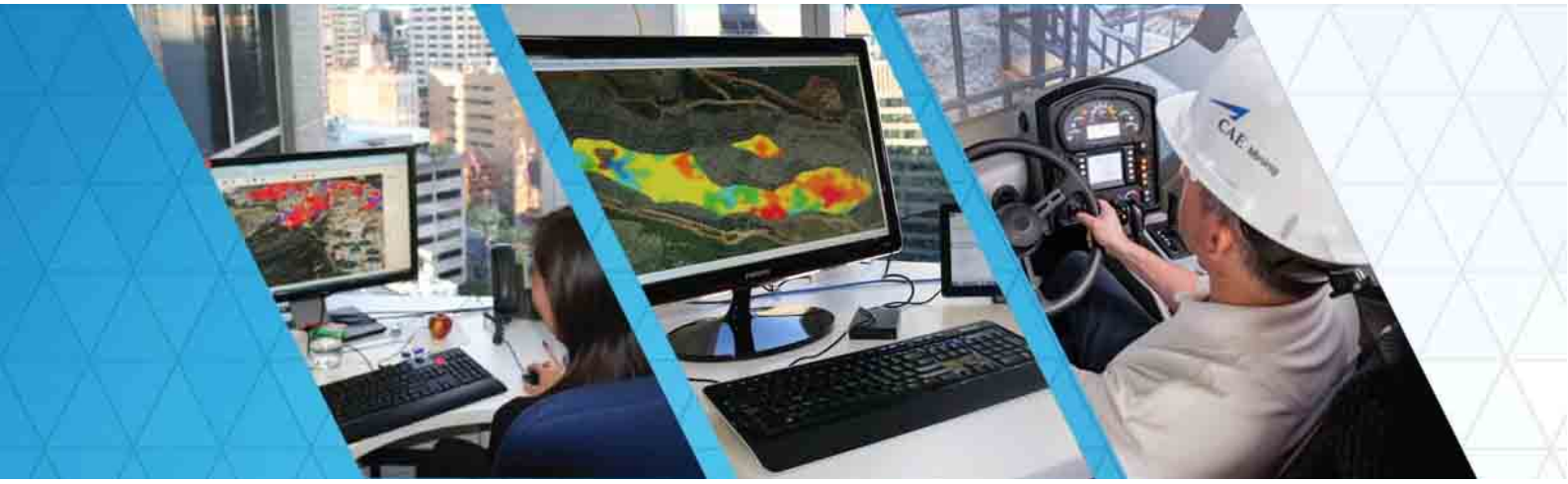
# Studio 3

## Dynamic Anisotropy User Guide



# EXECUTIVE SUMMARY

The **ESTIMA** command in Studio 3 is a comprehensive process for interpolating grades into a block model. It uses a search volume, centred on each block in turn, in order to select samples to be used for estimation by one of several methods. The search volume is usually a 3D ellipsoid, which is defined by the length and orientation of its three axes. The continuity of mineralization often varies with direction and so the search ellipsoid should be oriented to follow the direction of the mineralization. In addition the anisotropy weighting for the estimation methods should also follow the direction of mineralization.

In earlier releases of Studio, several techniques were available to allow the search volume to be oriented appropriately, but in general they were approximations which required complex data manipulation. It can be shown that a misalignment of only a few degrees can cause the extrapolation of ore into waste and waste into ore, so it is very important to get the orientation of the search volume and estimation parameters correctly aligned.

The exception to the approximation methods is Studio 3's Unfolding option, which provides an exact solution to the problem of estimating grade in folded and deformed orebodies, and has proved to be a very useful tool in complex situations. However the Unfold solution often requires the user to create a detailed set of strings to define the folding, which can be a time consuming task.

The dynamic anisotropy option has been added to Studio 3 and allows the anisotropy rotation angles for defining the search volume and variogram models to be defined individually for each cell in the model. Thus, the search volume is oriented precisely and follows the trend of the mineralization. However this is only part of the solution as the rotation angles need to be assigned to each cell in the model in the first place. Studio 3 offers two new processes that facilitate the preparation of data for dynamic anisotropy modelling, providing an easy to use and precise method of calculating the anisotropy angles.

This document describes the recommended method for estimating grade using the dynamic anisotropy option, and gives a detailed example and macro.

# Contents

# 1 OVERVIEW

## Purpose

This user guide describes the recommended method for using the dynamic anisotropy options in Studio 3. It includes examples and shows the advantages of using the method.

## Prerequisites

It is assumed that the user is familiar with grade estimation methods in general and in particular with the **ESTIMA** process in Studio. A licence for the Enhanced Geostatistics (EGS) module is required to run the options in the **ESTIMA** process that are described here.

## Acronyms and Abbreviations

The following acronyms and abbreviations are used in this document:

| Acronym | Description |
|---|---|
| ESTIMA | Studio process for estimating grade |
| COGTRI | Studio process for calculating the centre of gravity and orientation angles of wireframe triangles |
| ANISOANG | Studio process for calculating orientation angles of wireframe triangles and strings |
| APTOTRUE | Studio process for converting apparent dip to true dip |
| TRIFIL | Studio process to create model cells from a wireframe |
| IPD | Inverse power of distance estimation method |
| NN | Nearest neighbour estimation method |
| DTM | Digital Terrain Model – wireframe surface |
| 3D | Three dimensional |

## More information

Supporting documentation is available from the following sources:

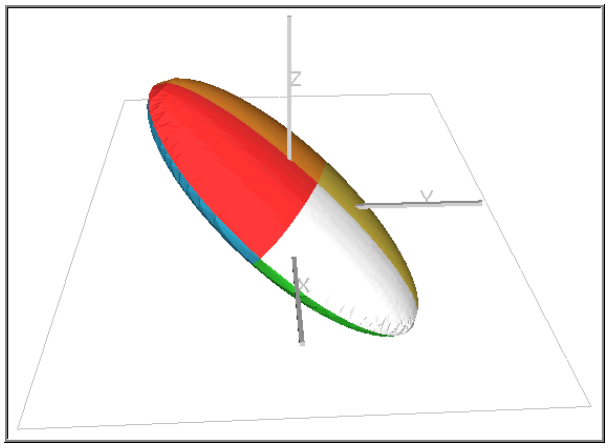
- **ESTIMA**, **ANISOANG** and **APTOTRUE** online help files.
- The Studio 3 Grade Estimation User Guide (available in both PDF and online Help formats)

For more information on using Studio 3, consult your online Help or contact your local CAE Mining representative.

# 2 INTRODUCTION TO DYNAMIC ANISOTROPY

## The Ellipsoid

The continuity of mineralization often varies with direction. This is usually represented by a 3D ellipsoid where the lengths and direction of the three orthogonal axes of the ellipsoid describe the continuity and orientation of the mineralization. The example below shows an ellipsoid with the major (longest) axis dipping by 40° with the dip direction (azimuth) being 20° (N20°E). The minor axis dips by 50° with an azimuth of 200°, and the intermediate axis is horizontal (dip 0°) with an azimuth of 110°.




The two main areas in the grade estimation process **ESTIMA** in which an ellipsoid is used are:

- Defining the search volume to select the subset of samples to be used for estimating the grade of a block.
- Calculating the weights to be assigned to each selected sample in order to make the estimate.

Normally the same ellipsoid is used for both purposes, but **ESTIMA** does allow different ellipses to be defined if required.

## Modelling Changes in Orientation

### Approximate Solution

If the orientation of mineralization is constant, then a single ellipsoid can be defined for the whole orebody. However this is often not the case as the orientation changes over the orebody. One way of taking this into account is to divide the orebody into areas of similar orientation and to define an ellipsoid with a different orientation for each area. This sometimes gives a satisfactory solution, although there can be problems when estimating model cells at the boundary between different areas.

### Exact Solution

The best solution is to use Studio's Unfold option which unfolds the mineralization in three dimensions to create a new orthogonal unfolded coordinate system. Structural analysis and grade estimation are then carried out in the unfolded system before estimates are assigned

to a standard block model. This requires variograms to be calculated and analysed in the unfolded system and usually requires detailed tag strings to be created to define the unfolding mechanism. Although this is the optimal solution it can be quite time consuming and requires a good understanding of the structure of the orebody.

### Dynamic Anisotropy Solution

The dynamic anisotropy option allows the orientation of the ellipsoid to be defined individually for each block in the model. However this does require that the angles are first interpolated into the model before they can be used for the estimation. The angles can be derived from the orientation of wireframe triangles and / or from strings digitised in plan and section. Process ANISOANG is provided to calculate dip and dip direction angles from string and wireframe data and these angles can be interpolated into the block model using ESTIMA. If the dip angle is the apparent dip then another process, APTOTRUE, is provided to convert from apparent dip angle to true dip angle.

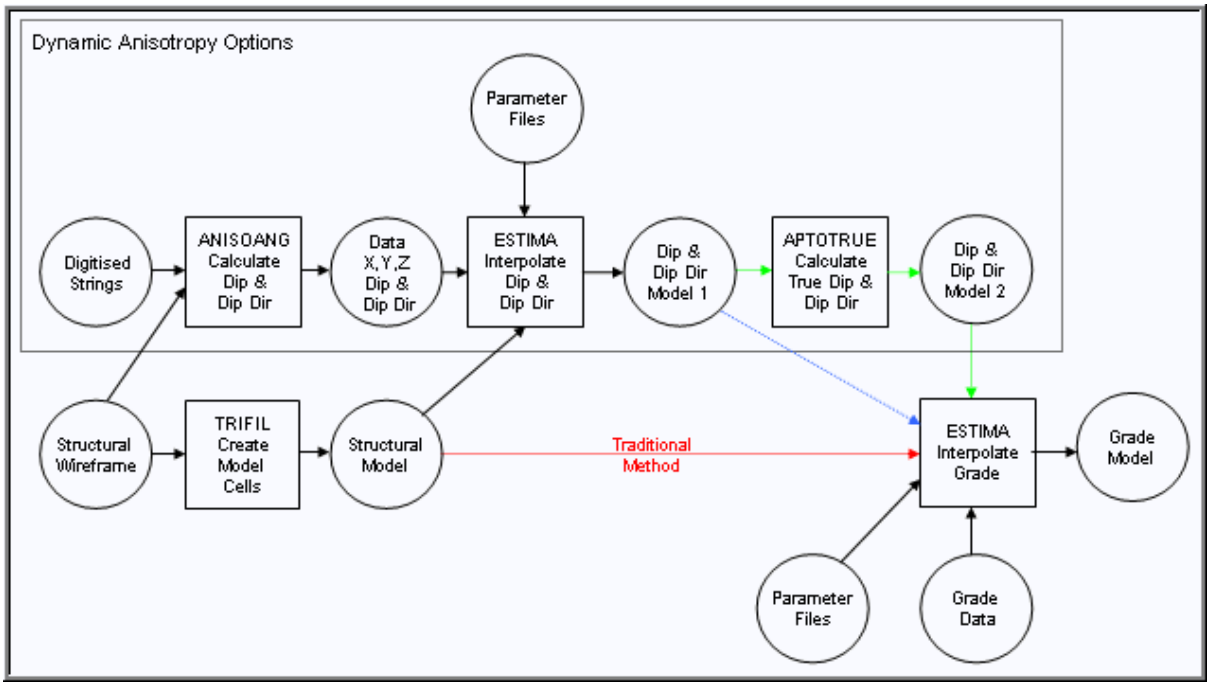
Although the orientation of the ellipsoid can be defined individually for each model cell, it is assumed that the dimensions of the ellipsoid, the lengths of the three axes, remain constant. They can either be constant over the whole orebody, or the orebody can be divided into areas within which the axes are constant.

The standard method of estimating the lengths of the axes of the ellipsoid is to use the ranges of the variogram model, although it must be recognised that the ranges will be somewhat distorted if the orebody is folded. However if the folding is not too severe then the variogram ranges calculated from the untransformed data will usually give a good enough approximation of the true values. It can be shown that a grade estimate is more sensitive to changes in the orientation of an ellipsoid than to changes in the length of the axes. A misalignment of only a few degrees can cause the extrapolation of ore into waste and waste into ore, so it is very important to ensure that the ellipsoid is correctly aligned.

# 3 DEFINING A DYNAMIC ANISOTROPY STUDY

## Introduction

The components of a grade estimation study using dynamic anisotropy are show in the figure below. The lower half represents the traditional method of grade estimation whereby a structural wireframe is created, filled with cells and subcells (**TRIFIL**) and then grade is interpolated into the block model (**ESTIMA**). The upper half shows the new options for processing the dip and dip direction data.




## Defining the Orientation Data

Dip and dip direction data are required to define the orientation of the mineralization. The two main sources for this data are:

- digitise strings in plan to define the strike and set the dip direction perpendicular to strike. Digitise strings in section to define the apparent or true dip.
- calculate dip and dip direction from the orientation of the triangles of the structural wireframe.

One or both of the above options can be selected. The data for both methods are processed by command **ANISOANG** which outputs a points file that contains both the XYZ coordinates of each point and the dip and dip direction data. Alternatively process **COGTRI** creates dip and dip direction data for just a wireframe.

## Interpolating Angles into a Block Model

When the dip and dip direction data has been created the next stage is to interpolate the two sets of angles into the block model. However it is not possible to use the standard interpolation methods in **ESTIMA** as angular data is circular – for example the average of $340^o$ and $30^o$ is $5^o$. A new method (*IMETHOD*=8) has been added to **ESTIMA** that has all the functionality of inverse power of distance (*IMETHOD*=2) but can be used with angular data.

The circular IPD method is then used to interpolate the dip and dip direction data into the block model.

## Converting Apparent Dip to True Dip

If the initial orientation data is from digitised sections and the sections are aligned in the dip direction, then the dip angle calculated from the string data will be the true dip. However if the sections are not aligned in the dip direction, then the apparent dip will be calculated by **ANISOANG**. In this case there is a restriction that all sections must be parallel to each other.

If the true dip has been calculated then the dip and dip direction model, Model 1, can be input directly to the **ESTIMA** process to interpolate the grades. However if the apparent dip has been calculated then the true dip must be calculated first. This is done by process **APTOTRUE**, and the resulting model is shown as Model 2 in the flow diagram.

Details of apparent and true dip can be found at http://www.uwrf.edu/~iw00/trigad.html.

## Interpolating Grades using Dynamic Anisotropy

The previous step ensures that the search volume rotation angles are now stored in the input model file – the first rotation angle is the dip direction, the second rotation angle is the true dip and the third rotation angle is set to zero. In order to use these angles the names of the angle fields in the input model file must be specified in the search volume parameter file using the fields *SANGL1_F* and *SANGL2_F*. A third rotation angle, *SANGL3_F*, can be specified if required, but there is no specific provision for this to be calculated by any of the Studio 3 commands.

The default angles for the search volume are defined by fields *SANGLE1*, *SANGLE2*, *SANGLE3*. If one or more dynamic fields *SANGLn_F* (n=1,2,3) are specified then they are used instead of the default values.

If nearest neighbour or inverse power of distance are used to estimate grade then the dynamic angles may be used when calculating the transformed distances and therefore the sample weights.

The variogram rotation angles can also be defined dynamically. They can be the same as the search volume angles, or a different set of angles can be defined.

# 4 CREATING DIP AND DIP DIRECTION DATA

## Wireframes

If the orebody is narrow and stratified and the orientation of the mineralization follows the hangingwall and footwall, then dip and dip direction data can be calculated for each triangle. This is done by process **ANISOANG** which calculates the true dip angle as well as the dip direction.

The above method is straightforward if the hangingwall and footwall are defined by individual DTMs. However, if the wireframe is enclosed, it will contain triangles joining the hangingwall to the footwall, and it is possible that the orientation of mineralization would not match the end triangles. **ANISOANG** includes an option to define a minimum and maximum acceptable dip and dip direction. Therefore if for example the end triangles are vertical, then they could be removed by setting the maximum dip to $89^{o}$, assuming of course that no real dip values of $90^{o}$ are expected. Otherwise the wireframe would need to be edited and the end triangles removed.

Even if the orebody is not stratified a wireframe, or wireframes, could be used to define the orientation of the mineralization. However it is probably easier to digitise a set of strings rather than create new wireframes.

## Digitised Strings

An alternative way of defining the dip and dip direction of mineralization is to digitise strings in plan and section that describe the orientation. The strings must be planar, the plans horizontal and the sections vertical. A summary is given below, but for more details refer to the **ANISOANG** Helpfile and Full Description.

### Sections

Strings are digitised in section to define the dip and optionally the dip direction. If the sections are oriented in the true dip direction then the dip will be the true dip of mineralization and the orientation of the section line will be the true dip direction. Both these angles will be calculated by process **ANISOANG** and written to the output Points file together with the coordinates of the mid-point of each string segment.

If the sections are not oriented in the true dip direction then only the apparent dip can be calculated. In this case the sections must be parallel to each other, so that they all have the same apparent dip direction. The apparent dip angle can then be interpolated into the model and process **APTOTRUE** used to convert from apparent to true dip.

The azimuth (dip direction) of a section can be calculated from any two points and the dip can be calculated for each string segment and assigned to the mid-point of that segment. The direction in which the strings are digitised is important as the dip is measured for each string segment from point N to point N+1.

### Plans

For plans, the strings can show either the true dip direction or the strike. In both cases the direction of the string is important. In the former case the direction of the string indicates the dip direction and in the latter case the dip direction is defined as either $90^{o}$ or $270^{o}$ to the direction of strike.

## Creating the Angle Data

The process **ANISOANG** takes wireframes and / or strings as input and creates a points file. This includes coordinate fields *XPT*, *YPT* and *ZPT*. It also includes a subset of four fields *TRDIPDIR*, *TRDIP*, *APDIPDIR* and *APDIP* as shown in the table below. Which fields are created depends on whether apparent or true angles are calculated.

| Field Description | True Dip Direction | True Dip | Apparent Dip Direction | Apparent Dip |
|---|---|---|---|---|
| **Field Name** | **TRDIPDIR** | **TRDIP** | **APDIPDIR** | **APDIP** |
| **Wireframe** | ✓ | ✓ | × | × |
| **Plan** | ✓ | × | × | × |
| **Sections in dip direction** | ✓ | ✓ | × | × |
| **Sections not in dip direction** | × | × | ✓ | ✓ |

As well as the above fields, five optional fields controlled by parameter ADDSYMB may be added. These five fields have the reserved field names for displaying 3D symbols in the Design and Visualizer windows, and are as follows.

- SYMBOL Symbol code. The symbol is selected by parameter *PLANSYMB* for points created from plan strings, *SECTSYMB* for points created from section strings and *WFSYMB* for points created from wireframe triangles. Codes range from 201 to 267 which are shown in the help file.

- COLOUR Colour of SYMBOL. This is defined by parameters *PLANCOL*, *SECTCOL* and *TRICOL*.

- DIPDIRN Field used by Design and Visualizer windows to define the dip direction of the 3D SYMBOL. This is set equal to *TRDIPDIR* or *APDIPDIR* depending on whether true or apparent dips have been calculated.

- SDIP Field used by Design and Visualizer windows to define the dip of the 3D SYMBOL. This field is set equal to *TRDIP* or *APDIP* depending on whether true or apparent dips have been calculated. For string data on plans *SDIP* is set equal to 0 (horizontal).

- SYMSIZE Size of the symbol in mm as defined by parameter *SYMSIZE*.

The symbol fields provide a simple and effective way of validating the angle data. The points data file can be loaded and displayed in both the **Design** Window and **Visualizer**. The symbol fields are recognised and a 3D symbol showing dip and dip direction is displayed.

# 5 INTERPOLATING ANGLES INTO A MODEL

Once the dip and dip direction data has been created the next stage is to interpolate the two sets of angles into the block model. However it is not possible to use the standard interpolation methods in **ESTIMA** as angle data is circular – for example the average of $340^{o}$ and $30^{o}$ is $5^{o}$. A new method (*IMETHOD*=8) has been added to **ESTIMA** that has all the functionality of inverse power of distance (*IMETHOD*=2) but can be used with angular data. Therefore interpolating the angular data can be done through the standard **ESTIMA** process using *IMETHOD*=8.

The angular data option has also been added to the **ESTIMATE** dialog as a check box adjacent to the Inverse Power of Distance method.

# 6 CALCULATING TRUE DIP ANGLES

## Introduction

As described in Section 4 the dip values interpolated into the model can be either apparent or true. If they are apparent values then they will need to be converted to true values before they can be used for grade estimation, and process **APTOTRUE** is designed to perform this function.

## Converting Apparent Dip to True Dip

The process **APTOTRUE** takes as input the model file into which the apparent dip and true dip direction angles have been interpolated using **ESTIMA** and creates an output model file that includes the true dip angle. The parameter *APDIPDIR* defines the apparent dip direction which enables the true dip to be calculated.

Further details can be found in the **APTOTRUE** Helpfile and Process Description.

# 7 ESTIMATING GRADE

## Introduction

The dynamic anisotropy option in **ESTIMA** allows the orientation of the search volume and / or the orientation of the variogram model to vary from block to block. The only differences between defining a fixed and a variable search volume orientation are:

- The input prototype model file &PROTO must contain the one, two or three angle fields.
- The search volume parameter must contain the names of the corresponding angle fields in fields *SANGL1_F*, *SANGL2_F*, *SANGL3_F*.

It must be remembered that the main purpose of the search volume is to select the samples to be used for the estimation and that it is independent of the estimation method. Therefore it can be used with any estimation method – IPD, nearest neighbour, ordinary, simple or indicator kriging, or Sichel's T estimator. However the search volume can also be used to define anisotropic weighting, as described below.

## Defining the Search Volume

The search volume orientation angles are specified as fields in the input prototype model. The names of these fields are defined by the user and are included as fields *SANGL1_F*, *SANGL2_F*, *SANGL3_F* in the search volume parameter file.

The default values of the three angle fields are defined in the standard fields *SANGLE1*, *SANGLE2* and *SANGLE3* in the search volume parameter file. These defaults are used if one or more of the angle fields are not defined in fields *SANGLn_F* in the search volume file. Therefore in the common situation where only two angle fields are used it is only necessary to define *SANGL1_F* and *SANGL2_F*. The third field *SANGL3_F* is optional – if it exists but is not required then its value should be left blank. The defaults are also used if the value of the angle in the prototype model file is absent data or is outside the range -360 to +360.

The fields used to define the lengths of the search volume axes (*SDIST1*, *SDIST2*, *SDIST2*) and the fields used to define the axes about which the volume is rotated (*SAXIS1*, *SAXIS2*, *SAXIS3*) are constant for each search volume.

## Inverse Power of Distance

If IPD is selected then one of the options in the estimation parameter file is to define whether the search volume anisotropy is to be used to transform the distances of each sample from the block centre. Field *ANISO* can have one of three values.

0 True distance. The distance is measured in the standard coordinate system – no transformation.

1 The distance is measured as a transformed distance, using the search volume shape and orientation.

2 The distance is measured as a transformed distance, using the shape and orientation defined in the estimation parameter file.

The default and most commonly used value for *ANISO* is 1 – use the search volume parameters. If this is selected then the orientation of the transformed distances used for IPD calculations vary from block to block.

### Nearest Neighbour

The *ANISO* field in the estimation parameter file also applies to the Nearest Neighbour method, as the transformed distance is used to determine the closest sample. If dynamic anisotropy is selected and *ANISO*=1 then the selection of the nearest sample will be influenced by the orientation of the search volume for each model block.

### Kriging

If one of the kriging methods is chosen then parameter *DYANKR* is used to select whether the variogram model rotation angles should use the dynamic anisotropy option. The possible values of this parameter are:

0 Do not use dynamic anisotropy. Use fixed angles *VANGLE1*, *VANGLE2*, *VANGLE3* as defined in the variogram model parameter file.

1 If the search volume uses dynamic anisotropy, then the variogram model uses the same set of angles. If the search volume does not use dynamic anisotropy, then the variogram model uses angles *VANGLE1*, *VANGLE2*, *VANGLE3*.

2 Use dynamic anisotropy but with a different set of angles from the search volume, defined by fields in the input model prototype file. The names of these are specified by fields *VANGL1_F*, *VANGL2_F*, *VANGL3_F* in the estimation parameter file.

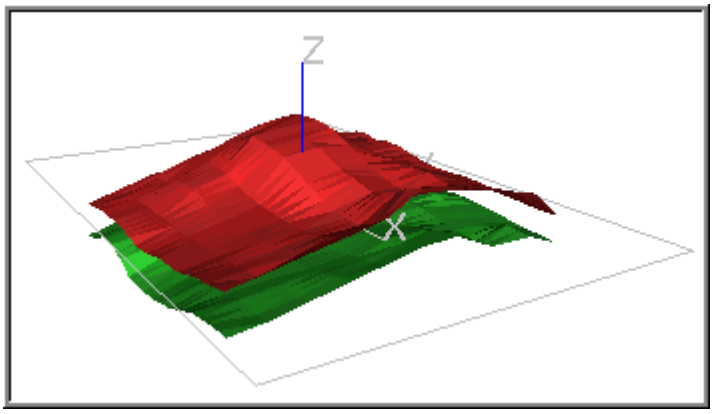
One or more of the variogram model rotation angles are stored in the block model. It is not necessary for all angles to be stored in the model. If one or two of the *VANGL*_F* fields are not in the model then their values will be defined by the corresponding *VANGLE** values in the variogram model parameter file. The *VANGLE** values are also used if the values of the angles in the input block model are absent data.

If parameter *DYANKR* is not specified, then the default value of 1 is applied.

# 8 EXAMPLE 1

## Introduction

This example illustrates how true dip and dip direction data can be derived the hangingwall and footwall DTM wireframes, and used to interpolate grade using the dynamic anisotropy option in **ESTIMA**.




The hangingwall and footwall DTMs are shown in the graphic on the right. The two DTMs (wireframe ORETR, OREPT) have approximately the same profile with a central ridge running east-west and dipping gently to the north and south.

The full macro to recreate this example is given in Appendix A:

## Dip and Dip Direction Angles

The first step is to calculate the dip and dip direction angles which can be done using either the **ANISOANG** or **COGTRI** processes, as shown below in macro format.

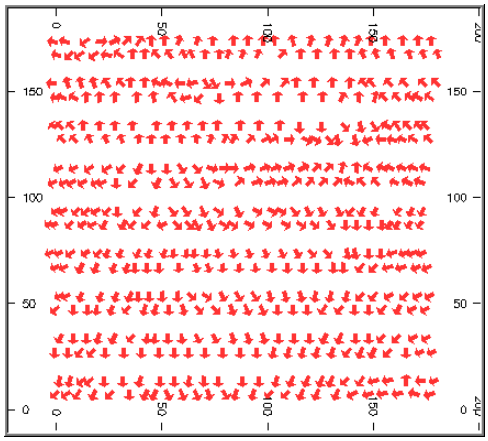
```
!COGTRI    &WTRIN(ORETR),&WPTIN(OREPT),&PTNOUT(POINTS1),
           @VERTEX=0,@SYMBOL=216,@SYMSIZE=2
```

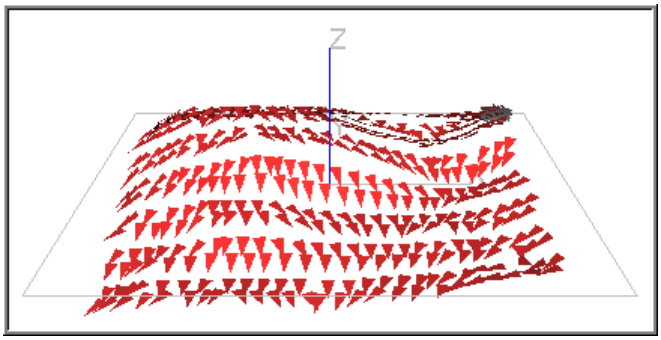
```
!ANISOANG &WIRETR(ORETR),&WIREPT(OREPT),&POINTS(POINTS1),
           @TRIPTS=1.0,@ADDSYMB=1.0,
           @WFSYMB=216.0,@WFCOL=3.0,@SYMSIZE=2.0
```

Using **ANISOANG** with *@ADDSYMB*=1 gives the additional symbol display fields. The full set of fields in the output points file is:

| RECORD | XPT (N) | YPT (N) | ZPT (N) | DIPDIRN (N) | SDIP (N) | TRDIPDIR (N) | TRDIP (N) | COLOUR (N) | SYMBOL (N) | SYMSIZE (N) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.16 | 6.67 | 42.23 | 226.52 | 22.75 | 226.52 | 22.75 | 3.00 | 216.00 | 2.00 |
| 2 | 1.68 | 13.33 | 44.13 | 189.61 | 12.07 | 189.61 | 12.07 | 3.00 | 216.00 | 2.00 |
| 3 | 5.26 | 6.67 | 43.30 | 234.62 | 20.47 | 234.62 | 20.47 | 3.00 | 216.00 | 2.00 |
| 4 | 6.92 | 13.33 | 44.76 | 193.90 | 8.46 | 193.90 | 8.46 | 3.00 | 216.00 | 2.00 |

As the angles are calculated from a wireframe, the dip will be the true dip value. The points file, POINTS1, can be displayed in the **Design** and **Visualizer** windows to check the data is correct. In the graphics below only the hangingwall points are displayed.






## Interpolating Angles into the Block Model

The second step is to interpolate the dip and dip direction angles into the block model. This must be done using the **ESTIMA** process, or using the **ESTIMATE** menu, so that the angle interpolation method (*IMETHOD*=8) can be selected. In this example the input search volume parameter file, *SPAR1*, defines a spherical search volume with a radius of 25m.

| RECORD | SREFNUM (N) | SMETHOD (N) | SDIST1 (N) | SDIST2 (N) | SDIST3 (N) | SANGLE1 (N) | SANGLE2 (N) | SANGLE3 (N) | SAXIS1 (N) | SAXIS2 (N) | SAXIS3 (N) | OCTMETH (N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.00 | 2.00 | 25.00 | 25.00 | 25.00 | 0.00 | 0.00 | 0.00 | 3.00 | 1.00 | 3.00 | 0.00 |

| RECORD | MINOCT (N) | MINPEROC (N) | MAXPEROC ... | MINNUM1 (N) | MAXNUM1 (N) | SVOLFAC2 (N) | MINNUM2 (N) | MAXNUM2 (N) | SVOLFAC3 (N) | MINNUM3 (N) | MAXNUM3 (N) | MAXKEY (N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.00 | 1.00 | 4.00 | 5.00 | 10.00 | 1.50 | 5.00 | 10.00 | 2.50 | 1.00 | 10.00 | 0.00 |

The estimation parameter file, *EPAR1*, has a record for each angle to be interpolated, *DIPDIRN* and *SDIP*, and uses the angular IPD method, *IMETHOD* 8.

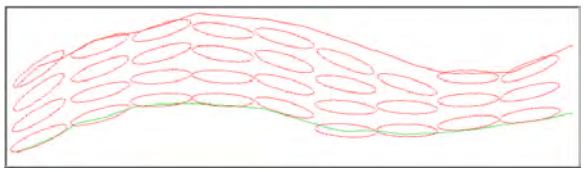
| RECORD | VALUE IN (... | NUMSAM F ... | SREFNUM (N) | IMETHOD (N) | POWER (N) |
|---|---|---|---|---|---|
| 1 | TRDIP | NSAMP | 1.00 | 8.00 | 2.00 |
| 2 | TRDIPDIR | | 1.00 | 8.00 | 2.00 |

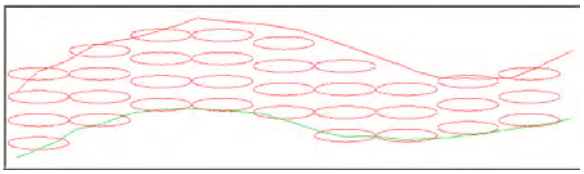
The input model file has been created by filling the volume between the hangingwall and footwall with cells using the **TRIFIL** process. The cells are all 5x5x2.5m in size.

The files, fields and parameters used to run **ESTIMA** are shown below:

```
!ESTIMA    &PROTO(OREMOD1),&IN(POINTS1),&SRCPARM(SPAR1),&ESTPARM(EPAR1),
           &MODEL(OREMOD2),*X(XPT),*Y(YPT),*Z(ZPT),@DISCMETH=1.0,
           @XPOINTS=3,@YPOINTS=3,@ZPOINTS=3,@PARENT=0.0
```

The output model file, *OREMOD2*, includes fields *TRDIPDIR*, *TRDIP* and *NSAMP*. The angles in the model can be displayed in the Design and Visualizer Windows using rotated symbols as for the input angle data. However an alternative way of representing the *TRDIPDIR* and *TRDIP* values in model *OREMOD2* is shown in the graphics below. A subset of model cells (not shown) has been selected on a west-east section and search ellipsoids with axes 10x10x2m are displayed. The lengths of the axes are not quite the same as the lengths used for grade estimation, as described in the next section, but have been chosen to illustrate the orientation of the ellipsoids.





The ellipsoids in the left graphic are oriented according to the *TRDIPDIR* and *TRDIP* angles, as used with dynamic anisotropy, whereas the ellipsoids in the right graphic are oriented horizontally, as would be used without dynamic anisotropy.

## Estimating Grade Using Dynamic Anisotropy

### Introduction

As the dip field, *TRDIP*, in model *OREMOD2* is a true dip value, then the final step is to interpolate the grade using the dynamic anisotropy option. However, as well as interpolating grade using the dynamic anisotropy option, grade is also estimated without the option. This enables the two methods to be compared.

### Search Volume Parameter File

The dynamic anisotropy option requires the search volume parameter file, SPAR2, to include the fields *SANGL1_F* and *SANGL2_F* to nominate fields *TRDIPDIR* and *TRDIP* in the model file. Two search volumes are defined – search volume 1 is horizontal whereas volume 2 uses the dynamic anisotropy fields.

| RECORD | SREFNUM (N) | SMETHOD (N) | SDIST1 (N) | SDIST2 (N) | SDIST3 (N) | SANGLE1 (N) | SANGLE2 (N) | SANGLE3 (N) | SAXIS1 (N) | SAXIS2 (N) | SAXIS3 (N) | OCTMETH (N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.00 | 2.00 | 25.00 | 25.00 | 2.50 | 0.00 | 0.00 | 0.00 | 3.00 | 1.00 | 3.00 | 0.00 |
| 2 | 2.00 | 2.00 | 25.00 | 25.00 | 2.50 | 0.00 | 0.00 | 0.00 | 3.00 | 1.00 | 3.00 | 0.00 |

| RECORD | MINOCT (N) | MINPEROC (N) | MAXPEROC ... | MINNUM1 (N) | MAXNUM1 (N) | SVOLFAC2 (N) | MINNUM2 (N) | MAXNUM2 (N) | SVOLFAC3 (N) | MINNUM3 (N) | MAXNUM3 (N) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.00 | 1.00 | 4.00 | 5.00 | 10.00 | 1.50 | 5.00 | 10.00 | 2.50 | 1.00 | 10.00 |
| 2 | 1.00 | 1.00 | 4.00 | 5.00 | 10.00 | 1.50 | 5.00 | 10.00 | 2.50 | 1.00 | 10.00 |

| RECORD | MAXKEY (N) | SANGL1 F (A8) | SANGL2 F (A8) |
|---|---|---|---|
| 1 | 0.00 | | |
| 2 | 0.00 | TRDIPDIR | TRDIP |

The *SANGLE1* and *SANGLE2* values are set to zero. These are the default values which are used if *TRDIPDIR* or *TRDIP* in the *OREMOD2* model file are absent data. The *SANGLE3* value, also zero, is used as the third rotation angle because *SANGL3_F* is not specified.

### Estimation Parameter File

The estimation parameter file, *EPAR2*, includes one record for each estimation:

| RECORD | VALUE IN (A8) | VALUE OU (A8) | NUMSAM F (A8) | SVOL F (A8) | SREFNUM (N) | IMETHOD (N) | POWER (N) |
|---|---|---|---|---|---|---|---|
| 1 | AU | AU1 | NSAMP1 | SVOL1 | 1.00 | 2.00 | 2.00 |
| 2 | AU | AU2 | NSAMP2 | SVOL2 | 2.00 | 2.00 | 2.00 |

Note that this file does not explicitly show which estimates use dynamic anisotropy. That is a function of the search volume definition. Search volume 2 includes dynamic anisotropy, and this is used to estimate AU2.

The estimation parameter file may include the optional field *ANISO* which controls how the anisotropic weighting for IPD and NN is defined. *ANISO* takes one of the following values:

- 0: no anisotropy i.e. isotropic. Distances are calculated from the coordinate system used in the sample data file and model.

- 1: distances are transformed according to the orientation and axes of the search volume. (The default)

- 2: distances are transformed according to the orientation and axes of the anisotropy ellipsoid defined by optional fields in the estimation parameter file.

In order to select dynamic anisotropy when using IPD or NN then *ANISO* must be set to 1. This is the default value which is used if field *ANISO* is not included in the estimation parameter file.

### Sample File

The sample data file, *DAHOLES*, is a desurveyed drillhole file with vertical holes on a 40m grid with 2.5m samples. In order to illustrate the results of dynamic anisotropy most effectively, the AU grades have been created so that the sample adjacent to the hangingwall has a grade of 10g/t and the sample adjacent to the footwall has a grade of 0g/t, with a linear gradation in between.

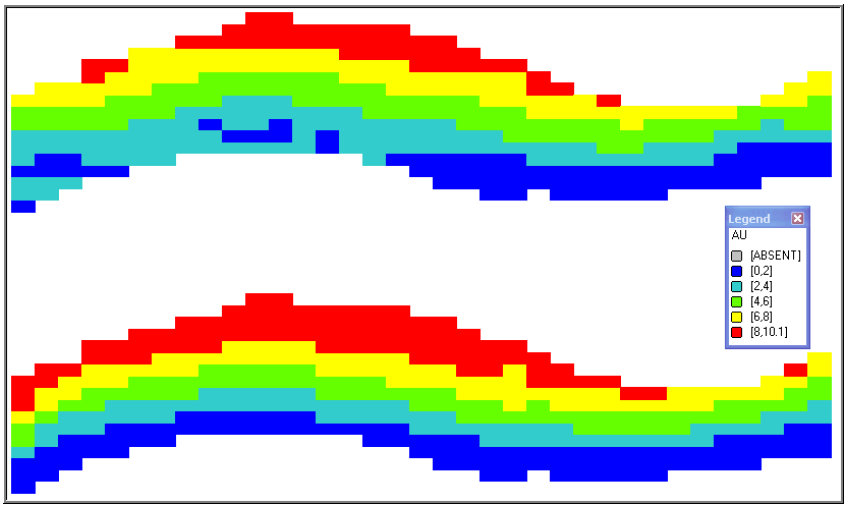
### Grade Estimation

The files, fields and parameters used for running the **ESTIMA** process are as follows:

```
!ESTIMA    &PROTO(OREMOD2),&IN(DAHOLES),&SRCPARM(SPAR2),
           &ESTPARM(EPAR2),&MODEL(OREMOD3),@DISCMETH=1.0,
           @XPOINTS=3.0,@YPOINTS=3.0,@ZPOINTS=3.0,@PARENT=0.0
```

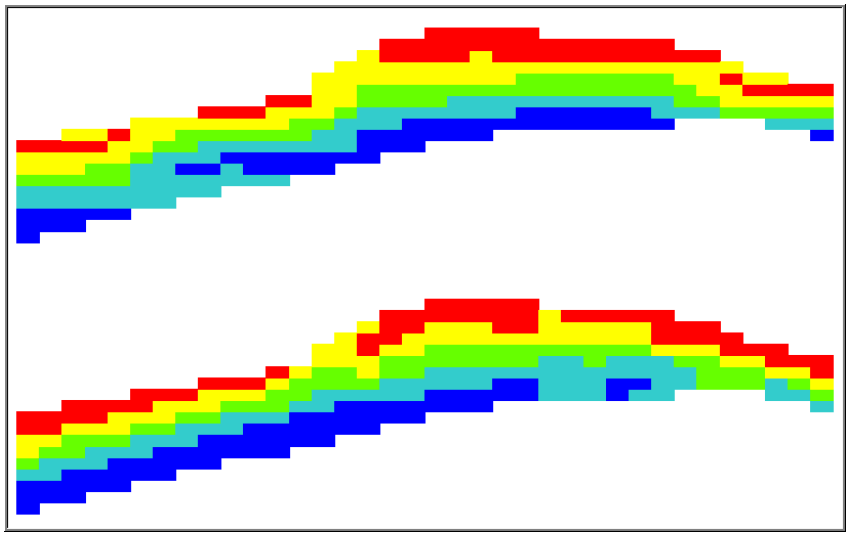
### The Grade Model

A west-east section through the output model, *OREMOD3*, coloured by AU is shown below. The upper section is for AU1, using a horizontal search ellipsoid, and the lower section for AU2, using dynamic anisotropy.




The effectiveness of dynamic anisotropy is immediately apparent, with the grade closely following the hangingwall and footwall contacts.

The next graphic is a south-north section which shows similar results.



**Kriging**

In this example IPD has been used for the grade estimate. If a different method such as kriging is required, then the only change is in the *IMETHOD* field in the estimation parameter file – 3 for ordinary kriging or 4 for simple kriging.

By default, the value of parameter *DYANKR* is 1 which means that if the search volume uses dynamic anisotropy, then the variogram model will use the same set of angles. Other options for *DYANKR* are described in section 7 in the paragraph entitled Kriging.

# 9 EXAMPLE 2

## Introduction

This example illustrates the use of both plan and section strings and a solid wireframe model to define the dip direction and dip. The study is divided into two parts:

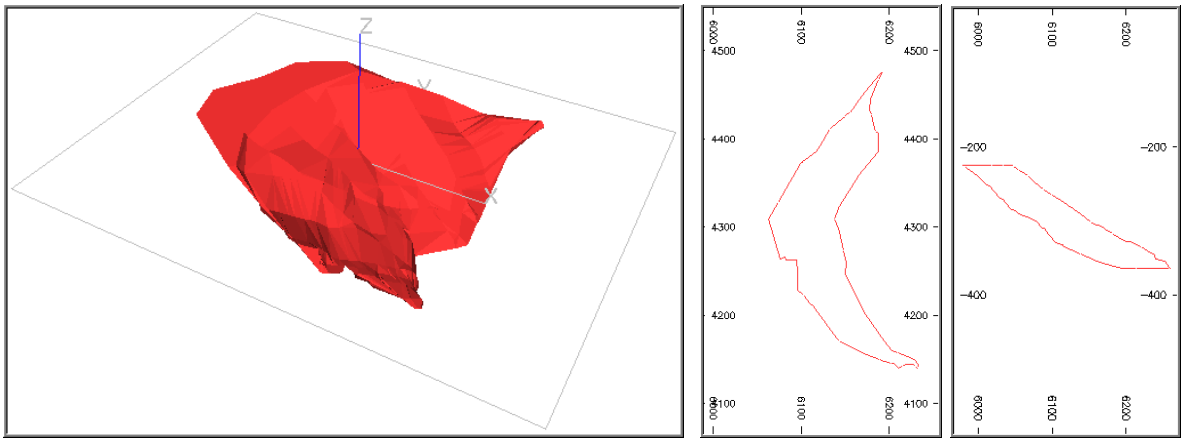
1. Calculate anisotropic angles from plan and section strings, and use these to estimates grades using dynamic anisotropy option in **ESTIMA**. Compare the results with the estimates from using a single average set of angles.

2. Same as 1 except that the anisotropic angles are derived from the orebody wireframe.

The processing for each part has been recorded in a macro which are included as Appendices B and C. The input data is taken from the underground tutorial data set which is installed in folder **Database\DMTutorials\Data\VBUG\Datamine**. The following files are used:

- Block Model: *_vsbmgeo*
- Drillholes: *_vsldhz*
- Plan Strings: *_vsplnst*
- Section Strings: *_vssecst*
- Wireframe: *_vsoretr*, *_vsorept*

The example uses the zone 1 orebody which is illustrated in the following 3D, plan and west-east section views. The orebody dips to the east with an average dip of about 32$^{o}$. The downdip distance is about 250m and strike length 450m. The average thickness is 25m with a maximum true thickness of almost 50m.

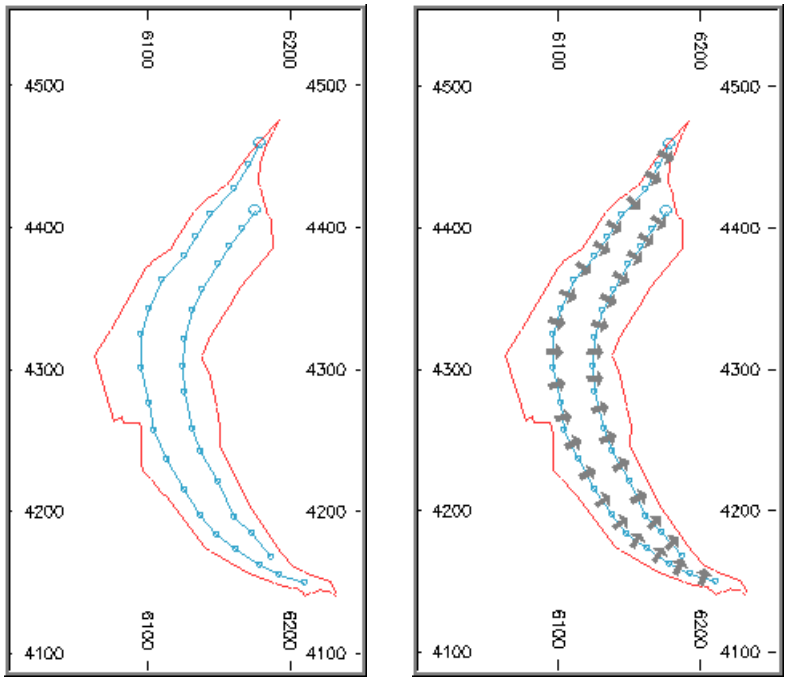



The block model has a parent cell size of 10x10x10m. It is split into subcells at the boundary with the subcell size being 10x10m in plan and variable in the Z direction. There are 8,838 records in the model.

## Anisotropic Angles from Strings

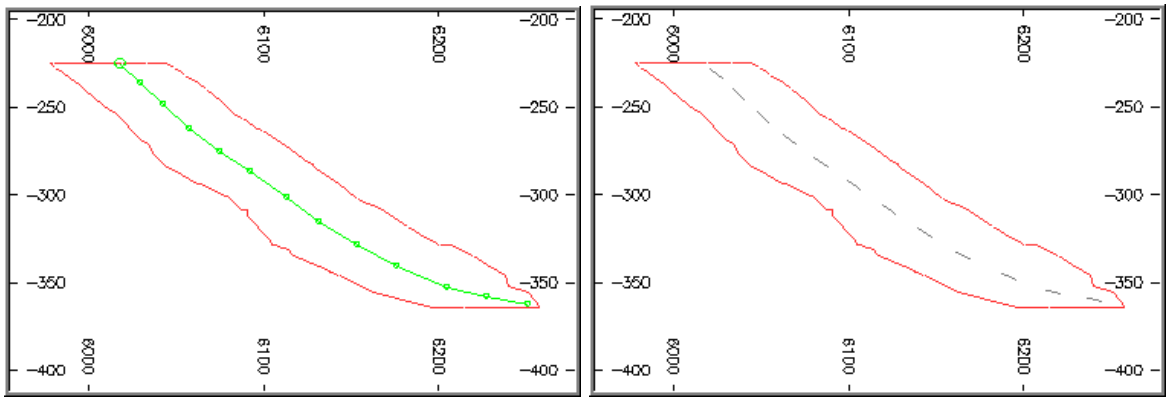
Plan strings have been digitised on 20m benches, from -335m to -235m elevation. Two strings were digitised from north to south for each bench with the average length of the

chords being 18m. The strings were input to the **ANISOANG** command to create the *POINTS1* file. Parameter *PLANMODE* was set to 2 so that the strike direction was calculated as 270o clockwise from strike.



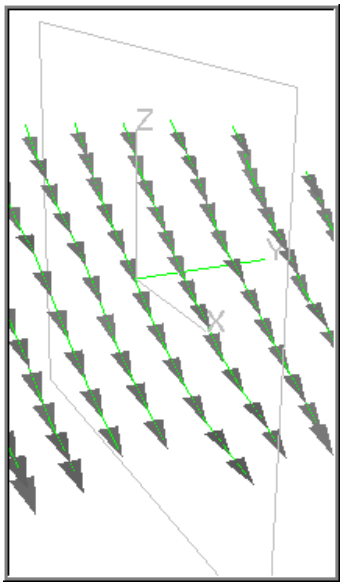

The figure on the left shows the strings for bench -295m. The strings were then processed by **ANISOANG** to create the *POINTS1* file. The figure on the right shows the points as arrows oriented in the dip direction.

Dip strings were digitised from top to bottom on west-east sections at 30m intervals with an average chord length of 12m and one string per section.




The left figure above shows the string for section 4295N, and the right figure the points as line segments after processing by **ANISOANG**. The strings and point symbols can also be displayed in the Visualizer as shown in the figure below.

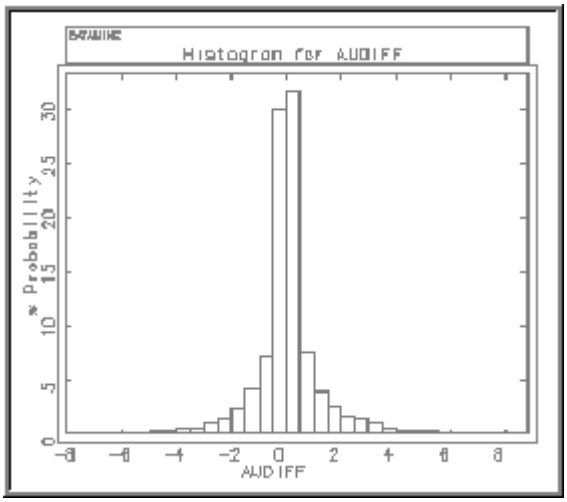
As can be seen from the macro in Appendix B, the apparent dip (*APDIP*) and true dip direction (*TRDIPDIR*) fields in *POINTS1* are interpolated into *MODEL2* using the **ESTIMA** command. The interpolation method (*IMETHOD*) is set to 8 so that inverse power of distance method is used to estimate the angle data. *MODEL2* is then input to the APTOTRUE command in order to calculate the true dip field (TRDIP) which is output to model MODEL3.

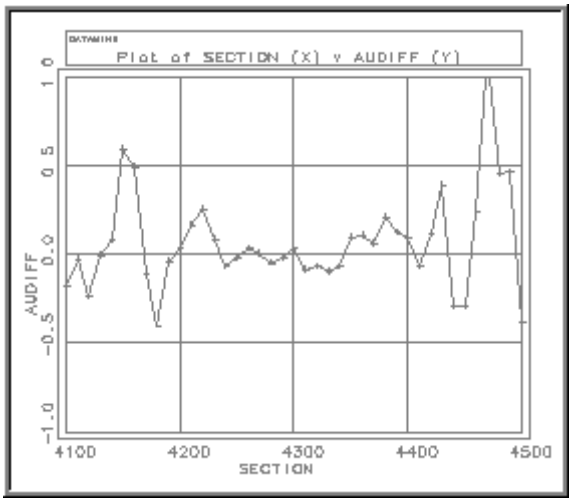



The AU grade can then be estimated using the dynamic anisotropy option in **ESTIMA**. This is selected by including the fields *SANGL1_F* and *SANGL2_F* in the search volume parameter file, and setting them to *TRDIPDIR* and *TRDIP* respectively. *MODEL4* then includes the estimated grades

Grades are then estimated using a search volume with fixed angles of 91° for the true dip direction and 36° for the dip. *MODEL5* then includes both sets of grade estimates. The difference between the two estimates is calculated into *MODEL6* which is then evaluated.

A histogram of the difference between the dynamic anisotropy *AU* estimate and the fixed angle AU estimate for each block in the model is shown in the figure below. It can be seen that the differences are normally distributed and that 75% of the differences are between -1 and +1. The average grade for the model was 2.83 g/t for the dynamic anisotropy estimate and 2.80 g/t for the fixed angle estimate.



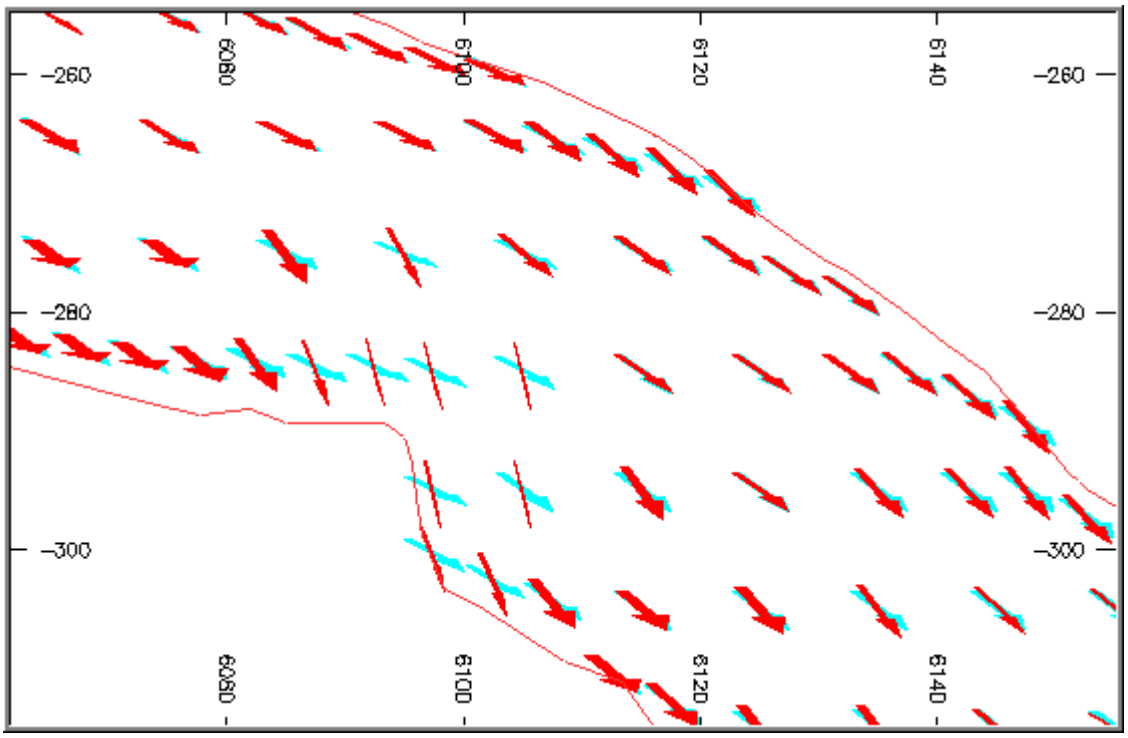

The figure on the right above shows the mean AU difference averaged over 10m east-west sections. For the central sections between about 4230N and 4370N the differences are less than 0.1 g/t. However for the outside sections the difference is much higher with the difference for section 4470N being over 1.0 g/t. This is because for the sections at the north and south ends of the deposit the dip direction is no longer close to 91° and so the estimates are based on less accurate parameters. This difference demonstrates the errors that are made by using average orientation angles and the effectiveness of using dynamic anisotropy.

## Anisotropy Angles from Wireframe Triangles

It can be seen from Appendix C that the procedure for processing the anisotropy angles derived from wireframe triangles is very similar to that for processing the angles derived from plan and section strings. The main difference is that true dip (*TRDIP*) and true dip direction (*TRDIPDIR*) angles are created from the wireframe triangles, so command *APTOTRUE* is not required.

The average grade over the total model was 2.83 g/t, the same as using angles from strings, and a visual comparison of the histogram and line plots showed that they were similar. The figure below shows rotated arrows for model cells on section 4243N. The red arrows are for the orientation from wireframe triangles and the cyan arrows from strings. It can be seen that where the orientation of the wireframe changes quite rapidly over a small area then the

orientation of the neighbouring blocks based on triangles also changes significantly. The orientation based on strings is much smoother and in general provides a better description of the mineralization. Therefore if the wireframe is not smooth and does include rapid local changes in the orientation of triangles then using string data for the orientation data is the better method.



# 10 CONCLUSIONS

## Summary

- The Dynamic Anisotropy option allows the rotation angles for the search volume and variogram to be defined individually for each model cell.
- The search volume can be oriented to follow the trend of the mineralization precisely.
- Previously this could only be achieved using the **UNFOLD** option, which often required detailed digitising of tag strings to define the folding.
- The misalignment of the search volume by just a few degrees can cause the extrapolation of ore into waste and waste into ore.
- Dynamic Anisotropy provides an easy to use and fast way of improving the accuracy of grade estimation for gently folded and rolling orebodies.

## Practical Considerations

The macros in Appendices A – C are intended to give a detailed description of the commands used in a dynamic anisotropy study. However some of the parameters for **ESTIMA** have been chosen for the purpose of expediency and may not always be the most appropriate for an auditable resource project. In particular the number of discretisation points used in runs of **ESTIMA** is 2x2x2. If a sensitivity study has not been undertaken then 3x3x3 would probably be better.

When interpolating angles from strings the maximum number of samples in the search volume should be kept small. The string data already represents an average angle so further averaging is unnecessary. There is an argument for using the nearest neighbour method (*IMETHOD*=1) for interpolating angles.

If the model contains subcells then parent cell estimation (*PARENT*=1) should be considered when estimating angles. This will speed up the processing and in general will not have any effect on the resulting angles.

The spacing of digitised strings and the number of segments is dependent on the variability and geometry of the orebody. However it is quick and easy to digitise strings so it is better to err on the side of too much data.

Unless the orebody is narrow and has a regular outline it is usually better to interpolate angles from digitised strings rather than use wireframe triangles.

It is important to validate both the angle data created from the strings using **ANISOANG**, and the angle data after it has been converted to true angles using **APTOTRUE**. This can be done by displaying rotated 3D symbols in both the Design and Visualizer windows.

The search volume is oriented individually for each cell. However the lengths of the axes of the search volume are fixed for each search volume, as defined by fields *SDIST1*, *SDIST2* and *SDIST3*. Usually these lengths will be derived from the ranges of the variogram model which will be calculated relative to a fixed coordinate system which does not take into account the folded nature of the orebody. Therefore the lengths of the axes will be averaged

over the folding. If a more exact calculation of the variogram model is required then the Unfold command should be used.

## Kriging

Both examples have used IPD for estimating grades using **ESTIMA**. Field *ANISO* was not specified in the Estimation Parameter files, so the default of 1 was applied which means that the distances for IPD weighting are transformed using the axes and angles of the search volume. If kriging (*IMETHOD*=3) is selected instead of IPD (*IMETHOD*=2) and parameter *DYANKR* is set to 1, the default, then the variogram model rotation angles are set equal to the search volume rotation angles. The full range of values for *DYANKR* is:

0. Do not use dynamic anisotropy. Use angles *VANGLEn* as defined in the variogram model parameter file *VMODPARM*.

1. If the search volume uses dynamic anisotropy, then the variogram model uses the same set of axes and angles.

2. Use dynamic anisotropy, but with a different set of angles from the search volume. The names of the corresponding fields are specified by fields *VANGLn_F* in the estimation parameter file *ESTPARM*.

Note that if option 2 is used then one or more of the fields *VANGL1_F*, *VANGL2_F*, *VANGL3_F* must be added to the estimation parameter file. The angles are specific to the estimation, not to the variogram model. The actual names of the fields must then be included in the input prototype model.

# Appendix A: EXAMPLE 1 MACRO 1

The following macro can be used to recreate Example 1.

```
!START M1      Dynamic Anisotropy Example 1

# ------------------------------------------------------------------
#  Example of dynamic anisotropy in ESTIMA, as described in example 1 in
#  the user guide.  The following input files are required:
#   -  oretr, orept  The orebody wireframe
#   -  daholes       The drillhole sample file
#
#
#  The macro performs the following functions:
#   - defines a prototype model and fills it with cells using TRIFIL
#   - calculates the azi and dip of all triangles in the orebody wf
#     using ANISOANG
#   - uses IMETHOD 8 in ESTIMA to interpolate azi and dip into the model
#   - uses the dynamic anistropy option in ESTIMA to estimate AU values
#     into the model.
#
#  Malcolm Newton   April 2007
# ------------------------------------------------------------------

# ------------------------------------------------------------------
#  Create block model
# ------------------------------------------------------------------
!PROTOM   &OUT(PMOD)
n
y
0
0
0
5
5
2.5
40
36
64

!TRIFIL   &PROTO(PMOD),&MODEL(OREMOD1),&WIRETR(ORETR),&WIREPT(OREPT),
          @MODLTYPE=5.0,@MAXDIP=0.0,@SPLITS=0.0,@PLANE='XY  ',
          @XSUBCELL=1.0,@YSUBCELL=1.0,@ZSUBCELL=1.0,@RESOL=1.0

# ------------------------------------------------------------------
#  Calculate azi, dip and centre of each triangle
# ------------------------------------------------------------------
#!COGTRI   &WTRIN(ORETR),&WPTIN(OREPT),&PTNOUT(POINTS1),
#          @VERTEX=0,@SYMBOL=216,@SYMSIZE=2
!ANISOANG &WIRETR(ORETR),&WIREPT(OREPT),&POINTS(POINTS1),
          @TRIPTS=1.0,@ADDSYMB=1.0,
          @WFSYMB=216.0,@WFCOL=3.0,@SYMSIZE=2.0

# ------------------------------------------------------------------
#  Define search volume parameter file containing 3 search volumes:
#   1 - for interpolating angles (1st run of ESTIMA)
#   2 - for interpolating grades without dynamic anisotropy (2nd run)
```

```
#   3 - for interpolating grades with dynamic anisotropy (2nd run)
# ------------------------------------------------------------------
!INPFIL &OUT(SPAR1)
Field definition file for search volume
SREFNUM  N  Y  0
SMETHOD  N  Y  0
SDIST1   N  Y  0
SDIST2   N  Y  0
SDIST3   N  Y  0
SANGLE1  N  Y  0
SANGLE2   N  Y  0
SANGLE3   N  Y  0
SAXIS1    N  Y  0
SAXIS2    N  Y  0
SAXIS3    N  Y  0
OCTMETH   N  Y  0
MINOCT    N  Y  0
MINPEROC  N  Y  0
MAXPEROC  N  Y  0
MINNUM1   N  Y  0
MAXNUM1   N  Y  0
SVOLFAC2  N  Y  0
MINNUM2   N  Y  0
MAXNUM2   N  Y  0
SVOLFAC3  N  Y  0
MINNUM3   N  Y  0
MAXNUM3   N  Y  0
MAXKEY    N  Y  0
]
ok
    # no sys file
1,2,25,25,25 ,0,0,0,3,1,3,0,1,1,4,5,10,1.5,5,10,2.5,1,10,0
!rem

# ------------------------------------------------------------------
#  Estimation parameter file for interpolating angles
# ------------------------------------------------------------------
!INPFIL &OUT(EPAR1)
Field definition file for interpolating angles
VALUE_IN A 8 Y -
NUMSAM_F A 8 Y -
SREFNUM  N Y 0
IMETHOD  N Y 0
POWER    N Y 0
]
ok
    # no sys file
TRDIP,NSAMP,1,8,2
TRDIPDIR,,1,8,2
!rem




# ------------------------------------------------------------------
#  Interpolate dip and dip direction using IMETHOD=8
# ------------------------------------------------------------------
!ESTIMA   &PROTO(OREMOD1),&IN(POINTS1),&SRCPARM(SPAR1),&ESTPARM(EPAR1),
```

```
          &MODEL(OREMOD2),*X(XPT),*Y(YPT),*Z(ZPT),@DISCMETH=1.0,
          @XPOINTS=3.0,@YPOINTS=3.0,@ZPOINTS=3.0,@PARENT=0.0

# ------------------------------------------------------------------
#  Search volume parameter file for interpolating grade
#  Need to add the two dynamic anisotropy angle fields
#  - search volume 1 for horizontal search
#  - search volume 2 for dynamic anisotropy
# ------------------------------------------------------------------
!EXTRA    &IN(SPAR1),&OUT(SPAR2),@PRINT=1
SANGL1_F;a8 = "TRDIPDIR"
SANGL2_F;a8 = "TRDIP"
go
!INDATA   &IN(SPAR2),&OUT(SPAR2)
    # no sys file
1,2,25,25,2.5,0,0,0,3,1,3,0,1,1,4,5,10,1.5,5,10,2.5,1,10,0,,
2,2,25,25,2.5,0,0,0,3,1,3,0,1,1,4,5,10,1.5,5,10,2.5,1,10,0,TRDIPDIR,TRDIP
!rem

# ------------------------------------------------------------------
#  Estimation parameter file for interpolating grade
#  AU1 uses search volume 1 - horizontal search volume
#  AU2 uses search volume 2 - orientation defined from model cells
# ------------------------------------------------------------------
!INPFIL &OUT(EPAR2)
Field definition file for interpolating grade
VALUE_IN A 8 Y -
VALUE_OU A 8 Y -
NUMSAM_F A 8 Y -
SVOL_F   A 8 Y -
SREFNUM  N Y 0
IMETHOD  N Y 0
POWER    N Y 0
]
ok
    # no sys file
AU,AU1,NSAMP1,SVOL1,1,2,2
AU,AU2,NSAMP2,SVOL2,2,2,2
!rem

# ------------------------------------------------------------------
#  Estimate AU using dynamic anisotropy
# ------------------------------------------------------------------
!ESTIMA   &PROTO(OREMOD2),&IN(DAHOLES),&SRCPARM(SPAR2),&ESTPARM(EPAR2),
          &MODEL(OREMOD3),@DISCMETH=1.0,@XPOINTS=3.0,@YPOINTS=3.0,
          @ZPOINTS=3.0,@PARENT=0.0

!END
```

# Appendix B: EXAMPLE 2 MACRO 1

This macro can been used to recreate the results of Example 2, using string data.

```
!START M1      Zonal Anisotropy Using String Data

# Zonal Anisotropy Example Using UG Tutorial Data

# ------------------------------------------------------------------------
#  Data files used are:
#   - Block Model:     _vsbmgeo
#   - Drillholes:      _vsldhz
#   - Plan Strings:    _vsplnst      (new file)
#   - Section Strings: _vssecst      (new file)
# ------------------------------------------------------------------------

# ------------------------------------------------------------------------
#  Create data subset for zone 1 only
# ------------------------------------------------------------------------
!COPY   &IN(_VSBMGEO),&OUT(MODEL1),ZONE=1
!COPY   &IN(_VSLDHZ),&OUT(HOLES1),ZONE=1

# ------------------------------------------------------------------------
#  Calculate apparent dip and true dip direction from strings
# ------------------------------------------------------------------------
!ANISOANG &PLANSTR(_VSPLNST),&SECTSTR(_VSSECST),&POINTS(POINTS1),
          @TRIPTS=1.0,@PLANMODE=2.0,@SECTMODE=1.0,@ADDSYMB=1.0,
          @PLANSYMB=216.0,@SECTSYMB=216.0,@WFSYMB=224.0,@PLANCOL=1.0,
          @SECTCOL=2.0,@WFCOL=3.0,@SYMSIZE=3.0

# ------------------------------------------------------------------------
#  Search volume parameter file for interpolating angles
# ------------------------------------------------------------------------
!INPFIL &OUT(SPAR1)
Search Volume Parameter File
SREFNUM  N  Y  0
SMETHOD  N  Y  0
SDIST1   N  Y  0
SDIST2   N  Y  0
SDIST3   N  Y  0
SANGLE1  N  Y  0
SANGLE2   N  Y  0
SANGLE3   N  Y  0
SAXIS1    N  Y  0
SAXIS2    N  Y  0
SAXIS3    N  Y  0
OCTMETH   N  Y  0
MINOCT    N  Y  0
MINPEROC  N  Y  0
MAXPEROC  N  Y  0
MINNUM1   N  Y  0
MAXNUM1   N  Y  0
SVOLFAC2  N  Y  0
MINNUM2   N  Y  0
MAXNUM2   N  Y  0
SVOLFAC3  N  Y  0
MINNUM3   N  Y  0
```

```
MAXNUM3   N  Y  0
MAXKEY    N  Y  0
]
ok
    # no system file
1,2,25,25,25,0,0,0,3,1,3,0,1,1,4,2,4,2,2,4,3,1,4,0
!rem

# ------------------------------------------------------------------
#  Estimation parameter file for ESTIMA
#   - EPAR1 for interpolating angles (IMETHOD=8)
# ------------------------------------------------------------------
!INPFIL &OUT(EPAR1)
Estimation Parameter File for Interpolating Angles
VALUE_IN A 8 Y -
NUMSAM_F A 8 Y -
SREFNUM  N Y 0
IMETHOD  N Y 0
POWER    N Y 0
]
ok
    # no system file
APDIP,NDIP,1,8,2
TRDIPDIR,NDIPDIR,1,8,2
!rem

# ------------------------------------------------------------------
#  Interpolate APDIP and TRDIPDIR (IMETHOD=8)
# ------------------------------------------------------------------
!ESTIMA   &PROTO(MODEL1),&IN(POINTS1),&SRCPARM(SPAR1),&ESTPARM(EPAR1),
          &MODEL(MODEL2),*X(XPT),*Y(YPT),*Z(ZPT),@DISCMETH=1.0,
          @XPOINTS=2.0,@YPOINTS=2.0,@ZPOINTS=2.0,@PARENT=0.0

# ------------------------------------------------------------------
#  Calculate true dip angle TRDIP
# ------------------------------------------------------------------
!APTOTRUE &IN(MODEL2),&OUT(MODEL3),@APDIPDIR=90

# ------------------------------------------------------------------
#  Search volume file for interpolating grade using dynamic anisotropy
# ------------------------------------------------------------------
!INDATA &IN(SPAR1),&OUT(TEMP1)
    # no system file
1,2,50,50,20,91,36,0,3,1,3,0,1,1,4,5,15,2,5,15,3,1,15,0
!rem

!ADDDD    &IN(TEMP1),&OUT(SPAR2)
Adding fields SANGL1_F and SANGL2_F
SANGL1_F A 8 Y TRDIPDIR
SANGL2_F A 8 Y TRDIP
[
ok

# ------------------------------------------------------------------
#  Estimation parameter file for grade using dynamic anisotropy
#   - EPAR2 for interpolating grades (IMETHOD=2)
# ------------------------------------------------------------------
!INPFIL &OUT(EPAR2)
```

```
Estimation Parameter File for Interpolating Grades
VALUE_IN A 8 Y -
VALUE_OU A 8 Y -
SREFNUM  N Y 0
IMETHOD  N Y 0
POWER    N Y 0
]
ok
    # no sys file
AU,AU1,1,2,2
!rem

# ------------------------------------------------------------------------
#  Interpolate Grade using Dynamic Anisotropy
# ------------------------------------------------------------------------
!ESTIMA   &PROTO(MODEL3),&IN(HOLES1),&SRCPARM(SPAR2),&ESTPARM(EPAR2),
          &MODEL(MODEL4),*X(X),*Y(Y),*Z(Z),@DISCMETH=1.0,
          @XPOINTS=2.0,@YPOINTS=2.0,@ZPOINTS=2.0,@PARENT=0.0

# ------------------------------------------------------------------------
#  Search volume file for interpolating grade without dynamic anisotropy
# ------------------------------------------------------------------------
!SELDEL &IN(SPAR2),&OUT(SPAR3),*F1(SANGL1_F),*F2(SANGL2_F)

# ------------------------------------------------------------------------
#  Estimation parameter file for grade without dynamic anisotropy
#   - EPAR3 for interpolating grades (IMETHOD=2)
# ------------------------------------------------------------------------
!INPFIL &OUT(EPAR3)
Estimation Parameters for Grade with Dynamic Anisotropy
VALUE_IN A 8 Y -
VALUE_OU A 8 Y -
SREFNUM  N Y 0
IMETHOD  N Y 0
POWER    N Y 0
]
ok
    # no sys file
AU,AU2,1,2,2
!rem

# ------------------------------------------------------------------------
#  Interpolate Grade without Dynamic Anisotropy
# ------------------------------------------------------------------------
!ESTIMA   &PROTO(MODEL4),&IN(HOLES1),&SRCPARM(SPAR3),&ESTPARM(EPAR3),
          &MODEL(MODEL5),*X(X),*Y(Y),*Z(Z),@DISCMETH=1.0,
          @XPOINTS=2.0,@YPOINTS=2.0,@ZPOINTS=2.0,@PARENT=0.0

# ------------------------------------------------------------------------
#  Compare Grades with and without Dynamic Anisotropy
# ------------------------------------------------------------------------
!EXTRA   &IN(MODEL5),&OUT(MODEL6),@PRINT=1
VOL    = XINC*YINC*ZINC
AUDIFF = AU1 - AU2
go

!TONGRAD &IN(MODEL6),&OUT(RESULTS1),*F1(AU1),*F2(AU2),@DENSITY=2.5,@ROW=1
!DMEDIT  &IN(RESULTS1)
```

```
C
ROW
SECTION
E
!TONGRAD &IN(MODEL6),&OUT(RESULTS2),*F1(AU1),*F2(AU2),@DENSITY=2.5
!APPEND  &IN1(RESULTS1),&IN2(RESULTS2),&OUT(TEMP2)
!EXTRA   &IN(TEMP2),&OUT(RESULTS3),@PRINT=1
TONNES = int(TONNES)
AU1    = int(AU1*100)/100
AU2    = int(AU2*100)/100
AUDIFF = AU1 - AU2
go
!LIST    &IN(RESULTS3),*F1(SECTION),*F2(TONNES),*F3(AU1),*F4(AU2),
         *F5(AUDIFF),@PROMPT=0

# ---------------------------------------------------------------------
#  Plot AUDIFF by E-W Section
# ---------------------------------------------------------------------
!CHART    &IN(RESULTS3),&PLOT(AUDIFSEC),*X(SECTION),*Y(AUDIFF),@CHARTTYP=2.0,
          @HISTTYP=1.0,@BINSIZE=1.0,@BINMIN=0.0,@BINMETH=1.0,
          @XTRANS=1.0,@YTRANS=1.0,@LOGMIN=0.01,@FRAMETYP=2.0,
          @XFACTOR=1.0,@YFACTOR=1.0,@LINETYP1=1.0,@SYMBOL1=92.0,
          @SYMSIZE1=3.0,@COLOUR1=1.0,@LINETYP2=0.0,@SYMBOL2=0.0,
          @SYMSIZE2=3.0,@COLOUR2=0.0,@APPEND=0.0,@COLFLAG=1.0,
          @LEGCHSIZ=3.0,@TCHARSZ=5.0,@TCOLOUR=1.0,@XINC=100.0,
          @YINC=0.5,@NDX=0.0,@NDY=1.0,@IGRID=4.0,@FCHARSZ=5.0,
          @FCOLOUR=1.0,@XPAPER=240.0,@YPAPER=200.0,@XMIN=4100.0,
          @XMAX=4500.0,@YMIN=-1.0,@YMAX=1.0,@PROGRESS=1.0,
          @DISPLAY=1.0

# ---------------------------------------------------------------------
#  Plot AUDIFF Histogram
# ---------------------------------------------------------------------
!CHART    &IN(MODEL6),&PLOT(AUDIFHIS),*X(AUDIFF),@CHARTTYP=3.0,
          @HISTTYP=1.0,@BINSIZE=0.5,@BINMIN=-8.0,@BINMAX=8.0,
          @BINMETH=1.0,@XTRANS=1.0,@YTRANS=1.0,@LOGMIN=0.01,
          @FRAMETYP=2.0,@XFACTOR=1.0,@YFACTOR=1.0,@LINETYP1=1.0,
          @SYMBOL1=92.0,@SYMSIZE1=3.0,@COLOUR1=1.0,@LINETYP2=0.0,
          @SYMBOL2=0.0,@SYMSIZE2=3.0,@COLOUR2=0.0,@APPEND=0.0,
          @COLFLAG=1.0,@LEGCHSIZ=3.0,@TCHARSZ=5.0,@TCOLOUR=1.0,
          @XINC=2.0,@YINC=5.0,@NDX=0.0,@NDY=0.0,@IGRID=3.0,
          @FCHARSZ=5.0,@FCOLOUR=1.0,@XPAPER=240.0,@YPAPER=200.0,
          @PROGRESS=1.0,@DISPLAY=1.0

# ---------------------------------------------------------------------
#  Save the important files
# ---------------------------------------------------------------------
!COPY  &IN(POINTS1),&OUT(POINTS1A)
!COPY  &IN(MODEL6),&OUT(MODEL6A)
!COPY  &IN(RESULTS3),&OUT(RESULT3A)
!COPY  &IN(AUDIFSEC),&OUT(AUDIFSEA)
!COPY  &IN(AUDIFHIS),&OUT(AUDIFHIA)

!END
```

# Appendix C: EXAMPLE 2 MACRO 2

This macro can been used to recreate the results of Example 2, using wireframe data.

```
!START M2      Zonal Anisotropy Using Wireframe Data

# Zonal Anisotropy Example Using UG Tutorial Data

# ---------------------------------------------------------------------
#  Data files used are:
#   - Block Model:     _vsbmgeo
#   - Drillholes:      _vsldhz
#   - Wireframe:       _vsoretr, _vsorept
# ---------------------------------------------------------------------

# ---------------------------------------------------------------------
#  Create data subset for zone 1 only
# ---------------------------------------------------------------------
!COPY   &IN(_VSBMGEO),&OUT(MODEL1),ZONE=1
!COPY   &IN(_VSLDHZ),&OUT(HOLES1),ZONE=1
!COPY   &IN(_VSORETR),&OUT(WTR1),ZONE=1
!COPY   &IN(_VSOREPT),&OUT(WPT1)

# ---------------------------------------------------------------------
#  Calculate true dip and true dip direction from wireframe
# ---------------------------------------------------------------------
!ANISOANG &WIRETR(WTR1),&WIREPT(WPT1),&POINTS(POINTS1),
          @TRIPTS=1.0,@ADDSYMB=1.0,
          @MINDIP=5,@MAXDIP=85,@MINDIRN=20,@MAXDIRN=160,
          @WFSYMB=216.0,@WFCOL=3.0,@SYMSIZE=3.0

# ---------------------------------------------------------------------
#  Search volume parameter file for interpolating angles
# ---------------------------------------------------------------------
!INPFIL &OUT(SPAR1)
Search Volume Parameter File
SREFNUM  N  Y  0
SMETHOD  N  Y  0
SDIST1   N  Y  0
SDIST2   N  Y  0
SDIST3   N  Y  0
SANGLE1  N  Y  0
SANGLE2   N  Y  0
SANGLE3   N  Y  0
SAXIS1    N  Y  0
SAXIS2    N  Y  0
SAXIS3    N  Y  0
OCTMETH   N  Y  0
MINOCT    N  Y  0
MINPEROC  N  Y  0
MAXPEROC  N  Y  0
MINNUM1   N  Y  0
MAXNUM1   N  Y  0
SVOLFAC2  N  Y  0
MINNUM2   N  Y  0
MAXNUM2   N  Y  0
SVOLFAC3  N  Y  0
```

```
MINNUM3   N  Y  0
MAXNUM3   N  Y  0
MAXKEY    N  Y  0
]
ok
    # no system file
1,2,25,25,25,0,0,0,3,1,3,0,1,1,4,2,4,2,2,4,3,1,4,0
!rem

# ------------------------------------------------------------------
#  Estimation parameter file for ESTIMA
#   - EPAR1 for interpolating angles (IMETHOD=8)
# ------------------------------------------------------------------
!INPFIL &OUT(EPAR1)
Estimation Parameter File for Interpolating Angles
VALUE_IN A 8 Y -
NUMSAM_F A 8 Y -
SREFNUM  N Y 0
IMETHOD  N Y 0
POWER    N Y 0
]
ok
    # no system file
TRDIP,NDIP,1,8,2
TRDIPDIR,NDIPDIR,1,8,2
!rem

# ------------------------------------------------------------------
#  Interpolate APDIP and TRDIPDIR (IMETHOD=8)
# ------------------------------------------------------------------
!ESTIMA   &PROTO(MODEL1),&IN(POINTS1),&SRCPARM(SPAR1),&ESTPARM(EPAR1),
          &MODEL(MODEL2),*X(XPT),*Y(YPT),*Z(ZPT),@DISCMETH=1.0,
          @XPOINTS=2.0,@YPOINTS=2.0,@ZPOINTS=2.0,@PARENT=0.0

# ------------------------------------------------------------------
#  Calculate true dip angle TRDIP.  Not needed when using wireframes!
# ------------------------------------------------------------------
#!APTOTRUE &IN(MODEL2),&OUT(MODEL3),@APDIPDIR=90
!COPY &IN(MODEL2),&OUT(MODEL3)

# ------------------------------------------------------------------
#  Search volume file for interpolating grade using dynamic anisotropy
# ------------------------------------------------------------------
!INDATA &IN(SPAR1),&OUT(TEMP1)
    # no system file
1,2,50,50,20,91,36,0,3,1,3,0,1,1,4,5,15,2,5,15,3,1,15,0
!rem

!ADDDD    &IN(TEMP1),&OUT(SPAR2)
Adding fields SANGL1_F and SANGL2_F
SANGL1_F A 8 Y TRDIPDIR
SANGL2_F A 8 Y TRDIP
[
ok

# ------------------------------------------------------------------
#  Estimation parameter file for grade using dynamic anisotropy
#   - EPAR2 for interpolating grades (IMETHOD=2)
```

```
# ------------------------------------------------------------------
!INPFIL &OUT(EPAR2)
Estimation Parameter File for Interpolating Grades
VALUE_IN A 8 Y -
VALUE_OU A 8 Y -
SREFNUM  N Y 0
IMETHOD  N Y 0
POWER    N Y 0
]
ok
    # no sys file
AU,AU1,1,2,2
!rem

# ------------------------------------------------------------------
#  Interpolate Grade using Dynamic Anisotropy
# ------------------------------------------------------------------
!ESTIMA   &PROTO(MODEL3),&IN(HOLES1),&SRCPARM(SPAR2),&ESTPARM(EPAR2),
          &MODEL(MODEL4),*X(X),*Y(Y),*Z(Z),@DISCMETH=1.0,
          @XPOINTS=2.0,@YPOINTS=2.0,@ZPOINTS=2.0,@PARENT=0.0

# ------------------------------------------------------------------
#  Search volume file for interpolating grade without dynamic anisotropy
# ------------------------------------------------------------------
!SELDEL &IN(SPAR2),&OUT(SPAR3),*F1(SANGL1_F),*F2(SANGL2_F)

# ------------------------------------------------------------------
#  Estimation parameter file for grade without dynamic anisotropy
#   - EPAR3 for interpolating grades (IMETHOD=2)
# ------------------------------------------------------------------
!INPFIL &OUT(EPAR3)
Estimation Parameters for Grade with Dynamic Anisotropy
VALUE_IN A 8 Y -
VALUE_OU A 8 Y -
SREFNUM  N Y 0
IMETHOD  N Y 0
POWER    N Y 0
]
ok
    # no sys file
AU,AU2,1,2,2
!rem

# ------------------------------------------------------------------
#  Interpolate Grade without Dynamic Anisotropy
# ------------------------------------------------------------------
!ESTIMA   &PROTO(MODEL4),&IN(HOLES1),&SRCPARM(SPAR3),&ESTPARM(EPAR3),
          &MODEL(MODEL5),*X(X),*Y(Y),*Z(Z),@DISCMETH=1.0,
          @XPOINTS=2.0,@YPOINTS=2.0,@ZPOINTS=2.0,@PARENT=0.0

# ------------------------------------------------------------------
#  Compare Grades with and without Dynamic Anisotropy
# ------------------------------------------------------------------
!EXTRA   &IN(MODEL5),&OUT(MODEL6),@PRINT=1
VOL    = XINC*YINC*ZINC
AUDIFF = AU1 - AU2
go
```

```
!TONGRAD &IN(MODEL6),&OUT(RESULTS1),*F1(AU1),*F2(AU2),@DENSITY=2.5,@ROW=1
!DMEDIT  &IN(RESULTS1)
C
ROW
SECTION
E
!TONGRAD &IN(MODEL6),&OUT(RESULTS2),*F1(AU1),*F2(AU2),@DENSITY=2.5
!APPEND  &IN1(RESULTS1),&IN2(RESULTS2),&OUT(TEMP2)
!EXTRA   &IN(TEMP2),&OUT(RESULTS3),@PRINT=1
TONNES = int(TONNES)
AU1    = int(AU1*100)/100
AU2    = int(AU2*100)/100
AUDIFF = AU1 - AU2
go
!LIST    &IN(RESULTS3),*F1(SECTION),*F2(TONNES),*F3(AU1),*F4(AU2),
         *F5(AUDIFF),@PROMPT=0

# ---------------------------------------------------------------------
#  Plot AUDIFF by E-W Section
# ---------------------------------------------------------------------
!CHART    &IN(RESULTS3),&PLOT(AUDIFSEC),*X(SECTION),*Y(AUDIFF),@CHARTTYP=2.0,
          @HISTTYP=1.0,@BINSIZE=1.0,@BINMIN=0.0,@BINMETH=1.0,
          @XTRANS=1.0,@YTRANS=1.0,@LOGMIN=0.01,@FRAMETYP=2.0,
          @XFACTOR=1.0,@YFACTOR=1.0,@LINETYP1=1.0,@SYMBOL1=92.0,
          @SYMSIZE1=3.0,@COLOUR1=1.0,@LINETYP2=0.0,@SYMBOL2=0.0,
          @SYMSIZE2=3.0,@COLOUR2=0.0,@APPEND=0.0,@COLFLAG=1.0,
          @LEGCHSIZ=3.0,@TCHARSZ=5.0,@TCOLOUR=1.0,@XINC=100.0,
          @YINC=0.5,@NDX=0.0,@NDY=1.0,@IGRID=4.0,@FCHARSZ=5.0,
          @FCOLOUR=1.0,@XPAPER=240.0,@YPAPER=200.0,@XMIN=4100.0,
          @XMAX=4500.0,@YMIN=-1.0,@YMAX=1.0,@PROGRESS=1.0,
          @DISPLAY=1.0

# ---------------------------------------------------------------------
#  Plot AUDIFF Histogram
# ---------------------------------------------------------------------
!CHART    &IN(MODEL6),&PLOT(AUDIFHIS),*X(AUDIFF),@CHARTTYP=3.0,
          @HISTTYP=1.0,@BINSIZE=0.5,@BINMIN=-8.0,@BINMAX=8.0,
          @BINMETH=1.0,@XTRANS=1.0,@YTRANS=1.0,@LOGMIN=0.01,
          @FRAMETYP=2.0,@XFACTOR=1.0,@YFACTOR=1.0,@LINETYP1=1.0,
          @SYMBOL1=92.0,@SYMSIZE1=3.0,@COLOUR1=1.0,@LINETYP2=0.0,
          @SYMBOL2=0.0,@SYMSIZE2=3.0,@COLOUR2=0.0,@APPEND=0.0,
          @COLFLAG=1.0,@LEGCHSIZ=3.0,@TCHARSZ=5.0,@TCOLOUR=1.0,
          @XINC=2.0,@YINC=5.0,@NDX=0.0,@NDY=0.0,@IGRID=3.0,
          @FCHARSZ=5.0,@FCOLOUR=1.0,@XPAPER=240.0,@YPAPER=200.0,
          @PROGRESS=1.0,@DISPLAY=1.0

# ---------------------------------------------------------------------
#  Save the important files
# ---------------------------------------------------------------------
!COPY  &IN(POINTS1),&OUT(POINTS1B)
!COPY  &IN(MODEL6),&OUT(MODEL6B)
!COPY  &IN(RESULTS3),&OUT(RESULT3B)
!COPY  &IN(AUDIFSEC),&OUT(AUDIFSEB)
!COPY  &IN(AUDIFHIS),&OUT(AUDIFHIB)

!END
```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