Tutorial A (A First Geology Modelling Experience)

Parent topic:
User Manual and Tutorials

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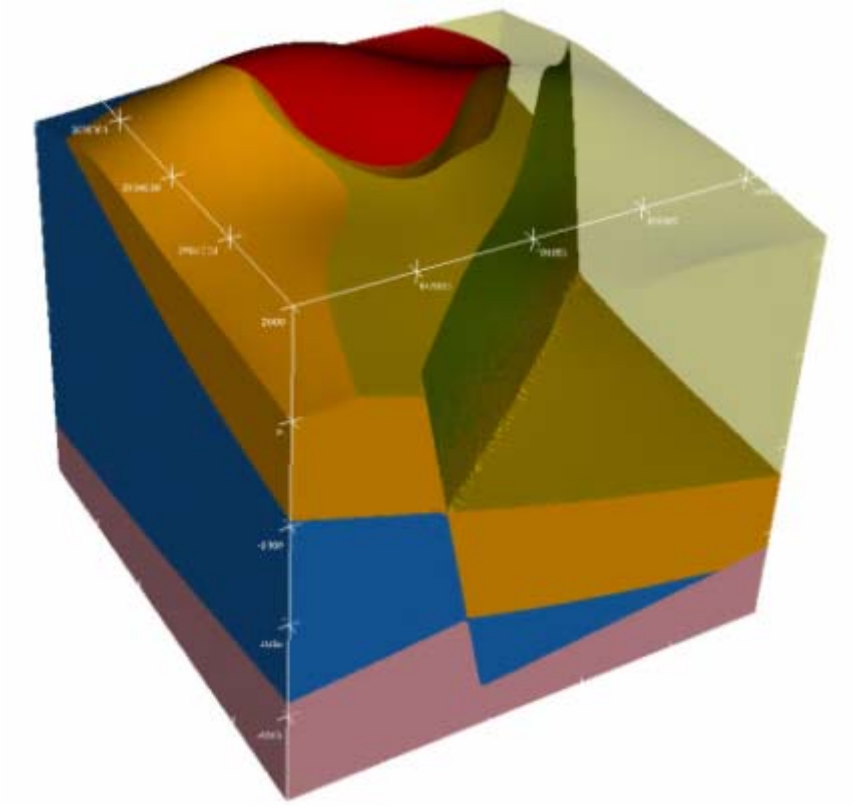


Disclaimer

It is Intrepid Geophysics' understanding that this tutorial document and associated data are provided for purpose of training in the use and application of 3D GeoModeller, and the material and data cannot be used or relied upon for any other purpose. Intrepid Geophysics is not liable for any inaccuracies (including any incompleteness) in this material and data.

In this case study:

- Tutorial A1—A simple model with two formations
- Tutorial A2—Several formations that overlap each other
- Tutorial A3—Intrusive bodies
- Tutorial A4—Geology with a fault
- Tutorial A5—Incorporating drillhole data
- Tutorial A6—Adding down-hole numerical data

Location of files

In this document we refer to files supplied with your GeoModeller software installation.

Generally: **`C:\GeoModeller`** (or your customised path)
`C:GeoModeller\GeoModeller2014*build#*\tutorial\TutorialA.zip`

Unpack this zip file into a work area of your choice.

NOTE: There must NOT be any spaces in the path

As you progress through the tutorial, you will produce and save your own GeoModeller project(s). We recommend you store these in another place, away from your GeoModeller installation. This way, the original tutorial files will be preserved for future use.

Warning: the name you choose to save your own project should not contain any spaces. Use _ instead (eg. **My_Tutorial_A1**)! It is important to regularly **Save** (and Save As) your work as you progress with the exercises.

Do not overwrite the original Tutorial zip files stored in:

`C:\GeoModeller\GeoModeller2014*Build#*\tutorial\TutorialA.zip`

Tutorial A1—A simple model with two formations

Parent topic: **Tutorial A (A First Geology Modelling Experience)**

This tutorial shows you how to use basic functions of GeoModeller by building a simple 3D model comprised of 2 geology formations.

You will learn how to:

- Create a project by defining its limits, its formations and geological pile
- Create a topographic surface, using a Digital Terrain Model (DTM)
- Create a section
- Import geology data to a map-view and a cross-section
- Compute the 3D model
- Render the 3D model in 2D views
- Display the model in 3D

Our project area is a cube with sides of 10km.

In Tutorial A1, we model two formations. These are named:

- UpperCover
- LowerCover

In this tutorial:

- A1 Stage 1—Start the project, create topography, formations, series and the stratigraphic pile
- A1 Stage 2—Create a section
- A1 Stage 3—Create & import geology data to the section
- A1 Stage 4—Compute the 3D model
- A1 Stage 5—Show the 3D model in 2D sections and in 3D

Note that a completed version of this tutorial is available in:

`TutorialA\TutorialA1\A1Completed_Project\A1Completed_Project.xml`

Do not overwrite it.

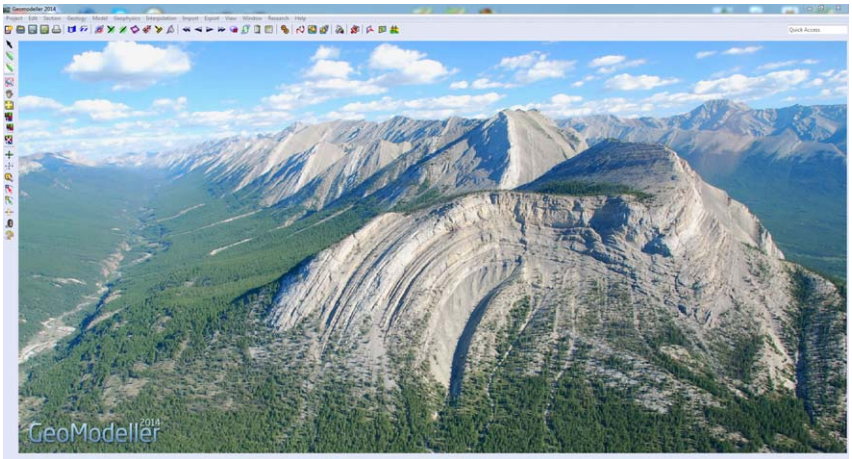
A1 Stage 1—Start the project, create topography, formations, series and the stratigraphic pile

Parent topic: **Tutorial A1—A simple model with two formations**

A GeoModeller project retains copies of all the data files (e.g., formations, faults, sections) used to build the modelling project. It sets the limits of the geographical region (a parallelepiped) which defines the project area.

A1 Stage 1-Steps

1 Launch the 3D GeoModeller software, to reveal the splash screen.



2 Create a new project (first close the current project if required):

From the main menu choose **Project > New**

OR From the **Project** toolbar choose **New**

OR Press CTRL+N

3 **Parent Directory:** Navigate to the required parent directory in which you want to create the new project. **Project Location:** will show the selected directory path.

Note: Spaces are NOT allowed in the directory path

4 Add the following parameters:

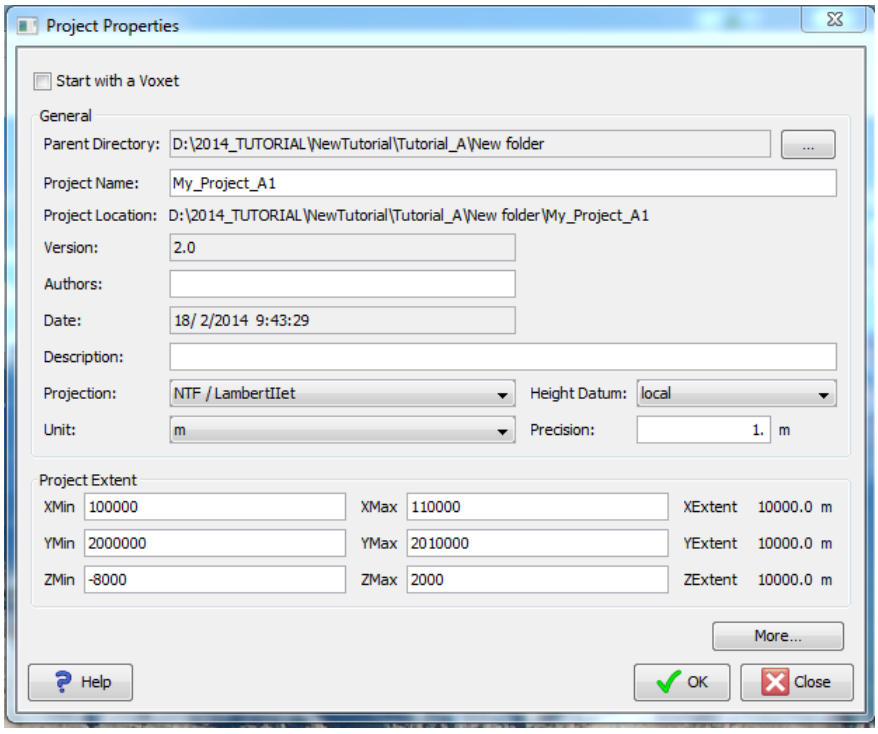
Project Name: **`My_Project_A1`** (Note: No spaces in the name!)
Authors: Your name or company name
Description: Training (or a comment of your choice)
Projection: NTF / LambertIIet
Unit: m

Project Extent (Geographical Area):

XMin	**100000**	XMax	**110000**	XExtent	**10000**
YMin	**2000000**	YMax	**2010000**	YExtent	**10000**
ZMin	**-8000**	ZMax	**2000**	ZExtent	**10000**

Except for the geographical limits and projection, all of the fields are text, purely for information. You can recall and edit them any time. They do not influence the project.

For other fields (not mentioned above) use default values.



Choose **OK.** A dialog box will now appear.

5 Import the topographic surface of your project.

When you import the topographic surface, GeoModeller opens a 2D Viewer showing a 2D (plan) view of your project (i.e. the topographic surface). In this view you can enter geology observations from your field mapping, and see the geology map plotted from the computed 3D geology model.

The surveyor has mapped the ground with GPS, processed the data and generated a Digital Terrain Model (DTM). The file is supplied.

Choose **Load from a DTM** in the **Project creation successful** dialog box.

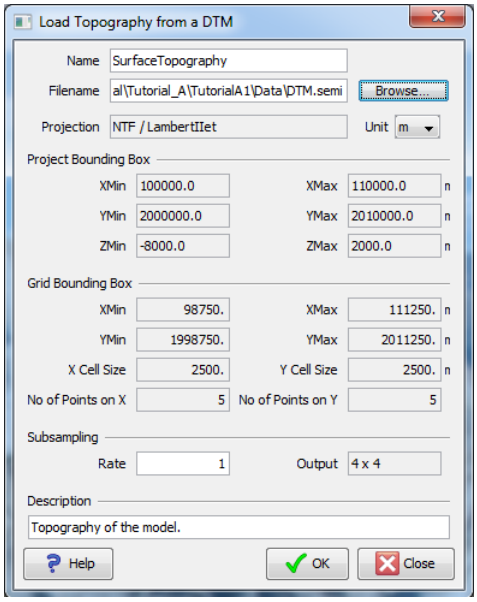
3D GeoModeller displays the **Load topography from a DTM** dialog box.

Choose **Browse** and select: **`TutorialA\TutorialA1\Data\DTM.semi`**

Also in the Load topography from a DTM dialog box, load the following properties:

- **Name:** Topography
- Browse to the Filename (of the source data **DTM.semi** see above):
- **Description:** Topography of the model

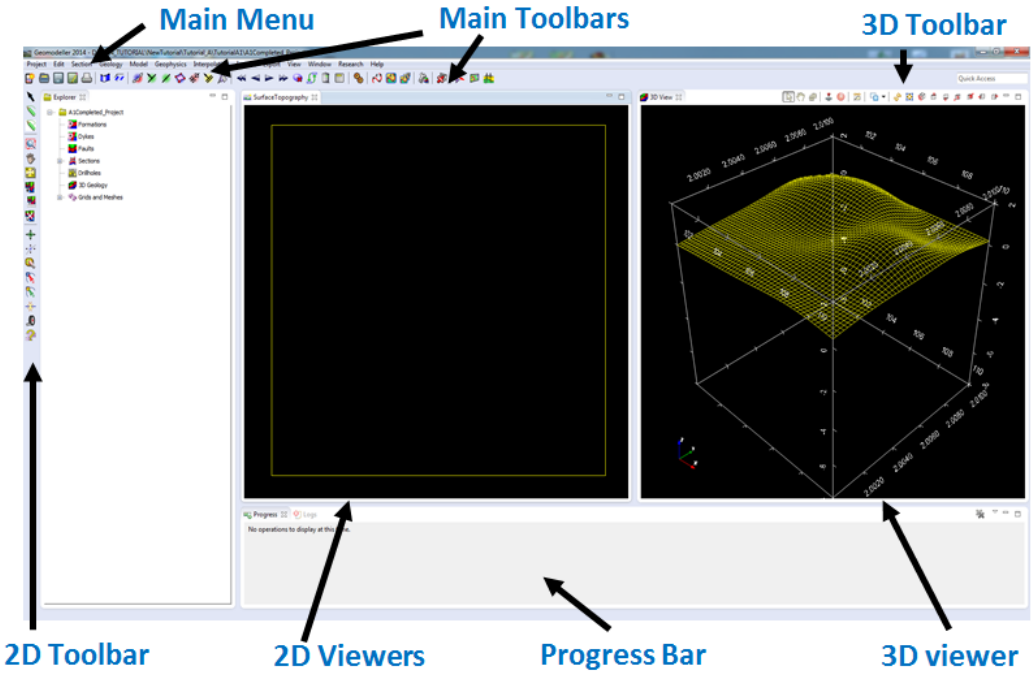
The resolution of the DTM file can be resampled on import, but we will not change this here.

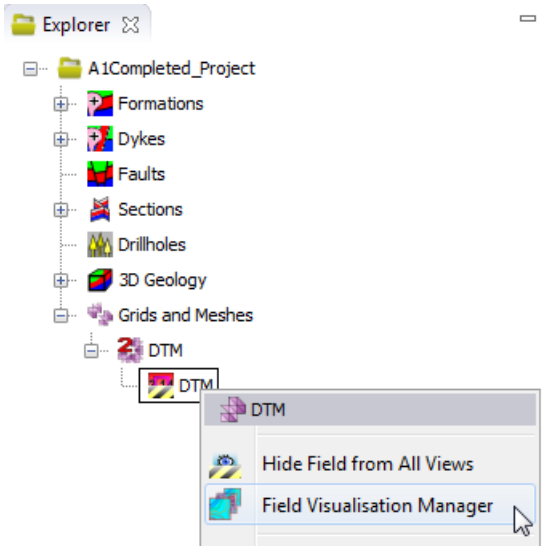


Other than a simple ascii grid (.semi), many grids formats are supported. Use the Browse menu to explore the options.

6 Choose **OK**

GeoModeller will open its 3D Viewer, and show the bounding box of your project, complete with an outline of the topographic surface (i.e. the **Topography** section)





7 Use project **Explorer** tree on the left hand side, to expand the **Sections** list (the "+" will change to a "-"). Note the **Explorer** tree now shows the DTM as part of the Grids & Meshes (by the "+" sign)

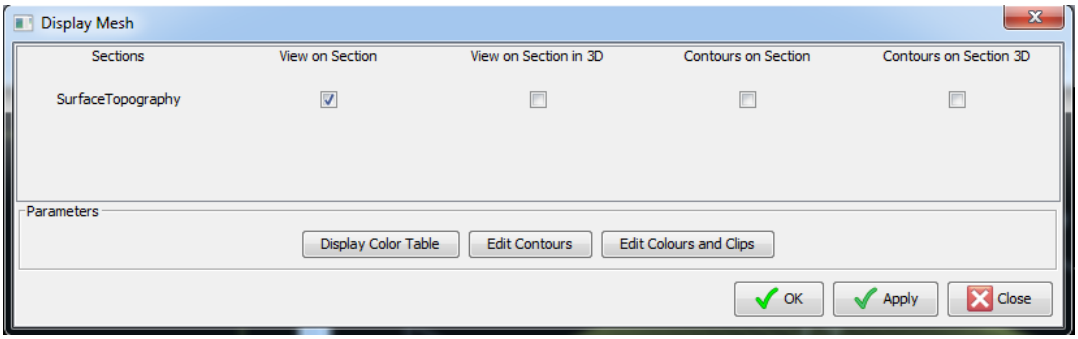
8 To **display** the DTM grid as a colour image in the section view: First, completely **expand** the DTM grid below **Grids and Meshes**

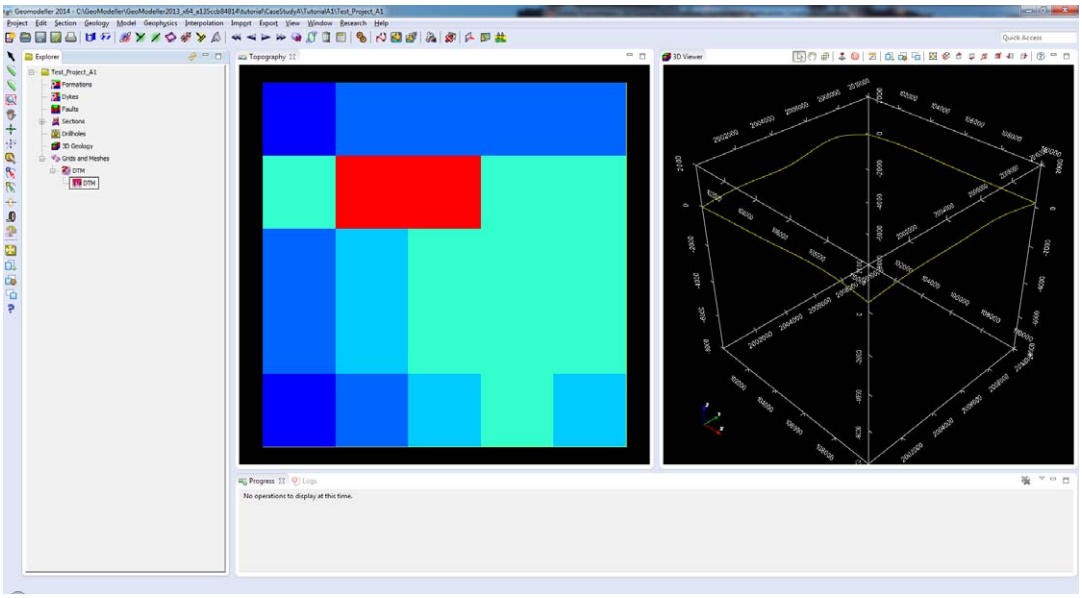
Then, choose the grid with a left-mouse click, and right-click to open the Menu.

Choose **Field Visualisation Manager**.

9 In the **Field Visualisation Manager** window tick:

View on section for **Topography**, then click **OK**





10 Remove the DTM grids:

In **Explorer**, Expand the DTM meshes, choose **DTM field** > Right Click **Remove Field From All Views**

11 Save the project

Ideally, Save As, to save the project in a folder outside the GeoModeller installation path.

From the main menu choose **Project > Save As** OR
From the **Project** toolbar choose **Save As** OR

Press CTRL+SHIFT+S.

Note: The 'Save as' operation is unusual. When you specify a project name you are actually specifying a folder name. GeoModeller saves the project as an **`*.xml`** (with the same name as the directory) in that directory, along with all associated or referenced files.

A completed version of the tutorial is available at:

`TutorialA\TutorialA1\A1CompletedProject\A1Completed_Project.xml`

Do not overwrite it.

12 Create geology formations

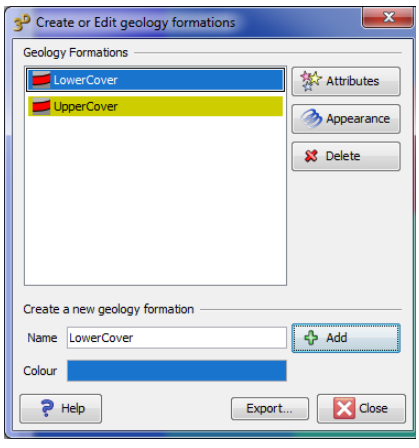
Use the parameters listed in the following table. Make sure you enter the names exactly as shown-case sensitive, no spaces; this is needed since we will be importing some geology data, and the data files have been prepared using the formation names as listed here: (Precise colours are optional.)

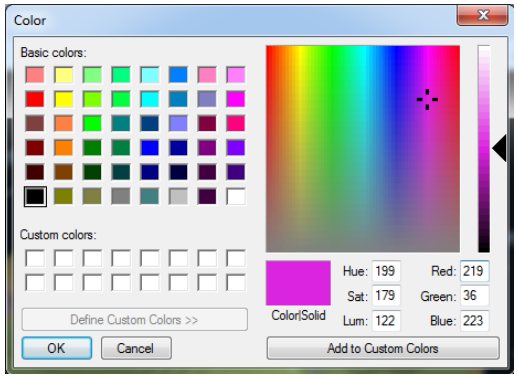
	Formation 1	**Formation 2**
Name	UpperCover	LowerCover
Colour	yellow (RGB 205 205 0)	blue (RGB 24 116 205)

Choose main menu option **Geology > Formations : Create or Edit.**

In the **Create or Edit geology formations** dialog box, use the following sequence:

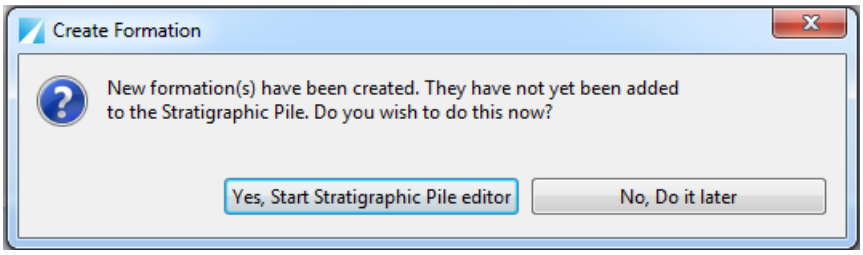
- Enter the **Name**
- Specify the **Colour** (Click the **Colour** field and select the colour from the palette. Use the **RGB** tab if you want to get it exact, but this is optional).
- Choose **Add**





Choose **Close** after you have created the two required geology formations.

When you choose **Close** in the previous step, GeoModeller may display the **New formation creation** tip box.



Choose **Yes, start Stratigraphic Pile editor**.

13 Create the geological pile for your project

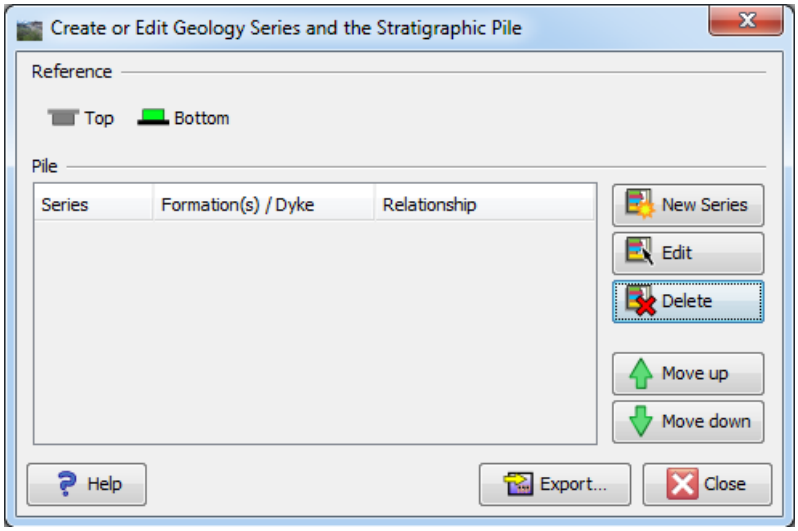
If the tip box and pop-up (like below) does not appear:

From the **main menu**, choose **Geology > Stratigraphic Pile: Create or Edit**

Select the Reference: **Bottom**

For this example we will use geology observations which will represent the '**bottom**' of the geological formations.

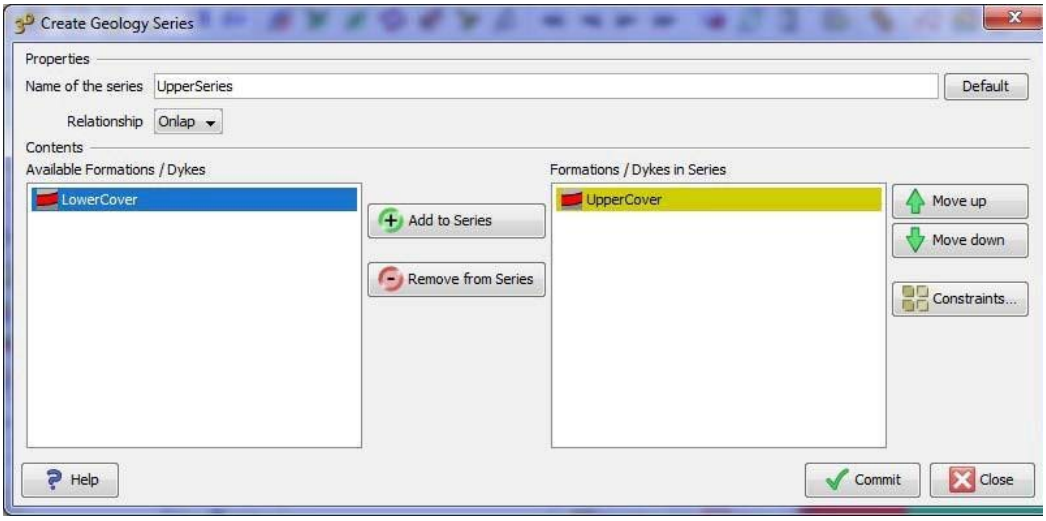
Choose **New series**



We will create two series as shown in the following table:

Series	Formations	Relationship
UpperSeries	UpperCover	Onlap
LowerSeries	LowerCover	Onlap

Choosing **New series** pops up the **Create Geology Series** dialog box:



14 For **Name of the series** a suggested name appears, but specify "**UpperSeries**"

- By default **UpperCover** is already listed on the right-hand-side in the **Formations / Dykes in Series** list; therefore no editing is required.

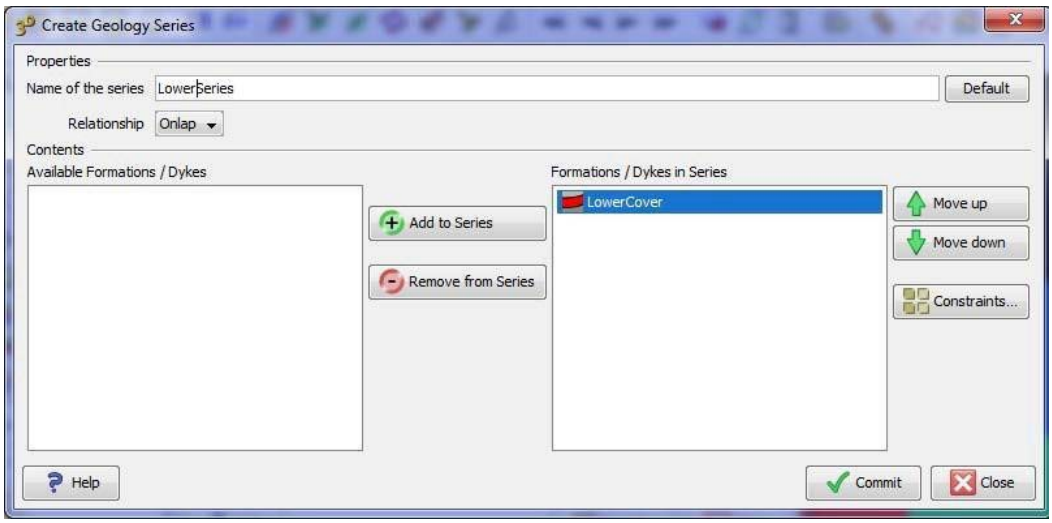
  To practice adding a geology formation to a series, select a formation from the left-hand-side list (**Available Formations / Dykes**) and choose **Add to Series.**

  Alternatively, to remove a formation, select a formation from the right-hand-side list (in **Formations / Dykes in Series**) and choose **Remove from Series**.

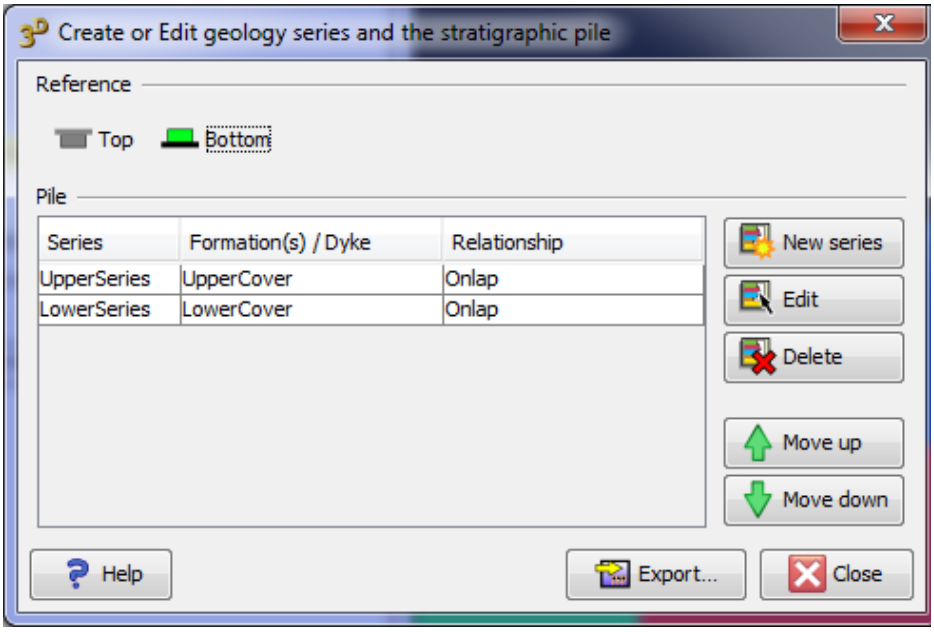
- Ensure **UpperCover** is listed on the right-hand-side for the **UpperSeries** (as pictured above). Check the relationship is "Onlap"

Then, choose **Commit**

15 Specify **LowerSeries** in a similar way, with **LowerCover** in the **Formation / Dykes in Series** list on the right. Ensure you have named the series **“LowerSeries”**



Choose **Commit**, and then choose **Close**.



16 If necessary, select one of the series and use **Move up** or **Move down** to put UpperSeries on top.

Check that **Reference** has been set to **Bottom**.
Choose **Close**.

Save your project

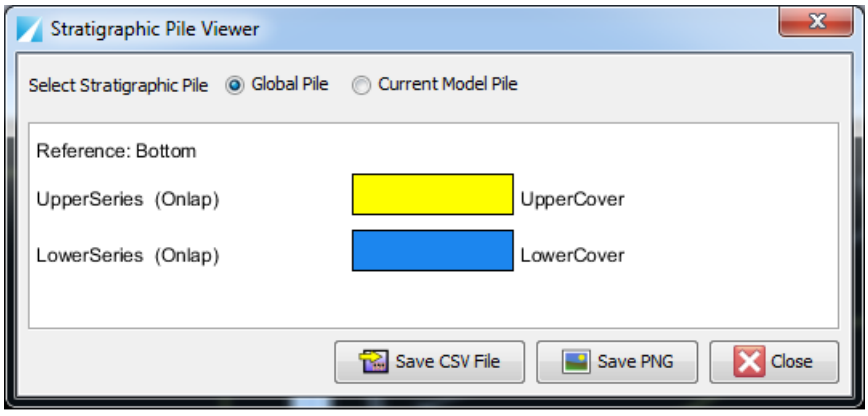
From the main menu choose **Project > Save** OR

From the Project toolbar choose **Save** OR

Press CTRL+S.

17 Check the effect of the above steps for the creation of the **Stratigraphic pile**

From the main menu choose **Geology > Stratigraphic Pile: Visualise**



A1 Stage 2—Create a section

Parent topic: Tutorial A1—A simple model with two formations

In a typical geology mapping project, we need to define one or more cross sections. Geology mapped at surface can be imported to the surface topography section. While geology interpreted or mapped on an (underground) section can be likewise imported to an appropriate pre-created cross-section.

Assume your field mapping area shows a NE–SW regional strike to the geology. You therefore decide to define a NW–SE cross section, orthogonal to regional strike.

The Points List and the **Points list editor** enable you to create points (a pair of coordinates) which will be contained within a section in a GeoModeller project. Two is the minimum number of points to define a section.

Now you will create a vertical section by defining its trace on the **Topography** section. Use the following parameters:

- **Name:** Section1
- **Coordinates** of the ends of the section on the topography

	X (East) = U	Y (North) = V
Start	100010	2009990
End	109990	2000010

- Default values for all the other parameters.

We will click the points (in an approximate position) to add them to the Points List Editor, and then edit them to achieve the exact coordinates (as defined in the table above).

A1 Stage 2-Steps

1 Add two points (at approximate locations) to the Points List.

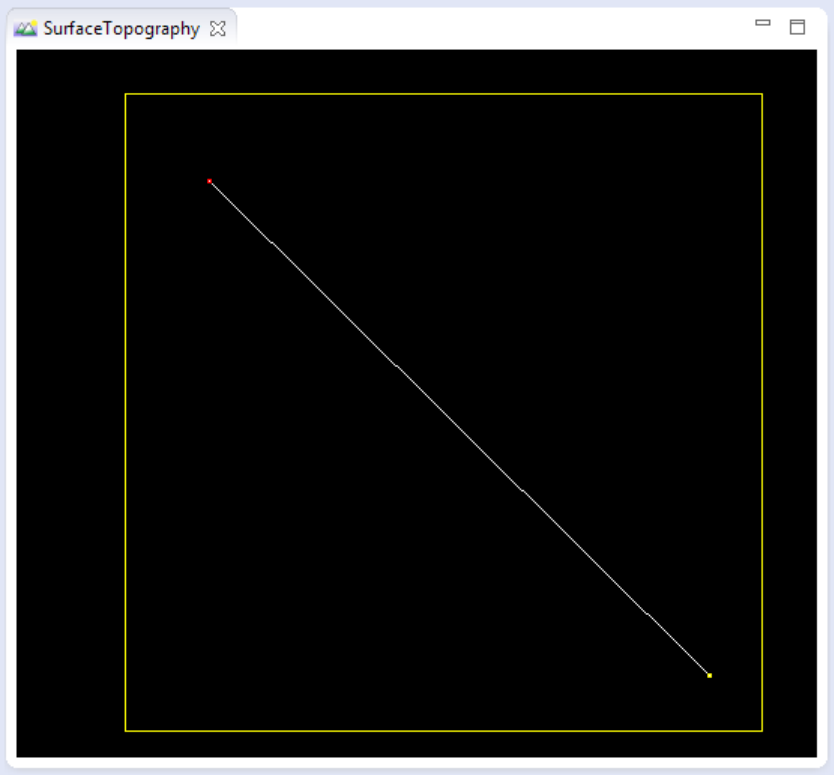
From the **2D Viewer** toolbar (far left), choose **Create (Lines)** 

From the Main menu (top) - **Points List Editor** toolbar choose **Delete all Points**  to erase any existing contents of the Points List.

Notice in the **2D Viewer**, when rolling the mouse over, you can observe the display of coordinates changing at the bottom left of the workspace.

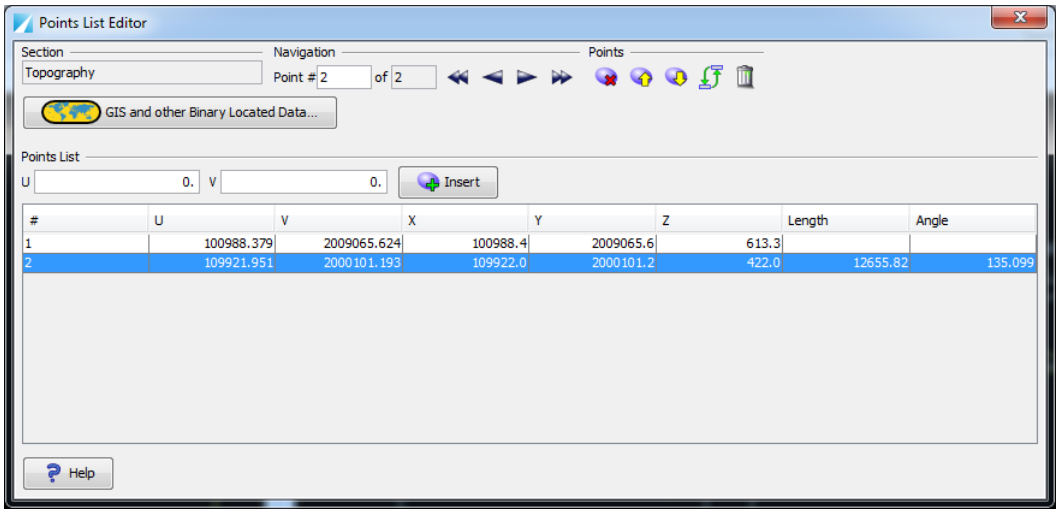
Notice that even though we are in a "plan-view" section, the "z" value is changing due to the topography it represents. In GeoModeller, the **Topography** section is a "special" section in the sense that it is highly non-planar.

2 Using the **Create (lines)** in the **Topography** section, left-mouse click approximate locations of the two points in the table above. Create 1 point on the **top-left corner** and 1 point on the **bottom -right corner**. It does not matter if they are not exact for the moment. (This line will also display in the 3D viewer.)



3 Edit the points using the **Points List Editor** so that they have the correct values.

In the **Points List Editor** toolbar choose **Float or Dock the Points List Editor**



The points just created (but not yet assigned) are displayed.

Edit the **U** and **V** point coordinates as required in the table above (the ends of the cross section we want to create).

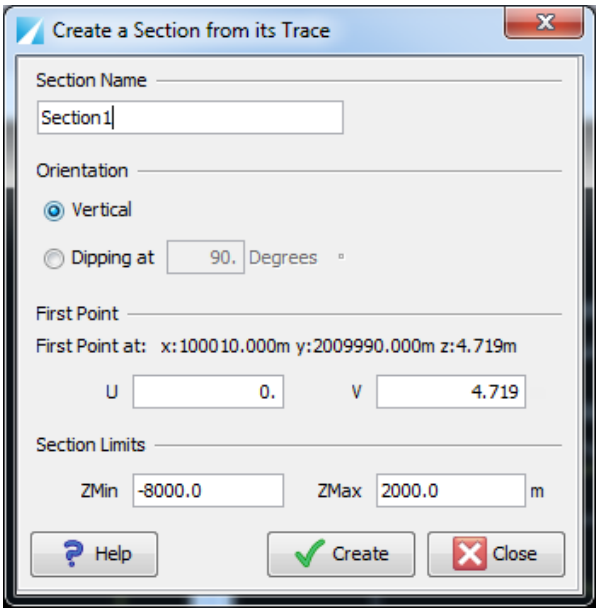
Change the U and V values for :

#	U	V
1	100010	2009990
2	109990	2000010

When finished **Close the Window** (the points will remain assigned).
You will notice the line in the 2D Viewer has adjusted to fit the values above.

4 Create the section from the points trace

From the main menu choose **Section > Create a Section from Its Trace** OR on the main toolbar, choose **Create a Section from ItsTrace**
OR choose CTRL+U.



- Enter the name **`Section1`**
- Accept all other defaults
- Choose **Create** and then **Close**.

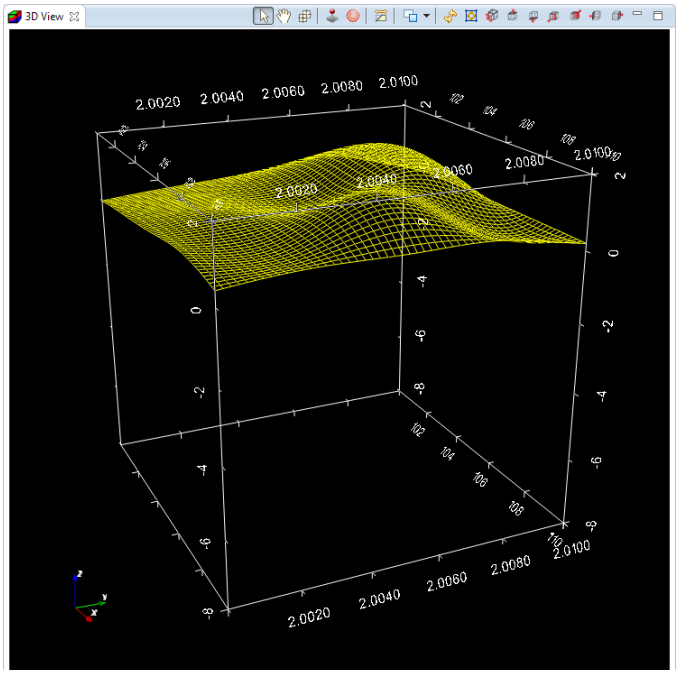
GeoModeller creates a new **Section1** tab in the **2D Viewer**, and shows the new section. Also shown on every section is the trace-line of any other intersecting section; thus the trace of **Section1** is shown on the **Topography** section, and the trace of the **Topography** section is shown on **Section1** (i.e. the profile of the topography you imported from **`DTM.semi`**). The outline of each section is also shown in the **3D Viewer.**

5 **Examine** the project in the 3D Viewer. Select the **3D Viewer**.

Locate the **3D Viewer toolbar** on top of the workspace.

Practice operating the 3D Viewer using the following operations:

Movement	Operation
Rotate diagram	Drag with left mouse button
Zoom *(make diagram larger or smaller)*	Roll the mouse wheel back and forth to zoom in and zoom out.
Pan *(move diagram)*	From the **3D Viewer** toolbar choose **Pan** and drag the display to the place you require using the left mouse button.



6 Save your project.

A1 Stage 2—Discussion

The sections you have created provide you with the traditional tools used by geologists: A map- view and one or more section-views of the 3D project space. You can use the sections to input geology **observations** from outcrop, such as geology contacts, or dip and dip direction data.

Your input data may also be interpretive - e.g. the **assumed** location of a contact, based on your understanding of the most likely 3D geology of the project area. Note you can tag data as 'observed' or 'interpreted' or 'model constructor' for future reference. See steps below in *Stage 3*.

Later in this tutorial we compute the 3D geology model. We will again use the sections as a means of examining the computed model by plotting from the model geology into the various section views.

A1 Stage 3—Create & import geology data to the section

Parent topic: Tutorial A1—A simple model with two formations

Now we use geology observations recorded in the field. We are interested in the points that define the 'contact', 'interface' or 'boundary' separating our two geological formations (depending on your terminology - there are several names for the same concept). These data points make it possible for GeoModeller to generate a 3D model of the two formations.

Our surface mapping database contains three points defining the location of the 'contact' at the base of the Upper Cover formation. Therefore, we have geology contact data to input to the **Topography** section:

X (East)	Y (North)	Associated Formation
102176	2002973	UpperCover
102879	2007144	UpperCover
105082	2008433	UpperCover

Also from surface mapping we have two pieces of orientation data (structural data-recording dip and dip direction):

X (East)	Y (North)	Dip Direction	Dip	Polarity	Associated Formation
102003	2008815	135	28	normal	UpperCover
102092	2005464	151	25	normal	UpperCover

Note that **X** and **Y** are respectively East and North coordinate values for these data points. In GeoModeller we refer to the full 3D coordinate of any point in terms of **X** (East), **Y** (North) and **Z** (up). In any general 2D section, however, the 'across' and 'up' axes of the section-view do not necessarily correspond to 'East' and 'North' since a section may be oriented at any angle through the 3D project space. Thus we express a coordinate position on a section in terms of a more generic coordinate pair - defined just for within the section of interest by: **U**, **V**.

For the **Topography** section (a map-view section), **U**, **V** will be identical to **X**, **Y** (i.e. East, North coordinates). For **Section1**, however, **U** is a 'measure from the start or origin of the section', and **V** is a vertical coordinate, equal to the **Z** coordinate value.

Since the data points listed above were recorded on the topographic surface, we must input these data on the **Topography** section, and the (**X**, **Y**) coordinates supplied in the above table will be the (**U**, **V**) coordinates that we will need to input.

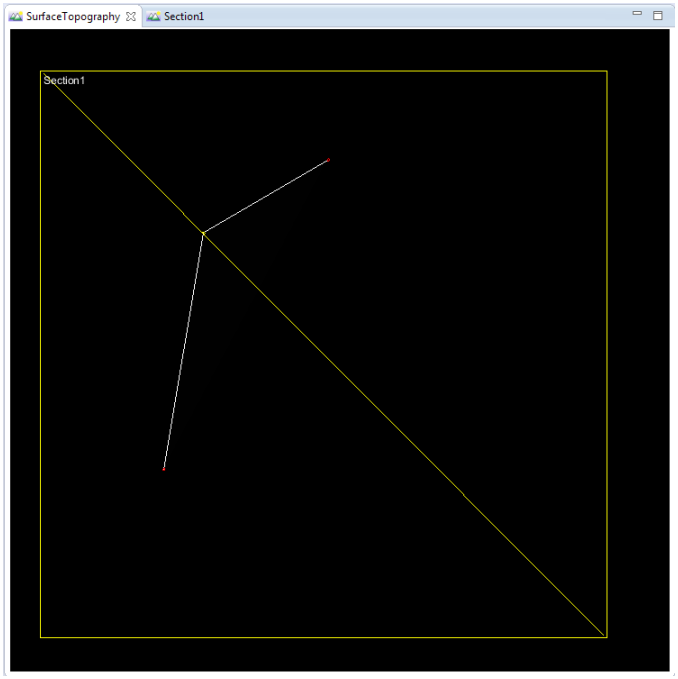
A1 Stage 3—Steps

1 First create the geology contacts.

From the **2D Viewer** toolbar, choose **Create (Lines)** .

From the **Points List Editor** toolbar choose **Delete all Points** .

In the **Topography** tab of the **2D Viewer**, click the three geology contact data point locations as per the table above (approximately). Ignore the lines joining the points in the display. They are not relevant to the current task.

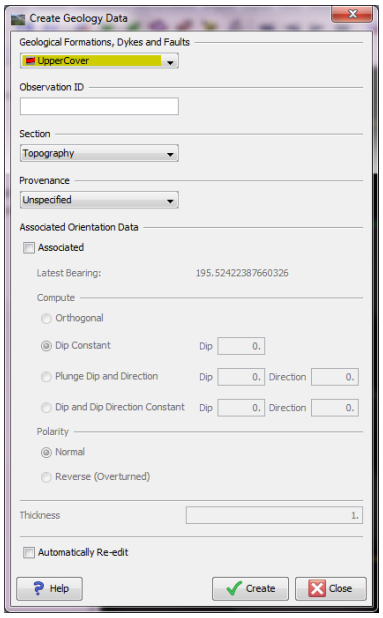


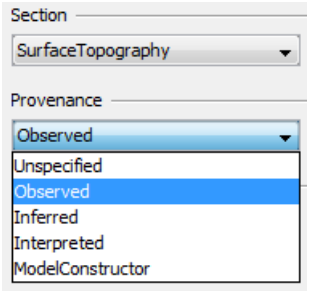
2 Using the **Points List Editor**, edit the **U** and **V** values of the points to be the correct coordinate values measured in the field and supplied in the data table above:

Now Repeated:

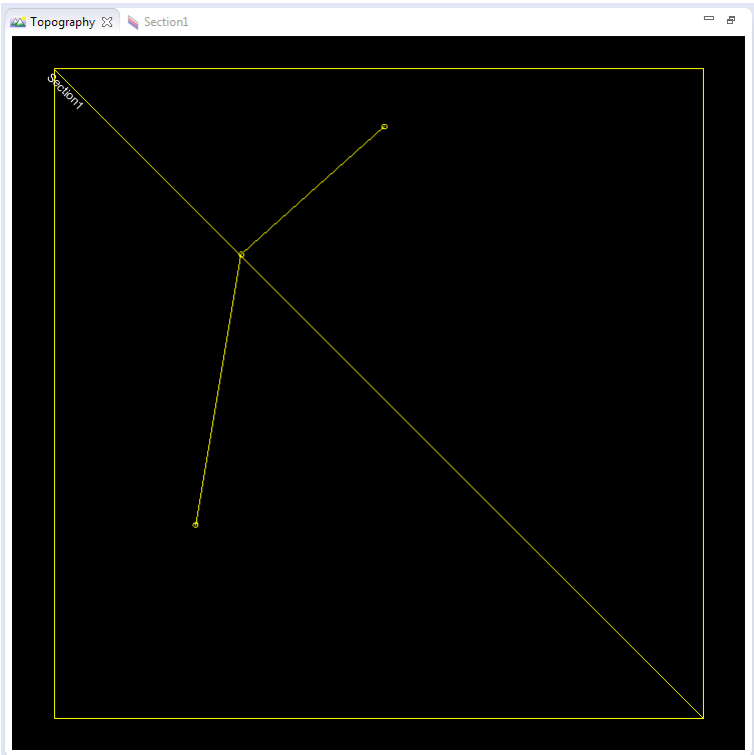
U (East)	V (North)	Associated Formation
102176	2002973	UpperCover
102879	2007144	UpperCover
105082	2008433	UpperCover

3 From the main menu choose **Geology > 2D Structural > Create geology data** OR
In the **Structural** toolbar, choose **Create geology data** OR
Press CTRL+G. The following window will open:





4 Ensure that **UpperCover** is selected (in **Geological Formations, Dyke, or Fault**)
Section: choose **Topography**
Provenance: choose **Observed**
Then, choose **Create**
And **Close**.



The Points becomes Yellow (colour of the UpperCover)

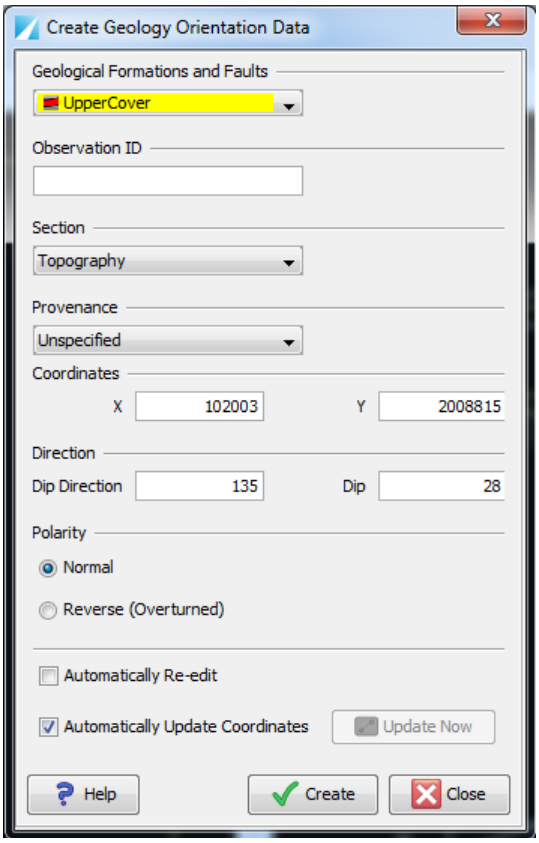
5 Now create the orientation data - one by one

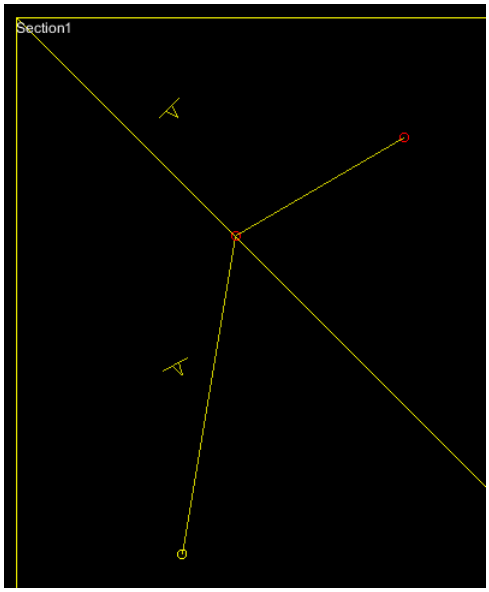
From the **2D Viewer** toolbar, choose **Create (Lines)**.

In the **Topography** section of the **2D Viewer**, click a location (approximate) for the first geology orientation data point. The table from above is repeated here for convenience:

X (East)	Y (North)	Dip Direction	Dip	Polarity	Associated Formation
102003	2008815	135	28	normal	UpperCover
102092	2005464	151	25	normal	UpperCover

6 From the main menu choose **Geology > 2D Structural > Create geology orientation data** OR in the **Structural** toolbar, choose **Create geology orientation data**.





7 In the **pop-up menu**, edit the **X** and **Y** values and enter the **Dip Direction** and **Dip** for the first point from the supplied data table.

8 Ensure that UpperCover is the selected **Formation**. Then choose **Create**.

9 Now enter the **X**, **Y**, **Dip Direction** and **Dip** for the *second* point.

10 Choose **Create**, and then choose **Close**.

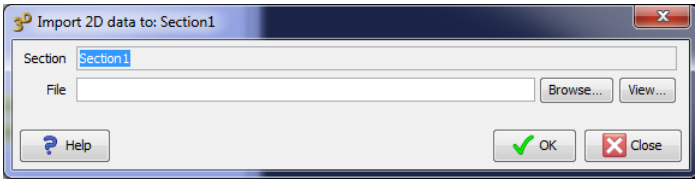
11 Import prepared structural data into Section1.

Another geologist in your team has created a **Section1** interpretation for the project. Import the data to the project. The file is:

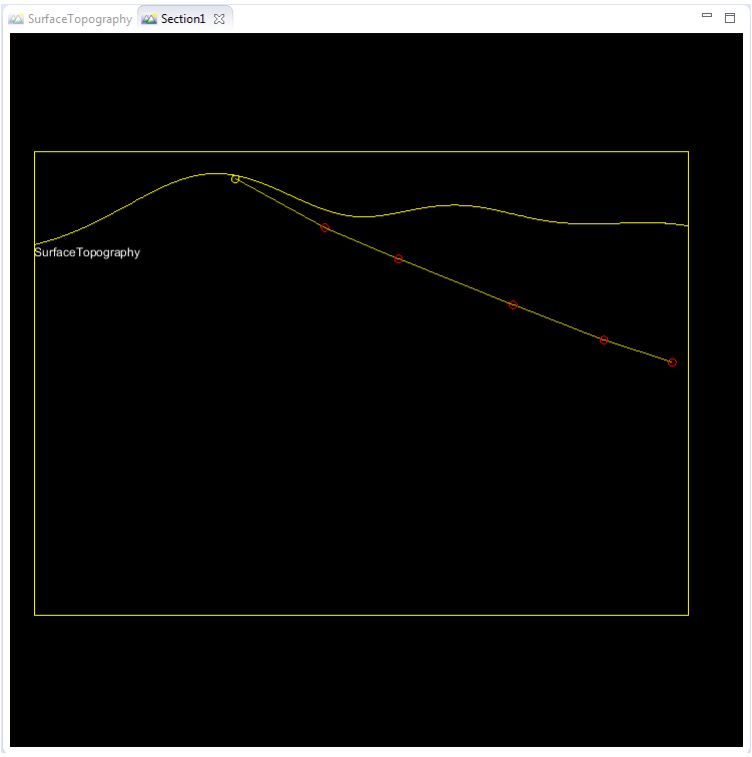
`TutorialA\TutorialA1\Data\Section1_UpperCover.data`

Select the **Section1** tab in the **2D Viewer**

From the main menu choose **Import > 2D Geology to Section > Contacts, Structure (BRGM)**.



Choose **Browse** and open the **`.data`** file. Choose **OK**.



12 Save your project.

A1 Stage 4—Compute the 3D model

Parent topic: Tutorial A1—A simple model with two formations

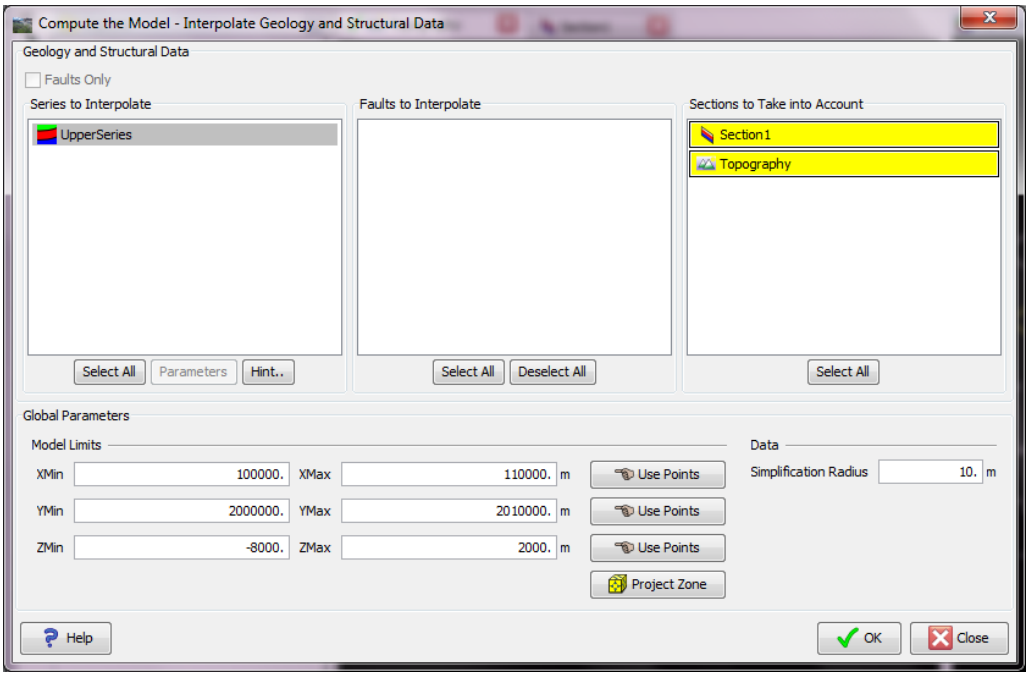
Our project now contains sufficient data to compute a 3D model.

A1 Stage 4—Steps

1 From the main menu choose **Model > Compute** OR

From the **Model** toolbar choose **Compute** OR

Press CTRL+M.



Use the default parameters:

- **Series to interpolate: Select All**.
- **Sections to take into account: Select All**.

2 Choose **OK**.

GeoModeller computes the 3D model based on the data in our project. Note that the model is a mathematical model - a set of interpolation parameters - based on the project data. In order to see the model, we need to interrogate the model and present it either in the **3D Viewer**, or render it onto 2D sections in the **2D Viewer**.

We will do this in the following sections.

3 Save your project.

From the main menu choose **Project > Save** OR

From the **Project** toolbar choose **Save** OR

Press CTRL+S.

A1 Stage 5—Show the 3D model in 2D sections and in 3D

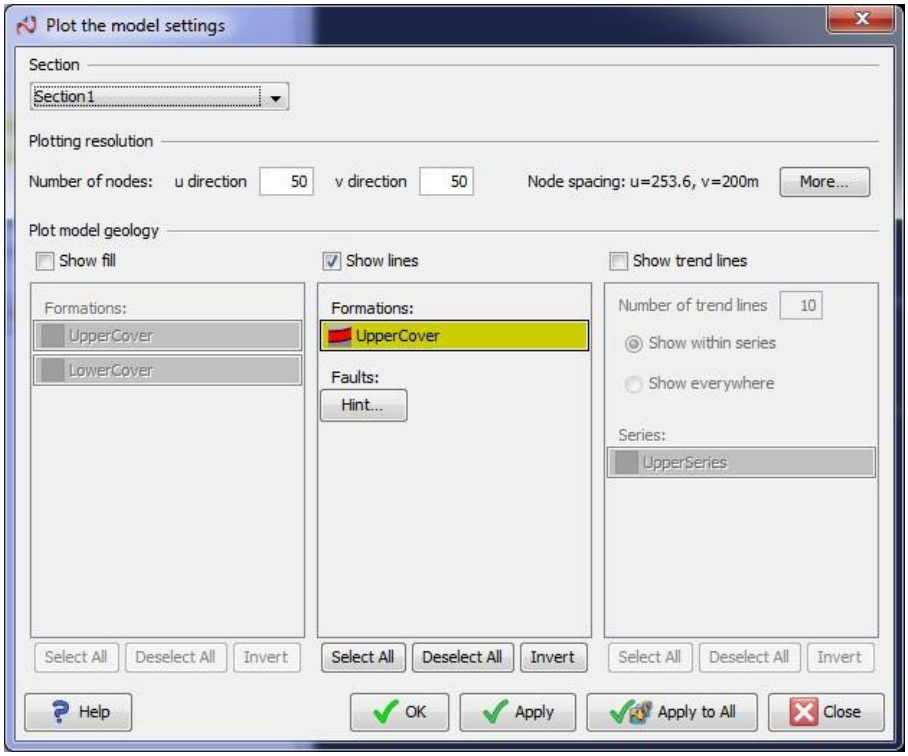
Parent topic: **Tutorial A1—A simple model with two formations**

In this stage of the tutorial we generate a representation of our model.

A1 Stage 5 Steps—Plotting the model in Section1 with *lines*

1 Select Section1 in the 2D Viewer.

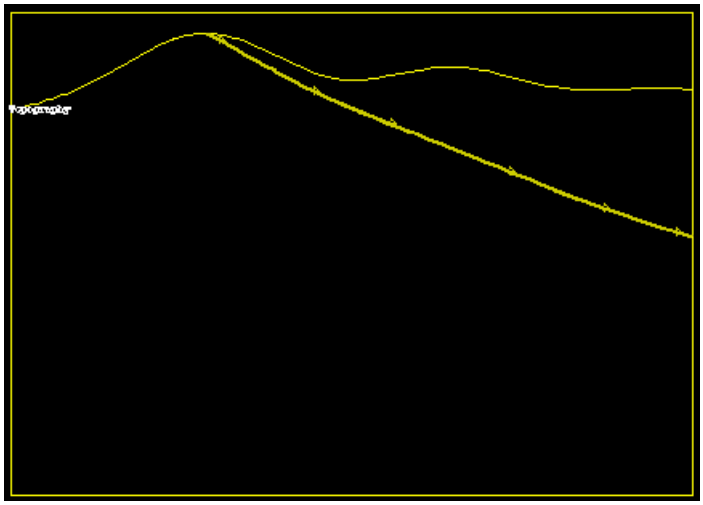
2 From the main menu choose **Model > Plot the model settings** OR
From the **Model** toolbar, choose **Plot the model settings** OR
Press CTRL+D.



Set the parameters:

- Check **Show lines** and clear **Show fill**.
- Use default values for the other parameters.

3 Choose **OK**.
(The modelled geology line is directly over the data; a darker yellow line)

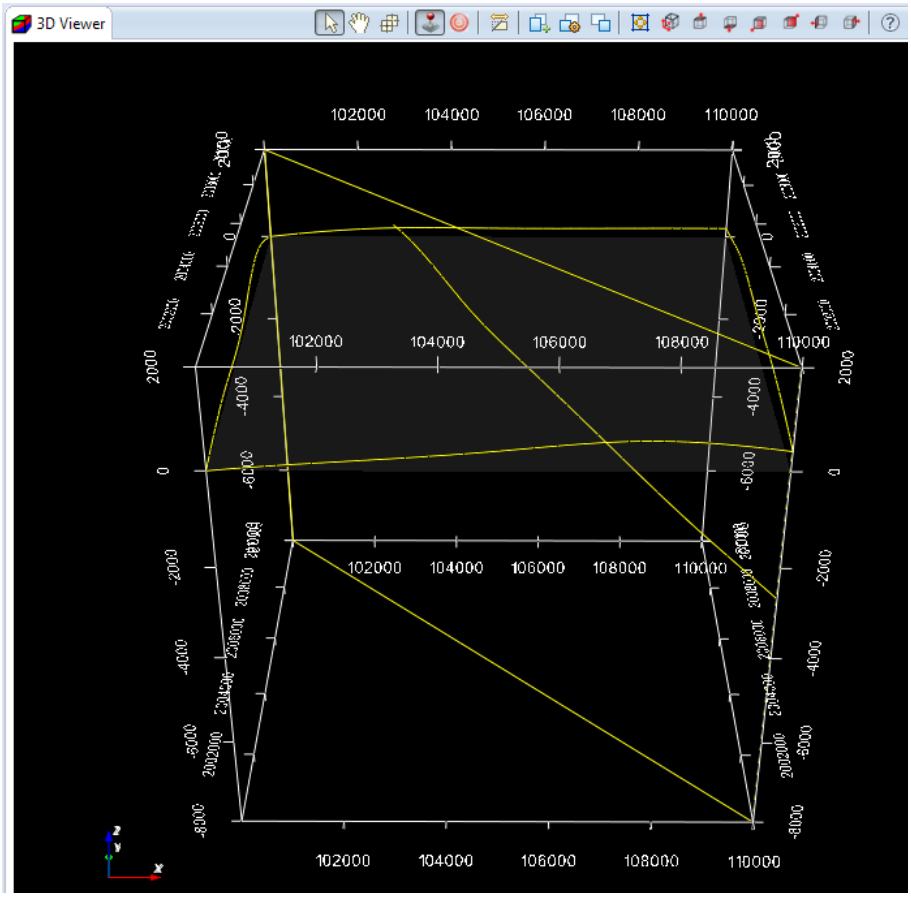


4 View the line plot in the **3D Viewer**.

From the shortcut menu in **Section1** in the **2D Viewer** (right-mouse click in the background zone)

Choose **Show Modelled Geology Lines in 3D Viewer.**

Examine the results in the **3D Viewer**.

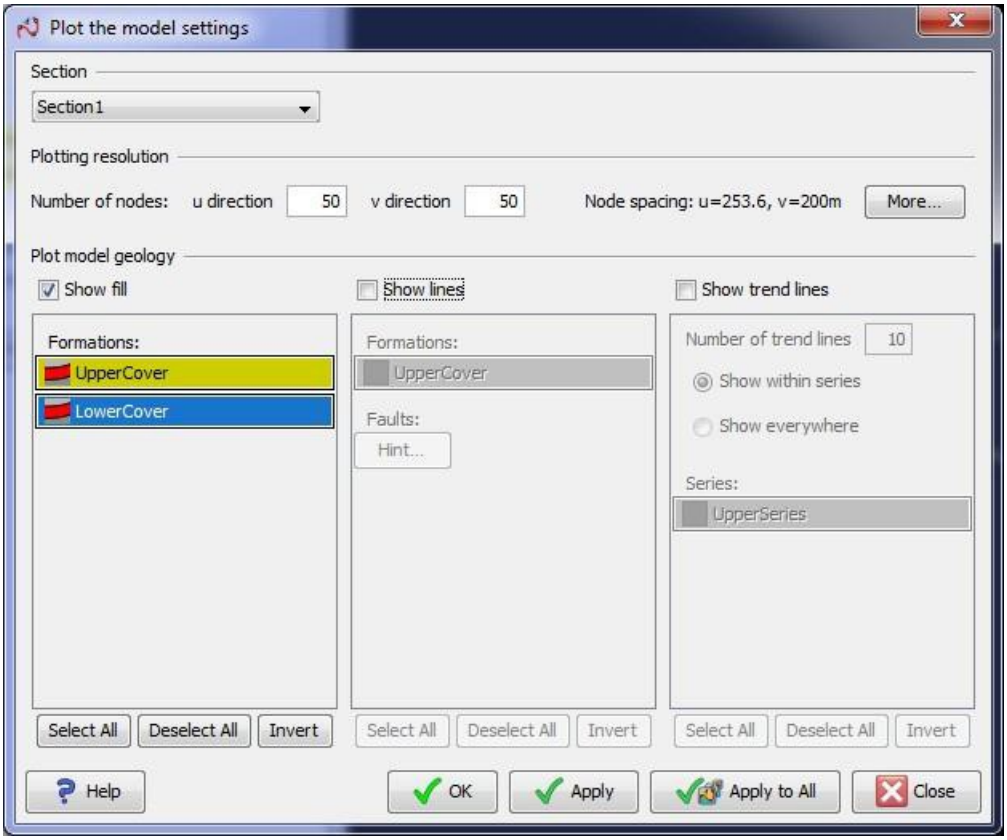


5 Save your project.

A1 Stage 5 Steps—Plotting the model in Section1 with *filled polygons*

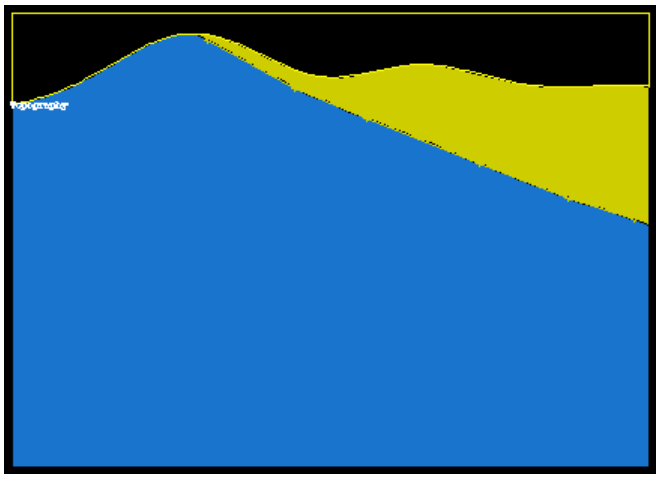
1 Select **Section1** in the **2D Viewer**.

2 From the main menu choose **Model > Plot the model settings** OR
From the **Model** toolbar, choose **Plot the model settings** OR
Press CTRL+D.



This time set alternative parameters:

- Check **Show fill** and clear **Show lines**.
- Default values for the other parameters.
- Choose **OK**.

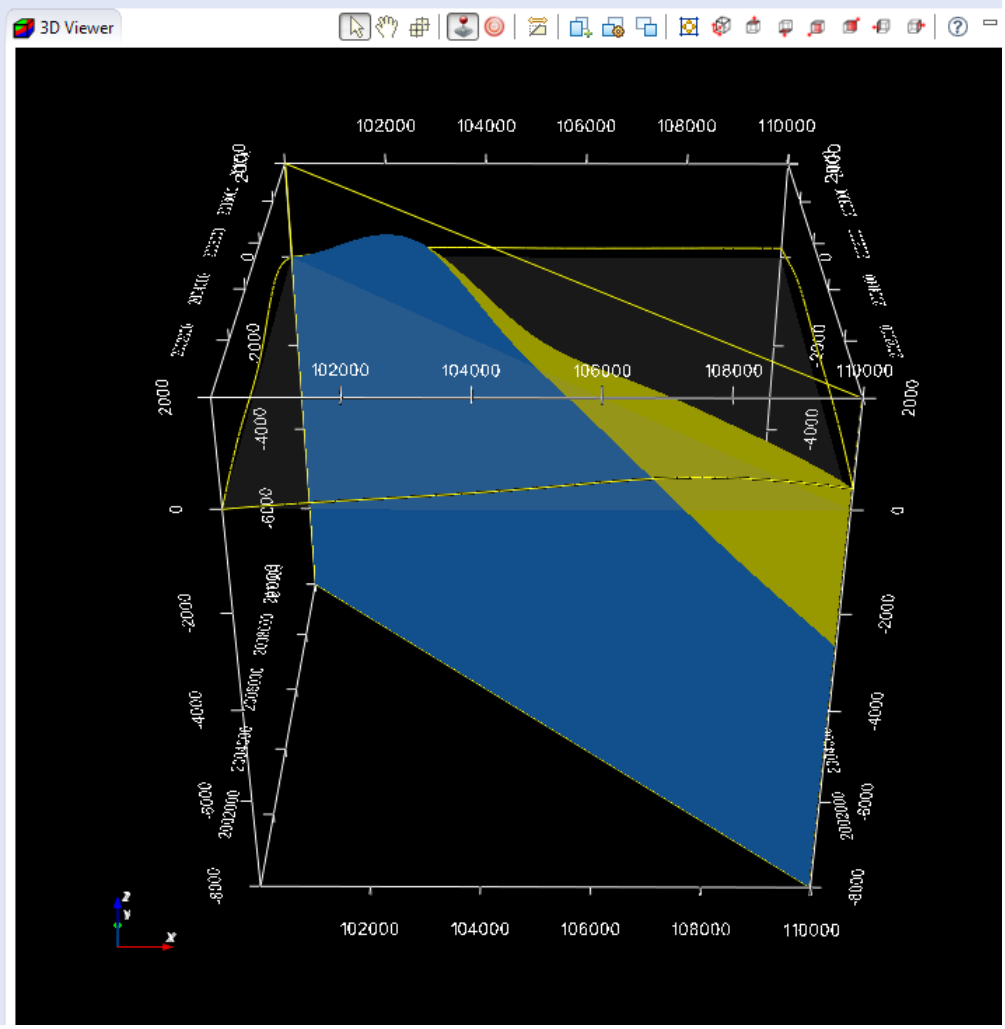


3 View the filled plot in the **3D Viewer.** (May already have auto-refreshed in 3D.)

Click inside the **2D Viewer**.

From the shortcut menu in **Section1** of the **2D Viewer** (right-mouse-click the background). Choose **Show Modelled Geology Polygons in 3D Viewer**.

Examine the results in the **3D Viewer**.



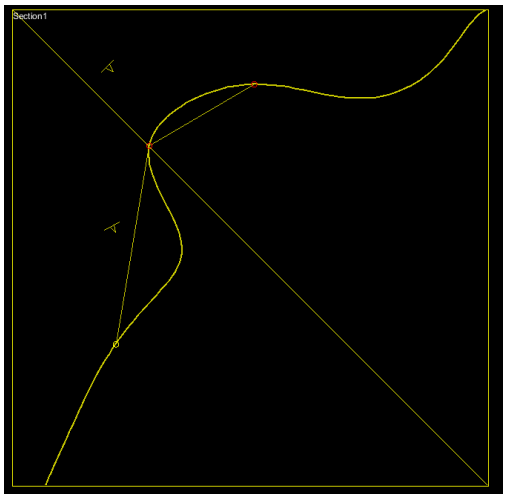
4 Save your project.

A1 Stage 5—Section1 plot discussion

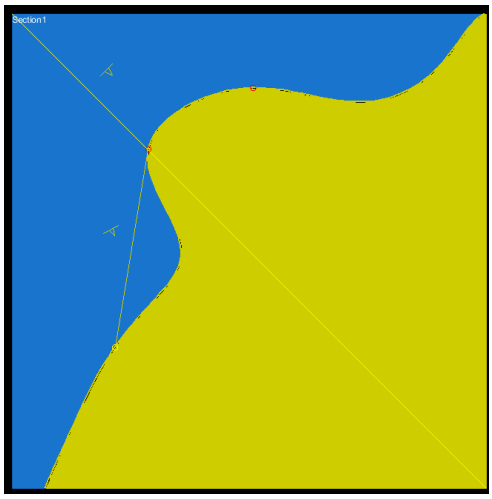
GeoModeller plots the model geology for **Section1** in the form of (geology 'contact') lines. In effect, this process plots the intersection of **Section1** with the 3D model. GeoModeller renders the base of UpperCover in the line-colour of the UpperCover formation. Since the geological pile is referenced to the 'bottom' of geology formations, the LowerCover-UpperCover contact is known only as the bottom of the UpperCover formation. Observe how the geology contact (plotted from the model) passes through our observed geology contact data points.

A1 Stage 5 Steps—Plotting the model in the Topography section

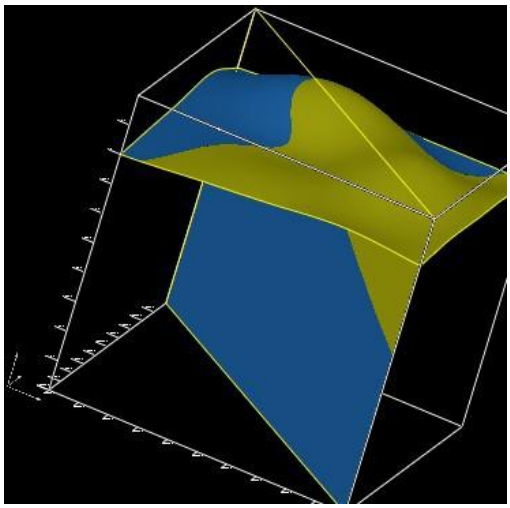
1 Repeat the previous two sets of steps using the **Topography** section..



Lines (Geology contact or interface)



Filled (Solid Geology)



Section1 and Topography section plot in 3D Viewer

The plot of modelled geology on the **Topography** section is, in effect, a **solid-geology map** of our project area. The blue colour represents the outcrop of LowerCover, which is overlain by the yellow UpperCover formation.

To hide wireframe display of **Topography**:

- In the Project **Explorer**, expand the **Sections** branch of the tree
- Choose **Topography** and then **Hide** from the shortcut menu (right-mouse-click).

A1 Stage 5 Steps—Build 3D formations

For the full picture, let us represent the model in 3D.

1 Turn off the display of the section plots in the 3D Viewer.

Select **Topography** in the **2D Viewer**.

From the shortcut menu for **Topography** (in the background of the **2D Viewer**), choose the following items if they are available:

- **Hide** modelled **geology lines** in 3D Viewer.
- **Hide** modelled **geology polygons** in 3D Viewer.

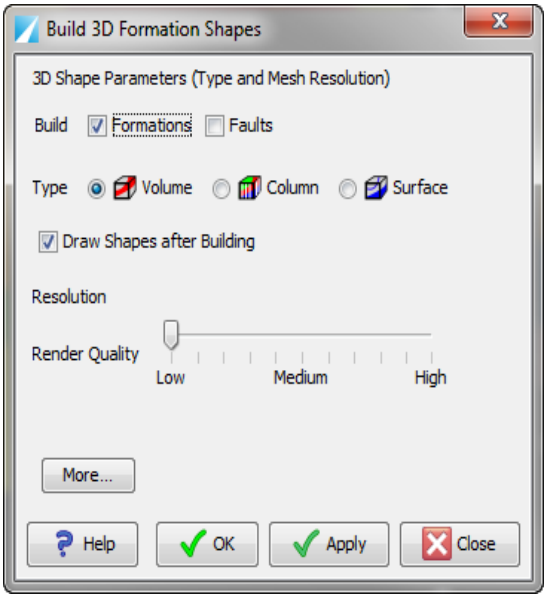
Repeat this step for **Section1**.

2 Choose main menu **Model > Visualise 3D Formations and Faults** OR
In the Model toolbar choose **Visualise 3D Formations and Faults**

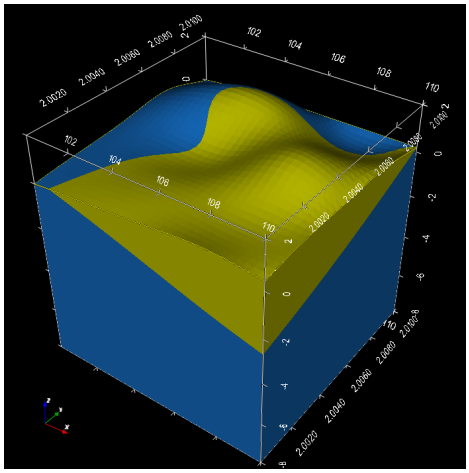
Check '**Formations**'

Check '**Volume**'

Leave other default values.



3 Choose **OK**

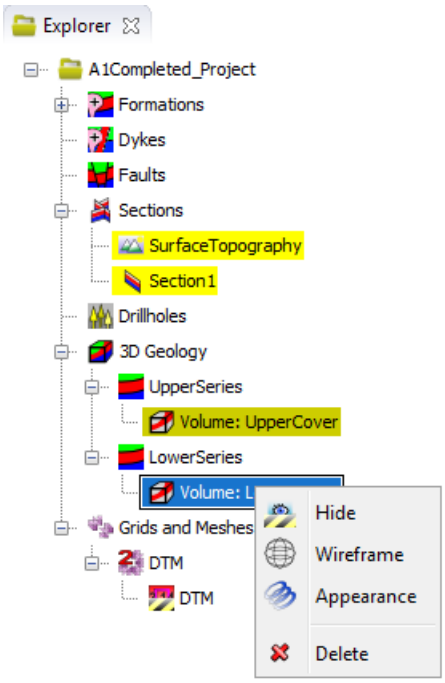


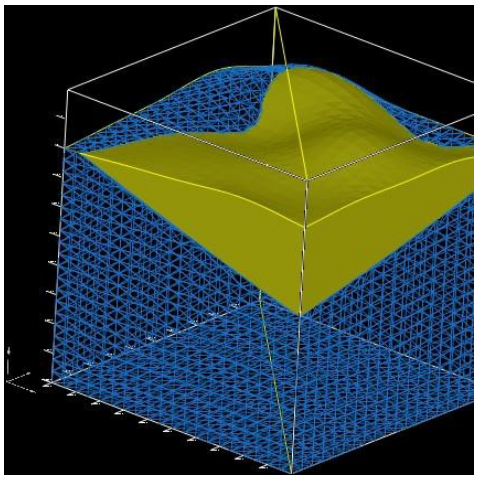
4 You can represent the formations in either wire frame or shaded style.

To change the view of a series or formation:

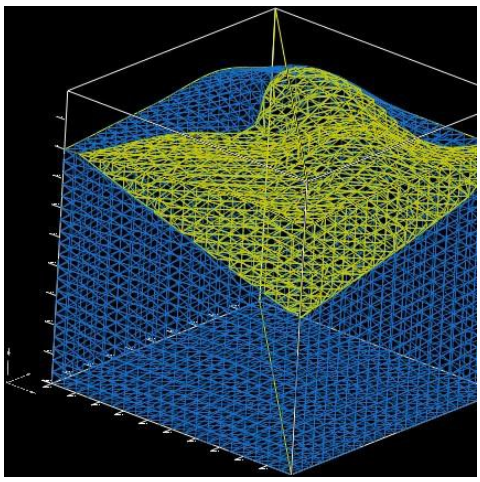
- In the Project **Explorer**, fully expand the **3D Geology** branch of the tree, and select a series or formation at the 'volume' level.
- Choose **Wireframe** or **Shading** from the shortcut menu (right-mouse-click).

Observe the effect on the model visualisation.





Shaded upper, Wireframe lower



All wireframe

5 Save your project.

From the main menu choose **Project > Save** OR
From the **Project** toolbar choose **Save** OR
Press CTRL+S.

Tutorial A2—Several formations that overlap each other

Parent topic: Tutorial A (A First Geology Modelling Experience)

In this tutorial you will build a 3D model with several geology formations that have more complex relationships.

Using GeoModeller, you will:

- Open an existing project
- Add geology formations to a project
- Modify the geological pile
- Plot model geology cross-sections that are automatically coherent with all other sections

The starting point is the work completed in Tutorial A1—A simple model with two formations. Note that a completed version of this new tutorial A2 is available in:

`TutorialA\TutorialA2\A2Completed_project\A2Completed_project.xml.`
Do not overwrite it.

In this tutorial:

- A2 Stage 1—Open the project
- A2 Stage 2—The basement and the sedimentary sequences
- A2 Stage 3—Intermediate models

A2 Stage 1—Open the project

Parent topic: Tutorial A2—Several formations that overlap each other

Open the completed project from Tutorial A1—A simple model with two formations. Or open the A2BeginningProject.xml in:
`TutorialA\TutorialA2\A2Beginning_project\A2Beginning_project.xml`

You do not need to have completed this perfectly yourself. We have provided a copy in the set of tutorial files.

A2 Stage 1—Steps

1 Open the completed project from Tutorial A1.

From the main menu choose **Project > Open** OR
From the Project toolbar choose **Open**  OR
Press CTRL+O.

Open your completed project from Tutorial A1 or the solution provided:

`TutorialA\TutorialA1\A1Completed_Project\A1Completed_Project.xml.`

If you opened the solution from tutorial A1 that we provided, save it with a new name in the folder you are using for your tutorial data.

From the main menu choose **Project > Save As** OR
From the Project toolbar choose **Save As**  OR
Press CTRL+SHIFT+S.

Note that a completed version of this tutorial A2 is available in:

`TutorialA\TutorialA2\A2Completed_Project\TutorialA2.xml.`

Do not overwrite it.

2 In the **2D Viewer**, select the tab **Section1**.

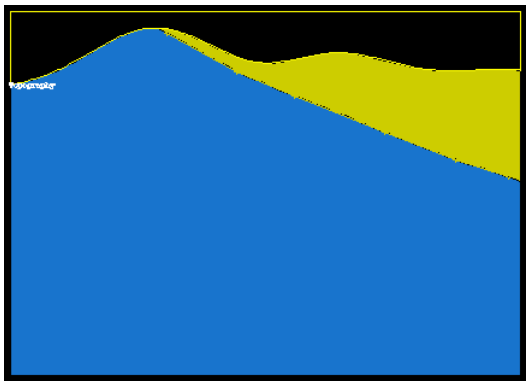
3 Plot the model in Section1 using filled polygons

From the main menu choose **Model > Plot the model settings** OR

From the **Model** toolbar, choose **Plot the model settings** OR
Press CTRL+D.

Set the parameters:

- Check **Show fill** and clear **Show lines**.
- Default values for the other parameters. Choose **OK**.



4 Save your project.

From the main menu choose **Project > Save** OR
From the **Project** toolbar choose **Save** OR

Press CTRL+S.

A2 Stage 2—The basement and the sedimentary sequences

Parent topic: **Tutorial A2—Several formations that overlap each other**

At the moment your project has two formations:

- UpperCover
- LowerCover

However, your recent mapping indicates the geology of the region is a little more complex. In particular, you observed the cover was made up of three distinct formations. Also, a literature review revealed the presence of Basement at 5 to 7 km depth in the project area.

In this tutorial we add the missing geology formations to our project.

The basement is located below LowerCover. Also, we insert the MiddleCover between the LowerCover and the UpperCover.

We will now create geology formations with the following parameters (names are case sensitive and you must enter them exactly as shown, due to pre-prepared data we will import later):

	Formation 1	Formation 2
Name	Basement	MiddleCover
Colour	pink (RGB 238 162 172)	orange (RGB 255 165 0)

We want to update the geological pile of our project. The current pile is as follows:

Series	Formations	Relationship
UpperSeries	UpperCover	Onlap
LowerSeries	LowerCover	Onlap

The **Reference** of the pile is the **Bottom** ('base' of geology formations). That means that the LowerCover-UpperCover contact represents the base of the UpperCover formation. The two 'series' - each having just a single formation - are interpolated separately. The 'Onlap' **Relationship** is determined from our field observation that the (younger) series simply 'onlap onto' the stratigraphically older formation (no erosional event occurred before it's deposition).

The literature study shows that the LowerCover formation is unconformable with the Basement. Thus we have to interpolate these 2 formations as different series (i.e., they would not share orientation data, and they have not been exposed to the same tectonic history). On the other hand, the MiddleCover and UpperCover formations are concordant. We can interpolate those two together in the same series.

The new pile will look like this:

Series	Formations	Relationship
UpperSeries	UpperCover; MiddleCover	Onlap
LowerSeries	LowerCover	Onlap
BasalSeries	Basement	Onlap

Notice that the UpperCover and MiddleCover formations belong to the same series, named UpperSeries.

A2 Stage 2—Steps

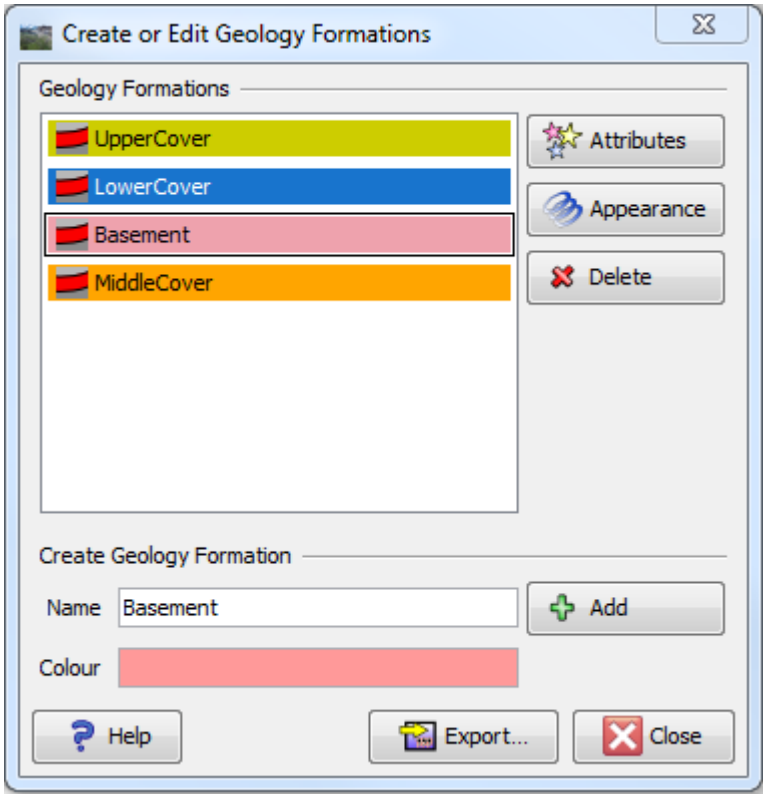
1 Add the two new formations specified above

Choose the main menu option **Geology > Formations : Create or Edit**.

In the **Create Geology Formations** dialog box, use the following sequence:

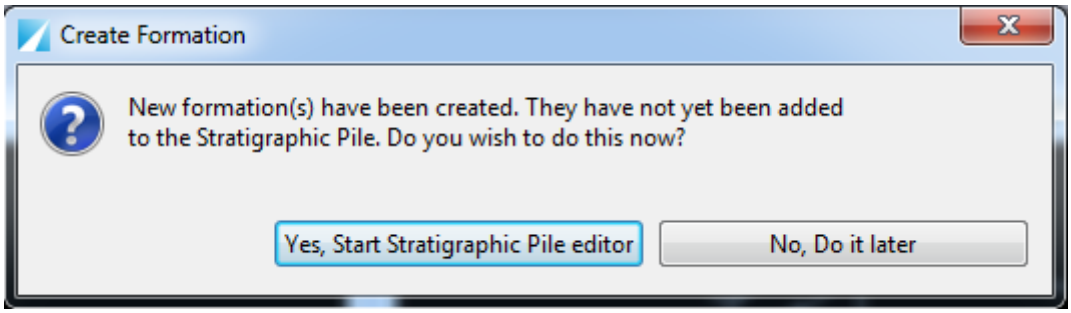
- Enter the **Name.**
- Specify the **Colour** (Click the **Colour** bar. Use the **RGB** tab and **OK** if you want to get it exact, but this is not vital).
- Choose **Add**.

When finished, choose **Close.**



2 Create a new series for the Basement as specified above.

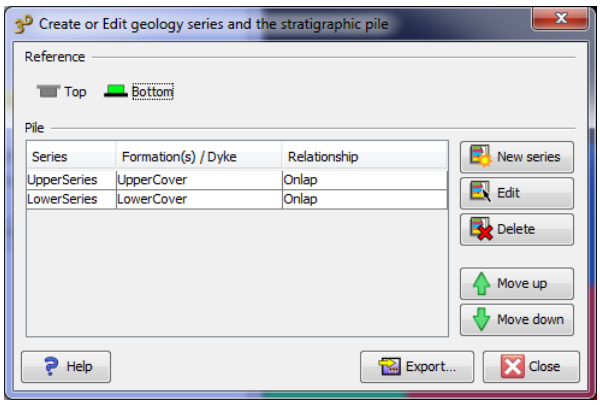
When you choose **Close** in the previous step, GeoModeller may display the **New formation creation** tip box.



After Basement is added, choose **Yes, start Stratigraphic Pile editor**.

If this box does not appear, from the main menu, choose **Geology: Stratigraphic Pile: Create or Edit**.

Ensure that **Reference** of the pile is set to **Bottom**.

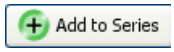


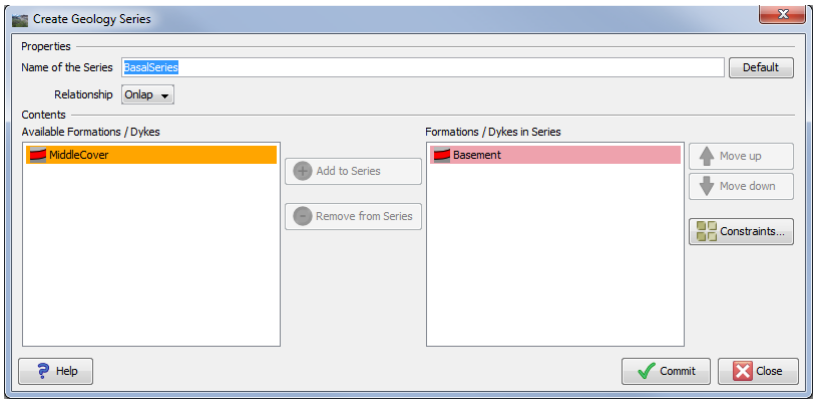
Choose **New series**.

Specify BasalSeries:

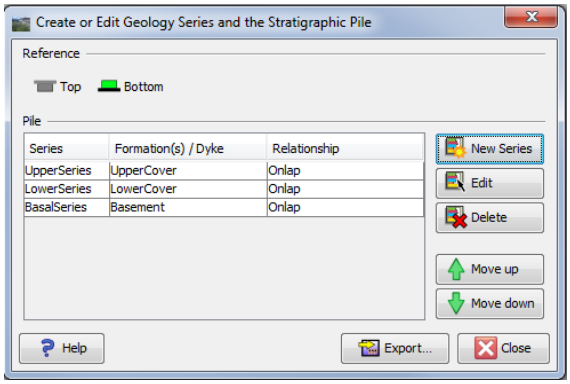
- Enter **BasalSeries** for **Name of the series**.
- Select formations (from the left-list) and use either **Add to Series** or **Remove from Series** to move the formations so that Basement is the only formation in the **Formations in Series** list (on the right-side).

  For example, to move Basement from the unassigned **Available Formations** into the **Formations in Series**, select Basement and then choose **Add to Series**





Choose **Commit**, and then choose **Close**.



If necessary, select a Series and use the **Move up** or **Move down** arrow buttons to put BasalSeries at the bottom.

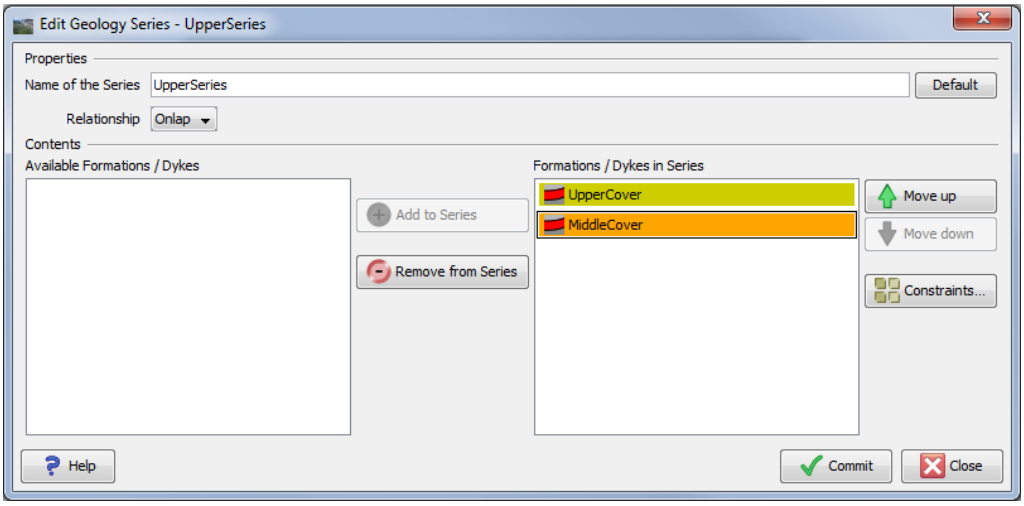
3 Insert the MiddleCover formation into the UpperSeries.

In the **Create or Edit Geology Series and the Stratagraphic Pile** dialog box, select UpperSeries.

Choose **Edit.**

Select MiddleCover from the **Available Formations/Dykes** and use **Add to Series** to move it right, to the **Formations/Dykes in Series**.

Then use **Move down** so that MiddleCover is below UpperCover in the **Formations in Series** list.



Choose **Commit** and **Close**.

Close the **Create or Edit Geology Series and the stratigraphic pile** dialog box.

4 Check the details of the revised stratigraphic pile

From the main menu choose **Geology > Stratigraphic Pile: Visualise**.

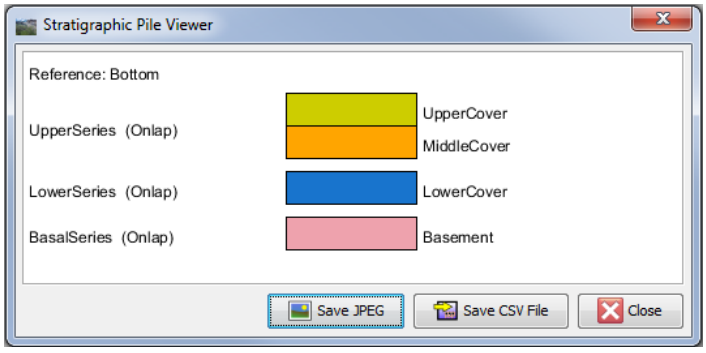
Check that the series are in the correct stratigraphic order from BasalSeries at the bottom (oldest), through LowerSeries to UpperSeries at the top.

Check that the two formations within the UpperSeries are in the correct stratigraphic order; the UpperCover must be on top, above the MiddleCover.

Also check the groupings for series breaks are correct, and check the Reference: Bottom

Choose **Close** to close the Stratigraphic Pile Viewer.

If required, from the main menu choose **Geology > Stratigraphic Pile: Create or Edit** and repeat steps 2 and 3 as required to rearrange the formations into the correct stratigraphic order.



5 Erase all model geology from Section1

Remove the model plot of the earlier model geology in **Section1**.

Select **Section1** tab in the **2D Viewer**.

From the main menu choose **Model > Erase All Model Geology** OR From the shortcut menu in the **2D Viewer** (right-click in the background) choose **Erase All Model Geology** OR In the **Model** toolbar choose **Erase all model geology** .

6 Import the prepared data into Section1.

One of your collaborators has already revised Section1 for you. Now you need to import the data. The file is:
`TutorialA\TutorialA2\Data\Section1_LowerCover_MiddleCover.data`

Select the **Section1** tab in the **2D Viewer**.

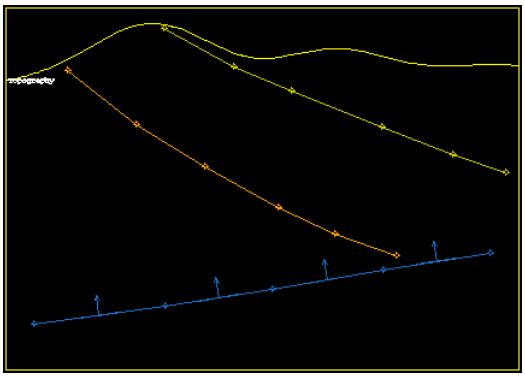
From the main menu choose **Import > 2D Geology to Section > Contacts, Structure (BRGM)**.

Choose **Browse** and open the file. Choose **OK**.

7 Save your project.

A2 Stage 2—Discussion

Section1 now includes the structural data for the basal contacts of the LowerCover, MiddleCover and UpperCover formations. Each data point has the colour of the geology formations with which it is associated. These new geology (contact) data will influence the positions of the contacts during the re-computation of the 3D model.



Note that the set of geology data points for LowerCover have 'associated' geology orientation data. This feature of GeoModeller allows you to define the position of some geology contact via a sequence of contact data points, and at the same time describe the attitude of that contact by means of 'associated' orientation data. The 'associated' geology orientation data are located at each mid-point between the geology contact points.

Note also that for GeoModeller to compute the model for any series, there must be at least 1 geology contact point for each formation within that series and at least 1 geology orientation data point for the series within the limits of the modelled zone. For the LowerSeries, the imported contact data, and their 'associated' geology orientation data, meet this requirement. For the UpperSeries, there are contact data points on both Section1 and the Topography section, and two orientation data points on the Topography section.

A2 Stage 3—Intermediate models

Parent topic: **Tutorial A2—Several formations that overlap each other**

It is now possible to calculate the revised 3D model based on these new data. To better understand how GeoModeller works, let's first build a model which takes into account only the Basement and LowerCover.

A2 Stage 3-Steps

1 Compute the 3D model with the following parameters:

From the main menu choose **Model > Compute** OR

From the **Model** toolbar choose **Compute** OR
Press CTRL+M.

- Series to interpolate: **LowerSeries** (**Uncheck** the UpperSeries)
- Sections to take into account: **Topography**, and **Section1**

Choose **OK**

Notice the BasalSeries does not appear in the calculation list as a "series to Compute". This is because there are no data given for the bottom of the BasalSeries (it is outside the model!). However, GeoModeller does recognize that Basement (BasalSeries) should be used in the space below the base of the LowerCover formation.

2 Plot the model geology in Section1 with the following parameters:

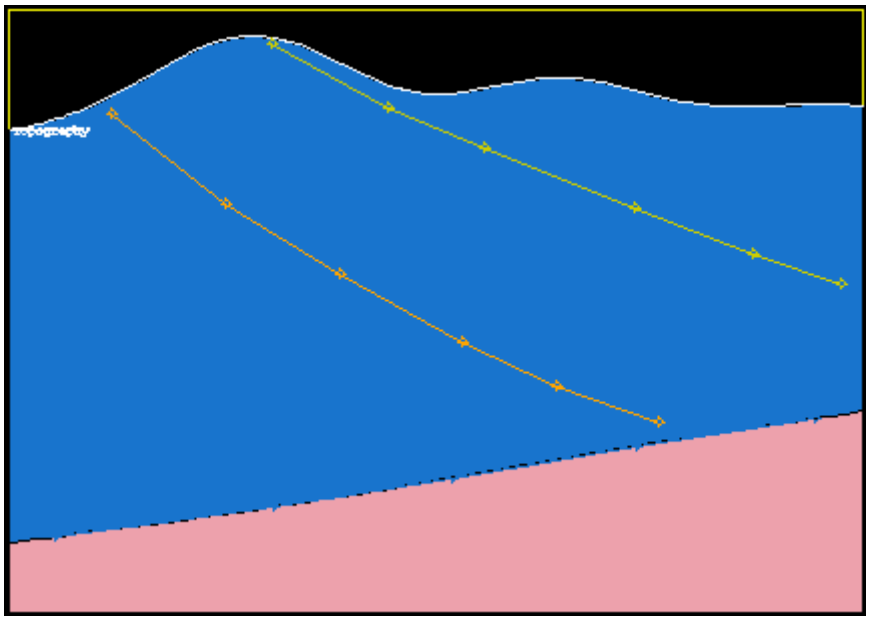
Select **Section1** tab in the **2D Viewer**.

From the main menu choose **Model > Plot the model settings** OR

From the **Model** toolbar, choose **Plot the model settings** OR
Press CTRL+D.

Check **Show fill** and clear **Show lines**.

Choose **OK**.



According with the current model computation, Section1 contains only two formations: Basement (at the bottom) and LowerCover (which fills the space up to the topographic surface).

3 Re-compute for the complete model

In this step we compute the complete model, with the UpperSeries which includes the MiddleCover and UpperCover formations.

This model uses both the structural data on **Section1** and the geology data of the UpperCover formation that we have observed on the topographic surface. It uses the information recorded in the geological pile to manage the relationships between the different series.

Compute the 3D model with the following parameters:

Model > Compute

- **Series to interpolate: Select All**
- **Sections to take into account: Select All**

4 Plot the model geology in Section1 using fill:

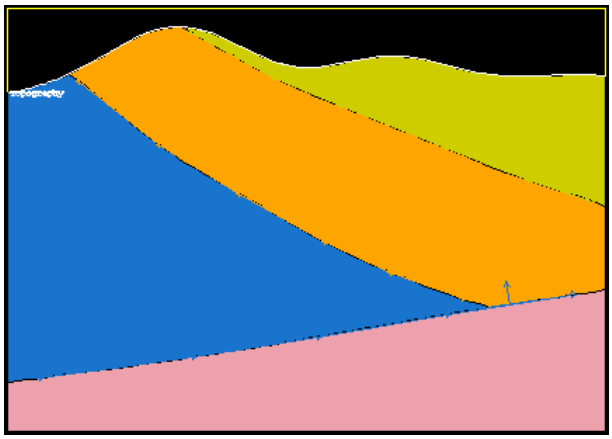
Select the **Section1** tab in the **2D Viewer**.

From the main menu choose **Model > Plot the model settings** OR

From the **Model** toolbar, choose **Plot the model settings** OR
Press CTRL+D.

Check **Show fill** and clear **Show lines**.

Choose **OK**.

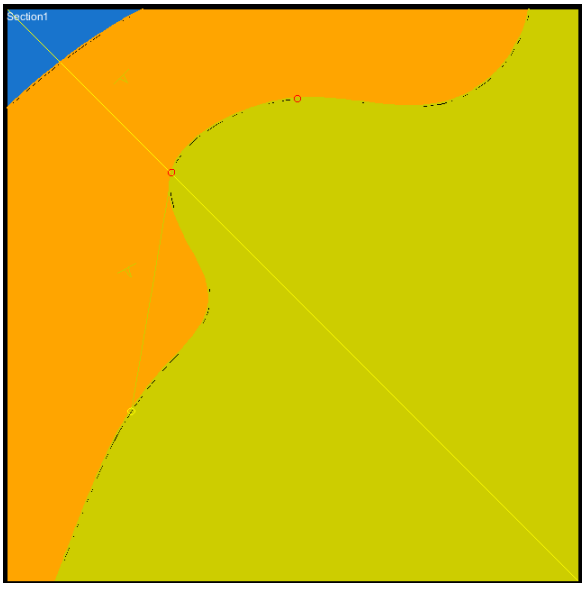


In agreement with the defined stratigraphic pile, the LowerCover (blue) is unconformable on the Basement (pink). On the other hand, the MiddleCover (orange) and the UpperCover (yellow) are concordant with each other (sub-parallel).

5 Plot the model using fill on the topographic surface

Select the **Topography** tab in the **2D Viewer**.

Plot the model using fill as you did in earlier steps.



You have just created the geology map, derived from your 3D model!

6 Save your project

Tutorial A3—Intrusive bodies

Parent topic: Tutorial A (A First Geology Modelling Experience)

In this tutorial we will add intrusive bodies to the geology. A granite body is created from surface data and interpretation of a seismic section. A dyke is created from surface data.

Using GeoModeller, you will:

- Open an existing project
- Import geological data onto surface topography and a cross-section
- Create a dyke
- Manage depositional and intrusive rock-relationships
- Render new model-geology sections that are automatically coherent with all other sections

The starting point is the work completed in Tutorial A2—Several formations that overlap each other. Note that a completed version of this tutorial A3 is available in: **`TutorialA\TutorialA3\A3Completed_project\A3Completed_project.xml.`** Do not overwrite it.

In this tutorial:

A3 Stage 1—Open the project

Parent topic: Tutorial A3—Intrusive bodies

A3 Stage 1—Steps

1 Open the completed project from Tutorial A2.

From the main menu choose **Project > Open** OR
From the Project toolbar choose **Open**  OR
Press CTRL+O.

Open your completed project from Tutorial A2 or the A3Beginning_Project in:

`TutorialA\TutorialA3\A3Beginning_Project\A3Beginning_Project.xml`

If you opened the solution that we provided, save it with a new name in the folder you are using for your tutorial data.

From the main menu choose **Project > Save As** OR
From the Project toolbar choose **Save As**  OR
Press CTRL+SHIFT+S.

A3 Stage 2—An intrusive granite

Parent topic: Tutorial A3—Intrusive bodies

During your field work you observed the presence of a granite in the project area. Due to poor outcrop you were not able to map its full extent. On the other hand, it was possible for you to measure some orientations that are representative of the geometry of the granite contacts.

In this stage we add information about the granite to our project and recompute the model.

A3 Stage 2—Steps

1 Add a new formation for the granite

Before integrating your geology orientation data (dip and dip direction data) for the granite into the project, you need to add the new geology formation.

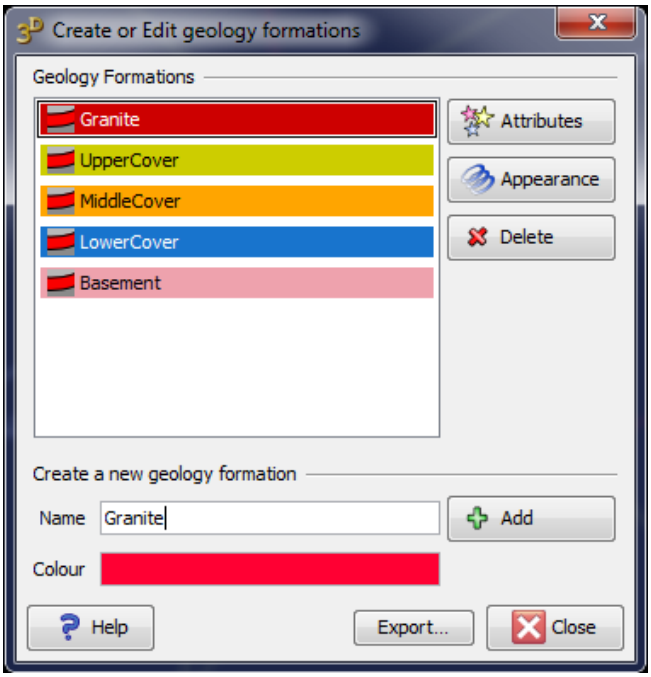
Add the new formation with the following parameters (Names are case sensitive and must be exactly as shown):

	Formation
Name	Granite
Colour	red (RGB 205 0 0)

Choose main menu option **Geology > Formations: Create or Edit**.

In the **Create or Edit geology formations** dialog box, use the following sequence:

- Enter the **Name**.
- Specify the **Colour** (use the **RGB** tab if you want to get it exact, but this is not vital).
- Choose **Add** and then **Close**.



GeoModeller may display the **Create Formation** tip box.

Choose **No, do it later**.

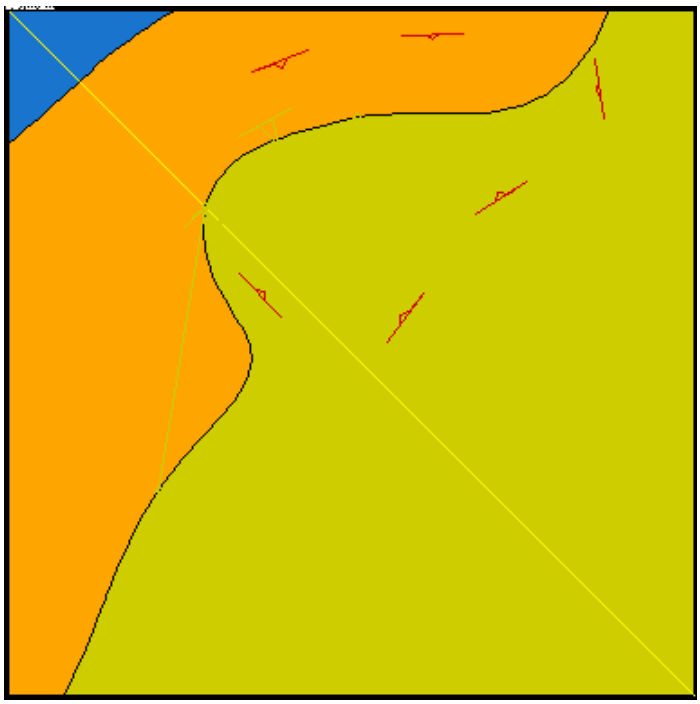
2 Import the structural data measurements observed on the granite into the Topography (Map_DTM) section.

The file is located in:
`TutorialA\TutorialA3\Data\Map_Granite.data.`

Import the data as you did in earlier steps. The data contains the name of the Granite formation, and GeoModeller automatically assigns it.

Select the **Topography** tab in the **2D Viewer**.

Select **Import > 2D Geology to Section > Contacts, Structure (BRGM)**



3 Save your project.

4 Start defining a new section for seismic data, Section2 by adding points to the Points List.

To learn more about the shape of this granite, you asked to review some seismic data shot on a line named **Section2_01**0. Your team geophysicist interprets the seismic reflection profile, and shows you the final interpreted shape of the granite in the section.

You need to define a new section, corresponding to this seismic profile.

On the **Topography** section, make the trace of the new section using the **Points List Editor**, and then create the section (**Section2**) from its trace. The coordinates of the ends of **Section2** are:

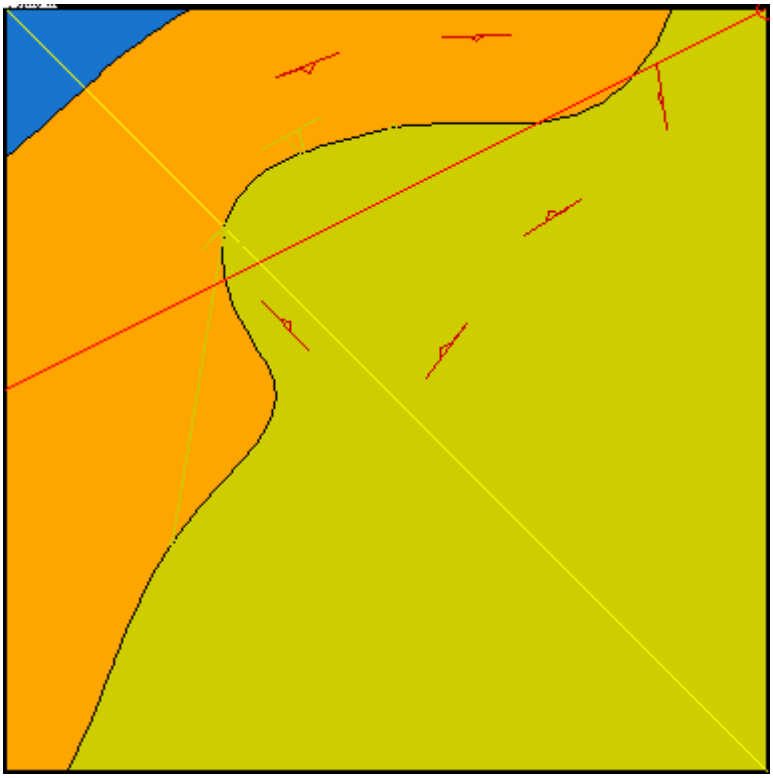
	X (East) = U	Y (North) = V
Start	100010	2005000
End	109990	2009990

Select the **Topography** section in the **2D Viewer**.

From the 2D Viewer toolbar, choose **Create (Lines)**

From the **Points List Editor** toolbar choose **Delete all Points** to erase any existing contents of the Points List.

Click two points close to those specified in the table above.



5 Edit the points using the **Points List Editor** so that they have the correct values.

On the **Points List Editor** toolbar choose **Float or Dock the Points List Editor**

Edit the **U** and **V** point coordinates as required.

For more detailed instructions and illustrations, refer to similar activity in A1 Stage 2—Create a section in Tutorial A1—A simple model with two formations

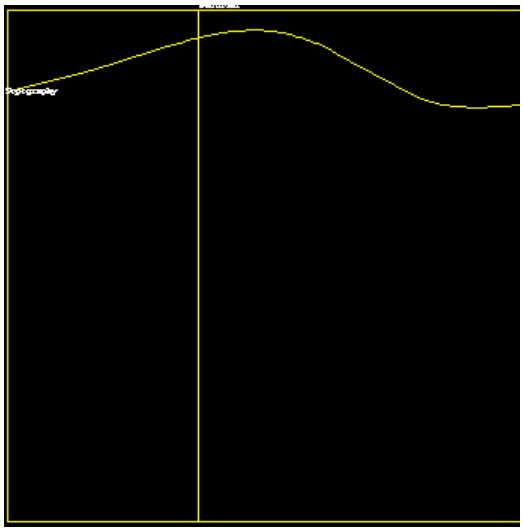
6 Create '**Section2**' from the points trace.

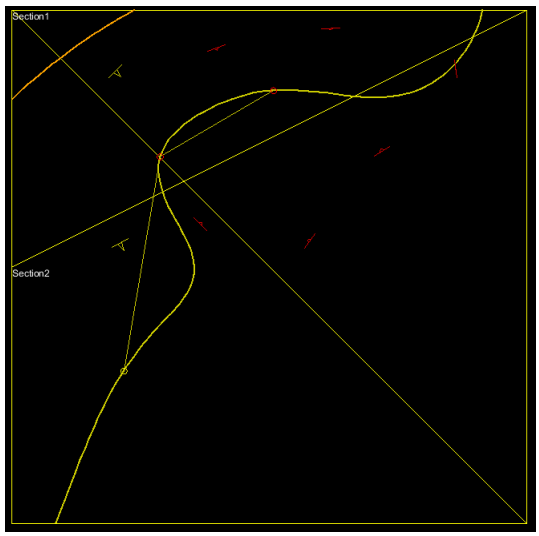
Choose menu option **Section > Create a Section from its Trace** OR

on the **Section** toolbar, choose **Create a Section from its Trace** OR
Choose CTRL+U.

In the **Create a Section from its Trace** dialog box, enter the name **Section2** (leaving other parameters with default values) and then choose **Create** and **Close**.

In the **2D Viewer**, GeoModeller shows the new section in the **Topography (Map_DTM)** tab and creates a new **Section2** tab. This tab shows a 2D view of the new section. You can see the profile of the topography.



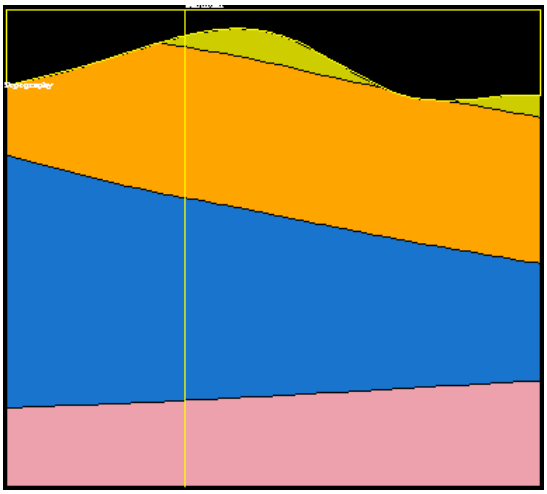


7 Save your project.

8 Plot the model geology as fill on Section2

Remember that the current 3D model does not take the granite into account.

Select the **Section2** tab. Right-click **2D Viewer** background then **Plot the Model on the Current Selection** (i.e. filled polygons).



GeoModeller automatically plots the section view according to the **last** computed model. All sections (the **Topography, Section1** and **Section2**) share the same 3D model. Thus the three sections present a coherent view on the modelled geology as **currently computed**; where the sections intersect with each other, the modelled geology plots are identical.

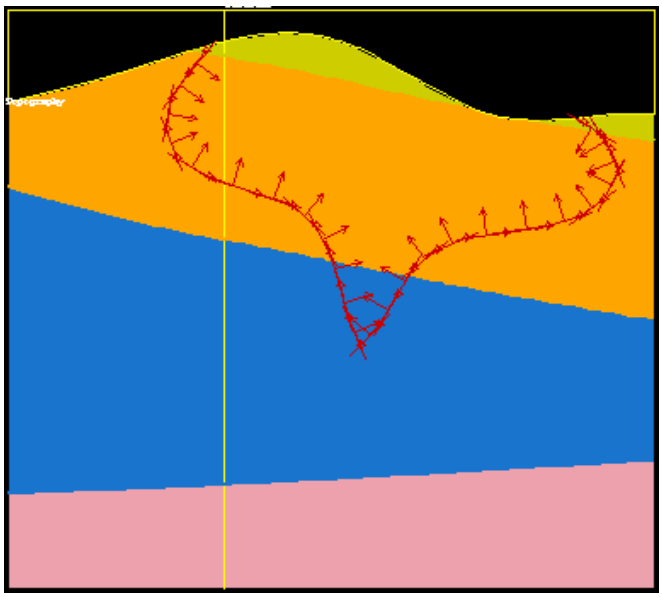
9 Import the interpretation of the granite into Section2.

The file is **`TutorialA\TutorialA3\Data\Section2_Granite.data.`**

Import the file using similar steps to previous stages in the tutorial.

Select the **Section2** tab in the **2D Viewer.**

Select **Import > 2D Geology to Section > Contacts, Structure (BRGM)**



10 Save your project.

Create a new series, IntrusiveSeries containing the Granite formation

Before computing a revised 3D model that takes account of the granite, we need to insert this latest formation or unit into the project's geological pile.

The seismic interpretation indicates clearly that the Granite intrudes all three of the Cover formations that we have defined. So that the model takes this 'cross-cutting' relationship into account, we will define the **Relationship** to be Erode in the geological pile.

We shall create a new series so that our geological pile has the following configuration (with Bottom reference):

Series	Formations	Relationship
IntrusiveSeries	Granite	Erode
UpperSeries	UpperCover; MiddleCover	Onlap
LowerSeries	LowerCover	Onlap
BasalSeries	Basement	Onlap

For a set of instructions with more detailed instructions and screen snaps, see A2 Stage 2—The basement and the sedimentary sequences above.

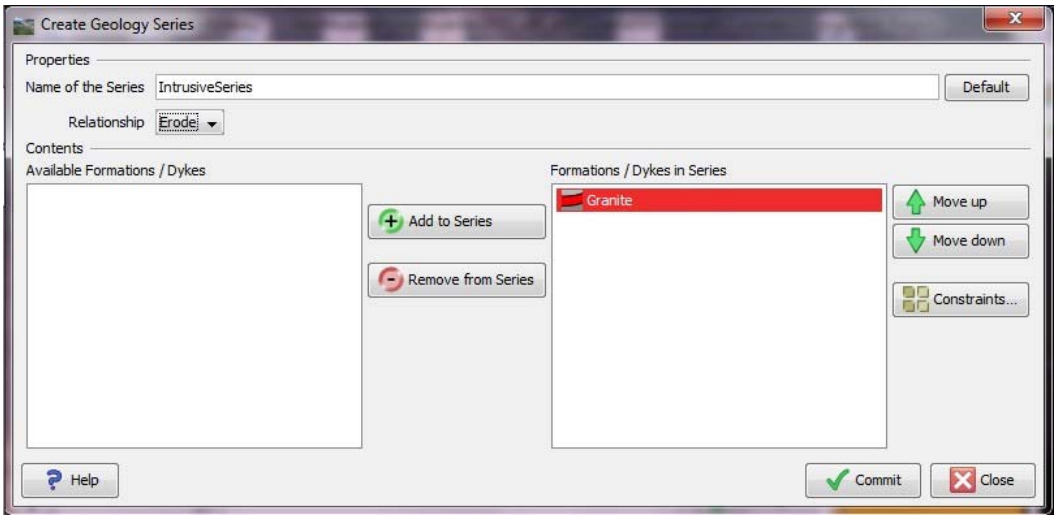
11 From the main menu, choose **Geology > Stratigraphic Pile: Create or Edit.**

Ensure the Reference of the pile is set to **Bottom.**

Choose **New Series**.

In Name of the Series type **IntrusiveSeries**
Ensure that the Relationship is set to **Erode**.

Move the formations so that **Granite** is the only formation in the **Formations/ Dykes in Series** list. [If required, select formations and use either **Add to Series** or **Remove from Series**]



Choose **Commit** and **Close**.

In the **Create or Edit Geology Series and the Stratigraphic Pile**, if necessary, select the **IntrusiveSeries** and use the **Move up** arrow buttons to put **IntrusiveSeries** at the top (i.e. the IntrusiveSeries is the youngest geological event recorded in the stratigraphic pile).

Choose **Close**.

12 Save your project

From the main menu choose **Project > Save** OR
From the **Project** toolbar choose **Save** OR
Press CTRL+S.

A3 Stage 3—An intrusive dyke

Parent topic: Tutorial A3—Intrusive bodies

During the same field trip one of your colleagues discovered the presence of a rhyolite dyke in the south east area of your project. The dyke was exposed in outcrop in two main areas. In both areas the dyke had the same petrology, but not the same thickness. Your colleague draws an outcrop map of the area including the new dyke.

We plan to import and geo-register the geological map so that it corresponds correctly within the model, and use it to digitise the dyke contacts.

The map has four located corners for aligning with the project. We only use three of them.

Registration Point	X Coordinate (East)	Y Coordinate (North)
Top left	100000	2010000
Top right	110000	2010000
Bottom right	110000	2000000

To summarise, in this stage of the tutorial we will:

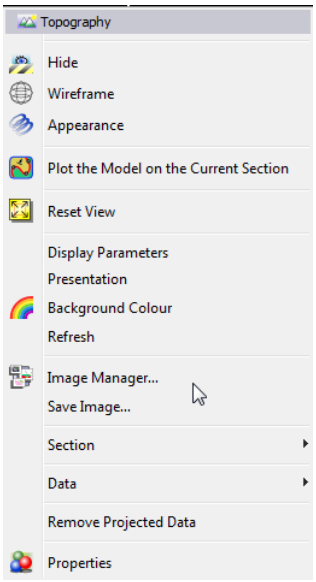
- Create a dyke
- Geo-locate an outcrop map image
- Measure the thickness of the new dyke on the map
- Digitise contact points for the boundary of the dyke

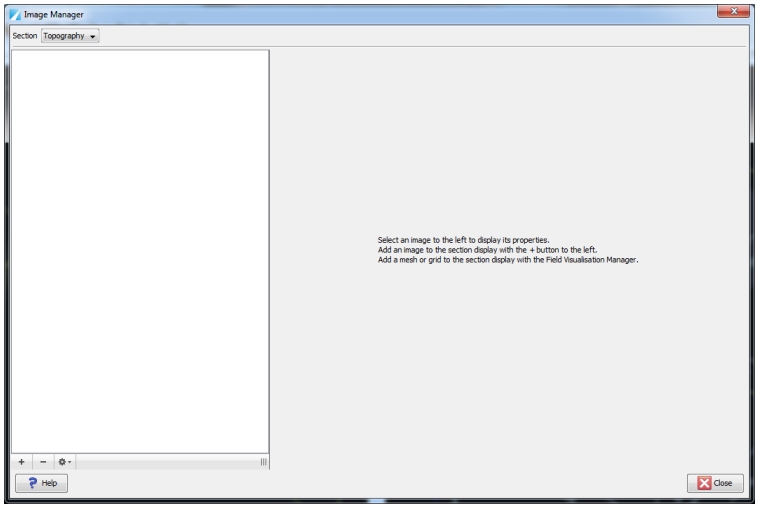
A3 Stage 3—Steps

1 Open Image Manager.

In the **2D viewer**, select the **Topography** tab

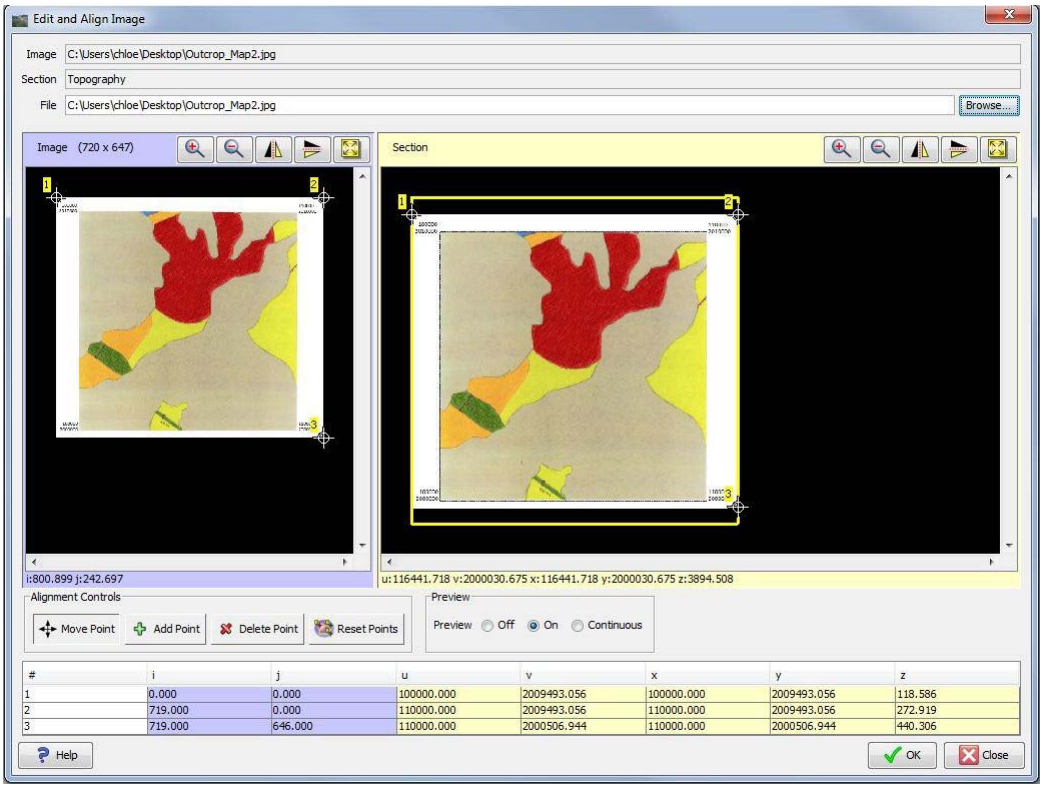
From the **Topography** shortcut Menu (right-click in the 2D viewer), choose **Image Manager**.





2 Press the **+** button in the bottom left hand corner. GeoModeller displays the **Edit and Align image** dialog box.

Choose **Browse** and open:
`TutorialA\TutorialA3\Data\FieldGeologyWithCOVER.jpg`



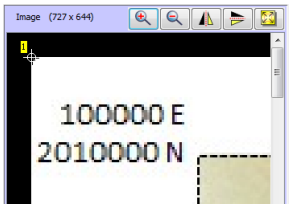
If your image has three or more points for which you know the geographical coordinates, you can use the **Edit and align image** dialog box to geo-register the image in your project. After geo-registration, each point in the image corresponds to the correct location in the GeoModeller project.

On the left is a copy of the image you have opened.

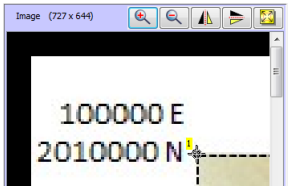
On the right is a copy of the image as registered in the GeoModeller project.

The left panel has three movable alignment points. You will move them to correspond with the three known registration points in the image.

3 Enlarge the image in the **Image** panel, and move the view to the top left corner so that you can see the registration point and alignment point 1.



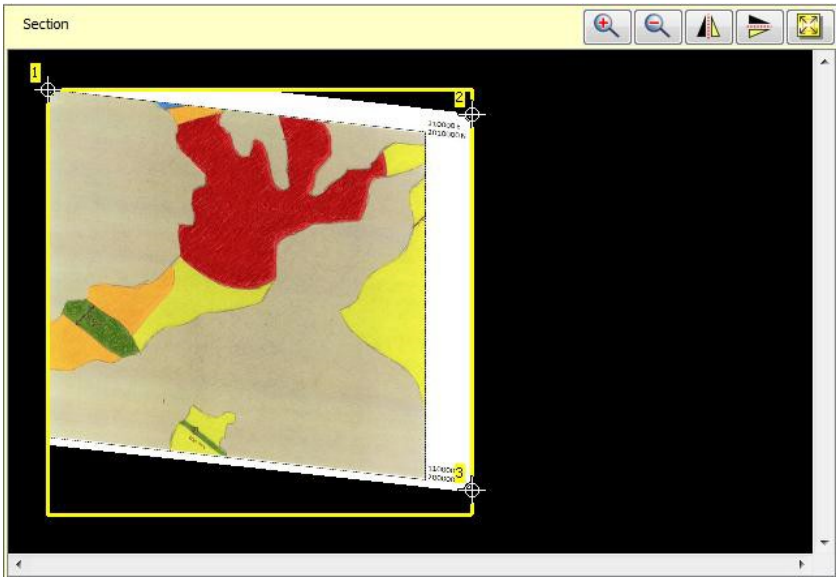
Select & Drag alignment point 1 to exactly align with the registration point in the image.



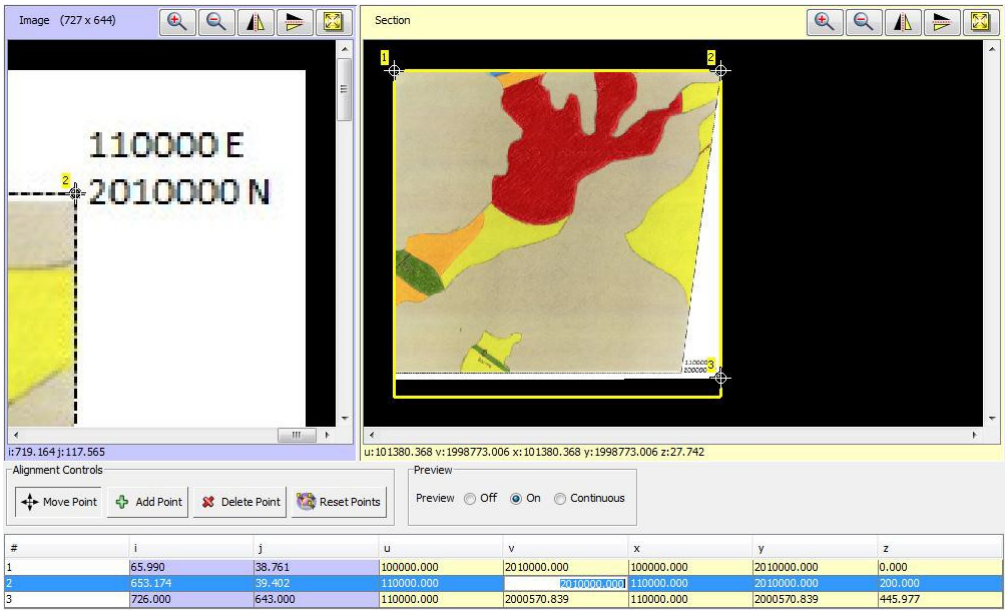
4 Enter the coordinates of this point (100000, 2010000) in the table at the bottom of the dialog box as **u** and **v** for alignment point 1.

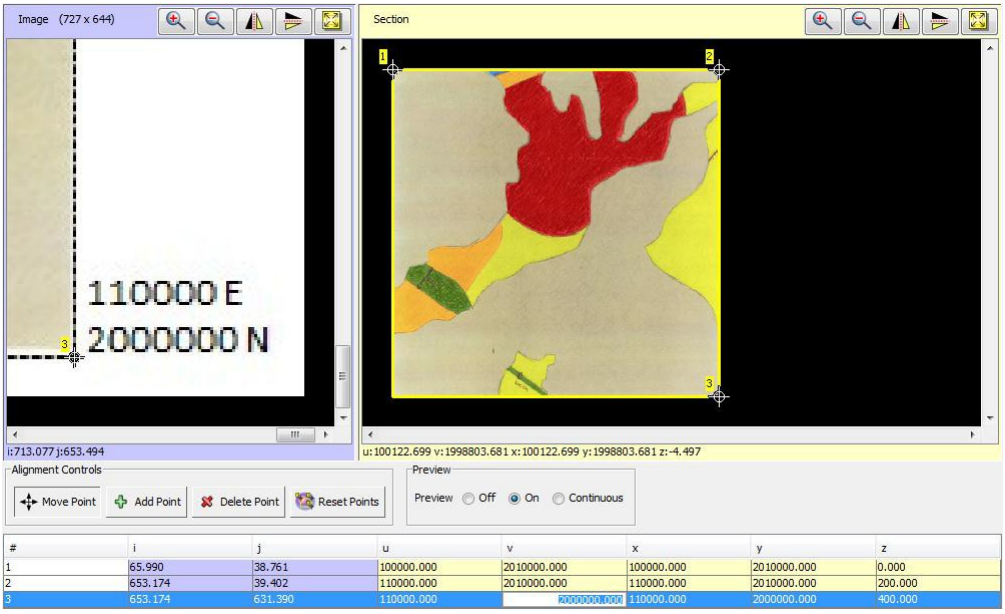
#	i	j	u	v	x	y	z
1	65.990	38.761	100000.000	2010000.000	100000.000	2010000.000	0.000
2	726.000	0.000	110000.000	2009429.161	110000.000	2009429.161	283.624
3	726.000	643.000	110000.000	2000570.839	110000.000	2000570.839	445.977

In the **Section panel**, GeoModeller warps the image to correctly geo-locate this point.



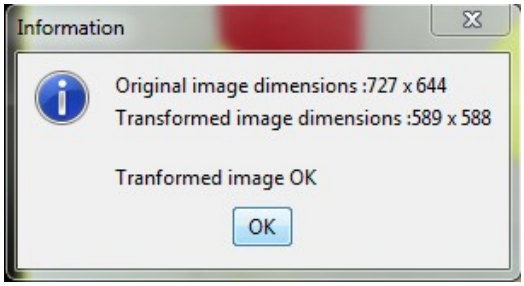
5 Repeat steps 3-4 for the top-right and bottom-right registration points, corresponding to alignment points 2 and 3. (Alternatively you can place all 3 points on the left-Image-side, then edit all three points in the U,V editor together.)



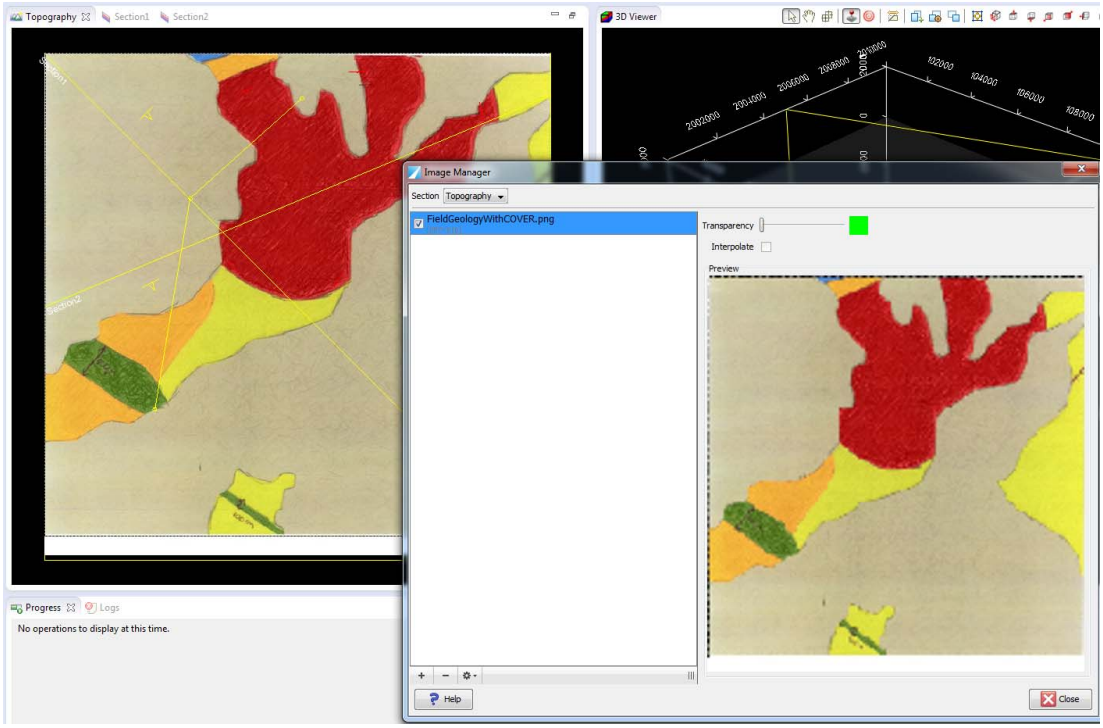


6 Choose **OK**.

GeoModeller reports the final dimension of the part of the image that it is using. Choose **OK** (if required).



GeoModeller lists the image in the **Image manager** and displays it in the **2D Viewer** in the **Topography** tab.



If it is not visible in the 2D Viewer, tick the box next to the file name (**`FieldGeologyWithCOVER.png`**) in the **Image manager**. You can also select a transparency level for the image. Close the **Image manager**.

7 Save your project.

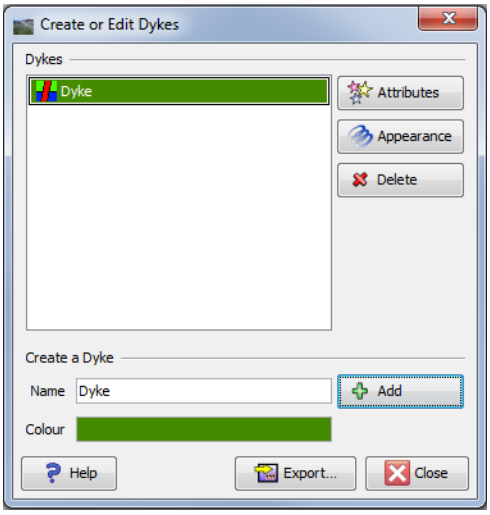
8 Create a dyke

Choose main menu **Geology > Dykes: Create or Edit**.

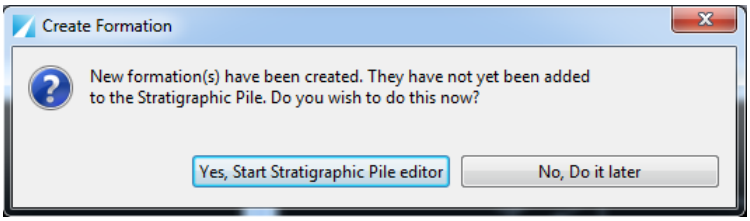
Use the following parameters (make sure you enter the names exactly as shown-case sensitive, no spaces):

- **Name:** Dyke
- **Colour:** green (RGB 68 138 0)

Click **Add** and then **Close**

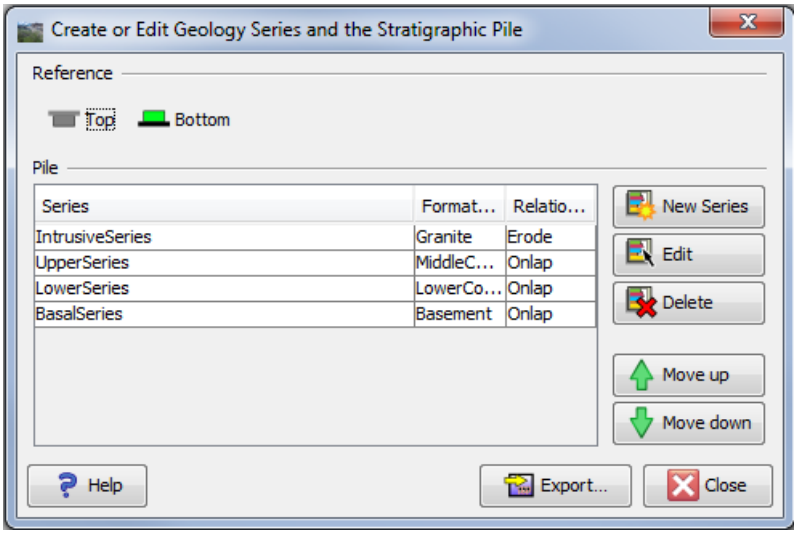


When you choose **Close** in the previous step, GeoModeller may display the **Create Formation** tip box.



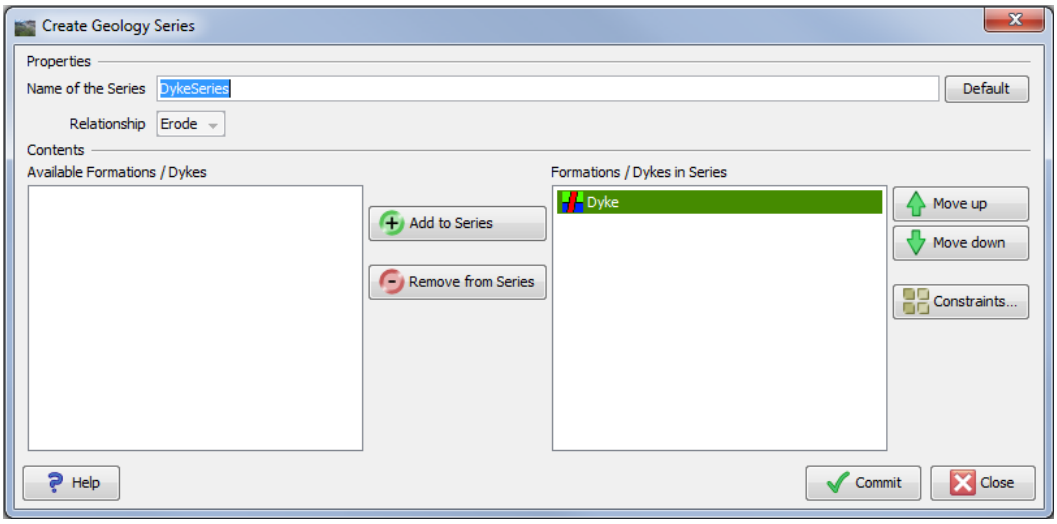
Choose **Yes, start Stratigraphic Pile editor**.

If this box does not appear, from the main menu, choose **Geology > Stratigraphic Pile: Create or Edit.**



Choose **New series**.

The **Create Geology Series** dialog box appears.



- For Name of the Series: enter **DykeSeries**
- By default the **Dyke** is already listed (right) in the **Formations/Dykes in Series.** [Otherwise, to add Dyke to a series, select Dyke from **Available Formations/Dykes** and choose **Add to Series**. Alternatively, to remove a formation, select it (from the right) in the **Formations/Dykes in Series** and choose **Remove from Series**.
- For dykes, the **relationship** is automatically set to **Erode**.
- Choose **Commit** and **Close**.

Select the DykeSeries and use **Move up** or **Move down** to put DykeSeries on top of the pile. Check that **Reference** has been set to **Bottom**.

Choose **Close**.

9 Save your project.

Note: On the handmade surface geology map that you just imported in GeoModeller, your colleague also wrote on the map some annotations of the thickness of the dyke. The annotations may be less visible in low resolution after being geo-located in GeoModeller, but are still available in native file format in a copy preserved automatically in your GeoModeller project folder.

The next steps are to create the dyke in GeoModeller and check the thickness of the dyke on the map where it outcrops.

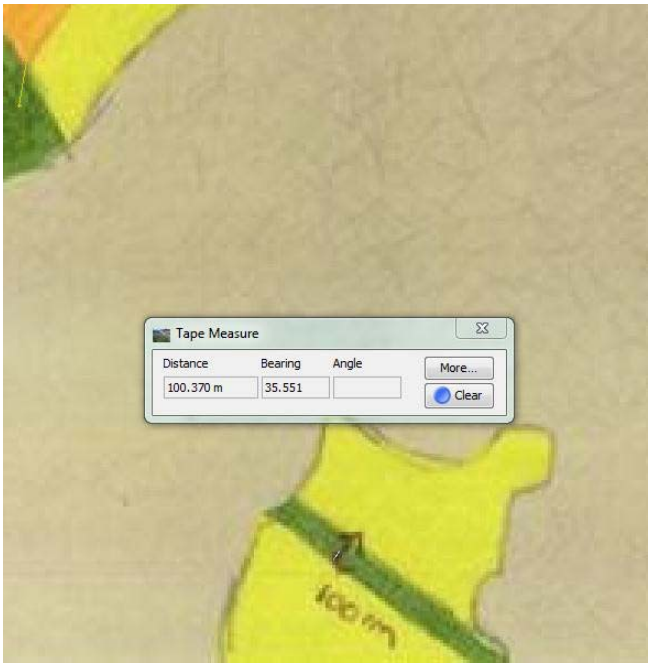
10 In the **2D toolbar** select the **Tape Measure**

Measure the thickness of the dyke in the larger area first by clicking on one side of the dyke in the image, and then dragging the cursor to the other edge.

Click again to fix the value measured in the **Tape Measure** window.

Thickness of the dyke in this area is about **800m**, and this confers with your colleague's notes.

Press on **Clear** to repeat the measure for the thinner part of the dyke.



Dyke thickness (second measurement) is approximately **100m**, again conferring with your colleagues notes.

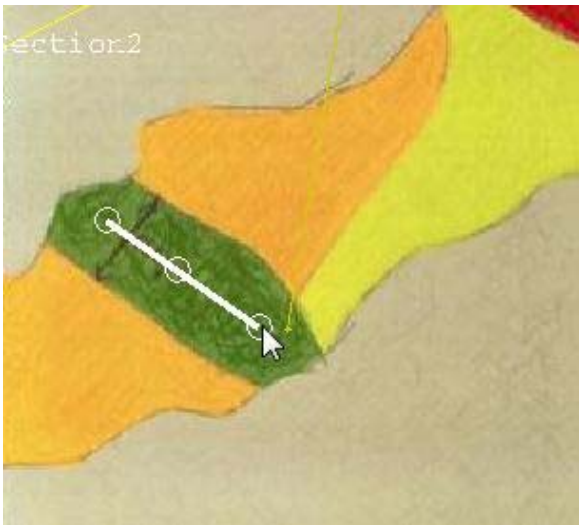
11 Digitise dyke geological data

From the **2D toolbar**, choose **Create (Lines)**

From the **Points List Editor** toolbar, choose **Delete all Points**

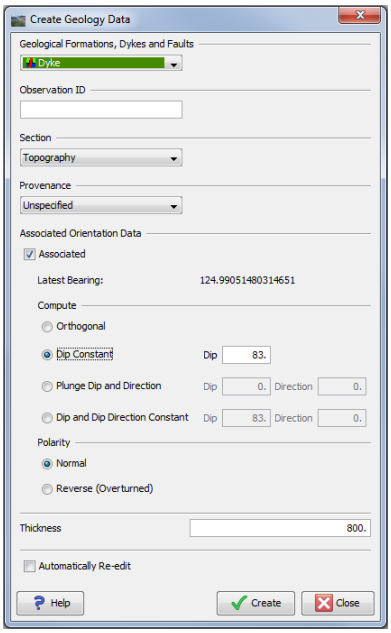
Starting at the top end, click **two or three points** along the length of the dyke, in the middle of the exposed dyke (like a backbone).

For digitising dykes, at least two points must be specified for each segment. This is because strike needs to be locally established. The thickness is then assumed to occur orthogonal to the dyke boundary and will need to be defined in metres. Also, an associated dip needs to be entered. These conditions must be met if you have chosen to build a dyke in GeoModeller using the dyke creation tool. You cannot compute your input until these requirements are entered.



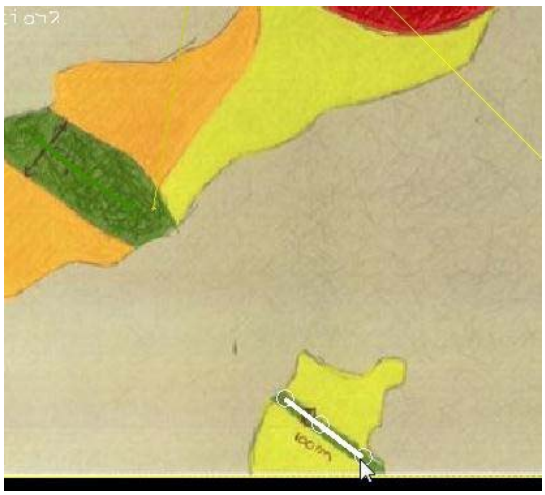
12 From the main menu **Geology > 2D Structural > Create Geology Data**

Or from the Structural toolbar choose **Create Geology Data**  or press CTRL+G



In the **Create Geology Data** dialog box:

- **Geological Formations, Dykes and Faults**—select **Dyke**
- This dialog box allows us to create some associated orientation data, too– these are orientation data created between each pair of digitised data points.
- Select **Dip Constant**, and set Dip = 83 (degrees)
- **Polarity**—select **Normal**
- Thickness = **800** metres
- Choose **Create,** and then **Close**



13 Repeat steps 11 and 12 for the next outcropping section of the dyke.

Again, starting at the top end, **click two or three points** along the length of the dyke, in the middle of the exposed dyke (like a backbone).

In the **Create Geology Data** dialog box:

- In: Geological Formations, Dykes and Faults—select **Dyke**
- Select **Dip constant**, and set Dip = 83 (degrees)
- **Polarity**—select **Normal**
- Thickness = **100** metres
- Choose **Create**, and then **Close**

A3 Stage 4—The final 3D model

Parent topic: Tutorial A3—Intrusive bodies

The final stage of Tutorial A3 is to compute the 3D model with the granite and dyke.

A3 Stage 4—Steps

1 Compute the 3D model with all sections and series.

From the main menu choose **Model > Compute** OR

From the **Model** toolbar choose **Compute** OR
Press CTRL+M.

Compute the 3D model with the following parameters:

- **Series to interpolate: Select All**
- **Sections to take into account: Select All**

2 Plot the model 'filled', in a section

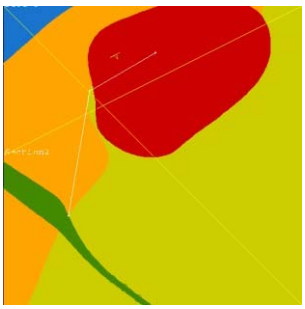
Select a section tab in the **2D Viewer**.

Plot the model in the section using the same steps you have used in previous stages.

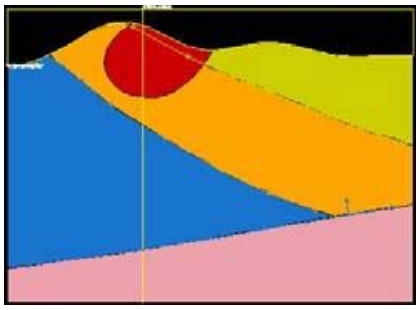
3 Plot the model using current settings in all sections.

From the main menu choose **Model > Plot Model on All Sections in 2D Viewer** OR

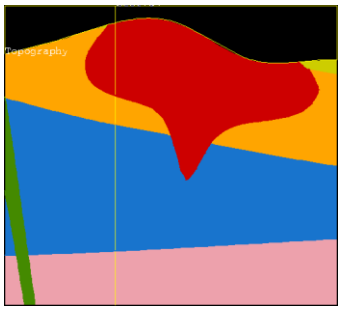
From the **Model** toolbar **Plot Model on All Sections in 2D Viewer**



Topography



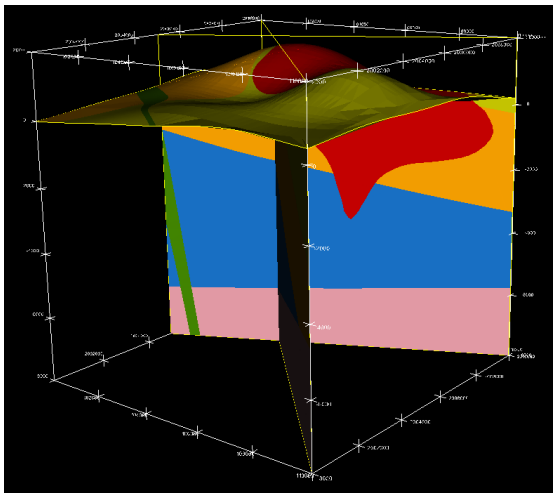
Section 1



Section 2

4 View the filled 2D plots in the **3D Viewer**.

In turn, select each section in the **2D Viewer** and, from the shortcut menu in the **2D Viewer** (right-click the background) choose **Show Modelled Geology Polygons in 3D Viewer**.



5 View the full model in the 3D Viewer

Remove the section displays in the **3D Viewer.**

For each section in turn in the **2D Viewer**, from the shortcut menu in the **2D Viewer** choose the following items if they are available:

- **Hide Modelled Geology Lines in 3D Viewer.**
- **Hide Modelled Geology Polygons in 3D Viewer.**

6 Choose main menu **Model > Visualise 3D Formations and Faults** OR

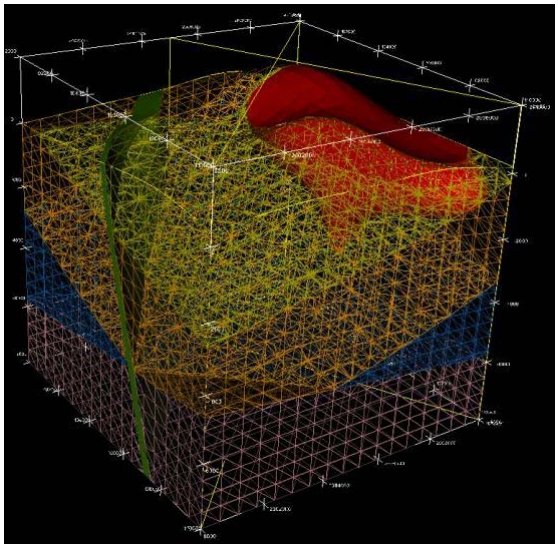
In the **Model** toolbar choose **Visualise 3D Formations and Faults**

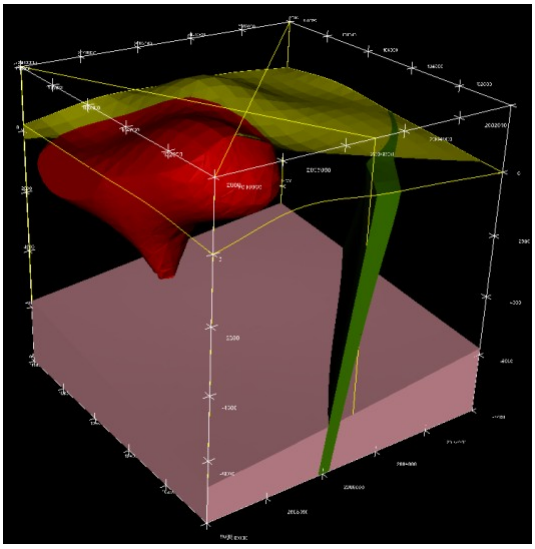
Accept the defaults (low resolution); Choose **OK**.

Examine the 3D view, changing the appearance of each formation as desired.

To view in wireframe (see image below left), in the **Explorer** menu right-click **3D Geology > Wireframe**.

See detailed instructions in A1 Stage 5—Show the 3D model in 2D sections and in 3D if required.





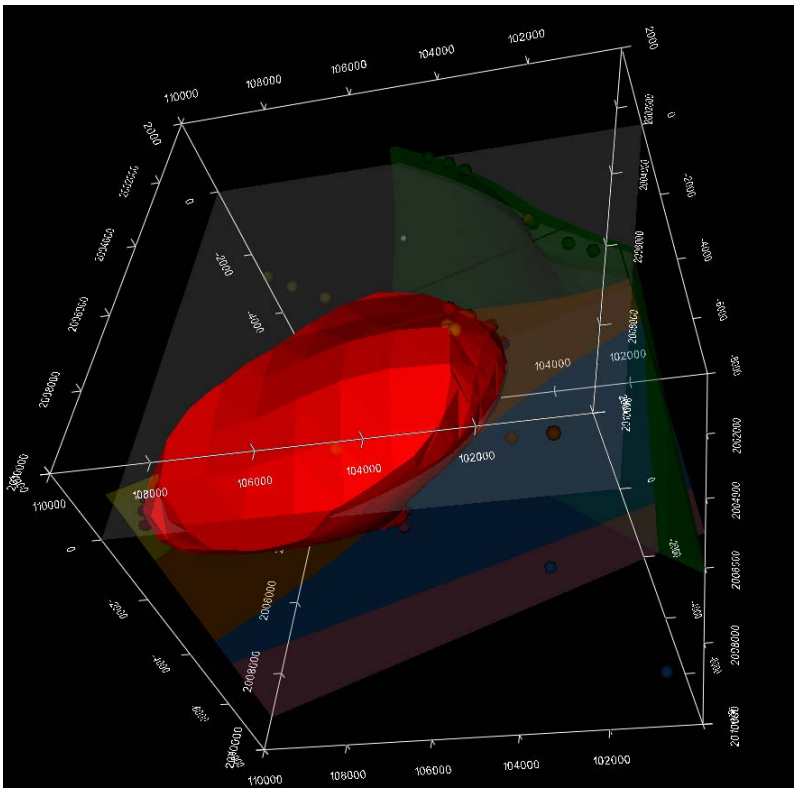
7 Interactive features of the 3D Viewer

In the 3D Viewer, two modes of model rotation are available: **Track ball mode** or **Joy stick mode**. To toggle between these modes, select the following from the 3D toolbar: . (click on/off to switch between the two modes)

In either mode: Try these **actions**:

- **Re-centre view**: Left mouse click to reset the 3D model to a centre-field view
- **Turn Focal Indicator ON/OFF:** Left mouse click
- **Zoom:** Use Mouse wheel
- **Reset Zoom:** Left mouse click (Fit All)
- **Pan**: Left mouse click

In the 3D viewer **Double-mouse-click** on a model element of interest.While this display is revealed, the remaining model parts are **transparent.**



In the **Explorer** menu, open 3D Geology by pressing **+**, then experiment with different views by right-clicking a series (e.g. UpperSeries) and toggling **Show/Hide** or **Shading/Wireframe**. You can also change the **Appearance** settings.

8 Save your project.

A3 Stage 4-Discussion

The revised geology surface map enables you to target areas of interest for your next field mapping campaign.

Observe how GeoModeller models both the intrusives (Granite and Dyke) with cross-cutting relationships to all other formations. This is due to the 'Erode' relationship that you assigned to the Granite and Dyke in the geological pile. And also a consequence of both of these units being located chronological young within the stratigraphic pile.

The Granite and Dyke do not intersect in this model, but if they did, the current "Rules of the Stratigraphic pile" would dictate that the Dyke would cross-cut the Granite - because it is placed "younger" in the Stratigraphic Pile. Try it! And then try and reverse the order of Granite and Dyke in the Stratigraphic Pile.

Tutorial A4—Geology with a fault

Parent topic: Tutorial A (A First Geology Modelling Experience)

In this tutorial you will add a fault to your 3D model.

Using GeoModeller you will learn how to:

- Define a fault and its geometry
- Revise your geology interpretation
- Import data with the **.mif** or **.mid** interchange format
- Define the relationships between faults and geology formations
- Compute the 3D model taking a fault into account

The starting point for this tutorial is the work completed in Tutorial A3.

In this tutorial:

A4 Stage 1—Open the project

Parent topic: Tutorial A4—Geology with a fault

The start point of this tutorial is the completed work from Tutorial A3—Intrusive bodies

A4 Stage 1-Steps

1 Open your completed project from Tutorial A3 or the solution provided:

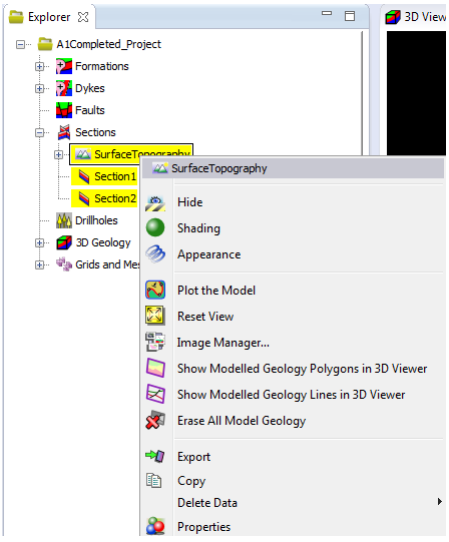
`TutorialA\TutorialA3\A3Completed_project\A3Completed_project.xml`

2 Save the project with a new name in the folder you are using for your tutorial data.

Note that a completed version of this tutorial is available in: **`TutorialA\TutorialA4\A4Completed_project\A4Completed_project.xml.`** Do not overwrite it.

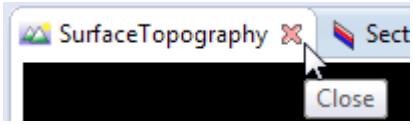
*Use the Project **Explorer** and tabs to practise opening and closing sections in the 2D Viewer; detaching & re-docking, and arranging multiple 2D Viewers.*

3 In the project **Explorer**, expand the Sections branch of the project tree. Use the shortcut (right click) menu to choose options for each section.



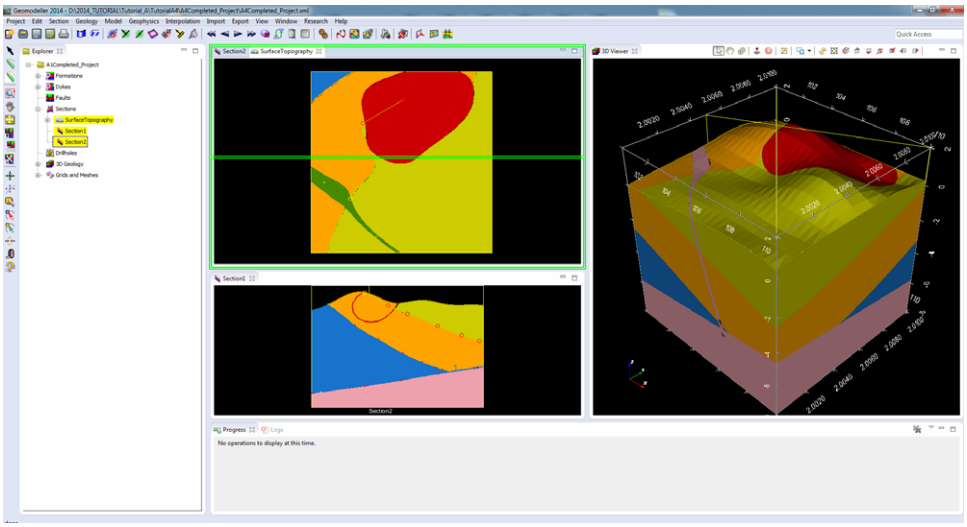
To ***open*** a section in the **2D Viewer**, (which is not already open):
Select the Section and choose the shortcut menu option (right-click) **Open 2D Viewer**.

To ***close*** a section view either:
Click the red Close cross on the section's **2D Viewer** tab.

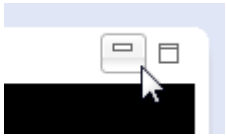


To ***view multiple panels of 2D Viewers simultaneously***,

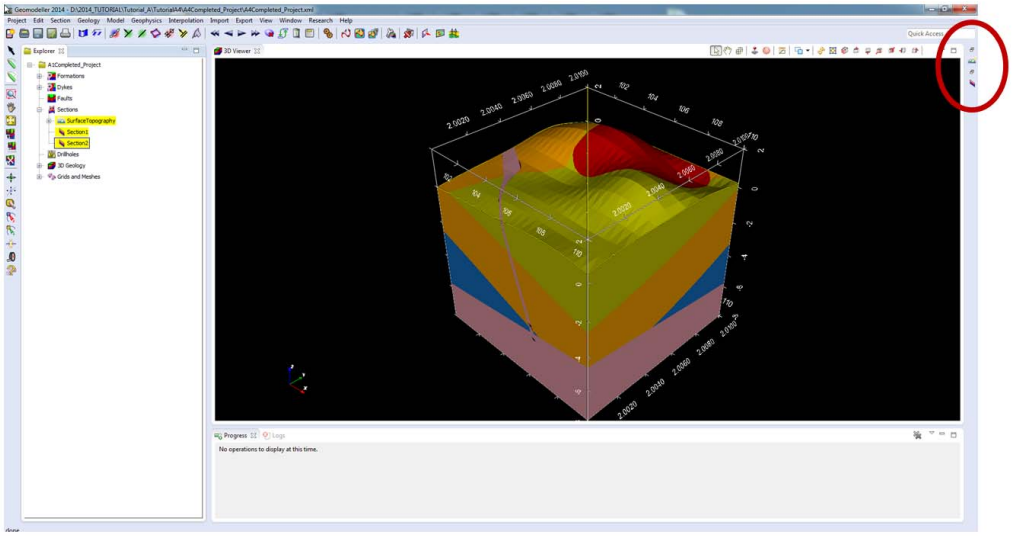
Select the tab of a chosen **2D Viewer**, then **drag & drop** (hold down left-mouse button) to move to a new location. Many 2D Viewer windows can be open at the same time, by repeating this step until the workspace is suitably arranged.



To ***Minimise or Maximise*** a section view use the icons on the right-hand side of the 2D Viewer:



Once the section is minimised you can reopen it by clicking on the section Icons that are located on the left-hand side of GeoModeller workspace.



4 Erase all model geology from the 2D Viewer

Select a tab of the chosen **2D Viewer**.

From the main menu choose **Model > Erase all model geology** OR
From the shortcut menu in the **2D Viewer** choose **Erase all model geology** OR

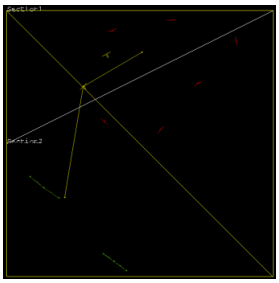
In the **Model** toolbar choose **Erase all model geology**

Repeat the step for every tab.

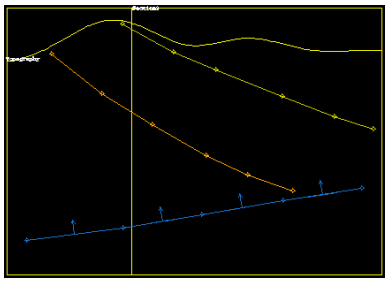
5 Erase all model geology from the 3D Viewer

In the project **Explorer**, select **3D Geology** and then choose **Delete** from its shortcut menu. Confirm the operation.

6 Review the geology shown on the three sections.



Topography



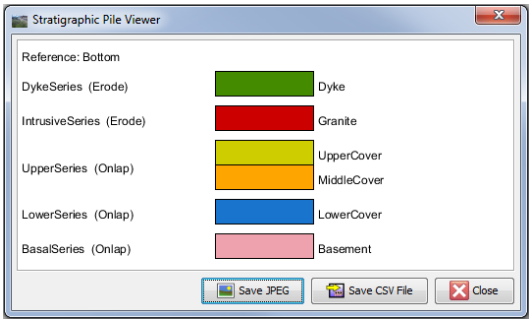
Section1

Section2

7 Examine the geological pile to review the formations in this project and understand their relationships.

Display the stratigraphic pile viewer.

From the main menu choose **Geology > Stratigraphic Pile: Visualise**



Choose **Close** when finished your review.

8 Save your project.

A4 Stage 1-Discussion

The Granite and Dyke are intrusives cross-cut pre-existing Cover and Basement units. Logically, they are placed youngest in the stratigraphic pile, and are assigned to 'Erode'. The remaining units are of type 'Onlap'. They are progressively deposited on the existing (older) formations without eroding them.

In the field, the UpperCover and MiddleCover formations are conformable, and share a common tectonic history. To account for this, we can assign them to the same "series" (UpperSeries). Therefore, the two formations will be treated jointly in computation of the model. They will remain sub-parallel everywhere and will share orientation data. The basal contacts of these two formations within a series can never intersect each other.

A4 Stage 2—Presence of a finite or infinite fault

Parent topic: Tutorial A4—Geology with a fault

Using the geology map plotted from your modelling in Tutorial A3, you decide to return to the field to clarify aspects of the geology. In particular, you suspect the presence of an oblique-slip fault in the south-east of your project area.

A thorough study of the outcrop confirms your ideas. You now observe evidence for a normal fault on two different outcrops. It was possible for you to measure dip and azimuth (80° towards 130°) on one of the fault planes. These observations raise questions about your geological assumptions and cast doubt on the validity of the current 3D model of the project area.

Before integrating the new observations into the model, we need to 'create' a fault (as an 'object' that can be used in the project). You will see this is a similar process to the creation of a geology formation.

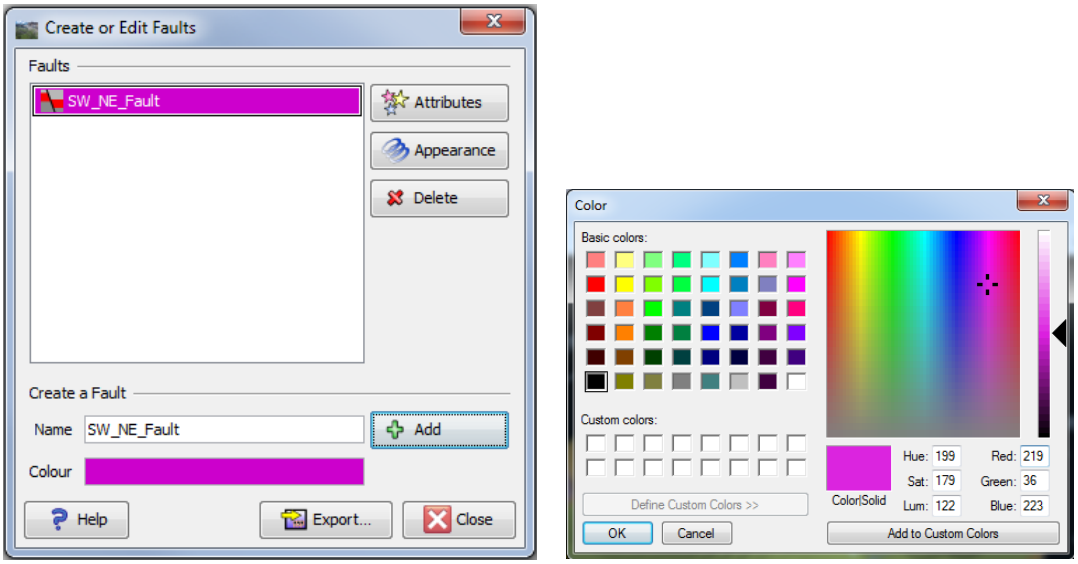
A4 Stage 2-Steps

1 Create a fault with the following parameters.

Use the following parameters (make sure you enter the name exactly as shown-case sensitive, no spaces (as we will import data matching this name later):

- **Fault:** infinite
- **Name:** SW_NE_Fault
- **Colour:** Purple (RGB 219 36 223)

Choose main menu **Geology > Faults: Create or Edit**. Enter the parameters given above and click **Add**, then choose **Close.**



Since you have just created a new fault, the **Create Fault** message tip suggests you might want to link the new fault to a geological series. Choose **No, do it later**.

Using the Points List, add the new location data for the fault plane you observed in outcrop.

In the **Topography** section, define two fault location points. Note that the field observations describing the position and attitude of **faults** are like geology 'contact' points. Thus we will use similar steps to create fault data as we used previously to create geology data.

The coordinates for the two points where the fault plane was observed are:

	X (East) = U	Y (North) = V	Fault Name
Point 1	105000	2002500	SW_NE_Fault
Point 2	107500	2005000	SW_NE_Fault

For more detailed instructions for using the Points List Editor in an operation like this, see the earlier stages in Tutorial A1—A simple model with two formations

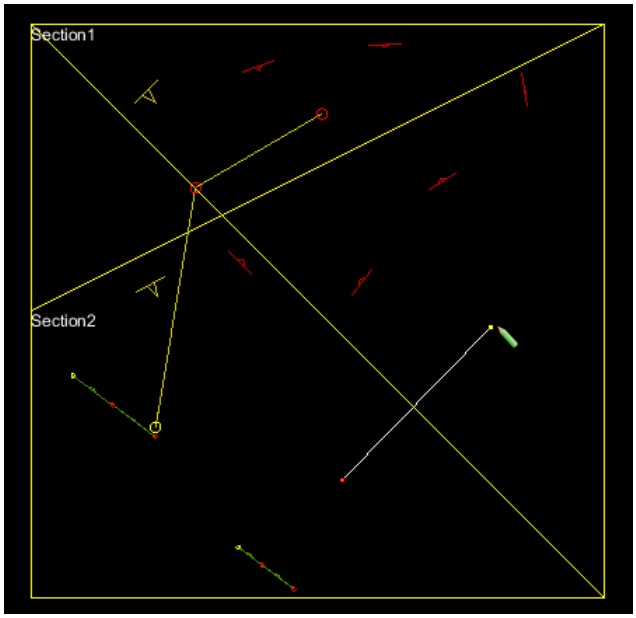
2 Select the **Topography** Section, and reveal the short-cut menu (right-click in the section- background). Choose **Set Layer Visibility**. In Model Geology, clear Geology-lines; and clear Geology - filled. Then **Close.**

If required, open **Topography** Section (press **+**) in **Explorer** menu. Right-click on **`FieldGeologyWithCOVER.png`** and select **Hide** to remove this image from view.

From the **2D Viewer** toolbar, choose **Create (Lines)**

From the Main menu - **Points List Editor** toolbar choose **Delete all Points** to erase any existing contents of the Points List.

In the **Topography** section, click two points approximately at the coordinates specified in the table above.



Click the **Float or Dock the Points List Editor** icon on the **Points List Editor** toolbar. In the **Points List Editor**, edit the **U** and **V** points as required (to match the table above).

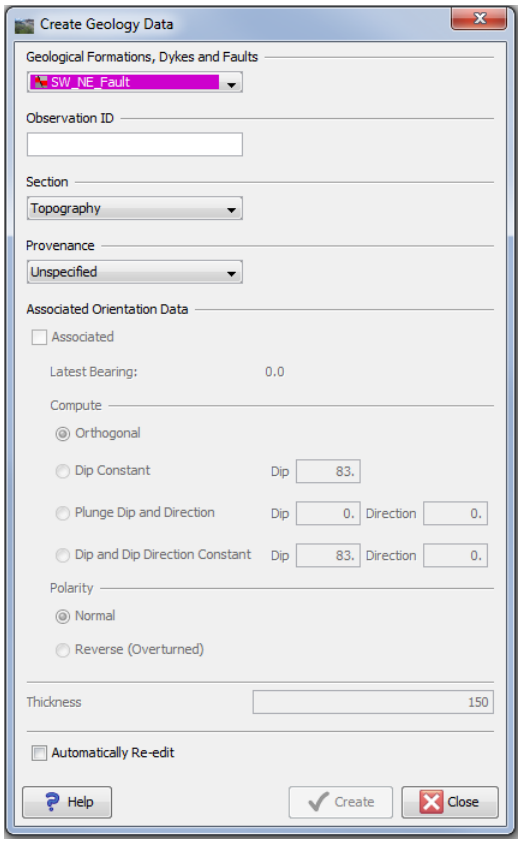
3 From the main menu choose **Geology > 2D Structural > Create Geology Data** OR

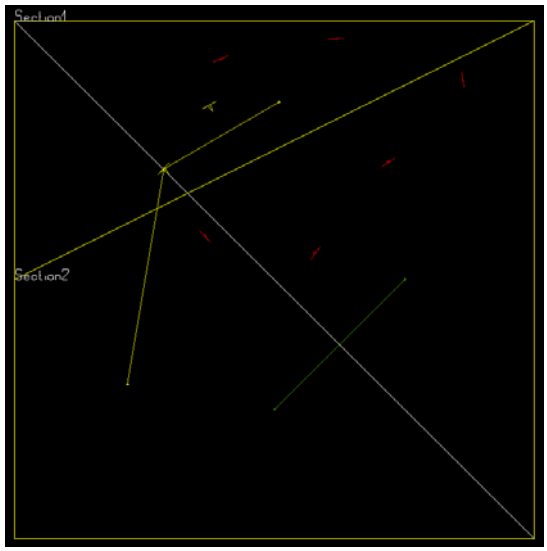
In the Structural toolbar, choose **Create Geology Data** . OR

Press CTRL+G.

In the **Create Geology Data** dialog set the **Geological Formations, Dykes and Faults** to: **SW_NE_Fault**,

Choose **Create** and then **Close**.





The fault location data may be edited after creation.
Using the **Select** tool, highlight the fault data in the **2D Viewer**.
Use the shortcut menu (right-click) **> Edit** to visit the **Edit Geology Data** pop-up menu. Make changes, then **> Edit** and **> Close**

4 Save your project.

5 Define one orientation point associated with the fault as follows:

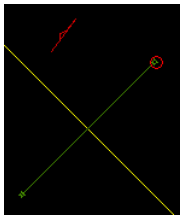
X	Y	Direction of dip	Dip	Polarity	Fault Name
107500	2005000	130	80	normal	SW_NE_Fault

See A1 Stage 3—Create & import geology data to the section in Tutorial A1—A simple model with two formations for detailed instructions about this type of step.

From the **2D Viewer** toolbar, choose **Create (Lines)** .

From the **Points List Editor** toolbar choose **Delete all Points** .

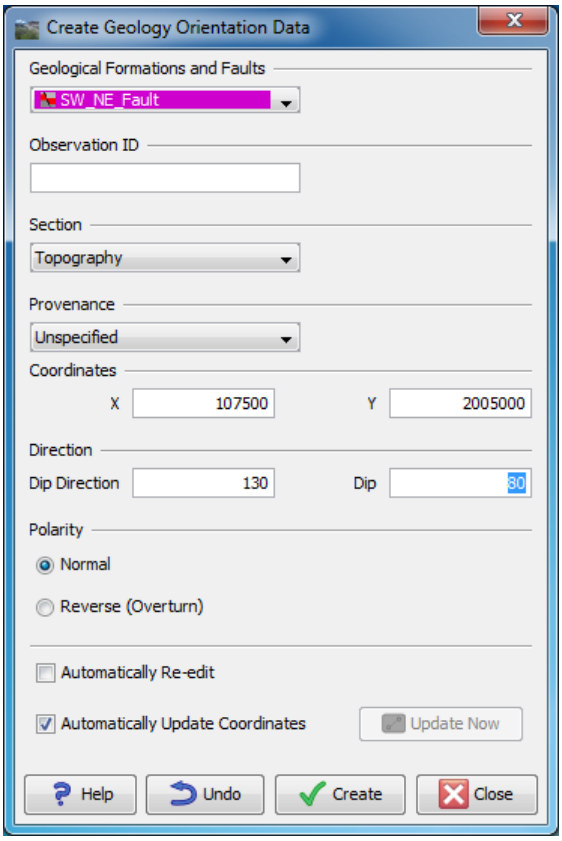
The attitude of the fault (dip and dip direction) has been measured in the field at the same place as the upper right data point of the fault. In the **Topography** tab in the **2D Viewer**, click this point.

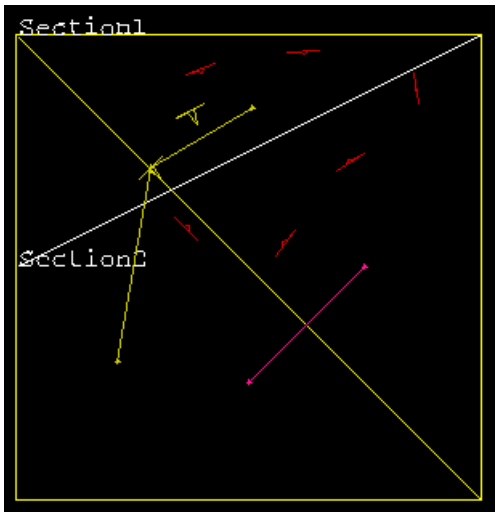


From the main menu choose **Geology > 2D Structural > Create Geology Orientation Data** OR In the **Structural** toolbar, choose **Create Geology Orientation Data** OR Press CTRL+R.

In the **Create Geology Orientation Data** dialog box:

- Select the **SW_NE_Fault**
- Correct the point **Coordinates**, if necessary
- Enter **Dip direction** and **Dip**
- Choose **Create** and then **Close.**





Again, the fault orientation data may be edited, after creation.
Using the **Select** tool, highlight the fault data in the **2D Viewer**.

Use the shortcut menu (right-click) **> Edit** to visit the **Edit Geology Orientation Data** pop-up menu

Make changes, then **> Edit** and **> Close**

6 Save your project.

Before computing the fault, you doubt the extended propagation of your fault and whether it offsets all formations in your project.

You decide to test one possible interpretation first: that the fault is finite. Afterwards you want to consider the fault may be infinite.

7 First set the fault as a finite fault

Choose main menu **Geology > Faults: Create or Edit**.

In the **Faults: Create or Edit window**, Select the **SW_NE_Fault**

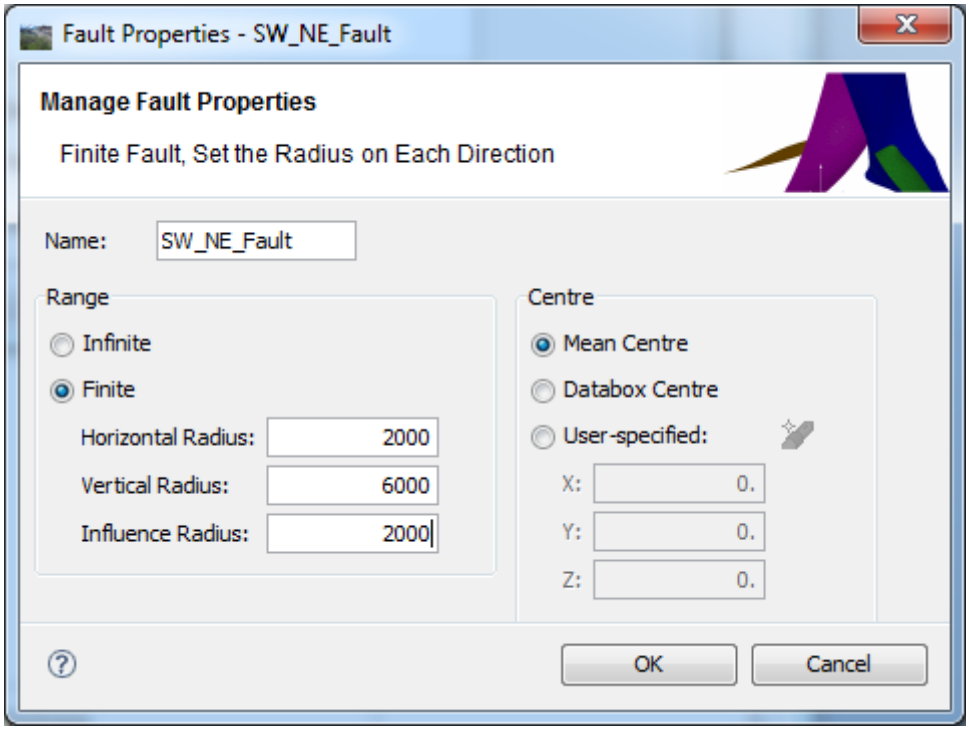
And choose **Attributes** 

By default the range of the fault is set on **Infinite**. Select **Finite** and enter the parameters given below:

- Horizontal Radius: **2000** (m)
- Vertical Radius: **6000** (m)
- Influence Radius: **2000** (m) same as the horizontal radius

These values set-up the axes of an unseen "ellipsoid" which will effectively clip the edges of the infinite fault plane - making it instead, a surface with finite extents (see Fig. in Step 9 below).

Accept other defaults in the window.



Choose **OK** and **Close**

8 Compute and plot the 3D model for the fault only, to check that it is correct.

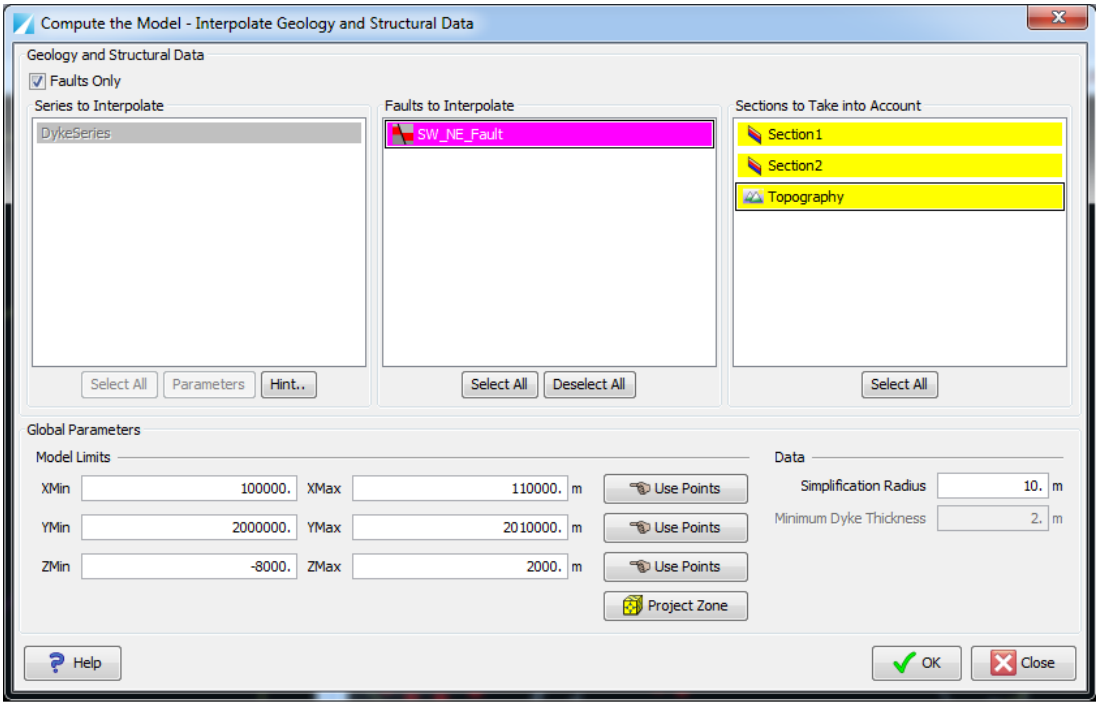
Model > Compute OR From the **Model** toolbar choose 

OR Press CTRL+M

Compute the 3D model with the following parameters:

- **Faults only:** Checked
- **Faults to interpolate:** SW_NE_Fault
- **Sections to take into account:** Select **Topography**

> OK



It is sufficient to use only the data from the topographic surface since all of our data relating to the fault are on that (map) section. This can be confirmed in **Explorer** by fully expanding the Faults tree (where the data-repository for both 'Interface' and 'Orientation' are listed).

9 Plot the model, with lines, in Topography

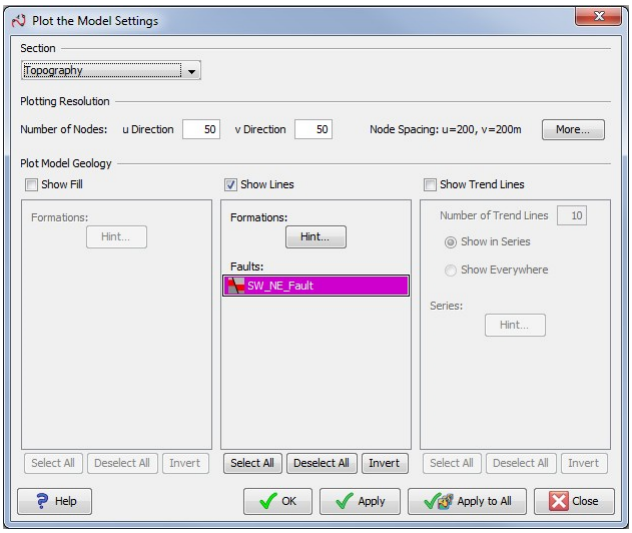
Select the **Topography** tab in the **2D Viewer**.

From the main menu choose, choose **Model > Plot the model settings** OR From the **Model** toolbar, choose **Plot the Model Settings** OR

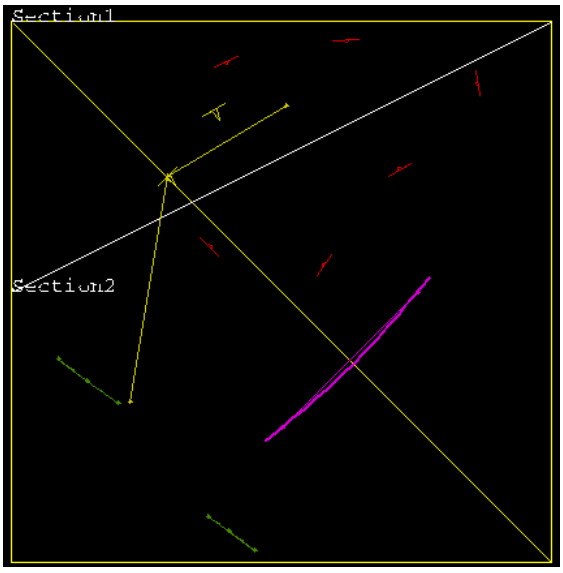
Press CTRL+D

Check **Show lines** and clear **Show fill**.

Choose **OK**.



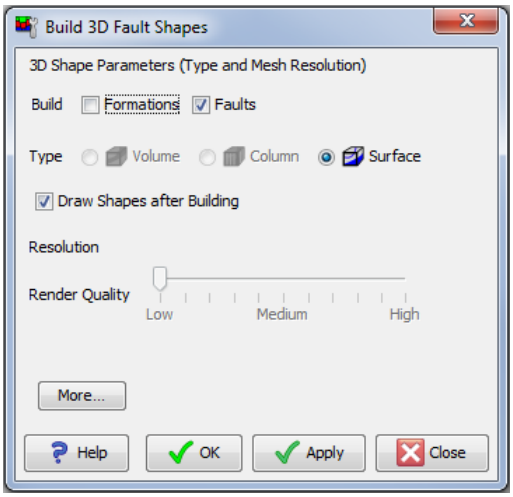
Our computed model is currently a model of the SW_NE_Fault **only**, so this plot of the current geology model on the topographic (map) surface shows only the trace of the fault (in magenta).

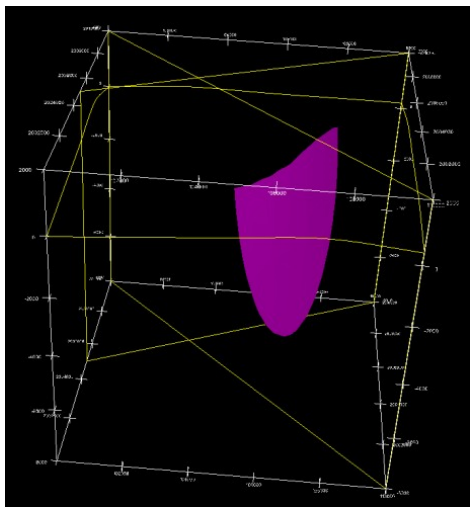


Note in the above image that **Section1** is oriented perpendicular to the fault. This will enable you to visualise the true dip of the fault in that section.

10 Plot the finite fault in the 3D viewer

Choose main menu **Model > Visualise 3D Formations and Faults** OR In the Model toolbar choose **Visualise 3D Formations and Faults** .





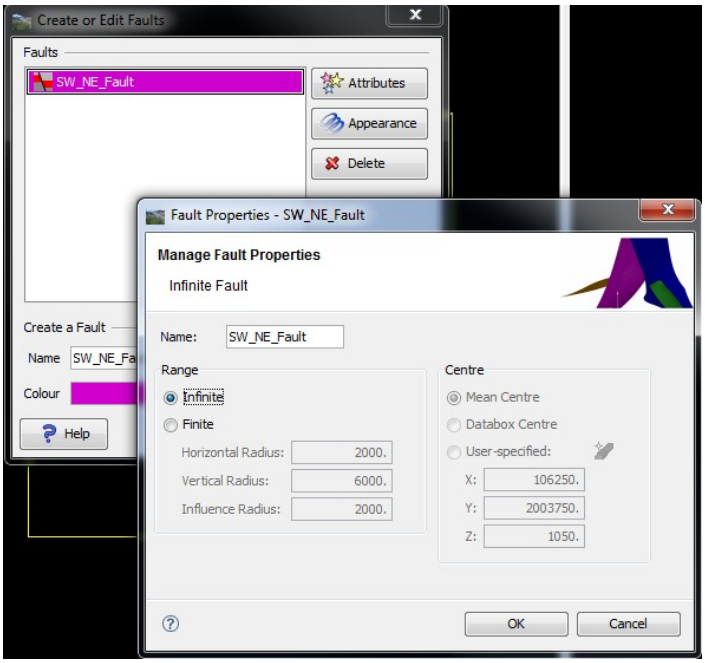
- Select Build **Faults** (only),
- Type: **Surface**
- Accept other defaults
- Choose **OK**.

After visualising the fault in 3D you decide to continue your interpretation with an infinite fault and re-set the parameters of the fault **SW_NE_Fault** to **infinite** fault.

11 Re-set the fault parameters to infinite

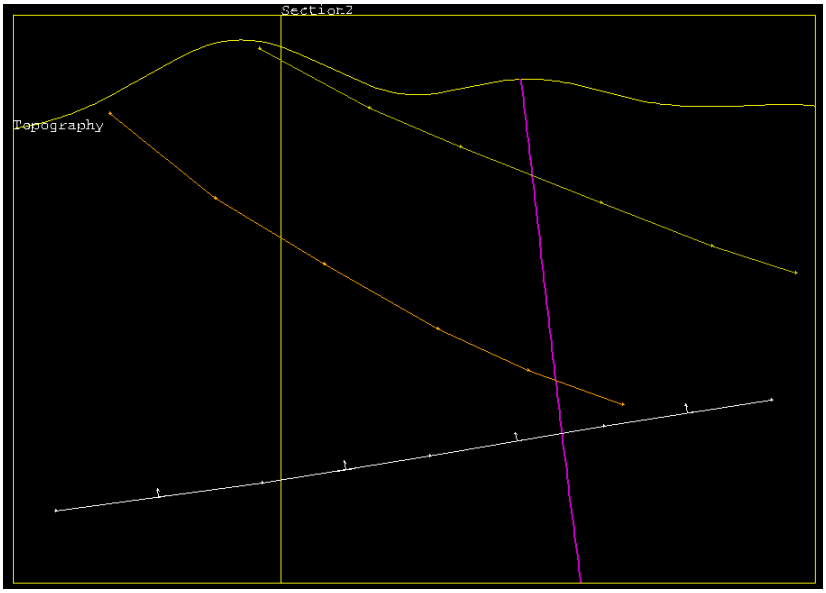
Choose main menu **Geology > Faults: Create or Edit**.
In the **Faults: Create or Edit window**, Select the **SW_NE_Fault**

And choose **Attributes** Attributes select **Infinite**. Select **OK**



12 Re-compute the Model and, plot the model, with lines, in Section1

Use instructions from the previous steps to re-compute the model (fault-only) and plot the infinite fault in **Section1**.



In Section1, GeoModeller plots the fault with a dip of 80° towards the south-east, consistent with your field-measured strike and dip data.

13 Save your project.

A4 Stage 3—Revising the geology interpretation

Parent topic: **Tutorial A4—Geology with a fault**

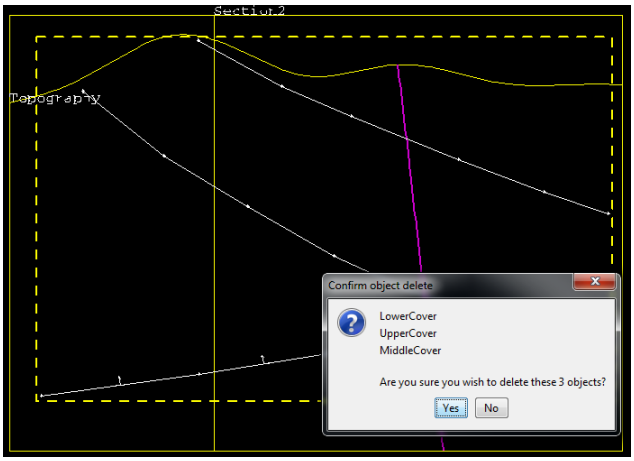
The presence of a fault in **Section1** requires us to reconsider our geological interpretation. In particular, there is the issue of defining the traces of the formation boundaries on approach to, and beyond, this oblique-slip fault (displacement is implicitly defined, rather than defining the offset everywhere on the fault).

One of your co-workers has already worked on this for you. The new interpreted traces of the geology contacts as they interact with the fault are represented in polygons in *MapInfo* GIS format. We will now import the interpretation into GeoModeller. To do this, we use the MapInfo interchange format (**`.mif/.mid`**).

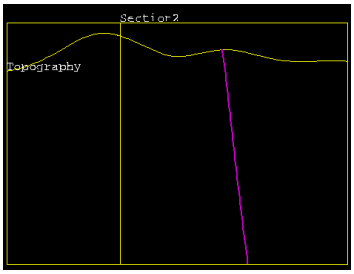
A4 Stage 3—Steps

1 Recall that the existing geology data in **Section1** is an **interpretation**. Further, that earlier interpretation did not take the fault into account. We need to replace the earlier work with revised data that does allow for the fault. We will first remove the geology data (contact points) that we previously imported into **Section1** in Tutorial A2.

- From the **2D Viewer** toolbar choose **Delete Objects** .
- In **Section1** in the **2D Viewer** drag a rectangle to include the three sets of geological data. GeoModeller displays a dashed outline around the selected objects.
- Confirm that you want to delete the selected geology data objects. Choose **Yes**. (You are not deleting the formations themselves.)



- **Alternative method:** Select **Section1** in the **2D Viewer**. From the **2D Viewer** shortcut menu, choose **Data > Delete > Geology Data**. Choose **Yes** to confirm the operation.



Exit from **Delete** mode.

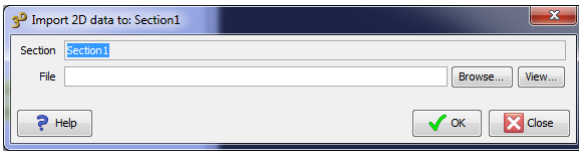
From the **2D Viewer** toolbar choose **Select** OR Press S.

2 Import new geology data into Section1 from a .mif file as follows:

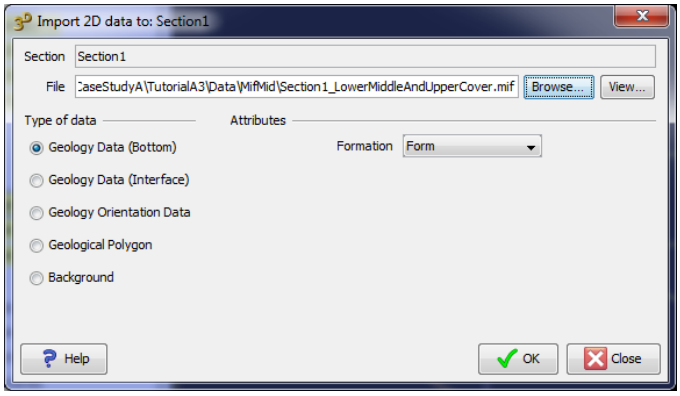
- Name of the file: **`TutorialA\TutorialA4\Data\MifMid\Section1_LowerMiddleAndUpperCover.mif`**
- **Type of data:** Geology data
- **Formation:** Form

In the **2D Viewer** select **Section1**.

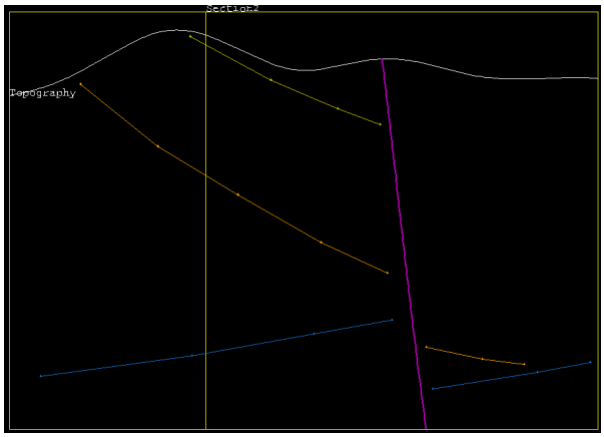
From the main menu choose **Import > 2D Geology to Section > Contacts (MIF,CSV)**



Choose **Browse** and open the specified MapInfo MIF/MID file.
Choose **OK**.



Specify the parameters Geology data (**Bottom**), and Formation (**Form**) and choose **OK**.



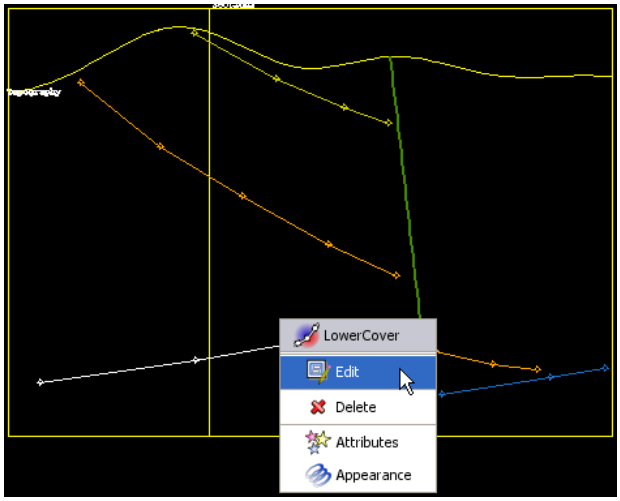
Examine **Section1** (above). Note that to the right-side (south-east) of the oblique-slip fault there are some interpreted geology data points for the bottom of LowerCover, and the bottom of MiddleCover, but no data for the bottom of UpperCover formation. Later we use the model to postulate the likely geometry for the UpperCover, south-east of the fault.

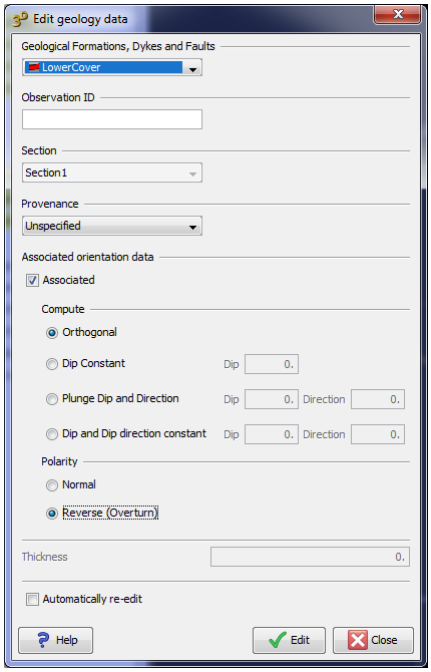
3 Recall the rule we noted earlier regarding 3D model computation: Before we can compute the model of a series, there must be at least 1 geology data (contact) point for each formation in the series and 1 geology orientation data point for the series (within the modelled zone).

We have met this condition for the IntrusiveSeries and UpperSeries, but not for the LowerSeries. The LowerSeries consists of a single geology unit (the LowerCover formation). There are some geology data (contact) points in **Section1** for LowerCover, but there are no **orientation data** for LowerCover formation.

In order to be able to model the LowerSeries, we must add **orientation data** for the LowerCover formation. One way to do this is to 'associate' geology orientation data with one of the two sets of LowerCover geology contact data that were imported to **Section1**.

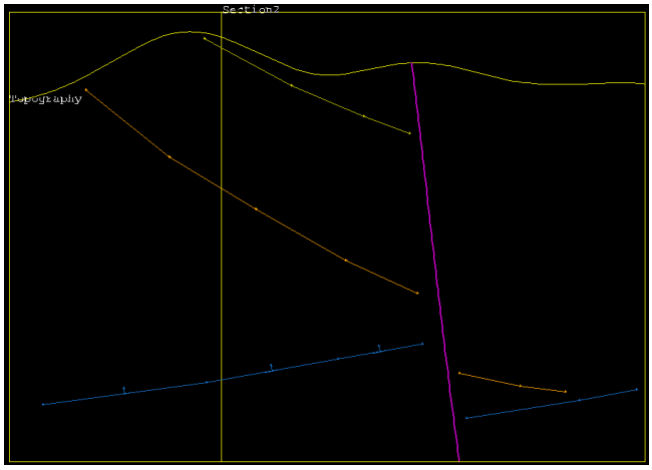
Using the **Select** tool **roll the mouse** over one of the points in the geological data that belongs to LowerCover (blue) north-west of the fault (left-side of section1). The data object becomes 'selected'when the data group is white. From the shortcut menu at this point, choose **Edit**. GeoModeller displays the **Edit geology data** dialog box.





- Check **Associated**.
- Select **Orthogonal** from the **Compute** options.
- Select **Normal** from the **Polarity** options.
- Choose **Edit** and then **Close**.

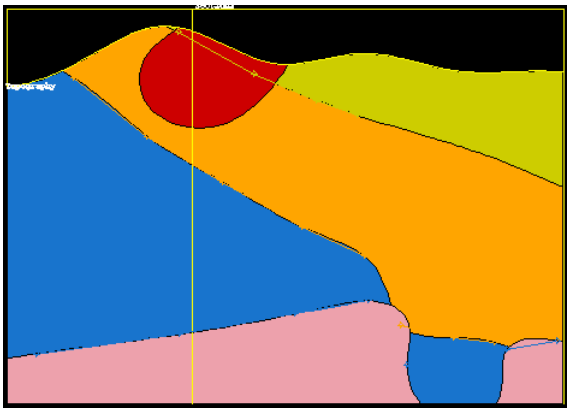
GeoModeller displays the new 'associated' orthogonal orientation data using dip symbols. Their azimuth is aligned to the strike of **Section1**, and the dip of each one is determined from the two geology data points either side.



4 Before considering data for the other side of the fault (SE), look at what our new interpretation yields **without** modelling the fault. Compute the 3D model with all components except the fault. Use the following parameters

- Clear **Faults only**.
- **Series to Interpolate:** Select All
- **Faults to Interpolate:** Deselect All
- **Sections to Take into Account:** Select All

5 Plot the model geology as filled polygons in **Section1**.



6 Save your project.

A4 Stage 3—Discussion

The result shows that the GeoModeller took into account the new geology data (and 'associated' orientation data). The model of the basal contacts of the LowerCover and the MiddleCover are forced to twist to honour the new observations. (The basal contact of the UpperCover is only slightly affected since there are no structural data providing constraints to the right of the normal fault position.)

It is now time to take the fault into account, and incorporate its effect in our model. Before recomputing the model, we need to learn about linking faults and series.

A4 Stage 4—Setting the links between faults and geology series

Parent topic: Tutorial A4—Geology with a fault

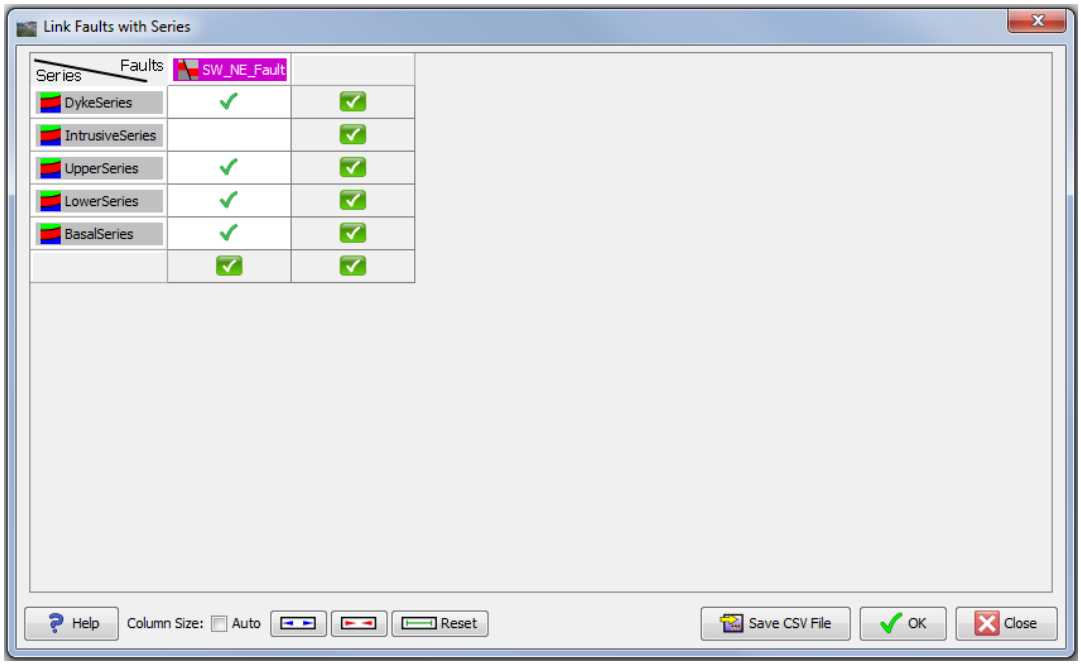
When we define links between faults and series, we are stating which fault interacts with which series of geology formations. In our project area, the oblique-slip fault displaces the Basement, Dyke and two 'Cover' series, but does not affect the Granite.

A4 Stage 4—Steps

1 Link faults with geology series as follows:

Series	SW_NE_Fault
DykeSeries	X
IntrusiveSeries	
UpperSeries	X
LowerSeries	X
BasalSeries	X

From the main menu choose **Geology > Link Faults with Series**. Click the table cells to check or clear a link.

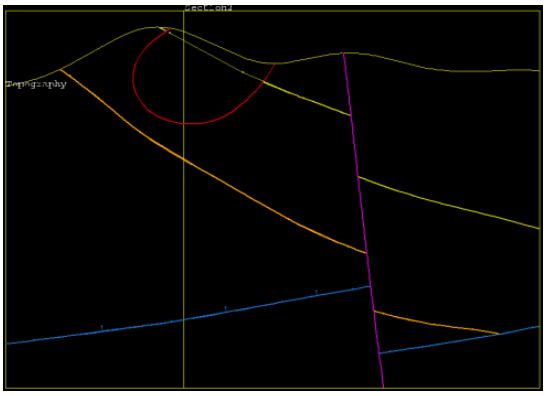


Choose **OK**.

2 Compute the model, taking all data in account.

- Clear **Faults only**.
- **Series to Interpolate:** Select All
- **Faults to interpolate:** Select All (Note: ensure the fault is selected)
- **Sections to take into account:** Select All

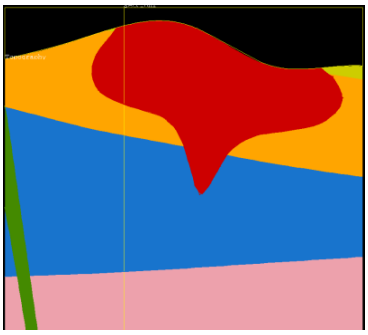
3 Plot the model using lines in Section1 and review the modelled geology contacts.



Recall that there were no data to the right of the fault for the MiddleCover-UpperCover contact. The model has proposed a geometry for this interface which is based on the other available data for the UpperSeries; in other words, the model has been used to predict the amount of throw for the fault on this section.

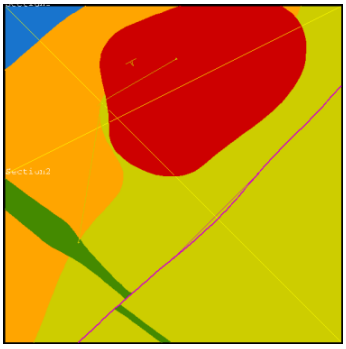
If you want, experiment by adding new geology data ('contact' points) which modify the position of the interface.

4 Plot the model as filled polygons ('solid' geology) on **Section2**.



As we would expect, the fault does not have any influence on this part of the model. The presentation of the 3D model in **Section2** is the same as at the beginning of this tutorial.

5 Plot the model as both lines (to plot the fault) and solid geology on the **Topography** (map) section. In the **Plot the model settings** dialog check both **Show fill** and **Show lines**. This is the geology map of your project area.



The geology map is similar to the one at the beginning of the tutorial, accept for the presence of the fault, visible by its trace.

6 Save your project.

Tutorial A5—Incorporating drillhole data

Parent topic: Tutorial A (A First Geology Modelling Experience)

This tutorial will show you how to use GeoModeller to incorporate drillhole data into your 3D model.

It also explores problems of inconsistency between sections (interpreted previously) and drillhole data (added later) - and how to revise your interpretive geological work to resolve and therefore improve your model.

Using GeoModeller, you will learn how to:

- Manage drillhole data
- Use drillhole data where partial intersection of a geology formation provides incomplete, but useful information
- Revise your (earlier) interpretation to make it coherent with new data added to the project

The starting point for this tutorial is the completed Tutorial A4.
In this tutorial:

A5 Stage 1—The project

Parent topic: Tutorial A5—Incorporating drillhole data

The start point of this tutorial is the completed work from Tutorial A4-Geology with a fault

A5 Stage 1—Steps

1 Open your completed project from Tutorial A4 or the solution provided:

`TutorialA\TutorialA4\A4Completed_Project\A4Completed_Project.xml`

2 Save the project with a new name in the folder you are using for your tutorial data.

Note that a completed version of this tutorial is available in:
`TutorialA\TutorialA5\A5Completed_Project\A5Completed_Project.xml`

Do not overwrite it.

A5 Stage 2—Import Drillhole data

Parent topic: Tutorial A5—Incorporating drillhole data

A5 Stage 2—Steps

1 Erase the model data from all 2D sections.

Select each **Section** in turn.
Model > Erase All Model Geology OR,
Short cut (right-click in the background of the 2D window) **Erase All Model Geology** (Repeat for each 2D section.)

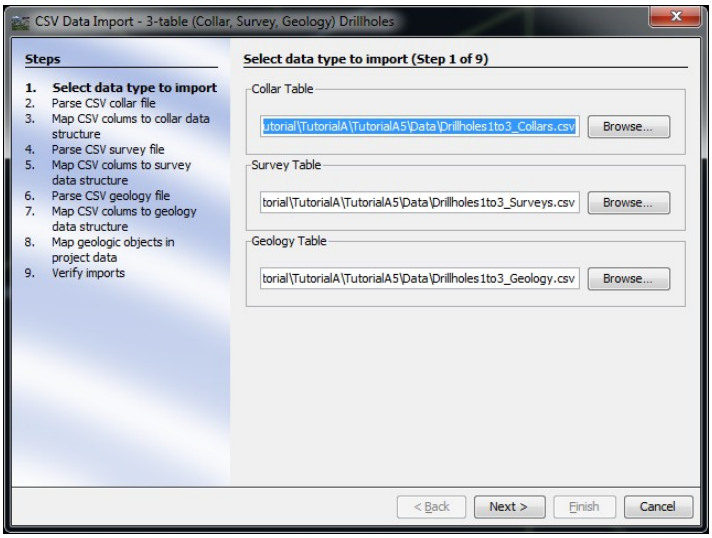
2 Import drillholes

From the main menu choose **Import > Drillhole > 3 Files (Collars, Surveys, Geology)** or alternatively,

Explore > Drillholes > (short cut /right-click) **Import > 3 Files (Collars, Surveys, Geology)**

In the **CSV Data Import** dialog box:

- **Browse** for and open the Collars table, the Survey table and the Geology table. Use the following files:
  - `TutorialA\TutorialA5\Data\Drillholes1to3_Collars.csv`
  - `TutorialA\TutorialA5\Data\Drillholes1to3_Surveys.csv`
  - `TutorialA\TutorialA5\Data\Drillholess1to3_Geology.csv`



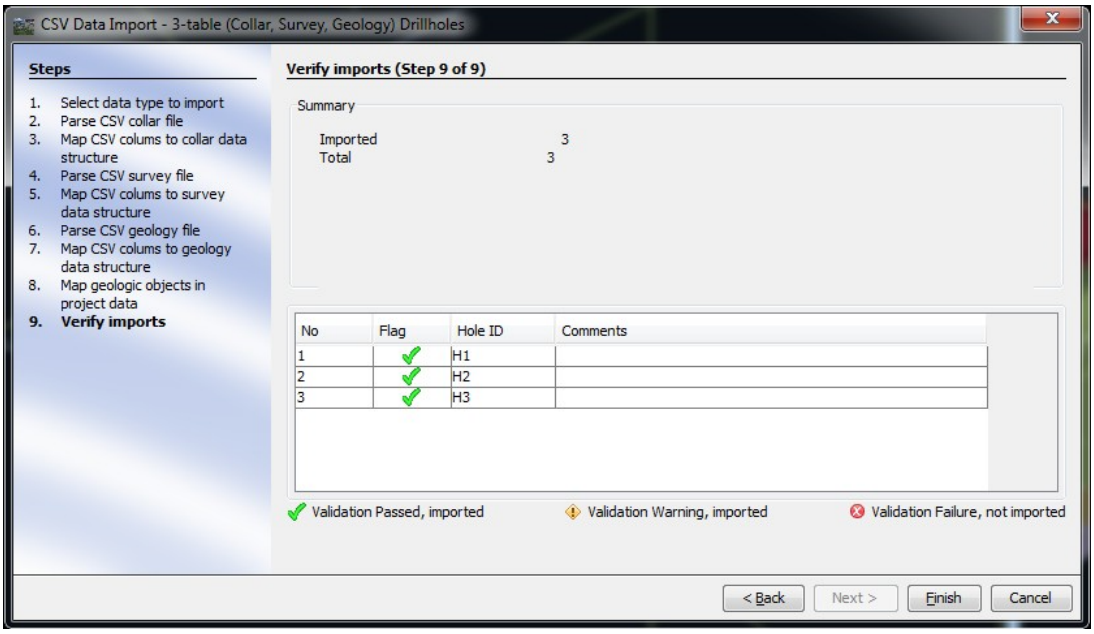
- Choose **Next** to move through the steps of the **CSV Data Import** dialog box.

In Step 2 of 9. Select Data start at row **2**, and tick **[']** Single quote for Text Qualifiers. In all remaining 7 steps, no changes are required. Just proceed with **Next.**

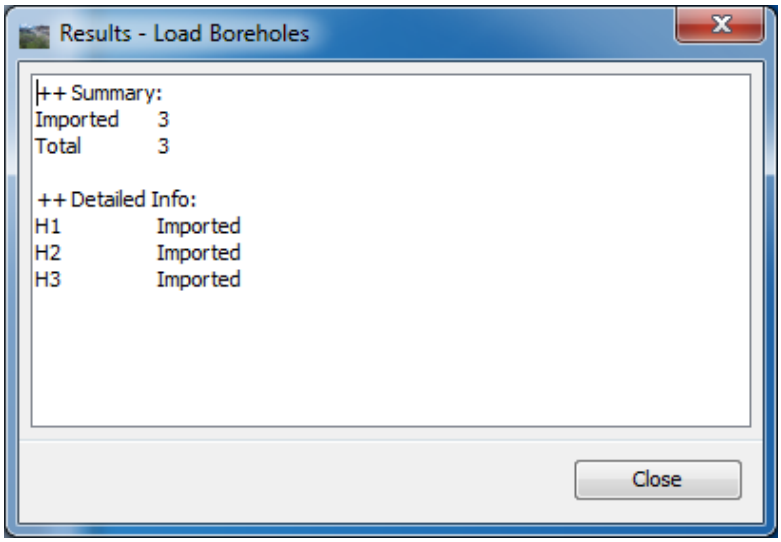
By default, GeoModeller expects the dip values for drillhole surveys to be positive downwards (i.e. a dip of 90 is a vertical, downwards drillhole). If (in your own data bases) drillhole-surveys use the opposite convention, you can check **Invert Dip** (treats negative dip as down) to import those data correctly.

- Choose **Finish** at Step 9 to complete the import and dismiss the message box reporting the successful import of the three drillholes.

This report is designed to help you progress through problem-solving issues in the logging data file. It is useful when dozens of drillholes are being imported at one time.



Close the results page



GeoModeller displays the drillholes in the **3D Viewer.**

View > 3D Viewer > Show Drillholes and choose Select All.

You may need to increase the **Radius** (e.g. 10m or more) to see the drillholes clearly in the 3D Viewer

You will not see the drillholes in the **2D Viewers** until you project them onto one or more sections.

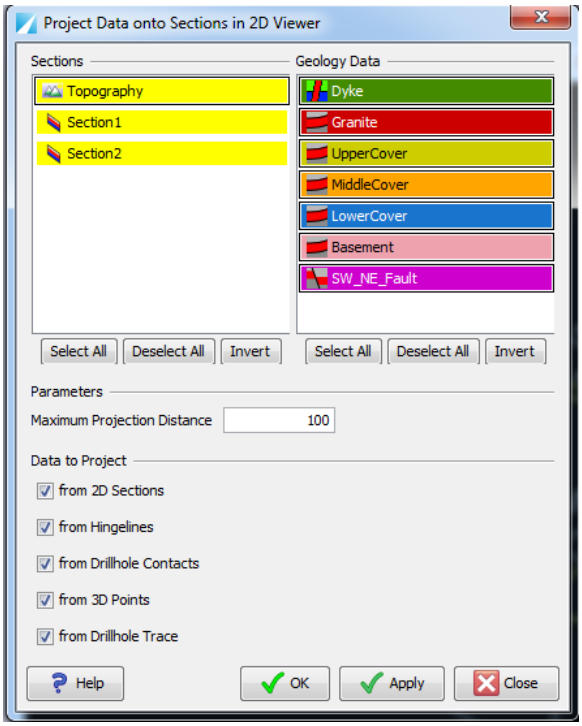
3 Project & locate new drillhole H1 on the Topography Section (plan view)

Select the **Topography** tab in the **2D Viewer**.

From the main menu choose **Model > Project Data onto Sections in 2D Viewer** OR

From the **Model** toolbar choose **Project Data onto Sections in 2D Viewer** OR Press CTRL+I

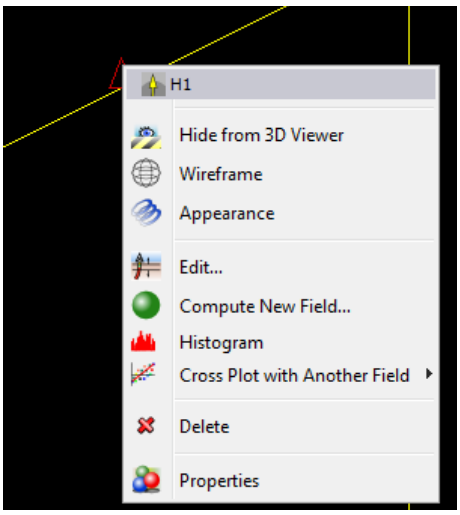
Enter **300m** as the **Maximum distance of projection**, and check **from Drillhole Trace**. Clear all the other checkboxes.



GeoModeller will project traces for the portion of all drillholes which lie up to 10 metres below the **Topography** section. Choose **OK**.

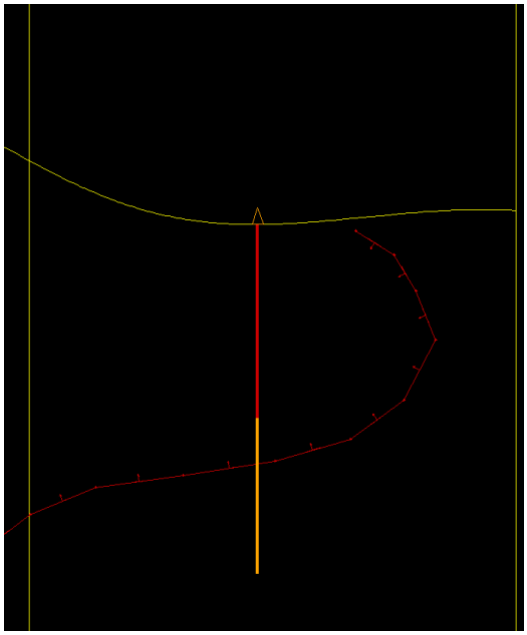
GeoModeller displays the drillhole collar location as a triangle, using the colour of the first geology interval in the drillhole.

Note the position of drillhole **H1** in the NE of the area. It is on, or very close to the trace of **Section2**. You can check this by first zooming, and then measuring with the tape measure tool on the 2D toolbar. (Also, check the identity of the drillhole using the Select tool, from the 2D toolbar - right-click to reveal properties.)



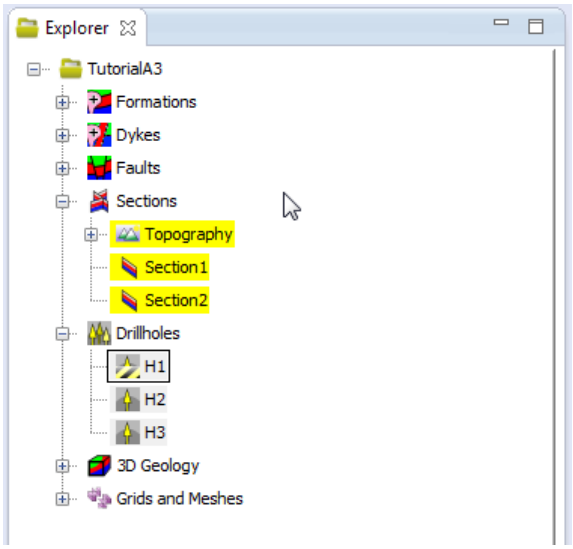
4 Now project drillhole **H1** onto **Section2**, again using **Maximum distance of projection** of **10m** (having discovered it is very close to this section).

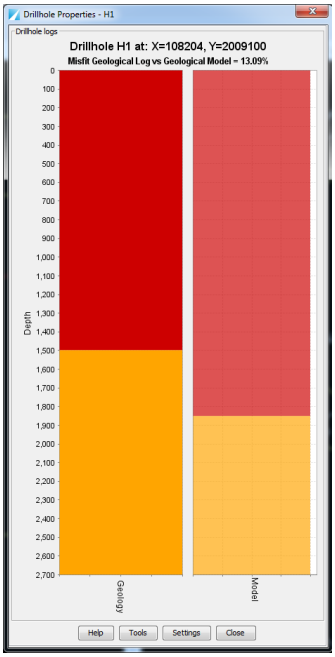
Check **from Drillhole Trace**.
Clear all the other checkboxes.



5 Also use **Explorer** to *show the drillhole **H1** log* compared with the current model (remembering we have not included drillholes in the compute yet!).

Explore > expand **Drillholes > H1 >** (Double-click)





- **Drillhole H1** (left-side plot) shows a contact for the 'bottom' of **Granite** which is shallower than the current model (right-side plot). We assume the drillhole data are more accurate than the Section 2 interpretation.

  By two visual checks (Steps 4 & 5 above), we anticipate an inconsistency may occur between the drillhole data in **H1**, and the current model. However, first we must re-compute the model including the drillholes.

A5 Stage 3—Re-compute including the drillholes & modify Granite contact

Parent topic: Tutorial A5—Incorporating drillhole data

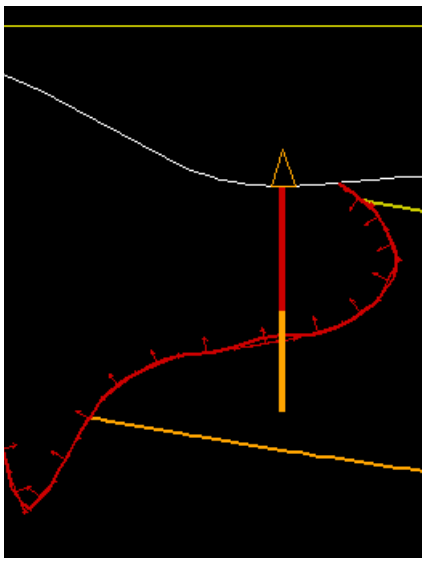
A5 Stage 3—Steps

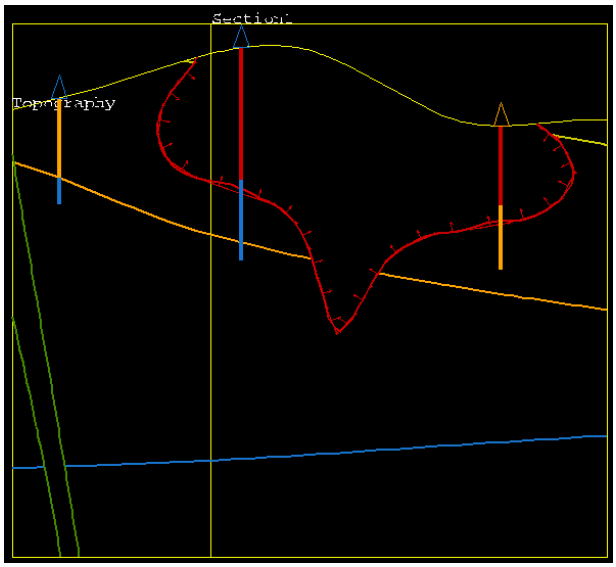
1 We now re-compute the model including all three drillholes

Compute the 3D model Selecting **all**: Series, Faults and Sections.

This time you will see **Drillholes to take into account** is offered too: **Select All**

2 Plot the model using **lines** on **Section2**.





Including the drillhole data in the model-compute, the inconsistencies still occur.

Therefore the interpreted shape of the **Granite** in **Section2** needs adjusting to fit with the observed data from drillholes, which has higher reliability.

3 Check you agree with these observations by utilising Pan & Zoom tools on 2D sections:

Movement	Operation
Zoom (make diagram larger or smaller)	Roll the mouse wheel back and forth to **zoom in** and **zoom out**.
Pan (move diagram)	From the **2D Viewer** toolbar choose **Pan** and drag the display to the place you require using the left mouse button.

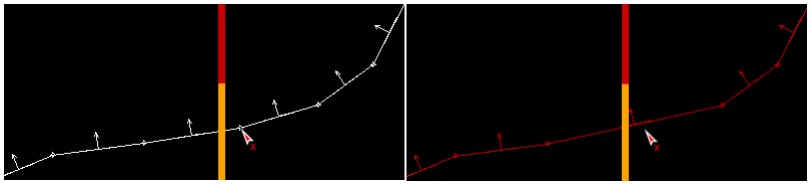
4 Save your project.

In the next step we describe methods for **moving and deleting points graphically** - on **Section2** - and thus fixing the bottom of **Granite inconsistency** compared with the **drillhole H1** data.

5 Deleting data points

In GeoModeller we recommend that you should not use **interpreted** data points that are close to **observed** data. In this case, we have an observed geology contact in the drillhole, so we want to delete the nearby **interpreted** point in **Section2**.

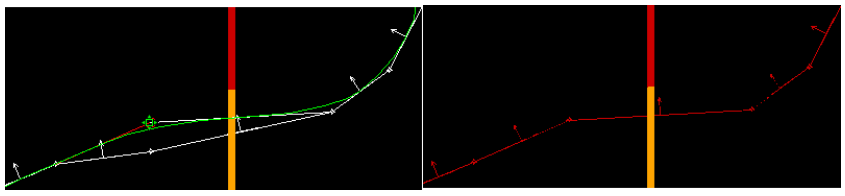
- Zoom into the area of interest. We want to delete the interpreted Granite contact point just to the right of the drillhole.
- To delete a point graphically (using the mouse), we need to change the mouse function to the 'delete points' mode.
  From the **2D Viewer** toolbar choose **Delete Points** .
- Select the **Granite** contact point—roll the mouse over to select (data turns white).
- Click left to delete this point.



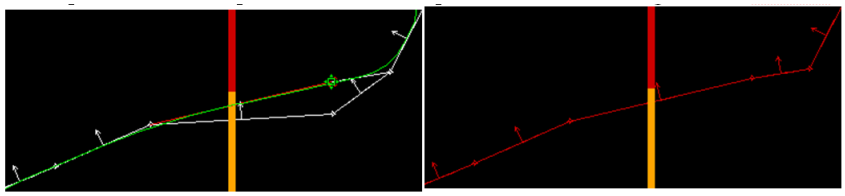
6 Moving data points

Now we want to **move** two or three of the (nearby) interpreted geology contacts, such that the interpreted **Granite** contact (in **Section2**) is better aligned with the drillhole **H1** observation. Using the instructions below, move two or three points to shallower locations. Recall that we don't want to place any interpreted points too close to the actual observed data in the drillhole.

- From the **2D Viewer** toolbar choose **Move points**
- **Select** the Granite contact points–mouse-roll over to **select** (data turns white). In turn, move the geology contact points just to the left & right of the drillhole.
- Click left, and 'drag' a point to the left of the drillhole upwards, so that the **interpreted** contact point will be in better agreement with the **observed** contact in the drillhole **H1**.



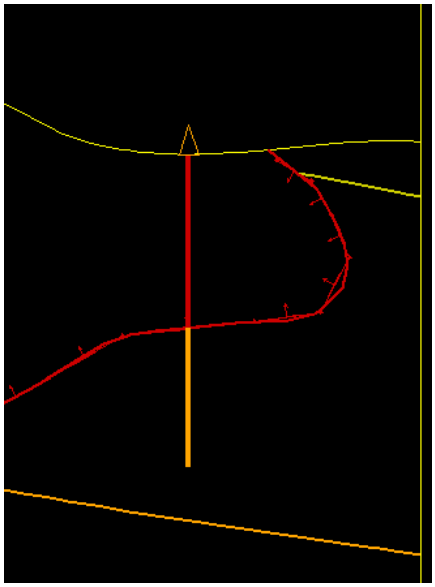
- Repeat the above steps to move a second point - the one to the right of the drillhole.



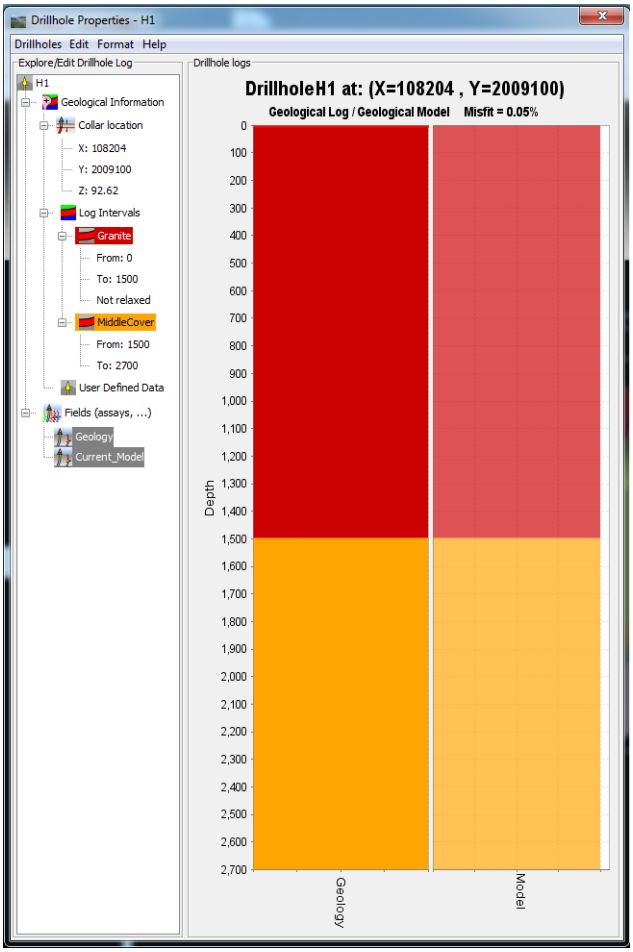
- To exit from the Delete points mouse-mode, choose **Select** from the **2D Viewer** toolbar.

7 Save your project

8 **Check** the impact of your modifications to **Granite:**
Recompute the 3D model and plot it with lines in **Section2**.



9 Check the comparison of drillhole **H1** with the geology model, by right-clicking on the well of interest and choosing **Edit...**



Better! Your interpretation of the **Granite** contact in **Section2** now honours the drillhole data (H1 observations) – and the model is now revised.

10 **Save** your project.

A5 Stage 4—Re-compute using drillholes & modify the MiddleCover contact

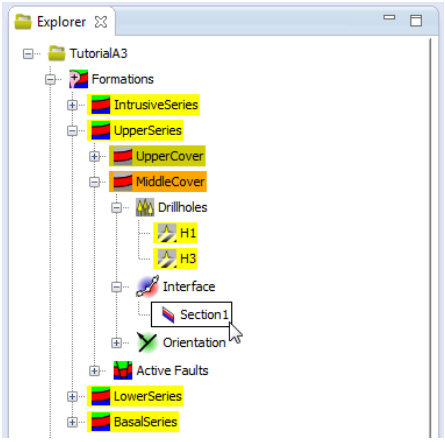
Parent topic: Tutorial A5—Incorporating drillhole data

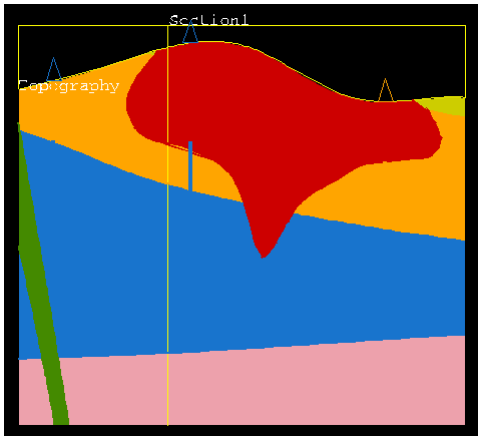
There is still an inconsistency between the current model and drillhole **H2**. The MiddleCover (yellow) unit should be absent in **H2**. One possible interpretation for this scenario is that the basal MiddleCover contact is shallower (than currently modelled), and becomes consumed by the **Granite** intrusion near the **H2** trace, coming from the west. Again, we assume the drillhole data are reliable.

A5 Stage 4—Steps

1 **Explorer** tree reminds us that data for MiddleCover exist only on **Section1** and in **drilllholes H1 & H3**.

We therefore suspect a need to edit the interpretive data on **Section1** and/or add more data around the area of drillhole **H2** (which lies very close to **Section2**.)

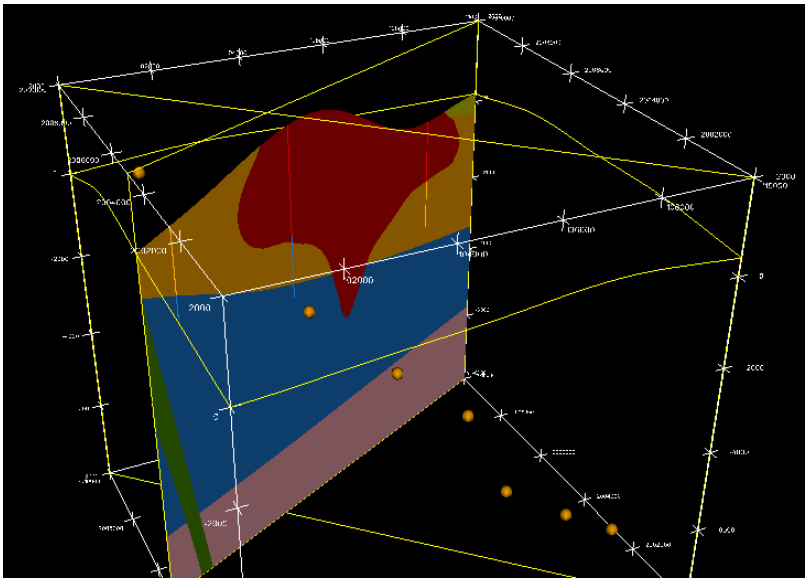




2 Another way to view the geology contacts, and trouble-shoot "why is the model wrong?" is to view the geology contact data and drillholes at the same time, in 3D.

From the main menu: **View > 3D Viewer > Show Interface Data**. Select the geology data to display (MiddleCover), then **OK**.

Similarly: **View > 3D Viewer > Show Drillholes**. Set radius as exaggerated ~150m.

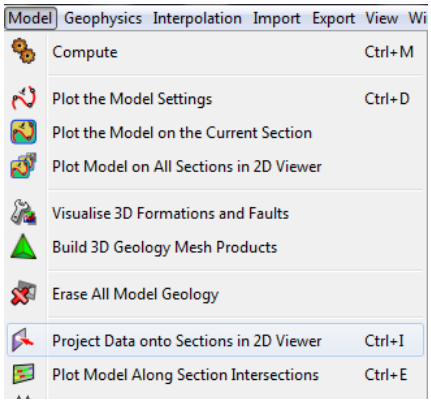


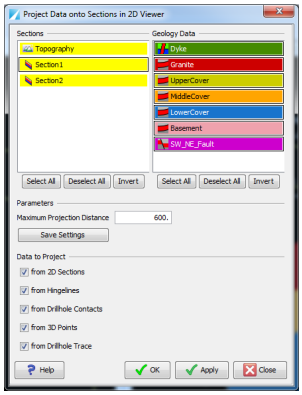
Clearly, the orange contact points (on **Section1**) are too deep. We will now edit them on **Section1**.

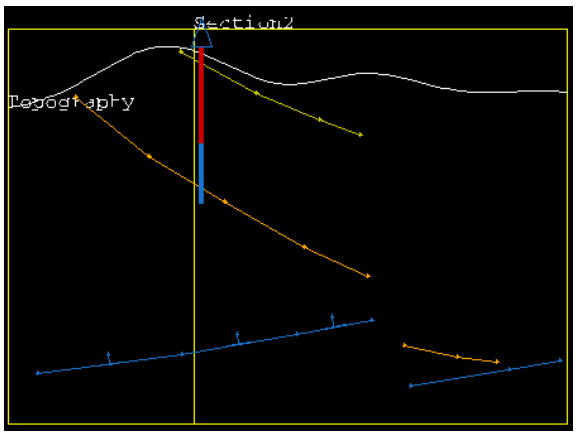
3 Revise **MiddleCover** data in **Section1**

In the **Topography** Section, we used the tape measure tool from the 2D toolbar, and measured the location of **H2** from the **Section1** trace. It is located nearly 600 m to the north- east. As a rough guide we decide to project the Drillhole **H2** trace onto **Section1**.

Model > Project Data onto Sections in 2D Viewer

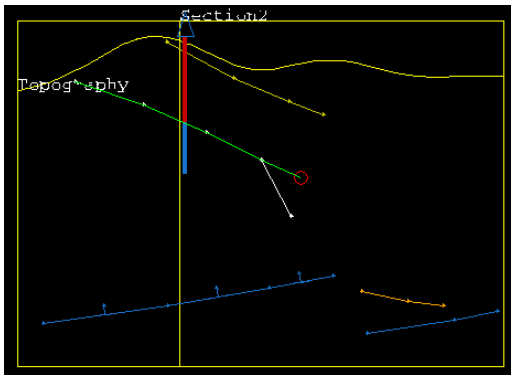






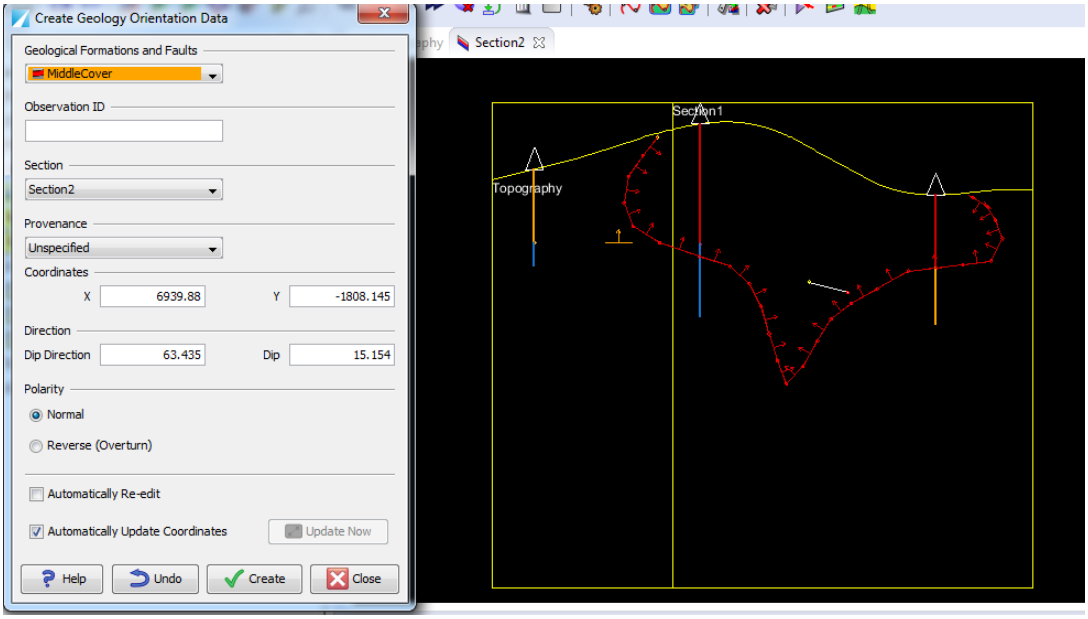
4 Using the steps to move data points (described above), we shifted the four deepest points for **MiddleCover**, up to shallower depths, closer to the bottom of **Granite** in the **H2** projection.

- From the **2D Viewer** toolbar choose **Move points**  .
- **Select** the MiddleCover contact points- Click left, and 'drag' each point upwards, so they will be in better agreement with the **projected** contact in the drillhole **H2**. (Take care not to drag any shallow points across the location of the fault zone, not shown.)



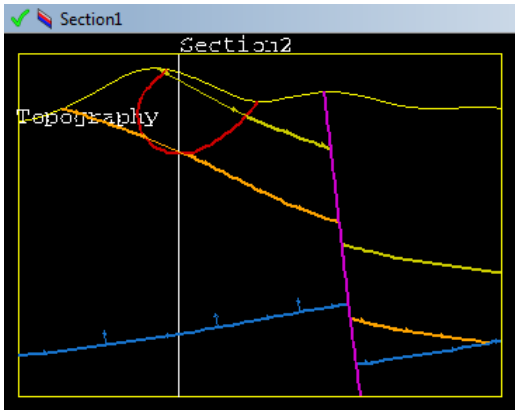
5 Additionally, in **Section2** (orthogonal to **Section1**), we need to guide the basal MiddleCover contact correctly through this section, where our interpretation is based on 3 drillholes. We suggest two pieces of orientation data, as shown below.

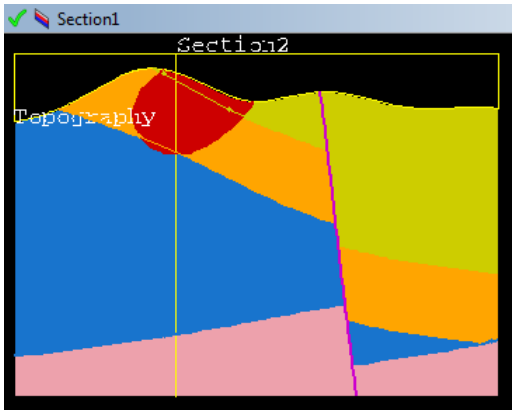
- Using the **Create (lines)** tool from the 2D toolbar, **make two points** between the 1st and 2nd drillholes from the left-side (H3 & H2). [Clicking left, and then right.]
- Then, select **Create Geology Orientation data** (OR Press CTRL+R).
- **Accept** the suggested dip & dip direction data, providing it suggests a shallow dip in the plane of the section, with upward facing.
- **Create**. Repeat for the next pair of points. Noting that the points can be quite far apart. **Create, Close**



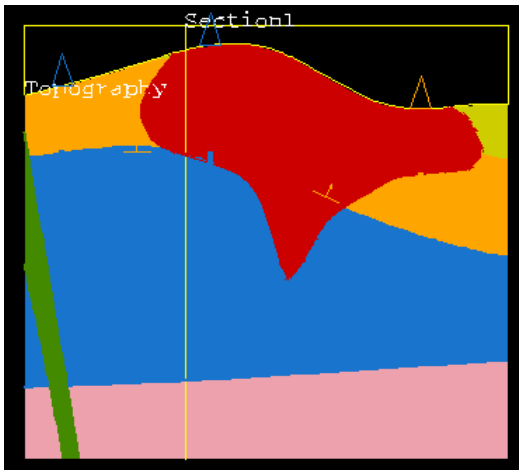
6 **Check** the impact of your modifications to **MiddleCover**:

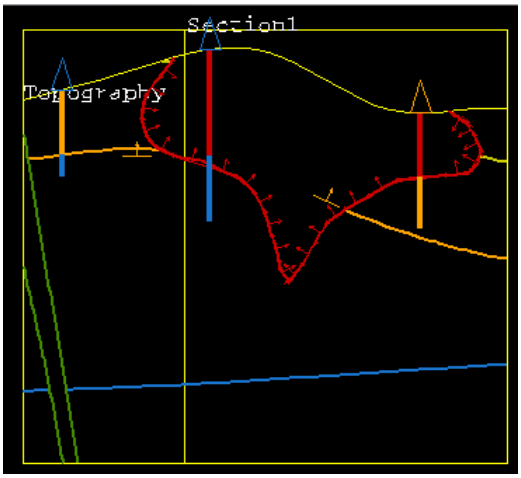
Recompute the 3D model and plot it with 'lines' and then 'fill' in **Section1**.



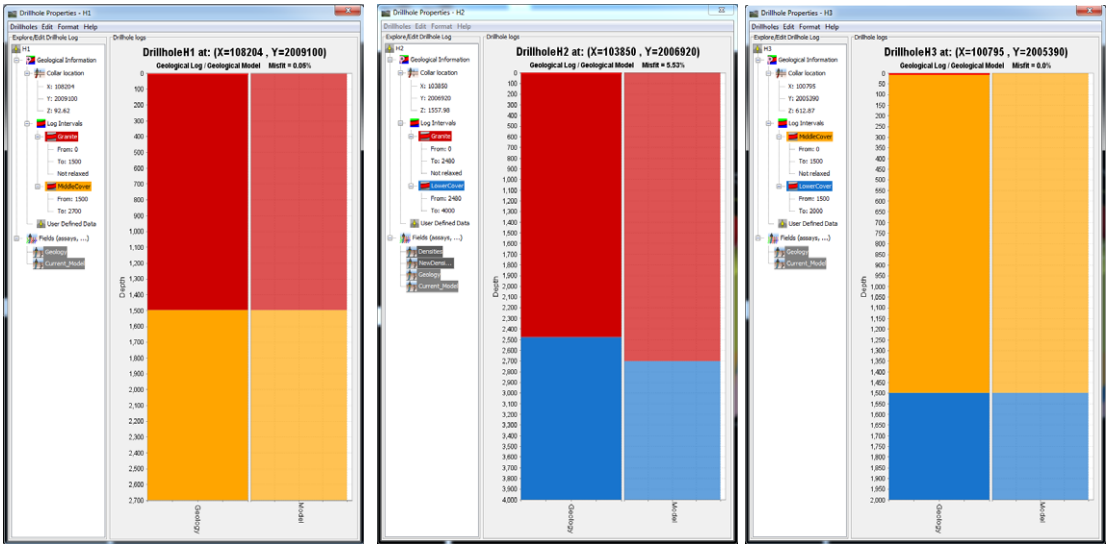


Also plot the model with 'lines' and then 'fill' in **Section2**.





7 Check the comparisons of drillholes **H1, H2 & H3** with the modelled-geology.



Better, in that the base of the **MiddleCover** is correctly modelled. However, the modelled **Granite** contact could still be improved in relation to drillhole evidence in **H2.**

8 **Save** your project.

A5 Stage 4—Discussion and further investigation of the 3D Viewer

- Is every part of the revised new model consistent with all of your data?
- What do you think of **Drillhole H1**?
- Model refinement is still required near the basal granite contact in **H2**?

These are all queries you should ask yourself when validating a model. Each will require checking, and may need adjustment using the methods we have given above.

Render the model in the **3D Viewer** again.

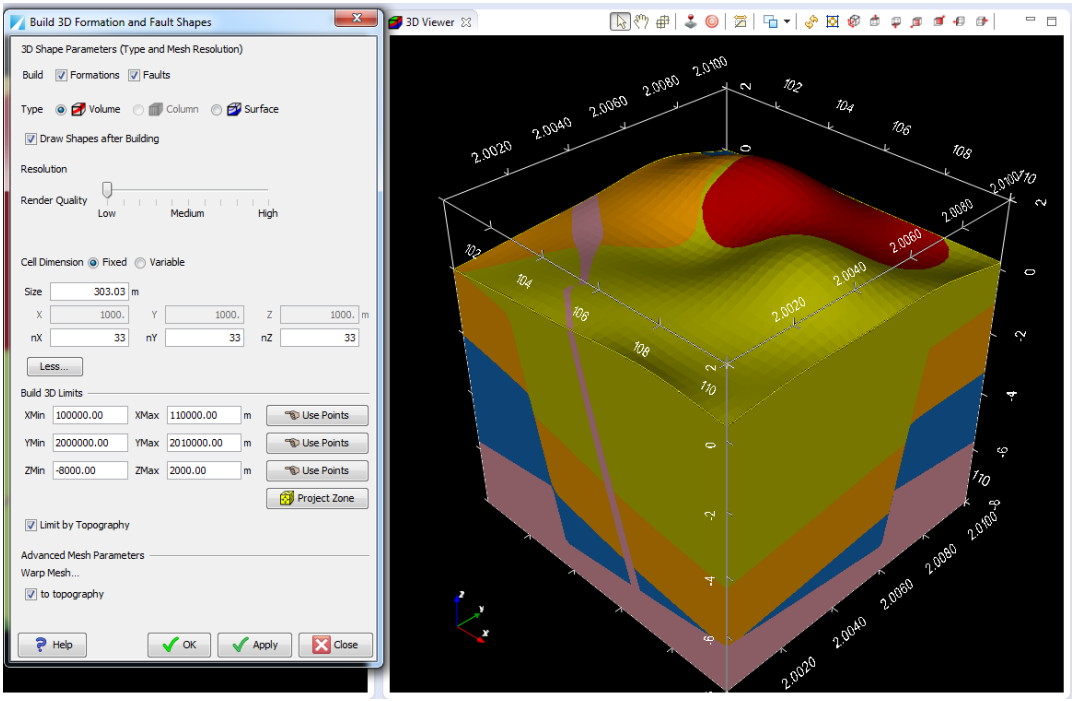
1 First you may need to **clear the 3D Viewer**.

View > 3D Viewer > Show interface data > Deselect All
View > 3D Viewer > Show Drillholes > Deselect All

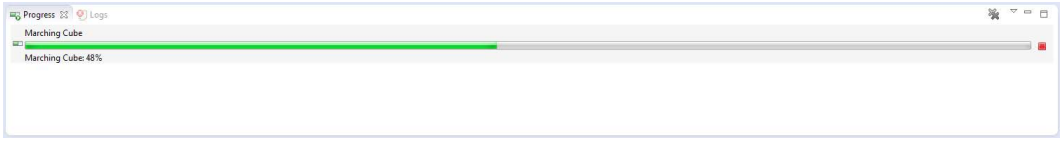
2 Choose **Model > Visualise 3D Formations and Faults**

This time, expand the "**More**" section and investigate options for plotting at higher resolution.

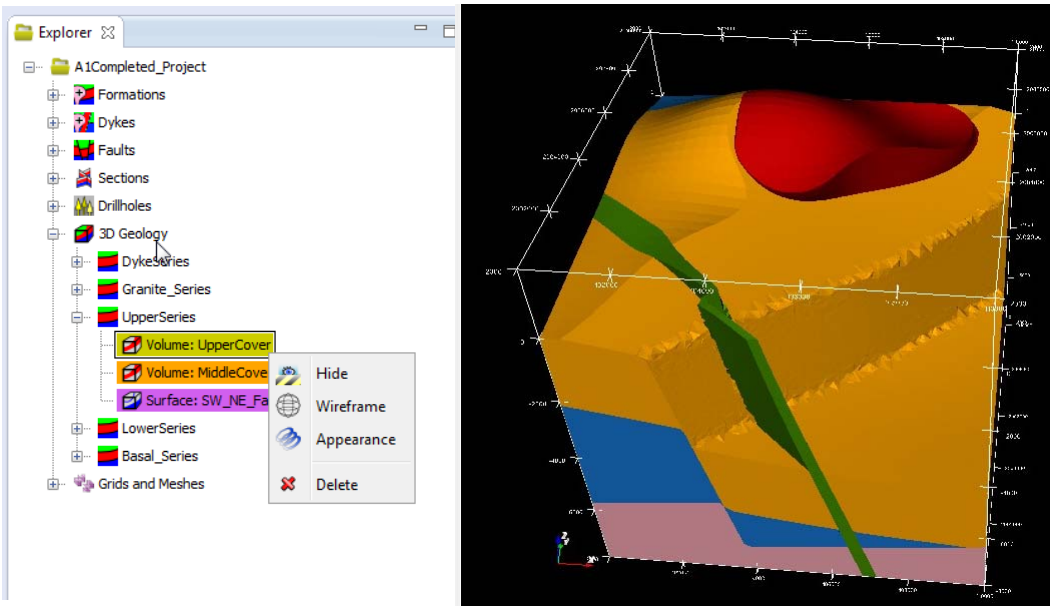
- Choose Fixed Cell: **300 m**
- Build: **Formations & Faults**
- Type: **Volumes**



OK, Close. The model will take a long time to build (a couple of minutes.) **A progress bar** in the bottom of the GeoModeller work space indicates the time it will take. The operation can be stopped by clicking on the red square on the right-hand side of the progress bar (see below).



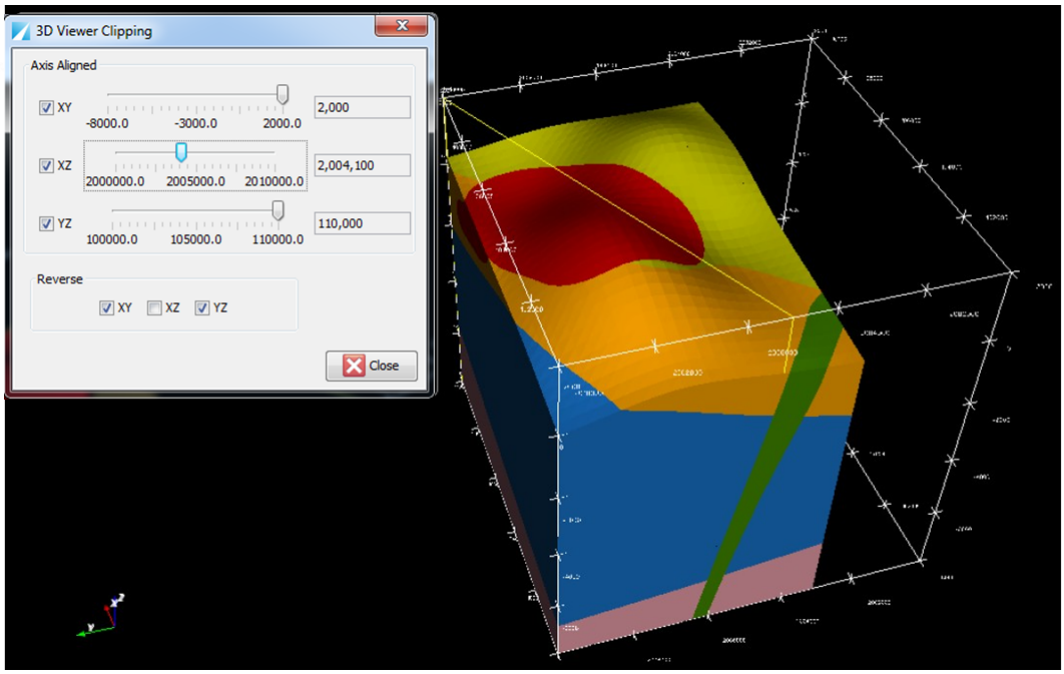
3 To better reveal your rendered 3D model, fully expand the **Explorer** tree in the area of the **+3D Geology** model and use the short-cut menu (right-click) to **Hide/ Show** each volume or surface, in turn.



4 Note the rendered 3D Model can also be clipped in viewing, in directions orthogonal to the principle axes:

Choose **Set Clipping Parameters** from the 3D toolbar 

Slide your choice of aligned axes to slice the model



Tutorial A6—Adding down-hole numerical data

Parent topic: Tutorial A (A First Geology Modelling Experience)

In this tutorial:

A6 Stage 1—The project

Parent topic: Tutorial A6—Adding down-hole numerical data

The start point of this tutorial is the completed work from Tutorial A5—Incorporating drillhole data

A6 Stage 1—Steps

1 **Open** your completed project from Tutorial A5 or the solution provided:

`TutorialA\TutorialA5\A5Completed_Project\A5Completed_Project.xml`

2 **Save** the project with a new name in the folder you are using for your tutorial data.

Note that a completed version of this tutorial is available in:

`TutorialA\TutorialA5\A5Completed_Project\A5Completed_Project.xml`
Do not overwrite it.

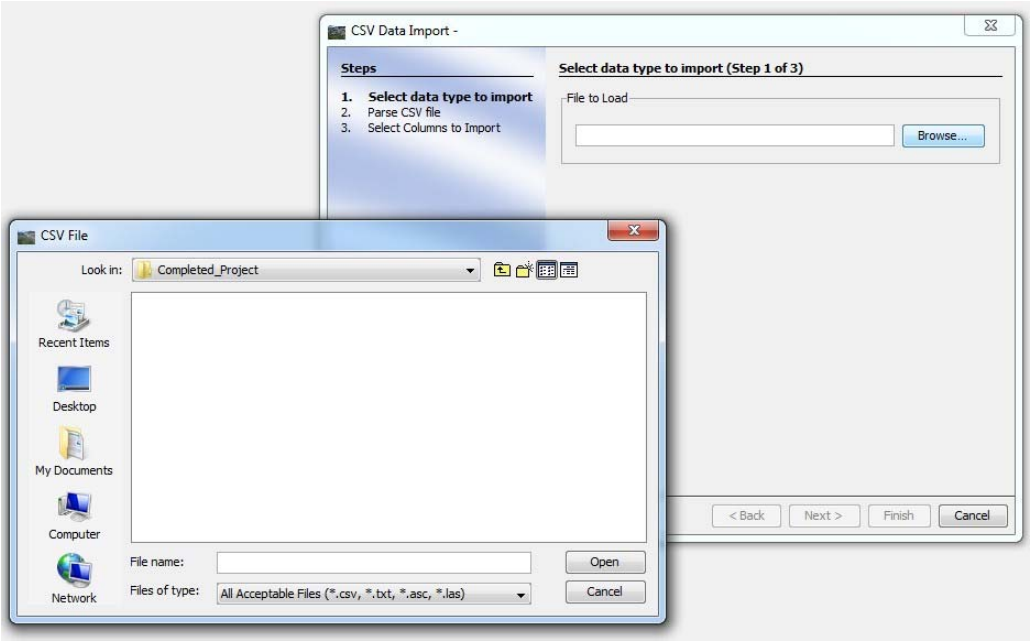
A6 Stage 2—Import down-hole density data for H2

Parent topic: Tutorial A6—Adding down-hole numerical data

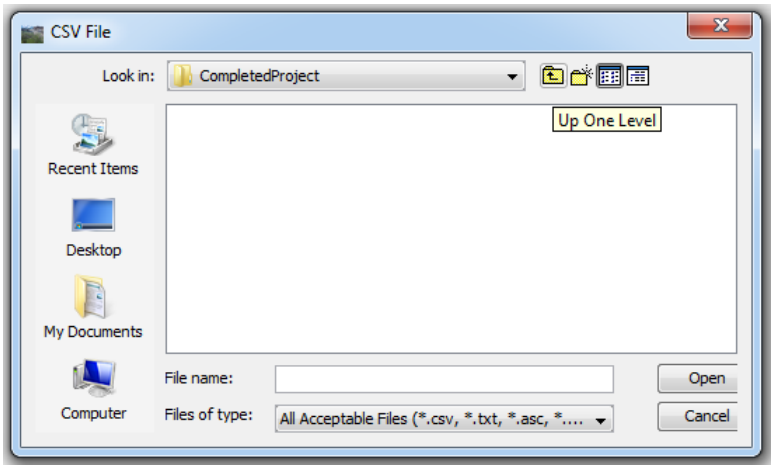
A6 Stage 2—Steps

1 From the main menu choose **Import > Drillhole > Numeric Data into Existing Drillholes**

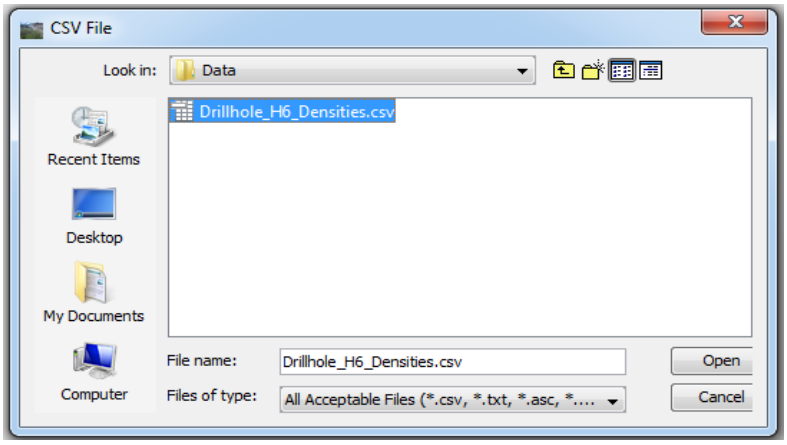
2 From CSV Data Import wizard, choose **Browse**



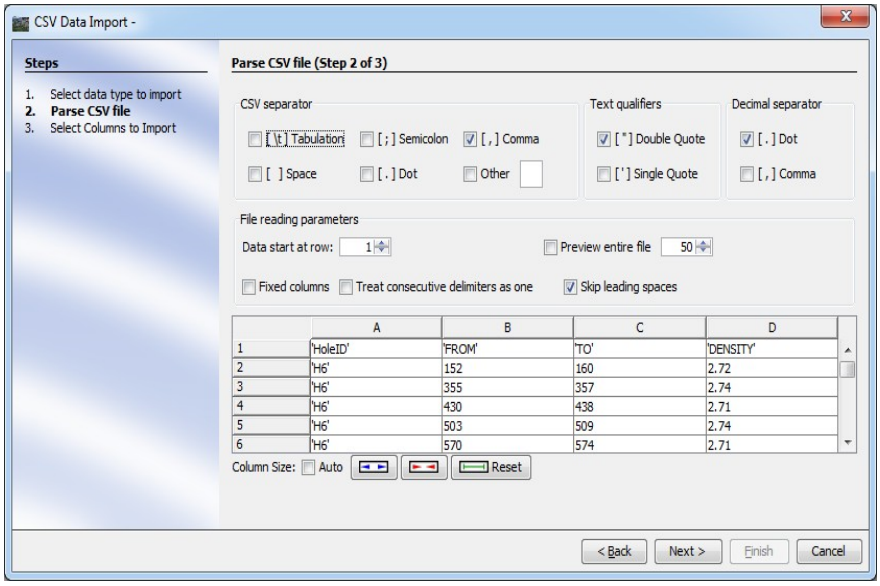
3 Use **Folder** Button to go **Up One Level**



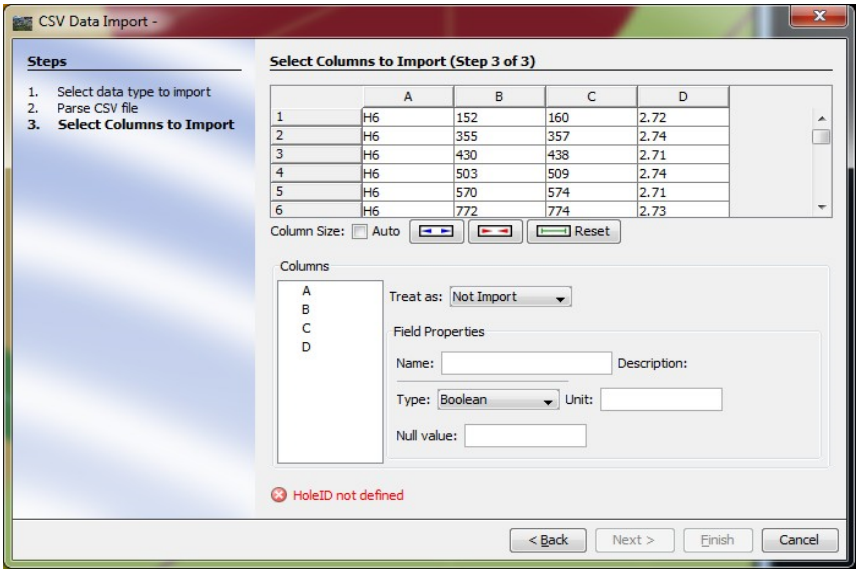
4 In the **Data Folder** (under Tutorial A6) find: **`Drillhole_H2_Densities.csv`** **> Open** and then **> Next**



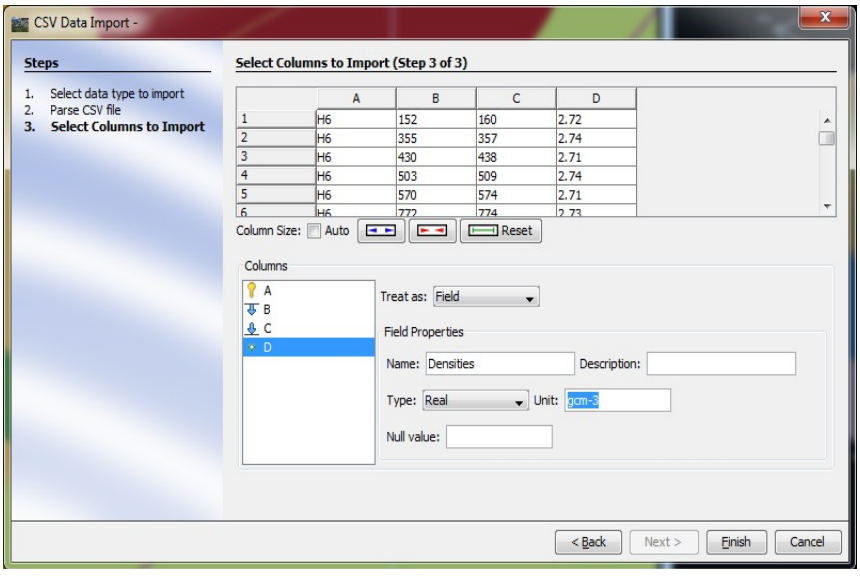
5 Next, parse the CVS file (Step 2 of 3): Two issues need resolving.
First, for the **Text Qualifier: tick ['] Single Quote**
Second, for the File reading parameters: change **Data start at row** to "2"
Then > **Next**



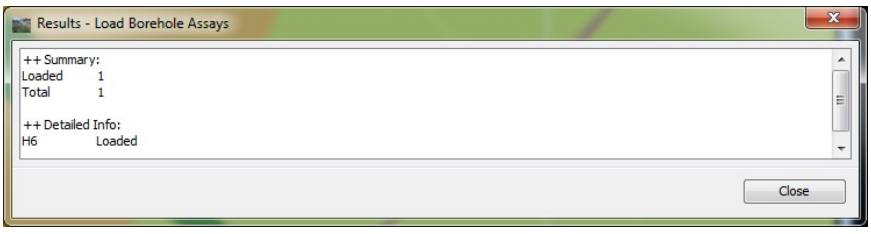
6 Next, Select columns to Import (Step 3 of 3): Select Columns in turn
First, **Column 'A'** treat as: **'Hole ID'**
Then, **Column 'B'** treat as: **'From'**
Then, **Column 'C'** treat as: **'To'**



7 For **Column 'D'** treat as: **'Field'**
Additionally, (just for column D"), you are advised to **add Field Properties** names:
For **'Name'** use **'Densities'**
For **'Unit'** use **'gcm-3'**
Then > **Finish**



8 Check the import Report,
Then, **Close**

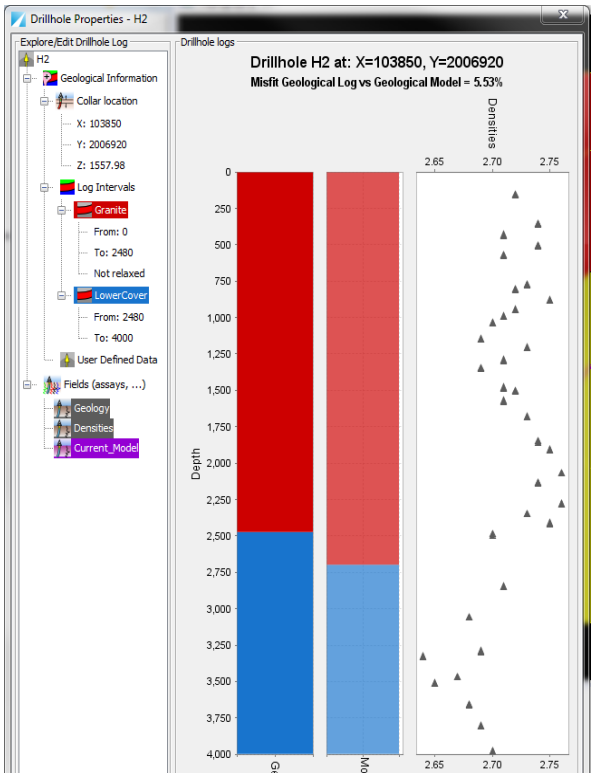


A6 Stage 3—Display down-hole density data for H2

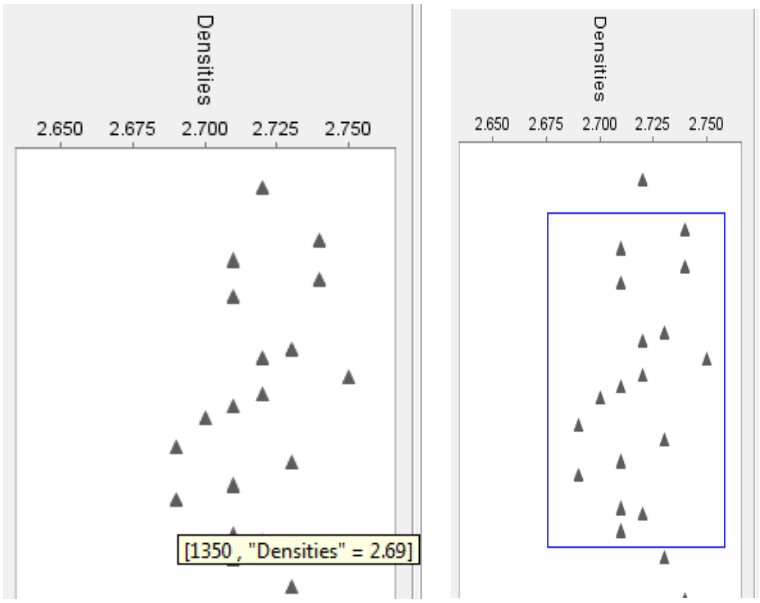
Parent topic: Tutorial A6—Adding down-hole numerical data

A6 Stage 3—Steps

1 To display your recently imported down-hole values,
Expand the Drillholes list in the **Explorer** Menu (left side).
The '+' will become a "-". Then, **Double-click** on **H2**



2 The display of the log is interactive,
Hover the cursor of the mouse on the **log points** to view depth & value **details** (Figure left). A **left mouse-drag** on the **log** will **zoom** the display (Figure right)



3 To re-set the zoomed view, Close the log, and re-open with a **Double-click** on **H2** (repeat Step1).

A6 Stage 4—Edit the density log & display the histogram for H2

Parent topic: Tutorial A6—Adding down-hole numerical data

A6 Stage 4—Steps

1 If you wish to **replace** or **Edit/Add** another density log, you need to:

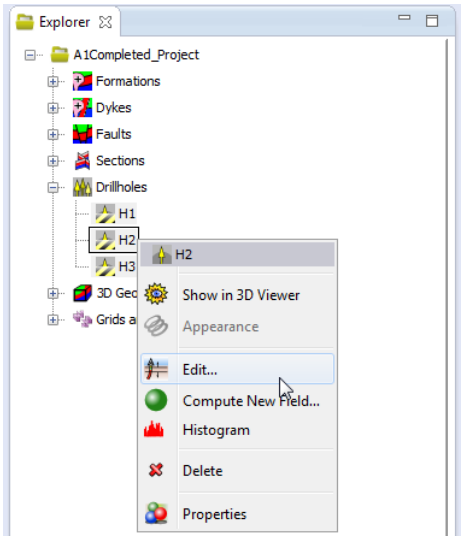
Firstly, **edit** the cvs file in the Data Folder
`TutorialA\TutorialA6\Data\Drillhole_H2_Densities.csv`

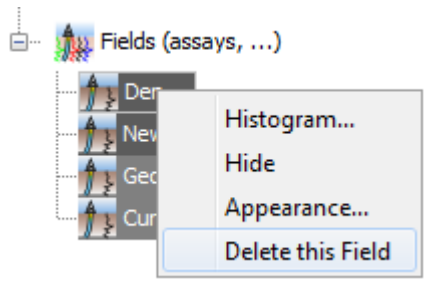
Then, **either re-import** the field, (Using A6 Stage 2—Import down-hole density data for H2 steps) assigning Column D with another name (eg., "**New Densities**")

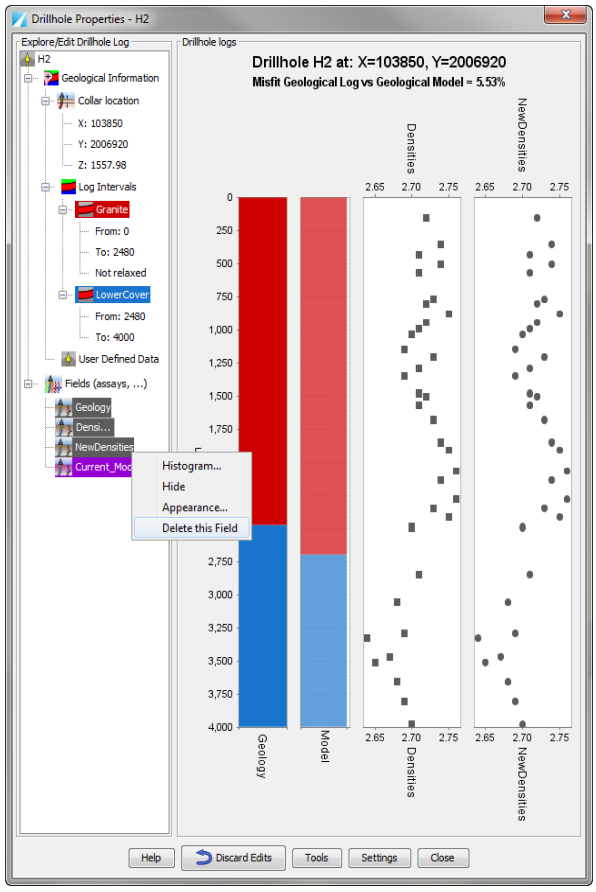
OR Delete the first-imported file (see below), and then simply re-import (Using the A6 - Stage 2 steps). **Note:** Multiple Fields can exist for a Drill hole.

2 If you wish to **delete a field** from the **H2** drillhole, you need to:

Expand the Drillholes list in the **Explorer** Menu (left side).
The '+' will become a "-". Then, **Right-click** on **H2** and > **Edit**



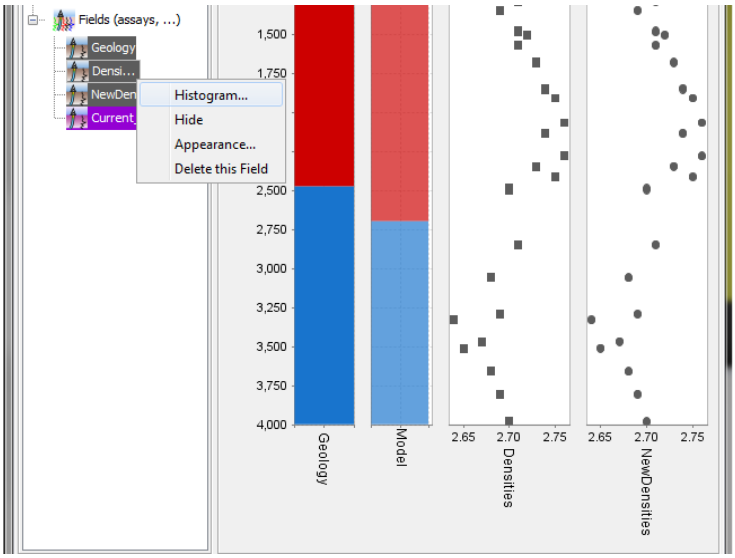


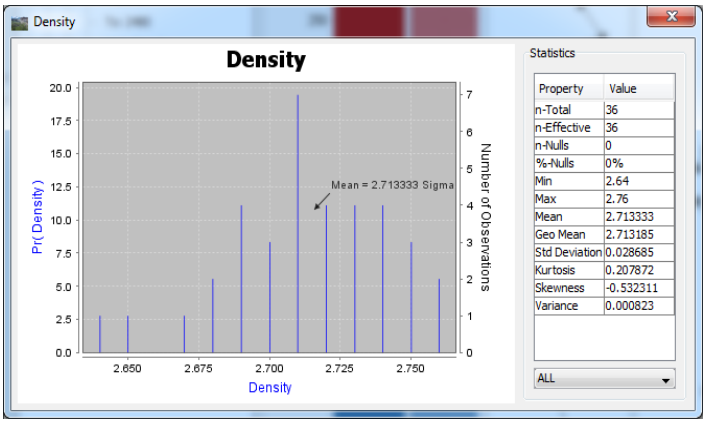


3 If you wish to **Display the histogram** of a density log, you need to:

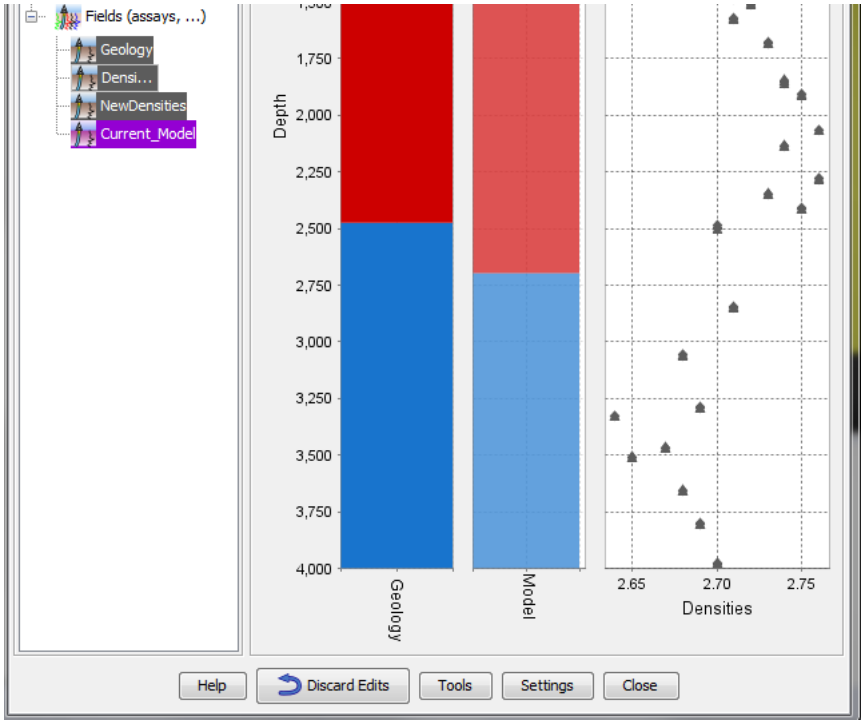
Expand the Drillholes list in the **Explorer** Menu (left side).
The '+' will become a "-". Then, **Right-click** on **H2** and **> Edit**

From the list of Fields (in gray), **Select** the field of choice, **Right-click > Histogram**





4 If you wish to **view one log at a time**, with a **graticule** display, Choose **Settings> Fields: Single View**



Congratulations!
You have completed Tutorial A