells. If it is empty, however, then cells and subcells will be created if there are sufficient samples within the search volume.

Search Volume

A search volume ellipsoid defines the spatial limits and associated parameters used for selecting which samples are to be used when estimating grades into a block model cell; this search volume and its parameters will be the same for each cell in a particular zone and is centered on the cell being estimated.

More than one search volume may be defined e.g. for zonal control or for different grade fields.

Variogram Models

Variogram model parameters are defined according to a particular standard and are stored either in a parameter file e.g. as output from the **VARFIT** variogram modeling process, or as parameters within the Studio 3 process. The following variogram models are available.

- Spherical (single or multiple structures)
- Power
- Exponential
- Gaussian
- De Wijsian.

Panels

Panels are stored as closed strings (perimeters) within a strings file and are required for the PANELEST process. Perimeters need to be coplanar and define the limits of each panel whose grade is to be estimated.

Estimation Parameters

It is necessary to provide a set of estimation parameters for each grade to be estimated. These parameters may be stored as a parameter file, or they can be defined as parameters within the process. The parameters should include items such as the estimation method, the search volume reference number and variogram reference number (if a kriging estimation method is used).

Grade Estimation Outputs

The output from a block model grade estimation method is a grade block model which contains values for each estimated grade field. Additional output fields may include estimation variance, number of samples and search volume information. These additional fields can be used for the determination of confidence limits for the grade estimates or for controlling detailed evaluations. Detailed or summary evaluations can be performed on these grade block models to generate tonnage-grade reports.

In the case of the panel estimation process, the output is a results file i.e. a summary tonnage-grade report.

The Grade Estimation Data Sets

Viking Bounty - Soil Sampling Data Set (2 Dimensions)

Geological Setting

The initial exploration programme for the Viking Bounty project consisted of a soil sampling campaign focused on delineating the extent of Au and Cu anomalies associated with the hydrothermal Cu-Au mineralization in the project area. The sampling points have an approximate spacing of 80m outside the main anomaly zones and 40m within these zones. The extent of the mineralization zones has been determined by using various grade estimation methods in a 2D 40x40x10m celled block model. The surface contours, sampling points and block model cells are shown in the image below:

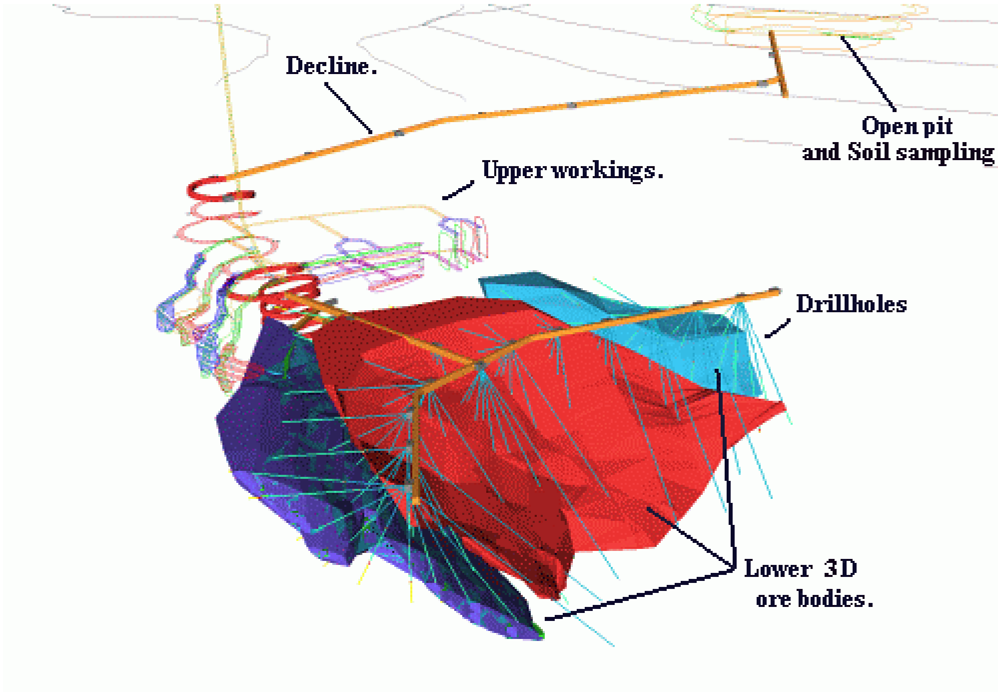
The grade estimation data set consists of the following:

- topography contours
- surface sampling data points (mineralization zone field ANOM, 'grade' fields AU [ppb], CU [ppm]; Z - sample point elevation)
- search, variogram model and estimation parameter tables
- mineralization zones block model (zone field ANOM)
- grade block models (grade estimates using a variety of different estimation methods).

Viking South - Lower Ore Body (3 Dimensions)

Geological Setting

A recent underground exploration project, down dip of the existing Viking South upper mining operations has identified a lower ore body consisting of three separate ore body zones. This hydrothermal Cu-Ag-Au-Co deposit is hosted within calc-silicates and calc-breccias. The limits of these three bodies are indicated by the red(ZONE=1) blue(ZONE=2) and cyan(ZONE=3) volumes shown in the image below. The major hanging wall rock type is limestone while the foot wall consists primarily of sandstones. The drillholes, drilled in fans spaced 50m apart along the strike of the ore body, contain density and sampling grade information (Cu [%], Ag [g/t], Au [g/t] Au and Co [%]) on 50cm intervals.



The grade estimation data set consists of the following:

- underground drillholes (containing rock type, density, Cu [%], Ag [g/t], Au [g/t] Au and Co [%] grades)
- lower ore body geological model (section strings, wireframes)
- mineralization zones block model (flagged with zones and rock densities)
- grade block models (5x5 precise vertical and also 5x5x5m regular celled).

File Locations

Assuming that a default installation has been performed, all sample files referenced by this tutorial can be found under:

- **C:\Database\DMTutorials\Data\VBOP\Datamine**
- **C:\Database\DMTutorials\Data\VBUG\Datamine**

These folders contain a series of data-type-specific folders including amongst others, CAD files, spreadsheet files for importing and individual (native) Datamine files. Please note that these folders contain a wide range of files and that only the files listed in the table below are relevant to the grade estimation tutorial.

File Names and Descriptions

The following table contains a list of the relevant files used in this tutorial. Each entry lists the existing *Sample File Name*, the suggested *User File Name* and a file *Description*. They are grouped according to the name of the folder in which the file is located.

Sample File Name	User File Name	Description
...\VBOP\Datamine:		
_2dblks	-	Strings - 2D panel outlines (mining blocks) used in panel estimation
_2delp1pt / _2delp1tr	2delp1pt / 2delp1tr	Wireframe points/triangles - Sample search ellipse for 2D soil sampling
_2depar1	2depar1	Estimation Parameters - 2D (NN, IPD, OK; no zonal control)(soil sampling grade estimates)
_2depar2	-	Estimation Parameters - 2D (NN, IPD and OK; zonal control)(soil sampling grade estimates)
_2depar3	2depar3	Estimation Parameters - 2D (NN, IPD, OK and SK; zonal control)(soil sampling grade estimates)
_2depar4	2depar4	Estimation Parameters - 2D (IK; zonal control)(soil sampling grade estimates)

_2dgmod1	2dgmod1	Block Model - 2D (soils sampling AU grade estimates using IPD, no zonal control)
_2dgmod2	2dgmod2	Block Model - 2D (soils sampling AU grade estimates using IPD and OK; zonal control field ANOM)
_2dgmod3	2dgmod3	Block Model - 2D (soils sampling AU grade estimates using IPD, OK and SK; zonal control field ANOM)
_2dgmod4	2dgmod4	Block Model - 2D (soils sampling AU grade estimates using IK; zonal control field ANOM)
_2dpres1	2dpres1	Table - panel estimation results file
_2dpmod1	-	Block Model - 2D 40x40x10m prototype block model
_2dres1	geres1	Results table - evaluation results by category for the 40x40m grade block model
_2dspar1	2dspar1	Search Parameters - 2D (soil sampling grade estimates)
_2dvpar1	2dvpar1	Variogram Model Parameters - 2D (soil sampling grade estimates)
_2dvpar2	-	Variogram Model Parameters - 2D (IK of mineralization zones, field ANOM)
_2dxvs1	2dxvs	Table - Cross validation results for 2D soil sampling estimation parameters
_2dzmod1	2dzmod1	Block Model - 2D (soils sampling mineralization zones, field ANOM)
_ostopo	-	Strings - surface topography contours
_srfsamp	-	Points – Soil sampling (grades: Au [ppb], Cu [ppm]; Z - elevation)
...\VBUG\Datamine:		
_3depar1	3depar1	Estimation Parameters - 3D underground ore body(grade fields CU, AG for ZONE =1 only, zonal control field ZONE)

_3dspar1	3dspar1	Search Parameters - 3D underground ore body
_caf5so	-	Strings - cut-and-fill stoping outlines (mining blocks) for -255m level
_geres2	geres2	Results table - evaluation results by category for the '_caf5so' cut-and-fill stoping outlines
_geres3	geres3	Results table - evaluation results by category for the '_uoretr / _uorept' ore body wireframe
_geres4	geres4	Cut-off grades results table - evaluation of the ore body block model '_ubm5g' at 2g/t Au grade intervals
_qqouAU	qqouAU	Table - QQ output for field AU (5x5x5m block model cells vs 5m composited drillholes)
_qqplAU	qqplAU	Plot - QQ plot for field AU (5x5x5m block model cells vs 5m composited drillholes)
_ubm5cat	ubm5cat	Block Model - 3D underground ore body (5x5x5m regular celled grade model; additional informal resource classification field CAT)
_ubm5g	3dbm5g	Block Model - 3D underground ore body (5x5x5m regular celled grade model; zonal control using field ZONE)
_ubm5z	-	Block Model - 3D underground ore body (5x5x5m regular celled mineralization zones model; zone field ZONE)
_ubmlim	-	Strings - 3D underground block model prototype limits
_ubmm	-	Block Model - 3D underground mining model i.e. grade model with 15m waste envelope (5x5x5m regular celled mineralization zones model; zone field ZONE)
_ubmz	-	Block Model - 3D underground ore body (10x10x10m parent celled mineralization zones model; zone field ZONE)
_udhz	-	Drillholes - (Density, grades: Au, Cu, Co, Ag, zone field ZONE; not composited)

_udhz5c	-	Drillholes - (Density, grades: Au, Cu, Co, Ag, zone field ZONE; composited on 5m intervals)
_uepe	-	Estimation Parameters - 3D
_ueps	-	Search Parameters - 3D
_uepv	-	Variogram Model Parameters - 3D
_uoretr / _uorept	-	Wireframe traingles and points - underground ore body consisting of three zones

Grade Estimation Terms

The table below contains a list of terms that are used in this tutorial.

Term	Also Known As	Definition
Attributes	-	User defined, numeric or alphanumeric fields (also known as columns), typically added to geological tables, drillholes, sample points, strings and wireframes. These are added in order to aid in the geological modeling and grade estimation process and enhance presentation and reporting output. Examples include ZONE (a numeric mineralization zone number) and LEVEL (a numeric mining level identifier).
Anisotropic model	-	A variogram model in which the Ranges are different for each of the three variogram axes.
Evaluation	-	Calculating the summary tonnes and grade of a volume, typically defined by outlines (singles or pairs), wireframe volumes or the entire block model. Outlines and wireframes can also be evaluated against drillholes.
Experimental Variogram	Sample variogram	A table or plot of (semi)variance vs distance. It describes how the spatial continuity of a variable (e.g. Au grade) varies with distance and direction. This (semi)variance is calculated for different sample spacings (lags). Output file generated by **VGRAM**.
Footwall	-	The rock on the underside of a vein or ore body; the floor of a drive.
Hangingwall	Back	The rock on the upper side of a vein or ore body; the roof of a drive.
Isotropic model	-	A variogram model in which the Ranges are the same for each of the three variogram axes.

Level	-	The horizontal openings on a working horizon in a mine; these levels are typically accessed from a shaft and/or decline system. Levels are generally established at regular intervals, 10s of metres apart.
Model Variogram	-	A variogram model is a 'best fit' curve/surface, fitted to an experimental variogram data set. In **Studio 3**, the available models include Spherical, Power, Exponential, Gaussian and De Wijsian. The model is defined by a function which uses various parameters e.g. nugget, spatial variance, range, power. These parameters vary according to the type of model selected. Output file generated by **VARFIT**.
Nugget (Co)	Nugget variance	The sum of inherent geological variability at the micro scale, and if not removed, then it includes the measurement, sampling and assaying errors. The value on a Variogram model plot where the variogram intersects the Y axis.
Outline	Perimeter, String	In Studio 3, a closed (or open) coplanar perimeter defining the limits of a geological boundary, drive or stope as viewed in the reference plane. The reference plane is typically horizontal or vertical, but can also be inclined.
QQ Plot	Quantile-quantile plot	A plot of the quantiles (of a particular grade field or other numeric variable) of one data set (e.g. block model cells) against the quantiles of another data set (e.g. composited drillholes).
Quantile	-	Quantiles are points taken at regular intervals from the cumulative distribution function of a random variable. Dividing ordered data into *q* essentially equal-sized data subsets is the motivation for *q*-quantiles; the quantiles are the data values marking the boundaries between consecutive subsets. Examples are quartiles (ordered data set divided into 4 equal subsets) and deciles (ordered data set divided into 10 equal subsets).

Range	Variogram Range	The distance (lag) at which a variogram model reaches the sill.
Sample File	-	Sample files are generally either drillholes or points.
Sill	Total variance, Variance	The maximum variance attained by the variogram model.
Spatial variance (C)	-	Spatial Variance = Sill - Nugget i.e. the difference between the sill and the nugget variances.
Spherical Model	-	The Spherical variogram model (commonly used) is defined by a function which uses the parameters: Nugget, Range(s) and Spatial variance(s).
Zonal Control	Mineralization domain control	Estimation of grades into block model cells within a particular zone using only the corresponding zone samples. This requires a numeric or alphanumeric zone field(s) to be present in both the sample and block model data.
Variogram	-	See Experimental and Model Variogram terms above.
Wireframe Ellipse	Wireframe Ellipsoid	A 3 dimensional wireframe volume representing a sample search ellipsoid used in grade estimation. The size of the wireframe volume is defined by the search volume's three axes' lengths and rotation angles. Generated using **ELLIPSE**.

The Grade Estimation Process in Studio 3

Process Inputs

The process of grade estimation in **Studio 3** makes use of the following:

- results of geostatistical analyses (identification of mineralization zones/populations, variogram modeling)
- estimation parameters (search, variogram and estimation parameters)
- sample data (points or drillholes)
- block model(s)
- perimeters for panel estimation or grade-tonnage evaluation.

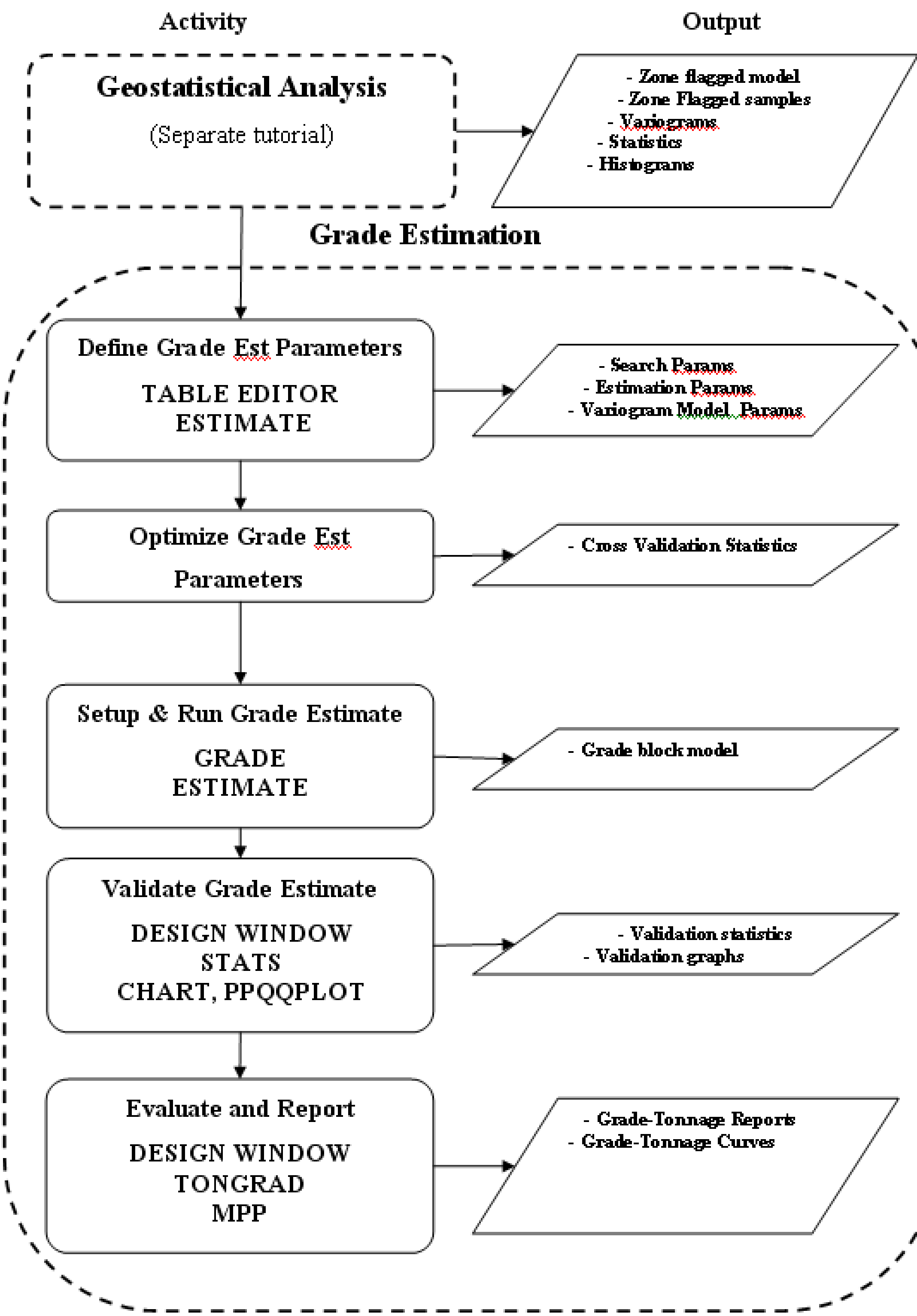
The results of the geostatistical analysis are used to prepare the geological sample and block model data before it is used in the grade estimation process. This preparation typically includes the following (in no specific order):

- flagging the following with a mineralization code (used for zonal control in grade estimation):
    - sample data
    - block model data
- declustering:
    - point data
    - drillhole data
- compositing drillhole data on fixed lengths
- regularizing block model data to produce models with with fixed X, Y and Z cell sizes.

The Process Flow

The general grade estimation process is summarized in the flow diagram below. The different activities, together with their **Studio 3** processes (capitalized), are shown on the left; the outputs from the activity are shown on the right.

The Grade Estimation Process Data Flow



TOOLS USED IN GRADE ESTIMATION

The **Studio 3** grade estimation tools are available as:

Menus

Toolbars

Processes

Studio Products

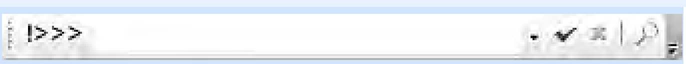
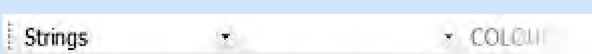
Menus

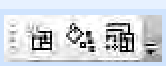
The majority of commands used in the grade estimation process can be found under the following menus:

- Design | Query
- Models | Interpolation Processes
- Models | Reserves Processes
- Models | Evaluate
- **Applications | Conditional Simulation**
- **Applications | Interpolation Processes**
- **Applications | Reserves Processes.**

Toolbars

The following toolbars are typically used in the grade estimation process:

Toolbar group and Image	Toolbar Title	Contains...
Design Window - General Toolbars		
	Command *	Find Command, Run Command
	Current Objects *	Data object control

	Data Display *	Format Display, Format Legends, show and hide different data objects.
	Point and String Editing: Standard *	Point and string creation and editing.
	Point and String Editing: Advanced **	Point and string creation and editing.
	Snapping *	Snapping control.
	View Control *	Viewplane definition and control buttons.
	Format **	Data formatting (legends, display)
Design Window - Grade Estimation Related Toolbars		
	Modeling - **	Basic grade interpolation (GRADE)
	Mine Design - Evaluation	String and wireframe evaluation,

	buttons **	string projetion and evaluation control tools.

Table Notes:

- only the first portion of wide toolbars is displayed.
- the buttons in toolbars, which are highlighted in blue, are toggle buttons that are currently set to "On".
- * Toolbars displayed by default when Studio 3 is first started.
- ** Toolbars needing to be activated by the user before they are displayed.

Processes

The following table lists the Studio 3 processes commonly used in the grade estimation process.

Command	Description	Exercise
General Processes		
EXTRA	Add or manipulate Fields using simple or advanced string and numeric transformations	
MGSORT	Sort table records on multiple fields	
COPY	Copy a table	
PICREC	Copy table records using relational or pattern matching record selection expressions	

SELCOP	Copy selected table fields
SORTX	Sort a records according to key fields
JOIN	Join two files on sorted key field values.
STATS	Compute summary statistics on multiple numeric fields
CHART	Create and display scatter, line or histogram charts
PPQQPLOT	Create and display PP and QQ plots
Grade Estimation Processes	
GRADE	Basic grade interpolation
ESTIMA	Advanced grade interpolation (use when recording a macro/script)
ESTIMATE	Advanced grade interpolation via interactive dialogs
PANELEST	Estimate grades into panels (perimeters)
ELLIPSE	Create a sample search ellipse wireframe
XVALID	Cross validate a set of estimation parameters
Evaluation and Reserves	

Reporting	
TONGRAD	Calculate the tonnage and grade of a model, using the current block model display legend
MODRES	Generates RESULTS file of reserves from orebody model using an optional input perimeter file and ore grade or type categories. Perimeters can be individual or pairs of outlines
TRIVAL	Evaluate a grade block model within a wireframe
TONGRAD	Calculate a grade block model tonnes and grade

See the **Studio 3** Command Table in the Help documentation for a comprehensive list of Processes and their uses.

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Studio Products

The following Studio Products are used in the grade estimation process:

Product	Description	Menu Path
Mining Power Pack - MPP	An Add-In for **MS Excel®** **97**, **2000** and **2002**, primarily focused on providing utilities for working with geological and mining-related data	**Tools | Datamine Products | Mining Power Pack - MPP**

within Excel.

STUDIO 3 GRADE ESTIMATION USER GUIDE

The following topics are available:

Grade Estimation Help Files

This section of the Studio 3 Help file deals with the processes and concepts involved in Grade Estimation. This is a complex and extensive subject, and for this reason, the subject has been broken down into the following categories.

- **Introduction** (this topic): introducing **ESTIMA**
- **Search Volume Introduction**: defining shape and orientation of search.
- **Dynamic Search Volumes**: categorizing reserves based on the number of samples in a volume.
- **Using Octants**: declustering samples to achieve an even spread.
- **Key fields**: restricting the number of samples from any one borehole.
- **The Search Volume Parameter File**: a table summarizing all fields required for a SV file.
- **Cell Discretisation**: representing cells by a three-dimensional array of points.
- **Estimation Methods**: an overview of the methods available to estimate grade, including:
    - **Nearest Neighbour**: more details on this grade estimation method.
    - **Inverse Power of Distance**: more details on this grade estimation method.
    - **Kriging**: more details on this grade estimation method.
    - **Sichel's T Estimator**: more details on this grade estimation method.
- **The Estimation Parameter file**: a table summarizing all fields required for the Estimation Parameter file.
- **Additional Features**: more functions of the grade estimation processes.
- **Variograms**: variogram models available for kriging. Also a table showing the fields required for the Variogram Model Parameter file.
- **Run Time Optimization**: minimizing the amount of time taken to run grade estimation processes.
- **Rotated Models and Unfolding**: how ESTIMA handles rotated data, and an overview of the unfolding process.
- **Output and Results**: understanding the output files.

- **Examples**: some useful examples that highlight how the **ESTIMA** process works.
- **Parameters, Files and Fields Reference**: tables containing all required estimation fields and parameters.
- **System Limits**: information relating to the amount of data **ESTIMA** can process.
- **Bibliography**: published articles relating to grade estimation.

At the end of each section, you can either use *Related Topics* to see the next topic in sequence, or click the **Next Section** button.

Features of ESTIMA

The main features of **ESTIMA** are:

- A consistent set of search volume and estimation parameters for all interpolation methods
- Optimization of sample searching to improve speed
- Multiple grades can be estimated in a single run
- The same grade can be estimated by different methods
- Different search volumes and estimation parameters can be used for the different grades
- Rectangular or ellipsoidal search volume with anisotropy
- A dynamic search volume allowing the volume to be increased if there are insufficient
- samples
- Restriction of the number of samples by octant and key field
- Estimation by zone, with separate parameters for each zone
- Wide selection of variogram model types for both normal and lognormal kriging
- Automatic transformation of data if the input model is a rotated model
- Unfolding option available for all estimation types
- Parent cell estimation
- Selective update of partial model

Estimation Methods

The estimation methods provided by **ESTIMA** include:

- Nearest Neighbor
- Inverse Power of Distance
- Ordinary Kriging
- Lognormal Kriging
- Simple Kriging
- Sichel's t Estimator

Overview of ESTIMA

ESTIMA requires an *Input Prototype Model* and a set of *Sample Data* as input. Usually the *Input Prototype Model* will already contain cells and sub-cells which represent, for example, a geological structure. In this case, grade values are interpolated into the existing set of cells and sub-cells. If however an empty prototype is specified (i.e. it does not contain any cells or sub-cells), **ESTIMA** will create cells and sub-cells in the area around the samples as defined by the search volume.

From here on any reference to a model cell will include both cells and sub-cells. A full cell is referred to as a *parent* cell.

The Sample Data file contains the data which is used to estimate cell grades. At a minimum, the data must include the X, Y and Z coordinates of each sample and at least one grade value. **ESTIMA** requires a *search volume* to be defined. This is the volume, centered on the cell being estimated, which contains the samples to be used for grade estimation. More than one search volume can be defined, so that different grades can have different search volumes. The parameters describing the search volume(s) are supplied to **ESTIMA** from the Search Volume Parameter file.

ESTIMA also requires a set of estimation parameters to be defined for each grade to be estimated. These parameters are also supplied to **ESTIMA** from a file called the *Estimation Parameter* file. It will include items such as the estimation method, the search volume reference number the power (for *Inverse Power of Distance* calculations). Each cell is selected in turn from the *Input Prototype Model* and the samples lying within the search volume are identified. Each grade specified in the *Estimation Parameter* file is estimated, and the results are written to the *Output Model* file.

A summary of the files used by **ESTIMA** is as follows:

Process	Description
PROTO	Input Prototype Model
IN	Sample Data

SRCPARM	Search Volume Parameters
ESTPARM	Estimation Parameters
VMODPARM	Variogram Model Parameters
STRING	Unfolding Strings
MODEL	Output Model
SAMPOUT	Sample Output

Other information is supplied to the process as fields and parameters.

Introduction to Grade Estimation Methods

The information contained in the following topics concentrates on the different methods of interpolating grades into the model cells using methods such as Inverse Power of Distance and Kriging.

There are four commands in Studio 3 that deal specifically with grade estimation into a block model. All four commands use the same application code but have different interfaces and provide different sets of functions.

- **GRADE**: this is the simplest command and has the least number of options. It is restricted to Nearest Neighbor (NN), Inverse Power of Distance (IPD) and Ordinary Kriging (OK) using a 1 or 2 structure spherical model variogram model. Only one grade can be estimated at a time.
  GRADE command Help...
- **ESTIMA**: a multi-featured command allowing all options except Indicator Estimation. Multiple grades can be estimated using multi-structure variogram models of different types. The interface is the standard files, fields, parameters dialog.
  ESTIMA command Help...
- **INDEST**: this is similar to ESTIMA except that it only offers Indicator Estimation. It uses the standard files, fields, parameters dialog.
  INDEST Command Help...
- **ESTIMATE**:

  …offers all the functionality of ESTIMA and INDEST (excluding unfolding) plus more through a tailored dialog. It includes the ability to save and restore search volume, estimation type and variogram model information through the use of parameter files.
  ESTIMATE Dialog Help...

All four commands are available through the **Models | Interpolation Processes** menu or can be run by typing the name in the **Command** window.

- **GRADE**: Basic Grade Interpolation
- **ESTIMA**: Interpolate Grades into Model
- **ESTIMATE**: Interpolate Grades from Menu
- **INDEST**: Indicator Estimation

Overview of Estimation Method

All four commands require an input model to define the cell structure and an input sample file to define the sample grades to be used for making the estimates. They then create an output model where the estimated grade is a field in the model file.

Input Model

All the estimation methods require an input prototype block model into which the sample grades are interpolated.

The usual situation is that the prototype model already contains cells and subcells defining the geology, so that values will be interpolated into the existing cell structure. If the prototype model is empty, however, then cells and subcells will be created if there are sufficient samples within the search volume.

A prototype model containing cells and sub-cells may also contain one or two classification fields e.g. rocktype, lithology, weathering profile, fault block zone. If the same classification field(s) also exist in the input sample file then zone control can be selected. This means, for example, that only samples that are rocktype A would be used to estimate cells that are rocktype A.

Output Model

If the input model contains cells and sub-cells then the output model will contain the same set of cells and sub-cells. It will also include additional fields corresponding to the grades that were estimated.

Input Samples

The input sample file must contain the three coordinate fields X, Y and Z and at least one grade field. This will often be a desurveyed drillhole file which may also contain classification fields if zone control is to be selected.

Search Volume Parameters

A Search Volume is a 3D shape containing the samples to be used for the grade estimation and is centered on the cell being estimated. The volume may be either a 3D ellipsoid or a cuboid.

All methods require a search volume. For GRADE, a single search volume is defined in the parameters tab, whereas the other commands (ESTIMA, ESTIMATE, INDEST) allow multiple search volumes which are stored in a Search Volume Parameter file. The ESTIMATE command provides specific dialogs to facilitate the definition, import and export of search volumes. Multiple search volumes allow different grades to be estimated with different search volumes.

Variogram Model Parameters

If kriging is selected as one of the estimation methods then a variogram model must be defined. As for search volumes, GRADE allows a single model to be defined through the parameters tab, whereas ESTIMATE provides specific dialogs for definition and import and export to and from the Variogram Model Parameter file. Variograms are calculated using the VGRAM command, and models fitted using VARFIT.

Estimation Type Parameters

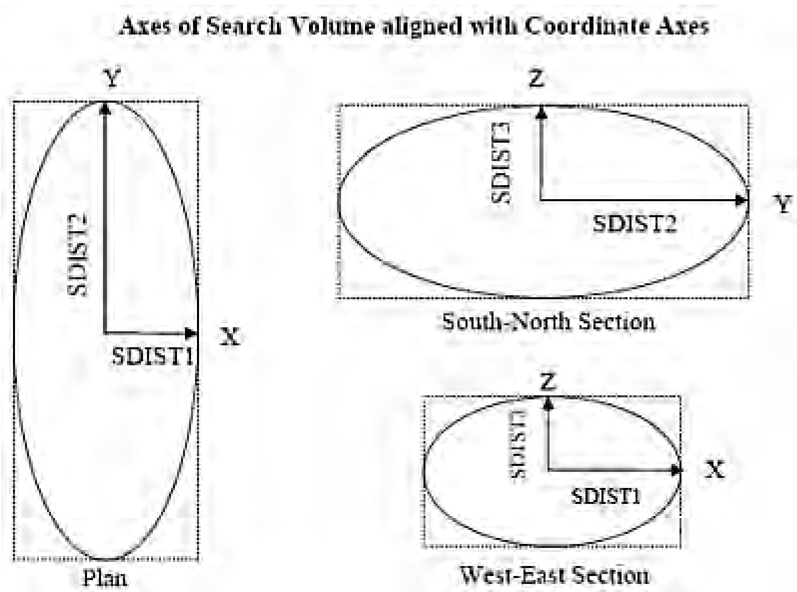
It is necessary to provide a set of estimation parameters for each grade to be estimated. For GRADE with a single estimate these parameters are defined on the parameters tab. For the other processes the parameters may be imported as an Estimation Parameter file. ESTIMATE provides dialogs to define and save these parameters. The parameters include items such as the estimation method, the search volume reference number and estimation-method-specific data like the power, if the Inverse Power of Distance method has been selected.

SEARCH VOLUMES

One or more search volumes are defined using the Search Volume Parameter file (&SRCPARAM). Each record in the file defines a separate search volume and each search volume has a unique *Search Volume Reference Number* (field *SREFNUM*). This means that a search volume may be unique to an individual grade or can be shared by two or more grades.

The search volume method is defined using field *SMETHOD*. Setting *SMETHOD* to 1 gives a three dimensional rectangle and setting it to 2 gives an ellipsoid. The only difference is that the rectangular method will select samples in the 'corners' of the search volume as illustrated in the diagram. The default value for *SMETHOD* is 2 (ellipsoid).

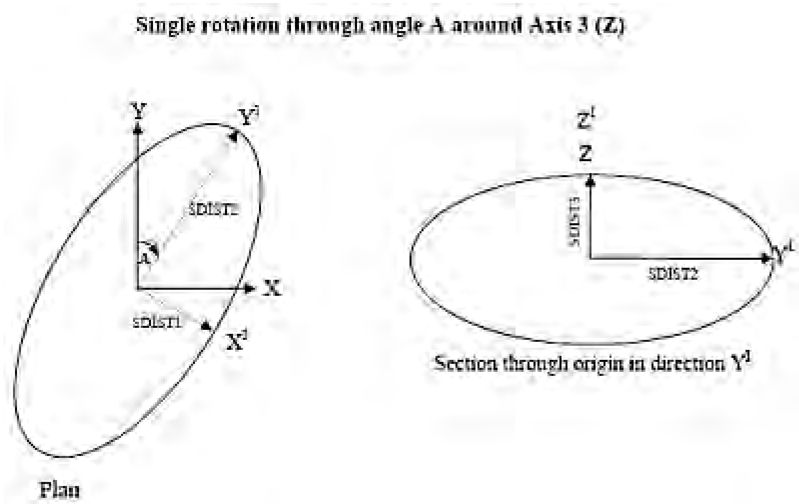
The lengths of the axes of the ellipsoid are defined using fields *SDIST1*, *SDIST2* and *SDIST3*. Initially *SDIST1* is along the X-axis, *SDIST2* along the Y-axis and SDIST3 along the Z-axis:



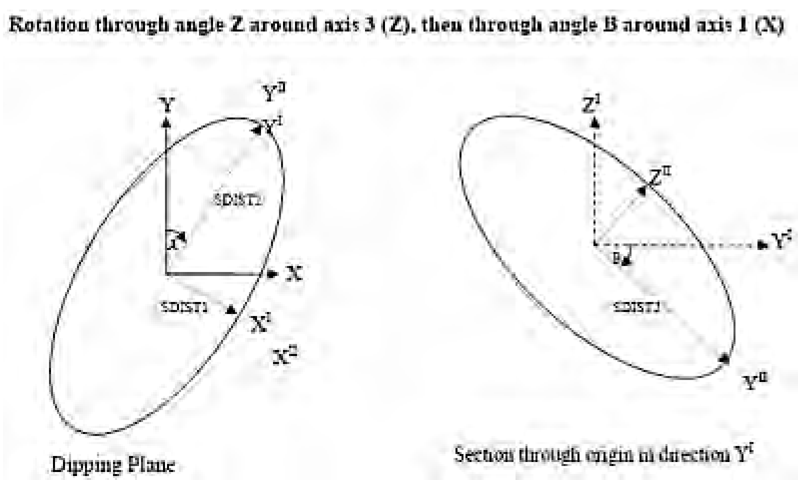
One, two or three rotations may then be defined. For each rotation, it is necessary to define both the rotation angle and the axis about which the rotation is applied. For this purpose, the X-axis is denoted as axis 1, the Y-axis as axis 2, and the Z-axis as axis 3.

The rotation angle is measured in a clockwise direction when viewed along the positive axis towards the origin. A negative rotation angle means an anticlockwise rotation.

For example if the first rotation is through A degrees around axis 3 (Z) then the search ellipse is oriented as shown below:



If the search ellipsoid is then rotated through B degrees around the new XI axis the result is as shown below:



This example illustrates a conventional rotation of azimuth and dip. However, any rotation method can be used by defining both the angles and axes for up to three rotations.

Simulate with left hand

It can sometimes be helpful to use the fingers of your left hand to simulate the rotations. Point your index finger straight out in front of you, your thumb up in the air, and your second finger to the right across your body. Write the number 1 on your second finger, 2 on your index finger and 3 on your thumb. Your second finger is the X-axis, pointing East, your index finger is the Y-axis pointing North and your thumb is the Z-axis pointing up.

To simulate the two rotations in the previous example first hold your left thumb with your right hand and rotate the other two fingers clockwise. Then hold your second finger and rotate your index finger and thumb clockwise in a vertical plane. Your fingers are now pointing along the axes of your rotated search ellipsoid.

SANGLE and SAXIS fields

The fields in the Search Volume Parameter file that define the first rotation are *SANGLE1* and *SAXIS1*. Using the previous example *SANGLE1* is angle A, and *SAXIS1* is 3 (Z). The second rotation is then defined by putting *SANGLE2* to B and *SAXIS2* to 1 (X). Setting *SANGLE3* and *SAXIS3* to - (absent data) or 0 means rotation 3 is not used.

Dynamic Search Volumes

This topic is part of the Grade Estimation range of topics. For more information on Search Volumes in general, see Grade Estimation Search Volume Introduction.

It is often useful to be able to categorize reserves based on the number of samples within a search volume. For example:

- **Measured** - at least 6 samples within 20m
- **Indicated** - at least 4 samples within 40m
- **Inferred** - at least 2 samples within 60m

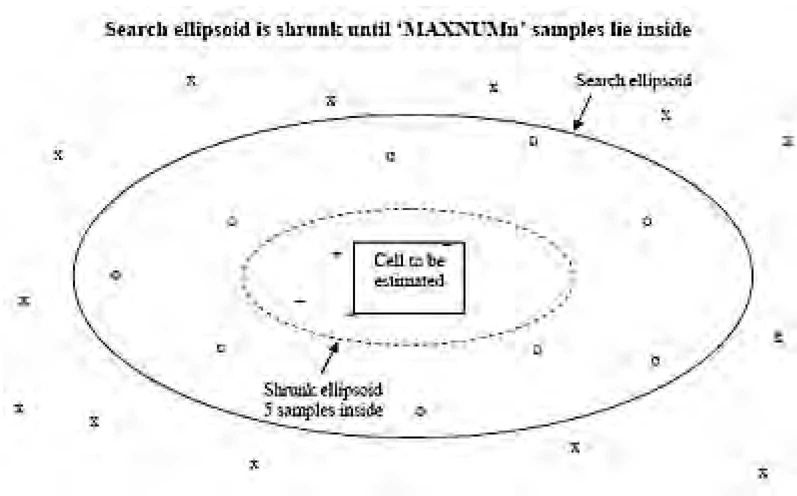
You can do this in a single run of ESTIMA by defining three concentric search volumes, and a minimum and maximum number of samples for each volume. The first search volume (which must be the smallest volume) is defined using the search axes *SDIST1*, *SDIST2* and *SDIST3* as described previously. The second search volume is defined by multiplying these search axes by *SVOLFAC2*. The value of *SVOLFAC2* must be either 0 or >=1. If it is set to zero then neither the second or third search volumes are used.

If SVOLFAC2=1 then the second search volume will have the same dimensions as the first search volume. In this case, the minimum number of samples for the second volume should be less than the minimum number for the first volume in order for the second volume to be of any practical use.

SVOLFAC3 is the multiplying factor for search volume 3. It must be either zero, or >= SVOLFAC2.

For each search volume, a minimum and maximum number of samples can be defined; *MINNUM1* and *MAXNUM1* apply to the first search volume; *MINNUM2* and *MAXNUM2* apply to the second, and *MINNUM3* and MAXNUM3 to the third. If there are more than *MAXNUMn* samples within search volume n, then the 'nearest' *MAXNUMn* samples will be selected. Nearest is defined in terms of a transformed distance, depending on the search volume.

The search ellipse is shrunk concentrically, until only *MAXNUMn* samples lie within it. This is illustrated in the following diagram:



The samples shown annotated with x lie outside the search ellipsoid. There are 13 samples inside the ellipsoid, annotated with o and +. If *MAXNUM1* is set to 4, then the ellipsoid is shrunk until only the 4 samples annotated with + lie inside it. These 4 samples are then used for estimating the cell value.

Search volume 1 is applied first. If there are less than *MINNUM1* samples then search volume 2 is applied. If there are still less than *MINNUM2* samples search volume 3 is applied. If there are less than *MINNUM3* samples, then the grade value for that cell is set to absent data.

You can record which search volume has been used for each cell by defining the *SVOL_F* field in the Estimation Parameter file. This is a numeric field which is added to the Output Model file and has a value of 1, 2 or 3 depending on the search volume.

Transformed distance

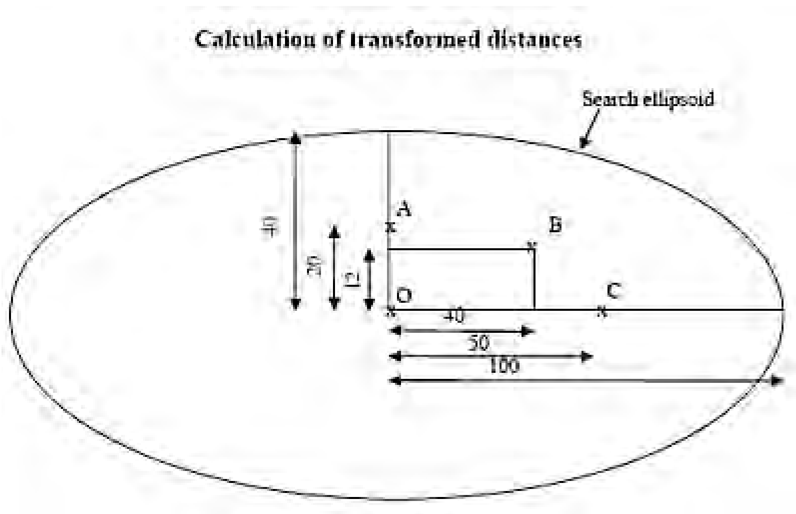
If there are more than *MAXNUMn* samples in the search volume then the search ellipsoid shrinks until only *MAXNUMn* remain. Within ESTIMA, this is achieved by calculating a transformed distance for each sample, and then sorting the samples on the transformed distance.

In order to calculate the transformed distance, the sample data is first rotated into the coordinate system of the search ellipsoid. In the rotated system if the origin of the ellipsoid is at point (0, 0, 0) and a sample is at (X, Y, Z) then its transformed distance D is defined by:

D = √ [(X/SAXIS1)2 + (Y/SAXIS2)2 + (Z/SAXIS3)2]

A sample lying on the search ellipsoid will therefore have a transformed distance of 1, and all samples inside the ellipsoid will have transformed distances of less than 1.

The calculation of the transformed distance is illustrated below with a simple example:



The diagram shows the samples at A, B and C rotated into the coordinate system of the search ellipsoid. The axes of the search ellipsoid are SAXIS1=100 and SAXIS2=40. This example is in two dimensions, and so the value of *SAXIS3* is not relevant. The transformed distances of points A, B and C from origin O are calculated as:

- **Point A** at X = 0, Y = 20:

  $DA = \sqrt{[(0 / 100)^2 + (20 / 40)^2]} = 0.5$

- **Point B** at X = 40, Y = 12:

  $DB = \sqrt{[(40 / 100)^2 + (12 / 40)^2]} = 0.5$

- **Point C** at X = 50, Y = 0:

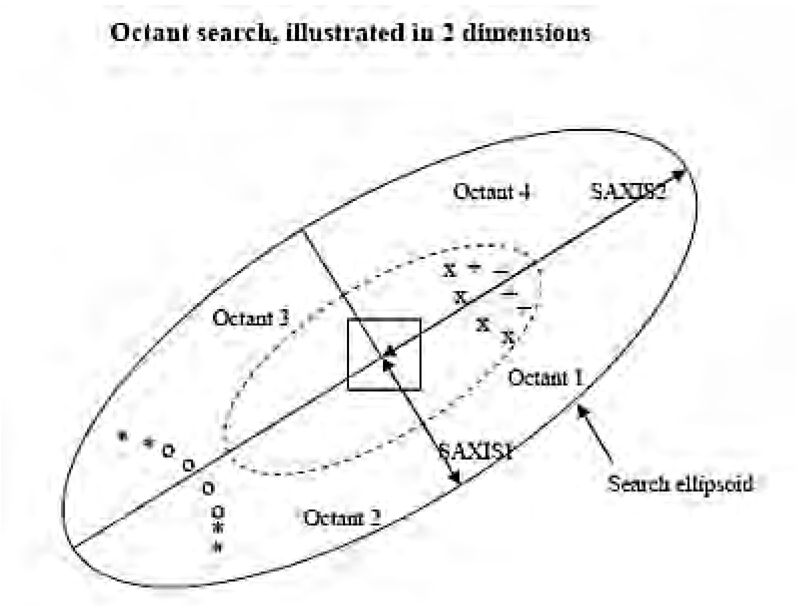
  $DC = \sqrt{[(50 / 100)^2 + (0 / 40)^2]} = 0.5$

Therefore, in this example all three points are at the same distance from the centre.

Using Octant Calculations

Generally samples are not evenly distributed around the cell being estimated, but are clustered together. Using the search volume shrinking method described previously, this may lead to samples in one area having an undue influence on the grade of the cell. This problem is avoided by dividing the search volume into octants and ensuring that a minimum number of octants have samples in them.

By defining three planes parallel to the axes of the search ellipsoid eight octants are created. These planes intersect at the ellipsoid origin, which is also the centre of the cell being estimated, e.g.:



The previous diagram illustrates the octant method. The search ellipsoid contains sixteen samples annotated by O, *, X, and +, and for the purpose of this example all sixteen samples lie above the XY plane. If MAXNUM1 were sixteen or greater, then all sixteen samples would be selected. However if MAXNUM1 is set to eight, then the eight samples annotated X and + will be selected. The estimated grade of the cell would obviously then be biased towards the samples in the North-East of the search volume.

If octant search were applied with the maximum number of samples per octant set to 2, then the two samples in each octant, which are nearest to the cell centre, would be selected. These samples are annotated O and X. This would definitely be preferable to selecting all eight samples from the North-East area.

Octants 1 to 4 lie above the XY plane as illustrated in the diagram, with octant 1 lying in the North-East top octant. Octants 5 to 8 lie below the XY plane, underneath octants 1 to 4 respectively.

There are four values controlling the octant search, defined by fields in the Search Volume Parameter file. If there are sufficient samples in an octant, it is considered 'filled'. If sufficient octants are 'filled' then the cell is estimated:

Process	Description
OCTMETH	The octant definition method: 0 = do not use octant search 1 = use octant search
MINOCT	the minimum number of octants to be filled before a cell will be estimated.
MINPEROC	the minimum number of samples in an octant before it is considered to be filled.
MAXPEROC	the maximum number of samples in an octant, to be used for estimation. If there are more than MAXPEROC samples in an octant, then the samples nearest to the cell centre are selected, using the transformed distance of the shrinking ellipsoid method.

MINNUMn and *MAXNUMn* still apply even if octant search is selected. If the total number of samples is less than *MINNUMn* then the cell will not be estimated. If the total number of samples is greater than *MAXNUMn* then the furthest sample (transformed distance) is removed until *MAXNUMn* is reached. However if removing the sample would cause the number of samples in the octant to be less than *MINPEROC* then that sample is NOT removed. The next furthest away is used instead. It may be impossible to satisfy both *MAXNUMn* and the octant constraints; in this case the cell will not be estimated.

KEY FIELDS

If each record in the sample data file is identified by a key field, then the number of samples per key field value can be restricted. The most obvious use of this feature is to prevent samples from a single hole having an overpowering influence on the estimated grade of a cell. In the following example the key field is defined as *BHID*. The name of the key field is specified as field *KEY* (i.e. *KEY(BHID)). The maximum number of samples with the same key field value is defined using field *MAXKEY* in the Search Volume Parameter file. If *MAXKEY* is set to absent data or zero, then the key field option is not be used.

If octant search is selected then the *MAXKEY* parameter applies to the number of samples within an octant.

Search Volume Parameters

The Search Volume Parameter file contains the 24 fields shown in the table. All fields are numeric and are compulsory. The default value for a field is the value used by the process if the field value has been entered as - (absent data).

The following fields are included:

Search Volume Parameters File		
Field Name	**Default**	**Description**
SRENUM		Search volume reference number
SMETHOD	2	Search volume shape (1 = 3D rectangular, 2 = ellipsoid)
SDIST1	100	Maximum search distance in direction 1 (X)
SDIST2	100	Maximum search distance in direction 2 (Y)
SDIST3	100	Maximum search distance in direction 3 (Z)
SANGLE1	0	First rotation angle for search volume
SANGLE2	0	Second rotation angle for search volume
SANGLE3	0	Third rotation angle for search volume
SAXIS1	3	Axis for first rotation (1 = X, 2 = Y, 3 = Z)
SAXIS2	1	Axis for second rotation
SAXIS3	3	Axis for third rotation

MINNUM1	1	Minimum number of samples for first dynamic search volume
MAXNUM1	20	Maximum number of samples for first dynamic search volume
SVOLFAC2	0	Axis multiplying factor for second dynamic search volume
MINNUM2	1	Minimum number of samples for second dynamic search volume
MAXNUM2	20	Maximum number of samples for second dynamic search volume
SVOLFAC3	0	Axis multiplying factor for third dynamic search volume
MINNUM3	1	Minimum number of samples for third dynamic search volume
MAXNUM3	20	Maximum number of samples for third dynamic search volume
OCTMETH	0	Octant definition method (0 = do not use, 1 = use octants)
MINOCT	2	Minimum number of octants to be filled
MINPEROC	1	Minimum number of samples in an octant
MAXPEROC	4	Maximum number of samples in an octant
MAXKEY	0	Maximum number of samples with same key field value

CELL DISCRETISATION

In the Input Model Prototype file, the coordinates of the cell centre are held in fields *XC*, *YC* and *ZC* and the cell dimensions in fields *XINC*, *YINC* and *ZINC*. For an estimation method such as Inverse Power Distance it would be possible to use just the cell centre coordinates and make the estimate as a function of the distance of each sample from the cell centre. However, this means the dimensions of the cell are ignored and so the resultant estimate is the value of a point at the cell centre. The average value of the grade over the whole cell should be estimated.

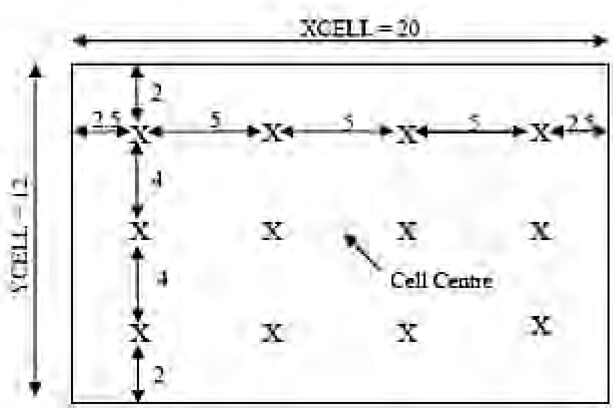
Rather than represent a cell by just a single point, ESTIMA allows you to simulate the cell by a three dimensional array of points, distributed regularly within the cell. For Inverse Power Distance, the value at each discretised point is estimated, and then the arithmetic mean of all points calculated. For kriged estimates, the discretised points are used for calculating the covariance of the cell with each of the surrounding samples. This is then used in calculating the kriging weights.

Neither the Nearest Neighbor estimation method nor Sichel's t estimator use discretisation points. Nearest Neighbor is based on the distance to the cell centre, and Sichel's t is a function of the lognormal distribution.

Method 1 – Define Points

There are two ways of defining discretisation points, depending on the parameter *@DISCMETH*. If @DISCMETH=1, then the parameters *@XPOINTS, @YPOINTS* and *@ZPOINTS* are used to define the number of discretisation points in the X, Y and Z directions respectively.

Twelve discretisation points using @DISCMETH=1, @XDSPACE=4, @YDSPACE=3

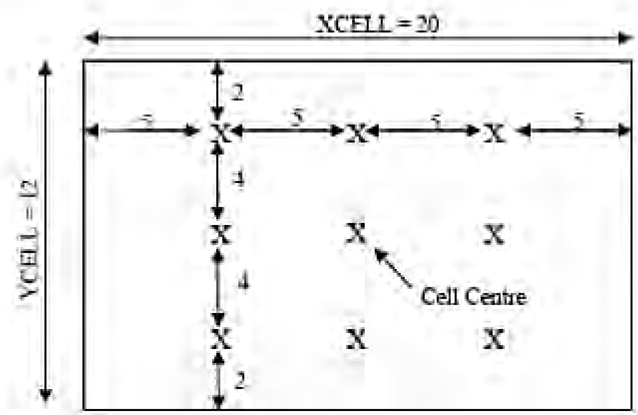


If an even number of points in a direction are defined, then the points will be spaced around the centre line. If an odd number of points are defined then there will be a point on the centre line and the others will be spaced regularly towards the edges. This is illustrated, in two dimensions, in the following diagram.

Method 2 – Define Spacing

If @DISCMETH = 2, then the distance between discretisation points is defined rather than the number of points. This is achieved using parameters *@XDSPACE, @YDSPACE* and *@ZDSPACE*. Using this method there is always one point at the cell centre and all other points are located at the specified distance from it.

Nine discretisation points using @DISCMETH=2, @XDSPACE=5, @YDSPACE=4



The previous diagram illustrates the location of discretisation points using @DISCMETH = 2 with @XDSPACE = 5 and @YDSPACE = 4. If a point is calculated to lie exactly on a cell boundary, then it will not be created.

The advantage of the first method is that the same number of discretisation points will occur in every cell, irrespective of the cell dimensions. However, the disadvantage is that the spacing in one direction may be very much larger than in another direction, depending on the relative dimensions of the cell.

The advantage of the second method is that by setting *@XDSPACE, @YDSPACE* and *@ZDSPACE* equal to each other a completely regular set of points over a cell are created. However, the disadvantage is that for small cells there may be very few and possibly only one discretisation point.

Grade Estimation Methods

It is possible to select different grades to estimate, using different methods and different parameters all in a single run of **ESTIMA**. The different combinations of grades/methods/parameters etc. are each defined by a record in the Estimation Parameter file (&ESTPARM).

Methods available

The estimation method is defined by the field *IMETHOD*. This can take the following values (links shown launch external topics):

1. Nearest Neighbour (NN)
2. Inverse Power of Distance (IPD)
3. Ordinary Kriging (OK)
4. Simple Kriging (SK)
5. Sichel's T Estimator (ST)

The Estimation Parameter File

A simple example of an Estimation Parameter file is shown below. In this example AU is estimated using Inverse Power Distance (2) and AG using Ordinary Kriging (3):

Description	Name of field to be estimated	Search volume reference number	Estimation method	Weighting power for IPD method	Model variogram reference number
Field Name	VALUE_IN	SREFNUM	IMETHOD	POWER	VREFNUM
Field Type	A-8 Chars	N	N	N	N
Record 1	AU	1	2	2	-
Record 2	AG	2	3	-	1

Each estimate is defined as a separate record in the file. In this example different search volumes have been defined for the two grades. The search volume reference numbers (*SREFNUM*) refer to the equivalent field in the Search Volume Parameter file.

Each estimation method (*IMETHOD*) has a numeric code, as described previously. The field POWER only applies to Inverse Power Distance (IMETHOD=2), and so is set to absent data for other methods. The model variogram reference number refers to a record in the Variogram Model Parameter file, which is described later in a section in Grade Estimation Variogram Parameters File.

VALUE_IN and VALUE_OU

As can be seen in the example, the *VALUE_IN* field is an alphanumeric field of 8 characters, and is used to define the grades to be estimated. These grade fields (AU and AG) must exist in the Sample Data file. There is also an optional *VALUE_OU* field (alphanumeric - 8 characters) which allows you to specify a name for the field in the Output Model file. If you do not specify a *VALUE_OU* field, (i.e. it is left blank) then the name of the field in the Output Model file is the same as the name of the *VALUE_IN* field. In the previous example, there is no *VALUE_OU* field and so fields *AU* and *AG* would be created in the Output Model file.

The *VALUE_OU* field is particularly useful if you want to estimate the same grade by different methods or by the same method but using different parameters. For example if you want to estimate AU by both Inverse Power Distance and Ordinary Kriging methods, the *VALUE_OU* field could be *AU-IPD* and *AU-OK*. In both cases, the *VALUE_IN* field would be *AU*.

Description	Name of field to be estimated	Name of field in output file	Search volume reference number	Estimation method	Weighting power for IPD method	Model variogram reference number
Field Name	VALUE_IN	VALUE_OU	SREFNUM	IMETHOD	POWER	VREFNUM
Field Type	A-8 Chars	A-8 Chars	N	N	N	N
Record 1	AU	AU-IPD	1	2	2	-
Record 2	AG	AU-OK	1	3	-	1

Zonal Control

In some cases it may be necessary to use different parameters for the same grade field in different areas. For example, *AU* may have a different set of estimation parameters depending on the rock type. It is possible to specify one or two Zone fields using Zonal control and to have different parameters for each Zone.

Zones are defined using the **ZONE1_F* and **ZONE2_F* fields. For example if different parameters are to be applied depending on Rock Type and Fault Zone then the following fields should be specified:

*ZONE1_F(ROCK), *ZONE2_F(FLTZONE)

The fields *ROCK* and *FLTZONE* must exist in both the Sample Data file and the Input Prototype Model file. Zonal control cannot be used if the Input Prototype Model file does not contain any cells.

Zone fields may be either alphanumeric or numeric. If they are alphanumeric then they may contain a maximum of 20 characters (5 words). In the following example field *ROCK* is alphanumeric and field *FLTZONE* is numeric.

Description	**Name of field to be estimated**	**Search volume reference number**	**Estimation method**	**Rock type field {ZONE1_F}**	**Rock type field {ZONE2_F}**	**Weighting power for IPD method**	**Model variogram reference number**
Field Name	VALUE_IN	SREFNUM	IMETHOD	ROCK	FLTZONE	POWER	VREFNUM
Field Type	A-8 Chars	N	N	A-4 chars	N	N	N
Record 1	AU	1	3	A	1	-	1
Record 2	AU	1	3	B	1	-	2
Record 3	AU	2	2	A	2	2	-
Record 4	AU	2	2	B	2	3	-
Record 5	AU	2	2			2	-

Record 5 has absent data for both the Zone fields (blank for the alphanumeric field *ROCK*, and for the numeric field *FLTZONE*). This set of parameters (the default option) is used for estimating any cells whose *ROCK* and *FLTZONE* fields are not explicitly defined in the Estimation Parameter file. In order to use this default option with two Zone fields, it is necessary to specify both values as absent data.

If two Zone fields are defined then it is not possible to specify one field explicitly and have the other field as absent data. For example, you cannot have *ROCK* as B and *FLTZONE* as - "".

If there is only one Zone field then the estimation parameters corresponding to an absent Zone value will apply to all values whose Zone field is not otherwise specified in the Estimation Parameter file. Therefore, if all Zones are estimated using a single set of parameters then it is only necessary to have one record in the Estimation Parameter file which has the *Zone* field as absent data.

Secondary Fields

The grade being estimated is always written to the Output Model file with its field name determined by the *VALUE_IN/VALUE_OU* fields. In addition to the grade field, some of the estimation methods also calculate secondary fields. For example, kriging also calculates the number of samples used for kriging and the kriged variance. In order for **ESTIMA** to write these secondary fields to the Output Model file the field names must be defined using the Estimation Parameter file. For example:

Description	Name of field to be estimated	Search volume reference number	Estimation method	Number of samples used for estimate	Variance of estimate	Dynamic search volume number	Distance to nearest sample
Field Name	VALUE_IN	SREFNUM	IMETHOD	NUMSAM_F	VAR_F	SVOL_F	MINDIS_F
Field Type	A-8 Chars	N	N	A-8 chars	A-8 chars	A-8 chars	A-8 chars
Record 1	AU	1	3	N-AU	VAR-AU	SVOL-AU	MIDST-AU
Record 2	AG	1	3	N-AG	VAR-AG	SVOL-AG	MIDST-AG

The dynamic search volume was described earlier. It takes values 1, 2 or 3 depending on which search volume is used. In the above example fields *SVOL-AU* and *SVOL-AG* are created in the Output Model file to record which dynamic search volume is used for each grade.

The calculation of the transformed distance of a sample from the cell centre was also described earlier in the Search Volume section. The field name in which to record the transformed distance of the nearest sample is defined by the *MINDIS_F* field. This could be used to assist in categorizing reserves.

The other secondary fields used in this example are *NUMSAM_F* for recording the number of samples used to make the estimate, and *VAR_F* to record the variance of the estimate. The latter field is only applicable to some of the estimation methods.

If there were no absent data *AU* or *AG* values in the Sample Data file and both variables were estimated using the same search volume parameters, then the *NUMSAM_F*, *SVOL_F* and *MINDIS_F* values would be the same. In this case there would be no need to specify different output field names and so records 1 and 2 could be defined as:

Description	Name of field to be estimated	Search volume reference number	Estimation method	Number of samples used for estimate	Variance of estimate	Dynamic search volume number	Distance to nearest sample
Field Name	VALUE_IN	SREFNUM	IMETHOD	NUMSAM_F	VAR_F	SVOL_F	MINDIS_F
Field Type	A-8 Chars	N	N	A-8 chars	A-8 chars	A-8 chars	A-8 chars
Record 1	AU	1	3	N	VAR-AU	SVOL	MIDST
Record 2	AG	1	3	N	VAR-AG	SVOL	MIDST

If the variogram parameters are different, then the kriged variances will be different, and therefore different output field names should be used.

If the same output field names are used but different search volume parameters applied, then values will be written to the Output Model file, but it is not possible to distinguish if the values apply to AU or AG. Care must therefore be taken when specifying secondary field names.

Secondary field names must not be the same as the field name in the estimation parameter file. For example, the field name for the variance must not be *VAR_F* and the field name for the search volume number must not be *SVOL_F*.

Nearest Neighbour

For overview information on all grade estimation methods in general, see Grade Estimation Methods.

IMETHOD = 1

This method is chosen if the *IMETHOD* field in the Estimation Parameter file is set to 1.

Using this method the cell is assigned the value of the 'nearest' sample, where 'nearest' is defined as a transformed or anisotropic distance which takes account of any anisotropy in the spatial distribution of the grade.

The Nearest Neighbor method does not involve weighting sample values, and so either a numeric or an alphanumeric field can be estimated. The alphanumeric field may have up to 20 characters (5 words).

Anisotropy Ellipsoid

All samples lying within the search volume are identified as described previously. The anisotropic distance from the sample to the cell centre is then calculated based on an *anisotropy ellipsoid* which is defined using an identical method to the search ellipsoid. It is usual for the search ellipsoid and the anisotropy ellipsoid to be the same. It is possible to define different ellipsoids if necessary.

The field *ANISO* is used to define which transformed distance to use. This field can have the values:

- **0** - no transformation i.e. isotropic. Distances are calculated from the coordinate system used in the Sample Data file.
- **1** - use the transformed distances defined by the search volume.
- **2** - use the transformed distances defined by the anisotropy ellipsoid.

If ANISO = 2, then it is necessary to specify the anisotropy ellipsoid using fields *ANANGLE1, ANANGLE2, ANANGLE3* and *ANDIST1, ANDIST2, ANDIST3*. These are defined in an identical manner to *SANGLEn* and *SDISTn* as described in the Search Volume section.

Although it is possible to define different angles and axes for the anisotropy ellipsoid, the rotation axis convention must be the same as for the Search Volume, i.e. the first rotation is around *SAXIS1*, then *SAXIS2* and finally *SAXIS3*.

Inverse Power of Distance

For overview information on all grade estimation methods in general, see *Grade Estimation Methods*.

IMETHOD = 2

This method is chosen if the *IMETHOD* field in the Estimation Parameter file is set to 2.

For Inverse Power Distance (IPD) the estimated value is calculated by weighting each sample by the inverse power of its distance from the cell. The required power is defined using the field POWER. If *POWER* is set to zero, then the arithmetic mean of the samples is calculated.

All samples lying within the search volume are identified as described previously, and restrictions on the minimum and maximum number of samples applied. An estimate is made of the grade of each discretised point in the cell. This is done using the anisotropic distance in exactly the same way as described for the Nearest Neighbor method. The estimated cell value is then calculated as the arithmetic mean of the estimates of the discretised points.

ADDCON

If a sample lies exactly on a discretised point, then it will be at zero distance from that point and will get 100% of the weight. This can lead to a biased estimate, particularly if there is only one discretised point and there are other samples lying within the cell. However, this can be avoided by specifying a positive value for the field *ADDCON*.

The value of *ADDCON* is first normalized by dividing the value specified by the length of the largest anisotropy axis. The process will then add the value of *ADDCON* to each distance before estimating the value at the discretised point.

Length and Density Weighting

It is possible to include both length and/or density weighting in the Inverse Power Distance calculation by specifying fields **LENGTH_F* and/or **DENS_F*. For example:

*LENGTH_F(LENGTH), *DENS_F(DENSITY)

If density and length weighting are used then the weight Wi assigned to sample i for estimating a discretised point is:

$W_i = L_i \times \rho i / D_i^P$

where:

- L_i is the length of sample i
- ρ_i is the density of sample i
- $D_i^{\,P}$ is the transformed distance of sample i from the discretised point, raised to the power P

The estimate E_k of discretised point k is then given by:

$$Ek = \Sigma\, W_i \times G_i \,/\, \Sigma\, W$$

where:

- G_i is the grade of sample i.

The cell estimate E_c is then calculated as the arithmetic mean of all discretised points:

$$E_c = \Sigma\, E_k \,/\, N$$

where:

- N is the number of discretised points.

If *LENGTH_F and/or *DENS_F have been specified, but a record in the Sample Data file has absent data value(s) for these field(s), then that sample will not be used in the estimation.

Inverse Power Distance Variance

In addition to the Inverse Power Distance estimate, the variance, V, of the samples is also calculated. This is simply the classical statistical variance of all the samples used for making the Inverse Power Distance estimate:

$$V = (\Sigma G_i^2 - (\Sigma G_i)^2 / N_S) / (N_S - 1)$$

where:

- G_i is the grade of sample i
- N_S is the number of samples used in making the estimate

This secondary field can be saved in the Output Model file using field *VAR_F* as described in *Grade Estimation Methods*.

Kriging

For overview information on all grade estimation methods in general, see Grade Estimation Methods.

IMETHOD = 3 or IMETHOD = 4

Kriging is the geostatistical method for estimating the grade of a volume. The two variations of kriging available in **ESTIMA** are Ordinary Kriging and Simple Kriging, which are identified by the *IMETHOD* field in the Estimation Parameter file:

- **Ordinary Kriging** (OK): IMETHOD = 3
- **Simple Kriging** (SK): IMETHOD = 4

As with Inverse Power of Distance method (IPD), kriging assigns weights to the surrounding data. However, one of the major advantages of kriging is that the weights are calculated in order to minimize the error variance.

Spatial Location of Samples

When minimizing the error variance, kriging takes into account the spatial location of the samples relative to each another. Hence, if several samples are bunched together, this will be taken into account when the weights are calculated and the weights reduced accordingly. This is not the case for IPD, where the weight is only dependent on the distance of the sample from the point being estimated, and does not take account of the location of the other samples.

The calculation of the kriged weights is based on the model variogram, which describes the correlation between two samples as a function of the distance between them. Further details of variogram models are given in the Variogram Model Parameter file section.

Ordinary and Simple Kriging

For Ordinary Kriging (OK) a weight is calculated for each sample, and the sum of these weights is 1. For Simple Kriging(SK) a weight W_i is calculated for each sample and a weight of (1 - ΣW) is assigned to the mean grade.

Simple Kriging is not as responsive as Ordinary Kriging to local trends in the data, since it depends partially on the mean grade, which is assumed to be known, and constant throughout the area. Ordinary Kriging is therefore the most commonly used method of kriging. For further details of the kriging methodology and the calculation of weights, please consult the geostatistical references.

The inputs for Ordinary Kriging and Simple Kriging are very similar and so the following description applies to both methods. There is a small section towards the end which is specific to Simple Kriging.

Lognormal Kriging

ESTIMA allows linear and lognormal kriging for both Ordinary Kriging and Simple Kriging.

The field *LOG* in the Estimation Parameter file is used to select whether linear or lognormal kriging is to be used.

For linear kriging the weights are applied to the sample grades, whereas for lognormal kriging the weights are applied to the logs of the grade and then back transformed. All transformations are done within **ESTIMA**. For Ordinary Kriging the lognormal back transformation used is:

$$E_c = \exp(\Sigma\ W_i \times \log(G_i) + 0.5 \times (\Sigma\ W_i \times \sigma(L_i,L_i) - \Sigma\ \Sigma W_i \times W_j \times \sigma(L_i,L_j)))$$

Where:

- E_c is the kriged estimate
- Wi is the weight for sample i
- Gi is the grade for sample i
- $\sigma(L_i,L_j)$ is the covariance of the logs of the grades of sample i and j

The algorithm for lognormal kriging is based on the method by P.A Dowd in his paper entitled ‘Lognormal Kriging – The General Case’, referred to in the Bibliography.

Two methods of calculation are allowed – *Rendu’s approximation* method, and the *General* Method. It should be noted that the General method is an iterative process and can require several solutions of the kriging matrix for each panel kriged. It therefore has a longer run time than Rendu’s method. You are strongly recommended to read the paper by P.A.Dowd, but its conclusions are summarized below. The variable C is the spatial variance for a spherical variogram model.

a. For small values of C(<1), the general case of lognormal kriging, assuming conservation of lognormality, gives results which are not significantly different from those obtained without the assumption of conservation of lognormality. As C increases the kriging variances obtained from both methods remain very similar, but the difference in kriging weights become increasingly significant.

b. Rendu’s approximation consistently underestimates the kriging variance even for relatively small panels (e.g. sides equal to 20% of the range).

c. Ordinary kriging consistently overestimates the kriging variance.

d. All methods give similar results for very small panels (sides of 5% or les of the range), except when a nugget variance (C_o) is present; then ordinary kriging results differ significantly from the others.

e. As Co increases, the results obtained from Rendu’s approximation approach those obtained without the assumption of conservation of lognormality, although the approximation still significantly underestimates the kriging variance. The significance of the differences in the results obtained from ordinary kriging and from the other methods increases as the nugget variance increases.

You are also strongly recommended to read other papers on the subject. In particular, pages 119-120 of the Handbook of Applied Advanced Geostatistical Ore Reserve Estimation by Michel David show that great care must be taken when applying lognormal kriging.

If lognormal kriging is selected then it is necessary to indicated whether Rendu's approximation or the General Case is to be applied by entering the appropriate value for the field *GENCASE*.

- *GENCASE*= 0 use Rendu's approximation
- *GENCASE*= 1 use the General Case method

If the General Case is selected then three more fields, *DEPMEAN*, *TOL* and *MAXITER* should be included in the Estimation Parameter file, as described below.

The lognormal kriged variance is calculated as a relative variance, VR , relative to the square of the mean, m, of the deposit:

VR = VA / m2

In order for the process to calculate the absolute variance, VA, it is necessary to specify either the actual deposit mean, m, or set it to zero. If the absolute variance is set to zero, then the process uses the kriged estimate of the cell as the mean.

- *DEPMEAN* > 0 use this value as the mean
- *DEPMEAN* = 0 use the kriged estimate as the mean

The General Case method uses an iterative procedure for calculating the kriged weights. The weights are calculated and compared with their previous estimates. If each weight lies within a certain tolerance of its previous value then the new weights are accepted; otherwise, another set of weights is calculated. The tolerance, field *TOL*, and the maximum number of iterations, field *MAXITER* are user defined. If the weights have not converged after *MAXITER* iterations then the calculation for that cell terminates and the newest set of weights are used.

Variogram Model

For each VALUE_IN field to be estimated by kriging, the corresponding variogram reference number (VREFNUM) should be defined in the Estimation Parameter file. This is simply a reference to the model variogram type and parameters as stored in the Variogram Model Parameter file. Therefore any numeric value can be used so long as it is unique in the Variogram Model Parameter file.

The models stored in the Variogram Model Parameter file can be either normal or lognormal.

The field *LOG* in the Estimation Parameter file is used to select whether linear or lognormal kriging is to be used.

Kriging the Cells

As for Nearest Neighbor and Inverse Power Distance, the first step is to identify all samples lying in the search volume, restricted by the constraints on the minimum and maximum number of samples. The kriging matrix is then set up and solved to produce the kriging weights and hence the kriged estimate.

In addition to the kriged estimate, three secondary variables can be calculated for each cell and saved in the Output Model file.

- the number of samples used for kriging
- the kriged variance
- the transformed distance to the nearest sample

In order to save these secondary variables, their field names must be defined in the Estimation Parameter file, as described previously.

Negative Kriging Weights

Under certain conditions, the weights assigned to one or more of the samples can be negative. This is most likely to happen when the model variogram has a low nugget variance and a sample is shielded from the cell by other samples lying directly between it and the cell. It is unlikely that negative weights would account for more than a few percent of the total weight. Although negative weights are mathematically correct, there is a school of thought which considers that negative weights are incorrect and should be set to zero. This can be done using the field *KRIGNEGW*:

- *KRIGNEGW* = 0 negative weights kept and used
- *KRIGNEGW*= 1 negative weights set to zero

If negative weights are set to zero, then the weights of the other samples are proportionally adjusted so that the sum of the weights still equals 1. Any checks on the minimum number of samples (*MINNUMn*) are applied before kriging weights are calculated, so it is possible to have less than *MINNUMn* samples.

Kriging Variance > Sill

Due to the mathematical complexities of the kriging calculations it can sometimes happen that the kriged variance is slightly greater than the sill of the model variogram. Field *KRIGVARS* in the Estimation Parameter file controls whether the calculated variance remains above the sill or is set equal to the sill.

- *KRIGVARS* = 0 keep variances > sill
- *KRIGVARS* = 1 reset variances > sill equal to sill

This control only applies to linear kriging. Variances for lognormal kriging are dependent on the value of *DEPMEAN* and are therefore often greater than the sill.

Simple Kriging

Simple kriging assigns a weight to a local mean value, as well as assigning weights to the surrounding samples. Fields *LOCALMNP* and *LOCALM_F* in the Estimation Parameter file are used to select how this local mean value is defined:

- *LOCALMNP* = 1 use a field in the Input Prototype Model file to define the local mean.
- *LOCALMNP* = 2 calculate the local mean as the arithmetic mean of all samples lying in the search volume.

If *LOCALMNP* = 1 then the name of the field in the Input Prototype Model file which defines the local mean must also be specified. The field name in the Estimation Parameter file is *LOCALM_F* and is an 8 character alphanumeric field. For example:

Description	Name of field to be estimated	Name of field in output model	Search volume reference number	Estimation method	Method for estimating local mean for SK	Local mean field in Input Prototype Model File	Model variogram reference number
Field Name	VALUE_IN	VALUE_OU	SREFNUM	IMETHOD	LOCALMNP	LOCALM_F	VREFNUM
Field Type	A-8 Chars	A-8 Chars	N	N	N	A-8 chars	N
Record 1	AU	AU-OK	1	3	-		1
Record 2	AG	AU-OK	1	3	1	AU-LMEAN	1

The grade AU is to be estimated by both Ordinary Kriging (*IMETHOD* = 3) and Simple Kriging (*IMETHOD* = 4). For Simple Kriging the local mean is provided by field *AU-LMEAN* in the Input Prototype Model file. Therefore, this field must have been created previously. This could be done in a prior run of **ESTIMA**, using IPD with POWER = 0 and a large search radius. This would give the arithmetic mean of all samples lying in the search volume. Alternatively, the mean values depending on a rock type or other geological feature could be assigned.

The grade AG will also be estimated using simple kriging. As *LOCALMNP* = 2 the local mean will be calculated as the arithmetic mean of all samples lying in the search volume. This is calculated before the maximum number and key field constraints are applied.

Sichel's T Estimator

For overview information on all grade estimation methods in general, see Grade Estimation Methods.

IMETHOD = 5

Sichel's T Estimator can be used to estimate the grade of a cell when the statistical distribution of the samples is lognormal. Unlike IPD and kriging it does not take account of the distance of the sample from the cell. Therefore, it is most suitable for estimating large cells each of which contain several samples, and where the search volume is approximately the same size as the cell.

In summary the t estimator is defined as:

$$t = \exp(\bar{x})\ \gamma_n(V)$$

where:

$$\gamma_n(V) = 1 + \sum_{r=1}^{\infty} (n-1)^r V^r / [\,2^r r!\,(n-1)(n+1) \ldots\ldots (n+2r-3)]$$

$$\bar{x} = [\sum_{i=1}^{n} x_i] / n$$

$$V = [\sum_{i=1}^{n} (x_i - \bar{x})^2] / n$$

$$x_i = \log_e [G_i + \alpha]$$

- Gi is the grade of sample i
- α is a constant such that [Gi+α] is lognormally distributed

If the distribution of the samples follows a 3 parameter lognormal distribution, then you should specify the additive constant α using field *ADDCON* in the Estimation Parameter file. This is the same field as used by *IPD*, but it has a totally different meaning in this context. The secondary fields *NUMSAM_F*, *SVOL_F*, *VAR_F* and *MINDIS_F* are defined in an identical manner to the Inverse Power of Distance method.

Estimation Parameter File

The following table summarizes the fields in the Estimation Parameter file. Only fields *VALUE_IN* and *SREFNUM* are compulsory; if other fields are not included in the file then their default values are used.

The field names for the Zone fields are enclosed in { ... }. This signifies that this is not the actual name of the field in the file; the actual name you should use is the name of the Zone field that is included in your Input Sample and Input Prototype Model files e.g. *ROCK* or *FLTZONE*.

The default value of the *VALUE_OU* field is the name you have specified as the *VALUE_IN* value.

The Estimation Parameter File contains the following fields:

Estimation Parameter File				
Field Name	**Type**	**Default**	**Methods**	**Description**
VALUE_IN	A-8		All	Name of field to be estimated
VALUE_OU	A-8	{VALUE_IN}	All	Name of field to be created
SREFNUM	N		All	Search volume reference number
{ZONE1_F}	A or N		All	1st field controlling estimation by zone
{ZONE2_F}	A or N		All	2nd field controlling estimation by zone
NUMSAM_F	A-8		All except NN	Field to contain number of samples used.
SVOL_F	A-8		All	Field to contain dynamic search volume.
VAR_F	A-8		All except NN	Field to contain variance.

MINDIS_F	A-8		All	Field to contain transformed distance to nearest sample.
IMETHOD	N	1	All	Estimation method: 1=NN, 2=IPD, 3=OK, 4=SK, 5=ST
ANISO	N	1	NN,IPD	Anisotropy method: 1=search vol, 2=use ANANGLE, etc
ANANGLE1	N	0	NN,IPD	Anisotropy angle 1
ANANGLE2	N	0	NN,IPD	Anisotropy angle 2
ANANGLE3	N	0	NN,IPD	Anisotropy angle 3
ANDIST1	N	1	NN,IPD	Anisotropy distance 1
ANDIST2	N	1	NN,IPD	Anisotropy distance 2
ANDIST3	N	1	NN,IPD	Anisotropy distance 3
POWER	N	2	IPD	Power of distance for IPD weighting
ADDCON	N	0	IPD, ST	IPD - constant added to distance ST - additive constant for lognormal
VREFNUM	N	1	OK, SK	Variogram model reference number

LOG	N	0	OK, SK	Lognormal kriging flag: 0=linear, 1=log
GENCASE	N	0	LOG=1	Variogram kriging flag: 0=Rendu, 1=General Case
DEPMEAN	N	0	LOG=1	Mean for lognormal variance calculation
TOL	N	0.01	GENCASE=1	Convergence tolerance for log kriging
MAXITER	N	3	GENCASE=1	Maximum iterations for log kriging
KRIGNEGW	N	0	OK, SK	Treatment of negative kriging weights: 0=keep & use, 1=ignore -ve wg samples
KRIGVARS	N	1	Linear Kriging	Treatment of negative kriging variance >sill: 0=keep KV>sill, 1=set KV equal to sill
LOCALMNP	N	2	SK	Method for calculation of local mean: 1=field from &PROTO, 2 = calculate mean
LOCALM_F	A-8		SK	Name of local mean in &PROTO
VANGL1_F	A-8	(NO DEFAULT)	OK, SK	Name of field in &PROTO

				representing 1st dynamic anisotropy variogram angle
VANGL2_F	A-8	(NO DEFAULT)	OK, SK	Name of field in &PROTO representing 2nd dynamic anisotropy variogram angle
VANGL3_F	A-8	(NO DEFAULT)	OK, SK	Name of field in &PROTO representing 3rd dynamic anisotropy variogram angle

Additional Features

More Grade Estimation functions:

Parent Cell Estimation

When creating the geological block model cell splitting is generally applied so that the cells give a good volumetric representation of the geological boundaries. It is then common practice to estimate a separate grade for each cell, so that grades differ between cells in the same parent cell.

This is sometimes an unnecessary refinement, particularly if the grade data is sparse. It is also unnecessarily time consuming to estimate several cells, if a parent cell estimation would suffice.

This is especially true in the early stages of grade estimation when you are not too concerned with the finest detail.

ESTIMA includes an option which allows the grade of the parent cell to be estimated, and then for that value to be assigned to all cells inside the parent. Zonal control is still applicable, so that if for example the parent cell contains 4 cells of rock A and 5 cells of rock B then the parent cell would first be estimated using rock A samples and this value applied to the 4 cells. Then the parent would be estimated for rock B in an identical manner.

Discretisation Options

The discretised points in the parent cell can be calculated by one of two methods. If @PARENT = 1, then the parent cell is represented by a full set of discretised points covering the entire parent cell. If however @PARENT = 2, then the full set of discretisation points is still calculated, but only those points which lie within one of the corresponding cells are selected and used.

In the 2D example there are 6 subcells within a parent cell, and a set of 5 x 5 discretisation points has been superimposed. If @PARENT=1 then all 25 points (X and O) are used to represent the cell, whereas if @PARENT=2 then only the points annotated with a X are used.

Minimum Number of Points

In the second case (@PARENT = 2) it would be possible to have very few or even no discretisation points lying in the cells. In order to allow for this you can specify a minimum acceptable number of discretisation points using the parameter *@MINDISC*. If this minimum is not reached, then the number of points in all three directions is doubled and the points are recalculated.

The advantage of the second method is that it provides a better representation of the cells, but the disadvantage is that the calculation takes a little longer. If @PARENT = 0, then the parent cell feature will not be used.

Copying Field Values

If the Input Prototype Model has cells and already includes the field being estimated, and there is insufficient data within the search volume to estimate a cell, a choice of actions is available controlled by the value of the parameter *@COPYVAL*. If *@COPYVAL* = 0, then an absent data grade value is assigned to the Output Model. If @COPYVAL = 1, then the existing value in the Input Prototype Model is copied to the Output Model.

Update Volume

In certain circumstances it may be necessary to update the grades in one part of the block model. One method is to copy the part of the model which requires updating into a separate submodel, run **ESTIMA** on the sub-model and then add the models back together using ADDMOD.

Alternatively if the part of the model to be updated can be defined as a cuboid, then it is possible to use parameters *@XMIN, @XMAX, @YMIN, @YMAX, @ZMIN, @ZMAX* and do the updating in place. Note that @COPYVAL = 1. Only cells which overlap this update volume will be estimated, although samples from outside the update volume will be used.

Whatever values of *@XMIN, @XMAX* etc. are provided, they will be adjusted by **ESTIMA** to the nearest parent cell boundary before updating begins. Minimum values will be adjusted down and maximum values will be adjusted up. If one or more of the parameters are not specified or are absent data (the default), then the minimum or maximum coordinates of the model are used.

In-place Operation

If all grade fields (as defined by *VALUE_OU* in the Estimation Parameter file) and their corresponding secondary fields (as defined by *NUMSAM_F, SVOL_F, VAR_F and MINDIS_F*) already exist in the Input Prototype Model file, then in-place operation is allowed. This means that the Input Prototype Model and the Output Model files can be the same file. For example:

&PROTO (MODEL1), &MODEL (MODEL1)

If the Input Prototype File and the Model File have the same file name then the process checks to make sure that the file includes all the necessary fields, and terminates with an error message if this is not the case.

An in-place operation allows you to use retrieval criteria on fields in the Input Prototype Model file. Records which do not satisfy the retrieval criteria will remain unaltered in the Output Model file. This can therefore be used for doing a selective update of the model.

Remember that if different Input Prototype Model and Output Model files names are specified and retrieval criteria is used, then only those records that satisfy the criteria will be copied to the Output Model file.

If a grade value cannot be estimated due to insufficient data in the search volume, then the parameter *@COPYVAL* dictates whether an absent data value or the previous value should be assigned.

Pseudo Estimation Methods

The main estimation methods (Inverse Power Distance, Ordinary Kriging, etc) are described in previous sections. However, there are two additional options which are specified using the *IMETHOD* field in the Estimation Parameter file, but which are not actually grade estimates.

If IMETHOD=101, then the value written to the *VALUE_OU* field in the Output Model is the geostatistical F value i.e. the average value of the variogram in the cell. If IMETHOD=102, then the value is the Lagrange multiplier calculated when solving the Ordinary Kriging matrix.

In order to use either of these options you should set all other fields and parameters as if you were selecting Ordinary Kriging.

VARIOGRAMS

Variogram Model Parameter File

A variogram model consists of a nugget variance, Co, and up to 9 individual structures, $\gamma i(h)$. The combined model, $\gamma(h)$, is of the form:

$$\gamma(h) = Co + \gamma1(h) + \gamma2(h) + \gamma3(h) + ... + \gamma9(h)$$

The individual models $\gamma i(h)$ can be *spherical*, *power*, *exponential*, *gaussian* or *De Wijsian*. If kriging is selected as an estimation method, then it is necessary to specify the variogram parameters using the Variogram Model Parameter file. The required fields are shown in the table below:

Field	Default	Description
VREFNUM	1	Variogram reference number (pointer from Estimation Parameter file)
VANGLE1	0	Rotation angle 1, defining orientation of range ellipsoid
VANGLE2	0	Rotation angle 2, defining orientation of range ellipsoid
VANGLE3	0	Rotation angle 3, defining orientation of range ellipsoid
VAXIS1	3	First rotation axis (1=x, 2=y, 3=z)
VAXIS2	1	Second rotation axis (1=x, 2=y, 3=z)
VAXIS3	3	Third rotation axis (1=x, 2=y, 3=z)
NUGGET	0	Nugget variance
ST1	1	Variogram model type for structure 1
ST1PAR1	-	First parameter of structure 1
ST1PAR2	-	Second parameter of structure 1
ST1PAR3	-	Third parameter of structure 1
ST1PAR4	-	Fourth parameter of structure 1

(ST2 to ST8)

ST9	-	Variogram model type for structure 9
ST9PAR1	-	First parameter of structure 9
ST9PAR2	-	Second parameter of structure 9
ST9PAR3	-	Third parameter of structure 9
ST9PAR4	-	Fourth parameter of structure 9

All fields are numeric and are optional except for the variogram reference number. If a field is not included in the file, then its default value will be used.

The variogram reference number is a pointer from the Estimation Parameter file. Any numeric value may be used for this field.

Variogram Ellipsoid

The variogram ellipsoid is used to define any parameter which is not isotropic, the most common example being the range of the spherical model. The variogram ellipsoid is defined using fields *VANGLE1*, *VAXIS1*, etc in an identical manner to the search ellipsoid, described in the Search Volume section. An example using these rotation fields is given further on in this section.

The default values specify no rotation. Therefore if the variogram ellipsoid is to have the same orientation as the search ellipsoid the fields *SANGLE1*, *SAXIS1*, etc in the Search Volume Parameter file must be the same as fields *VANGLE1*, *VAXIS1*, etc in the Variogram Model Parameter file.

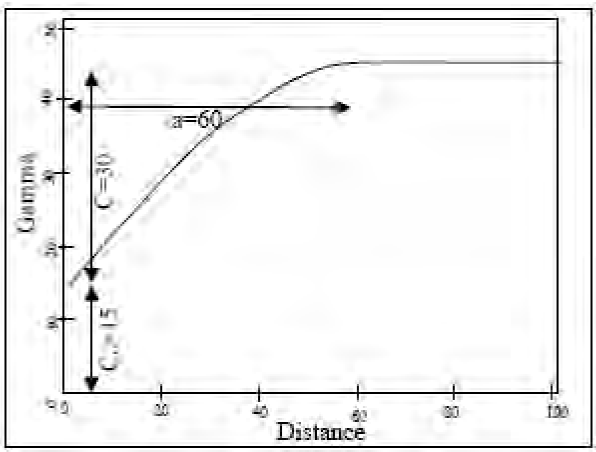
Variogram Model Types

Field STs defines the model type for structure s. The options for STs are:

1. **spherical**
2. **power (eg linear)**
3. **exponential**
4. **gaussian**
5. **De Wijsian**

Examples of the 5 model types are shown in the diagrams below. The diagrams also include a two-structure spherical model:

Spherical Model – Type 1



The spherical model is defined by the range a, and the spatial variance C:

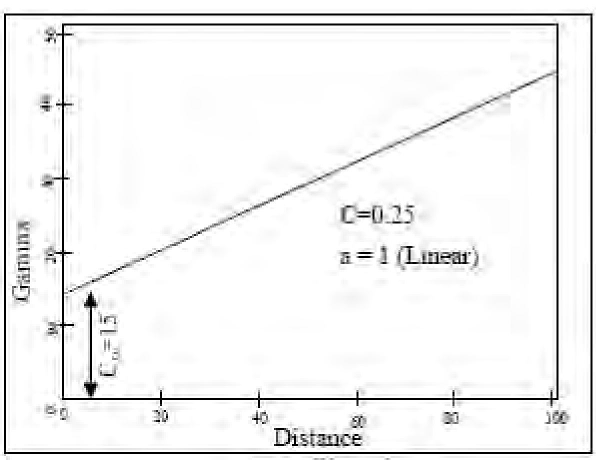
$\gamma_i(h) = C\ [1.5 \text{ x } h / a - 0.5 \text{ x } (h / a)^3\ ]$ if $h \leq a$

$= C$ if $h > a$

The five fields required are:

- **STs** =1 for a spherical model
- **STsPAR1** range in direction 1 (X axis after rotation)
- **STsPAR2** range in direction 2 (Y axis after rotation)
- **STsPAR3** range in direction 3 (Z axis after rotation)
- **STsPAR4** spatial variance C.

Power Model – Type 2



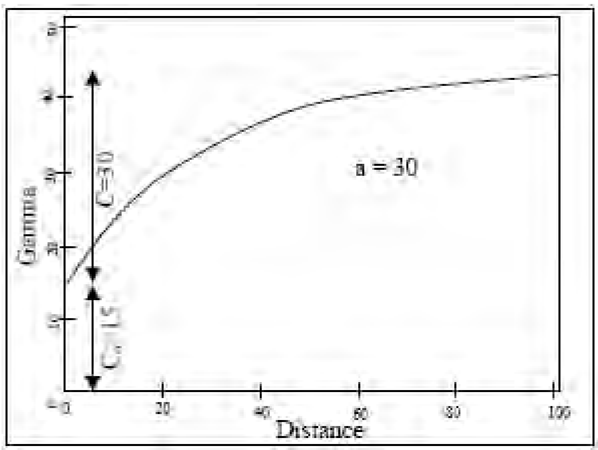
The power model is defined by a power a (0 < a < 2) and a positive slope C:

$\gamma_i(h) = C \text{ x } h^a$

The five fields required are:

- **STs** =2 for a power model
- **STsPAR1** power in direction 1 (X axis after rotation)
- **STsPAR2** power in direction 2 (Y axis after rotation)
- **STsPAR3** power in direction 3 (Z axis after rotation)
- **STsPAR4** slope C

Exponential Model – Type 3



The exponential model is defined by parameter a and spatial variance C:

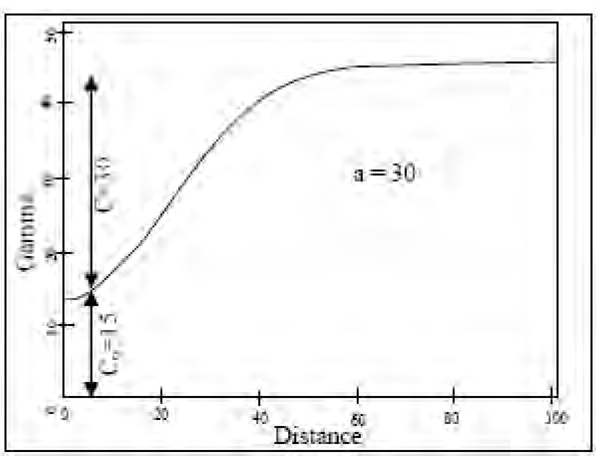
$\gamma_i(h) = C[1 - \exp(-h/a)]$

The five fields required are:

- **STs** =3 for a exponential model
- **STsPAR1** parameter a in direction 1 (X axis after rotation)
- **STsPAR2** parameter a in direction 2 (Y axis after rotation)
- **STsPAR3** parameter a in direction 3 (Z axis after rotation)
- **STsPAR4** spatial variance C

The parameter **a** is often referred to as 1/3 range. In the graphic **a**=30, so the range is 90m. At a distance of 90m the Gamma value has reached 95% of the sill (nugget variance + spatial variance).

Gaussian Model – Type 4



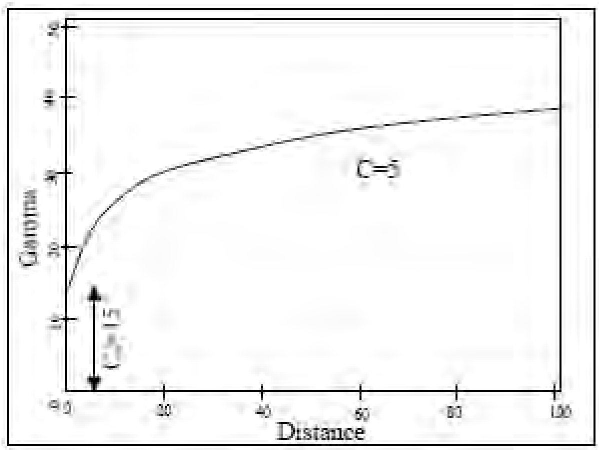
The Gaussian model is defined by parameter a and spatial variance C:

$\gamma_i(h) = C\,[1 - \exp(-h^2 / a^2)]$

The five fields required are:

- **STs** =4 for a gaussian model
- **STsPAR1** parameter a in direction 1 (X axis after rotation)
- **STsPAR2** parameter a in direction 2 (Y axis after rotation)
- **STsPAR3** parameter a in direction 3 (Z axis after rotation)
- **STsPAR4** spatial variance C

De Wijsian Model – Type 5



The De Wijsian Model is defined by parameter c:

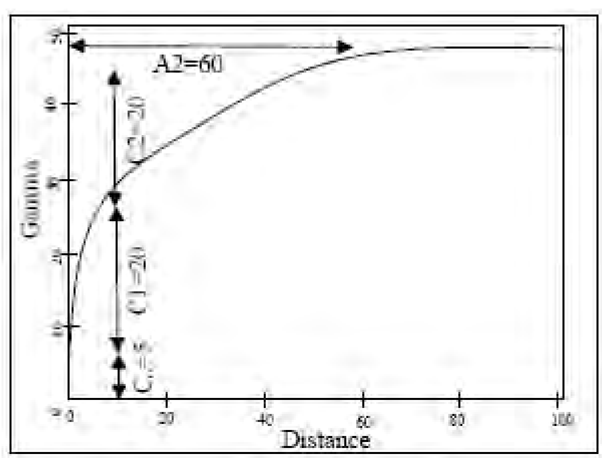
$\gamma_i(h) = C \times \log_e(h)$ h>1

= 0 h≤1

The four fields required are:

- **STs** =5 for a De Wijsian model
- **STsPAR1** parameter C in direction 1 (X axis after rotation)
- **STsPAR2** parameter C in direction 2 (Y axis after rotation)
- **STsPAR3** parameter C in direction 3 (Z axis after rotation)

Two-structure spherical model type



Two-structure Spherical model type graph shown for comparison

Rotation Example

This example illustrates the case where three rotations are required to describe the anisotropy.

The first rotation is a conventional azimuth rotation of 20o around the Z-axis, the second rotation is a dip of 40 o around the new X-axis, and the final rotation is 60o around the new Y-axis. Ranges for structure 1 are 100m, 200m and 300m in the new X, Y and Z directions. The fields are:

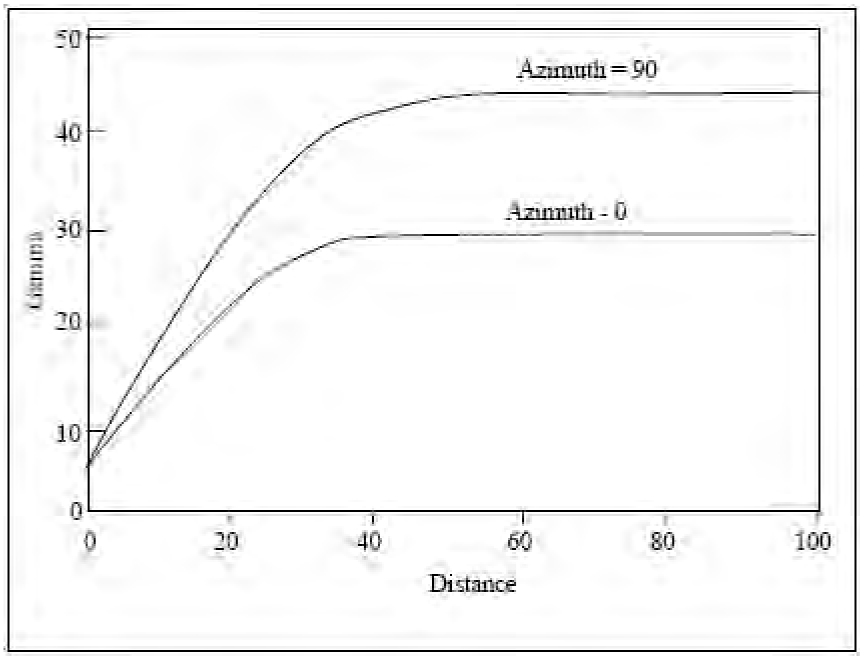
Field	Value

VANGLE1	20
VANGLE2	40
VANGLE3	60
VAXIS1	3
VAXIS2	1
VAXIS3	2
ST1PAR1	100
ST1PAR2	200
ST1PAR3	300

Zonal Anisotropy

The definition of the variogram model in **ESTIMA** does not allow anisotopic C_o or C values for model types 1 to 4. An anisoptopic C value for the De Wijsian model (type 5) is acceptable because the model equation does not have any other anisotropic variables.

In ESTIMA zonal anisotropy can be represented by a multi-structure model. The following example shows a two structure spherical model with a sill of 30 for an azimuth of 0^o and a sill of 45 for the 90^o direction.



The nugget variance Co is 5, and all the rotation angles (*VANGLEn*) are zero. Setting range 2 in direction 0° to a large distance (10000m) has the effect of creating a lower sill over the part of the variogram model that is of interest. Of course if the distance axis were plotted up to 10000m, the variogram for 0o would eventually reach a sill of 45.

The full set of field values for this model as stored in the Variogram Model Parameter file is as follows:

Field Name	Value
VREFNUM	1
VANGLE1	0
VANGLE2	0
VANGLE3	0
VAXIS1	3
VAXIS2	1
VAXIS3	3
NUGGET	5

ST1	1
ST1PAR1	40
ST1PAR2	40
ST1PAR3	40
ST1PAR4	25
ST2	1
ST2PAR1	60
ST2PAR2	10000
ST2PAR3	60
ST2PAR4	15

Note that in this example the anisotropy is orthogonal to the coordinate system, and so all angles are zero. In this case the axis values are irrelevant.

Run-time Optimization

This topic is part of the Grade Estimation range of topics.

Several features included in **ESTIMA** have been designed to minimize run time. Some of these are activated automatically whereas others are user controlled.

It is strongly recommended that estimation parameters are tested on a small model first. This may be either a representative subset of the full model or a model with a larger cell size and less cell splitting than the final model. Also for those features where there is a choice, always select a suitable approximation for the first test run.

Sample Search

One of the most time consuming parts is the selection of samples within the search volume. A 'super-block' search algorithm has been implemented in order to minimize this part of the process.

There is no need to sort the Sample Data file on any particular field, because **ESTIMA** sets up its own indexes. However, it is necessary to ensure that the Input Prototype Model is sorted on IJK, or the process will terminate with an error message.

Multiple Variables

The ability to estimate multiple variables in a single run of **ESTIMA** leads to a significant reduction in run times. If two or more grades are estimated using the same search volume and the same estimation parameters, then the incremental time for the second and subsequent grades is very small. Even if different estimation parameters are used there is still a time saving when estimating multiple grades.

Discretisation Points

Cell discretisation points are used for the Inverse Power Distance, Ordinary Kriging and Simple Kriging estimation methods. The more points the longer the processing time but the better the cell representation. It is recommended that a small number of discretisation points are used for test runs.

Number of Samples

Processing time is also a function of the number of samples used for making each estimate. For methods such as Inverse Power Distance and Sichel's t estimator, the actual calculation involved is fairly small and so using a large maximum number of samples will only slow the process down in so far as the search time is increased. However, for kriging, each estimate involves solving a set of **n** simultaneous linear equations, where **n** is the number of samples used for the estimate.

The time taken to solve each set of n equations is approximately proportional to n2.

Kriging Variance

Calculating the kriging variance involves calculating the geostatistical F value - the average value of the variogram in a cell. In order to do this the variogram function is called approximately n2/2 times, where **n** is the total number of discretisation points in the cell.

Obviously, this can be a time consuming operation if the number of points is large. Therefore, if the kriged variance is not going to be used in the presentation of reserves there is no point in calculating it. If a value for the *VAR_F* field in the Estimation Parameter file is not specified then the variance will not get calculated.

If the kriging variance is calculated, then **ESTIMA** stores the F value for a parent cell. Therefore, calculating the variance for a model which contains nearly all parent cells is not nearly as time-consuming as a model containing mainly sub-cells.

Parameter @FVALTYPE

A time saving option has been included which allows the dimensions of a cell to be approximated by a discrete number of cell sizes. This is controlled by parameters *@FVALTYPE* and *@FSTEP*. Parameter *@FVALTYPE* takes one of the following values:

- =1 - the exact dimensions of the cell are used, and so the F value is calculated for every cell in the model, except the parent cell which is calculated just once.

- =2 - each cell is approximated to one of a discrete number of cells. As each cell is processed reference is made to a look up table to see whether the F value for that size cell has already been calculated. If it exists then the value is used; if not then it is calculated and stored in the table for future use. This gives a large speed improvement.

It is not possible to have @FVALTYPE=2 if the parent cell estimation with discretisation points within cells (@PARENT=2) has been specified. If this combination is specified, then *@FVALTYPE* will be reset to 1.

Parameter @FSTEP

Parameter *@FSTEP* defines the step size which is used for approximating the dimensions of the cell. F values are stored for subcells whose dimensions are an integer multiple of the step size.

For example if @FSTEP=2, then any cell with dimensions in the range:

5 < XINC <_ 7, 1 < YINC <_ 3, 7 < ZINC <_ 9

would be approximated by a cell of dimensions 6 x 2 x 8.

If the dimension of a cell in one direction is less than half the step size, then it will be approximated by a dimension equal to the step size. Therefore in the previous example the criteria should really be stated as:

5 < XINC <_ 7, 0 < YINC <_ 3, 7 < ZINC <_ 9

As with discretisation points a test on a small part of the model should be carried out to find the effect of differing the step size. A step size of 1 will generally significantly improve processing speed without making any significant difference to the kriging variance.

Rotated Models

A *Rotated Model* is one whose axes, and therefore cells, are rotated with respect to the coordinate system. It is particularly useful in the situation where a stratified orebody is dipping and/or plunging. As can be seen from the diagram below the model cells provide a much better fit when the model is rotated. A detailed description is given in the Rotated Block Models User Guide, and the Studio 3 Technical Notes Help file (available on request).

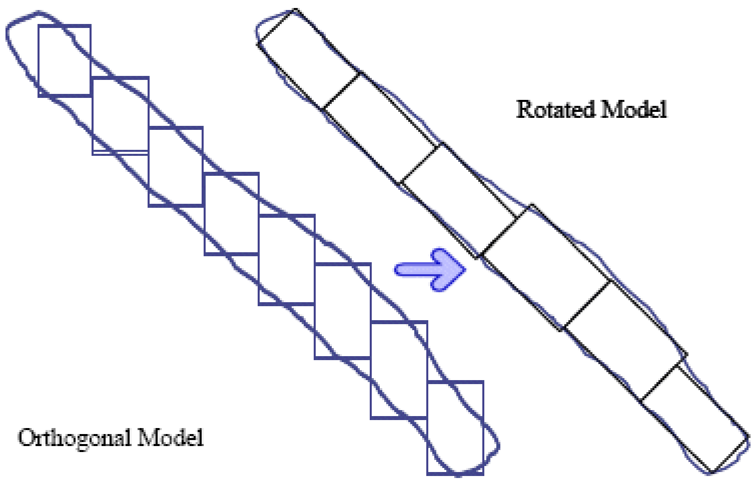


Fig 1. The Rotated Model Concept

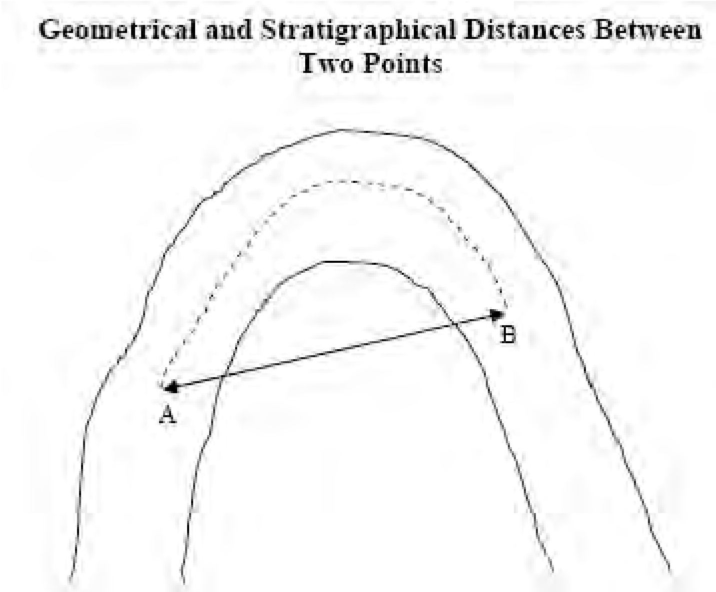
ESTIMA will automatically recognize if the Input Prototype Model is a rotated model. If it is then **ESTIMA**will inversely translate and rotate the model cell coordinates back into the world system before calculating the grade estimates. It does this by rotating the actual discretised points immediately prior to estimation. This is an internal operation only - the coordinates of the cells in the Output Model file will be rotated; i.e. they will be the same as the Input Prototype Model.

Because the process rotates the model cells internally, this means that it is necessary to supply all search volumes, anisotropy parameters, variogram models, coordinates of the Sample Data, etc. in the world coordinate system. In summary, a rotated model must be supplied as the Input Prototype Model. There are no other files, fields or parameters which need to be set.

Unfolding

The estimation methods of Nearest Neighbor, Inverse Power of Distance and Kriging all involve calculating the distance between each sample and either the centre of the cell or the discretisation points. These measurements are usually made in the standard Cartesian XYZ coordinate system.

However, for a folded deposit, where mineralization has occurred pre-folding, a line measured in the pre-folded orebody is required.



The problem is illustrated by the simple example above, which shows two samples either side of an anticline. Using the XYZ coordinate system, the standard geometrical distance between A and B is a straight line. However, from a geological point of view the distance separating them is a line following the anticline structure, shown as a broken line in the diagram. This is the distance between samples prior to folding.

The unfolding method allows the sample coordinates and model cells to be transformed into the original unfolded system, grade estimation is carried out in the unfolded system, and then

convert back to the folded system for reserve evaluation and planning. The method is described in detail in the Unfold User Guide (available on request). There is also a description in a paper by Dr. M.J.Newton, referenced in *Grade Estimation References*.

The **UNFOLD** process must be used prior to grade estimation to calculate the unfolded coordinates of sample data. This file should then be input to **ESTIMA** as the Sample Data file. All search volumes, anisotropy parameters, variogram models, etc must be specified in the unfolded system. The only exception to this is the Input Prototype Model, which is in the world (i.e. folded) coordinate system. The way **ESTIMA** works is to unfold the discretisation points so that the estimation is carried out in the unfolded system. The estimated grade and any secondary variables are then assigned back to the corresponding cell in the folded model. The unfolding option is selected by specifying the optional String file. This must contain the string data describing the hangingwall and footwall outlines on two or more sections. It is also necessary to specify the unfolding parameters and fields, as described in the Unfold Reference Manual.

⚠ Unfolding is not allowed for a rotated model. If this combination is selected then the process will terminate with an error message.

Output and Results

The two output files **ESTIMA** creates are the Output Model file and the Sample Output file. The former is simply a copy of the Input Prototype Model file with the estimated grade and secondary field(s). If retrieval criteria have been specified then only a subset of the cells will be copied to the Output Model file, unless **ESTIMA** is running an in-place operation.

Sample Output File

The Sample Output file is optional, and records the weight of each sample for each cell for each grade which is estimated. Each weight is a separate record and so the file could become very large. In normal circumstances this output is generally not required. However, the Sample Output file does provide useful data if you want to find out how the estimated value for any cell was calculated. The fields created in the Sample Output file are:

Search Volume Parameters File	
Field Name	**Description**
XC	X coordinate of centre of cell being estimated
YC	Y coordinate of centre of cell being estimated
ZC	Z coordinate of centre of cell being estimated
X	X coordinate of the sample
Y	Y coordinate of the sample
Z	Z coordinate of the sample
ACTDIST	The actual distance of the sample from the cell centre
TRANDIST	The transformed distance of the sample from the cell centre, using the search volume transformation
FIELD	The name of the grade field being estimated
GRADE	The name of the sample grade
WEIGHT	The weight assigned to the sample
OCTANT	The octant number; only if octant search is used

{ZONE1_F}	The actual field name in the file be whatever you have specified as *ZONE1_F, e.g. 'ROCK'. The value recorded will then be the value of the rock field.
{ZONE2_F}	As for {ZONE1_F}
AV-VGRAM	Average value of the variogram between the cell and the sample. Only recorded if kriging is used.

Sample Output Example

An example of part of a Sample Output file is shown below:

XC	YC	ZC	X	Y	Z	ACT DIST	TRAN DIST	FIELD	GRDE	WGT	OCT	ROCK	AV-VGRM
350	250	150	321	222	131	44.6	0.374	AU	3.51	0.284	7	A	6.128
350	250	150	351	301	174	56.4	0.350	AU	5.78	0.237	1	A	6.912
350	250	150	248	248	153	0.044	0.044	AU	9.14	0.324	2	A	4.730
350	250	150	245	245	117	0.792	0.792	AU	2.79	0.155	6	A	8.636

Screen Display

An example of the information displayed on the screen during processing is shown here. The first item gives information on the use of virtual memory, and is displayed if @PRINT≥1.

The Estimation Table provides a summary of each estimate to be calculated. If Zonal Control is used then the corresponding zone values are shown. In this example there are two zone fields – one alphanumeric and one numeric.

If, in the Estimation Parameter file a single set of parameters have been applied to all zones then a record will be shown in the Estimation Table for each possible combination of zones. It may therefore appear that there are more combinations of zones than have been specified.

The estimates are carried out in the order shown in the table. This is not necessarily the same as the order you specified in the Estimation Parameter file, because the order has been arranged to minimize run-time.

Screen Display

```
>>> The total number of virtual memory files is  11
    The total number of words in the vm files is          47942

Estimation Table
----------------
Estimations will be carried out for the following combinations of grade and
zone fields:

      Sample    Output    Zones .......................... Search  Est
      Data      Model                                      Vol.Ref Mech
      Grade     Grade
   1  AU        AU-IPD    OXIDE             1.000              1.0     2
   2  AU        AU-KRG    OXIDE             1.000              1.0     3
   3  AU        AU-IPD    SULPHIDE          1.000              1.0     2
   4  AU        AU-KRG    SULPHIDE          1.000              1.0     3
   5  AU        AU-IPD    OXIDE             2.000              3.0     2
   6  AU        AU-KRG    OXIDE             2.000              3.0     3
   7  AU        AU-IPD    SULPHIDE          2.000              3.0     2
   8  AU        AU-KRG    SULPHIDE          2.000              3.0     3

 Number of records in the output model =      9500
 Number of different grade fields      =         2
 Maximum number of estimates           =     19000

This maximum number ignores retrieval criteria, selective updating,
unestimated zones etc, and so the % figure in the progress report may be
too low.

 >>>     19000 estimates,  100.0% completed.    Time  12:24:21 <<<

 Total number of estimates                    19000

 Summary Statistics for Kriging
 ------------------------------
 The total number of kriged estimates calculated is      9500
 The number of kriged estimates with:
  - one or more samples with zero covariance               50
  - error in solving kriging matrix                         0
  - kriging variance greater than the sill                  0
  - one or more negative kriging weights                  202
  - only one discretisation point                           0
  - maximum iterations in log kriging                       0

 >>>    9500 RECORDS IN FILE MODEL1   <<<
```

The maximum number of estimates is calculated as the number of records in the Output Model multiplied by the number of different grade fields to be created. There are several situations where the actual number of estimates may be less than this number:

- Zonal control is used, but only certain combinations of zone fields have been specified, and a default set of estimation parameters have not been specified.
- The estimation is in-place and you have specified retrieval criteria.
- If the selective update parameters *@XMIN*, *@XMAX* etc are being used.

The progress report shows the number of estimates completed, both as an absolute figure and as a percentage of the maximum number of estimates. For the reasons described previously it is possible that the percentage figure is too low.

It is also possible that the percentage figure in the progress report may exceed 100%. This would happen if, in the Estimation Parameter file, two or more *VALUE_OU* fields had been incorrectly defined and had the same field name. For example in the Screen Display table, if the Output Model Grade were *AU* for all 8 records then there would only be one different grade, and so the number of estimates would be 9500, even though 19000 estimates would be calculated.

The Output Model file would only include the kriged estimate, because although the IPD estimate would be calculated, it would be overwritten by the kriged estimate. Therefore if the progress report exceeds 100%, check the *VALUE_OU* fields in your Estimation Parameter file.

The table entitled 'Summary Statistics for Kriging' (in the image shown above) is only displayed if Simple Kriging or Ordinary Kriging have been specified as one of the estimation methods. The information included in this table is:

- One or more samples with zero covariance: This shows the number of estimates which included one or more samples whose distance from the cell exceeded the range of the variogram. This is not an error, or even a problem, but just gives an indication that for some cells it may be possible to reduce the maximum number of samples without significantly affecting the kriged variance.
- Error in solving the kriging matrix: If an error has occurred while trying to solve the kriging matrix the kriged estimate will be set to absent data (-). If @PRINT>_1 is used, then the cell coordinates will be displayed and saved in the print file if @ECHO=1. The probable may be caused by very high anisotropy on the variogram ranges, so check the variogram model. Also make sure that lognormal kriging with a normal variogram model is not being used.
- Kriging variance greater than sill: This is simply for information, and is not a problem. The treatment of variances greater than the variogram sill is described in the topic on Kriging.
- One or more negative kriging weights: This is also for information, and is not a problem. The treatment of negative kriging weights is described in the section on Kriging.
- Only one discretisation point: This situation only occurs with parent cell estimation if @PARENT=2. The number of discretisation points in each direction is doubled until the number exceeds *@MINDISC*.
- Maximum iterations in log kriging: The General Case option for lognormal kriging is an iterative procedure. This item records the number of times an iteration is terminated because the maximum number of iterations has been reached. If this happens very frequently consider increasing the maximum number allowable - field *MAXITER* in the Estimation Parameter file.

Grade Estimation Examples

This topic is part of the Grade Estimation range of topics.

Example 1 – Nearest Neighbor and Inverse Power Distance

The first example is a run of **ESTIMA** using the Nearest Neighbor and Inverse Power Distance methods.

The Search Volume Parameter file, *SRCPARM1*, is shown below. Remember that all 24 fields are compulsory. Three separate search volumes have been defined. The first two will be used for this example, and the third for example 2.

The first search ellipsoid has an axis of 100m dipping at 45° in the direction N25°E. The second axis is 40m and is aligned horizontally in the direction E25°S. The third axis of the search ellipsoid is 10m, perpendicular to the other two. The second search ellipsoid has the same rotations as the first ellipsoid, and then a third clockwise rotation of 65° is applied in the new XY plane.

	SREFNUM	SMETHOD	SDIST	Y	Z	ACT DIST	TRAN DIST	FIELD
1	1	2	40	100	10	25	45	0
2	2	2	40	100	10	25	45	65
3	3	2	70	60	80	12	34	56

	SAXIS1	SAXIS2	SAXIS3	MINNUM1	MAXNUM1	SVOLFAC2	MINNUM2	MAXNUM2
1	3	1	3	1	10	-	-	-
2	3	1	3	1	500	-	-	-
3	3	1	3	1	11	-	-	-

	SVOLFAC3	MINNUM3	MAXNUM3	OCTMETH	MINOCT	MINPEROC	MAXPEROC	MAXKEY
1	-	-	-	0	-	-	-	-
2	-	-	-	0	-	-	-	-
3	-	-	-	0	-	-	-	-

All fields in the Estimation Parameter file, except *VALUE_IN*, are optional. In this example 7 fields are specified for file *ESTPARM1*, and so the remaining fields all take their default values.

In particular this means that ANISO=1, so the anisotropy ellipsoid for distance weighting is the same as the search ellipsoid.

	VALUE_IN	VALUE-OU	NUMSAF_F	SREFNUM	IMETHOD	POWER	ADDCON
1	AU	AU-NN	-	1	1	-	-
2	AU	AU-IPD	IPD-NUM	2	2	1	5

The required files for **ESTIMA** are shown below. No fields or parameters have been specified as they all take their defaults.

```
!ESTIMA &PROTO(PROTOMOD), &IN(SAMPLES), &MODEL(MOD1EST),

&SRCPARM(SRCPARM1), &ESTPARM(ESTPARM1)
```

Example 2 – Ordinary Kriging

The Search Volume Parameter file used here is the same file as used for example 1. The Estimation Parameter file, ESTPARM2, contains the following fields:

	VALUE_IN	VALUE-OU	NUMSAF_F	VAR_F	SREFNUM	IMETHOD	VREFNUM	LOG
1	AU	AU-KRG	N-KRG	KV-KRG	3	3	5	0
2	AU	AU-LOG	N-LOG	KV-LOG	1	3	6	1

The Variogram Model Parameter file, *VMODPARM* is:

	VREFNUM	VANGLE1	VANGLE2	VANGLE3	VAXIS1	VAXIS2	VAXIS3	NUGGET
1	5	12	34	56	3	1	3	10
2	6	25	45	0	3	1	3	0.1

	ST1	ST1PAR	ST1PAR2	ST1PAR3	ST1PAR4
1	1	40	30	50	20
2	1	45	35	55	0.2

The required fields and parameters for ESTIMA are shown below. All fields and all other parameters take their defaults.

```
!ESTIMA &PROTO(PROTOMOD), &IN(SAMPLES), &MODEL(MOD2EST),

&SRCPARM(SRCPARM1), &ESTPARM(ESTPARM2),

@XPOINTS=3, @YPOINTS=3, @ZPOINTS=3
```

Parameter Summary

A summary of all parameters is given in the following table. All parameters are optional, and if not specified will take their default values:

ESTIMA - Summary of Parameters			
Parameter	**Default**	**Method(s)**	**Description**
XSUBCELL	1	All	Number of subcells in X if &PROTO is empty
YSUBCELL	1	All	Number of subcells in Y if &PROTO is empty
ZSUBCELL	1	All	Number of subcells in Z if &PROTO is empty
DISCMETH	1	IPD, OK, SK	Cell discretisation method: • 1=use @XPOINTS etc • 2=use @XDSPACE etc
XPOINTS	1	@DISCMETH=1	Number of discretisation points in X
YPOINTS	1	@DISCMETH=1	Number of discretisation points in Y
ZPOINTS	1	@DISCMETH=1	Number of discretisation points in Z
XDSPACE	1 pt at cell centre	@DISCMETH=2	Distance between discretisation points in X
YDSPACE	1 pt at cell centre	@DISCMETH=2	Distance between discretisation points in Y
ZDSPACE	1 pt at cell centre	@DISCMETH=2	Distance between

			discretisation points in Z
PARENT	0	All	Parent cell flag: • 0=estimate individual cells • 1=parent, all disc.pts • 2=parent, select disc.pts
MINDISC	1	@PARENT=2	Minimum number of discretisation points
XMIN	&PROTO min X	All	Minimum X value for model updating
XMAX	&PROTO max X	All	Maximum X value for model updating
YMIN	&PROTO min Y	All	Minimum Y value for model updating
YMAX	&PROTO max Y	All	Maximum Y value for model updating
ZMIN	&PROTO min Z	All	Minimum Z value for model updating
ZMAX	&PROTO max Z	All	Maximum Z value for model updating
COPYVAL	0	All	Copy flag: • 0=absent data in insufficient data • 1=copy existing value(s) to Output Model

FVALTYPE	1	OK, SK	F value approximation: • 1=use exact cell dimensions • 2=approximate cell dimensions
FSTEP	1	@FVALTYPE=2	Step size for cell approximation for F value
LINKMODE	3	Unfold	Method of defining string linking
UCSAMODE	2	Unfold	The type of UCSA coordinate
UCSBMODE	3	Unfold	The type of UCSB coordinate
UCSCMODE	2	Unfold	The type of UCSC coordinate
PLANE	1	Unfold	The plane of the structural interpretations
HANGID	-	Unfold	The value of hangingwall field in &STRING file
FOOTID	-	Unfold	The value of footwall field in &STRING file
TOLRNC	0	Unfold	Tolerance in the calculation of UCSA coordinate
ORGTAG	-	Unfold	Tag number defining origin of UCSB axis
PRINT	0	All	Flag controlling quantity of displayed output: • 0=minimum

			• 1=medium • 2=maximum
ECHO	0	All	Flag controlling output sent to print file: • 0=do not send to file • 1=send to file

Files and Fields

A summary of all the files used by **ESTIMA** is given in the following table:

File Name	Input/Output	Mandatory/Optional	Description
PROTO	I	M	Input prototype model
IN	I	M	Sample data file
SRCPARM	I	M	Search volume parameter file
ESTPARM	I	M	Estimation parameter file
VMODPARM	I	O	Variogram model parameter file
STRING	I	O	Unfolding strings file
MODEL	O	M	Output model
SAMPOUT	O	O	Sample output file

Most of these files have been described in detail in the previous sections. A brief description of the Input Prototype Model and Sample Data files is given here:

Input Prototype Model

This is a standard Datamine model file containing the 13 compulsory fields. In addition it may contain the following three fields:

- **LOCALM_F**: the local mean for simple kriging
- **ZONE1_F**: first field for zonal control
- **ZONE2_F**: second field for zonal control

Sample Data File

This file must contain the X, Y and Z coordinates of the samples, and at least one grade field.

ESTIMA expects the names of the coordinate fields to be X, Y and Z. However, if other names have been used then they can be specified, for example:

```
*X(EAST), *Y(NORTH), *Z(RL)
```

The name(s) of the grade field(s) are defined using the fields VALUE_IN in the Estimation Parameter file. The other fields (all optional) in the Sample Data file are:

- **ZONE1_F**: first field for zonal control
- **ZONE2_F**: second field for zonal control
- **KEY**: field used to restrict samples per keyfield
- **LENGTH_F**: field for Inverse Power Distance length weighting
- **DENS_F**: field for Inverse Power Distance density weighting

These fields are specified in the same way as specifying coordinates e.g. *KEY(BHID).

However, please note that if there was a field named KEY in the Sample Data file and MAXKEY was set to 1 or more in the Estimation Parameter file, then the process would use the field KEY for restricting samples even if *KEY(KEY) was not specified.

A similar situation to the KEY field example applies to the other fields, which is why they have been given names which are unlikely to occur in normal use.

Summary of Fields

ESTIMA uses the standard CAE Mining field naming conventions. The fields which are prompted for are shown below. Note that all fields are optional:

Parameter	Default	Method(s)

IN	X	X coordinate of sample data
	Y	Y coordinate of sample data
	Z	Z coordinate of sample data
	KEY	Key field used to restrict samples for estimation
	LENGTH_F	Field used for length weighting for IPD
	DENS_F	Field used for density weighting for IPD
IN, PROTO, MODEL, ESTPARM	ZONE1_F	First field for zonal control
	ZONE2_F	Second field for zonal control
STRING	SECTION	Section identifier for unfolding
	BOUNDARY	Boundary identifier for unfolding
	WSTAG	Within section tag
	BSTAG	Between section tag
	TAG	Tag field

System Limits

There is no restriction on the number of records in either the Sample Data file or the Input Prototype Model file. However, there are certain restrictions on some variables.

Number of Zones

There is a limit of 100 on the maximum number of zone combinations in the Sample Data file or the Input Prototype Model files. In only one zone field is defined then this means a maximum of 100 different zones. If there are two zone fields this means 100 unique combinations of zone 1 and zone 2.

Length of Zone Field

If a zone field is alphanumeric it must be less than or equal to 20 characters (5 words).

Grade Fields

The maximum number of different grades defined by the *VALUE_IN* field in the Estimation Parameter file is 31. There can be more than 31 records in the Estimation Parameter file so long as some of the grade values are the same e.g. different parameters for the same grade field in different zones. There is also a limit of 31 on the number of *VALUE_OU* fields in the Estimation Parameter file.

Length of Key Field

If the *KEY field is alphanumeric it must be less than or equal to 40 characters (10 words)

Samples for Each Estimate

There is no limit to the number of samples within the search volume for the estimation methods Nearest Neighbor, Inverse Power Distance or Sichel's t. However for Ordinary Kriging and Simple Kriging there is a limit of 1400 samples. This limit should be taken into account when defining the *MAXNUMn* fields in the Search Volume Parameter File.

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List of Exercises

The following table contains a list of the exercises covered in this Grade Estimation tutorial, grouped according to the different headings.

Heading	Page	Exercise
Getting Started	Creating a New Project	Creating and Saving a New Project
	Displaying Toolbars	Displaying grade estimation toolbars
		Customizing a toolbar
		Saving the toolbar settings to a Profile
	Defining Settings	Defining project settings
		Setting the gradient convention
Defining Grade Estimation Parameters **- 2 Dimensions**	Search Parameters	Defining Search Parameters using the CAE Table Editor
	Variogram Parameters	Defining Variogram Model Parameters using the CAE Table Editor
	Estimation Parameters	Defining Estimation Parameters using the CAE Table Editor

Defining Grade Estimation Parameters **- 3 Dimensions**	Search Parameters	Defining and exporting Search Parameters using ESTIMATE
	Variogram Parameters	Importing Variogram Model Parameters using ESTIMATE
	Estimation Parameters	Defining and exporting Estimation Parameters using ESTIMATE
Optimizing Grade Estimation Parameters	Cross Validation	Optimizing Estimation Parameters using Cross Validation
Block Model Estimation **GRADE - Basic Grade Estimation**	Inverse Power Distance	Using GRADE to perform Basic Grade Estimation Run
Block Model Estimation **ESTIMATE - Advanced Grade Estimation**	Nearest Neighbour, Inverse Distance & Ordinary Kriging	Using ESTIMATE for NN, IPD and OK grade estimates
	Ordinary vs Simple Kriging	Using ESTIMATE for Ordinary and Simple Kriging
	Indicator Estimation	Using ESTIMATE for Indicator Estimation

	Estimation using Drillhole Data and Advanced Options	Estimation using ESTIMATE, drillhole data and advanced options
Panel Estimation	Panel Estimation using PANELEST	Using PANELEST for estimating grades into panels
Estimation Validation	Visual Validation	Visual validation of grade estimates in the Design window
	Statistical Validation	Validation of block model grade estimates using STATS
	Graphical Validation	Graphical Validation of Block Model Grade Estimates using Q-Q Plots
Resource Classification	Informal Classification	Informal Classification of grade estimates using the kriging variance
Evaluation and Reporting	Creating an Evaluation Legend	Creating an Evaluation Legend Applying a Legend
	Defining Evaluation Settings	Defining Evaluation Settings

	Interactive Evaluation - Single Strings	Interactive Evaluation using Single Strings
	Interactive Evaluation - String Pairs	Interactive Evaluation using String Pairs
	Interactive Evaluation - Wireframes	Interactive Evaluation using Wireframes
	Grade-Tonnage Reports	Creating a grade-tonnage report using TONGRAD
	Grade-Tonnage Curves	Creating grade-tonnage curves using MPP
Presentation	Creating Plot Sheets	Creating a new Plot Sheet Setting View, Page Orientation and Scale options Formatting the Overlays Inserting Plot Items

GETTING STARTED

The sections below introduce you to the creation and saving of a project.

Prerequisites

- Check that you have the **Studio 3** tutorial data folders. These are located (with a standard installation) under **C:\Database\DMTutorials**. This path should exist and contain two sub-folders; *Data* and *Projects*. The contents of the *Data* folder will be accessed throughout the tutorial, and any files you create will be stored in the *Projects* area.

  If you cannot locate these folders, please reinstall Studio 3. If this does not resolve the issue, please contact your CAE Mining Support Consultant.

- Read through the pages under the tutorial heading "General"

Exercise: Creating and Saving a New Project

In this lesson, you are going to crate a new **Studio** project file "GradeEst", in a new folder **C:\Database\MyTutorials\GradeEst**, add the relevant data files and then save the project. This includes the following tasks:

- Creating a data folder and copying in files
- Creating a new project
- Checking and saving the project.

Creating a Data Folder and Copying In Files

1. In **Windows Explorer** create the folder **C:\Database\MyTutorials\GradeEst**.
2. Browse to and open the folder **C:\Database\DMTutorials\Data\VBOP\Datamine**.
3. Copy these 21 files:
    - _2dblks.dm
    - _2delp1pt.dm
    - _2delp1tr.dm
    - _2depar1.dm
    - _2depar2.dm
    - _2depar3.dm

- _2depar4.dm
- _2dgmod1.dm
- _2dgmod2.dm
- _2dgmod3.dm
- _2dgmod4.dm
- _2dpmod1.dm
- _2dpres1.dm
- _2dres1.dm
- _2dspar1.dm
- _2dvpar1.dm
- _2dvpar2.dm
- _2dxvs1.dm
- _2dzmod1.dm
- _ostopo.dm
- _srfsamp.dm

4. Paste the files into your new data folder **C:\Database\MyTutorials\GradeEst**.
5. Browse to and open the folder **C:\Database\DMTutorials\Data\VBUG\Datamine**.
6. Select the following 21 files, click **Open**:
    - _3depar1.dm
    - _3dspar1.dm
    - _caf5so.dm
    - _geres2.dm
    - _geres3.dm
    - _geres4.dm
    - _qqouAU.dm

- _qqplAU.dm
- _ubm5cat.dm
- _ubm5g.dm
- _ubm5z.dm
- _bmlim.dm
- _ubmm.dm
- _ubmz.dm
- _udhz.dm
- _udhz5c.dm
- _uepe.dm
- _ueps.dm
- _uepv.dm
- _uorept.dm
- _uoretr.dm

7. Paste the files into your new data folder **C:\Database\MyTutorials\GradeEst**.

8. Minimize or close the **Explorer Window**.

Creating a New Project

1. Start **Studio 3** using the desktop shortcut or **Start | (All) Programs | CAE | Studio 3**.

2. In the **Studio 3** window, select **File | New...**.

3. If the **Studio Project Wizard** (Welcome ...) dialog is displayed, click **Next>**.

> The welcome screen is not displayed if the 'Skip this page in future' option was selected the last time a new project was created.

4. In the **Studio Project Wizard** (Project Properties) dialog, define the project *Name* as 'GradeEst', browse for the *Location* 'C:\Database\MyTutorials\GradeEst', select the *Automatically add files...* option, click **Project Settings...**:

5. In the **Project Settings** dialog, *Automatic Project Updates* group, enable:

    - Detect new files in the project folder when the project is opened
    - Detect files added to or removed from the project folder while the project is open
    - Automatically update project (no prompts)

    (Note that the final option is greyed out and not available to single-precision projects.

6. Back in the **Studio Project Wizard** (Project Properties) dialog, click **Next>**.
7. In the **Studio Project Wizard** (Project Files) dialog, check that 42 files have been added automatically, click **Next>**.
8. In the **Studio Project Wizard** (Your project is ready to create) dialog, click **Finish**.

Checking and Saving the Project

1. In the **Project Files** control bar, check that all of the files, selected in the previous sections, have been added to the project and that they are listed in one or more of the various data folders.
2. With the **Files** window displayed, select different folders in the **Project Files** control bar and view their details in the **Files** window.

> Take general note of which files are listed in each folder and that:
>
> - all added files (36), irrespective of file type, are listed in the *All Files* folder
> - all Datamine (*.dm) files are listed in the *All Tables* folder.

3. Repeat step 2 for individual files.
4. Select **File | Save** or, click Save on the **Standard** toolbar.

> This project file will be used for the remaining exercises in this guide
>
> The project file can be set to be automatically updated after project changes have been made e.g. importing data, generating legends. This is set in the **Options** dialog as follows:
>
> 1. Select the **Design** window.
> 2. Select **Tools | Options**.
> 3. In the Options dialog, select the *Project* tab, then the *Automatic Updating* sub-tab.

4. In the *Detect Changes* group, select the *Detect New Files...* , *Detect Files Added...* and *Automatically update...* options, click **OK**.

For more information on project options, consult your Studio 3 Help (**Help | Contents**), or the reference topic (open the **Project Options** dialog and press <F1> on your Keyboard or click **Help**).

Displaying Grade Estimation Toolbars

In this portion of the user guide you are going to display and customize the **Design** window toolbars that are typically used in the mine design process.

Prerequisites

- Created a new project and added all the required data files i.e. the exercises on the *Creating a New Grade Estimation Project* page

Exercise: Displaying Grade Estimation Toolbars

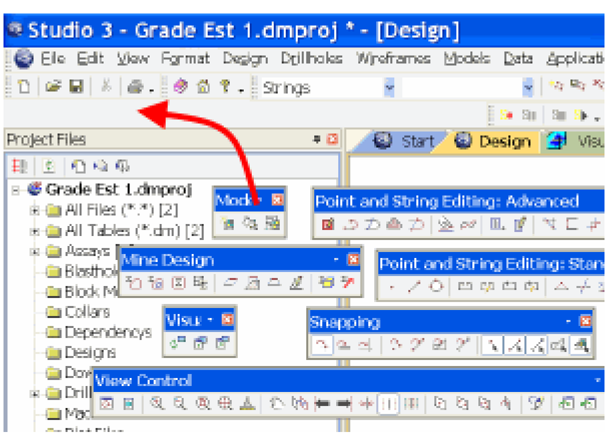
In this exercise you are going to display and dock the toolbars required for completing the exercises in this user guide.

Displaying the Toolbars

1. Select the **Design** window tab.
2. Select **View | Customization | Toolbars | Mine Design**.
3. Select **View | Customization | Toolbars | Modeling**.
4. Select **View | Customization | Toolbars | Point and String Editing: Standard**.
5. Select **View | Customization | Toolbars | Point and String Editing: Advanced**.
6. Select **View | Customization | Toolbars | Snapping**.
7. Select **View | Customization | Toolbars | View Control**.

Docking the Floating Toolbars

1. Drag-and-drop (selecting the toolbar inside the title bar) the floating **Modeling** toolbar into the grey area below the **Menu Bar**, as shown in the image below:



2. Repeat the above step for the remaining, floating toolbars.

> Toolbars can be floated inside the Studio 3 main window, docked in the header area or docked against the bottom or sides of the Studio 3 main window.

Exercise: Customizing a Toolbar

In this exercise you are going to add the **Query Line**, **Query String** and **Gradient Convention** buttons to the **Mine Design** toolbar.

Adding Buttons to the Toolbar

1. Select the **Design** window tab.
2. In the **Modeling** toolbar, click More Buttons, select **Add or Remove Buttons | Customize...**.
3. In the **Customize** dialog, *Commands* tab, *Categories* list, select [Models].
4. In the *Commands* list, drag-and-drop [Interpolate Grades from Menu] into the right side of the **Modeling** toolbar.
5. In the *Commands* list, drag-and-drop [Create Wireframe Ellipse] into the right side of the **Modeling** toolbar.
6. In the **Customize** dialog, click **Close**.
7. The toolbar should now contain the extra button as shown in the image below:

> The button image and text can be customized, e.g. shortened, using the **Button Appearance** dialog. This dialog is accessed by right-clicking a toolbar button, when the **Customize** dialog is displayed, and selecting **Button Appearance...**.

Saving the Toolbar Settings to a Profile

1. Select **View | Customization | Customization State | Save...**.
2. In the **Save As** dialog, select your project folder and define the *File name* 'GradeEstProfile.xml', click **Save**.

- Each time **Studio** is exited, the currently displayed toolbars, menu and control bars are saved to the default Customization File profile.xml, which is located under **C:\Users\[Username]\AppData\Roaming\CAE\Studio** (Windows 7).
- A custom profile can be loaded from a saved Customization File using **View | Customization | Customization State | Load...**

Defining Settings

In this portion of the user guide you are going to define conventions, general interface and project settings that are typically used during the grade estimation process.

Prerequisites

- Created a new project and added all the required data files i.e. the exercises on the *Creating a New Project page*.

Exercise: Defining Project Settings

In this exercise you are going to define evaluation control and automatic redraw settings that will be required for this exercise.

Setting a Default Symbol Size for Displayed Data

1. Select the **Design** window tab.
2. Select **File | Settings...**.
3. In the **Project Settings** dialog, *Project Settings* folder, select the *Data Display* option.
4. In the *Symbols* group, set a *Default symbol size:* of '0.2' mm.

Evaluation Control Settings

1. In the *Project Settings* folder, *select the Mine Design* option.
2. In the *Evaluation Control* group, select the *Evaluate Block Model* radio button.
3. Clear the following check boxes:
    - *Fast evaluation - No wireframe verify*
    - *Full cell evaluation*
    - *Use Display Legend*

- Clearing the *Full cell evaluation* check box allows the evaluation commands to run a partial cell evaluation i.e. the portions of block model cells falling outside the evaluated strings or wireframes do not form part of the evaluation. This allows a more accurate evaluation to be done, but is also generally slower.
- The default selected item in the *Legend* drop-down list is left as is for now, as an evaluation legend will be defined in a later exercise i.e. *Defining Evaluation Settings.*

Enabling Automatic Redraw

1. In the *Project Settings* folder, select the *Design* option.
2. In the *Control* group, select the *Enable automatic redraw* check box.
3. Click **OK**.

> The Design window's background color is also set here. Using the background color [White] can be useful when creating screen captured images for inclusion in a document or presentation. The default grid color settings will also need to be changed if the background color [White] is selected. This is done using **Format | Grids**.

Exercise: Setting the Gradient Convention

In this exercise you are going to set the gradient convention to Degrees and positive up.

Setting the Gradient Convention

1. Select the **Design** window tab.
2. Select **Format | Gradient Convention**.
3. In the **Gradient Convention** dialog, *Gradient In* group, select *Degrees*.
4. In the *Direction* group, select *+ve UP* .
5. Click **OK**.

Defining Grade Estimation Parameters - 2 Dimensions

In this portion of the user guide you are going to use the **CAE Table Editor** to define a set of 2-dimensional (2D) sample search parameters. These will be used in a later exercise to estimate gold (Au) grades for a 2 dimensional block model.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Read the introductory page *Search Volumes,* in the Grade Estimation User Guide.
- Files required for the exercises on this page:
    - none

Exercise: Defining Search Parameters using the CAE Table Editor

As a starting point for defining sample search parameters:

- Base the search ellipse axes lengths and orientations on the existing variogram model parameters for the data set i.e.
    - use the variogram model ranges as ellipse search distances
    - use variogram rotation angles as search ellipse rotation angles
- Define a search volume for each grade field for each geological or mineralization zone or domain
- Store the set of search volume parameters in a single search parameters file and define a unique search reference number (SREFNUM) for each set.

In this exercise you are going to define a dynamic search volume as follows:

- using an elliptical search method
- with a first search volume based on a set of variogram model parameters
- not using octant search
- including a second search volume with a multiplying factor of 2.

Creating a New Search Volume Parameter Table

The new search volume parameters file 2dspar1 will have the parameters listed in the table below:

Field (Column)	Record (Row) 1	Description
SDESC (A16)	Search Volume 1	Unique search volume description
SREFNUM (N)	1	Unique search volume reference number
SMETHOD (N)	2	1=Rectangular search, 2=Elliptical search
SDIST1 (N)	240	Search distance 1 [m]
SDIST2 (N)	100	Search distance 2 [m]
SDIST3 (N)	10	Search distance 3 [m]; a value of 0 cannot be used
SANGLE1 (N)	-10	1st rotation angle i.e. about SAXIS1
SANGLE2 (N)	0	2nd rotation angle i.e. about SAXIS2
SANGLE3 (N)	0	3rd rotation angle i.e. about SAXIS3
SAXIS1 (N)	3	1st rotation axis (1=X, 2=Y, 3=Z axis)
SAXIS2 (N)	1	2nd rotation axis
SAXIS3 (N)	3	3rd rotation axis
OCTMETH (N)	2	Use Octant search; 1=Yes, 2=No
MINOCT (N)	2	Number of octants to contain samples; Set if OCTMETH=1
MINPEROC (N)	1	Minimum number of samples per octant; Set if OCTMETH=1

MAXPEROC (N)	4	Maximum number of samples per octant; Set if OCTMETH=1
MINNUM1 (N)	3	Minimum total number of samples in the first search volume
MAXNUM1 (N)	20	Maximum total number of samples in the first search volume
SVOLFAC2 (N)	2	Multiplying factor defining the size of the second search volume based on size of the first search volume i.e. the SDIST1, SDIST2 and SDIST3 parameters
MINNUM2 (N)	3	Minimum total number of samples in the second search volume
MAXNUM2 (N)	20	Maximum total number of samples in the second search volume
SVOLFAC3	0	Multiplying factor defining the size of the third search volume based on size of the first search volume i.e. the SDIST1, SDIST2 and SDIST3 parameters
MINNUM3 (N)	1	Minimum total number of samples in the third search volume
MAXNUM3 (N)	20	Maximum total number of samples in the third search volume
MAXKEY (N)	0	Maximum number of samples with same key field value

1. Select the **Design** window.
2. Select **Tools | CAE Products | Table Editor**.
3. In the **CAE Table Editor** dialog, select **File | New Table | From More Definitions…**.
4. In the **Insert Definition** dialog, select [Search Volume Standard], click **OK.**

5. In the **CAE Table Editor** dialog, select **Add | Record**.

6. Type in the values shown in the parameters table above step 1.

7. Select **File | Save**.

8. In the **Save As** dialog, select your project folder and define the *File name* '2dspar1.dm', click **Save**.

9. In the **CAE Table Editor** dialog, select **File | Exit**.

When defining 2D search ellipse parameters, assuming that the SDIST3 direction is perpendicular to the plane of the 2D sample set (the default), then:

- Search distance 3 (SDIST3) is usually set to 1 or greater; a value of 0 should not be used
- Rotation angle 1 (SANGLE1) and rotation axis 1 (SAXIS1) set to 3 i.e. the Z axis, are used to define the direction of the major search axis (other axes and rotation angle combinations can be used to obtain the same search ellipse result)
- Rotation angle 2 (SANGLE2) and Rotation angle 3 (SANGLE3) are set to 0.

Defining 2D Variogram Model Parameters

In this portion of the user guide you are going to use the **CAE Table Editor** to define two sets of 2-dimensional (2D) variogram model parameters. These will be used in a later exercise to estimate gold (Au) grades for a 2 dimensional block model.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Read the introductory page *Variogram Models*, in the Grade Estimation User Guide.
- Files required for the exercises on this page:
    - none

Exercise: Defining Variogram Model Parameters using the CAE Table Editor

When modeling experimental variograms in Studio 3, using the process VARFIT, the resultant models are saved to a variogram model file using the standard Studio variogram model conventions. If you have modeled experimental variograms using a different program, make sure that you use the correct transformations when converting the external modeling program's model results into Studio's variogram model parameter format. As an example, check the conversions to the following Studio variogram parameters:

- Variogram axes and angles of rotation
- Nugget, Spatial Variance (i.e. Sill - Nugget) and Sill.

Creating a New Variogram Model Parameter Table

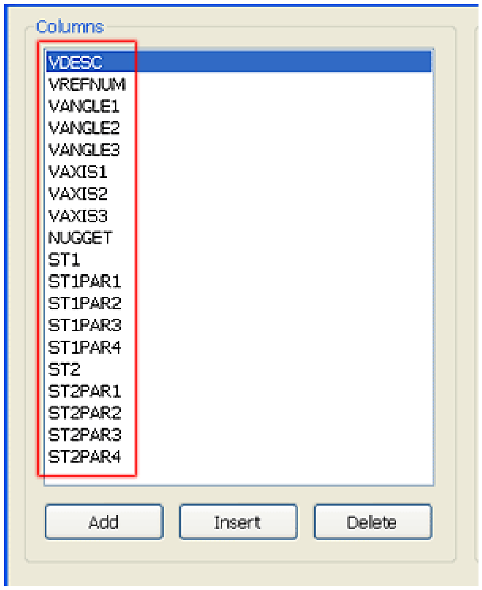
Define a new variogram model parameters file 2dvpar1 with two variogram models, the first a single structure spherical model and the second a two structure spherical model, using the following standard Studio variogram model parameters:

Field (Column)	Record (Row)		Description/Comments
	1	2	

VDESC	AU 1-structure	AU 2-structure	Unique variogram description
VREFNUM	1	2	Unique variogram reference number
VANGLE1	-10	-10	Rotation angle 1, defining orientation of range
VANGLE2	0	0	Rotation angle 2, defining orientation of range
VANGLE3	0	0	Rotation angle 3, defining orientation of range
VAXIS1	3	3	First rotation axis (1=X axis, 2=Y axis, 3=Z axis)
VAXIS2	1	1	Second rotation axis (1=X axis, 2=Y axis, 3=Z axis)
VAXIS3	3	3	Third rotation axis (1=X axis, 2=Y axis, 3=Z axis)
NUGGET	0	0	Nugget variance (Co)
ST1	1	1	Variogram model type for structure 1 (1=spherical, 2=power, 3=exponential, 4=gaussian, 5=De Wijsian)
ST1PAR1	240	40	Structure 1, parameter 1 (Range in X direction for spherical model)
ST1PAR2	80	40	Structure 1, parameter 2 (Range in Y direction for spherical model)
ST1PAR3	80	80	Structure 1, parameter 3 (Range in Z direction for spherical model)
ST1PAR4	90000	30000	Structure 1, parameter 4 (Spatial variance for spherical model - C value)

ST2	0	1	Variogram model type for structure 1 (1=spherical, 2=power, 3=exponential, 4=gaussian, 5=De Wijsian)
ST2PAR1	0	240	Structure 2, parameter 1 (Range in X direction for spherical model)
ST2PAR2	0	100	Structure 2, parameter 2 (Range in Y direction for spherical model)
ST2PAR3	0	80	Structure 2, parameter 3 (Range in Z direction for spherical model)
ST2PAR4		60000	Structure 2, parameter 4 (Spatial variance for spherical model - C value)
All remaining fields	0	0	Parameters for the 3rd - 9th structures

1. Select the **Design** window.
2. Select **Tools | CAE Products | Table Editor**.
3. In the **CAE Table Editor** dialog, select **File | New Table | Variogram-Model**.
4. Click in the column header of field **ST3 (N)**, drag the horizontal slider bar all the way to the right, <Shift>+Click in the column header of field **ST9PAR4 (N)** , click **Delete Column**.
5. In the **CAE Table Editor** dialog, select **Tools | Definition Editor...**.
6. In the **Definition Editor** dialog, *Columns* group, check that the table now only contains the 19 fields shown below, click **Close**:



7. In the **CAE Table Editor** dialog, select **Add | Record** (x2).

8. Type in the two sets of variogram model parameters shown in the table above step 1.

> When defining 2D variogram model parameters, assuming that the Z axis direction is perpendicular to the plane of the 2D sample set (the default), then:
>
> - Rotation angle 1 (VANGLE1) and rotation axis 1 (SAXIS1) set to 3 i.e. the Z axis, are used to define the direction of the major search axis (other axes and rotation angle combinations can be used to obtain the same search ellipse result)
> - Rotation angle 2 (VANGLE2) and Rotation angle 3 (VANGLE3) are both set to 0.
> - Parameter 3 i.e. the Range in the Z direction for spherical model (ST1PAR3), is usually set to an arbitrary value greater than 0.

8. Select **File | Save As...**.

9. In the **Save As** dialog, select your project folder and define the *File name* '2dvpar1.dm', click **Save.**

10. Select **File | Exit**.

Defining 2D Estimation Parameters

In this portion of the user guide you are going to use the **CAE Table Editor** to define two sets of estimation parameters. This set of parameters will be stored in a parameter file and will make use of the previously defined search parameter and variogram parameter files.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Read the introductory page *Grade Estimation Parameter File*, in the Grade Estimation User Guide.
- Files required for the exercises on this page:
    - none

Exercise: Defining Estimation Parameters using the CAE Table Editor

In this exercise you are going to define three sets of estimation parameters for the 'Au' grade field:

- a Nearest Neighbour (NN) run, an Inverse Power Distance (IPD) run and an Ordinary Kriging (OK) run
- output grade fields AU_NN, AU_IPD and AU_OK respectively
- using no zonal control
- using the search volume to control anisotropy.

Use the search parameters and first variogram parameter set (i.e. VREFNUM = 1) from the previous three exercises.

Add a description field to your estimation parameter file:

- Use the CAE Table Editor to add a field to the parameter file, name it e.g. DESCRIP(A24))
- Briefly describe each estimation parameter set in the estimation parameter file
- The addition of this description field makes it easier to distinguish between different grade estimation runs when dealing with multiple grade fields and/or zones or when comparing different grade estimation runs for a single grade field.

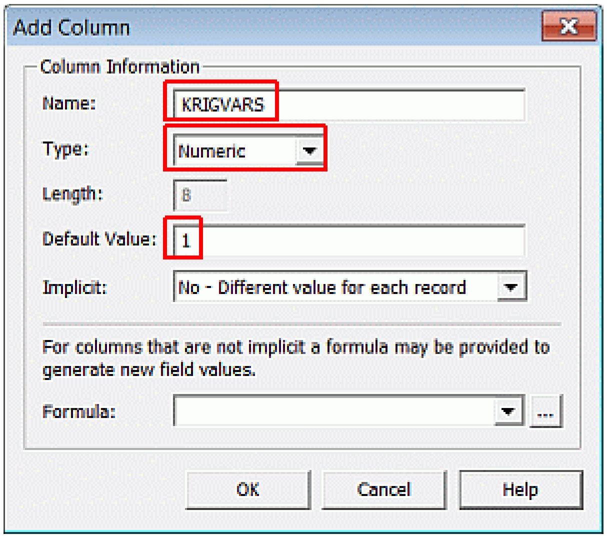
Creating a New Estimation Parameter Table

Create a new estimation parameters file 2depar1 with the three grade runs for 'Au'. The estimation parameters are listed in the table below:

Field (Column)	Record (Row)			Description
	1	2	3	
EDESC (A16)	AU - NN Method	AU - IPD Method	AU - OK Method	Estimation Parameter Set Description
VALUE_IN (A8)	AU	AU	AU	Input grade field
VALUE_OU (A8)	AU_NN	AU_IPD	AU_OK	Output grade field names;a different name is required for each run
NUMSAM_F (A8)	-	-	-	Output field to contain number of samples used (optional)
SVOL_F (A8)	-	-	-	Output field to contain search volume number (optional)
VAR_F (A8)	VAR_NN	VAR_IPD	VAR_OK	Output field to contain estimation variance (optional)
MINDIS_F (A8)	-	-	-	Output field to contain transformed distance to nearest sample (optional)
SREFNUM (N)	1	1	1	Search volume reference number (in this exercise, both runs use the same set of search parameters)
IMETHOD (N)	1	2	3	Estimation method: 1=NN, 2=IPD, 3=OK, 4=SK, 5=ST

POWER (N)	2	2	2	Power of distance for IPD weighting
ADDCON (N)	0	0	0	IPD - constant added to distance ST - additive constant for lognormal
VREFNUM (N)	0	0	1	Variogram reference number (only applicable if IMETHOD=3,4)
KRIGNEGW (N)	0	0	0	Treatment of negative kriging weights: 0=keep & use, 1=ignore -ve weighted samples
KRIGVARS (N)	0	0	1	Treatment of negative kriging variance >sill: 0=keep KV>sill, 1=set KV equal to sill (only applicable if LOG=0)

1. Select the **Design** window.
2. Select **Tools | CAE Products | Table Editor**.
3. In the **CAE Table Editor** dialog, select **File | New Table | From More Definitions...**.
4. In the **Insert Definition** dialog, select [Estimation Parameters - Standard] and click **OK**.
5. In the **CAE Table Editor** dialog, click **Add Column**.
6. In the **Add Column** dialog, define a new field *Name:* 'KRIGVARS' using the parameters shown below, click **OK:**



7. In the **CAE Table Editor** dialog, select **Add | Record** (x3).

8. Type in the values shown in the parameters table above step 1.

9. Select **File | Save As...**.

10. In the **Save As** dialog, select your project folder and define the *File name* '2depar1.dm', click **Save**.

11. Select **File | Exit**.

When defining estimation parameters in an estimation parameter file:

- define a search parameter file
- define a variogram model file if kriging estimation methods are used
- give these set of parameter files a project prefix in their filenames so that they can easily be recognised as belonging to the same set.

DEFINING 3D SEARCH PARAMETERS

In this portion of the user guide you are going to use the process **ESTIMATE** to define and export a set of 3D sample search parameters.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Read the introductory page *Search Volumes,* in the Grade Estimation User Guide.
- Files required for the exercises on this page:
    - none

Exercise: Defining and Exporting Search Parameters Using ESTIMATE

In this exercise you are going to define three dynamic search volumes with the following general characteristics:

- using an elliptical search method
- using a first search volume based on a set of variogram model parameters
- not using octant search
- using a second search volume with a multiplying factor of 2

As a starting point for defining sample search parameters:

- Base the search ellipse axes lengths and orientations on the existing variogram model parameters for the data set i.e.
    - use the variogram model ranges as ellipse search distances
    - use variogram rotation angles as search ellipse rotation angles
- As a minimum, define a search volume for each grade field for each geological zone

The search volume parameters are listed in the table below:

Field (Column)	Record (Row) 1	2	3	Description
SDESC	Search Volume 1	Search Volume 2	Search Volume 3	Unique search volume description
SREFNUM	1	2	3	Unique search volume reference number
SMETHOD	2	2	2	1=Rectangular search, 2=Elliptical search
SDIST1	150	120	60	Search distance 1 [m]
SDIST2	90	115	50	Search distance 2 [m]
SDIST3	30	15	15	Search distance 3 [m]; a value of 0 cannot be used
SANGLE1	123	45	123	1st rotation angle i.e. about SAXIS1
SANGLE2	42	40	42	2nd rotation angle i.e. about SAXIS2
SANGLE3	0	0	0	3rd rotation angle i.e. about SAXIS3
SAXIS1	3	3	3	1st rotation axis (1=X, 2=Y, 3=Z axis)
SAXIS2	1	1	1	2nd rotation axis
SAXIS3	3	3	3	3rd rotation axis
MINNUM1	5	1	1	Minimum total number of samples in the first search volume
MAXNUM1	20	20	20	Maximum total number of samples in the first search volume
SVOLFAC2	2	2	2	Multiplying factor defining the size of the second search volume based on

				size of the first search volume i.e. the SDIST1, SDIST2 and SDIST3 parameters
MINNUM2	5	1	1	Minimum total number of samples in the second search volume
MAXNUM2	20	20	20	Maximum total number of samples in the second search volume
SVOLFAC3	0	0	0	Multiplying factor defining the size of the third search volume based on size of the first search volume i.e. the SDIST1, SDIST2 and SDIST3 parameters
MINNUM3	1	1	1	Minimum total number of samples in the third search volume
MAXNUM3	20	20	20	Maximum total number of samples in the third search volume
OCTMETH	0	0	0	Use Octant search; 1=Yes, 2=No
MINOCT	2	2	2	Number of octants to contain samples; Set if OCTMETH=1
MINPEROC	1	1	1	Minimum number of samples per octant; Set if OCTMETH=1
MAXPEROC	4	4	4	Maximum number of samples per octant; Set if OCTMETH=1
MAXKEY	0	0	0	Maximum number of samples with same key field value

Defining a Set of Search Parameters using ESTIMATE

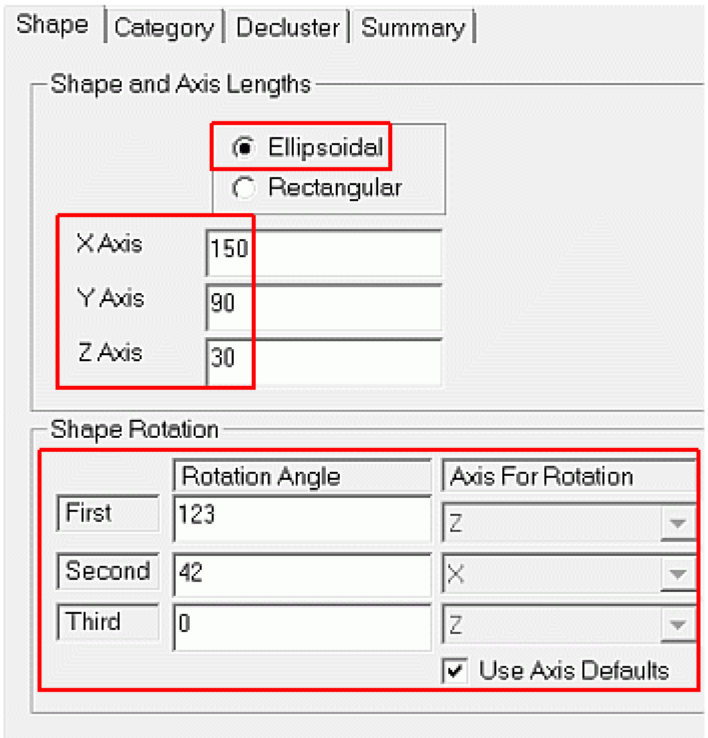
1. Select the **Design** window.
2. Select **Models | Interpolation Processes | Interpolate Grades from Menu**.

3. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, click **Next >>**.

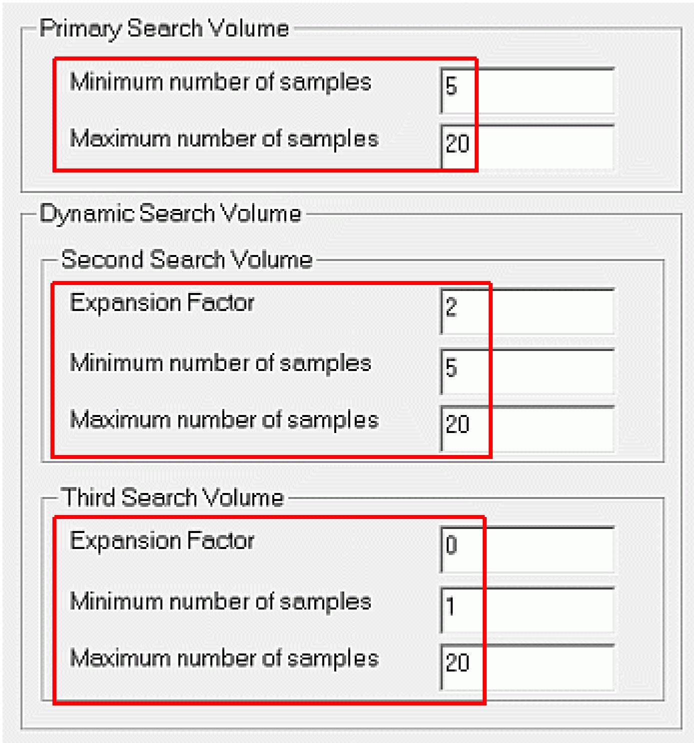
4. In the *Search Volumes* tab, *Index* group, click **Add**.

5. In the search volume list, check that a new search volume 'Search Volume 1' has been added.

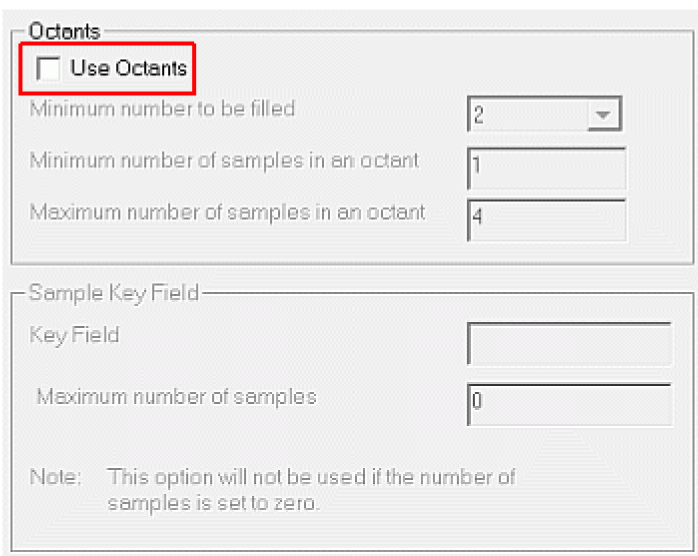
6. In the *Shape* sub-tab on the right, referring to the table of parameters at the start of the exercise, define the parameters as shown below:



7. In the *Category* sub-tab, referring to the table of parameters at the start of the exercise, define the parameters as shown below:



8. In the *Decluster* sub-tab, Octants group, make sure that *Use Octants* option is cleared:



9. Repeat steps 5 to 8 for the second and third sets of search parameters, using the values listed in the second and third rows of the table at the start of the exercise.

10. In the *Summary* sub-tab, referring to the table of parameters at the start of the exercise, check that the three sets of parameters are as shown below:

Search Parameter Table

	1	2	3
SDESC	Search Volume 1	Search Volume 2	Search Volume 3
SREFNUM	1	2	3
SMETHOD	2	2	2
SDIST1	150	120	60
SDIST2	90	115	50
SDIST3	30	15	15
SANGLE1	123	45	123
SANGLE2	42	40	42
SANGLE3	0	0	0
SAXIS1	3	3	3
SAXIS2	1	1	1
SAXIS3	3	3	3
MINNUM1	5	1	1
MAXNUM1	20	20	20
SVOLFAC2	2	0	2
MINNUM2	5	1	1
MAXNUM2	20	20	20
SVOLFAC3	0	2	0
MINNUM3	1	1	1
MAXNUM3	20	20	20
OCTMETH	0	0	0
MINOCT	2	2	2
MINPEROC	1	1	1
MAXPEROC	4	4	4
MAXKEY	0	0	0
SANGL1_F			

When defining 3D search ellipsoid parameters,

- the SDIST1, SDIST2 and SDIST3 parameters need to be set
- the search ellipsoid typically has a dip direction and a dip defined by rotations about two axes:
  - First rotation SANGLE1 about SAXIS1 (typically = 3 i.e. axis Z)
  - Second rotation SANGLE2 about SAXIS2 (typically = 1 i.e. axis X)
- a 3D search ellipsoid may require a third rotation SANGLE3 about another axis.
- define axes and rotations as dip direction, dip, cross dip.

When defining search ellipsoid axes and rotations:

- use SDIST1, SANGLE1 about SAXIS1 (=3) to define the Dip Direction/Plunge axis
- use SDIST2, SANGLE2 about SAXIS2 (=2) to define the Strike axis

- if required, then use SDIST3, SANGLE3 about SAXIS3 to define the rotation for a more complex orientation
- **Note**: this convention has not been used in the above exercise.

Exporting the Search Parameters

1. In the **Grade Estimation (ESTIMATE)** dialog, *Search Volumes* tab, *Index* group, click **Export**.
2. In the **Project Browser** dialog, select your project folder and define the *Filename* '3dspar1', click **OK**.
3. In the **Grade Estimation (ESTIMATE)** dialog, click **Cancel**.

Please see Estimate - Search Volumes for help on using the additional features in the *Search Parameters* tab.

Defining 3D Variogram Parameters

In this portion of the user guide you are going to use the process **ESTIMATE** to import and check a set of 3D variogram parameters.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Read the introductory page *Variogram Models*, in the Grade Estimation User Guide.
- Files required for the exercises on this page:
    - _uepv

Exercise: Importing Variogram Model Parameters Using ESTIMATE

In this exercise you are going to import a set of variogram model parameters that have been output from the variogram modeling process **VARFIT**. The set of variogram model parameters have the following general characteristics:

- the set contains 12 sets of parameters i.e. one for each of the grade fields Cu, Ag, Au and Co for each of three grade zones (ZONE = 1, 2, 3)
- the variograms have been modelled with 1 or 2 structure spherical models
- the variogram models are omni-directional i.e. the same in all directions
- record 5 i.e. for Cu zone 2 contains a set of dummy parameters.

When modeling experimental variograms in Studio 3, using the process VARFIT, the resultant models are saved to a variogram model file using the standard Studio variogram model conventions. If you have modeled experimental variograms using a different programme, make sure that you use the correct transformations when converting the external modeling programme's model results into Studio's variogram model parameter format. As an example, check the conversions to the following Studio variogram parameters:

- Variogram axes and angles of rotation
- Nugget, Spatial Variance (i.e. Sill - Nugget) and Sill.

Importing An Existing Set of Variogram Model Parameters Using ESTIMATE

1. Select the **Design** window.

2. Select **Models | Interpolation Processes | Interpolate Grades from Menu**.

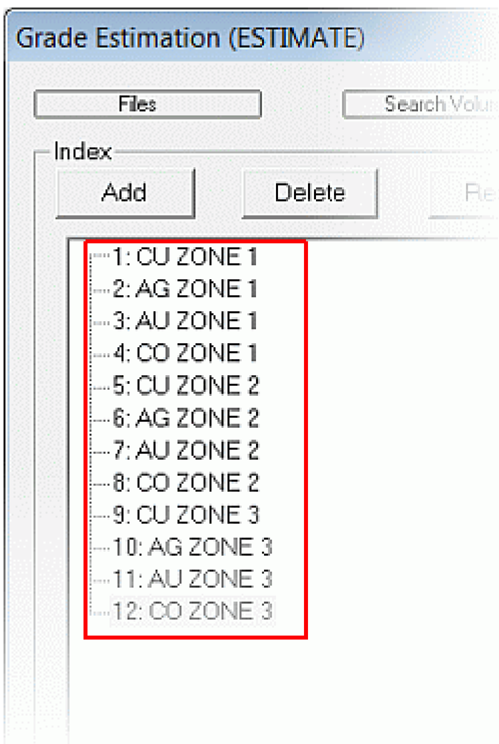
3. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, click **Next >>**.

4. In the *Search Volumes* tab, click **Next >>**.

5. In the *Variogram Models* tab, *Index* group, click **Import**.

6. In the **Project Browser** dialog, *Database Tables* pane, *All Tables* folder, select the table _uepv , click **OK**.

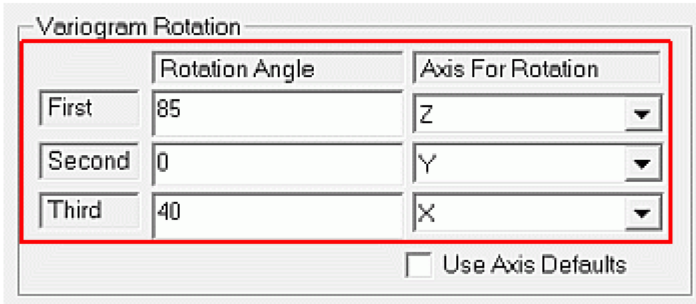
7. In the *Index* group, check that 12 variogram models are listed, as shown below:



Checking the Imported Variogram Model Parameters

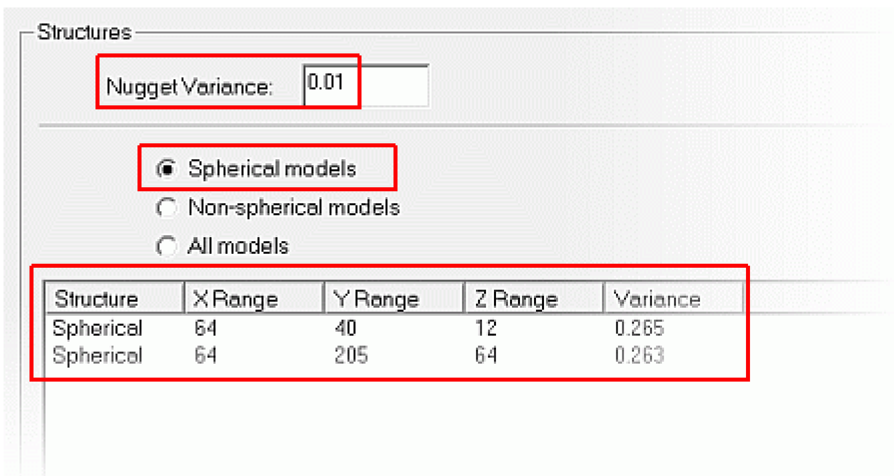
1. In the **Grade Estimation (ESTIMATE)** dialog, *Variogram Models* tab, *Index* group, select the *1:CU ZONE 1* item from the list.

2. In the *Rotation* sub-tab, *Variogram Rotation* group, check that the rotation parameters are as shown below:



The *Second Rotation Angle* value is set to 0. This indicates that there is no rotation about the second variogram axis.

3. In the *Structures* sub-tab, *Structures* group, check that the variogram structure parameters are as shown below:



This variogram model has the following characteristics:

- has a *Nugget Variance* of 0.01
- consists of two spherical structures, indicated by the two records shown in the summary pane
- the structures are anisotropic, indicated by the same values listed in the *X Range*, *Y Range* and *Z Range* columns
- has a first and second spatial variance of 0.265 and 0.263 respectively.

- The *Rotation* and *Structures* sub-tabs can be used to edit the variogram parameters.
- These parameters would then need to be saved to the projects variogram model file by using the **Export** button in the *Index* group.

Checking The Variogram Model Parameters Summary

1. In the **Grade Estimation (ESTIMATE)** dialog, *Variogram Models* tab, *Summary* sub-tab, check that the variogram parameters for the first four models are as shown below:

Variogram Model Table

	1	2	3	4	5	6
VDESC	CU ZONE 1	AG ZONE 1	AU ZONE 1	CO ZONE 1	CU ZONE 2	A
VREFNUM	1	2	3	4	5	6
VANGLE1	85	85	85	0	40	4
VANGLE2	0	0	0	0	39	3
VANGLE3	40	40	40	0	22.5	2
VAXIS1	3	3	3	3	3	3
VAXIS2	2	2	2	2	1	1
VAXIS3	1	1	1	1	3	3
NUGGET	0.01	174	0.85	0.0003	0.039	1
ST1	1	1	1	1	1	1
ST1PAR1	64	9.5	66	9	73.5	7
ST1PAR2	40	12.5	17	9	185	1
ST1PAR3	12	7	7	9	11.5	1
ST1PAR4	0.265	784	5	0.00224	0.35	1
ST2	1	1	1	1	1	1

This *Summary* sub-tab is used to view and not edit parameter values.

2. In the **Grade Estimation (ESTIMATE)** dialog, click **Cancel**.

DEFINING 3D ESTIMATION PARAMETERS

In this portion of the user guide you are going to use the process **ESTIMATE** to define and export two sets of estimation parameters. These parameters will be exported to a parameter file and will make use of the previously defined 3D search and variogram parameter files.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Read the introductory page *Grade Estimation Parameter File*, in the Grade Estimation User Guide.
- Files required for the exercises on this page:
    - _ubmz
    - _udhz
    - _ueps
    - _uepv

Exercise: Defining and Exporting Estimation Parameters Using ESTIMATE

In this exercise you are going to define two sets of estimation parameters i.e. one set for each of the Cu and Ag grades for zone 1 and use:

- zonal control and restrict estimation of the two grades into zone 1 only i.e. ZONE=1.
- the search volume to control anisotropy.
- search volume 1 (SREFNUM=1) for the zone 1 estimates
- ordinary kriging
- Cu and Ag estimates to use variogram models 1 and 2 (VREFNUM=1, 2) respectively.

The estimation parameters for this exercise are listed in the table below:

Field	Record	Description/Comments

(Column)	(Row)		
	1	**2**	
EDESC	Estima Param 1	Estima Param 2	Estimation run description
EREFNUM	1	2	Estimation run reference number
VALUE_IN	CU	AG	Input grade field
VALUE_OU	CU	AG	Output grade field names
SREFNUM	1	1	Search volume reference number (in this exercise, both runs use the same set of search parameters)
ZONE *	1	1	First field controlling estimation by zone
[ZONE2_F] *	0	0	Second field controlling estimation by zone
NUMSAM_F **	NCU	NAG	Output field to contain number of samples used (optional)
SVOL_F **	SCU	SAG	Output field to contain search volume number (optional)
VAR_F **	VCU	VAG	Output field to contain estimation variance (optional)
MINDIS_F **			Output field to contain transformed distance to nearest sample
IMETHOD	3	3	Estimation method: 1=NN, 2=IPD, 3=OK, 4=SK, 5=ST
ANISO *	1	1	Anisotropy method: 1=search volume, 2=use ANANGLE
ANANGLE1 *	0	0	Anisotropy angle 1 (only applicable if IMETHOD=1,2.)

ANANGLE1 *	0	0	Anisotropy angle 2 (only applicable if IMETHOD=1,2.)
ANANGLE1 *	0	0	Anisotropy angle 3 (only applicable if IMETHOD=1,2.)
ANDIST1 *	1	1	Anisotropy distance 1
ANDIST2 *	1	1	Anisotropy distance 2
ANDIST3 *	1	1	Anisotropy distance 3
POWER	2	2	Power of distance for IPD weighting
ADDCON	0	0	IPD - constant added to distance ST - additive constant for lognormal
VREFNUM	1	2	Variogram reference number (only applicable if IMETHOD=3,4)
LOG	0	0	Lognormal kriging flag: 0=Linear Kriging, 1=Lognormal Kriging
MKNUG_F *			
GENCASE	0	0	Lognormal kriging flag: 0=Rendu, 1=General Case (only applicable if LOG=1)
DEPMEAN	0	0	Mean for lognormal variance calculation (only applicable if LOG=1)
TOL	0.010	0.010	Convergence tolerance for lognormal kriging (only applicable if GENCASE=1)
MAXITER	3	3	Maximum iterations for log kriging (only applicable if GENCASE=1)
KRIGNEGW	0	0	Treatment of negative kriging weights: 0=keep & use, 1=ignore -ve weighted samples

KRIGVARS	1	1	Treatment of negative kriging variance >sill: 0=keep KV>sill, 1=set KV equal to sill (only applicable if LOG=0)
LOCALMNP	2	2	Method for calculation of local mean: 1=field from &PROTO, 2 = calculate mean (only applicable if IMETHOD=4)
LOCALM_F			Name of local mean field in the input block model file (only applicable if IMETHOD=4)
CUTOFF *			Indicator Kriging parameter
BINGRADE *			Indicator Kriging parameter
ABVGRADE *			Indicator Kriging parameter

Table Notes:

* Advanced option fields.

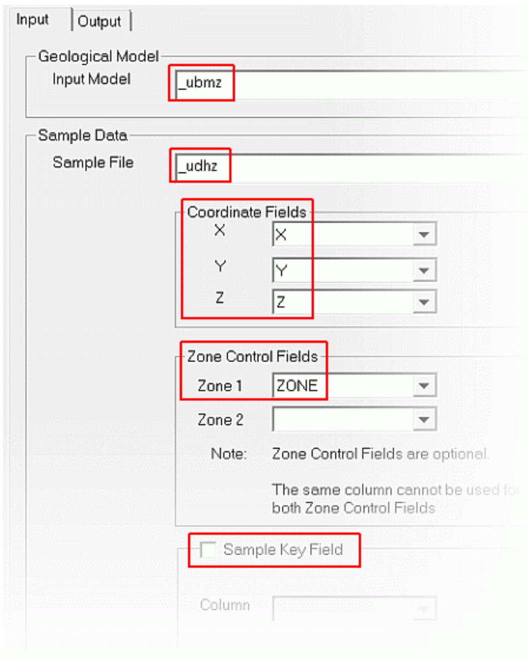
** Optional data fields added to the output model file.

Defining the Input Block Model and Samples Files

1. Select the **Design** window.
2. Select **Models | Interpolation Processes | Interpolate Grades from Menu**.
3. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, select the *Input* sub-tab.
4. In the *Geological Model* group, click **Browse**.
5. In the **Project Browser** dialog, *Database Tables* pane, *Block Models* folder, select _ubmz , click **OK**.
6. In the *Sample Data* group, click **Browse**.
7. In the **Project Browser** dialog, *Database Tables* pane, *Drillholes* folder, select _udhz , click **OK**.
8. In the *Coordinates Fields* group, use the default *X*, *Y*,and *Z* values.

9. In the *Zone Control Fields* group, select [ZONE] for *Zone 1*.

10. Check that your parameters are as shown below:



- Both the *Input Model* and the *Sample File* need to be defined so that the *Zone Control Fields* can be selected.
- The *Zone Control Fields* need to be present (and contain suitable matching zone field values) in both the *Input Model* and the *Sample File*.

Defining The Input / Output Search Volume and Variogram Model Files

1. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, select the *Output* subtab.

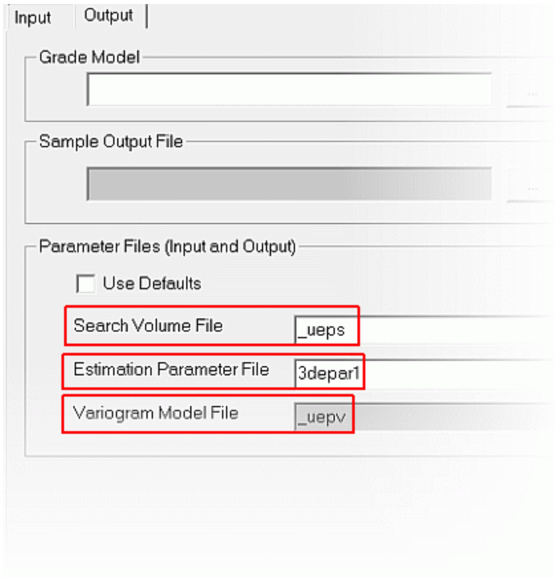
2. In the *Parameter Files (Input and Output)* group, clear the *Use Defaults* check box.

3. Browse for and select the *Search Volume File* _ueps.

4. Define a new *Estimation Parameter File* '3depar1'.

5. Browse for and select the *Variogram Model File* _uepv.

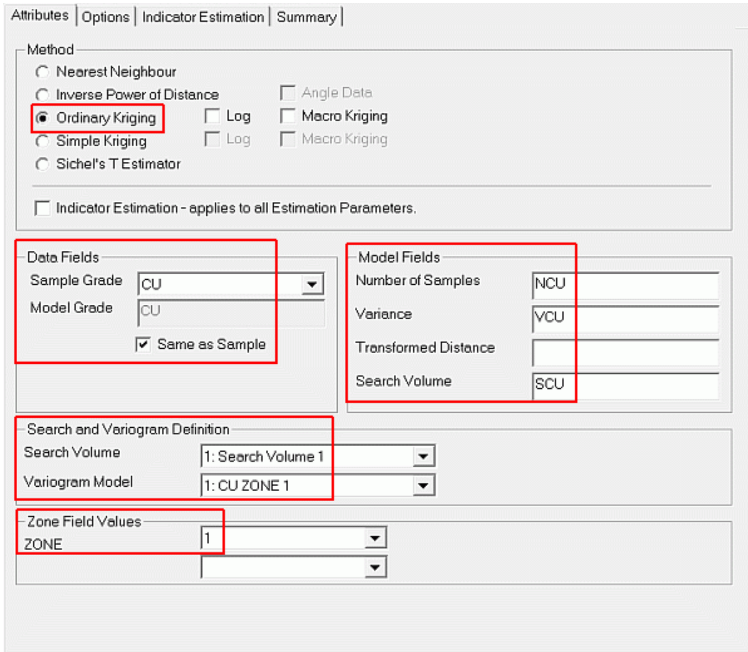
6. Check that your parameters are as shown below:



- Both the *Search Volume File* and the *Variogram Model File* need to be defined here so that the correct search and variogram reference numbers can be selected in the *Estimation Types* tab.

Defining the Estimation Types

1. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, click **Next >>**.
2. In the *Search Volumes* tab, check that 3 search volumes are listed in the *Index* pane, click **Next >>**.
3. In the *Variogram Models* tab, check that 12 variogram models are listed in the *Index* pane, click **Next >>**.
4. In the *Estimation Types* tab, *Index* group, click **Add**.
5. In the estimation parameter list, check that a new estimation parameter description '1: Estima Param 1' has been added.
6. In the *Attributes* subtab on the right, referring to the table of estimation parameters at the start of this exercise, define the settings shown below:

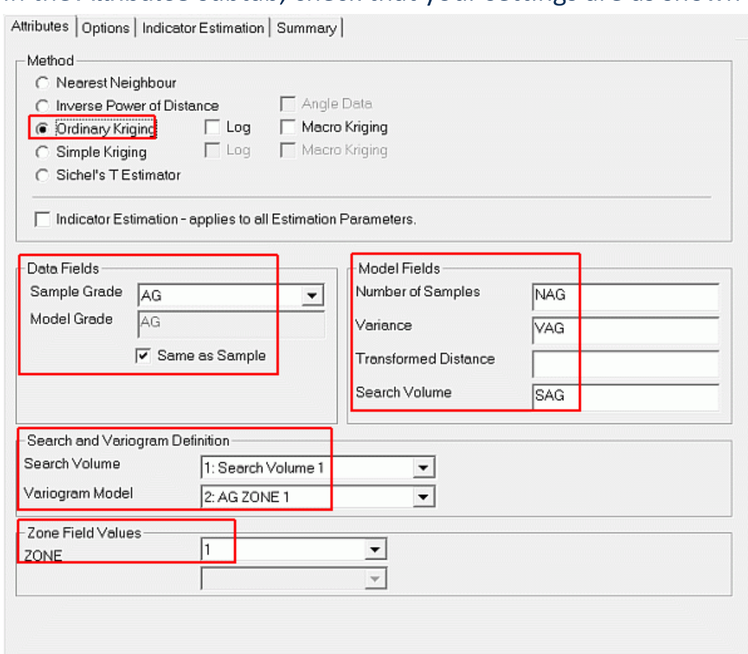


7. In the *Options* subtab, check that the *Negative Kriging Weights* and *Macro Kriging* group options are unchecked and empty.

8. In the *Indicator Estimation* subtab, check that all options are greyed out.

9. Repeat steps 3 to 7 ,referring to the table of parameters at the start of this exercise, define the parameters for the Ag grade field.

10. In the *Attributes* subtab, check that your settings are as shown below:



11. In the *Summary* subtab, check that your parameters are as shown below:

Estimation Parameter Table

	1	2
EDESC	Estima Param 1	Estima Param 2
EREFNUM	1	2
VALUE_IN	CU	AG
VALUE_OU	CU	AG
SREFNUM	1	1
NUMSAM_F	NCU	NAG
SVOL_F	SCU	SAG
VAR_F	VCU	VAG
MINDIS_F		
IMETHOD	3	3
ANISO	1	1
ANANGLE1	0	0
ANANGLE2	0	0
ANANGLE3	0	0
ANDIST1	1	1
ANDIST2	1	1
ANDIST3	1	1
POWER	2	2
ADDCON	0	0
VREFNUM	1	2
LOG	0	0
MKNUG_F		
DEPMEAN	0	0
TOL	0.01	0.01
MAXITER	3	3
KRIGNEGW	0	0
KRIGVARS	1	1
LOCALMNP	2	2
LOCALM_F		
CUTOFF		
BINGRADE		
ZONE	1	1
ZONE2_F		

Exporting the Estimation Parameters to File

1. In the **Grade Estimation (ESTIMATE)** dialog, *Estimation Types* tab, *Index* group, click **Export**.
2. In the **Project Browser** dialog, define a *Filename* of '3depar1', click **OK**.
3. In the **Grade Estimation (ESTIMATE)** dialog, click **Cancel** to exit the **ESTIMATE** dialog.

Please see Estimate - Estimation Types for help on using the additional features in the *Estimation types* tab.

CHECKING SEARCH PARAMETERS

In this portion of the user guide you are going to be introduced to a visual method of checking a set of search parameters. This will be done by first, by creating a search ellipsoid wireframe using the process **ELLIPSE** and a search parameters file and secondly, by viewing this ellipse wireframe together with the sample data in the **Design** window.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Read the introductory page Defining Search Volumes, in the Grade Estimation User Guide.
- Read the help documentation page ELLIPSE .
- Files required for the exercises on this page:
    - _srfsamp
    - _2dspar1

Exercise: Checking Search Parameters Using a Wireframe Ellipsoid

In this exercise you are going to check the search parameters stored in the search parameter file _2dspar1 .This includes the following tasks:

- Creating a wireframe search ellipsoid using the **ELLIPSE** process
- Loading and inspecting the sample data and the wireframe ellipsoid.

Checking your search parameter file (or parameters if using GRADE) using a wireframe ellipsoid and sample data loaded in the **Design** window to:

- check that the orientation and distance of the axes have been correctly defined
- check to see if sample coverage in different areas of the data set matches your MINNUMn and MAXNUMn parameters i.e. the parameters defining the minimum and maximum numbers of samples required for estimating a grade value
- check that the quardrant search criteria (if used) are valid within different areas of your data set.

The search parameters stored in the search parameters file _2dspar1 are listed in the table below:

Parameter	Value	Description
SREFNUM	1	Unique search volume reference number
SMETHOD	2	1=Rectangular search, 2=Elliptical search
SDIST1	240	Search distance 1 [m]
SDIST2	100	Search distance 2 [m]
SDIST3	1	Search distance 3 [m]; a value of 0 cannot be used
SANGLE1	-10	1st rotation angle i.e. about SAXIS1
SANGLE2	0	2nd rotation angle i.e. about SAXIS2
SANGLE3	0	3rd rotation angle i.e. about SAXIS3
SAXIS1	3	1st rotation axis (1=X, 2=Y, 3=Z axis)
SAXIS2	1	2nd rotation axis
SAXIS3	3	3rd rotation axis
OCTMETH	0	Use Octant search; 1=Yes, 2=No
MINOCT	0	Number of octants to contain samples; Set if OCTMETH=1
MINPEROC	0	Minimum number of samples per octant; Set if OCTMETH=1
MAXPEROC	10	Maximum number of samples per octant; Set if OCTMETH=1
MINNUM1	3	Minimum total number of samples in the first search volume

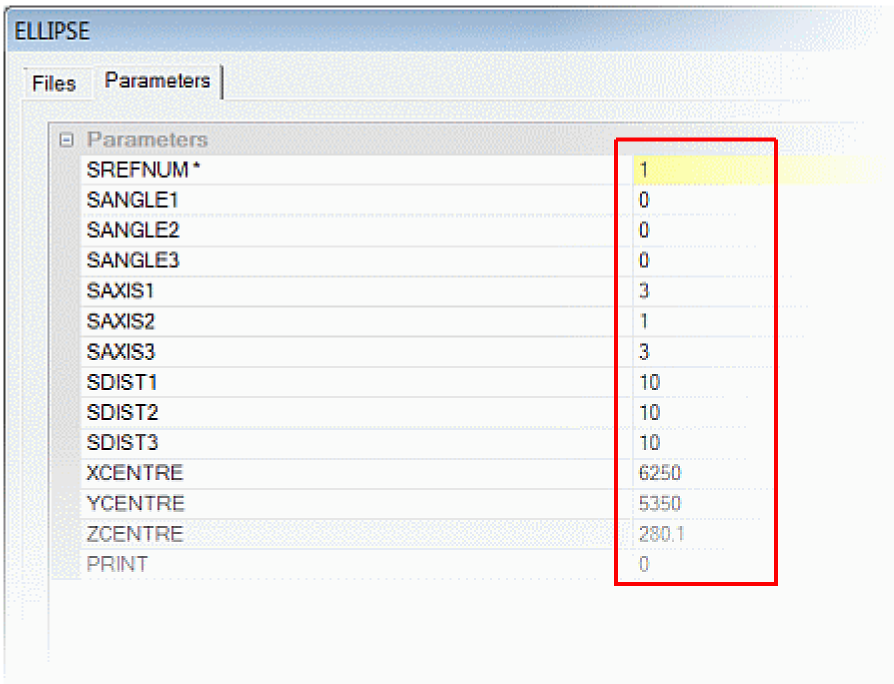
MAXNUM1	20	Maximum total number of samples in the first search volume
SVOLFAC2	2	Multiplying factor defining the size of the second search volume based on size of the first search volume i.e. the SDIST1, SDIST2 and SDIST3 parameters
MINNUM2	3	Minimum total number of samples in the second search volume
MAXNUM2	20	Maximum total number of samples in the second search volume
SVOLFAC3	0	Multiplying factor defining the size of the third search volume based on size of the first search volume i.e. the SDIST1, SDIST2 and SDIST3 parameters
MINNUM3	0	Minimum total number of samples in the third search volume
MAXNUM3	0	Maximum total number of samples in the third search volume
MAXKEY	0	Maximum number of samples with same key field value

Creating a Wireframe Search Ellipsoid

1. Select the **Design** window.
2. Select **Models | Interpolation Processes | Create Wireframe Ellipse**.
3. In the **ELLIPSE** dialog, *Files* tab, *Input files* group, set *SRCPARM** by browsing for and selecting the file _2dspar1.
4. In the *Output files* group, define *WIRETR** as '*2delp1tr*'.
5. In the *Output files* group, define *WIREPT** as '*2delp1pt*'.
6. In the *Parameters* tab, define a value of '1' for *SREFNUM** .

This *SREFNUM** value i.e. the search reference number, refers to a search reference number in the search parameter file which contains the relevant set of search volume parameters.

7. In the *Parameters* tab, define a value of '6250' for *XCENTRE** .
8. In the *Parameters* tab, define a value of '5350' for *YCENTRE** .
9. In the *Parameters* tab, define a value of '280.1' for *ZCENTRE** , as shown below.



The sample data lies at an elevation of 280m. Setting the wireframe ellipse ZCENTRE=280.1 makes sure that the wireframe plan view intersection lies slightly above and not on the same plane as the wireframe ellipsoid octant boundary. The resultant intersection view shows as four octant boundaries and not a mass of wireframe triangles.

10. Click **OK**.
11. Select the **Command** control bar, check that **ELLIPSE** has finished running, check that the output files *2delp1tr* and *2delp1pt* have been created and confirm the ellipsoid parameters listed in the output summary.

The wireframe containing the ellipsoid is:

2delp1tr , 2delp1pt

This can now be loaded into the Design Window and Visualiser.

The following parameters were used:

Length of X,Y,Z axes: 240 , 100 , 10

Rotation angles: -10 , 0 , 0

Rotation axes: 3, 1, 3

There are 3 components to the ellipsoid wireframe, each with a different value for field ZONE in the triangle file:

1 - the outside surface of the ellipsoid

2 - the three planes orthogonal to the axes of the ellipsoid

3 - a set of wireframed axes for the world coordinate system

Each octant of the ellipsoid is displayed in a different COLOUR (1 to 8), and the axes are COLOUR 13.

You can use the filter-wireframe-triangles (fwt) command to select components of the wireframe, for example:

- NOT COLOUR=1 will filter out the first octant.
- ZONE=1 will show only the outside of the ellipsoid.

Loading the Sample Points and Wireframe Ellipsoid into the Design Window

1. Select the **Design** window.
2. Select the **Project Files** control bar.
3. Double-click the *Points* folder to display all project points files.
4. Select , drag and drop the following points file into the **Design** window:
   - _srfsamp
5. Double-click the *Wireframe Triangles* folder to display all project wireframe triangles files.
6. Select , drag and drop the following wireframe triangles file into the **Design** window:

- 2delp1tr

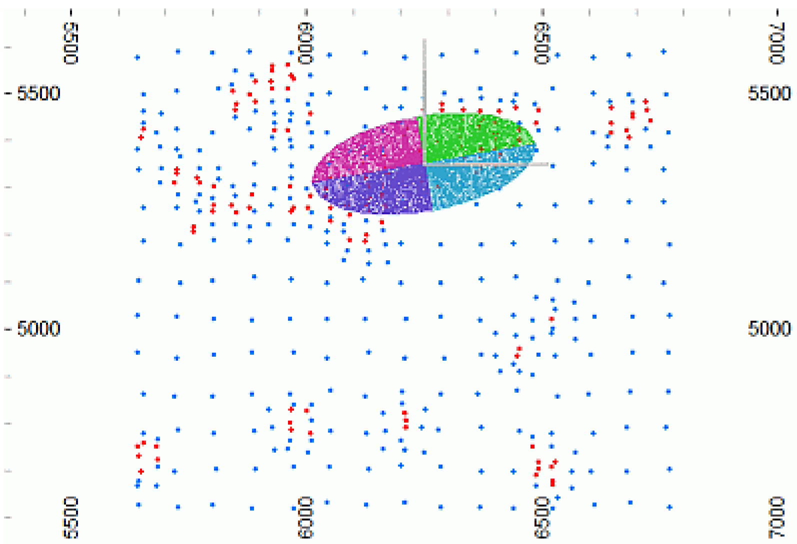
7. In the **View Control** toolbar, click Plane by One Point.

8. Right-click on a sample point in the **Design** window.

9. In the **Select View Orientation** dialog, select *Plan* and click **OK**.

10. Click Zoom Extents in the **View Control** toolbar.

11. View the loaded data in the **Design** window and compare your view to that shown in the image below:



The sample data have the following spatial characteristics:

- sampling covers an area 970m in the X and 1130m in the Y direction.
- sampling locations are clustered, with a higher sampling density in the higher value areas (indicated by the red points)
- lower value areas have a sample spacing of approximately 80m in both X- and Y-coordinate directions.

Formatting the Sample Points

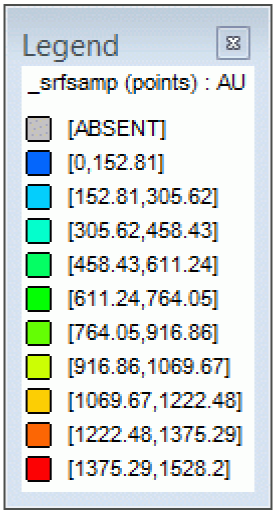
1. Select the **Design** window.

2. In the **Sheets** control bar, expand the *Design-Overlays* folder.

3. Right-click *_srfsamp (points)*, select **Quick Legend**.

4. In the **Quick Legend** dialog, *Object* group, select the *Field* [AU].

5. In the *Display* group, click **Preview** ,check that your legend is as shown below:



The soil sampling Au values are measured in units of ppb, have a minimum of 191ppb (approx.) and a maximum of 1528ppb (approx.).

6. Click **Apply**.

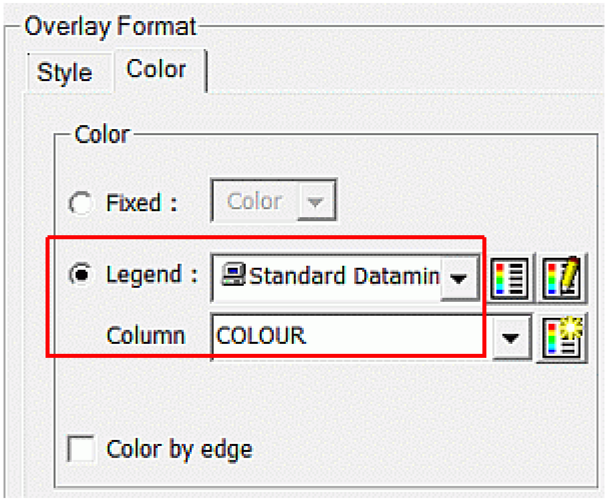
7. Close the dialog.

Formatting the Wireframe Ellipsoid

1. In the **Sheets** control bar, *Design-Overlays* folder, double-click *2delp1tr/2delp1pt(wireframe)* .

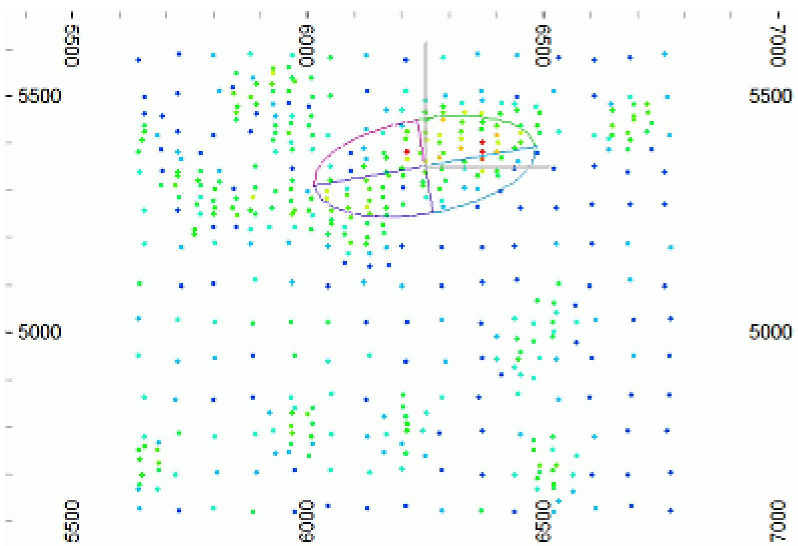
2. In the **Format Display** dialog, *Overlay Format* group, *Style* tab, *Display As:* group, select the *Intersection* option.

3. In the *Overlay Format* group, *Color* tab, check that your settings are as shown below:



4. Click **Apply** and then **OK**.

5. In the **Design** window check that your data is formatted as shown below:



- The sample data lies at an elevation of 280m.
- Setting the wireframe ellipse ZCENTRE=280.1 makes sure that the wireframe plan view intersection lies slightly above and not on the same plane as the wireframe ellipsoid octant boundaries.
- The resultant wireframe ellipse intersection view shows as four (of a total of 8) octant boundaries and not a mass of wireframe triangles.
- Viewing the wireframe ellipsoid as Intersections allows you to see the sample data falling within each of the ellipsoid octants without the wireframe surfaces

obscuring the view.

- Place the wireframe ellipsoid at different locations by change the X- and Y-coordinates of the ellipsoid when running the ELLIPSE process.

Checking the Search Ellipsoid Against the Sample Data

1. Select the **Design** window.
2. Inspect the wireframe ellipsoid and sample points for the following:
   - check the orientation of the major ellipsoid axis against the orientation of the high and low value zones
   - check the lengths of the major and minor axes against the search parameters SDIST1 and SDIST3
   - count the number of samples falling within the ellipse and compare the total to the MINNUMn and MAXNUMn search parameter values
   - check to see if the MINNUMn and MAXNUMn search parameter criteria would be met if the search ellipse lay in a less densely sampled area
   - select potential octant search parameters for the displayed sampling density.

OPTIMIZING GRADE ESTIMATION PARAMETERS

In this portion of the user guide you are going to be introduced to the **XVALID** process which is used to optimize search, variogram and estimation parameters using the cross validation technique.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Read the process description for **XVALID** .
- Read the help documentation notes page for Cross Validation Notes.
- Files required for the exercises on this page:
    - _srfsamp
    - _2dspar1
    - _2depar1
    - _2dvpar1

Exercise: Optimizing Estimation Parameters Using Cross Validation

In this exercise you are going to choose an 'optimum' set of estimation parameters, for estimating the output grade field AU_OK, by comparing the cross validation statistics results for different variogram models and search parameters as follows:

- Variograms: compare a single vs. a double spherical model, keeping all other parameters constant
- Search Volume: compare a non-octant vs. an octant search, keeping all other parameters constant.

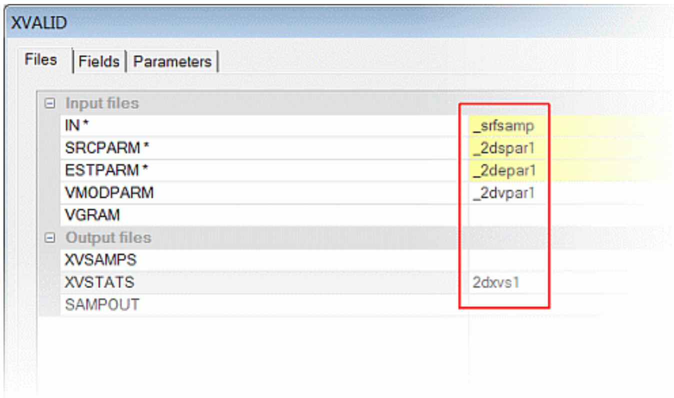
The estimation parameter file _2depar1 contains three separate runs for estimating the input grade field AU. These three output grade fields are AU_NN, AU_IPD and AU_OK. This exercise focuses on optimizing the parameters for the AU_OK output grade field.

How does the Cross-validation Technique work?

- It removes each sample point in turn from the data file and estimates its value from the remaining data.
- In this way a table of actual and estimated values is created.
- A detailed statistical analysis is then carried out comparing the actuals and estimates.
- One (or more) of the estimation parameters can then be changed and the process rerun to see whether the new parameter(s) improve the results of the statistical analysis.
- The method is iterative, requiring several runs to establish the best set of parameters.

Generating the First Set of Cross Validation Results using XVALID

1. Select the **Design** window.
2. Select **Applications | Statistical Processes | Variograms | Cross Validate**.
3. In the **XVALID** dialog, *Files* tab, *Input files* group, set *IN** by browsing for and selecting the file _srfsamp.
4. Set *SRCPARM** by browsing for and selecting the file _2dspar1.
5. Set *ESTPARM** by browsing for and selecting the file _2depar1.
6. Set *VMODPARM** by browsing for and selecting the file _2dvpar1.
7. In the *Output files* group, check that *XVSAMPS* is undefined.
8. Define a new *XVSTATS* output file '2dxvs1'.
9. Check that *SAMPOUT* is undefined, check that your file names are as shown below:

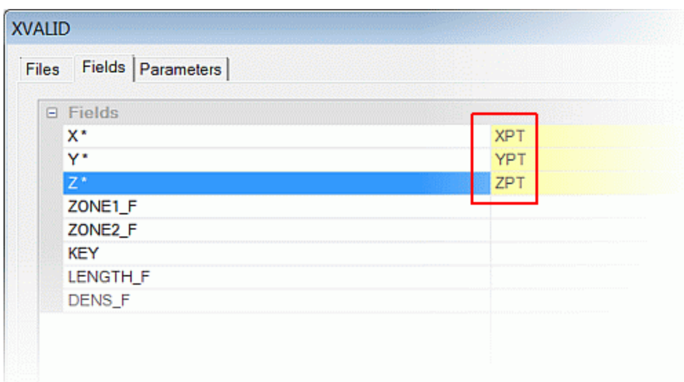


10. In the *Fields* tab, select the *X** field [XPT].

11. Select the *Y** field [YPT].

12. Select the Z* field [ZPT].

13. Check that your fiields are undefined as shown below:



14. In the *Parameters* tab, check that the value of *SMINFAC* is '0.0001'

15. Click **OK**.

16. In the **Output** window, check that the Summary Input Parameters are as shown below:

Command

```
SUMMARY OF INPUT PARAMETERS
---------------------------
Grade field                       = AU

Minimum number of samples         = 3
Maximum number of samples         = 20

Estimation Method: Ordinary Kriging (IMETHOD=3)

Model variogram reference number  = 1
Variogram rotations are:
  1st rotation around Z axis (VAXIS1) of -10 degrees (VANGLE1)
  2nd rotation around X axis (VAXIS2) of 0 degrees (VANGLE2)
  3rd rotation around Z axis (VAXIS3) of 0 degrees (VANGLE3)

Number of structures              = 1
Nugget variance      (NUGGET)     = 0
1st Structure:
  Type               (ST1)        = 1   (spherical)
  Range in X         (ST1PAR1)    = 240
  Range in Y         (ST1PAR2)    = 80
  Range in Z         (ST1PAR3)    = 80
  Spatial variance   (ST1PAR4)    = 90000

Search Volume:
  Search distance in X    (SDIST1) = 240
  Search distance in Y    (SDIST2) = 100
  Search distance in Z    (SDIST3) = 10

  Search volume rotations are:
  1st rotation around Z axis (SAXIS1) of -10 degrees (SANGLE1)
  2nd rotation around X axis (SAXIS2) of 0 degrees (SANGLE2)
  3rd rotation around Z axis (SAXIS3) of 0 degrees (SANGLE3)

The minimum search volume (the exclusion volume) is calculated as the
volume defined above multiplied by a factor of 0.0001
```

17. Check that the Cross-Validation Statistics for AU i.e. the third AU grade estimate (the output grade field AU_OK) are as shown below:

```
CROSS-VALIDATION STATISTICS FOR AU
----------------------------------------
Number of samples estimated        = 470
Number of samples not estimated    = 0

Mean of actual values              = 436.45
Mean of estimated values           = 442.67

Mean difference (act - est)        = -6.2169
Mean difference (as % of actual)   = -1.424
Mean absolute difference           = 145.19

Variance of actual values          = 89912.7
Variance of estimated values       = 65101.24

Correlation coefficient            = 0.791

Kriging Variance:
  Mean of KV estimated from model  = 32843.8
  Mean of squared differences      = 33906.29
  Ratio                            = 0.968

Regression Equation:
  Actual          =  24.5734  +  0.9304  *  Estimate
  Standard Error  =  183.17
```

18. Record your key input parameters and output statistics in a table similar to that shown below:

CROSS VALIDATION RESULTS

Datafile: _______________ Variable: ______________ Date: ____________ Page: ______

Description: ____

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Run No.	Estimation Parameters		Search Parameters					Variogram Parameters			Cross-Validation Statistics							
	Est. Type	Other Est. Params	Min Radius Factor	Radii XYZ	Sample No MinMax	Octant Search Params.	Key Fields	Nugget Var.	Struct n Ranges in X,Y,Z	Struct n Spatial Var.	No. of Samples	Mean Diff. (% of Act.)	M.A.D.	Corrl. Coeff.	K.V. Mean Sq Diff.	K.V. Ratio	Regr. Eqn. Slope	Comments
	IMETHOD	e.g. POWER KRGNEGW	SMINFAC	SDIST1 SDIST2 SDIST3	MINNUM1 MAXNUM1	MINOCT MINPEROC MAXPEROC	MAXKEY	NUGGET	STnPAR1 STnPAR2 STnPAR3	STnPAR4	Est. Non Est.							

Comparing Variogram Model Parameters using XVALID

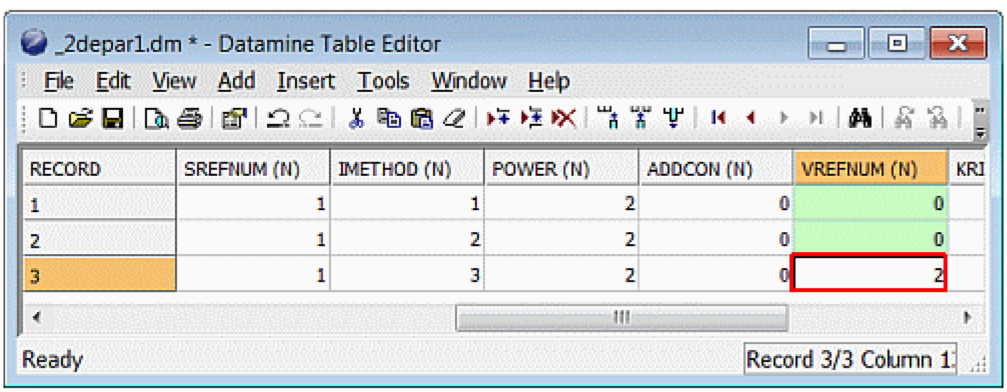
1. In the **Output** window, note the following Cross-Validation Menu options:

```
                  CROSS-VALIDATION MENU
                  ---------------------

    Select from:

      1  -  edit search volume parameter file _2dspar1
      2  -  edit estimation parameter file _2depar1
      3  -  edit variogram model parameter file _2dvpar1
      5  -  examine cross-validation statistics file 2dxvs1
      6  -  delete cross-validation statistics file 2dxvs1

      8  -  re-run cross-validation

      0  -  exit cross-validation

    Note that options 1,2,3 and 5 use AED. You may prefer to edit
    the parameter files directly with the Table Editor.

Enter your selection [8] >
```

2. In the **Command** toolbar (by default at the bottom-left of the **Studio 3** main window) type in '2', press <Enter>.

3. In the **CAE Table Editor** dialog, move down to Record 3, the VREFNUM field cell.

4. Change the value from '1' to '2', press <Enter>:



5. Select **File | Save**, then close the dialog.

6. Back in the **Command** toolbar, type in '8', press <Enter>.

7. Select the **Output** window and check that the summary parameters and validation statistics for the modified third AU grade estimate (i.e. output grade field AU_OK) are now as shown below:

```
SUMMARY OF INPUT PARAMETERS
---------------------------
Grade field                        = AU

Minimum number of samples          = 3
Maximum number of samples          = 20

Estimation Method: Ordinary Kriging (IMETHOD=3)

Model variogram reference number   = 2
Variogram rotations are:
  1st rotation around Z axis (VAXIS1) of -10 degrees (VANGLE1)
  2nd rotation around X axis (VAXIS2) of 0 degrees (VANGLE2)
  3rd rotation around Z axis (VAXIS3) of 0 degrees (VANGLE3)

Number of structures               = 2
Nugget variance      (NUGGET)      = 0
1st Structure:
  Type               (ST1)         = 1   (spherical)
  Range in X         (ST1PAR1)     = 40
  Range in Y         (ST1PAR2)     = 40
  Range in Z         (ST1PAR3)     = 80
  Spatial variance   (ST1PAR4)     = 30000
2nd Structure:
  Type               (ST2)         = 1   (spherical)
  Range in X         (ST2PAR1)     = 240
  Range in Y         (ST2PAR2)     = 100
  Range in Z         (ST2PAR3)     = 80
  Spatial variance   (ST2PAR4)     = 60000

Search Volume:
  Search distance in X   (SDIST1) = 240
  Search distance in Y   (SDIST2) = 100
  Search distance in Z   (SDIST3) = 10

  Search volume rotations are:
  1st rotation around Z axis (SAXIS1) of -10 degrees (SANGLE1)
  2nd rotation around X axis (SAXIS2) of 0 degrees (SANGLE2)
  3rd rotation around Z axis (SAXIS3) of 0 degrees (SANGLE3)

The minimum search volume (the exclusion volume) is calculated as the
volume defined above multiplied by a factor of 0.0001
```

```
CROSS-VALIDATION STATISTICS FOR AU
----------------------------------------
Number of samples estimated        = 470
Number of samples not estimated    = 0

Mean of actual values              = 436.45
Mean of estimated values           = 447.27

Mean difference (act - est)        = -10.8165
Mean difference (as % of actual)   = -2.478
Mean absolute difference           = 139.79

Variance of actual values          = 89912.7
Variance of estimated values       = 55135.49

Correlation coefficient            = 0.807

Kriging Variance:
  Mean of KV estimated from model  = 51704.84
  Mean of squared differences      = 31461.31
  Ratio                            = 1.643

Regression Equation:
  Actual         =  -24.7412  +  1.0311  *  Estimate
  Standard Error =  176.89
```

These statistics are saved to the output statistics file 2dxvs1 that was defined under the *Output files* tab when first setting up the process.

8. Compare the results of these two cross validation runs which use different sets of variogram model parameters i.e. VREFNUM = 1 and then VREFNUM = 2.

The following guidelines should be used when using Cross-Validation statistics to compare different runs. The statistics are listed in order of decreasing importance:

- For an unbiased estimate, the means of the Estimates and Actuals should ideally be equal
- mean difference (as % of actual) - aim is to make the statistic as close as possible to zero. It should be < 5% and hopefully < 2%.
- kriging variance ratio - it should lie in the range between 0.8 and 1.2, and be as close as possible to 1.
- correlation coefficient - always lies between -1 and +1 (a value of +1 shows perfect positive correlation). Aim to make the correlation coefficient as large as possible.
- mean absolute difference - aim to make it as close as possible to zero
- regression line slope (constant b) - slope of the line should ideally be equal to 1.

A change in the one of the input model variogram parameters (,estimation or search parameters) will often result in some of the statistics improving and others getting worse. The end result is likely to be a compromise.

For a full description of the use of these Cross-validation statistics, please see the Cross Validation Notes

8. Repeat steps 2 to 6 and reset the VREFNUM to '1'.

9. In the **Command** toolbar type in '0', press <Enter> (to stop running **XVALID**).

Cross Validation can be used to compare sets and combinations of:

- Variogram parameters
- Search Volume parameters

- Estimation parameters.

The optimization of variogram, search and estimation parameters using Cross Validation is an iterative process.

See the Studio 3 Command Table in the Help documentation for a comprehensive list of Processes and their uses.

GRADE - Basic Grade Estimation

In this portion of the user guide you are going to use the process **GRADE** to estimate grades using the Inverse Distance method.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Read the help documentation notes page for **GRADE**, in your Studio 3 Help file.
- Files required for the exercises on this page:
  - _2dpmod1
  - _srfsamp

Exercise: Using Grade to Perform a Basic Grade Estimation Run

In this exercise you are going to estimate Au grades into a 2D block model using the following parameters:

- Grade field: AU
- Estimation method: Inverse Power Distance (IPD)
- Search Volume: see parameters below
- Variogram model: see parameters below
- No zonal control.

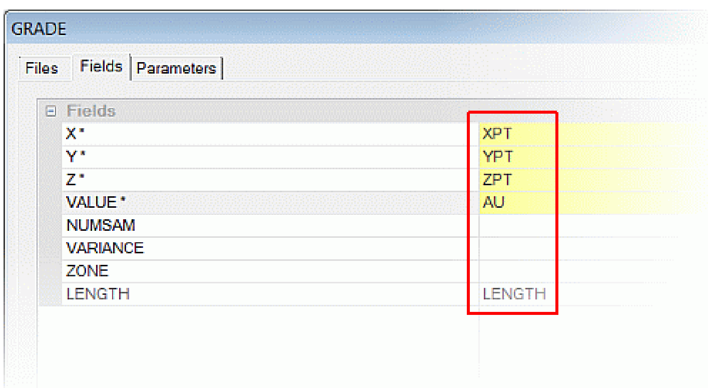
Use GRADE to estimate grades into a block model when using:

- a single grade field
- estimation method NN, IPD or OK
- a single search volume, parameters not saved in a search parameter file.

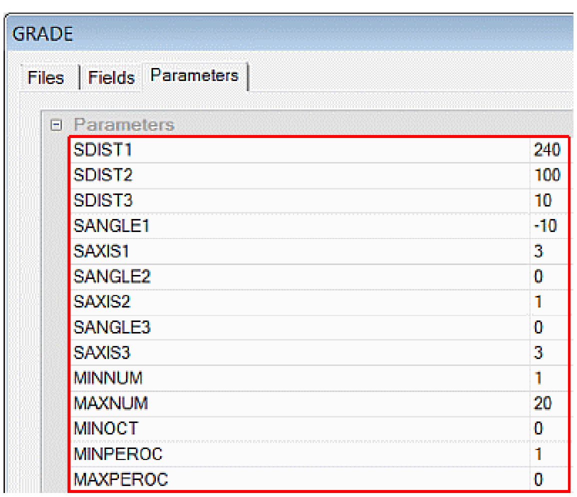
Estimating AU Using the Inverse Power Distance Method

1. Select the **Design** window.

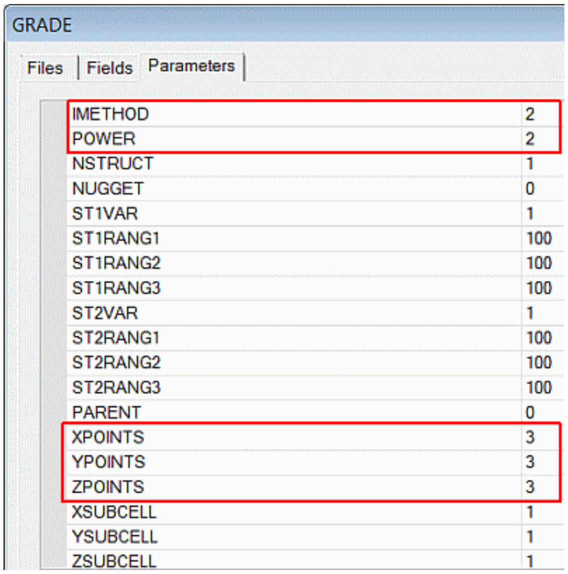
2. In the **Modeling** toolbar, click Basic Grade Interpolation.
3. In the **GRADE** dialog, *Files* tab, *Input files* group, set *PROTO** by browsing for and selecting the file _2dpmod1.
4. Set *IN** by browsing for and selecting the file (from the *All Tables* folder) _srfsamp.
5. In the *Output files* group, define a new output *MODEL** '2dgmod1':
6. In the *Fields* tab, select the *X** field [XPT].
7. Select the *Y** field [YPT].
8. Select the Z* field [ZPT].
9. Select the *VALUE** field [AU].
10. Check that your fields are defined as shown below:



11. In the *Parameters* tab, define the search parameters as shown below:



12. In the *Parameters* tab, define the estimation parameters as shown below:



13. Click **OK**.

14. In the **Command** control bar, check that the grade estimation process has run successfully and that the output file *2dgmod1* contains 780 records:

```
GRADE - interpolate a grade into a block model

... input validation.
... checking field names.
... checking prototype model file _2dpmod1.
... checking sample data file _srfsamp.
... checking output model file.
... checking parameters.
... setting up search volume parameter file.
... setting up estimation parameter file.

ESTIMA    TIME >17:22: 7
ESTIMA - Grade Estimation
-------------------------
Initialization: Checking input files ............................
Initialization: Checking estimation parameter file ..............
Initialization: Creating estimation table .......................
Initialization: Checking model file .............................
Initialization: Creating virtual files ...........................           I
nitialization: Storing data in memory ..........................            In
itialisation: Completed.
Estimation Table
----------------
Estimations will be carried out for the following combinations of grade and
zone fields:
     Sample    Output    Zones ................................ Search   Est
     Data      Model                                           Vol.Ref  Meth
     Grade     Grade
  1  AU        AU        ........................................    1.0      2
Number of records in the output model =      780
Number of different grade fields      =        1
Maximum number of estimates           =      780
This maximum number ignores retrieval criteria, selective updating, unestimated
zones etc, and so the % figure in the progress report may be too low.
>>>        10 estimates,    1.3% completed.     Time  17:22: 7 <<<
Number of records in the output model =      780
Number of different grade fields      =        1
Maximum number of estimates           =      780
This maximum number ignores retrieval criteria, selective updating, unestimated
zones etc, and so the % figure in the progress report may be too low.
>>>       780 estimates, 100.0% completed.     Time  17:22: 7 <<<
Total number of estimates                    780
>>>      780 Records in File C:\Database\DMTutorials\Projects\S3GrdEstTut\ProjFi
les\MyProj1\2dgmod1.dm <<<

... deleting temporary work files.

Grade estimation complete.  The output model file is
  2dgmod1
The file contains 780 records.
```

Multiple grade estimates can be done by:

- generating the first grade block model using **GRADE**
- if required, renaming the block model's grade field using the **CAE Table Editor**
- running **GRADE** on the next grade field, using the file output from the previous run as input.

ESTIMATE - Advanced Grade Estimation

In this portion of the user guide you are going to use the process **ESTIMATE** to estimate grades using Nearest Neighbour, Inverse Distance and Ordinary Kriging methods.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Read the help documentation notes page for **ESTIMATE**, in your Studio 3 Help file.
- Read the Studio 3 Grade Estimation User Guide page on *Grade Estimation Methods*.
- Files required for the exercises on this page:
    - _2dzmod1
    - _srfsamp
    - _2depar2
    - _2dspar1
    - _2dvpar1

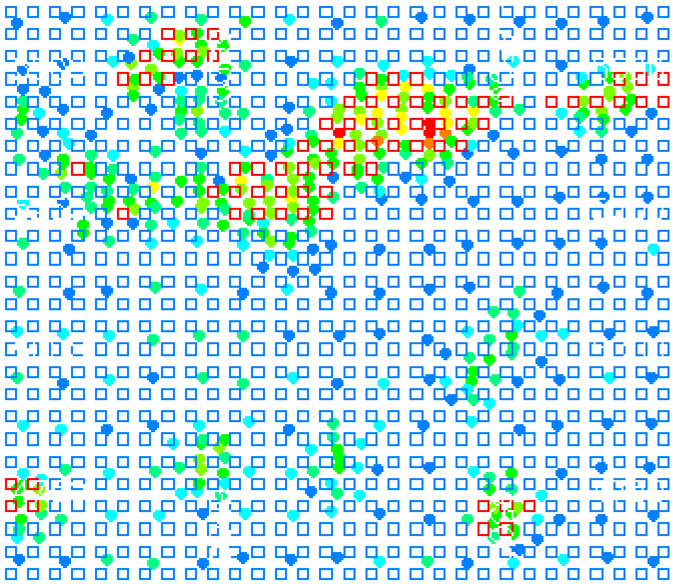
Exercise: Using ESTIMATE for NN, IPD and OK grade estimates

In this exercise you are going to estimate Au grades into a 2D block model using three different estimation methods and the following parameters:

- Input Grade field: AU
- Output Grade fields: AU_NN, AU_IPD and AU_OK
- Estimation methods: Nearest Neighbour (NN), Inverse Power Distance (IPD) and Ordinary Kriging
- Search Volume: search volume 1 (SREFNUM=1)
- Variogram model: variogram model 2 (VREFNUM=2)
- Estimation options: zonal control (field ANOM).

The block model and sample points are shown in the image below. The blue block model cells represent the lower grade zone (field ANOM=1) while the red cells represent the higher grade zone (field

ANOM=2). The displayed sample points have low grade values colored blue and higher grade values colored in red.



Use ESTIMATE to estimate grades into a block model when using:

- multiple grade fields
- estimation method NN, IPD, OK or Simple Kriging
- Indicator Kriging or Sichel's T estimation
- dynamic search volumes
- advanced estimation options e.g. model updating
- search, variogram and estimation parameters stored in files.

Defining the Input Block Model and Samples Files

1. Select the **Design** window.
2. Select **Models | Interpolation Processes | Interpolate Grades from Menu**.
3. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, select the *Input* subtab.
4. In the *Geological Model* group, click **Browse**.

5. In the **Project Browser** dialog, *Database Tables* pane, *Block Models* folder, select _2dzmod1 , click **OK**.

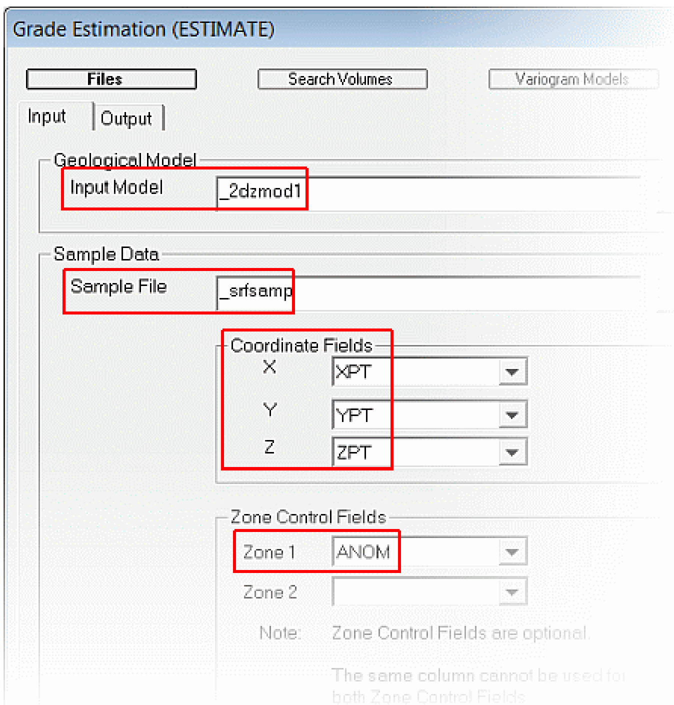
6. In the *Sample Data* group, click **Browse**.

7. In the **Project Browser** dialog, *Database Tables* pane, *All Tables* folder, select _srfsamp , click **OK**.

8. In the *Coordinates Fields* group, select the X, Y and Z fields [XPT], [YPT], [ZPT].

9. In the *Zone Control Fields* group, select the *Zone 1* field [ANOM].

10. Check that your parameters are as shown below:



- Drillholes or suitable points data can be used as Sample Data files.
- Both the *Input Model* and the *Sample File* need to be defined so that the *Zone Control Fields* can be selected.
- The *Zone Control Fields* need to be present (and contain suitable matching zone field values) in both the *Input Model* and the *Sample File*.

Defining the Output Block Model, Input/Output Search Volume and Variogram Model Files

1. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, select the *Output* subtab.

2. In the *Grade Model* group, define a new model file '2dgmod2'.

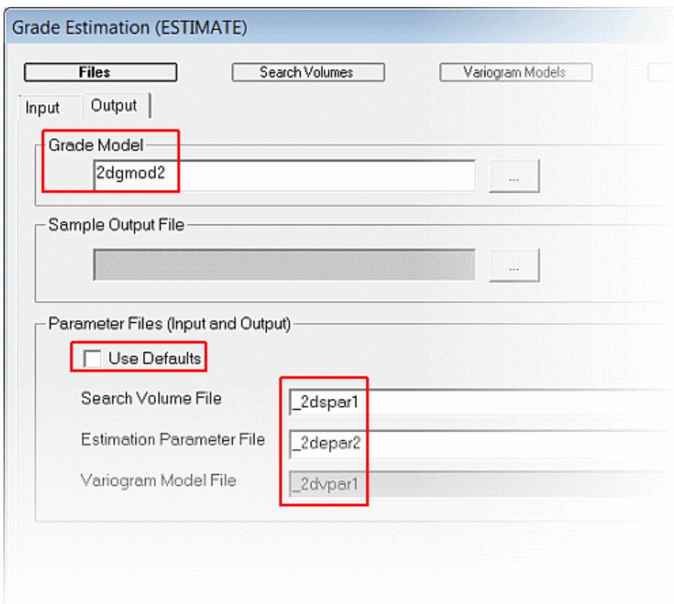
3. In the *Parameter Files (Input and Output)* group, clear the *Use Defaults* checkbox.

4. Browse for and select the *Search Volume File* _2dspar1.

5. Browse for and select the *Estimation Parameter File* _2depar2.

6. Browse for and select the *Variogram Model File* _2dvpar1.

7. Check that your parameters are as shown below:



The *Search Volume File*, *Variogram Model File* and the *Estimation Parameter File* need to be defined here so that the relevant search, variogram model and estimation parameters are displayed in the relevant tabs.

Checking the Search Parameters

1. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, click **Next >>**.

2. In the *Search Volumes* tab, *Summary* subtab, check that the *Search Parameter Table* contains a single sets of parameters, as shown below:

Search Parameter Table

	1
SDESC	Search Volume 1
SREFNUM	1
SMETHOD	2
SDIST1	240
SDIST2	100
SDIST3	10
SANGLE1	-10
SANGLE2	0
SANGLE3	0
SAXIS1	3
SAXIS2	1
SAXIS3	3
MINNUM1	3
MAXNUM1	20
SVOLFAC2	0
MINNUM2	0

Checking the Variogram Model Parameters

1. In the **Grade Estimation (ESTIMATE)** dialog, *Search Volumes* tab, click **Next >>**.

2. In the *Variogram Models* tab, *Summary* subtab, check that the *Variogram Model Table* contains two sets of parameters, as shown below:

Variogram Model Table

	1	2
VDESC	AU 1-structure	AU 2-structure
VREFNUM	1	2
VANGLE1	-10	-10
VANGLE2	0	0
VANGLE3	0	0
VAXIS1	3	3
VAXIS2	1	1
VAXIS3	3	3
NUGGET	0	0
ST1	1	1
ST1PAR1	240	40
ST1PAR2	80	40
ST1PAR3	80	80
ST1PAR4	90000	30000
ST2	-	1
ST2PAR1	-	240

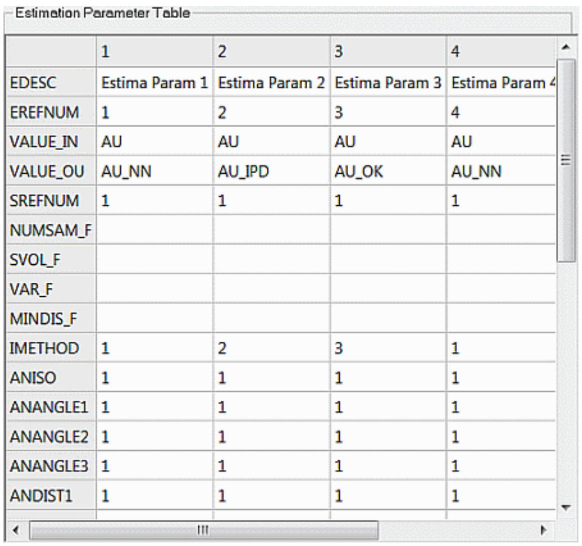
Variogram Model Table

ST1PAR2	80	40
ST1PAR3	80	80
ST1PAR4	90000	30000
ST2	-	1
ST2PAR1	-	240
ST2PAR2	-	100
ST2PAR3	-	80
ST2PAR4	-	60000
ST3	-	-
ST3PAR1	-	-
ST3PAR2	-	-
ST3PAR3	-	-
ST3PAR4	-	-
ST4	-	-
ST4PAR1	-	-
ST4PAR2	-	-
ST4PAR3	-	-

Checking the Estimation Types Parameters

1. In the **Grade Estimation (ESTIMATE)** dialog, *Variogram Models* tab, click **Next >>**.

2. In the *Estimation Types* tab, *Summary* subtab, check that the *Estimation Parameter Table* contains six sets of parameters, 4 are shown below:



Estimation Parameter Table

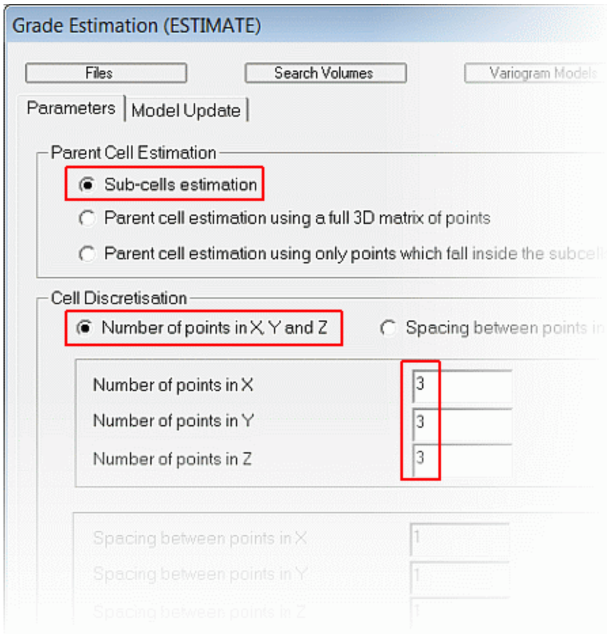
	1	2	3	4
EDESC	Estima Param 1	Estima Param 2	Estima Param 3	Estima Param 4
EREFNUM	1	2	3	4
VALUE_IN	AU	AU	AU	AU
VALUE_OU	AU_NN	AU_IPD	AU_OK	AU_NN
SREFNUM	1	1	1	1
NUMSAM_F				
SVOL_F				
VAR_F				
MINDIS_F				
IMETHOD	1	2	3	1
ANISO	1	1	1	1
ANANGLE1	1	1	1	1
ANANGLE2	1	1	1	1
ANANGLE3	1	1	1	1
ANDIST1	1	1	1	1

The *Estimation Parameter Table* contains six sets of parameters i.e. one for each of the output grade fields AU_NN, AU_IPD and AU_OK for each of the two grade zones (ANOM=1 and ANOM=2). This zone field ANOM is present within the input block model and the sample points file. It contains one of two values: for the lower grade zone ANOM=1, while for the higher grade zone ANOM=2.

Setting the Controls Parameters

1. In the **Grade Estimation (ESTIMATE)** dialog, *Estimation Types* tab, click **Next >>**.

2. In the *Controls* tab, *Parameters* subtab, check that the default parameters are selected, as shown below:



The input block model contains only parent cells and not subcells: this can be identified by all the cells having the same size in the image shown at the top of the page. In this case, the default *subcells estimation* option is selected; selecting the *Parent cell estimation using a full 3D matrix of points* option will produce the same results. These two options will produce different estimation results when selected using a block model with subcells.

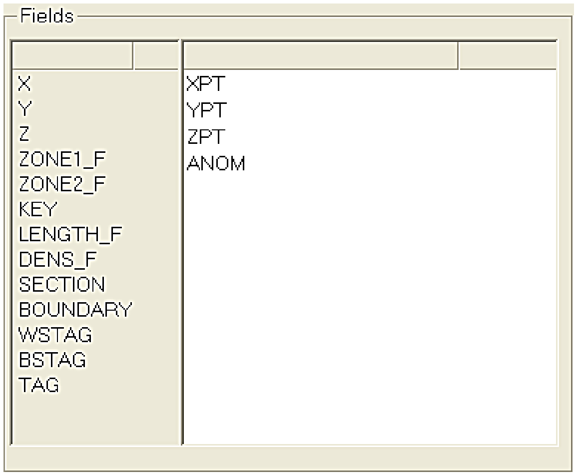
Checking the Parameters in the Preview tab

1. In the **Grade Estimation (ESTIMATE)** dialog, *Controls* tab, click **Next >>**.
2. In the *Preview* tab, *Summary* subtab, check that the *Files* group parameters are as shown below:

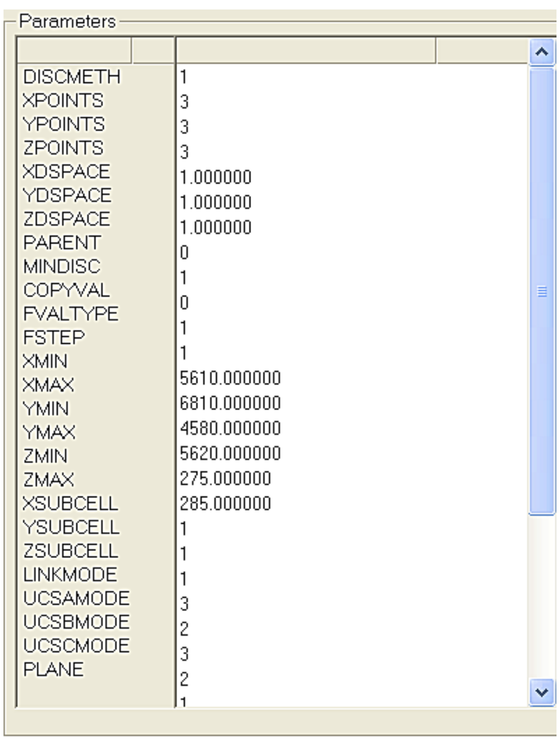
Files

Geological Model	_2dzmod1	Search Volumes	_2dspar1
Sample	_srfsamp	Variogram Models	_2dvpar1
Grade Model	2dgmod2	Estimation	_2depar2
Output Sample			

3. In the *Preview* tab, *Summary* subtab, check that the *Fields* group parameters are as shown below:



4. In the *Preview* tab, *Summary* subtab, check that the *Parameters* group settings are as shown below:



5. Click **Run**.

6. In the **Command** control bar, check that ESTIMATE has run successfully and that the output file *2dgmod2* contains 780 records.

ORDINARY VS. SIMPLE KRIGING

In this portion of the user guide you are going to use the process **ESTIMATE** to estimate grades using the Ordinary and Simple Kriging methods.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Read the help documentation notes page for **ESTIMATE**, in your Studio 3 Help file.
- Read the Grade Estimation User Guide page *Kriging*.
- Files required for the exercises on this page:
    - _2dzmod1
    - _srfsamp
    - _2depar2
    - _2dspar1
    - _2dvpar1

Exercise: Using ESTIMATE for Ordinary Kriging and Simple Kriging

In this exercise you are going to estimate Au grades into a 2D block model using the Ordinary and Simple Kriging estimation methods and the following parameters:

- Input Grade field: AU
- Output Grade fields: AU_OK, AU_SK
- Estimation methods: Ordinary Kriging (OK), Simple Kriging (SK)
- Search Volume: search volume 1 (SREFNUM=1)
- Variogram model: variogram model 2 (VREFNUM=2)
- Estimation options: zonal control (field ANOM), values 1 and 2
- Simple Kriging Method: 2 (LOCALMNP=2) i.e. the local mean is calculated automatically.

This will be done by adding two Simple Kriging runs (one for each of the zones i.e. ANOM=1 and ANOM=2) to the existing estimation parameter file _2depar2 . The modified estimation estimation parameter file will then be saved out to a new file 2depar3.

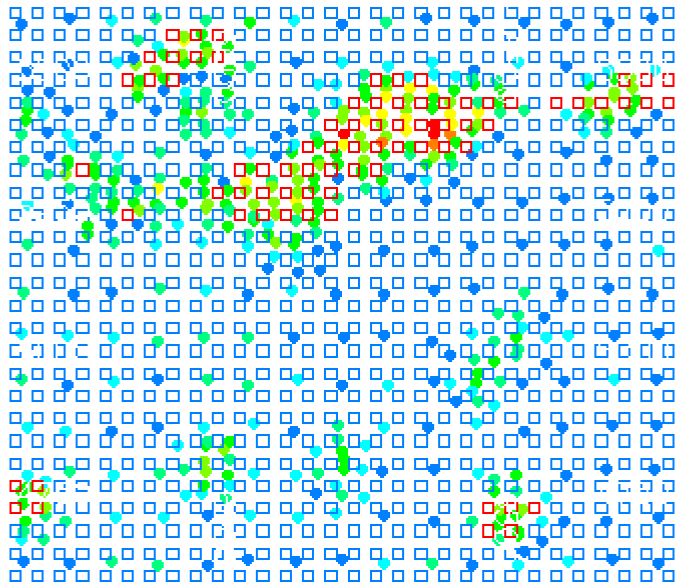
Ordinary vs Simple Kriging

For Ordinary Kriging (OK) a weight is calculated for each sample, and the sum of these weights is 1. For Simple Kriging(SK) a weight Wi is calculated for each sample and a weight of (1 - ΣWi) is assigned to the mean grade. Simple Kriging is not as responsive as Ordinary Kringing to local trends in the data, since it depends partially on the mean grade, which is assumed to be known, and constant throughout the area.

The local mean value required by Simple Kriging can be defined in one of the following two ways:

- The local mean is obtained from a 'local mean' field in the input block model
    - Set estimation parameter LOCALMNP = 1
    - Define the name of the local mean field in the block model using the estimation parameter LOCALM_F
- The local mean is calculated as the arithmetic mean of all samples lying in the search volume
    - Set estimation parameter LOCALMNP = 2.

The input block model and sample points are shown in the image below. The blue block model cells represent the lower grade zone (field ANOM=1) while the red cells represent the higher grade zone (field ANOM=2). The displayed sample points have low grade values colored blue and higher grade values colored in red.



Use Simple Kriging when:

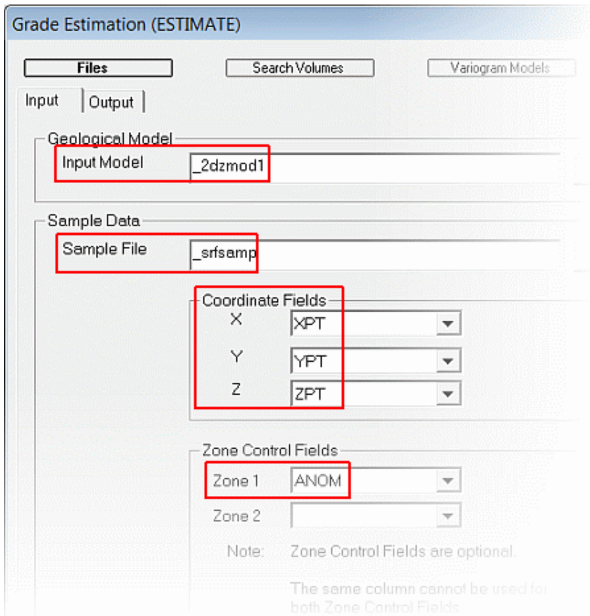
- requiring the local mean to play a role in the grade estimate
- wanting to reduce the effects of clustered data
- wanting to produce a result that is "smoother" and more aesthetically pleasing.

Defining the Input Block Model and Sample Files

1. Select the **Design** window.
2. Select **Models | Interpolation Processes | Interpolate Grades from Menu**.
3. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, select the *Input* subtab.
4. In the *Geological Model* group, click **Browse**.
5. In the **Project Browser** dialog, *Database Tables* pane, *Block Models* folder, select _2dzmod1 , click **OK**.
6. In the *Sample Data* group, click **Browse**.
7. In the **Project Browser** dialog, *Database Tables* pane, *All Tables* folder, select _srfsamp , click **OK**.
8. In the *Coordinates Fields* group, select the X, Y and Z fields [XPT], [YPT], [ZPT].

9. In the *Zone Control Fields* group, select the *Zone 1* field [ANOM].

10. Check that your parameters are as shown below:



- Drillholes or suitable points data can be used as Sample Data files.
- Both the *Input Model* and the *Sample File* need to be defined so that the *Zone Control Fields* can be selected.
- The *Zone Control Fields* need to be present (and contain suitable matching zone field values) in both the *Input Model* and the *Sample File*.

Defining the Output Block Model, Input/Output Search Volume and Variogram Model Files

1. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, select the *Output* subtab.

2. In the *Grade Model* group, define a new model '2dgmod3'.

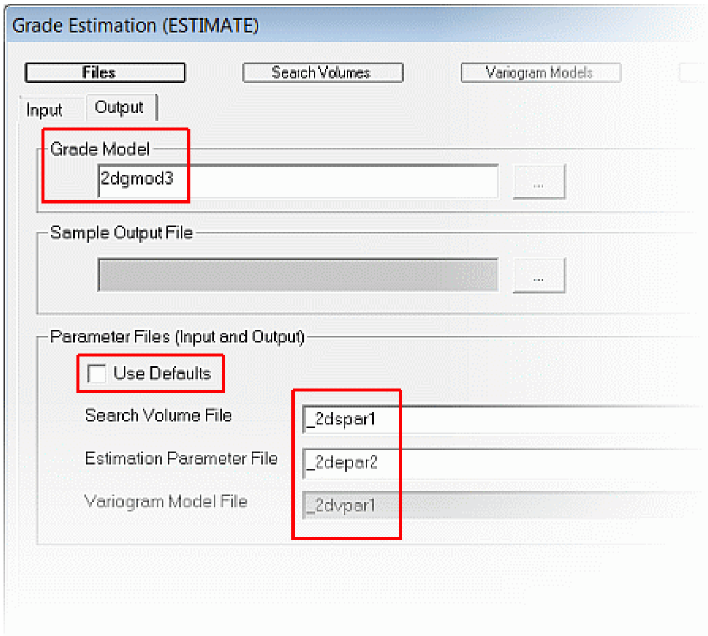
3. In the *Parameter Files (Input and Output)* group, clear the *Use Defaults* checkbox.

4. Browse for and set the *Search Volume File* to _2dspar1.

5. Browse for and set the *Estimation Parameter File* to _2depar2.

6. Browse for and set the *Variogram Model File* to _2dvpar1.

7. Check that your parameters are as shown below:



The *Search Volume File*, *Variogram Model File* and the *Estimation Parameter File* need to be defined here so that the relevant search, variogram model and estimation parameters are displayed in the different tabs.

Checking the Search Parameters

1. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, click **Next >>**.

2. In the *Search Volumes* tab, *Summary* subtab, check that the *Search Parameter Table* contains a single sets of parameters, as shown below:

Search Parameter Table

	1
SDESC	Search Volume 1
SREFNUM	1
SMETHOD	2
SDIST1	240
SDIST2	100
SDIST3	10
SANGLE1	-10
SANGLE2	0
SANGLE3	0
SAXIS1	3
SAXIS2	1
SAXIS3	3
MINNUM1	3
MAXNUM1	20
SVOLFAC2	0
MINNUM2	0

Checking the Variogram Model Parameters

1. In the **Grade Estimation (ESTIMATE)** dialog, *Search Volumes* tab, click **Next >>**.

2. In the *Variogram Models* tab, *Summary* subtab, check that the *Variogram Model Table* contains two sets of parameters, as shown below:

Variogram Model Table

	1	2
VDESC	AU 1-structure	AU 2-structure
VREFNUM	1	2
VANGLE1	-10	-10
VANGLE2	0	0
VANGLE3	0	0
VAXIS1	3	3
VAXIS2	1	1
VAXIS3	3	3
NUGGET	0	0
ST1	1	1
ST1PAR1	240	40
ST1PAR2	80	40
ST1PAR3	80	80
ST1PAR4	90000	30000
ST2	-	1
ST2PAR1	-	240
ST2PAR2	-	100
ST2PAR3	-	80
ST2PAR4	-	60000

Adding the Simple Kriging Runs in the Estimation Types Tab

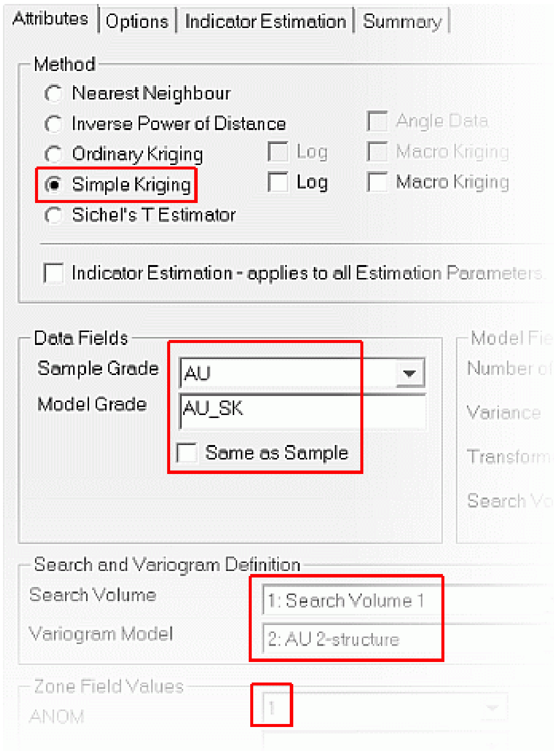
1. In the **Grade Estimation (ESTIMATE)** dialog, *Variogram Models* tab, click **Next >>**.

2. In the *Estimation Types* tab, *Index* group, check that 6 sets of estimation parameters are listed in the *Index* pane.

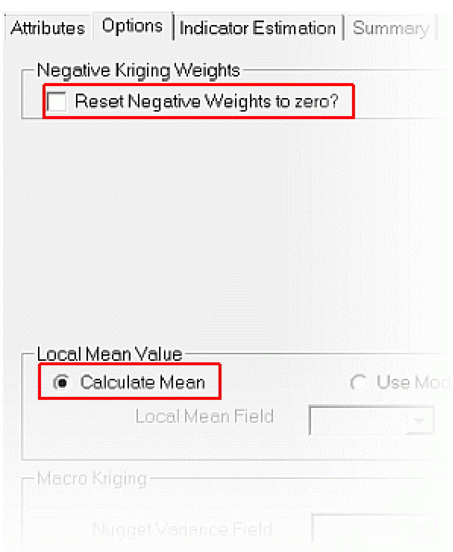
3. In the *Index* group, click **Add**.

4. In the estimation parameter list, check that a new estimation parameter description '7: Estima Param 7' has been added.

5. In the *Attributes* subtab on the right, define the parameters as shown below for ANOM=1:



6. In the *Options* subtab, define the parameters as shown below:



7. In the *Indicator Estimation* subtab, check that all options are greyed out.

8. Repeat steps 3 to 7 , defining the parameters for the zone field, second zone i.e. ANOM=2.

9. In the *Summary* subtab, check that your additional parameters are as shown below:

7	8
Estima Param 7	Estima Param 8
7	8
AU	AU
AU_SK	AU_SK
1	1
4	4
1	1
0	0
0	0
0	0
1	1

1	1
1	1
2	2
0	0
2	2
0	0
0	0
0.01	0.01
3	3
0	0
1	1
2	2

1	2

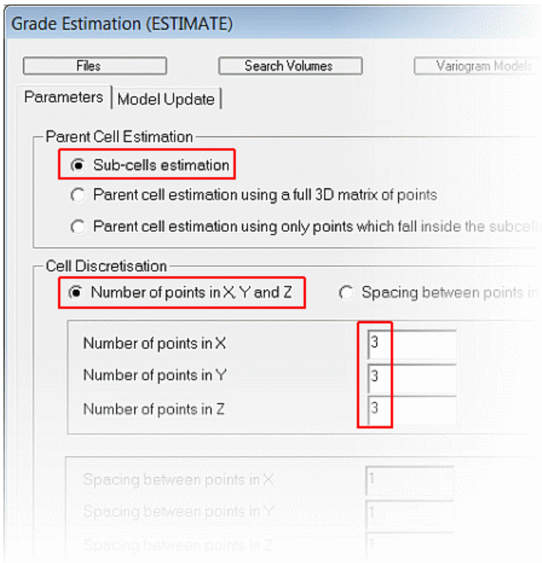
Exporting the New Estimation Parameters

1. In the **Grade Estimation (ESTIMATE)** dialog, *Estimation Types* tab, *Index* group, click **Export**.
2. In the **Project Browser** dialog, define a new *Filename* '2depar3', click **OK**.

Setting the Controls Parameters

1. In the **Grade Estimation (ESTIMATE)** dialog, *Estimation Types* tab, click **Next >>**.

2. In the *Controls* tab, *Parameters* subtab, check that the default parameters are selected, as shown below:

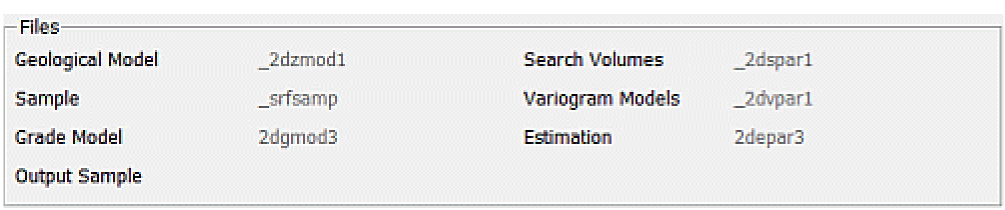


The input block model contains only parent cells and not subcells: this can be identified by all the cells having the same size in the image shown at the top of the page. In this case, the default *subcells estimation* option is selected; selecting the *Parent cell estimation using a full 3D matrix of points* option will produce the same results. These two options will produce different estimation results when selected using a block model with subcells.

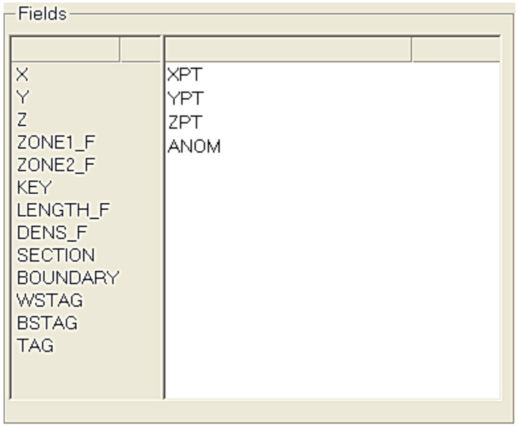
Previewing and Running the Estimate

1. In the **Grade Estimation (ESTIMATE)** dialog, *Controls* tab, click **Next >>**.

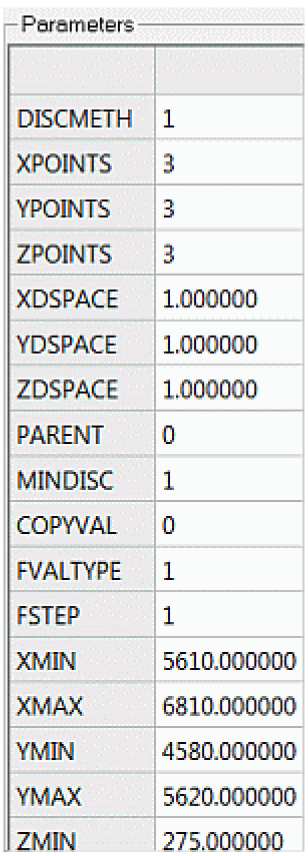
2. In the *Preview* tab, *Summary* subtab, check that the *Files* group parameters are as shown below:



3. In the *Preview* tab, *Summary* subtab, check that the *Fields* group parameters are as shown below:



4. In the *Preview* tab, *Summary* subtab, check that the *Parameters* group settings are as shown below:



Parameters

DISCMETH	1
XPOINTS	3
YPOINTS	3
ZPOINTS	3
XDSPACE	1.000000
YDSPACE	1.000000
ZDSPACE	1.000000
PARENT	0
MINDISC	1
COPYVAL	0
FVALTYPE	1
FSTEP	1
XMIN	5610.000000
XMAX	6810.000000
YMIN	4580.000000
YMAX	5620.000000
ZMIN	275.000000

ZMIN	275.000000
ZMAX	285.000000
XSUBCELL	1
YSUBCELL	1
ZSUBCELL	1
LINKMODE	3
UCSAMODE	2
UCSBMODE	3
UCSCMODE	2
PLANE	1
HANGID	
FOOTID	
TOLRNC	0.000000
ORGTAG	
GRMETHOD	3
PGFIELDS	0
ORDER	3
PRINT	0

5. Click **Run**.
6. In the **Command** control bar, check that ESTIMATE has run successfully with the additional Simple Kriging runs and that the output file *2dgmod3* contains 780 records:

```
Welcome to Datamine Studio
Version 3.0.1805.4
(C) 2007 Datamine Corporate Limited


Space reserved for strings of up to 1024 points each.
 ESTIMA - Grade Estimation
 -------------------------
 Initialization: Checking input files ............................
 Initialization: Checking estimation parameter file ..............
 Initialization: Checking zone fields ............................
 Initialization: Creating estimation table .......................
 Initialization: Checking model file .............................
 Initialization: Creating virtual files ..........................
Initialization: Storing data in memory ...........................
 Initialization: Completed.
 Estimation Table
 ----------------
 Estimations will be carried out for the following combinations of grade and
 zone fields:
      Sample     Output    Zones .................................. Search   Est
      Data       Model                                              Vol.Ref  Meth
      Grade      Grade
   1  AU         AU_NN         1.000          ....................     1.0      1
   2  AU         AU_IPD        1.000          ....................     1.0      2
   3  AU         AU_OK         1.000          ....................     1.0      3
   4  AU         AU_SK         1.000          ....................     1.0      4
   5  AU         AU_NN         2.000          ....................     1.0      1
   6  AU         AU_IPD        2.000          ....................     1.0      2
   7  AU         AU_OK         2.000          ....................     1.0      3
   8  AU         AU_SK         2.000          ....................     1.0      4
 Number of records in the output model =       780
 Number of different grade fields      =         4
 Maximum number of estimates           =      3120
 This maximum number ignores retrieval criteria, selective updating, unestimated
 zones etc, and so the % figure in the progress report may be too low.
 >>>        10 estimates,   0.3% completed.    Time  16: 8:12 <<<
 Number of records in the output model =       780
 Number of different grade fields      =         4
 Maximum number of estimates           =      3120
 This maximum number ignores retrieval criteria, selective updating, unestimated
 zones etc, and so the % figure in the progress report may be too low.
 >>>      3120 estimates, 100.0% completed.    Time  16: 8:13 <<<
 Total number of estimates                      3120
 Summary Statistics for Kriging
 ------------------------------
 The total number of kriged estimates calculated is      1560
 The number of kriged estimates with:
  - one or more samples with zero covariance                0
  - error in solving kriging matrix                         0
  - negative kriging variance                               0
  - kriging variance greater than the sill                  0
  - one or more negative kriging weights                 1435
  - only one discretisation point                           0
  - maximum iterations in log kriging                       0
 >>>      780 Records in File C:\Database\DMTutorials\Projects\S3GrdEstTut\ProjFi
les\MyProj1\3dgmod3.dm <<<
>>> ESTIMA   Complete <<<
```

INDICATOR ESTIMATION

In this portion of the user guide you are going to use the Studio 3 process **ESTIMATE** to estimate grades using an Indicator Estimation method.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in *the Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Read the help documentation notes page for **ESTIMATE**, in your Studio 3 Help file.
- Read the Studio 3 Grade Estimation User Guide page on Kriging.
- Files required for the exercises on this page:
    - _2dzmod1
    - _srfsamp
    - _2dspar1
    - _2dvpar2

Using ESTIMATE for Indicator Estimation

In this exercise you are going to estimate Au grades into a 2D block model using a Median Indicator Kriging estimation method and the following parameters:

- Input Grade field: AU
- Output Grade fields: AU
- Estimation methods: Indicator Kriging (IK)
- Search Volume: search volume 1 (SREFNUM=1)
- Variogram model: variogram model 1 and 2 (VREFNUM=1,2)
- Estimation options: zonal control (field ANOM), values 1 and 2
- Median Indicator values: AU=267 (for zone ANOM=1) and AU=752 (for zone ANOM=2)
- Cutoff Grades for ANOM = 1: AU=104, 266, 431, 570 (these are the grades at the 25%, 50%, 75% and 95% quantiles)

- Cutoff Grades for ANOM = 2: AU=652, 746, 874, 1083 (these are the grades at the 25%, 50%, 75% and 95% quantiles).

This will be done by defining a total of eight Indicator Kriging runs, one for each of the four cutoffs (listed above) for each of the zones i.e. ANOM=1 and ANOM=2. These estimation parameters will then be saved to a new estimation parameter file 2depar4.

Indicator Estimation

Indicator Estimation is a non parametric estimation method and so does not depend on the statistical distribution of the data as in standard (i.e. non-indicator estimation) Ordinary and Simple Kriging methods. The estimation method used with indicator estimation is typically ordinary kriging although other estimation methods can also be used e.g. inverse power distance, simple kriging.

Advantages and Disadvantages of Indicator Kriging

Advantages:

- in general the indicator variograms are better behaved i.e. smoother
- outliers do not cause a problem
- the sill of the variogram can be calculated theoretically
- gives recovered grade and tonnes by cutoff
- non parametric i.e. it does not depend on the grade distribution (histogram) of the samples.

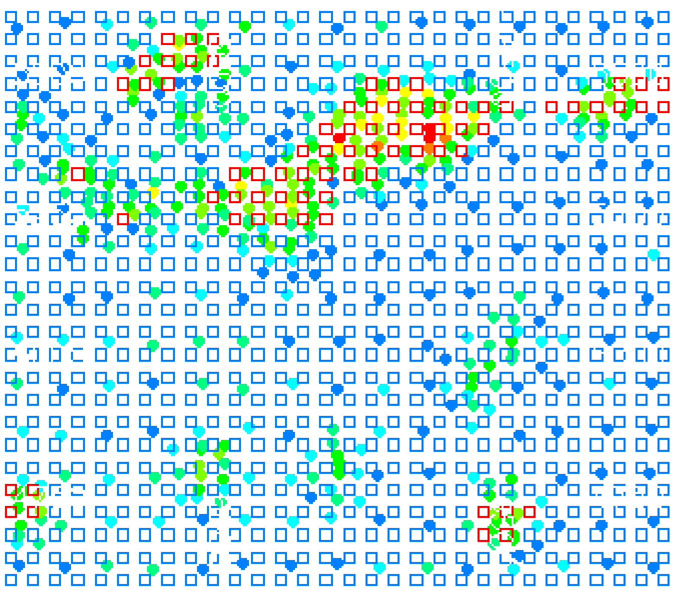
Disadvantages:

- it can take longer to set up as in theory you need to calculate a variogram for each cutoff, although median IK can be used to avoid this
- indicator variograms can be affected by clustering of samples
- the recovered grades and tonnes cannot be related to a specific size of SMU
- there can be order relation problems
- there is no theoretical kriged variance
- the Indicator Estimation method cannot be combined with non indicator estimation

methods in the Datamine estimation parameter file

- only one set of indicators (per Zonal Control zone) can be defined in a set of estimation parameters in the Datamine estimation parameter file.

The input block model and sample points are shown in the image below. The blue block model cells represent the lower grade zone (field ANOM=1) while the red cells represent the higher grade zone (field ANOM=2). The displayed sample points are colored using a rainbow blue-red legend, with the lower grade values colored blue and the higher grade values colored in red.

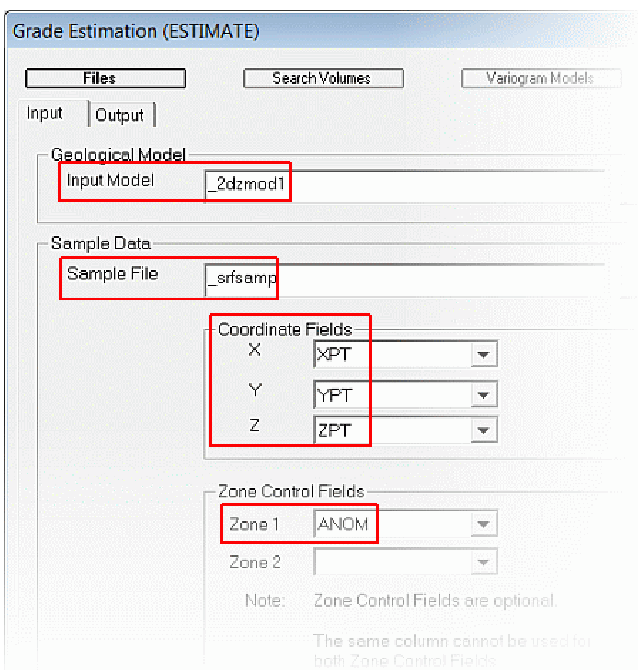


Indicator Kriging is typically used for:

- automatically defining boundaries between different zones in a block model e.g. low/high grade ore zones or rock types
- estimating grades for complex (and inseparable) mixed data populations
- estimating grades for highly skewed grade distributions
- as an alternative to log normal kriging.

Defining the Input Block Model and Sample Files

1. Select the **Design** window.
2. Select **Models | Interpolation Processes | Interpolate Grades from Menu**.
3. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, select the *Input* subtab.
4. In the *Geological Model* group, click **Browse**.
5. In the **Project Browser** dialog, *Database Tables* pane, *Block Models* folder, select _2dzmod1 , click **OK**.
6. In the *Sample Data* group, click **Browse**.
7. In the **Project Browser** dialog, *Database Tables* pane, *All Tables* folder, select _srfsamp , click **OK**.
8. In the *Coordinates Fields* group, select the X, Y and Z fields [XPT], [YPT], [ZPT].
9. In the *Zone Control Fields* group, select the *Zone 1* field [ANOM].
10. Check that your parameters are as shown below:

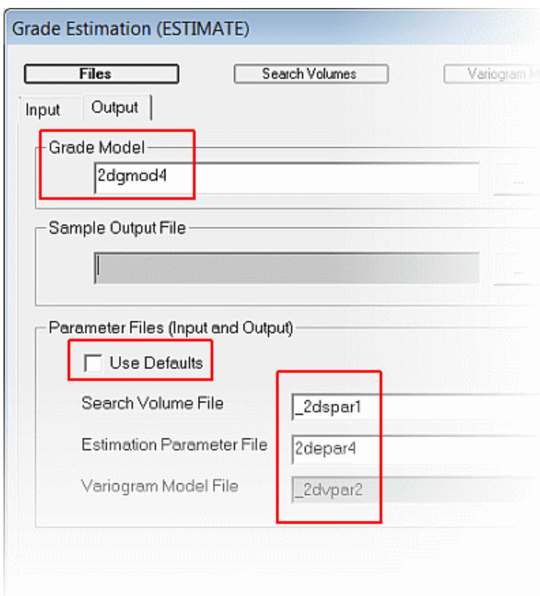


- Drillholes or suitable points data can be used as Sample Data files.
- Both the *Input Model* and the *Sample File* need to be defined so that the *Zone Control Fields* can be selected.

- The *Zone Control Fields* need to be present (and contain suitable matching zone field values) in both the *Input Model* and the *Sample File*.

Defining the Output Block Model, Input/Output Search Volume, Estimation and Variogram Model Files

1. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, select the *Output* subtab.
2. In the *Grade Model* group, define a new model file '2dgmod4'.
3. In the *Parameter Files (Input and Output)* group, clear the *Use Defaults* check box.
4. Browse for and set the *Search Volume File* to _2dspar1.
5. Define a new *Estimation Parameter File* '2depar4'.
6. Browse for and set the *Variogram Model File* to _2dvpar2.
7. Check that your parameters are as shown below:



The *Search Volume File*, *Variogram Model File* and the *Estimation Parameter File* need to be defined here so that the relevant search, variogram model and estimation parameters are displayed in the various tabs.

Checking the Search Parameters

1. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, click **Next >>**.

2. In the *Search Volumes* tab, *Summary* subtab, check that the *Search Parameter Table* contains the set of search parameters shown below:

Search Parameter Table

	1
SDESC	Search Volume 1
SREFNUM	1
SMETHOD	2
SDIST1	240
SDIST2	100
SDIST3	10
SANGLE1	-10
SANGLE2	0
SANGLE3	0
SAXIS1	3
SAXIS2	1
SAXIS3	3
MINNUM1	3
MAXNUM1	20
SVOLFAC2	0
MINNUM2	0

Multiple Indicator Kriging Search Volumes

When using multiple indicator kriging, the same set of search volume parameters must be used for each indicator cutoff in the set.

Checking the Variogram Model Parameters

1. In the **Grade Estimation (ESTIMATE)** dialog, *Search Volumes* tab, click **Next >>**.

1. In the *Variogram Models* tab, *Summary* subtab, check that the *Variogram Model Table* contains two sets of parameters, as shown below:

Variogram Model Table

	1	2
VDESC	IK Var Mod ANOM1	IK Var Mod ANOM2
VREFNUM	1	2
VANGLE1	0	0
VANGLE2	0	0
VANGLE3	0	0
VAXIS1	3	3
VAXIS2	1	1
VAXIS3	3	3
NUGGET	0.098966	0.101442
ST1	1	1
ST1PAR1	85.21973	42.66373
ST1PAR2	85.21973	42.66373
ST1PAR3	85.21973	42.66373
ST1PAR4	0.078727	0.089125
ST2	1	1
ST2PAR1	162.2258	139.9346
ST2PAR2	162.2258	139.9346
ST2PAR3	162.2258	139.9346
ST2PAR4	0.074008	0.061134
ST3	-	-

The variogram model file contains two variogram models:

- model 1 is for the median indicator AU=267 (for zone ANOM=1)
- model 2 is for the median indicator AU=752 (for zone ANOM=2)
- each model consists of two spherical structures.

Defining a New Set of Indicator Kriging Estimation Parameters

Selecting Suitable Cutoffs

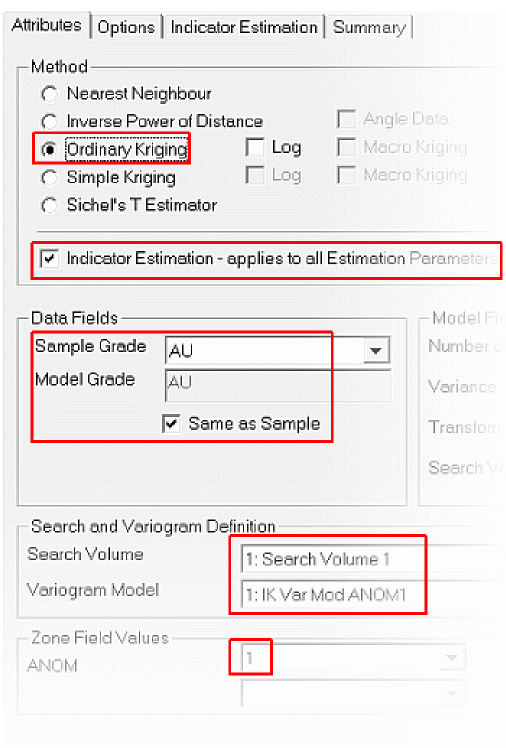
The following methods are typically used to select cutoffs for multiple indicator kriging:

- Use the maximum quartile (25%, 50%, 75%) and the maximum 95%* quantile grade values
- Use the maximum decile (10%, 20%, ... 90%) and the maximum 95%* quantile grade values
- Base cutoffs on values related to mineralization zones or grade control category boundaries.

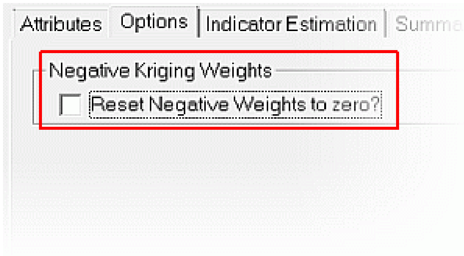
* - The 95% quantile (or another more suitable top end quantile) is typically used, in addition

to the quartiles or deciles, to cater for the 'upper tails' i.e. the high grade values in high positively skewed data distributions.

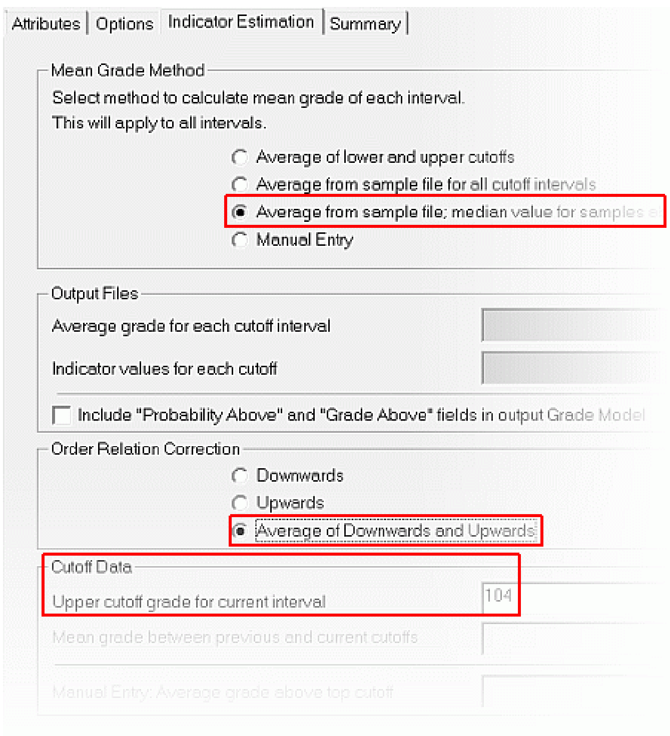
1. In the **Grade Estimation (ESTIMATE)** dialog, *Variogram Models* tab, click **Next >>**.
2. In the *Estimation Types* tab, *Index* group, click **Reset** and then **Yes** to remove any previous parameters.
3. Check that the *Index* pane does not contain any items.
4. In the *Index* group, click **Add**.
5. In the estimation parameter list, check that a new estimation parameter description '1: Estima Param 1' has been added.
6. Select the *Attributes* subtab on the right.
7. In the *Method* group, select the *Indicator Estimation-applies to all Estimation Parameters* option.
8. Define the remaining parameters as shown below:



9. In the *Options* subtab, define the parameters as shown below:



10. In the *Indicator Estimation* subtab, define the parameters as shown below:

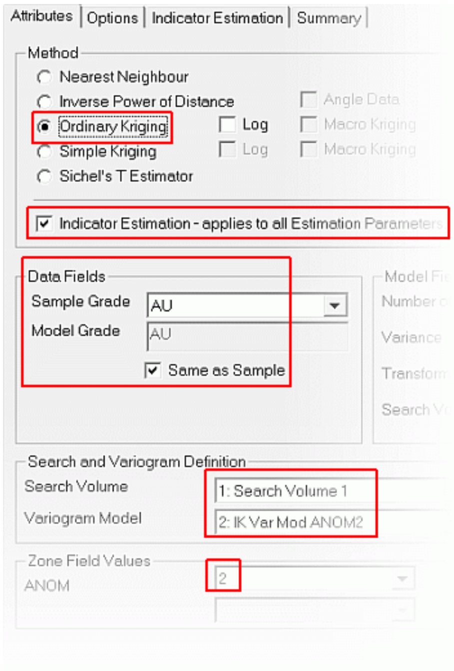


11. Repeat steps 4 to 10 , defining a set of parameters for each of the remaining cutoffs (266, 431, 570) for the first zone (i.e. ANOM=1).

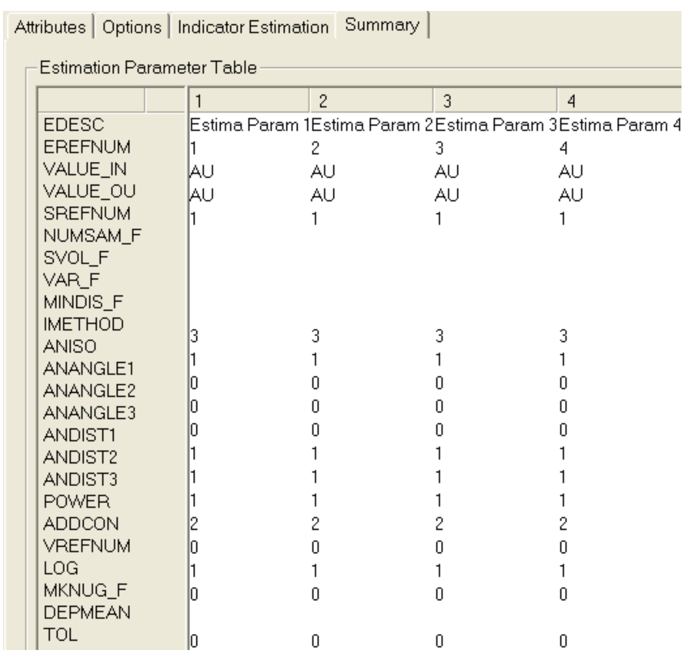
> The cutoff values (listed in the brackets in step 11.) are used in the *Indicator Estimation* subtab, Cutoff Data group, *Upper cutoff grade for current interval* field when defining each set of cutoff parameters.

12. Repeat steps 4 to 8 , for the second zone (i.e. setting ANOM=2 and using variogram model 2), defining a set of parameters for each of the cutoffs (652, 746, 874, 1083), remembering to select

the correct *Search and Variogram Definition* and *Zone Field Values* groups' field values as highlighted below:



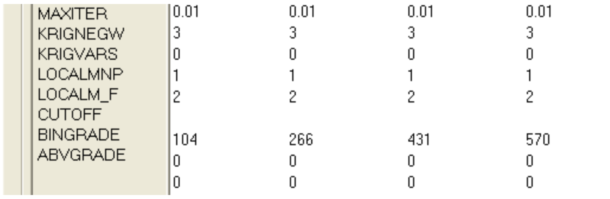
13. In the *Summary* subtab, check that your 8 sets of parameters are the same as those shown below:



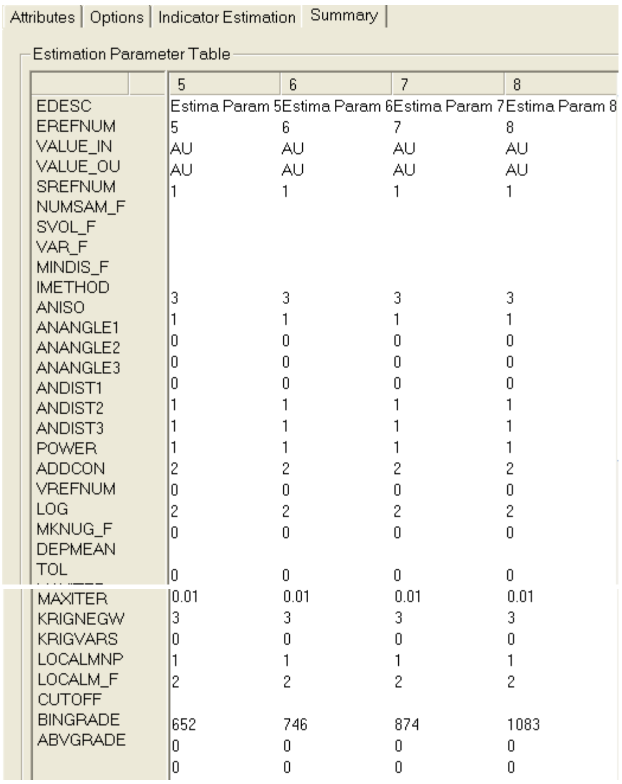
Attributes | Options | Indicator Estimation | Summary

Estimation Parameter Table

	1	2	3	4
EDESC	Estima Param 1	Estima Param 2	Estima Param 3	Estima Param 4
EREFNUM	1	2	3	4
VALUE_IN	AU	AU	AU	AU
VALUE_OU	AU	AU	AU	AU
SREFNUM	1	1	1	1
NUMSAM_F				
SVOL_F				
VAR_F				
MINDIS_F				
IMETHOD	3	3	3	3
ANISO	1	1	1	1
ANANGLE1	0	0	0	0
ANANGLE2	0	0	0	0
ANANGLE3	0	0	0	0
ANDIST1	1	1	1	1
ANDIST2	1	1	1	1
ANDIST3	1	1	1	1
POWER	2	2	2	2
ADDCON	0	0	0	0
VREFNUM	1	1	1	1
LOG	0	0	0	0
MKNUG_F				
DEPMEAN	0	0	0	0
TOL				



MAXITER	0.01	0.01	0.01	0.01
KRIGNEGW	3	3	3	3
KRIGVARS	0	0	0	0
LOCALMNP	1	1	1	1
LOCALM_F	2	2	2	2
CUTOFF				
BINGRADE	104	266	431	570
ABVGRADE	0	0	0	0
	0	0	0	0



Attributes | Options | Indicator Estimation | Summary

Estimation Parameter Table

	5	6	7	8
EDESC	Estima Param 5	Estima Param 6	Estima Param 7	Estima Param 8
EREFNUM	5	6	7	8
VALUE_IN	AU	AU	AU	AU
VALUE_OU	AU	AU	AU	AU
SREFNUM	1	1	1	1
NUMSAM_F				
SVOL_F				
VAR_F				
MINDIS_F				
IMETHOD	3	3	3	3
ANISO	1	1	1	1
ANANGLE1	0	0	0	0
ANANGLE2	0	0	0	0
ANANGLE3	0	0	0	0
ANDIST1	1	1	1	1
ANDIST2	1	1	1	1
ANDIST3	1	1	1	1
POWER	2	2	2	2
ADDCON	0	0	0	0
VREFNUM	2	2	2	2
LOG	0	0	0	0
MKNUG_F				
DEPMEAN	0	0	0	0
TOL				
MAXITER	0.01	0.01	0.01	0.01
KRIGNEGW	3	3	3	3
KRIGVARS	0	0	0	0
LOCALMNP	1	1	1	1
LOCALM_F	2	2	2	2
CUTOFF				
BINGRADE	652	746	874	1083
ABVGRADE	0	0	0	0
	0	0	0	0

Exporting the New Set of Estimation Parameters

1. In the **Grade Estimation (ESTIMATE)** dialog, *Estimation Types* tab, *Index* group, click **Export**.
2. In the **Project Browser** dialog, define a new *Filename* '2depar4', click **OK**.

Running the Estimation From the Preview Tab

1. In the **Grade Estimation (ESTIMATE)** dialog, *Controls* tab, click **Next >>**.
2. In the *Preview* tab, *Summary* subtab, check your parameters.
3. Click **Run**.
4. In the **Command** control bar, check that ESTIMATE has run successfully with the Indicator Kriging runs and that the output file *2dgmod4* contains 780 records.

Estimation Using Drillhole Data and Advanced Options

In this portion of the user guide you are going to use the process **ESTIMATE** to estimate grades into a 3D block model using drillhole data and the two different estimation methods.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Read the help documentation notes page for **ESTIMATE** in your Studio 3 Help file.
- Read the Grade Estimation User Guide page on *Kriging*.
- Files required for the exercises on this page:
    - _ubm5z
    - _udhz
    - _ueps
    - _uepv
    - _uepe

Exercise: Estimation Using ESTIMATE, Drillhole Data and Advanced Options

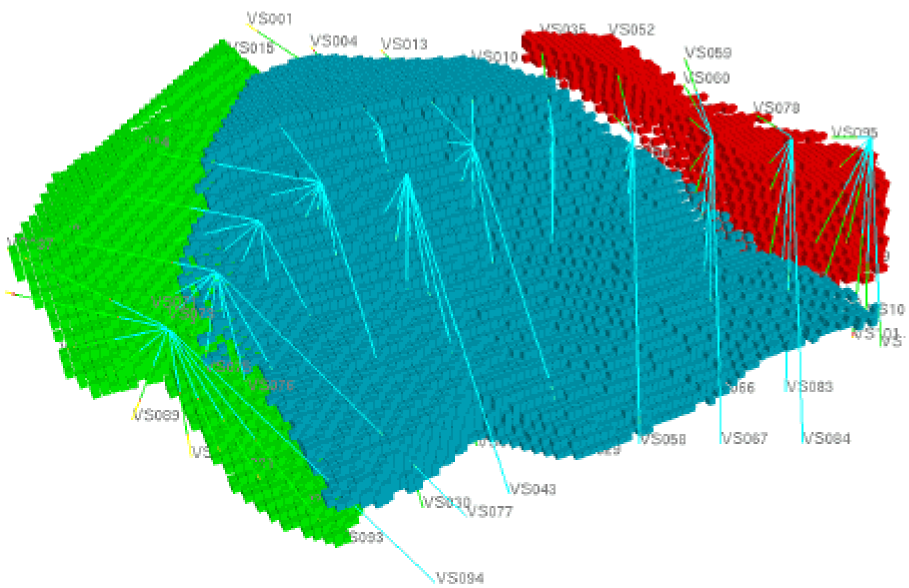
In this exercise you are going to estimate a variety of grades (and Density) into a 3D block model using drillhole sample data and parameters, as listed below:

- Input block model: 5m regular celled (no sub-cells), zone flagged, block model
- Sample data file: drillholes
- Input Grade fields: AU (g/t), CU (%), AG (g/t), CO (%)
- Output Grade fields: same as input field names
- Estimation methods: Inverse Power Distance, Ordinary Kriging (OK)
- Search Volumes: one for each of the three mineralization zones (see parameter file)
- Variogram models: one for each of the 4 grades for each of the three mineralization zones (see parameter file)

- Estimation options:
    - zonal control (field ZONE), values 1, 2 and 3
    - set negative kriging weights to zero.

This will be done by using the existing Search, Variogram and Estimation parameter files _ueps, _uepv and _uepe respectively.

The input 3D block model and drillhole samples are shown in the image below:



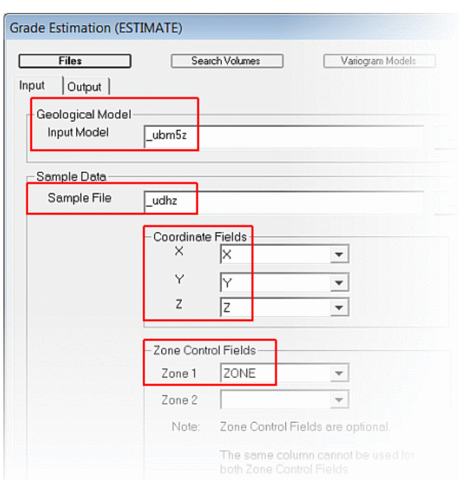
In the above image, the block model cells are colored according to three separate mineralization zones (cyan: ZONE=1, green: ZONE=2, red: ZONE=3). The fold axis of the ore body plunges at 35 degrees towards the east, the tabular to massive shaped limbs have a dip of 40 degrees, a maximum down dip length of 240m and a thichkness (perpendicular to the bottom contact) of between 5 and 45m . The drillholes are set in fans which are parallel with the dip direction of each limb and are spaced approximately 50m apart.

Use Drillhole sample data when:

- estimating grades into a 3D block model
- estimating grades into a pseudo 3D block model i.e. Z coordinate has been set to a constant reference elevation e.g. flat dipping tabular ore bodies
- using sample length as a weighting factor for estimation.

Defining the Input Block Model and Sample Files

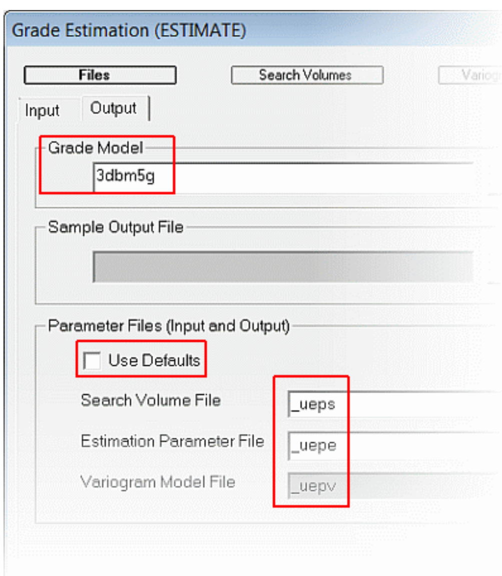
1. Select the **Design** window.
2. Select **Models | Interpolation Processes | Interpolate Grades from Menu**.
3. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, select the *Input* subtab.
4. In the *Geological Model* group, click **Browse**.
5. In the **Project Browser** dialog, *Database Tables* pane, *Block Models* folder, select _ubm5z, click **OK**.
6. In the *Sample Data* group, click **Browse**.
7. In the **Project Browser** dialog, *Database Tables* pane, *All Tables* folder, select _udhz , click **OK**.
8. In the *Coordinates Fields* group, select the X, Y and Z fields [X], [Y], [Z] (defaults).
9. In the *Zone Control Fields* group, select the *Zone 1* field [ZONE].
10. Check that your parameters are as shown below:



- Drillholes or suitable points data can be used as Sample Data files.
- Both the *Input Model* and the *Sample File* need to be browsed and selected so that the *Zone Control Fields* can be selected.
- The *Zone Control Fields* need to be present (and contain suitable matching zone field values) in both the *Input Model* and the *Sample File*.

Defining the Output Block Model, Input/Output Search Volume and Variogram Model Files

1. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, select the *Output* subtab.
2. In the *Grade Model* group, define a new model filename '3dbm5g'.
3. In the *Parameter Files (Input and Output)* group, clear the *Use Defaults* check box.
4. Browse for and select the *Search Volume File* _ueps.
5. Browse for and select the *Estimation Parameter File* _uepe.
6. Browse for and select the *Variogram Model File* _uepv.
7. Check that your parameters are as shown below:



The *Search Volume File*, *Variogram Model File* and the *Estimation Parameter File* need to be defined here so that the relevant search, variogram model and estimation parameters are displayed in the different tabs.

Checking the Search Parameters

1. In the **Grade Estimation (ESTIMATE)** dialog, *Files* tab, click **Next >>**.
2. In the *Search Volumes* tab, *Summary* subtab, check that the *Search Parameter Table* contains three sets of parameters, as shown below:

Search Parameter Table

	1	2	3
SDESC	Search Volume 1	Search Volume 2	Search Volume 3
SREFNUM	1	2	3
SMETHOD	2	2	2
SDIST1	207	105	111
SDIST2	100	187.5	111
SDIST3	50	34	111
SANGLE1	85	40	0
SANGLE2	40	39	0
SANGLE3	0	22.5	0
SAXIS1	3	3	3
SAXIS2	1	1	1
SAXIS3	3	3	3
MINNUM1	5	1	1
MAXNUM1	20	20	20
SVOLFAC2	2	2	2
MINNUM2	5	1	1
MAXNUM2	20	20	20
SVOLFAC3	0	0	0
MINNUM3	1	1	1
MAXNUM3	20	20	20
OCTMETH	0	0	0
MINOCT	2	2	2
MINPEROC	1	1	1
MAXPEROC	4	4	4
MAXKEY	0	0	0
SANGL1_F			
SANGL2_F			
SANGL3_F			

In this example, the search parameter file contains three sets of search parameters, one for each mineralized zone. The orientation of the axes and the ranges of the AU grade variograms were used to determine the search volume parameters for all grade fields. Typically each grade field for each zone has a different set of search parameters.

Checking the Variogram Model Parameters

1. In the **Grade Estimation (ESTIMATE)** dialog, *Search Volumes* tab, click **Next >>**.

2. In the *Variogram Models* tab, *Summary* subtab, check that the *Variogram Model Table* contains twelve sets of parameters. The first five are shown below:

Variogram Model Table

	1	2	3	4	5	6
VDESC	CU ZONE 1	AG ZONE 1	AU ZONE 1	CO ZONE 1	CU ZONE 2	A
VREFNUM	1	2	3	4	5	6
VANGLE1	85	85	85	0	40	4
VANGLE2	0	0	0	0	39	3
VANGLE3	40	40	40	0	22.5	2
VAXIS1	3	3	3	3	3	3
VAXIS2	2	2	2	2	1	1
VAXIS3	1	1	1	1	3	3
NUGGET	0.01	174	0.85	0.0003	0.039	1
ST1	1	1	1	1	1	1
ST1PAR1	64	9.5	66	9	73.5	7
ST1PAR2	40	12.5	17	9	185	1
ST1PAR3	12	7	7	9	11.5	1
ST1PAR4	0.265	784	5	0.00224	0.35	1
ST2	1	1	1	1	1	1

For the twelve sets of variogram model parameters:

- each model consists of two spherical structures (i.e. ST1* and ST2* parameters are set)
- models 1-3 and 5-8 are anisotropic
- models 4 and 9-12 are isotropic.

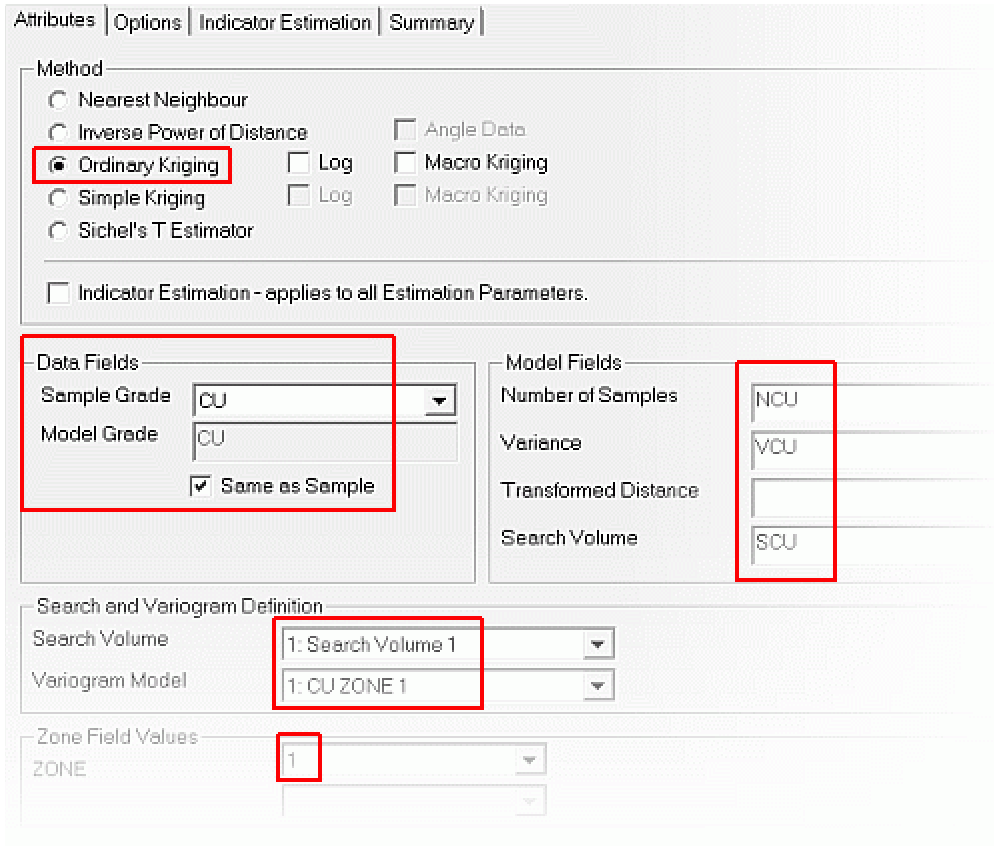
Checking the Estimation Types Parameters

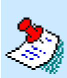
1. In the **Grade Estimation (ESTIMATE)** dialog, *Variogram Models* tab, click **Next >>**.

2. In the *Estimation Types* tab, *Index* group, check that 15 sets of estimation parameters are listed.

3. In the estimation parameter list, select the first item [1:CU ZONE 1].

4. In the *Attributes* subtab on the right, check that the parameters are as shown below:

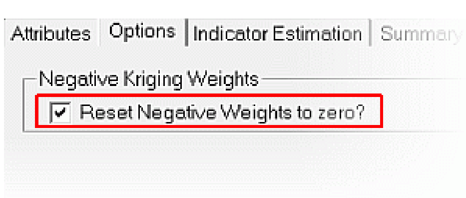




Note the following parameters:

- additional output model fields NCU, VCU and SCU, used to record, for each block model cell, the number of samples, estimation variance and search volume respectively used in the grade estimate for the cell (the other grade fields have corresponding field names)
- this set of estimation parameters is for the CU grade field of ZONE = 1 and uses search volume number 1 as well as variogram model number 1

4. In the *Options* subtab, check that the parameters are as shown below:



Resetting negative kriging weights to zero prevents the calculation of negative grade estimates.

5. In the *Indicator Estimation* subtab, check that all options are greyed out.

6. In the *Summary* subtab, check that 15 sets of parameters are listed. The first five are shown below:

Estimation Parameter Table

	1	2	3	4	5
EDESC	CU ZONE 1	AG ZONE 1	AU ZONE 1	CO ZONE 1	DENSITY ZONE
EREFNUM	1	2	3	4	5
VALUE_IN	CU	AG	AU	CO	DENSITY
VALUE_OU	CU	AG	AU	CO	DENSITY
SREFNUM	1	1	1	1	1
NUMSAM_F	NCU	NAG	NAU	NCO	NDENSITY
SVOL_F	SCU	SAG	SAU	SCO	SDENSITY
VAR_F	VCU	VAG	VAU	VCO	VDENSITY
MINDIS_F					
IMETHOD	3	3	3	3	2
ANISO	1	1	1	1	1
ANANGLE1	0	0	0	0	0
ANANGLE2	0	0	0	0	0
ANANGLE3	0	0	0	0	0
ANDIST1	1	1	1	1	1

Running the Estimation from the Preview Tab

1. In the **Grade Estimation (ESTIMATE)** dialog, *Estimation Types* tab, click **Next >>**.

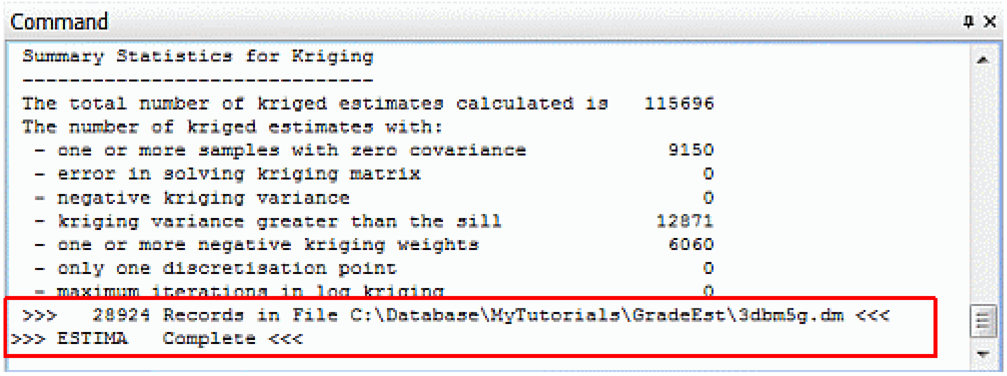
2. In the *Controls* tab, click **Next >>**.

3. In the *Preview* tab, *Summary* subtab, check your parameters.

4. Click **Run**.

The progress report (percentage completion) and summary results of the estimation calculations are output to the **Command** control bar, and may take several minutes to complete.

5. In the **Command** control bar, Summary Statistics section of the report at the bottom of the page, check that the grade estimation process has run successfully and that the output file *3dbm5g* contains 28,924 records.


Command
Summary Statistics for Kriging

The total number of kriged estimates calculated is 115696
The number of kriged estimates with:
- one or more samples with zero covariance 9150
- error in solving kriging matrix 0
- negative kriging variance 0
- kriging variance greater than the sill 12871
- one or more negative kriging weights 6060
- only one discretisation point 0
- maximum iterations in log kriging 0
>>> 28924 Records in File C:\Database\MyTutorials\GradeEst\3dbm5g.dm <<<
>>> ESTIMA Complete <<<

Panel Estimation

In this portion of the user guide you are going to use the process **PANELEST** to estimate a grade into a set of panels (mining block) defined by closed strings, using an Ordinary Kriging estimation method.

Prerequisites

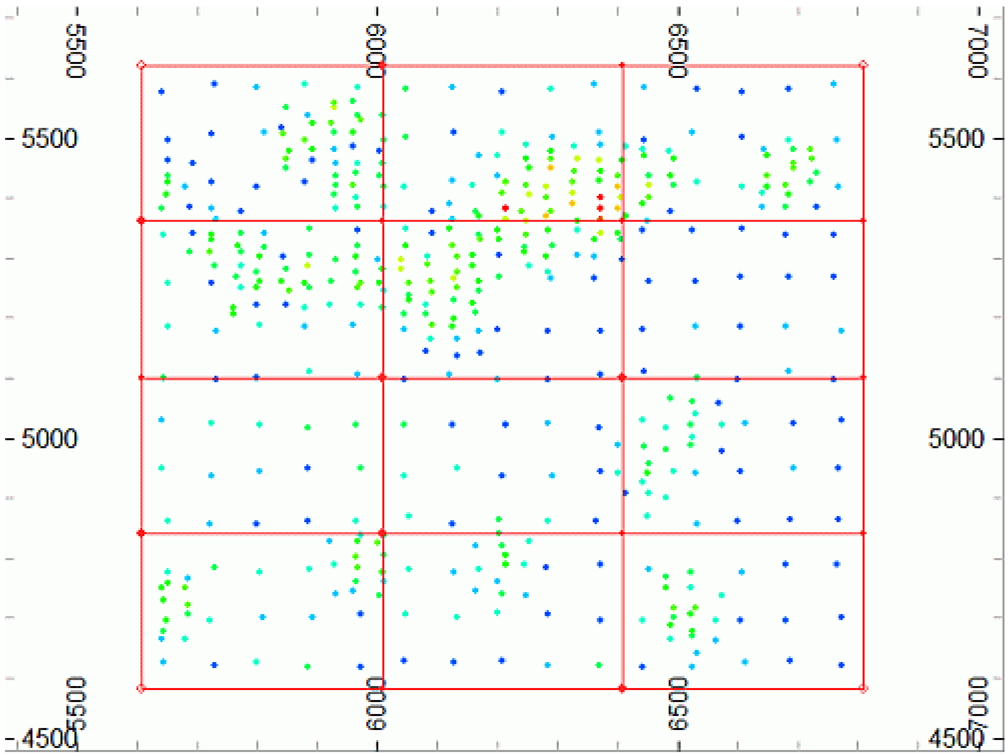
- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Read the process description for **PANELEST**.
- Files required for the exercises on this page:
  - _2dblks
  - _srfsamp
  - _2dvpar1

Exercise: Using PANELEST for Estimating Grades into Panels

In this exercise you are going to estimate a Au grade for a set of 2D panels using the Ordinary Kriging estimation methods and the following parameters:

- Input Grade field: AU
- Estimation method: Ordinary Kriging (IMETHOD=3)
- Search Volume: all samples within the panel are used for the estimate
- Variogram model: variogram model 1 (VMODNUM=1)
- Vertical thickness for volume calculation: 10m (DPLUS=5, DMINUS=5)
- Discretisation point spacing: 10m (XDSPACE=10, YDSPACE=10).

The panel outlines and sample points are shown in the image below. The panel strings are closed and each have an area of 104,000m^2. The displayed sample points have low grade values colored blue and higher grade values colored in red.



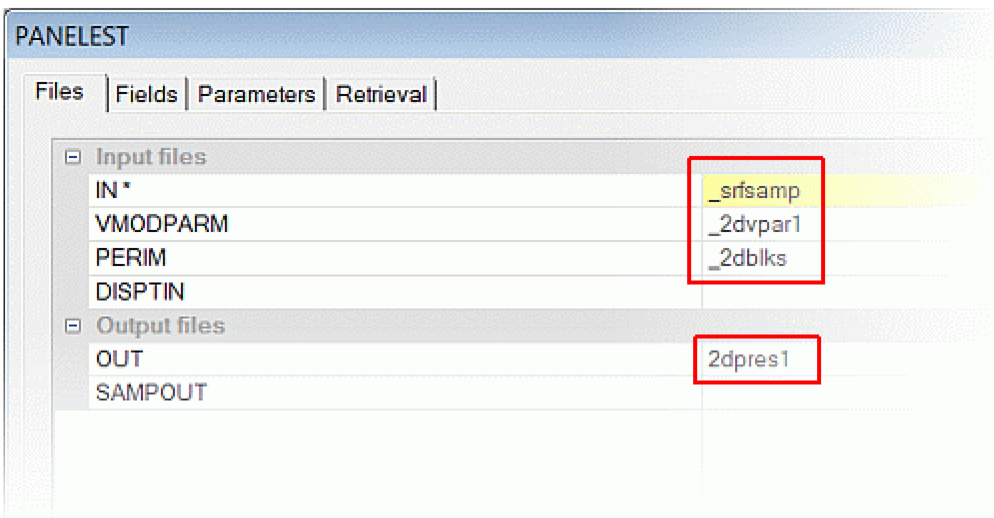
Use PANELEST to estimate grades when estimating:

- panel grades directly without first creating a block model
- a single grade field at a time
- into 2D or 3D panels e.g. open pit blast blocks, underground mining panels
- using the estimation method NN, IPD or Ordinary Kriging
- Indicator Kriging or Sichel's T estimation.

- 2D or 3D open or closed strings can be used to define panels.
- panel strings must be coplanar and orthogonal to either the X, Y or Z axis.
- panels can also be defined by sets of 2D or 3D discretisation points.
- drillholes or suitable points data can be used as Sample Data files.

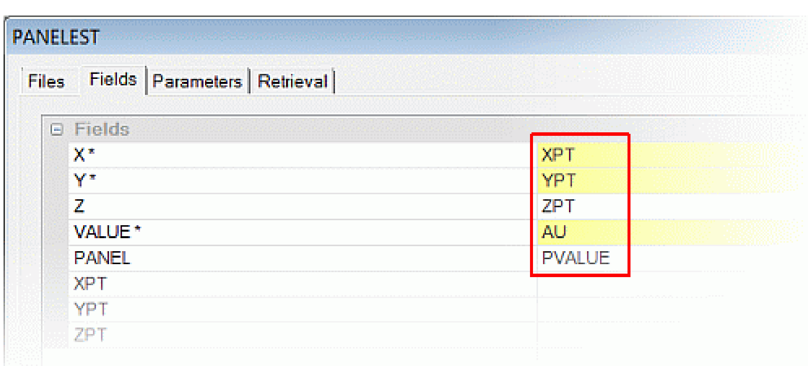
Defining the Input Samples, Variogram Model, Panel and Output Results Files

1. Select the **Design** window.
2. In the **Menu Bar**, select **Models | Interpolation Processes | Estimate Grade of Panels**.
3. In the **PANELEST** dialog, *Files* tab, *Input files* group, set *IN** by browsing for and selecting the sample file _srfsamp.
4. Set *VMOPARM** by browsing for and selecting the variogram model file _2dvpar1.
5. Set *PERIM** by browsing for and selecting the strings file _2dblks.
6. In the *Output files* group, define a new output results file *OUT** as *2dpres1*.



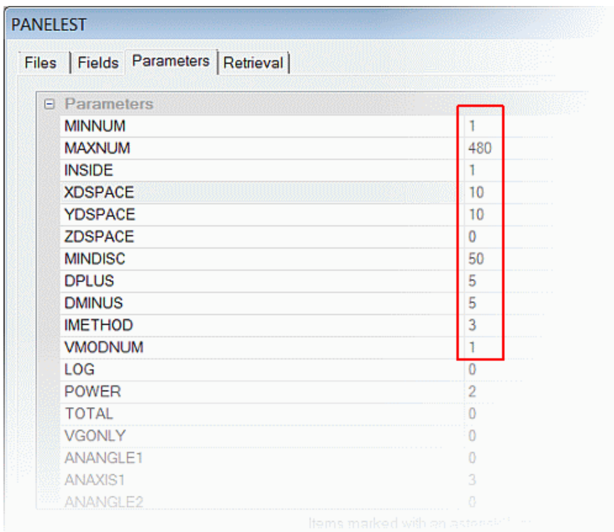
Defining the Fields

1. In the *Fields* tab, select the *X** field [XPT], *Y** field [YPT], Z* field [ZPT].
2. Select the *VALUE** field [AU] and the *PANEL** field [PVALUE].
3. Check that your fields are defined as shown below:



Defining the Parameters

1. In the *Parameters* tab, define *MINNUM* as '1' and *MAXNUM* as '480'.
2. Define *INSIDE* as '1'.
3. Define *XDSPACE* as '10', *YDSPACE* as '10' and *ZDSPACE* as '0'.
4. Define *MINDISC* as '50'.
5. Define *DPLUS* as '5' and *DMINUS* as '5'.
6. Define *IMETHOD* as '3' and *VMODNUM* as '1'.
7. Set the remainder of the parameters to their default values.
8. Check that your parameters are as shown below:



- The *MAXNUM* value is set to a value greater than the number of samples.
- The *XDSPACE* , *YDSPACE* and *ZDSPACE* values are typically set to half the sample spacing in the respective X, Y and Z directions.
- For a 2D panel estimation, the *ZDSPACE* is irrelevant; this value would be set to a suitable vertical spacing for example an open pit blast block estimated using blast hole samples.
- The *DPLUS* and *DMINUS* values are typically set to represent the height or width of the stoping panel above and below the string defining the panel limits. In this example, an arbitrary distance of '5' above and below the panel string gives a total

panel height of 10m.

Running the Estimation and Checking the Results

1. Click **OK**.
2. In the **Command** control bar, check that **PANELEST** has run to completion, check the summary results for each panel and that the file contains 12 records.
3. In the **Project Files** control bar, *All Tables* folder, double-click *2dpres1*.
4. In the **CAE Table Editor** dialog, check that the estimation results are as shown below, close the dialog:

PVALUE (N)	AU (N)	VARIANCE (N)	NUMSAM (N)	AREA (N)	VOLUME (N)	FVALUE (N)	NDISCPTS (N)
1	325.103241	710.668823	57	104000	1040000	82266.054688	1082
2	291.327484	1183.128052	44	104000	1040000	82255.5625	1081
3	467.526031	848.182922	61	104000	1040000	82266.054688	1082
4	206.434631	2026.372314	29	104000	1040000	82255.5625	1081
5	397.976959	966.80011	58	104000	1040000	82266.054688	1082
6	361.209839	1521.380249	36	104000	1040000	82247.546875	1080
7	290.574402	2075.320801	18	104000	1040000	82247.546875	1080
8	239.573898	1250.312012	29	104000	1040000	82255.5625	1081
9	195.484619	1503.797974	21	104000	1040000	82247.546875	1080
10	372.285553	873.726624	70	104000	1040000	82247.546875	1080
11	216.53743	1051.008545	35	104000	1040000	82266.054688	1082
12	94.034515	1665.786133	19	104000	1040000	82247.546875	1080

Estimation Validation

In this portion of the user guide you are going to validate the estimated block model cell grades by comparing them to the drillhole grades in the **Design** window.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Files required for the exercises on this page:
  - _ubm5g
  - _udhz5c
  - _ueps
  - _uepv
  - _uepe

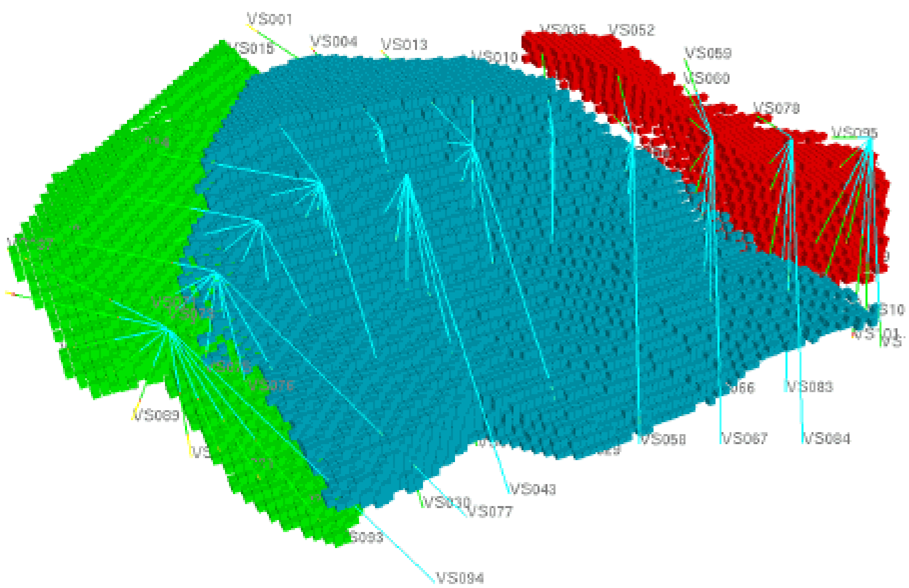
Exercise: Visual Validation of Grade Estimates in the Design Window

In this exercise you are going to visually compare grades in 5m composited drillhole sample intervals with corresponding grades in 5x5x5m block model cells in order to determine if the grade estimation process has run correctly:

- Grade block model: 5m regular celled (no sub-cells), zone flagged, block model
- Sample data file: 5m composited drillholes
- Grade fields: AU (g/t), CU (%), AG (g/t), CO (%).

The grades were estimated using the Search, Variogram and Estimation parameter files _ueps, _uepv and _uepe respectively.

The 3D grade block model and drillhole samples are shown in the image below.



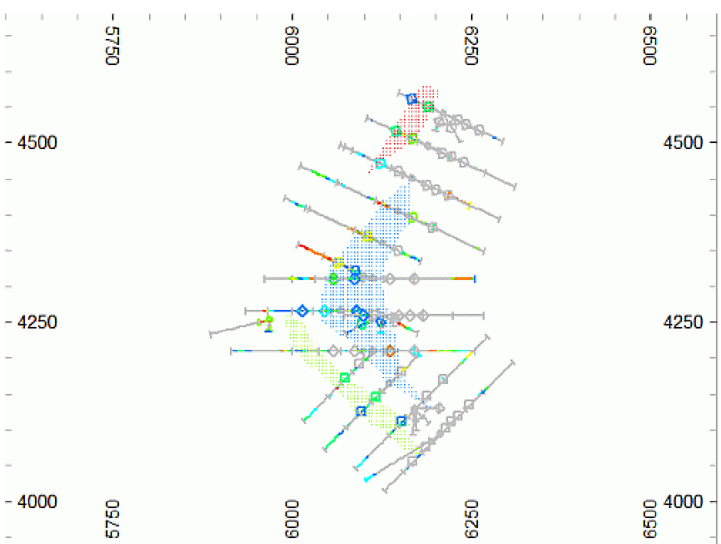
In the above image, the block model cells are colored according to three separate mineralization zones (cyan: ZONE=1, green: ZONE=2, red: ZONE=3). The fold axis of the ore body plunges at 35 degrees towards the East, the tabular to massive shaped limbs have a dip of 40 degrees, a maximum down dip length of 240m and a thichkness (perpendicular to the bottom contact) of 5m -45m . The drillholes are set in fans which are parallel with the dip direction of each limb and are spaced 50m apart .tom contact) of between 5 and 45m . The drillholes are set in fans which are parallel with the dip direction of each limb and are spaced approximately 50m apart.

Visual validation of block model cell vs drillhole values can be used to check:

- block model filling of geological wireframes or string boundaries
- zone flagging of block model cells
- grade estimates in block model cells according to grade and zone variations in drillholes.

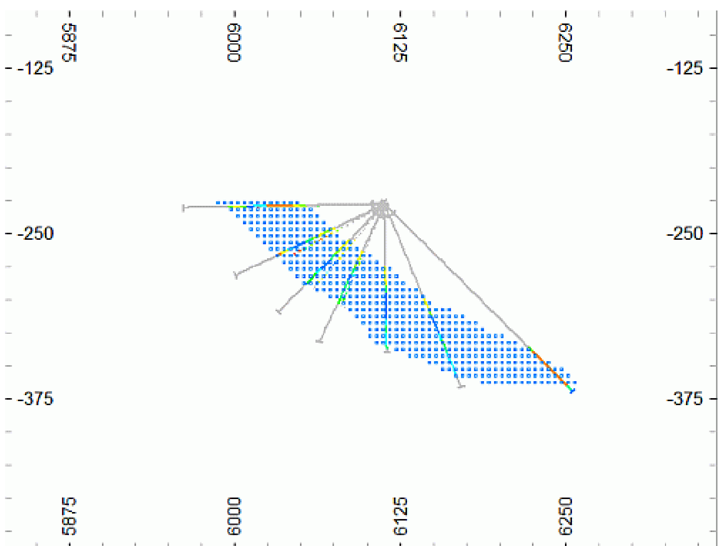
Loading the Block Model and Static Drillhole Data

1. Select the **Design** window.
2. Select the **Project Files** control bar.
3. Drag-and-drop the following files (if not already loaded) into the **Design** window:
    - _udhz5c (drillholes)
    - _ubm5g (block model)
4. In the **Sheets** control bar, *Design-Overlays* folder, select only the following check boxes (i.e. display these objects) :
    - _udhz5c (drillholes)
    - _ubm5g (block model)
5. In the **View Control** toolbar, click Plane by One Point.
6. Click at any point in the **Design** window.
7. In the **Plane By One Point** dialog, select *Plan* , click **OK**.
8. In the **View Control** toolbar, click Zoom All Data.
9. In the **Design** window, check that you have the following data displayed i.e. a horizontal slice through the block model and full-length drillholes displayed:



Defining a W-E Vertical Section

1. Select the **Design** window.
2. In the **View Control** toolbar, click **View Settings**.
3. In the **View Settings** dialog, *Section Orientation* group, select *East-West*.
4. Set the *Width* to '10', select *Apply Clipping*, click **OK**.
5. In the **View Control** toolbar, click Zoom Extents .
6. In the **Design** window, check that you have the data displayed in a vertical W-E section as shown below:



The management of a set of section and plan views is typically done using a Section Defintions file. This allows for set views to be defined and recalled in the Design window and increases the efficiency when working with different views of the data. Examples of section definitions can be viewed in the file _uviews. Please refer to the Help documentation and Geological Modeling user guide for further details.

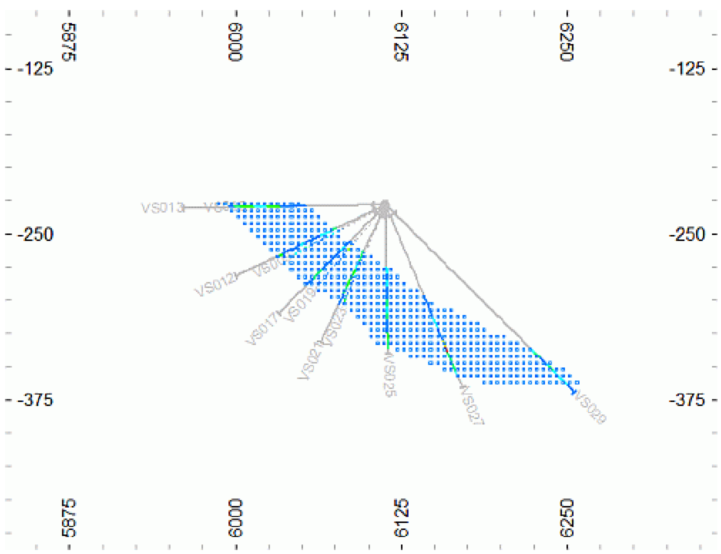
Formatting The Drillholes

1. In the **Sheets** control bar, *Design-Overlays* folder, right-click _dhz5c (drillholes), select Format... .
2. In the **Format Display** dialog, *Overlays* tab, *Overlay Format* group, *Drillholes* tab, click **Format...**
3. In the **Drillhole Traces** dialog, *Labels* tab, select the *End-of-Hole* option, select [_dhz5c (drilholes).BHID], click **Apply**
4. In the *Color* tab, *On Section* group, select the *Color using legend* option.

5. In the *Legend* group, select the *Column* option [_dhz5c (drilholes).AU].
6. Select the project *Legend* option [AU (_udhz5c)] or click **Use Default Legend**, then click **Font...**.

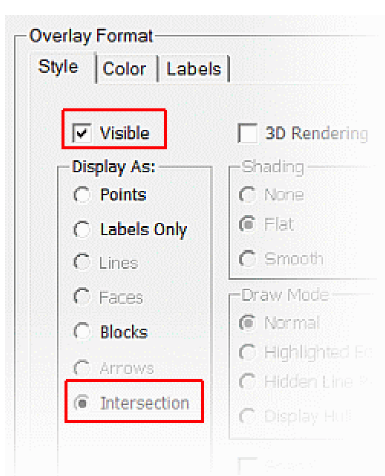
The selected legend can be previewed by clicking the **Show Legend** button.

7. In the **Font** dialog, select the *Size* [8], click **OK**.
8. In the **Drillhole Traces** dialog, click **Apply** and then **OK**.
9. Back in the **Format Display** dialog, click **Apply** and then **OK**.
10. In the **Design** window, check that your drillholes are labelled and colored as shown below:



Formatting The Block Model Cells

1. In the **Sheets** control bar, *Design-Overlays* folder, double-click _ubm5g (block model).
2. In the **Format Display** dialog, *Style* tab, check that the *Visible* and *Intersection* options are selected:



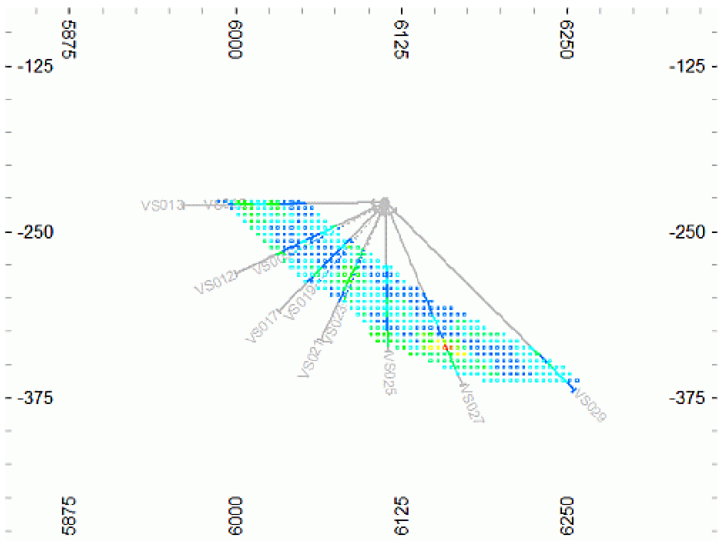
3. In the *Color* tab, *On Section* group, *Color* group, select the *Legend* option.
4. Select the *Column* [AU] and the *Legend* [AU (_udhz5c)].

> In the Legend drop-down, press <A> to move to each legend item starting with 'A'.

5.

> This is the same legend that is used to color the drillholes.

6. In the **Format Display** dialog, click **Apply** and then **OK**.
7. In the **Design** window, check that your block model cells are colored as shown below:



8. Starting at the top, zooming in if necessary, work down the ore body (ZONE=1), using the colored grade ranges as a guide and check that the grades in the block model cells agree with those shown in the drillholes.

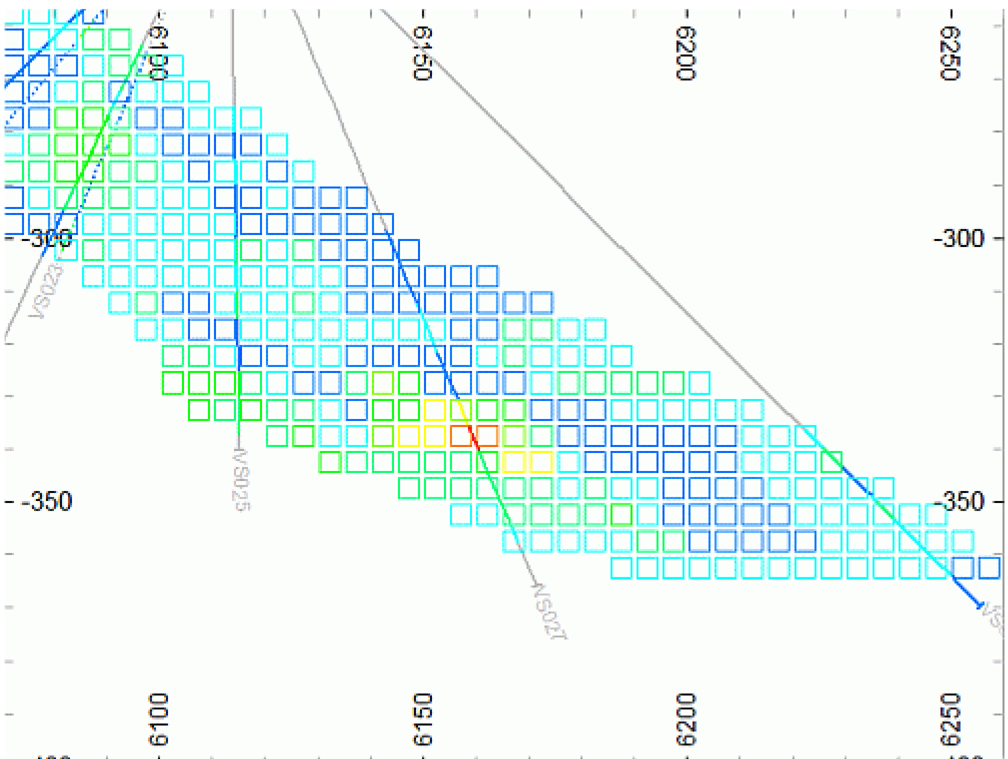
> Visual validation is typically used to check that the grades in the block model cells are consistent with:
>
> - the mineralization zone boundaries
> - the point or drillhole sample data
> - the estimation controls as defined by the search, variogram and estimation parameters
> - grade trends across or down the ore body
>
> Visual validation is typically used to identify and investigate:
>
> - anomalous grades displayed in the block model cells that do not correspond with the point or drilhole sample grades

Visual validation is typically done:

- for each estimated grade field, per mineralization zone
- on both a local (in a region surrounding a group of samples) and global (across the entire ore body) scale
- along the major variogram directions, in section and in plan views

Querying Block Model Points and Drillholes

1. Select the **Design** window.
2. In the **View Control** toolbar, click **Zoom In**, drag a zoom rectangle around the high grade zone shown in drillhole VS027:



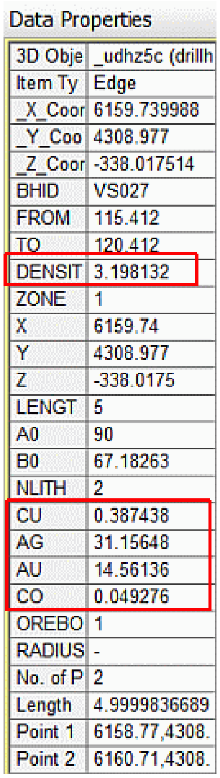
3. Select **Design | Query | Points**.
4. In the **Design** window, left-click in one of the red block model cells.
5. In the **Data Properties** control bar, check your query results, noting the values for the density and grade fields (Au, Ag, Cu and Co):

Data Properties

3D Obje	_ubm5g (bloc
Item Ty	Cell
_X_Coor	6162.5
_Y_Coo	4307.5
_Z_Coor	-337.5
XC	6162.5
YC	4307.5
ZC	-337.5
XINC	5
YINC	5
ZINC	5
IJK	309592
ZONE	1
CU	0.44822
AG	36.32229
AU	12.7385
CO	0.073466
DENSIT	3.268152
NCU	20

These query results are also listed in the Output control bar, where they can be selected, copied and pasted into another document for comparison purposes.

6. In the **Design** window, right-click on the red colored drillhole segment.
7. In the **Output** control bar, check your query results against those of your previous query, noting the values for the density and grade fields (Au, Ag, Cu and Co):



Data Properties

3D Obje	_udhz5c (drillh
Item Ty	Edge
_X_Coor	6159.739988
_Y_Coo	4308.977
_Z_Coor	-338.017514
BHID	VS027
FROM	115.412
TO	120.412
DENSIT	3.198132
ZONE	1
X	6159.74
Y	4308.977
Z	-338.0175
LENGT	5
A0	90
B0	67.18263
NLITH	2
CU	0.387438
AG	31.15648
AU	14.56136
CO	0.049276
OREBO	1
RADIUS	-
No. of P	2
Length	4.9999836689
Point 1	6158.77,4308.
Point 2	6160.71,4308.

8. Repeat steps 3 to 7 for various block model cells and drillhole segments.

9. In the **Design** window, click **Cancel**.

Statistical Validation

In this portion of the user guide you are going to validate the estimated block model cell grades by comparing the summary statistics of the block model and the drillhole grades using the process **STATS**.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Read the process description for **STATS**.
- Files required for the exercises on this page:
    - _ubm5g
    - _udhz5c

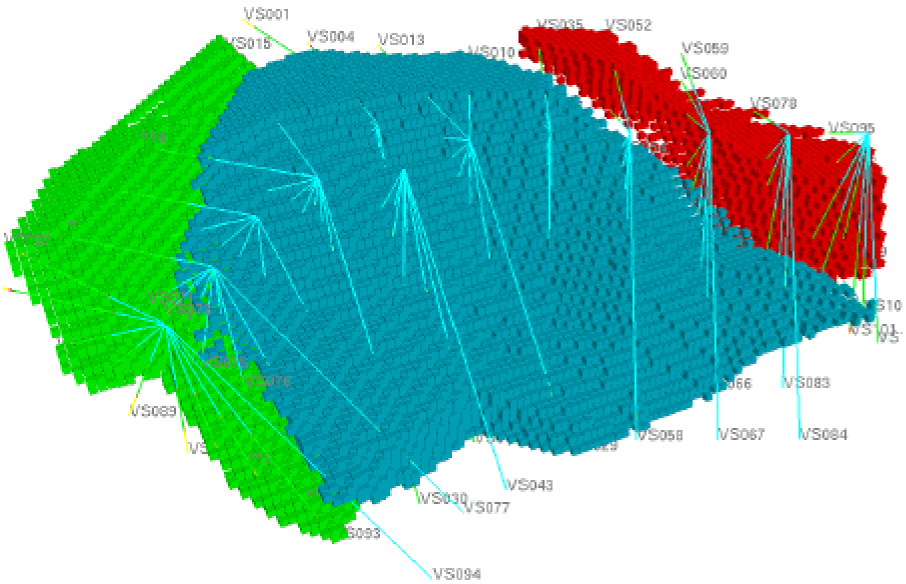
Exercise: Validation of Block Model Grade Estimates Using STATS

In this exercise you are going to validate the block model cell estimates for the cyan ore zone (ZONE=1) by comparing the summary statistics of the four grade fields in the 5m composited drillhole samples to those in the 5x5x5m block model cells:

- Grade block model: 5m regular celled (no sub-cells), zone flagged, block model
- Sample data file: 5m composited drillholes
- Grade fields: AU (g/t), CU (%), AG (g/t), CO (%)
- Filter criteria: ZONE = 1 (i.e. the summary statistics will be restricted to the first mineralized zone).

The grades were estimated using the Search, Variogram and Estimation parameter files _ueps, _uepv and _uepe respectively.

The 3D grade block model and drillhole samples are shown in the image below.



In the above image, the block model cells are colored according to three separate mineralization zones (cyan: ZONE=1, green: ZONE=2, red: ZONE=3). The fold axis of the ore body plunges at 35 degrees towards the East, the tabular to massive shaped limbs have a dip of 40 degrees, a maximum down dip length of 240m and a thichkness (perpendicular to the bottom contact) of 5m -45m . The drillholes are set in fans which are parallel with the dip direction of each limb and are spaced 50m apart .tom contact) of between 5 and 45m . The drillholes are set in fans which are parallel with the dip direction of each limb and are spaced approximately 50m apart.

Statistical validation of block model cell grades can be used to check:

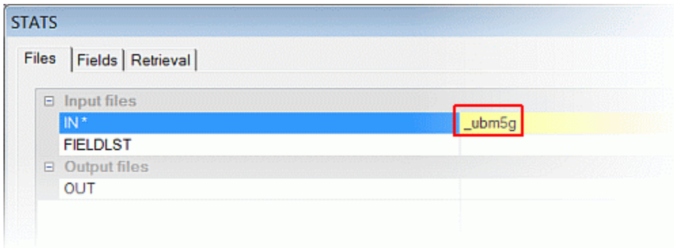
- presence of missing grade values
- summary statistics for each grade field per mineralization zone.

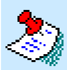
Calculating Summary Statistics for the ZONE=1 Block Model Cells

1. Select the **Design** window.

2. Select **Applications | Statistical Processes | Compute Statistics**.

3. In the **STATS** dialog, *Files* tab, *Input files* group, set *IN** by browsing for and selecting the block model file _ubm5g.

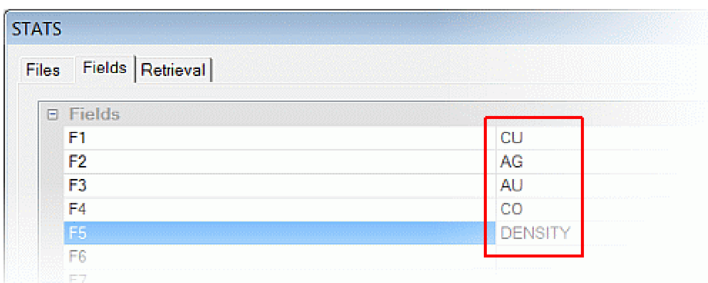




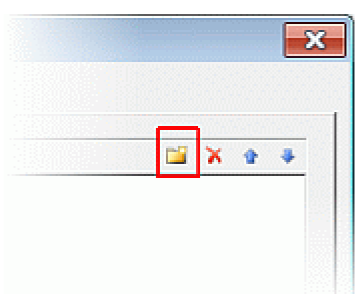
The summary statistics can also be saved to an output file by defining a new filename in the *OUT* field in the *Output files* group.

4. In the *Fields* tab, select the *F1* field [CU], select the *F2* field [AG].

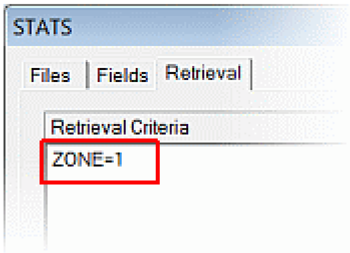
5. Select the *F3* field [AU], select the *F4* field [CO], select the *F5* field [DENSITY]:



6. In the *Retrieval* tab, click **New**.



7. In the *Retrieval Criteria* pane, type in 'ZONE = 1', click **OK**:



8. Follow the displayed output in the **Command** control bar, noting the 'Continue?' prompt.

9. In the **Command** toolbar, with the cursor flashing in the *Run Command* box, press <Enter> five times, once for each prompt i.e. for each of the selected input fields.

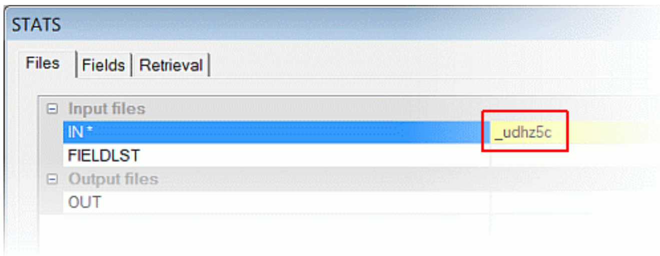
10. In the **Command** control bar, check that the process is complete and that your summary statistics for the CU and AU grade fields are as shown below:

```
 >>> CURRENTLY ESTABLISHED RETRIEVAL CRITERIA
 ZONE     =       1.0
 FILE: orials\projects\s3grdesttut\projfiles\myproj1
\_ubm5g.dm VARIABLE:CU

--------------------------------------------------------
-------------------
           TOTAL NUMBER OF RECORDS             28924
           NUMBER OF SAMPLES                   20361
           NUMBER OF MISSING VALUES             8563
           NUMBER OF VALUES > TRACE            20361
           MAXIMUM                            5.4499
           MINIMUM                            0.0024
           RANGE                              5.4476
           TOTAL                          12063.2722
           MEAN                               0.5925
           VARIANCE                           0.2661
           STANDARD DEVIATION                 0.5159
           STANDARD ERROR                 0.3615E-02
           SKEWNESS                            2.618
           KURTOSIS                            11.03
           GEOMETRIC MEAN                     0.3998
           SUM OF LOGS                   -18667.9056
           MEAN OF LOGS                      -0.9168
           LOGARITHMIC VARIANCE               1.1624
           LOG ESTIMATE OF MEAN               0.7149
Continue ?
```

```
\_ubm5g.dm VARIABLE:AU

--------------------------------------------------------
-------------------
           TOTAL NUMBER OF RECORDS             28924
           NUMBER OF SAMPLES                   20361
           NUMBER OF MISSING VALUES             8563
           NUMBER OF VALUES > TRACE            20361
           MAXIMUM                           13.4202
           MINIMUM                            0.0590
           RANGE                             13.3611
           TOTAL                          56534.7737
           MEAN                               2.7766
           VARIANCE                            3.737
           STANDARD DEVIATION                  1.933
           STANDARD ERROR                 0.1355E-01
           SKEWNESS                            1.652
           KURTOSIS                            4.277
           GEOMETRIC MEAN                     2.1739
           SUM OF LOGS                    15811.2073
           MEAN OF LOGS                       0.7765
           LOGARITHMIC VARIANCE               0.5675
           LOG ESTIMATE OF MEAN               2.8873
Continue ?
```

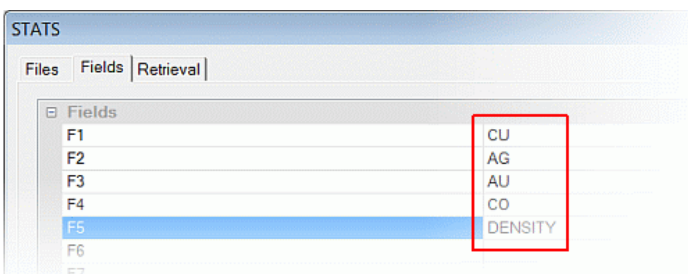
Calculating Summary Statistics for the Drillhole Data

1. Select the **Design** window.
2. Select **Applications | Statistical Processes | Compute Statistics**.
3. In the **STATS** dialog, *Files* tab, *Input files* group, set *IN** by browsing for and selecting the drillholes file _udhz5c.

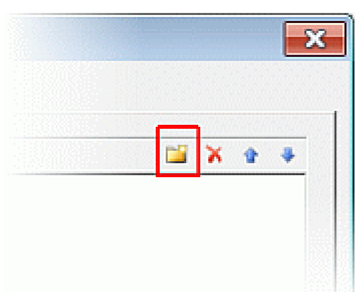


> The summary statistics can also be saved to an output file by defining a new filename in the *OUT** field in the *Output files* group.

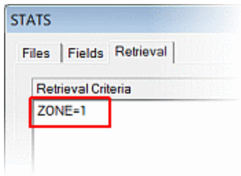
4. In the *Fields* tab, select the *F1* field [CU], select the *F2* field [AG].
5. Select the *F3* field [AU], select the *F4* field [CO], select the *F5* field [DENSITY]:



6. In the *Retrieval* tab, click the **New** button.



7. In the *Retrieval Criteria* pane, type in 'ZONE = 1', click **OK**:



8. Follow the displayed output in the **Command** control bar, noting the 'Continue?' prompt.

9. In the **Command** toolbar, with the cursor flashing in the *Run Command* box, press <Enter> five times, once for each prompt i.e. for each of the selected input fields.

10. In the **Command** control bar, check that the process is complete and that your summary statistics for the CU and AU grade fields are as shown below:

```
 >>> CURRENTLY ESTABLISHED RETRIEVAL CRITERIA
 ZONE     =        1.0
 FILE: rials\projects\s3grdesttut\projfiles\myproj1
\_udhz5c.dm VARIABLE:CU

--------------------------------------------------------
-------------------
          TOTAL NUMBER OF RECORDS              2554
          NUMBER OF SAMPLES                     518
          NUMBER OF MISSING VALUES             2036
          NUMBER OF VALUES > TRACE              518
          MAXIMUM                            5.9406
          MINIMUM                            0.0001
          RANGE                              5.9406
          TOTAL                            328.4279
          MEAN                               0.6340
          VARIANCE                           0.4055
          STANDARD DEVIATION                 0.6368
          STANDARD ERROR                     0.2798E-01
          SKEWNESS                            2.862
          KURTOSIS                            13.42
          GEOMETRIC MEAN                     0.3496
          SUM OF LOGS                     -544.3978
          MEAN OF LOGS                      -1.0510
          LOGARITHMIC VARIANCE               2.2296
          LOG ESTIMATE OF MEAN               1.0659
Continue ?


\_udhz5c.dm VARIABLE:AU

--------------------------------------------------------
-------------------
          TOTAL NUMBER OF RECORDS              2554
          NUMBER OF SAMPLES                     518
          NUMBER OF MISSING VALUES             2036
          NUMBER OF VALUES > TRACE              518
          MAXIMUM                           16.1233
          MINIMUM                            0.0111
          RANGE                             16.1122
          TOTAL                           1393.4306
          MEAN                               2.6900
          VARIANCE                            6.088
          STANDARD DEVIATION                  2.467
          STANDARD ERROR                     0.1084
          SKEWNESS                            1.871
          KURTOSIS                            4.645
          GEOMETRIC MEAN                     1.6941
          SUM OF LOGS                      273.0587
          MEAN OF LOGS                       0.5271
          LOGARITHMIC VARIANCE               1.2527
          LOG ESTIMATE OF MEAN               3.1693
Continue ?
```

11. Compare the CU and AU summary statistics for the block model cells and the drillhole composites.

Using the summary statistics for grade estimate validation, check that:

- the means of the block model cell estimates and the drillhole samples are equal
- the shapes of the distributions of the block model cell estimates and the drillhole samples are the same (this can be done using the summary statistics but is better done with histograms which can be generated using the Studio 3 process **CHART**)

Summary statistics are typically calculated:

- for each grade field per mineralization zone
- using a regular celled block model
- using composited or declustered sample data.

The Studio 3 process **STATNP** can be used to calculate non parametric statistics, which include the Median value.

Graphical Validation

In this portion of the user guide you are going to validate the estimated block model cell grades by generating and inspecting a Q-Q plot of the block model and the drillhole grades. This will be done using the process **PPQQPLOT**.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Read the full process description for **PPQQPLOT**.
- Files required for the exercises on this page:
    - _udhz5c
    - _ubm5g

What is a Q-Q Plot?

In the grade estimate context, the QQ plot is a plot of the quantiles of two grade distributions against each other i.e. of quantiles of a particular grade field from one data set (e.g. block model cells - the estimates) against the quantiles (for the same grade field) from another data set (e.g. composited drillholes - the).

A quantile is defined as the fraction (or percent) of the number of data points below the given value.

For example, the 0.2 (or 20%) quantile is the point at which 20% percent of the data fall below and 80% fall above that value.

If the two sets come from populations with the same probability distributions, then the plotted points should fall along the 45 degree reference line.

Exercise: Graphical Validation of Block Model Grade Estimates using Q-Q Plots

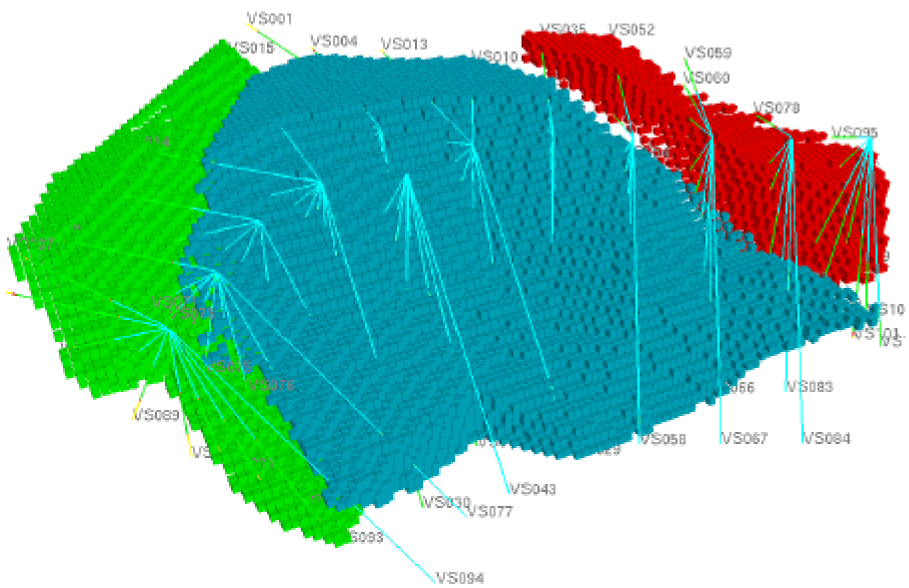
In this exercise you are going to graphically validate the AU grade block model cell estimates for the cyan ore zone (ZONE=1). This will be done by generating and inspecting a Q-Q plot of the AU grade field in the 5m composited drillhole samples vs the 5x5x5m block model cells:

- First Input file: 5m regular celled block model

- Second Input file: 5m composited drillhole samples
- Grade field: AU (g/t)
- Zone field: ZONE (values 1, 2 and 3).

The grades were estimated using the Search, Variogram and Estimation parameter files _ueps, _uepv and _uepe respectively.

The 3D grade block model and drillhole samples are shown in the image below.



In the above image, the block model cells are colored according to three separate mineralization zones (cyan: ZONE=1, green: ZONE=2, red: ZONE=3). The fold axis of the ore body plunges at 35 degrees towards the East, the tabular to massive shaped limbs have a dip of 40 degrees, a maximum down dip length of 240m and a thichkness (perpendicular to the bottom contact) of 5m -45m . The drillholes are set in fans which are parallel with the dip direction of each limb and are spaced 50m apart .tom contact) of between 5 and 45m . The drillholes are set in fans which are parallel with the dip direction of each limb and are spaced approximately 50m apart.

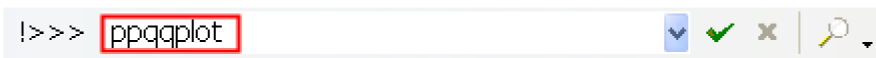
Use Q-Q Plots to check for:

- bias in the estimates.

Generating the QQ Plot

1. Select the **Design** window.

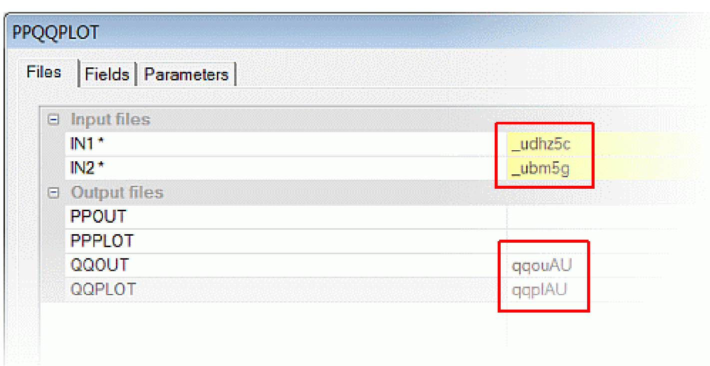
2. In the **Command** toolbar, *Run Command* drop-down, type in 'PPQQPLOT', press <Enter>.



3. In the **PPQQPLOT** dialog, *Files* tab, *Input files* group, set *IN1** by browsing for and selecting the drillholes file _udhz5c.

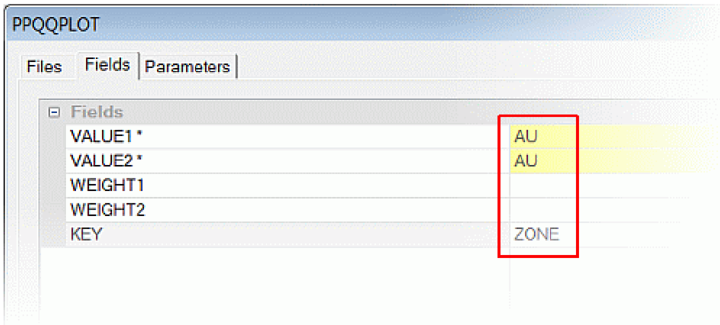
4. Set *IN2** by browsing for and selecting the block model file _ubm5g.

5. In the *Output files* group, define a new *QQOUT* output file 'qqouAU' and a new *QQPLOT* file 'qqplAU'.

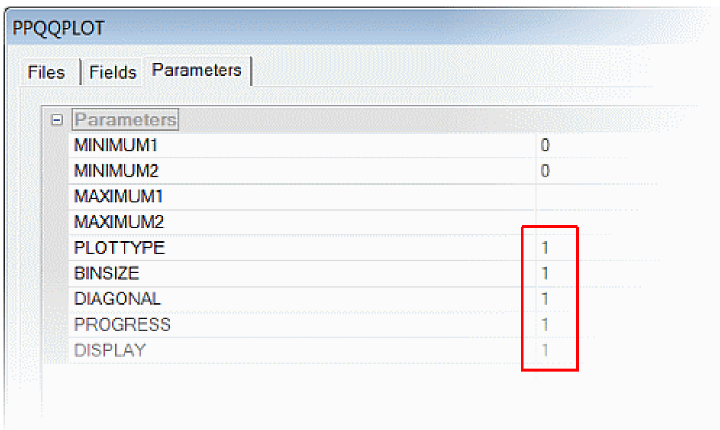


6. In the *Fields* tab, select the *VALUE1** field [AU], the *VALUE2** field [AU].

7. Select the *KEY** field [ZONE].

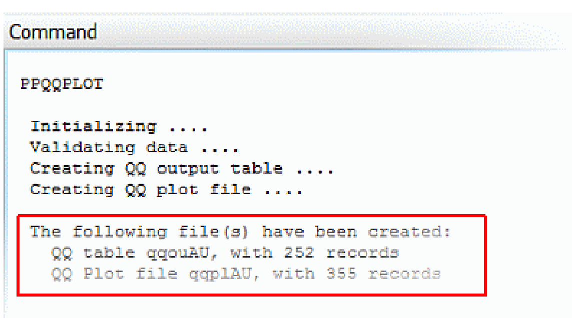


8. In the *Paramaters* tab, define the settings shown below, click **OK**.



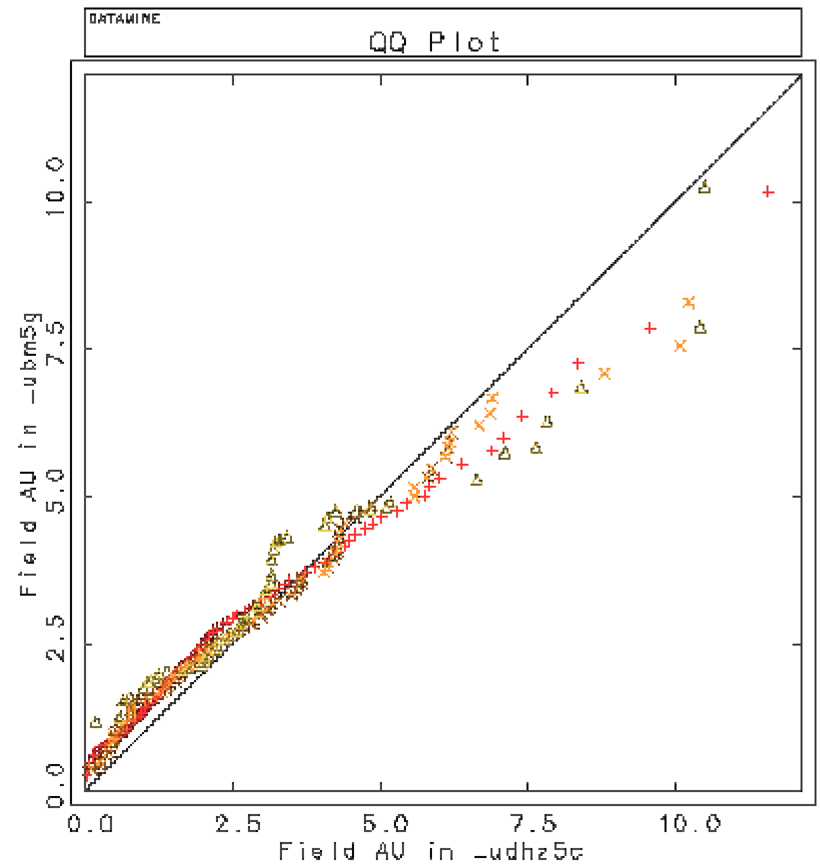
The minimum (*MINIMUM1*, *MINIMUM2*) and maximum (*MAXIMUM1*, *MAXIMUM2*) values displayed on the plot axes are automatically generated if not defined by the user.

9. In the **Command** control bar, check that the PPQQPLOT process has run to completion:



Viewing the Q-Q Plot

1. Select the **Graphics** window and check that your plot is as shown below (your background and symbol colors will probably be different to those shown below):



- The block model quantiles are plotted on the Y-axis and the drillhole quantiles on the X-axis.
- The symbols represent the three mineralization zones as follows:
  - **+** ZONE = 1
  - **x** ZONE = 2
  - **^** ZONE = 3 (triangles).

Using the Q-Q Plot for validating grade estimates:

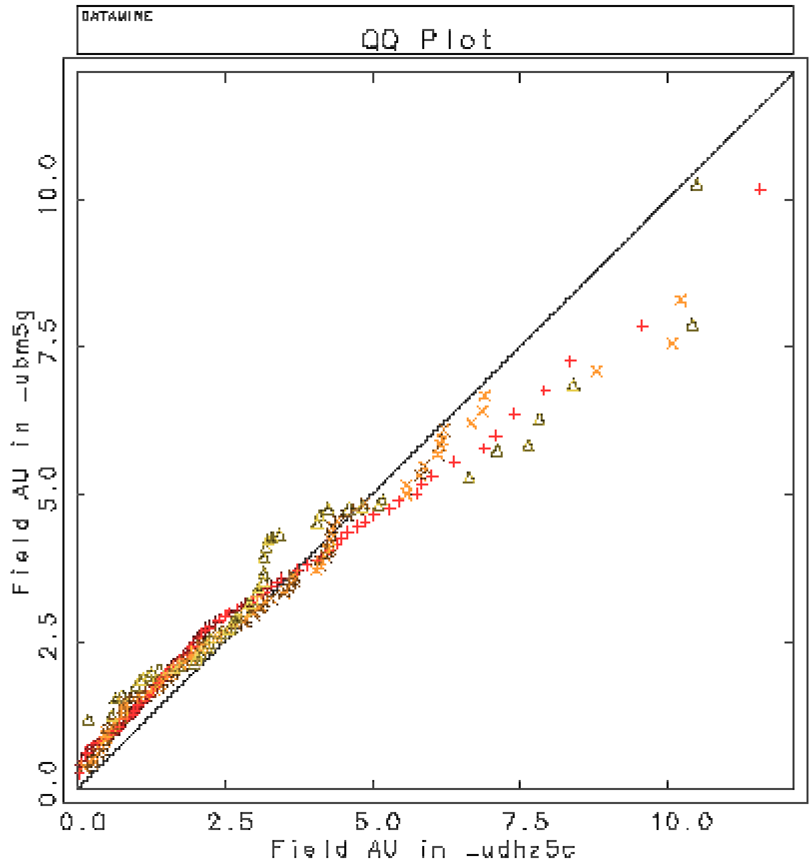
- the plotted points (i.e. model cells vs drillhole composites) should deviate as little as possible from the 1:1 line shown on the graph
- deviation away from the 1:1 line indicates bias in the estimates.

Viewing a Q-Q Plot File

1. In the **Project Files** control bar, expand the *Plot Files* folder.

2. Right-click on the plot file qqplau and select Display .

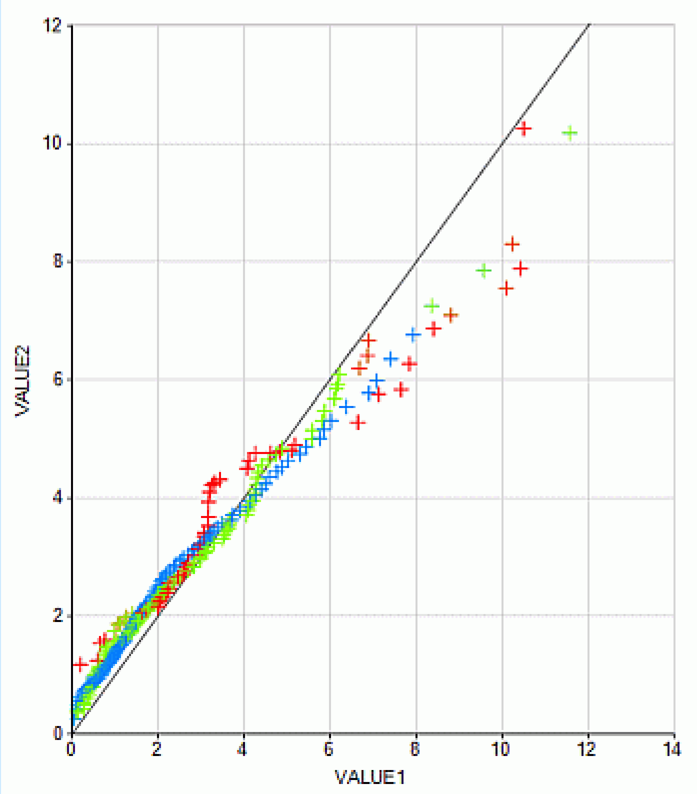
3. Select the **Graphics** window and check that your plot is as shown below (your background and symbol colors will probably be different to those shown below):



The 'BEEP' sound within the **Graphics** window can be temporarily disabled as follows:

- Right-click the **Volume** icon in the windows **Taskbar**.
- Select Open Volume Control.
- In the **Volume Control** dialog, *Volume Control* group, check the *Mute All* tick box.
- Click **Close**.

As an alternative to generating (and then viewing) plots from **PPQQPLOT**, the output data file qqouAU can be used to create a scatter plot in the Plots window (**Insert | Chart | Scatter Plot**). The VALUE1 field is selected for the X Axis and the VALUE2 field for the Y Axis, with ZONE being used as the Key Field:



Resource Classification

In this portion of the user guide you are going to classify a grade block model into confidence categories using the kriging variance values. This will be done visually in the **Design** window.

Prerequisites

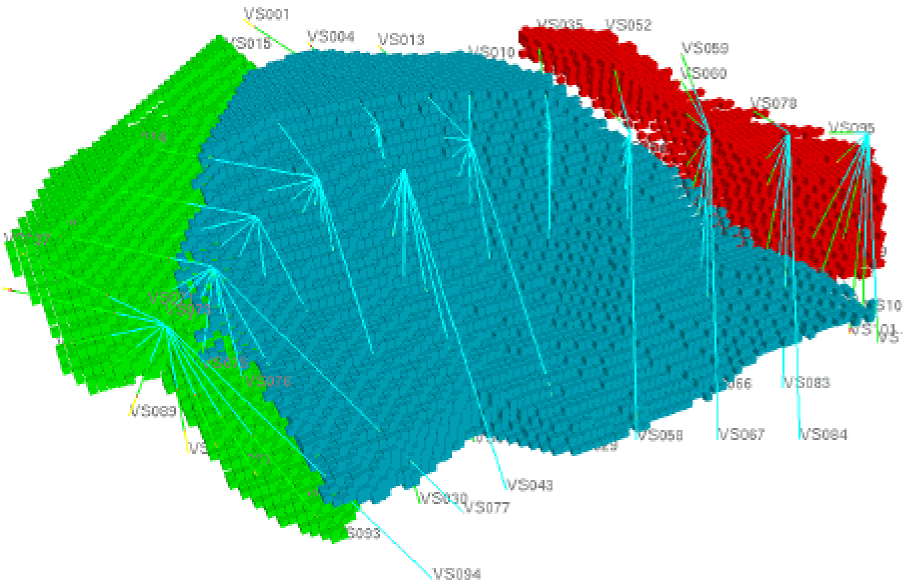
- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Files required for the exercises on this page:
    - _ubm5g

Exercise: Informal Classification of Grade Estimates Using the Kriging Variance

In this exercise you are going to calculate a category field in the block model using the process **EXTRA**, based on a set of kriging variance ranges for the Au grade estimates (field VAU). The resultant model will then be formatted and viewed in the **Design** window using the following parameters:

- Grade block model: 5m regular celled (no sub-cells), zone flagged, block model
- Kriging variance field: VAU
- Categories and variance ranges:
    - CAT = 1: VAU <= 3
    - CAT = 2: 3 > VAU <= 6
    - CAT = 3: 6 > VAU

The 3D grade block model and drillhole samples are shown in the image below. The block model cells are colored according to the three separate mineralization zones (cyan: ZONE=1, green: ZONE=2, red: ZONE=3). The fold axis of the ore body plunges at 35 degrees towards the East, the tabular to massive shaped limbs have a dip of 40 degrees, a maximum down dip length of 240m and a thichkness (perpendicular to the bottom contact) of 5m -45m . The drillholes are set in fans which are parallel with the dip direction of each limb and are spaced 50m apart .



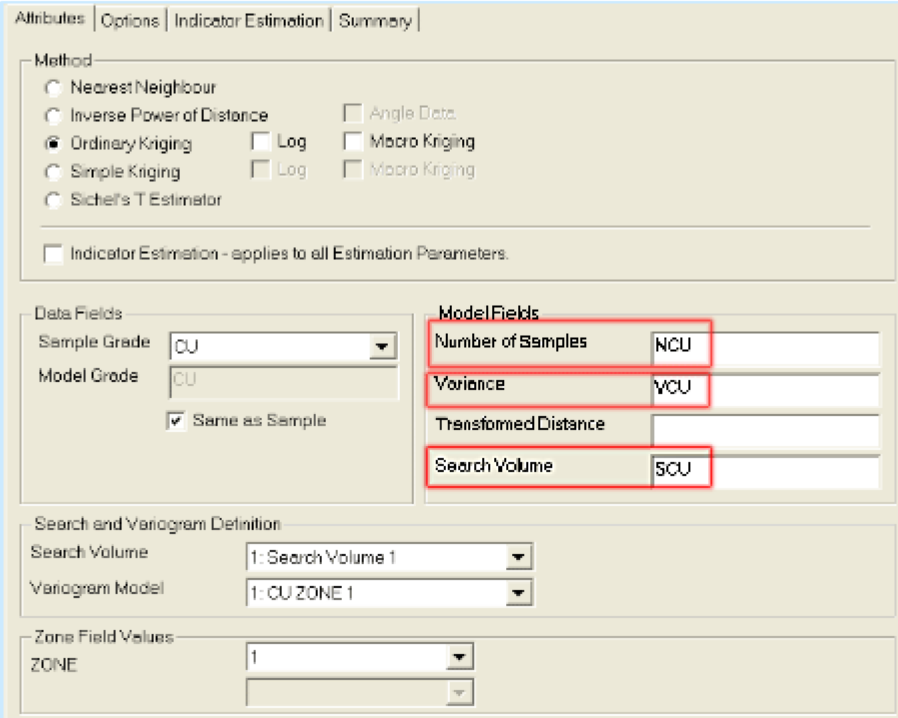
The informal classification of a block model's grade estimates using quantitative methods (e.g. search volume, number of samples, estimate variance) can be used to:

- identify areas within the project that need further information or investigation (i.e. sampling, mapping or drilling)
- provide the basis for formal resource/reserve classification and reporting methods used in association with internationally recognized codes (e.g. the JORC Code).

The following additional grade estimate fields can be included in the output block model :

- search volume number
- number of samples
- estimate variance

This is done in **ESTIMATE** by, in the *Estimation Types* tab, *Attributes* sub-tab, defining suitable field names in the *Model Fields* group, as shown in the image below:



Please see the exercise Estimation using Drillhole Data and Advanced Options for further details.

Calculating a Category Field for the Block Model

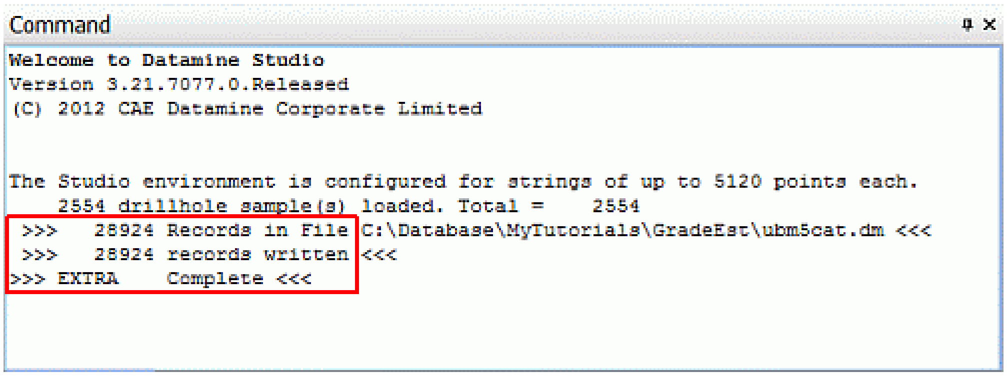
1. Select the **Design** window.
2. Select **Edit | Transform | General**.
3. In the **EXTRA** dialog, *Files* tab, *Input files* group, set *IN** by browsing for and selecting the file _ubm5g.
4. In the *Output files* group, define a new *OUT** file 'ubm5cat', click **OK**.
5. In the **Expression Translator** dialog, define the following set of commands, using the dialog controls or the keyboard, then click **Test**:

```
CAT;n = 1

IF(VAU > 3 and VAU <= 6)
```

```
 CAT = 2

ELSEIF(VAU > 6)

 CAT = 3

END
```

6. If the message in the *Status* pane is *OK*, as shown below, then click **Execute**.

7. Select the **Command** control bar, check that EXTRA has finished running and that the output file contains 28924 records, as shown by the message below:



Loading the Block Model

1. Select the **Design** window.

2. Select the **Project Files** control bar.

3. Drag-and-drop the following *Block Models* file into the **Design** window:

    - ubm5cat

4. In the **Sheets** control bar, *Design-Overlays* folder, select only the following check boxes (i.e. display these objects) :

    - ubm5cat (block model)

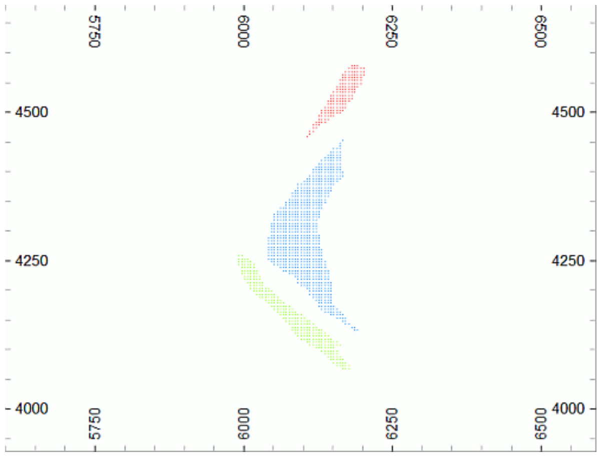
5. In the **View Control** toolbar, click Plane by One Point.

6. Click at any point in the **Design** window.

7. In the **Plane By One Point** dialog, select *Plan* , click **OK**.

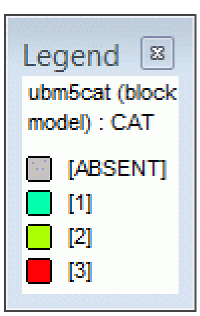
8. In the **View Control** toolbar, click Zoom All Data.

9. In the **Design** window, check that the block model is displayed as shown below:



Formatting The Block Model Cells

1. Select the **Design** window.
2. In the **Sheets** control bar, *Design-Overlays* folder, double-click ubm5cat (block model).
3. In the **Format Display** dialog, *Overlay Format* group, *Style* tab, *Display As* group, select the *Blocks* option, click **OK**.
4. In the **View Control** toolbar, toggle off **Use Clipping**.
5. In the **Sheets** control bar, *Design-Overlays* folder, right-click ubm5cat (block model) , select Quick Legend.
6. In the **Quick Legend** dialog, *Object* group, select the *Field* [CAT].
7. In the *Bins* group, select *Use Unique Values*, click **Preview**.
8. In the **Legend** dialog, check that your legend is as shown below, close the dialog:



9. Back in the **Quick Legend** dialog, click **OK**.

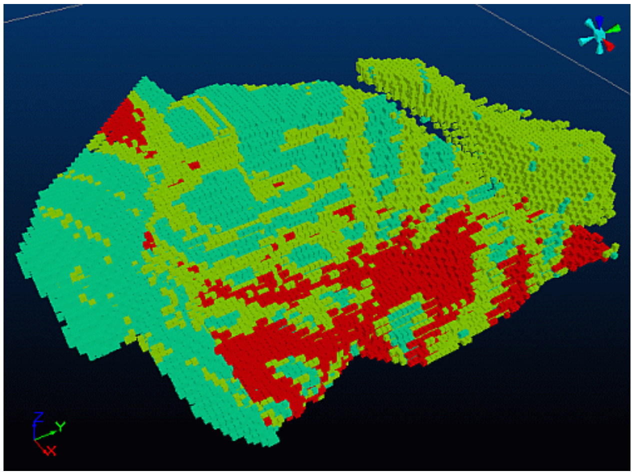
10. Select the **Design** window.

11. Select **Format | VR View | Update VR Objects** 'vro'.

12. In the **Sheets** control bar, *VR-Block Models* folder, double-click ubm5cat (block model).

13. In the **Block Model Properties** dialog, *Display Type* group, select the *Blocks* option, in the *Options* group, clear the *Show Hull* check box, click **OK**.

14. In the **VR** window, rotate and zoom the view, check that the block model is colored according to the field CAT as shown below:



15. Identify the areas of the block model that show a low (cyan), medium (green) or high (red) kriging variance.

> The legend used to color the block model on the CAT field, can also be used as an evaluation legend.

Evaluation and Reporting

In this portion of the user guide you are going to create a legend for the grade and tonnage evaluation of block models (or drillholes). It is recommended that you complete the exercises in the order shown below. The results of these exercises will be used later in the tutorial.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Files required for the exercises on this page:
  - _ubm5g

Exercise: Creating an Evaluation Legend

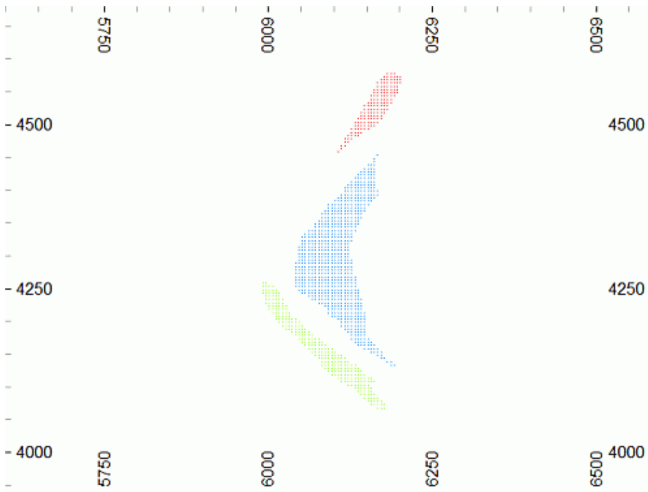
In this exercise you are going to create a new interval legend named Au Evaluation, using the following parameters:

- block model: _ubm5g.
- Gold grade field: AU [g/t]
- Legend details: 20 intervals, each 0.25% in size; linear; colored using the standard rainbow color palette.

Loading the Block Model

1. Select the **Design** window.
2. Select the **Project Files** control bar.
3. Drag-and-drop the following *Block Models* file (if not already loaded) into the **Design** window:
   - ubm5g
4. In the **Sheets** control bar, *Design-Overlays* folder, select only the following check boxes (i.e. display these objects) :
   - ubm5cat (block model)
5. In the **View Control** toolbar, click Plane by One Point.
6. Click at any point in the **Design** window.

7. In the **Plane By One Point** dialog, select *Plan* , click **OK**.
8. In the **View Control** toolbar, click Zoom All Data.
9. In the **Design** window, check that you have the following data displayed i.e. a horizontal slice through the block model at -285m elevation:



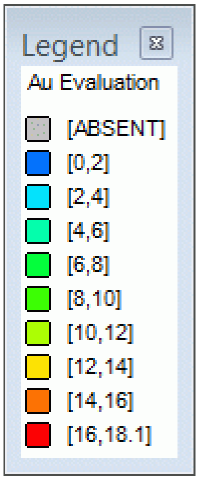
> The block model is currently colored on the ZONE field, using the automatically generated project file legend Datamine: ZONE (_ubm5g (block model)).

Creating the Legend

1. Select **Format | Legends...**.
2. In the **Legends Manager** dialog, click **New Legend...**
3. In the **Legend Wizard: Data Table Column** dialog, select the *Use Explicit Ranges* option, click **Next>**.
4. In the **Legend Wizard: Legend Storage** dialog, select the *Current Project File* option, click **Next>**.
5. In the **Legend Wizard: General** dialog, define the legend *Name* as 'Au Evaluation', select the *Type* [Numeric], select the *Ranges* option, click **Next>**.
6. In the **Legend Wizard: Data Range** dialog, define the legend's *Number of Items* as '9', the *Minimum Value* as '0', the *Maximum Value* as '18'*,* click **Next>**.
7. In the **Legend Wizard: Legend Distribution** dialog, select the *Distribution Type* [Linear], select the *Equal Widths option,* click **Next>**.

8. In the **Legend Wizard: Coloring** dialog, select the *Color Type Range* [Rainbow blue-red], select the *Anti Clockwise transition* option, click **Preview Legend...**.

9. In the **Legend** dialog, check that you legend appears as shown below, close the dialog:



10. Close the **Legend** preview dialog.

11. Back in the **Legend Wizard: Coloring** dialog click **Finish**.

12. Back in the **Legends Manager** dialog, check that the new Au Evaluation legend has been added to the list of project file legends, click **Close**.

Any legend with suitable categories i.e. unique values or ranges, can be used as an evaluation legend.

Exercise: Applying a Legend

In this exercise you are going to format the _ubm5g (block model) overlay in the **Design** window by coloring the block model slice using the newly created Au Evaluation legend.

This exercise follows on directly from the previous exercise i.e. Creating an Evaluation Legend, and assumes that it has already been completed.

Applying the Legend

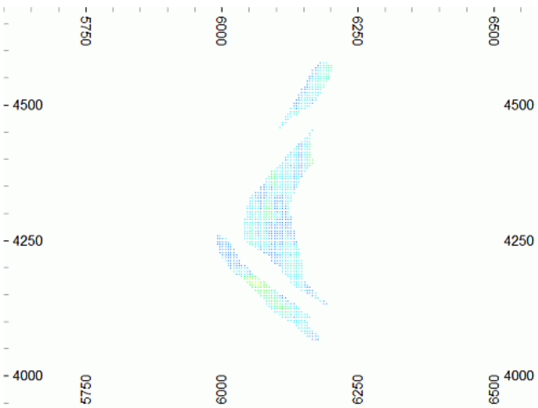
1. In the **Sheets** control bar, *Design-Overlays* folder, double-click ubm5g (block model).

2. In the **Format Display** dialog, *Overlay Format* group, *Color* tab, Color group, select the *Legend* option.

3. Select the *Legend* [Au Evaluation], select the *Column* [AU].

4. Click **Apply** and then **Close**.

5. In the **Design** window, check that the block model has been colored as shown below:

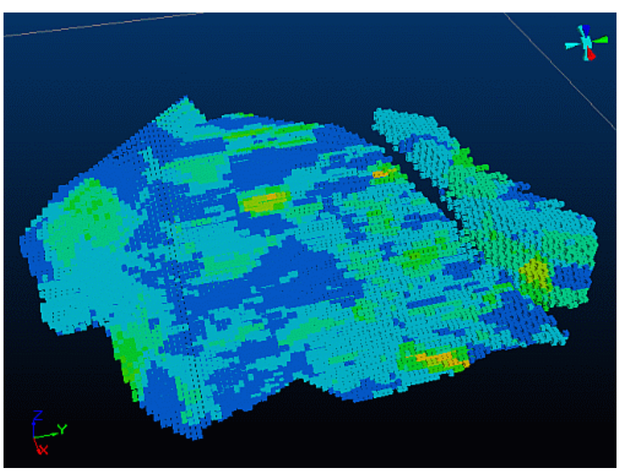


6. Select **Format | VR View | Update VR Objects** 'vro'.

7. In the **Sheets** control bar, *VR-Block Models* folder, double-click ubm5g (block model).

8. In the **Block Model Properties** dialog, *Display Type* group, select the *Blocks* option, in the *Options* group, clear the *Show Hull* check box, click **OK**.

9. In the **VR** window, rotate and zoom the view, check that the block model is colored according to the legend categories shown below:



10. Identify the low, medium and high grade areas of the block model.

DEFINING EVALUATION SETTINGS

In this portion of the user guide you are going to define the general settings to be used in tonnage grade evaluations. The results of these exercises will be used in later exercises.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Created and applied an evaluation legend - exercises on the *Creating an Evaluation Legend* page.
- Files required for the exercises on this page:
    - none

Exercise: Defining Evaluation Settings

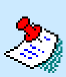
In this exercise you are going to define the following evaluation settings:

- Object type to evaluate: a block model (and not drill holes)
- Type of cell evaluation: Partial Cell evaluation (and not Full Cell)
- Evaluation legend: Au Evaluation

Full or Partial Cell Evaluation?

The *Evaluation Control* check box *Full cell evaluation* controls the way in which block model cells are treated during an evaluation:

- *Full cell evaluation* option checked - use full cells
- *Full cell evaluation* option cleared - use partial cells



In a full cell evaluation, cells, whose centres fall within the string or wireframe boundary, are included in the evaluation i.e. the entire cell volume is used. In a partial cell evaluation, only the portion of the cell falling within the boundary is included in the evaluation. This is generally relevant to cells straddling the string or wireframe defining the evaluation boundary. A partial cell evaluation will typically yield more accurate volume calculation results but takes longer to run.

Use **Full Cell** Evaluation when performing:

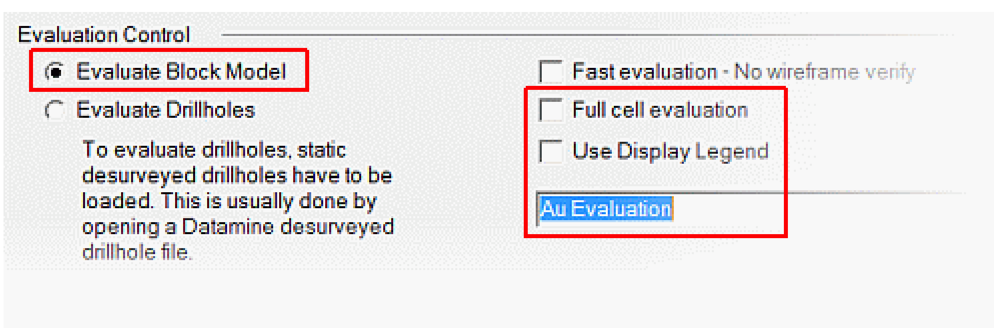
- quick evaluations
- approximate volume estimates
- global estimates on equi-dimensional ore body volumes.

Use **Partial Cell** Evaluation when performing:

- accurate evaluations of thinly shapes
- accurate evaluations of irregular, convoluted shapes
- shapes that do not follow cell boundaries.

Defining the Evaluation Settings

1. Select **File | Settings...**.
2. In the **Project Settings** dialog, *Project Settings* folder, select *Mine Design*.
3. In the *Evaluation Control* group, select the *Evaluate Block Model* option.
4. Clear the *Fast evaluation* check box.
5. Clear the *Full cell evaluation* check box.
6. Clear the *Use Display Legend* check box.
7. In the *Legend Name* drop-down, select [Au Evaluation], click **OK**:



- The *Full cell evaluation* option allows block model cells to be evaluated using either full or partial cell volumes.
- The *Use Display Legend* option, when not selected i.e. the check box is cleared, allows the block model to be colored on one legend and evaluated on another.

INTERACTIVE EVALUATION – SINGLE STRINGS

In this portion of the user guide you are going to evaluate a block model within single strings, interactively in the **Design** window, in order to generate summary tonnes and grades.

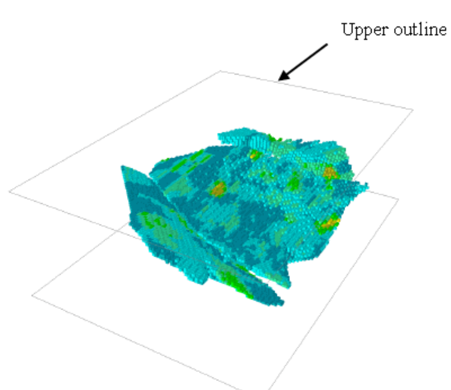
Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Created and applied an evaluation legend - exercises on the *Creating an Evaluation Legend* page.
- Defined evaluation settings - exercise on the *Defining Evaluation Settings* page.
- Files required for the exercises on this page:
    - _ubm5g
    - _ubmlim

Exercise: Interactive Evaluation using Single Strings

In this exercise you are going to evaluate the grade block model _ubm5g within the block model limits defined by the outlines in the strings file _ubmlim. The summary tonnes and grades will be calculated for the intervals defined in the evaluation legend Au Evaluation and saved to a new results table.

The strings file _ubmlim contains two coplanar closed strings, the upper one at -180m elevation and the other at -390m elevation. The upper string at -180m elevation will be used in this exercise.



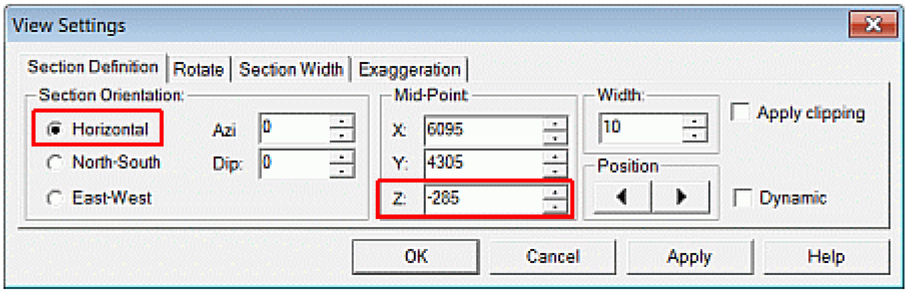
Use **Single Strings** when evaluating:

- block models or drillholes within a property boundary or lease area perimeter
- open pit mining blocks represented by single mid-bench (or crest or toe elevation) outlines
- cut-and-fill mining blocks represented by single horizontal outlines in steep dipping ore bodies
- horizontal/sub-horizontal mining development represented by single outlines

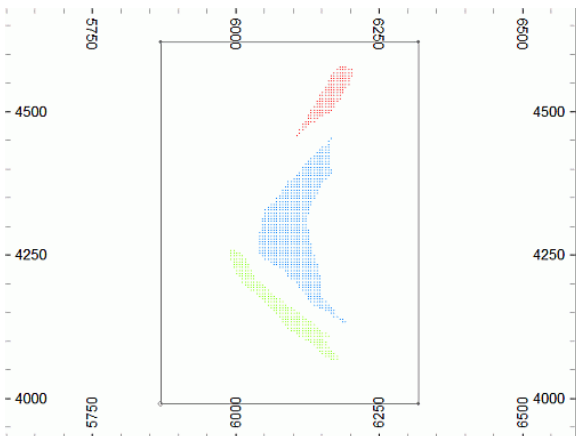
Loading the String and Block Model Data

1. Select the **Design** window.
2. Select the **Project Files** control bar.
3. Drag-and-drop the following block model and strings files into the **Design** window:
    - _ubm5g
    - _ubmlim
4. In the **Sheets** control bar, *Design-Overlays* folder, select only the following check boxes (i.e. display these objects):
    - _ubm5g (block model)
    - _ubmlim (strings)
5. In the **View Control** toolbar, click Zoom All Data.
6. In the **View Control** toolbar, click View Settings.
7. In the **View Settings** dialog, *Section Definition* tab, *Section Orientation* group, select the *Horizontal* option.

8. In the *Mid-Point* group, define the *Z:* elevation as '-285', click **OK**:

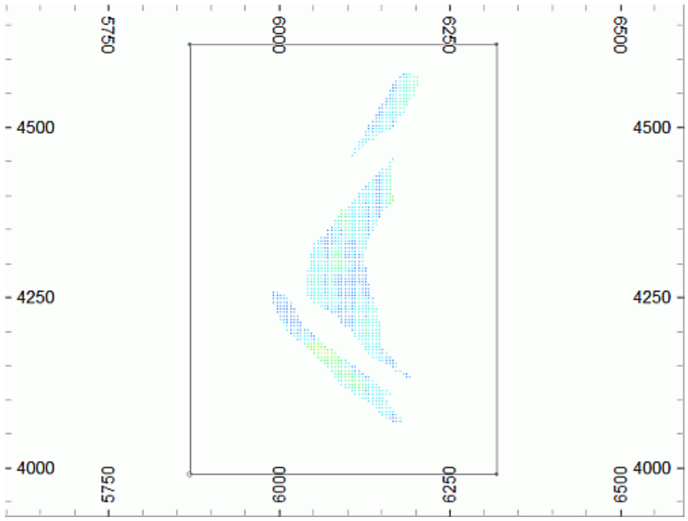


9. In the **Design** window, check that you have the following data displayed i.e. a horizontal slice through the block model at-285m elevation and the model limit outlines.



Formatting the Block model With the Evaluation Legend

1. In the **Sheets** control bar, *Design-Overlays* folder, double-click ubm5g (block model).
2. In the **Format Display** dialog, *Overlay Format* group, *Color* tab, *Color* group, select the *Legend* option.
3. Select the *Legend* [Au Evaluation], select the *Column* [AU].
4. Click **Apply** and then **Close**.
5. In the **Design** window, check that the block model has been colored as shown below:



Unloading any Existing Results Tables

1. Select the **Loaded Data** control bar.

2. Right-click on an existing results table, e.g. geres2 from the string pairs evaluation exercise, select **Data | Unload**.

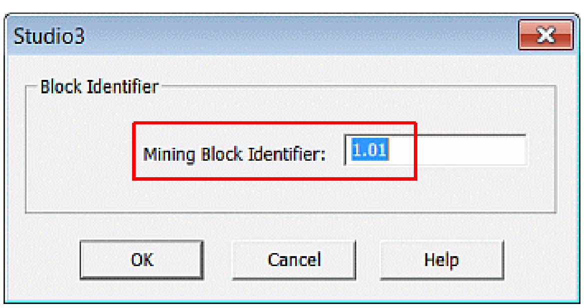
Evaluating Using the Upper String

1. Select the **Design** window.

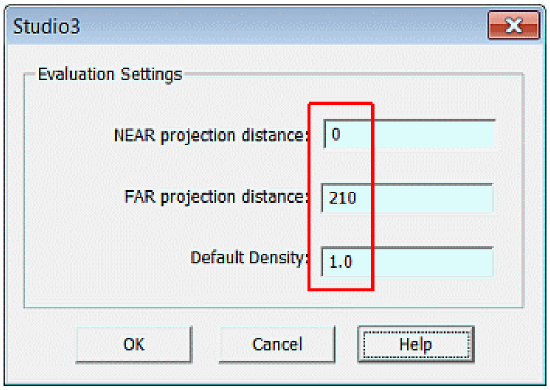
2. In the **Mine Design** toolbar, click Evaluate 1 String.'ev1'.

3. Click on the outline (by default, the -180m elevation outline is selected).

4. If prompted, in the **Studio 3** dialog, *Block Identifier* group, define the *Mining Block Identifier* as '1.01' and click **OK** :

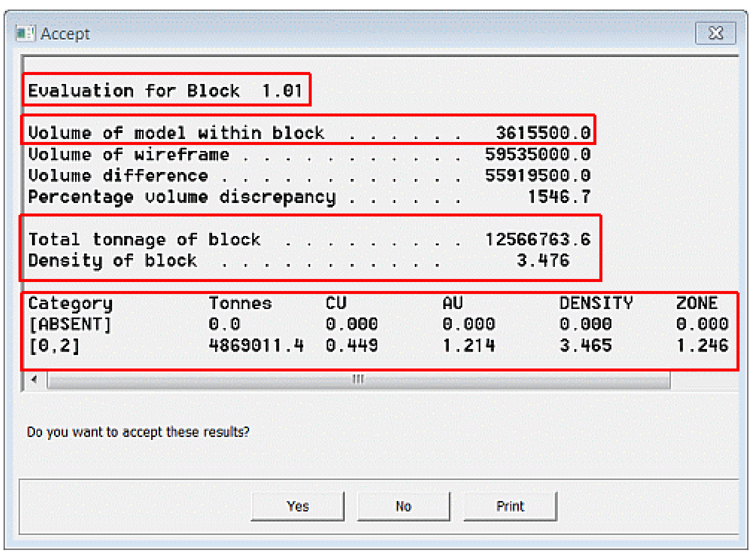


5. In the **Studio 3** dialog, *Evaluation Settings* group, define the *NEAR projection distance* as '0', *FAR projection distance* as '210', *Default density* as '1.0' and click **OK** :



The NEAR and FAR vertical projection distances define the upper and lower limits of the evaluation volume. In this exercise, these distances just need to be large enough so that the evaluation volume encloses the grade block model i.e. exact distances are not important. On the other hand, when the single outlines being evaluated represent open pit or cut-and-fill mining blocks, the NEAR and FAR projection distances need to accurately represent the vertical thickness of the mining block being evaluated.

6. In the **Accept** dialog, compare your results to those shown below, click **Yes**:



When **Yes** is clicked, the results listed in the **Accept** dialog are saved to a new results table object called RESULTS.

The results are listed according to the categories defined in the *Au Evaluation* legend

7. In the **Design** window, click **Cancel**.

> Multiple single strings can be evaluated individually by repeating steps 3 to 5 before clicking **Cancel**. Multiple single strings can also be evaluated in a single run by using the command Evaluate All Strings.

Saving the RESULTS Object to File

1. In the **Loaded Data** control bar, right-click on RESULTS , select **Data | Save As**.
2. In the **Save 3D Object** dialog, click **Single Precision Datamine(.dm) file**.
3. In the **Save RESULTS** dialog, browse to your project folder, define a new *File name* 'geres1.dm', click **Save**.
4. In the **Loaded Data** control bar, check that the RESULTS object has been renamed to geres1 (table).

Saving the Updated _ubmlim (strings) Object

1. In the **Loaded Data** control bar, right-click on the _ubmlim (strings) object, select **Data | Save As**.
2. In the **Save 3D Object** dialog, click **Single Precision Datamine(.dm) file**.
3. In the **Save** dialog, browse to your project folder, define a new *File name* 'ublim2.dm', click **Save**.
4. In the **Loaded Data** control bar, check that the _ubmlim (strings) object has been renamed to _ubmlim2 (strings).

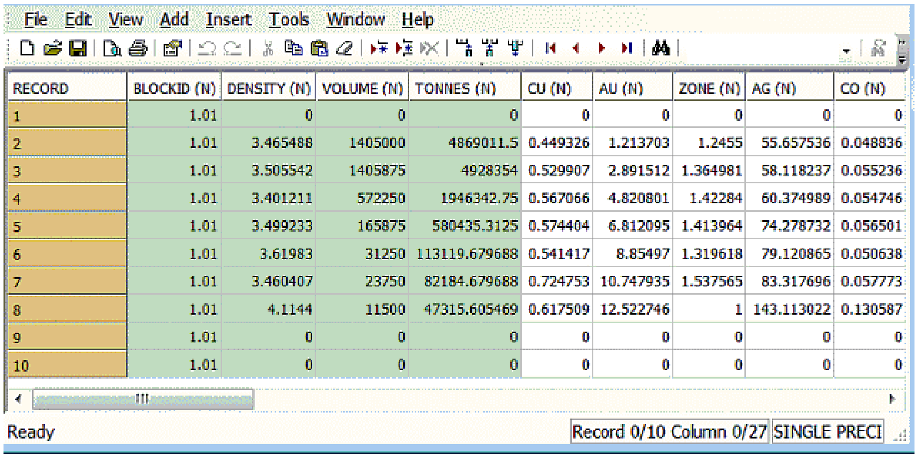
> The saved strings file ubmlim2.*dm* now contains an extra field (column) BLOCKID with a set value i.e. '1.01'; the evaluation results table also contains this field and value. This allows the results in the results table to be linked to the correct outline in the string file. This can be used to check results and join the results to the outlines using the process **JOIN**.

Checking the Results Table

1. Select the **Project Files** control bar, *Results* folder.
2. Right-click on *geres1* , select Open.
3. In the **CAE Table Editor** dialog, check that your results are as follows:
   - the table contains a total of 10 records

- the evaluation has only identified ore tonnage in 7 grade categories (the field CATEGORY is on the far right).

4. Compare your results to those shown in the results table below:



RECORD	BLOCKID (N)	DENSITY (N)	VOLUME (N)	TONNES (N)	CU (N)	AU (N)	ZONE (N)	AG (N)	CO (N)
1	1.01	0	0	0	0	0	0	0	0
2	1.01	3.465488	1405000	4869011.5	0.449326	1.213703	1.2455	55.657536	0.048836
3	1.01	3.505542	1405875	4928354	0.529907	2.891512	1.364981	58.118237	0.055236
4	1.01	3.401211	572250	1946342.75	0.567066	4.820801	1.42284	60.374989	0.054746
5	1.01	3.499233	165875	580435.3125	0.574404	6.812095	1.413964	74.278732	0.056501
6	1.01	3.61983	31250	113119.679688	0.541417	8.85497	1.319618	79.120865	0.050638
7	1.01	3.460407	23750	82184.679688	0.724753	10.747935	1.537565	83.317696	0.057773
8	1.01	4.1144	11500	47315.605469	0.617509	12.522746	1	143.113022	0.130587
9	1.01	0	0	0	0	0	0	0	0
10	1.01	0	0	0	0	0	0	0	0

5. In the **CAE Table Editor** dialog, select **File | Exit**.

> The Studio 3 process **MODRES** can also be used to generate a summary tonnes and grades results file from a grade block model. **TABRES** can then be used to tabulate the result file and generate an output system text file. See the Studio 3 Command Table in the Help documentation for a comprehensive list of Processes and their uses.

Interactive Evaluation – String Pairs

In this portion of the user guide you are going to evaluate a block model within a set of string pairs interactively in the **Design** window, in order to generate summary tonnes and grades.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Created and applied an evaluation legend - exercises on the *Creating an Evaluation Legend* page.
- Defined evaluation settings - exercise on the *Defining Evaluation Settings* page.
- Files required for the exercises on this page:
    - _ubmm
    - _caf5so

Exercise: Interactive Evaluation Using String Pairs

In this exercise you are going to evaluate the mining block model _ubmm within the -255m level cut-and-fill mining blocks _caf5so in order to generate a summary tonnes and grade table. The tonnes and average grades will be calculated for the intervals defined in the evaluation legend Au Evaluation, which was created in a previous exercise (see Prerequisites box).

The mining block model _ubmm has the following characteristics:

- it is a regularized block model consisting of 5x5x5m cells
- contains a 15m thick 'waste' envelope around the ore (AU, CU, CO and AG grades set to '0')

The -255m level cut-and-fill stoping outlines (mining blocks) _caf5so have the following characteristics:

- consist of 3 pairs of horizontal, closed strings
- each string pair has both a hangingwall and footwall position string defining the upper

and lower limits of the cut-and-fill stoping cut

- each cut is 5m thick.

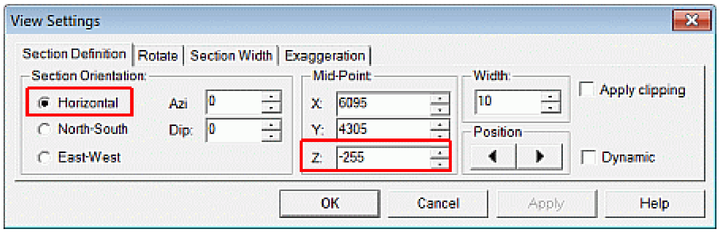
Use **String Pairs** when evaluating:

- open pit mining blocks represented by pairs of crest and toe elevation strings
- underground cut-and-fill mining blocks represented by pairs of hanging- and footwall strings
- pairs of dipping mining block strings e.g. sublevel open stoping, VCR or longwall mining blocks
- primary and secondary mining development represented by pairs of strings.

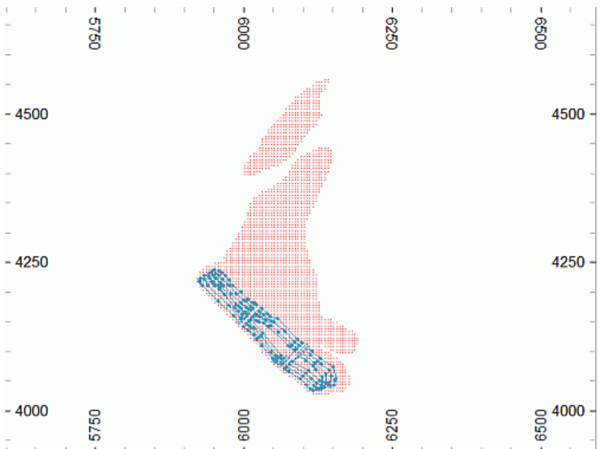
Loading the Block Model and Strings

1. Select the **Design** window.
2. Select the **Project Files** control bar.
3. Drag-and-drop the following block model and strings files into the **Design** window:
   - _ubmm
   - _caf5so
4. In the **Sheets** control bar, *Design* folder, *Overlays* folder, select only the following check boxes (i.e. display these objects) :
   - _ubmm (block model)
   - _caf5so (strings)
5. In the **View Control** toolbar, click Zoom All Data.
6. In the **View Control** toolbar, click View Settings.
7. In the **View Settings** dialog, *Section Definition* tab, *Section Orientation* group, select the *Horizontal* option.

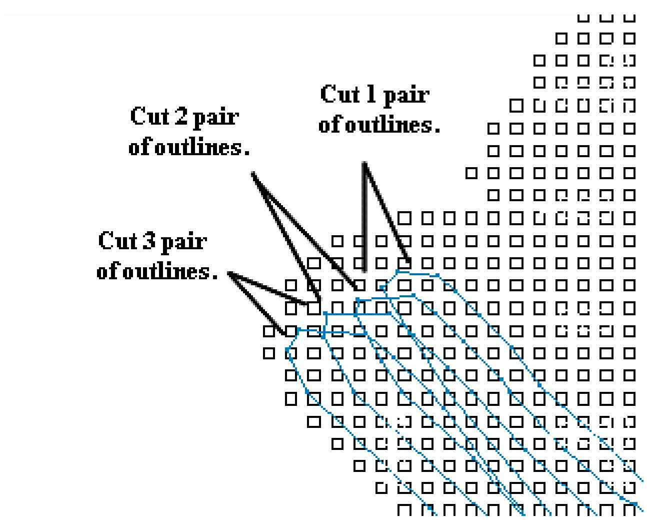
8. In the *Mid-Point* group, define the *Z:* elevation as '-255', click **OK**:



9. In the **Design** window, check that you have the following data displayed i.e. a horizontal slice through the block model at-255m elevation and the Cut and Fill stoping outlines for the -255m level.



10. Zoom in to the area around the outlines and identify the 3 cut's 9 stoping blocks, each defined by a pair of horizontal strings. Note that the top string for the 1st cut string pair becomes the bottom string for the 2nd cut string pair:



Applying the Evaluation Legend to the Block Model

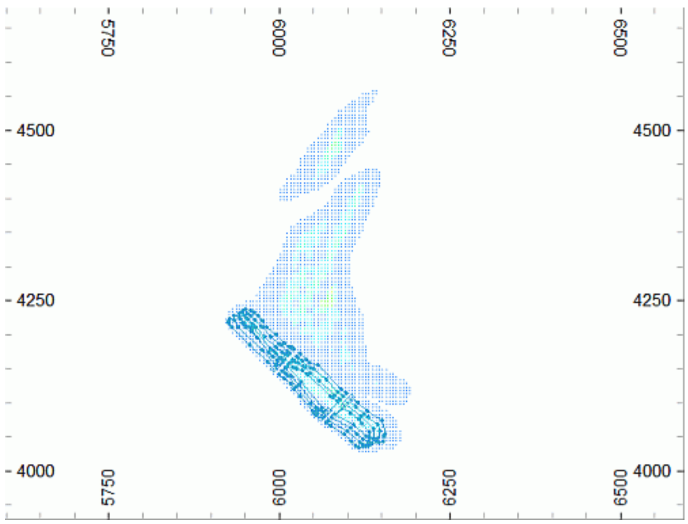
1. In the **Sheets** control bar, *Design-Overlays* folder, double-click ubmm (block model).

2. In the **Format Display** dialog, *Overlay Format* group, *Color* tab, *Color* group, select the *Legend* option.

3. Select the *Legend* [Au Evaluation], select the *Column* [AU].

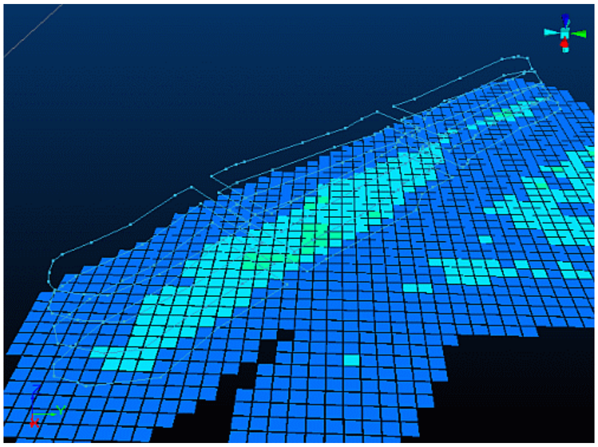
4. Click **Apply** and then **Close**.

5. In the **Design** window, check that the block model has been colored as shown below:



6. Select **Format | VR View | Update VR Objects** 'vro'.

7. In the **VR** window, rotate and zoom the view, check that the block model is colored according to the legend categories shown below::



Unloading any Existing Results Tables

1. Select the **Loaded Data** control bar.

2. Right-click on an existing results table, e.g. geres1 from the single string evaluation exercise, select **Data | Unload**.

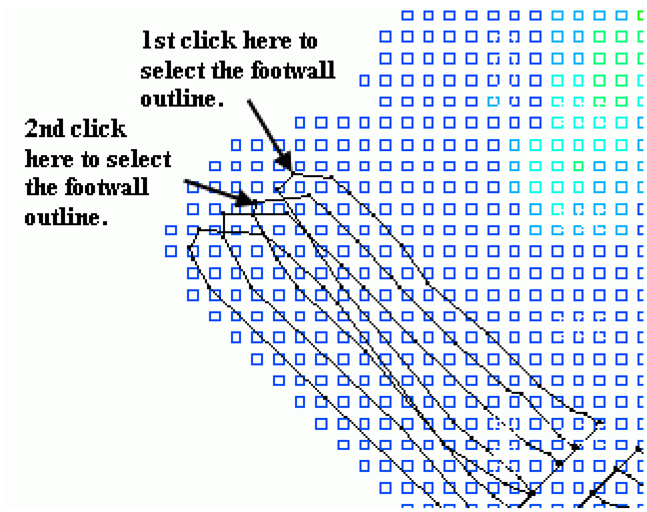
Evaluating the First Pair of Outlines

1. Select the **Design** window.

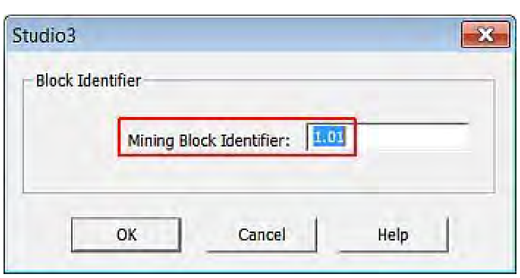
2. In the **View Control** toolbar, click Zoom In and drag a zoom rectangle around the northern set of outlines.

3. In the **Mine Design** toollbar, click Evaluate 2 Strings 'ev2'.

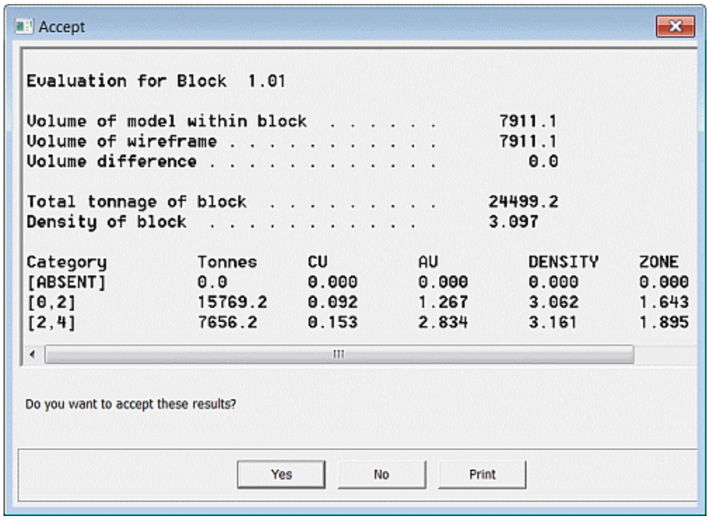
4. Following the prompts in the **Status Bar** (bottom left), select the footwall outline and then the hangingwall outline of the 1st cut, as shown below:



5. In the **Studio 3** dialog, define the *Mining Block Identifier* as '1.01' i.e. use the default value, click **OK**:



6. In the **Accept** dialog, compare your results to those shown below, click **Yes**:



When **Yes** is clicked, the results listed in the **Accept** dialog are saved to a new results table object called RESULTS.

Evaluating the Remaining Pairs of Outlines

1. Repeat steps 3. to 6. shown in the above section to evaluate the remaining 2 cuts for the northern block.
2. Increment the *Mining Block Identifier* by '0.01' for each evaluation i.e. '1.01, 1.02,...'

Other *Mining Block Identifier* numbering methods can be used as long as each identifier is unique e.g. '1, 2, 3, ...'.

3. Use the Pan Graphics view control and the above steps to evaluate the middle and southern sets.
4. Check that you have completed a total of 9 evaluations.

Saving the RESULTS Object

1. In the **Loaded Data** control bar, right-click on RESULTS , select **Data | Save As**.
2. In the **Save 3D Object** dialog, click **Single Precision Datamine(.dm) file**.
3. In the **Save RESULTS** dialog, browse to your project folder, define a new *File name* 'geres2.dm', click **Save**.

4. In the **Loaded Data** control bar, check that the RESULTS object has been renamed to geres2 (table).

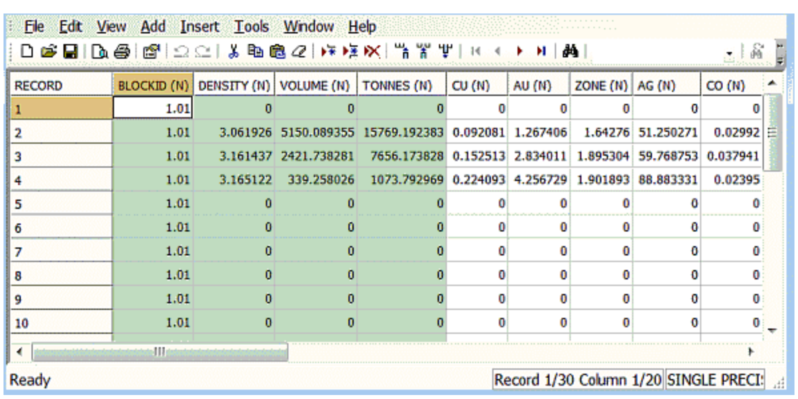
Saving the updated _caf5so Object

1. In the **Loaded Data** control bar, right-click on the _caf5so (strings) object, select **Data | Save As**.
2. In the **Save 3D Object** dialog, click **Single Precision Datamine(.dm) file**.
3. In the **Save** dialog, browse to your project folder, define a new *File name* 'caf6so.dm', click **Save**.
4. In the **Loaded Data** control bar, check that the _caf5so (strings) object has been renamed to caf6so.dm (strings).

> The saved outlines file caf6so.dm now contains an extra field (column) BLOCKID and block values; the evaluation results table also contains this field and values. This allows the results in the results table to be linked to the correct outline in the string file. This can be used to check results and join the results to the outlines using the process **JOIN**.

Checking the Results Table

1. Select the **Project Files** control bar, *Results* folder.
2. Right-click on geres2 and select Open.
3. In the **CAE Table Editor** dialog, check that your results are as follows:
   - the table contains a total of 90 records i.e. 10 records for each BLOCKID.
   - the evaluation has identified ore tonnage in the CATEGORY ranges '0,2', '2,4' and '2,6'.
4. Compare your results for BLOCKID '1.01', to those shown below:



RECORD	BLOCKID (N)	DENSITY (N)	VOLUME (N)	TONNES (N)	CU (N)	AU (N)	ZONE (N)	AG (N)	CO (N)
1	1.01	0	0	0	0	0	0	0	0
2	1.01	3.061926	5150.089355	15769.192383	0.092081	1.267406	1.64276	51.250271	0.02992
3	1.01	3.161437	2421.738281	7656.173828	0.152513	2.834011	1.895304	59.768753	0.037941
4	1.01	3.165122	339.258026	1073.792969	0.224093	4.256729	1.901893	88.883331	0.02395
5	1.01	0	0	0	0	0	0	0	0
6	1.01	0	0	0	0	0	0	0	0
7	1.01	0	0	0	0	0	0	0	0
8	1.01	0	0	0	0	0	0	0	0
9	1.01	0	0	0	0	0	0	0	0
10	1.01	0	0	0	0	0	0	0	0

5. In the **CAE Table Editor** dialog, select **File | Exit**.

> The Studio 3 process **MODRES** can also be used to generate a summary tonnes and grades results file from a grade block model. **TABRES** can then be used to tabulate the result file and generate an output system text file. See the Studio 3 Command Table in the Help documentation for a comprehensive list of Processes and their uses.

Interactive Evaluation - Wireframes

In this portion of the user guide you are going to evaluate a block model within a set of wireframe volumes interactively in the **Design** window, in order to generate summary tonnes and grades.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Created and applied an evaluation legend - exercises on the *Creating an Evaluation Legend* page.
- Defined evaluation settings - exercise on the *Defining Evaluation Settings* page.
- Files required for the exercises on this page:
  - _ubm5g
  - _uoretr / _uorept

Exercise: Interactive Evaluation using Wireframes

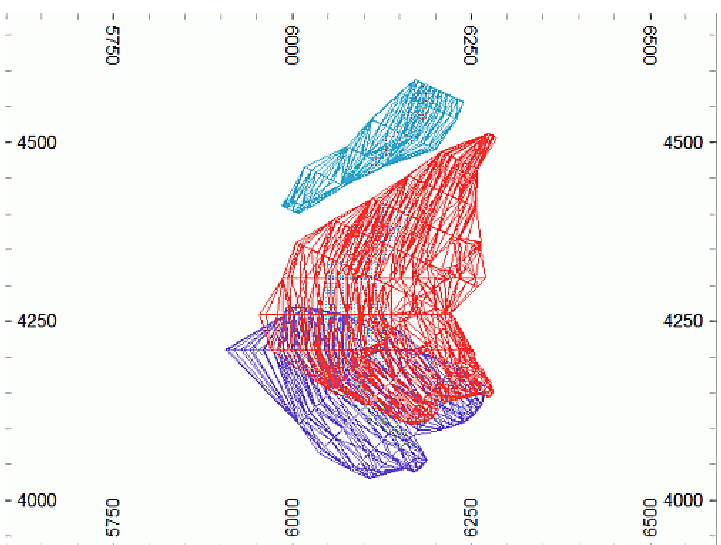
In this exercise you are going to evaluate the block model _ubm5g within the ore body wireframe _vsoretr / _vsorept in order to generate summary tonnes and grade. The tonnes and average grades will be calculated for the intervals defined in the evaluation legend Au Evaluation, which was created in a previous exercise.

Use **Wireframes** when evaluating:

- geological or ore body block models generated by wireframe volumes
- open pit mining blocks represented by wireframe volumes
- underground mining blocks represented by wireframe volumes
- underground mining development represented by wireframe volumes.

Loading the Block Model and Wireframe Data

1. Select the **Design** window.
2. Select the **Project Files** control bar.
3. Drag-and-drop the following block model and wireframe triangle file into the **Design** window:
   - _ubm5g
   - _uoretr
4. In the **Sheets** control bar, *Design-Overlays* folder, select only the following check boxes (i.e. display these objects) :
   - _ubm5g (block model)
   - _uoretr/_uorept (wireframe)
5. In the **View Control** toolbar, click Plane by One Point.
6. Click at any point in the **Design** window.
7. In the **Plane By One Point** dialog, select *Plan* , click **OK**.
8. In the **View Control** toolbar, click Zoom All Data.
9. In the **Design** window, check that you have the following data displayed i.e. a horizontal slice through the block model and the ore body wireframes :



Verifying the Wireframe

1. Select **Wireframes | Verify** 'wvf'.

2. In the **Verify Wireframe** dialog, *Name* group, select the *Name* [_uoretr/_uorept (wireframe)], select the Key Field [ZONE].

3. Define the remaining options:

    - **Store surface number**: enabled and set to [SURFACE] field
    - **Stop surface at shared edges**: enabled
    - **Remove duplicate vertices**: enabled (Tolerance = 0)
    - **Remove empty faces**: enabled
    - **Remove duplicate faces**: enabled
    - **Leave original**: enabled
    - **Check for open edges**: disabled
    - **Check for shared edges**: disabled
    - **Check for crossovers**: disabled
    - **Check for feature edges**: disabled
    - **Write normal to data table**: disabled
    - **Write adjacency to data table**: disabled
    - **Write crossovers to data table**: disabled

    ..and click **OK**:

4. In the **Verify Results Summary** dialog, click **OK**.

Unloading any Existing Results Tables

1. Select the **Loaded Data** control bar.

2. Right-click on an existing results table, e.g. geres2 from the string pairs evaluation exercise, select **Data | Unload**.

Evaluating the Wireframe

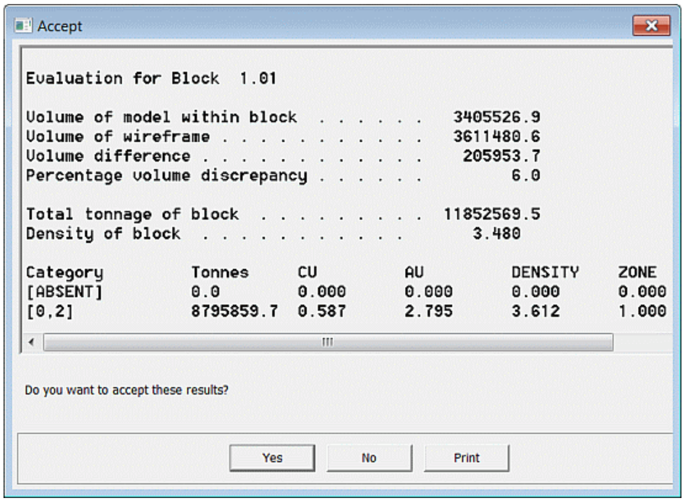
1. In the **Mine Design** toollbar, click Evaluate Wireframe or, select **Models | Evaluate | Wireframe** 'evw'.

2. In the **Evaluate Wireframe** dialog, *Wireframe Object* group, select [_uoretr/_uorept (wireframe)].

3. In the *Type* group, select the *Closed Volume* option, click **OK**.

4. In the **Studio 3** dialog, *Block Identifier* group, define the *Mining Block Identifier:* as '1.01', click **OK**.

5. In the **Accept** dialog, compare your results to those shown below, click **Yes**:



When **Yes** is clicked, the results listed in the **Accept** dialog are saved to a new results table object called RESULTS.

Saving the RESULTS Object

1. In the **Loaded Data** control bar, right-click on RESULTS , select **Data | Save As**.

2. In the **Save 3D Object** dialog, click **Single Precision Datamine(.dm) file**.

3. In the **Save** dialog, browse to your project folder, define a new *File name* 'geres3.dm', click **Save**.

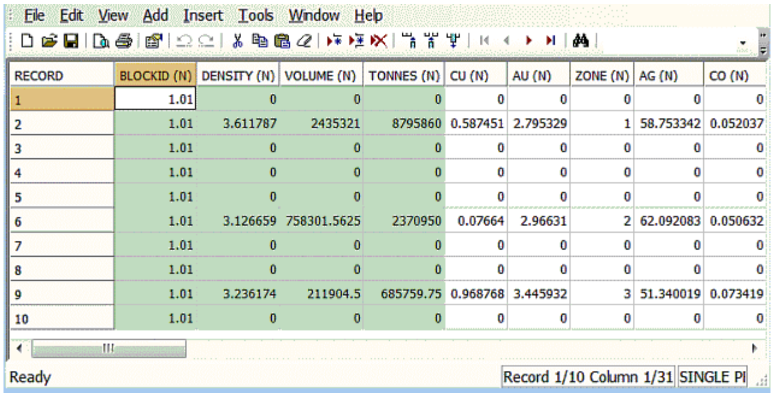
4. In the **Loaded Data** control bar, check that the RESULTS object has been renamed to geres3 (table).

Checking the Results Table

1. Select the **Project Files** control bar, *Results* folder.

2. Right-click on geres3 , select Open.

3. In the **CAE Table Editor** dialog, check that your results are as shown below:



File Edit View Add Insert Tools Window Help

RECORD	BLOCKID (N)	DENSITY (N)	VOLUME (N)	TONNES (N)	CU (N)	AU (N)	ZONE (N)	AG (N)	CO (N)
1	1.01	0	0	0	0	0	0	0	0
2	1.01	3.611787	2435321	8795860	0.587451	2.795329	1	58.753342	0.052037
3	1.01	0	0	0	0	0	0	0	0
4	1.01	0	0	0	0	0	0	0	0
5	1.01	0	0	0	0	0	0	0	0
6	1.01	3.126659	758301.5625	2370950	0.07664	2.96631	2	62.092083	0.050632
7	1.01	0	0	0	0	0	0	0	0
8	1.01	0	0	0	0	0	0	0	0
9	1.01	3.236174	211904.5	685759.75	0.968768	3.445932	3	51.340019	0.073419
10	1.01	0	0	0	0	0	0	0	0

Ready | Record 1/10 Column 1/31 | SINGLE PI

With reference to the above image:

- Ignore the results listed in the ZONE and TONNESA columns.
- Tonnes and average grades have been calculated per grade category (in this case the AU ranges defined in the Au Evaluation legend) listed in the column CATEGORY (on the right side of the table).
- The TONNES column contains the total tonnes evaluated in a specific category (column CATEGORY).
- The results shown above are for a Partial Cell evaluation. Evaluation using the Full Cell option will produce different results.

3. In the **CAE Table Editor** dialog, select **File | Exit**.

The Studio 3 process **MODRES** can also be used to generate a summary tonnes and grades results file from a grade block model. **TABRES** can then be used to tabulate the result file and generate an output system text file. See the Studio 3 Command Table in the Help documentation for a comprehensive list of Processes and their uses.

Grade-Tonnage Reports

In this portion of the user guide you are going to use the process **TONGRAD** to evaluate a block model and generate a cut-off grades results table.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Created and applied an evaluation legend - exercises on the *Creating an Evaluation Legend* page.
- Defined evaluation settings - exercise on the *Defining Evaluation Settings* page.
- Files required for the exercises on this page:
    - _ubm5g

Exercise: Creating a Grade-Tonnage Report using TONGRAD

In this exercise you are going to use the grade block model _ubm5g and the process **TONGRAD** to generate a cut-off grades results table. The tonnes and average grades will be saved to the results file geres4 and calculated for 10 cut-off intervals, each 2 g/t in size.

What is a Tonnage Grade Report?

- A table containing tonnes and average grades that have been calculated above a series of cut-off grades (typically for equally sized grade intervals)
- This cut-off grades results table can be used to directly generate a grade-tonnage curve i.e. typically a combined plot of Tonnage (Y axis 1) vs Cut-off Grade and Average Grade Above Cutoff (Y axis 2) vs Cut-off Grade

Use **TONGRAD** for evaluating when generating:

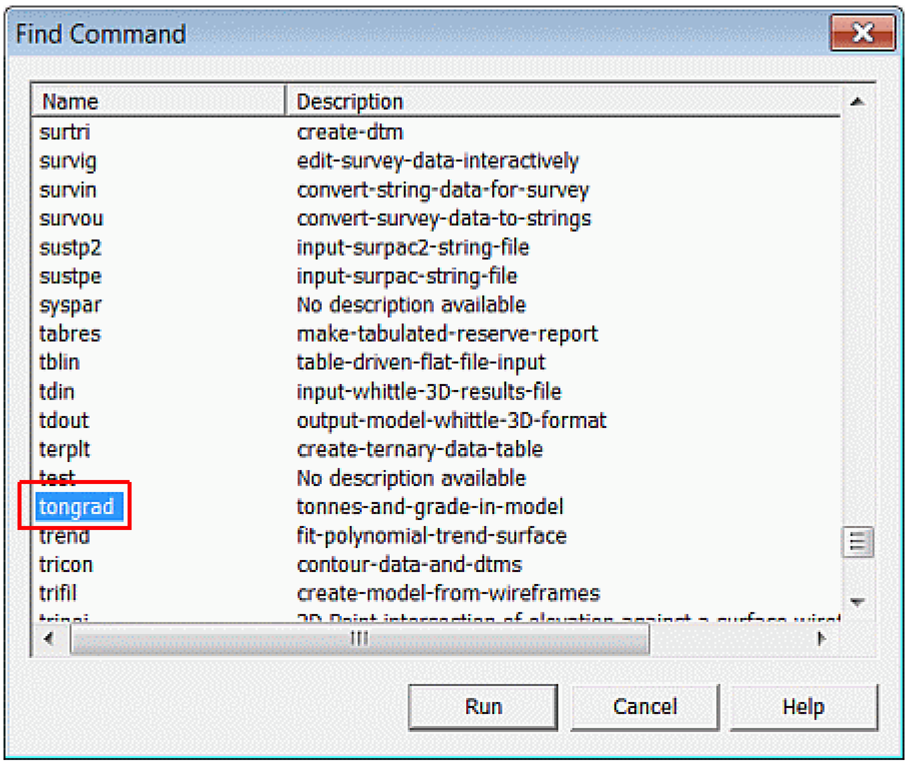
- an evaluation for a specific cut-off grade(s)
- generating Grade-Tonnage tables or charts.

Evaluating the Block Model

1. In the **Command** toolbar, click Find Command.

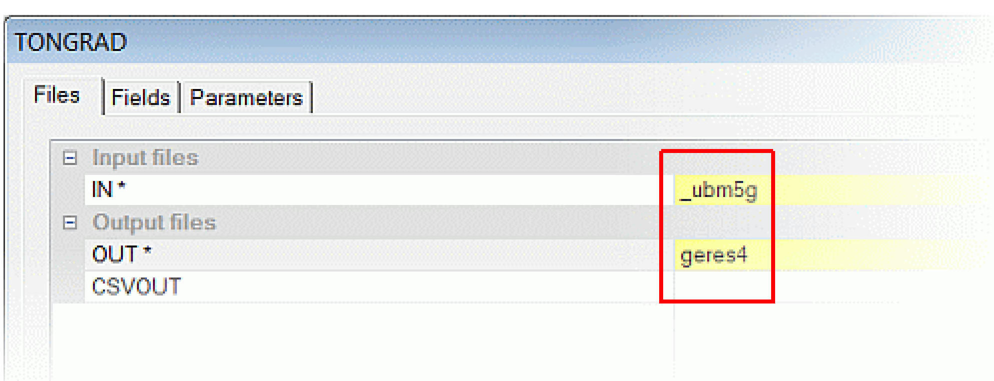
2. In the **Find Command** dialog, drag the vertical slider bar down to the very bottom and then page up by clicking in the space above the slider bar (x1).

3. In the *Name* column, select the command *tongrad* , click **Run**:



4. In the **TONGRAD** dialog, *Files* tab, *Input files* group, set *IN** by browsing for and selecting the file *_ubm5g*.

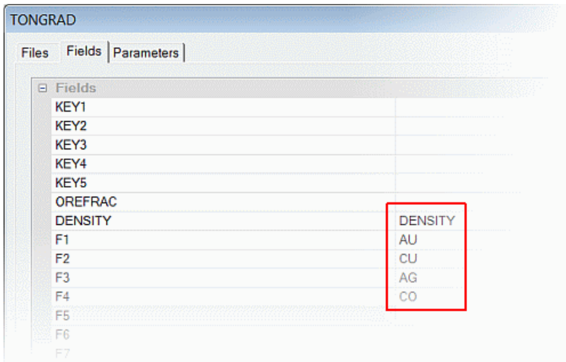
5. In the *Output files* group, define a new *OUT** file 'geres4'.



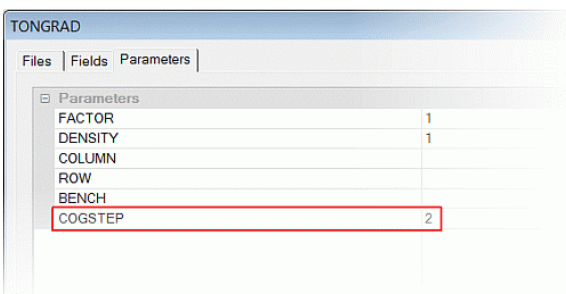
The optional CSVOUT output file is a Comma Separated Variable (CSV) file, suitable for input to a spreadsheet. The extension .CSV is added automatically. This system file is automatically saved to the project folder.

6. In the *Fields* tab, select the *DENSITY* field [DENSITY].

7. Select : the *F1* field [AU], the *F2* field [CU], the *F3* field [AG] and the *F4* field [CO]

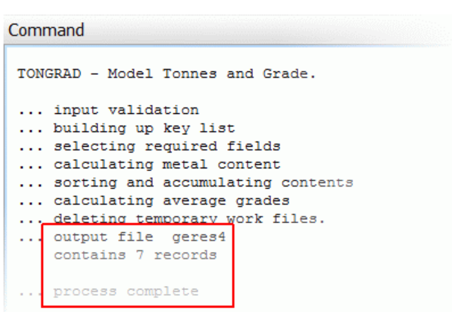


8. In the *Parameters* tab, define *COGSTEP* as '2' , click **OK**:



The COGSTEP cut-off grade step parameter applies to the selected F1 field, in this case AU.

9. Select the **Command** control bar, check that **TONGRAD** has run to completion and that the output file contains 7 records, as shown below:

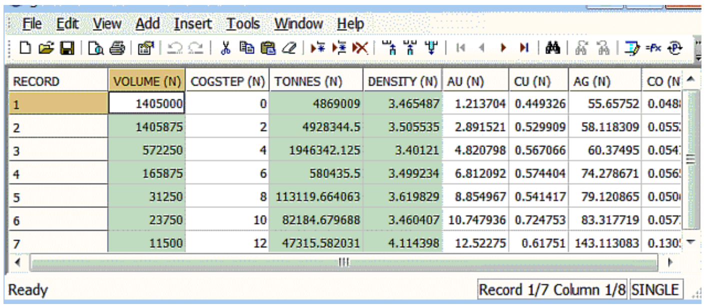


Checking the Results Table

1. Select the **Project Files** control bar, *Results* folder.

2. Right-click on geres4 , select Open.

3. In the **CAE Table Editor** dialog, check that your results are as shown below:



RECORD	VOLUME (N)	COGSTEP (N)	TONNES (N)	DENSITY (N)	AU (N)	CU (N)	AG (N)	CO (N
1	1405000	0	4869009	3.465487	1.213704	0.449326	55.65752	0.048
2	1405875	2	4928344.5	3.505535	2.891521	0.529909	58.118309	0.055
3	572250	4	1946342.125	3.40121	4.820798	0.567066	60.37495	0.054
4	165875	6	580435.5	3.499234	6.812092	0.574404	74.278671	0.056
5	31250	8	113119.664063	3.619829	8.854967	0.541417	79.120865	0.050
6	23750	10	82184.679688	3.460407	10.747936	0.724753	83.317719	0.057
7	11500	12	47315.582031	4.114398	12.52275	0.61751	143.113083	0.130

> The results shown above are for a Full Cell evaluation. **TONGRAD** does not have a Partial Cell evaluation option. Differences in the evaluation results from the different methods i.e. using Wireframes, Strings and Studio 3 processes, are to be expected.

4. In the **CAE Table Editor** dialog, select **File | Exit**.

> The Studio 3 process **SMUHIS** can also be used to generate cut-off grade results tables. It includes the ability to generate results for different SMU sizes. The input to this process is typically a grade block model and a variogram model file. See the Studio 3 Command Table in the Help documentation for a comprehensive list of Processes and their uses.

GRADE-TONNAGE CURVES

In this portion of the user guide you are going to use the **Studio 3** product **Mining Power Pack** to create grade-tonnage curves from a cut-off grades results table.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Project* page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Files required for the exercises on this page:
    - _geres4

Exercise: Creating Grade-Tonnage Curves Using MPP

In this exercise you are going to use **Mining Power Pack** and the cut-off grade results table _geres4, (output from the **TONGRAD** process) to generate a set of grade-tonnage curves. The table contains results for calculated for 10 cut-off intervals, each 2 g/t in size.

What is a Tonnage Grade Curve?

- Grade-Tonnage curves are plots of average grades and tonnes for a range of cut-offs.
- These plots can have a variety of formats e.g.:
    - Average Grade Above Cutoff (Y axis) vs Tonnes (X axis), for the range of cutoffs at a specific block size
    - A combined plot of Tonnage (Y axis 1) vs Cut-off Grade (X axis) and Average Grade Above Cutoff (Y axis 2) vs Cut-off Grade.
- This grade-tonnage curve can either be generated from a standard results table or a cut-off grades results table. The former is output when strings or wireframes are evaluated against a grade block model, while the latter is output from the **Studio 3** processes **TONGRAD** or **SMUHIS**.

What is Mining Power Pack?

- **Mining Power Pack** (2010) is an Add-In for **MS Excel 2010®**, primarily focused on providing utilities for working with geological and mining-related data within Excel.
- It is not automatically installed along with **Studio**, but needs to be installed separately.

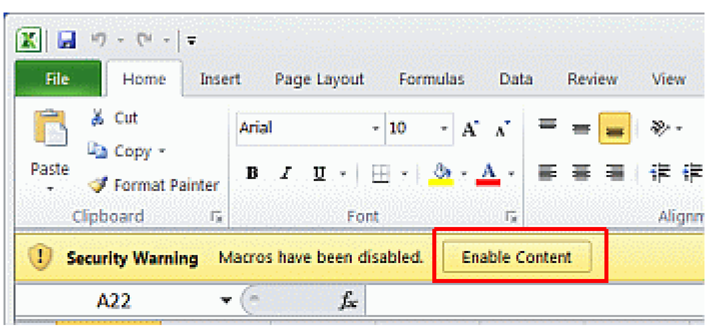
- Most of the utilities enable the rapid processing and manipulation of mining evaluation data. In particular, the facilities in Mining Power Pack enable automatic weighting of mineral grade values, which otherwise are only obtained in Excel by a tedious and time-consuming entry of functions cell-by-cell. These capabilities complement the existing standard Excel functionality.

Use **Mining Power Pack** for:

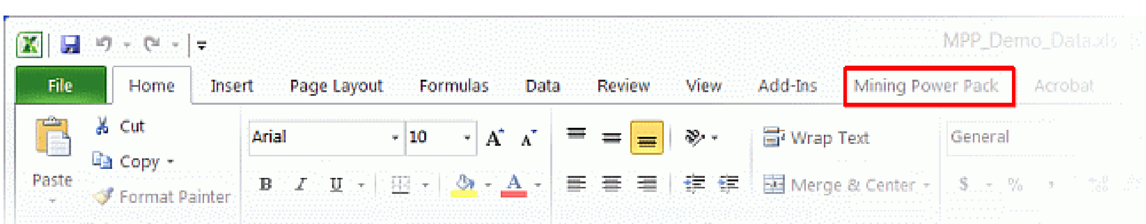
- Tabulation, combination and calculations with mining and geological data.
- Grade-tonnage curve generation and analysis.
- Color-coding of mining and geological data.
- Mining and geological unit conversion.
- Analysis of graphs depicting mining and geological data.

Starting Mining Power Pack

1. Select the **Design** window.
2. Select **Tools | CAE Products | Mining Power Pack**.
3. In **Excel**, on the **Message Bar**, click **Enable Content**.



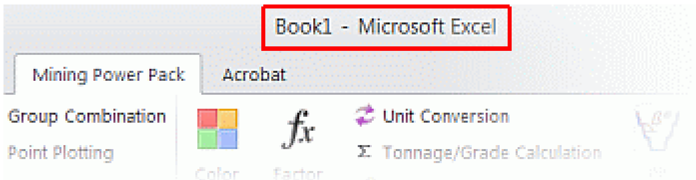
4. In **Microsoft Excel**, check that the Mining Power Pack menu bar item is displayed:



Inserting a New Worksheet

1. Select **File| New** , then double-click **Blank Workbook**.

2. In the title bar, check that a new worksheet has been created, as shown below:



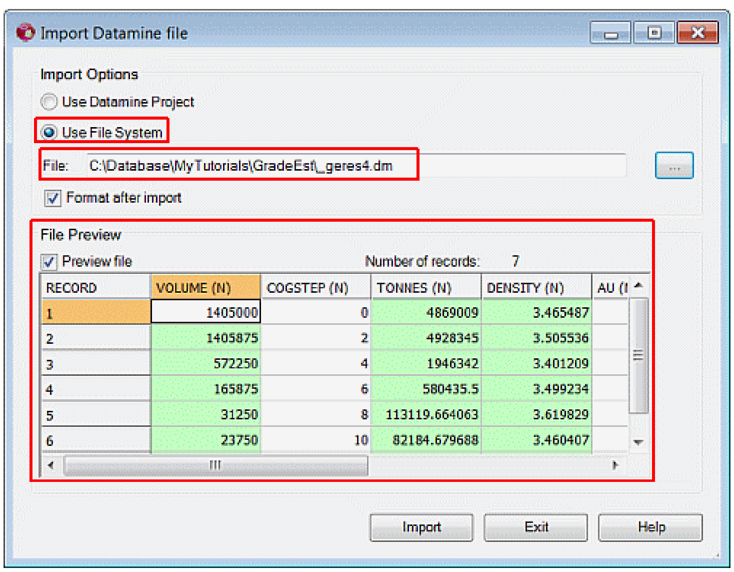
Importing a Datamine Table

1. Select Mining Power Pack| Import/Export | Import Datamine File.

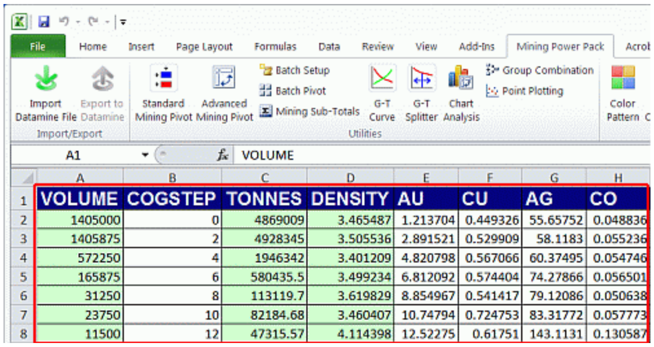
2. In the **Import Datamine File** dialog, *Import Options* group, select the *Use File System* option.

3. Set *File:* by browsing for and selecting the file *C:\Database\MyTutorials\GradeEst_geres4.dm*.

4. Check the file contents in the *File Preview* pane, click **Import**:



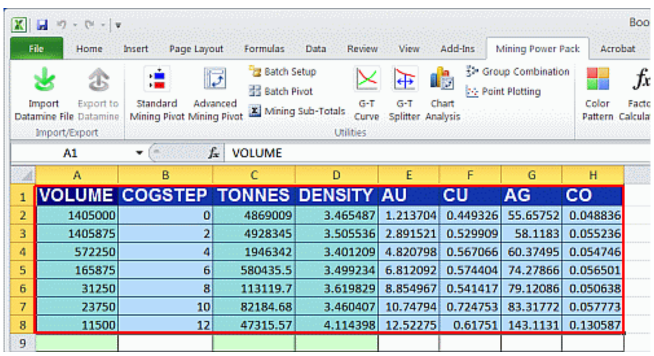
5. In Excel, check that the 8 rows (including the header) and 8 columns of the **Datamine** table have been imported, as shown below:



VOLUME	COGSTEP	TONNES	DENSITY	AU	CU	AG	CO
1405000	0	4869009	3.465487	1.213704	0.449326	55.65752	0.048836
1405875	2	4928345	3.505536	2.891521	0.529909	58.1183	0.055236
572250	4	1946342	3.401209	4.820798	0.567066	60.37495	0.054746
165875	6	580435.5	3.499234	6.812092	0.574404	74.27866	0.056501
31250	8	113119.7	3.619829	8.854967	0.541417	79.12086	0.050638
23750	10	82184.68	3.460407	10.74794	0.724753	83.31772	0.057773
11500	12	47315.57	4.114398	12.52275	0.61751	143.1131	0.130587

Creating a New Chart

1. In the **_geres4.dm** worksheet, select the range *A1:H8*, as shown below:

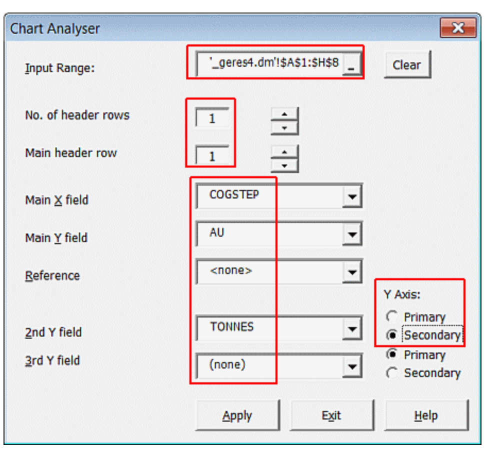


VOLUME	COGSTEP	TONNES	DENSITY	AU	CU	AG	CO
1405000	0	4869009	3.465487	1.213704	0.449326	55.65752	0.048836
1405875	2	4928345	3.505536	2.891521	0.529909	58.1183	0.055236
572250	4	1946342	3.401209	4.820798	0.567066	60.37495	0.054746
165875	6	580435.5	3.499234	6.812092	0.574404	74.27866	0.056501
31250	8	113119.7	3.619829	8.854967	0.541417	79.12086	0.050638
23750	10	82184.68	3.460407	10.74794	0.724753	83.31772	0.057773
11500	12	47315.57	4.114398	12.52275	0.61751	143.1131	0.130587

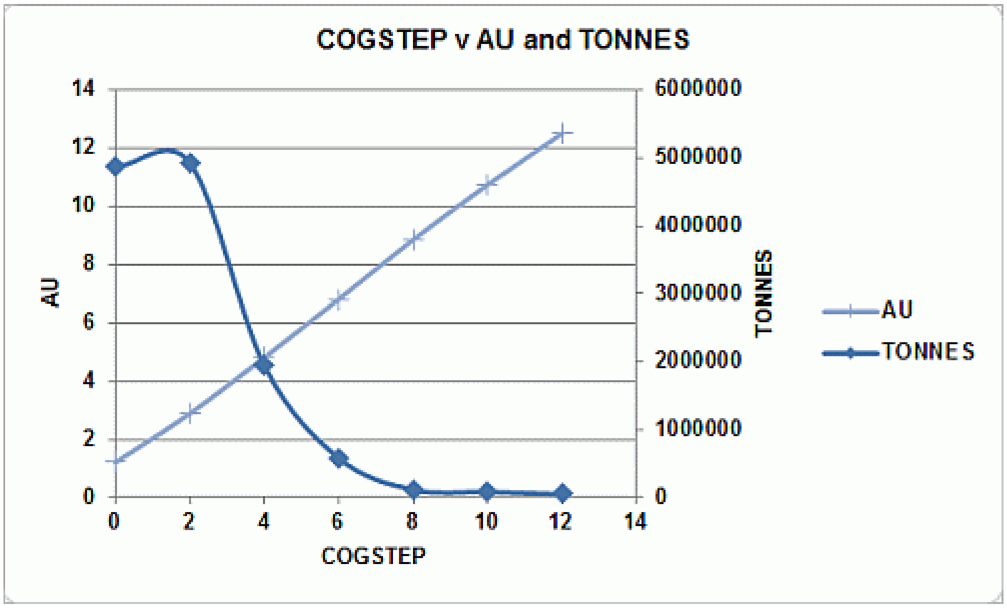
2. Select Mining Power Pack| Utilities | Chart analysis.

3. In the **Chart Analyser** dialog, check that the *Input Range:* is set to *'_geres4.dm'!$A$1:$H$8* .

4. Define the settings as shown below, click **Apply**:



5. Check that your chart has been generated as shown below:



6. In the **Chart Analyser** dialog, click **Exit**.

> Grade-Tonnage curves can also be created in Mining Power Pack using the following method:
>
> - Importing a standard results table i.e. not a cut-off grade results table.
> - Using the menu option Mining Power Pack| Utilities | Grade-Tonnage Curve.

Saving the Project and Exiting Mining Power Pack

1. Select **File | Save As**.
2. In the **Save As** dialog, browse to your project folder, define a new *File name* 'GTCurves1.xlsx', click **Save**.
3. Select **File |Exit**.
4. In the **Microsoft Excel** prompt dialog, click **Don't Save**.

> The grade-tonnage table and the grade-tonnage curve can be embedded in Word documents or printed.

Creating Plot Sheets

In this portion of the user guide you are going to be introduced to the general procedures and tools, used in the **Plots** window, to create and enhance a basic plot sheet. It is suggested that all four of the exercises on this page are completed in the order shown below.

Prerequisites

- Created a new project and added all the required files - exercises on the *Creating a New Grade Estimation Projec*t page.
- Displayed toolbars and defined project settings - exercises in the *Displaying Grade Estimation Toolbars* and *Defining Settings* pages.
- Files required for the exercises on this page:
    - _srfsamp
    - _ostopo
    - _2dgmod4
    - _2dres1

Exercise: Creating a new Plot Sheet

In this exercise you are going to create a new plan view plot sheet in the **Plots** window and display the following data:

- _srfsamp - surface sampling point data
- _ostopo - topography contours
- _2dgmod4 - 2D block model
- _2dres1 - evaluation results table.

Loading the Existing Data

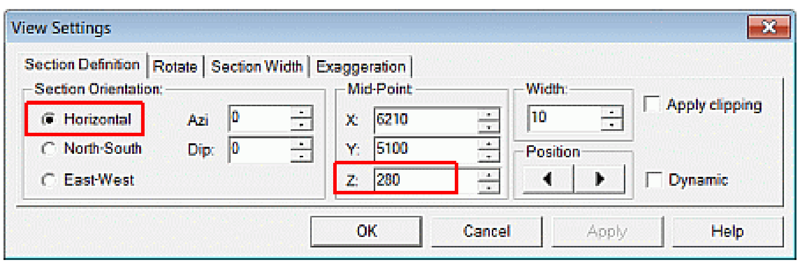
1. Select the **Design** window.
2. Select **Edit | Unload All Data**.
3. Select the **Project Files** control bar.
4. Drag-and-drop the following files into the **Design** window:
    - _2dgmod4

- _2dres1
- _ostopo
- _srfsamp

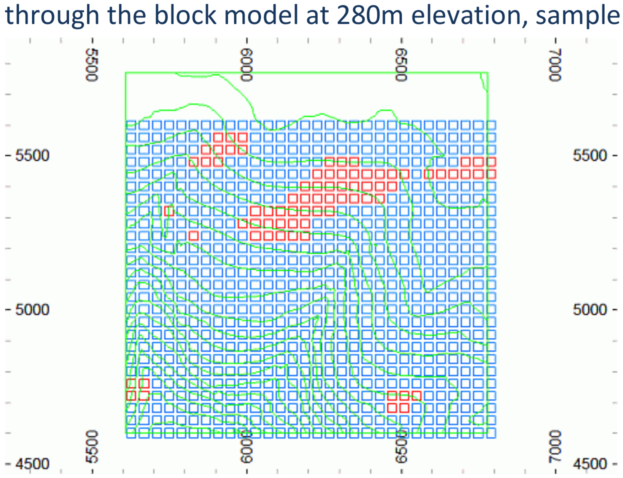
5. In the **Sheets** control bar, *Design-Overlays* folder, select only the following check boxes (i.e. display these objects) :

    - Default grid
    - _srfsamp (points)
    - _ostopo (strings)
    - _2dgmod4 (block model)

6. In the **View Control** toolbar, click View Settings.
7. In the **View Settings** dialog, *Section Definition* tab, *Section Orientation* group, select *Horizontal*.
8. In the *Mid-Point* group, define the *Z:* elevation as '280', click **OK**:



9. In the **View Control** toolbar, click Zoom Extents.
10. In the **Design** window, check that you have the following data displayed i.e. a horizontal slice through the block model at 280m elevation, sample points and topography contours.

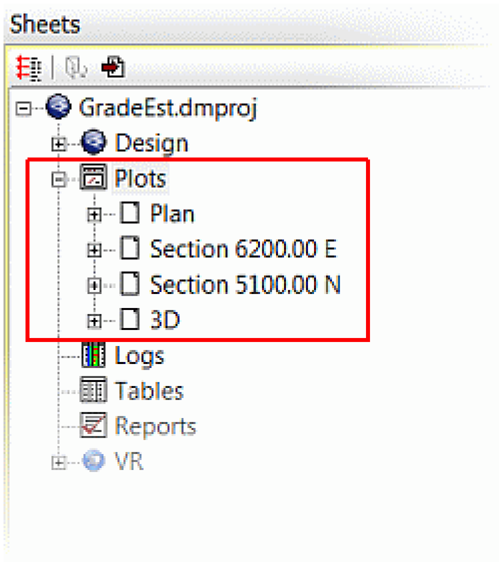


Creating a New Plot Sheet

1. Select the **Plots** window.

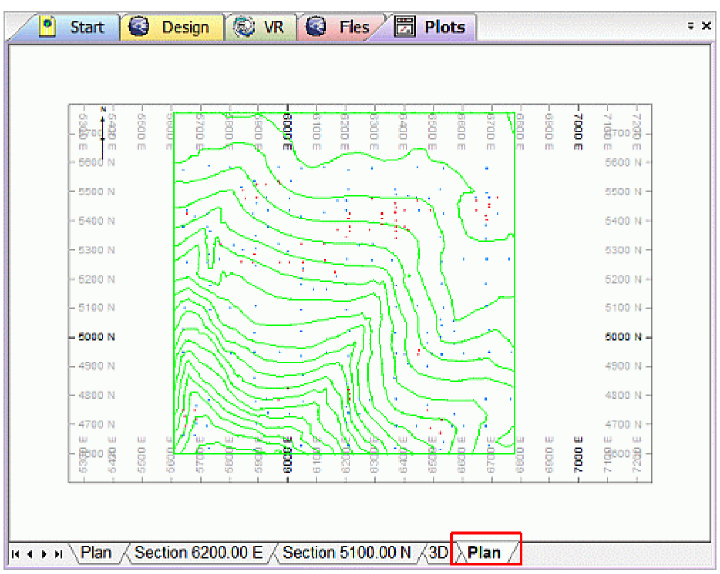
2. In the **Sheets** control bar, close the *Design* folder, expand the *Plots* folder.

3. Check that the *Plots* folder contains the following 4 standard sheets:

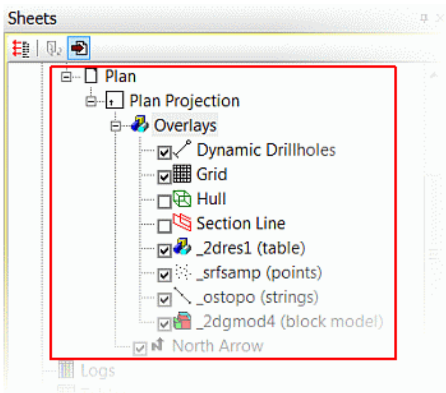


4. Select **Insert | Sheet | Plot | Plan**.

5. In the **Plots** window, check that the new *Plan* sheet tab is selected and displayed:



6. In the **Sheets** control bar, *Plots* folder, expand the new *Plan-Overlays* folder and check that you have the following:



Exercise: Setting View, Page Orientation and Scale options

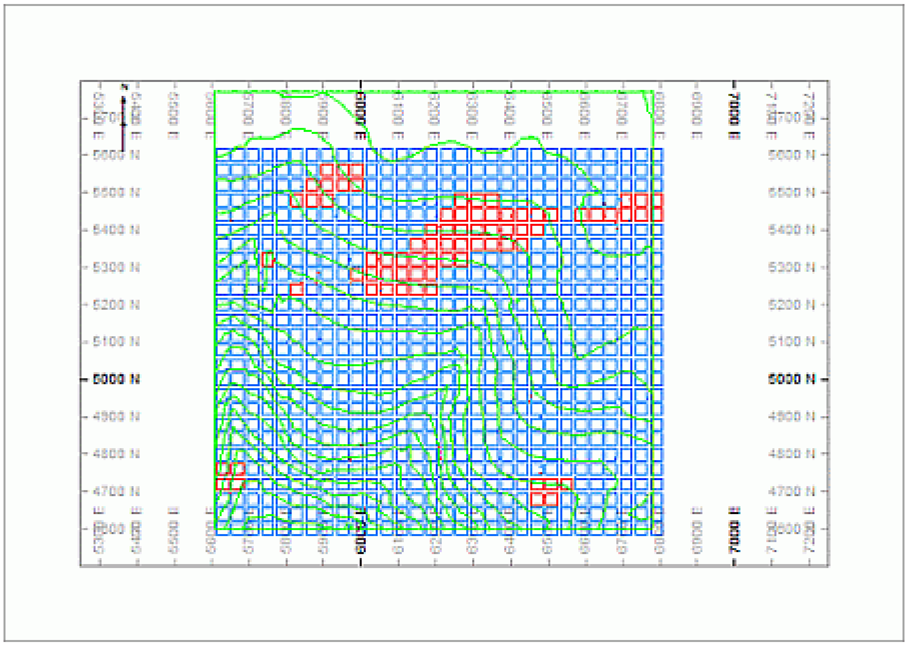
> This exercise follows on directly from the previous exercise and assumes that it has been completed.

In this exercise you are going to define the following options:

- a horizontal view at 280m elevation without clipping
- a portrait page layout
- a plot scale of 1:10000.

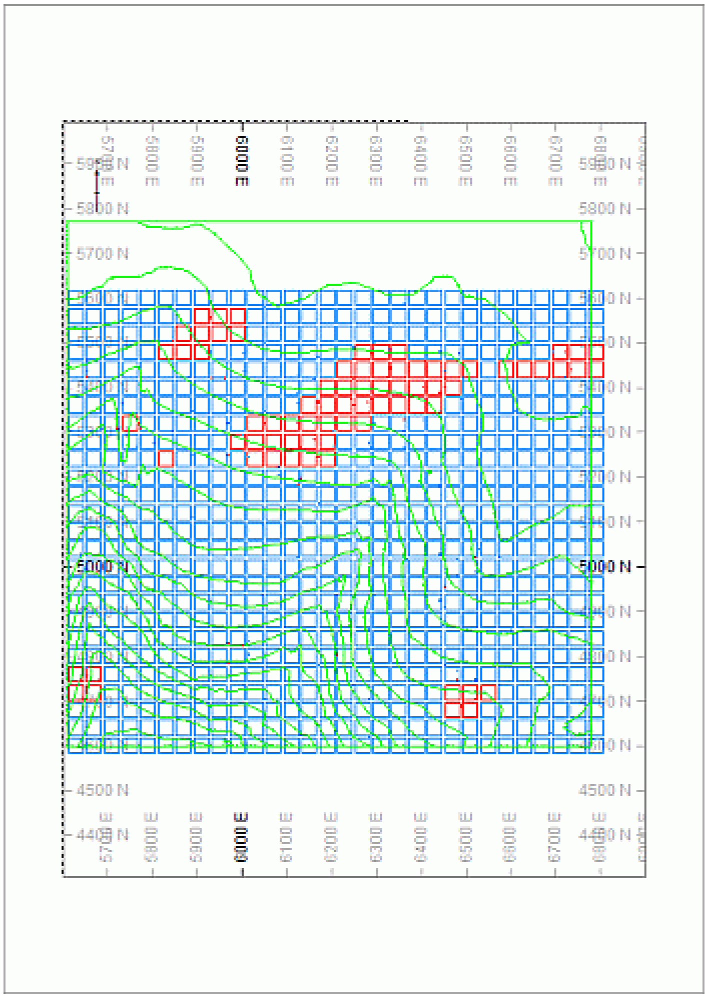
Setting View Parameters

1. In the **Plots** window, select the new *Plan* sheet.
2. In the **Section** toolbar, click Define Section.
3. In the **View Settings** dialog, *Section Definition* tab, *Section Orientation* group, select *Horizontal*.
4. In the *Mid-Point* group, define the *Z:* elevation as '280', clear the *Apply Clipping* check box, click **OK**.
5. In the **Plots** window, new *Plan* sheet, check that your sheet is as shown below:



Defining a Portrait Page Orientation and Scale

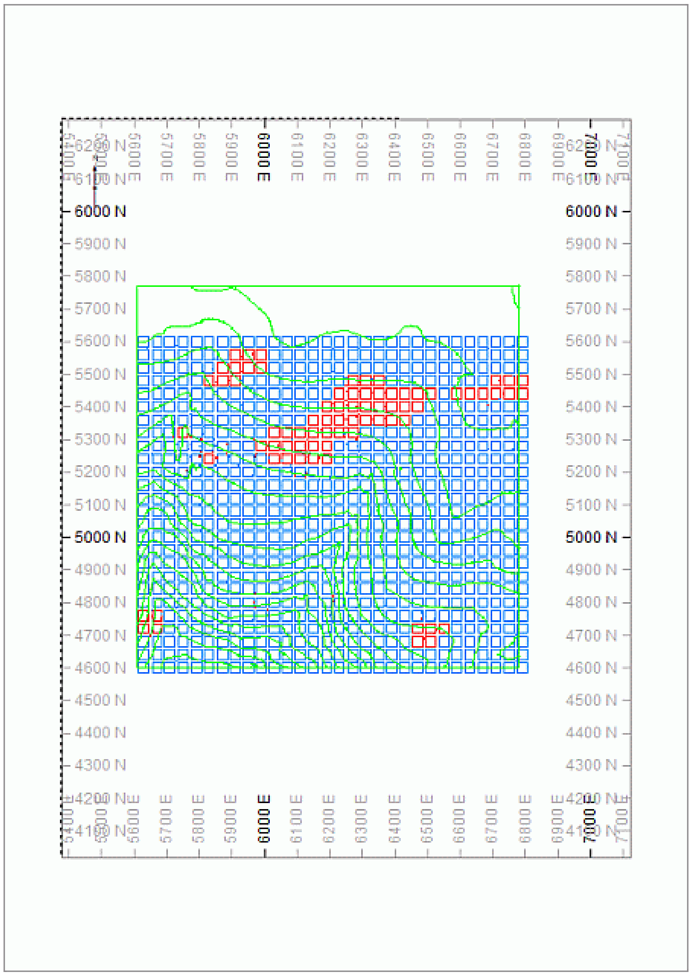
1. In the **Sheets** control bar, right-click on the new *Plan* folder, select **Plan Properties...**.
2. In the **Plan** dialog, *Page Size* tab, *Paper Size and Orientation* group, select the *Portrait* option, click **OK**.
3. In the **Studio 3** 'Rescale all plot items?' confirmation dialog, click **Yes**.
4. In the new *Plan* sheet tab, click inside the plan projection frame, so that it displays as dashed lines:



The above step ensures that the necessary toolbars are active.

5. In the **Scale View** toolbar, *Plot Scale* drop down, select *1:10000*.

6. Check that your sheet appears as shown below:



Exercise: Formatting the Overlays

> This exercise follows on directly from the previous exercise and assumes that it has been completed.

In the exercise you are going to format the overlays by:

- coloring the block model with a new default Au legend
- colouring the contour strings a fixed colour
- labeling the contour strings with the elevation field _Z_COORD .

Formatting the Grade Block Model

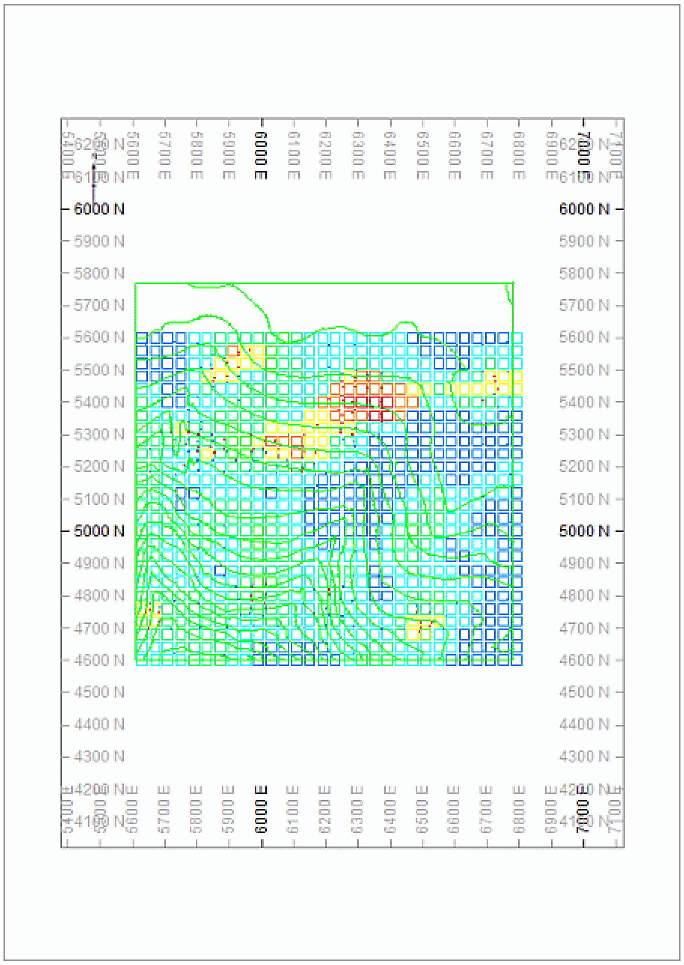
1. In the **Sheets** control bar, *Plan-Overlays* folder, double-click *_2dgmod4 (block model)*.

2. In the **Format Display** dialog, *Overlay Format* group, *Color* subtab, select the *Legend* option.

3. Select the *Column:* [AU], click **Use Default Legend**.

4. Click **Apply** (do not close the dialog).

5. Check that the block model has been colored as shown below:



Formatting the Contour Strings

1. In the **Format Display** dialog, *Overlay Objects* group, select the overlay *_ostopo (strings)*.

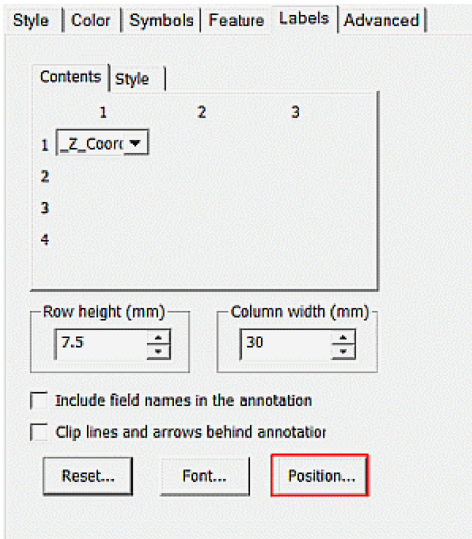
2. In the *Overlay Format* group, *Color subtab*, *Color group*, select the *Fixed* option and the *Color* [Black].

3. Click **Apply** (do not close the dialog).

4. In the *Overlay Format* group, *Labels* subtab, click **Reset...**.

5. In the **Reset Labels** dialog, *Labels to include* group, select *_Z_Coord* from the list (tick the box), click **OK**.

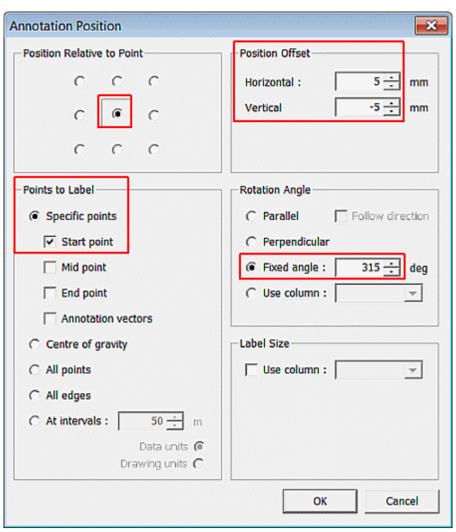
6. In the *Labels* subtab, click **Position...**.



7. In the **Annotation Position** dialog, *Points to label* group, select the *Specific Points* option, select *Start Point*.

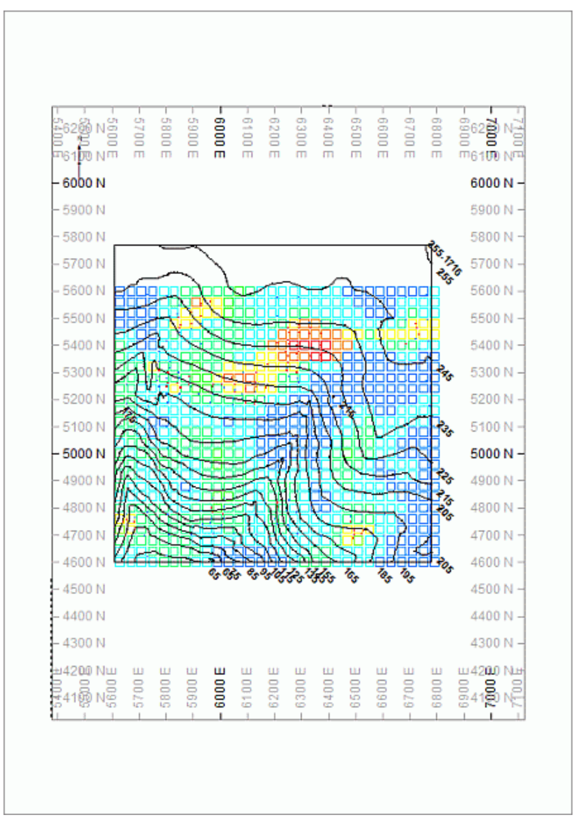
8. In the *Rotation Angle* group, select *Fixed Angle* and define the angle as '315' degrees.

9. In the *Position Offset* group, define the *Horizontal* offset as '5' mm, define the *Vertical* offset as '-5' mm, click **OK**:



10. In the *Labels* subtab, select the *Style* subtab, click **_Z_Coord**:

11. In the **Format for _Z_Coord** dialog, *Text* tab, select *Show Text*.
12. In the *Style* group, select *Bold*.
13. In the *Font Size* group, clear the *Use Defaults* check box, select [7].
14. In the *Color* group, select the *Fixed Color option,* select the color [Black], click **OK**.
15. Back in the **Format Display** dialog, click **Apply** and **OK**.
16. In the new *Plan* sheet, check that the contour strings have been colored and annotated as shown below:



Exercise: Inserting Plot Items

> This exercise follows on directly from the previous exercise and assumes that it has been completed.

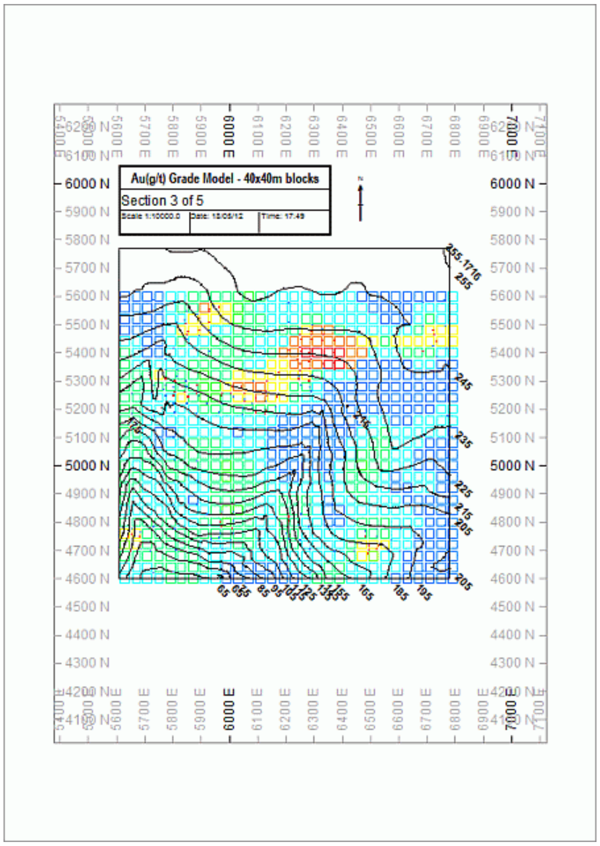
In this exercise you are going to enhance the plot by inserting the following plot items:

- Title Box
- Scale bar
- Evaluation results table.

Inserting a Title Box

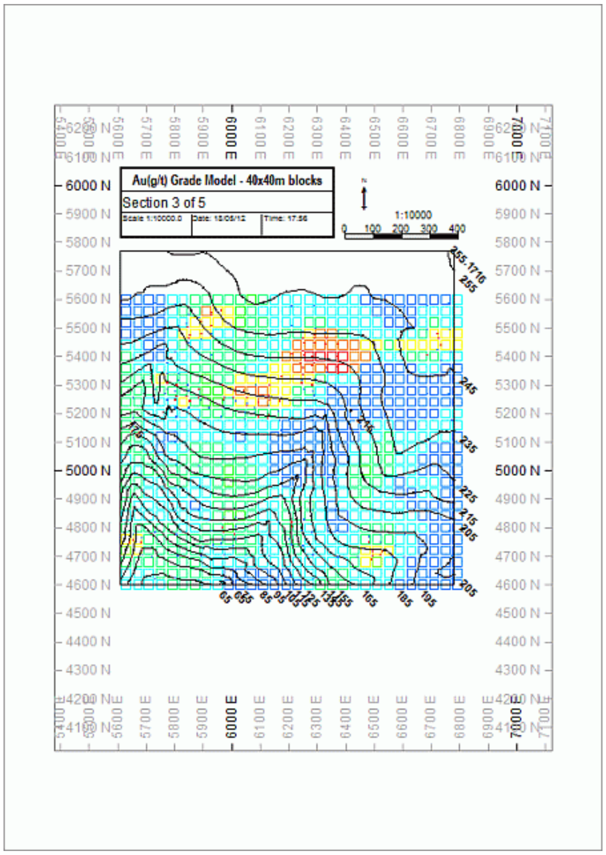
1. Select the **Plots** window.
2. Select the new *Plan* sheet tab.
3. Select **Insert | Plot Item | Title Box**.
4. In the **Title Box** dialog, *Contents* tab, select *Row* [1], select *Cell* [1], click **Contents...**.
5. In the **Cell Contents** dialog, *Category* group, select the *Static* option.
6. In the *Value* group, type 'Au(g/t) Grade Model - 40x40m blocks' in the text box, click **Apply** and **OK**.
7. Back in the **Title Box** dialog, click **Format...**.
8. In the **Cell Format** dialog, *Font* group, clear the *Use default font* check box, click **Modify...**.
9. In the **Font** dialog, *Font style:* list, select *Narrow Bold*.
10. In the *Size:* list, select *8 ,* click **OK**.
11. Back in the **Cell Format** dialog, click **OK**.
12. Back in the **Title Box** dialog, click **Apply** and **OK**.
13. In the plot sheet, select (click in the first row) and drag the Title Box to the top left of the contour data outline.
14. Drag the *North Arrow* to the right of the *Title Box*.
15. Double-click the *North Arrow*.
16. In the *North Arrow* dialog, select *Bold*, click **OK**.

17. Check that your plot is similar to that shown below:



Inserting a Scale Bar

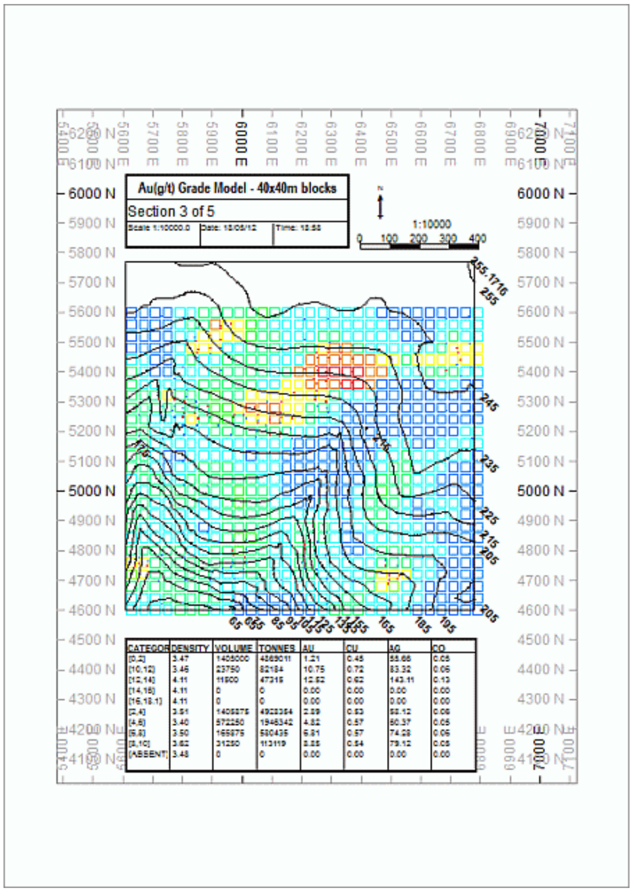
1. Select **Insert | Plot Item | Scale Bar**.
2. In the **Scale Bar Properties** dialog, select the *Color* [Black], click **Font**.
3. In the **Font** dialog, define the *Size* as '6', click **OK**.
4. Back in the **Scale Bar Properties** dialog, click **Finish**.
5. Drag the Scale Bar to just right of the top right of the contour data boundary.
6. Click outside the plot area and check that your plot is similar to that shown below:



Inserting a Results Table

1. Select **Insert | Plot Item | Table...**.
2. In the **Table** dialog, select *_2dres1 (table)* from the list, click **OK**.
3. Click inside the first table row (four headed arrow) and drag the Table to below the contour data boundary.
4. Increase the horizontal and vertical sizes of the Table by using the grabs.
5. Right-click in the Table and select **Table Properties...**.
6. In the **Table** dialog, *Contents* tab, clear the *Title Row* check box.
7. In the *Headings* group, click **Format...**.
8. In the **Cell Format** dialog, *Font:* group, clear the *Use default font* check box, click **Modify...**.
9. In the **Font** dialog, *Font style:* list, select *Narrow Bold*.
10. Define the *Size:* as '6', click **OK**.

11. Back in the **Cell Format** dialog, click **Apply** and **OK**.
12. Back in the **Table** dialog, in the *Columns* group, use **Delete** and **Up** to order or remove all but the following columns:
    - CATEGORY
    - DENSITY
    - VOLUME
    - TONNES
    - AU
    - CU
    - AG
    - CO
13. In the *Columns* group, select the *CATEGORY* column from the list, click **Format...**.
14. In the **Format for CATEGORY** dialog, *Text* tab, *Font Size* group, clear the *Use Defaults* check box, select [5].
15. In the *Color* group, select the *Fixed Color option,* select [Black].
16. In the *Number Format* group, select the *Decimal Places* option, select [2], click **OK**.
17. Repeat steps 13. to 16. for the remaining columns, the only exception, using the *Integer* format for the VOLUME and TONNES columns.
18. Back in the **Table** dialog, *Define Index* tab, select the *Column* CATEGORY and move it across to the *Index* list.
19. Click **Apply** and **OK**.
20. In the plot sheet, press <Esc> to deselect the plot items, check that your plot sheet is similar to that shown below:



21. Select **File | Save** or, click Save on the **Standard** toolbar.

This concludes the Studio 3 Grade Estimation User Guide. If you have comments about the content of this document, or any other enquiries relating to Grade Estimation in Studio 3, please contact your local CAE Mining office.

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