Working with truly 3-dimensional data types – 3D polylines and multipatches

Overview:

In this exercise, we will briefly introduce the way that ArcGIS can be used to visualise, query, and analyse truly 3-dimensional data. We will explore some multi-patch geological data for the city of Nottingham in the UK, and take a brief look at some of the ways in which 3-dimensional data can be processed. Note that this practical is intended only to provide a brief introduction to the visualisation and processing of 3-dimensional data in ArcGIS and is not a comprehensive tutorial on its functionality in this area.

Download the Data for the Exercise:

Go to the British Geological Survey's web site and download the 'Lithoframe250 Nottingham-Melton multipatch format' data here, after agreeing to the licence conditions: http://www.bgs.ac.uk/downloads/start.cfm?id=1855 . Lithoframes are British Geological Survey's 3-dimensional means of presenting geological data. For ESRI software, BGS generally use unclosed multipatch features. The above link contains a set of multi-patch data for geological formations underlying the Nottingham area of the UK, as well as Ordnance Survey data – a Digital Elevation Model and some raster backdrop imagery of the surface features. Unzip these data to a suitable folder location.

We have created two further map layers for use with this exercise:

- **Planned_bhole**: A 3D polyline, depicting the depth of a proposed borehole within the study area
- **Fencediag**: a 2D polyline, which we will use to generate a cross-sectional graph of the underlying geology later in this exercise.

Visualising Multipatch Data:

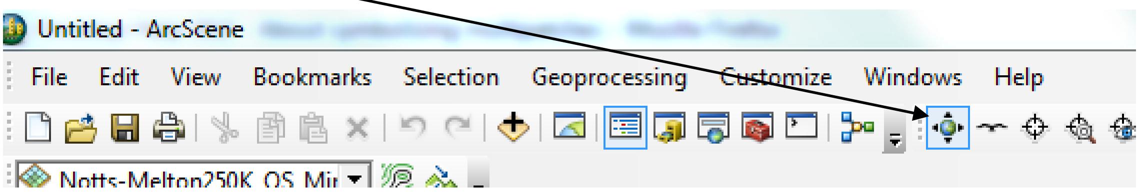
Let us begin by viewing these data within ArcMap: open up the 'Notts-Melton250k.lyr' file to display all of the data that you have just downloaded. The **Notts-Melton250k_OS_Miniscale.tf** layer provides a coarse spatial resolution raster tiff of the surface features in this study area, whilst the **Notts-Melton250k_OS_250k.tif** layer provides a 1:250,000 scale raster representation of surface features in this area. **OSDTM** is a digital elevation model for the study area. Begin by turning on and off the visibility of these three layers, to familiarise yourself with the study area. Load up the **fencediag** and **planned_bhole** layers too.

Next, so that we can explore the underlying geological map layers, right-click on each of these three layers in turn in the left-hand table of contents and select **remove**. If you right-click on any one of the geology layers that remain in the left-hand table of contents window and select *open attribute table*, you will see that each consists of a single feature and that its type is listed as *multipatch* in the second attribute field **shape** (other fields are simply feature unique ID numbers, Red-Green-Blue colour combinations for display, and the name of the strata to be displayed). If you right-click on **planned_bhole** in the left-hand table of contents and look at its table of attributes, under the *shape* field, you should see that it is listed as 'polyline ZM', meaning that the polyline has 'z' coordinates describing the height of vertices and is therefore 3-dimensional. Do the same for **fencediag** and you will see that in its table of attributes, the *shape* is listed as a regular *polyline*, without any mention of Z coordinates.

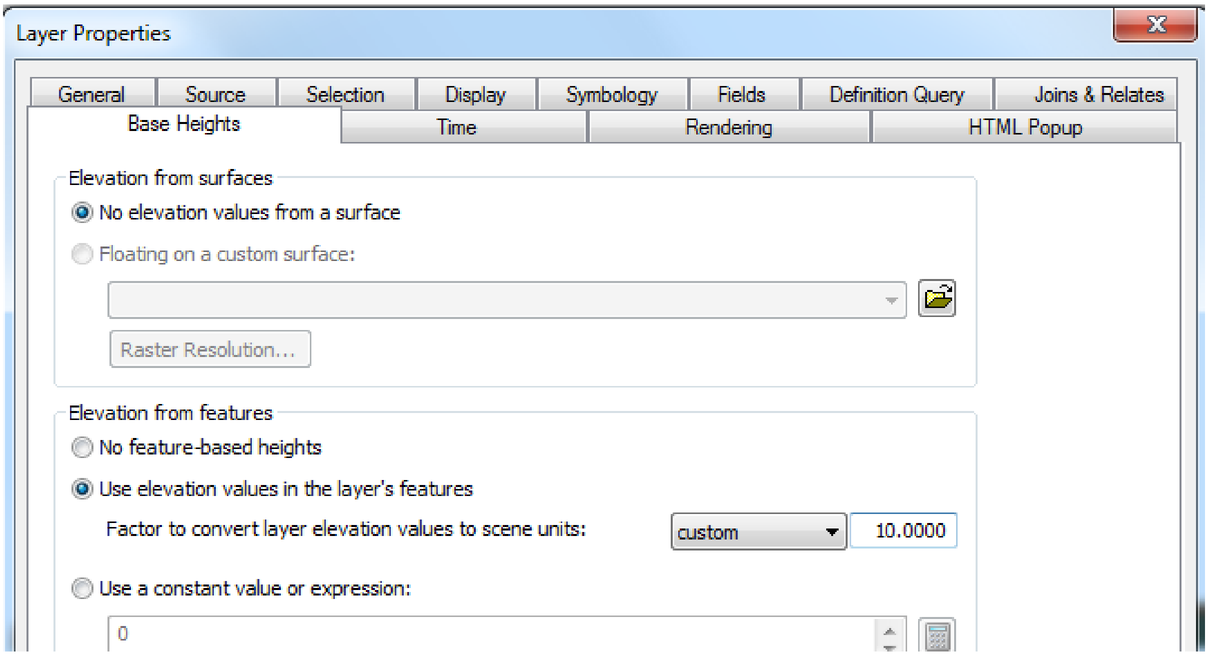
The difficulty in looking at these data in ArcMap is that whilst the 2-dimensional spatial extents of the various map layers are clear, their 3-dimensional spatial extents are not currently obvious.

To overcome this, now start up ArcScene and again open up the 'Notts-Melton250k.lyr' file to display all of the data that you have just downloaded. Load up the **fencediag** and **planned_bhole** layers too.

Recall that you can use these buttons to navigate around within ArcScene – you may find this button particularly useful:



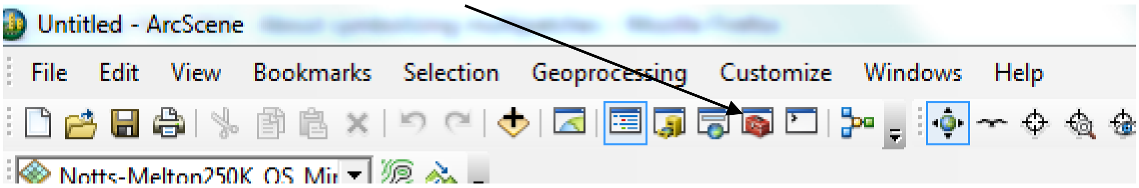
For each map layer, you may find it helpful to exaggerate the vertical differences between layers. To do this, click on the map-layer in the left-hand table of contents and then under *base heights,* set *factor to convert layer elevation values to scene units* to be 10.0 rather than 1.0. Repeat this for the other geological layers and it should be clearer how these various maps are orientated relative to one another:



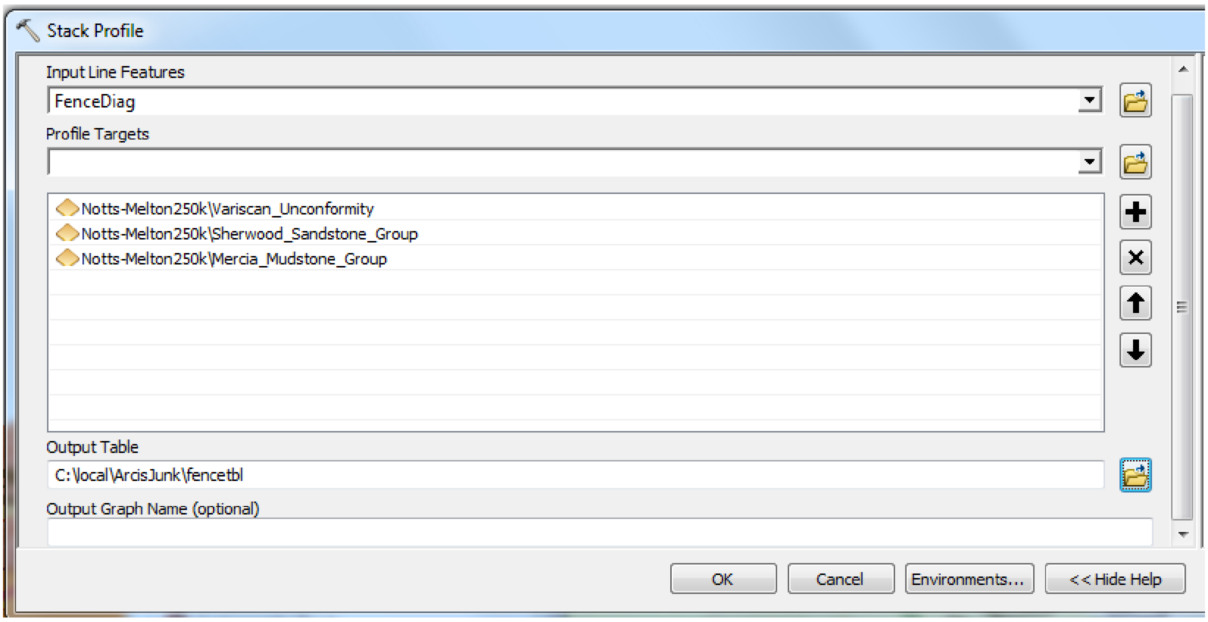
1. Question

Which layer is the deepest of the various geological layers? (For the answer, see the last page of this handout)

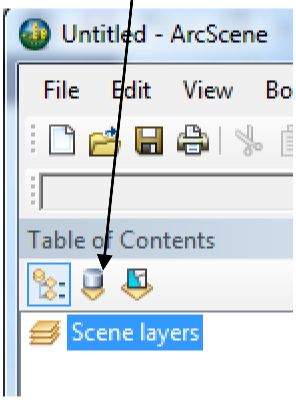
ArcGIS does not exactly support fence diagrams, but it is possible to produce graphs depicting feature depth. Here we will explore one means of doing this. Make sure that the ArcToolBox is visible by clicking on the relevant toolbar button:



Next, head for *3D Analyst tools*, then *functional surface*, and then *stack profile*. Choose **fencediag** as your input line features, then select the **variscan_unconformity, Sherwood_sandstone**, and **mercia_mudstone_group** layers as *profile targets*. Enter in an appropriate name for an *output table.*



ArcGIS will now generate a table with the locations and depths of these three strata along the length of the **fencediag** transect across our study area. To view this tabular output, you may need to click on the 'show by location' button:



Right-click on the table you have created and choose *open* to view the resultant file. The *First_dist* and *First_Z* fields contain the distances along the **fencediag** transect in metres. The *sec_dist* and

Sec_Z fields are essentially the same information, whilst *line_id* is the ID of the line in **fencediag** that was used to generate the table (there is only one line with ID zero). *Src_name* indicates the multipatch layer used to derive the height information.

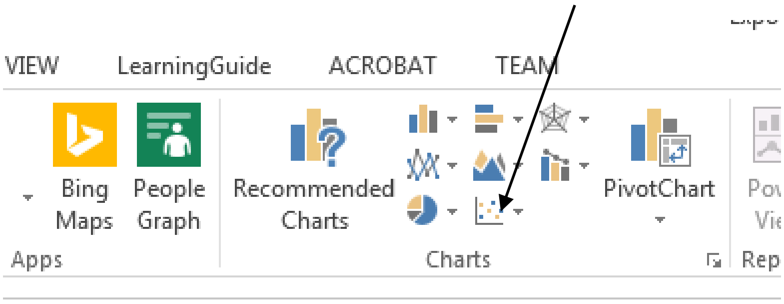
Table

fenceout

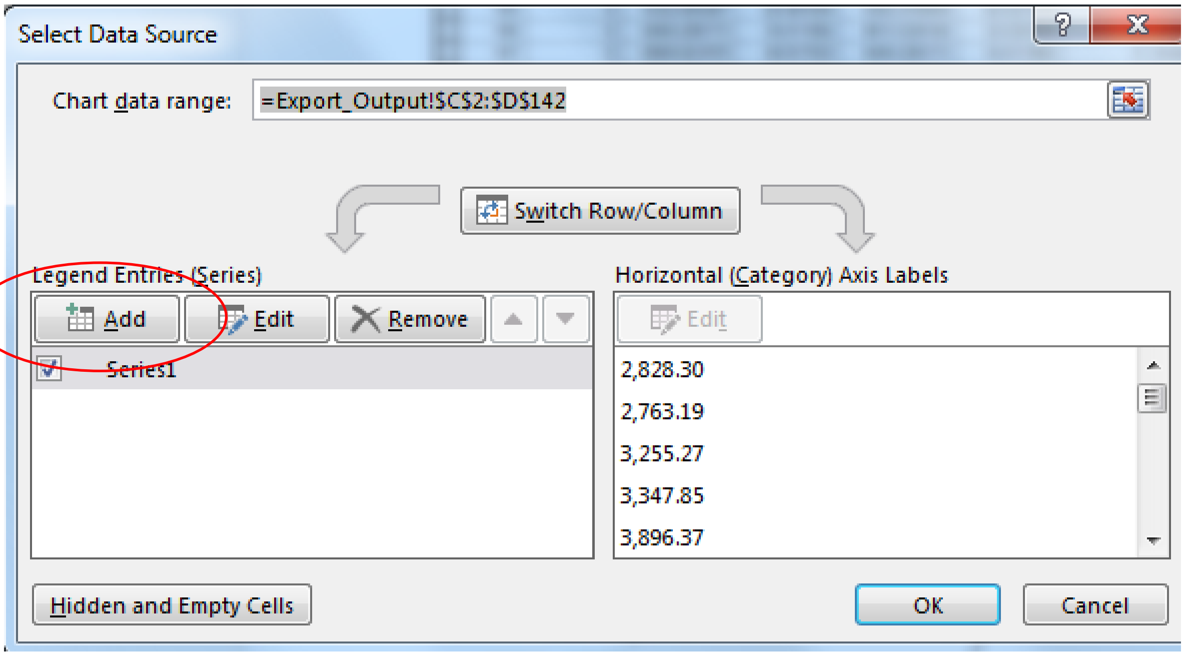
Rowid	OBJECTID	FIRST_DIST	FIRST_Z	SEC_DIST	SEC_Z	LINE_ID	SRC_TYPE	SRC_ID	SRC_NAME
178	0	4875.800045	59.890227	4897.487487	60.226647	0	Multipatch	0	Notts_Melton250k_Mercia_Mudstone_Group
179	0	5055.193622	63.197874	5155.806944	63.483532	0	Multipatch	0	Notts_Melton250k_Mercia_Mudstone_Group
180	0	4897.487487	60.226647	5010.404902	62.910204	0	Multipatch	0	Notts_Melton250k_Mercia_Mudstone_Group
181	0	6012.803706	58.626304	6657.932434	52.823521	0	Multipatch	0	Notts_Melton250k_Mercia_Mudstone_Group
182	0	6657.932434	52.823521	6908.821678	48.917832	0	Multipatch	0	Notts_Melton250k_Mercia_Mudstone_Group
183	0	5403.476849	62.521338	5483.59705	62.05983	0	Multipatch	0	Notts_Melton250k_Mercia_Mudstone_Group
184	0	5483.59705	62.05983	5939.69585	59.187533	0	Multipatch	0	Notts_Melton250k_Mercia_Mudstone_Group
185	0	5332.893267	62.981694	5403.476849	62.521338	0	Multipatch	0	Notts_Melton250k_Mercia_Mudstone_Group
186	0	8484.290173	34.011662	8613.529106	32.525354	0	Multipatch	0	Notts_Melton250k_Mercia_Mudstone_Group
187	0	6908.821678	48.917832	8484.290173	34.011662	0	Multipatch	0	Notts_Melton250k_Mercia_Mudstone_Group
188	0	8613.529106	32.525354	8718.702084	31.59812	0	Multipatch	0	Notts_Melton250k_Mercia_Mudstone_Group

Although ArcGIS can make a graph of these data, it is probably easier to do so in Excel. To export this table to excel, close it down and the right-click on it in the left-hand table of contents and select *data…export*. Under *output table*, click on the button to select **text file** next to *save as type* and choose an appropriate location to save your file. Finally, save your workspace (via file…save) and exit ArcScene.

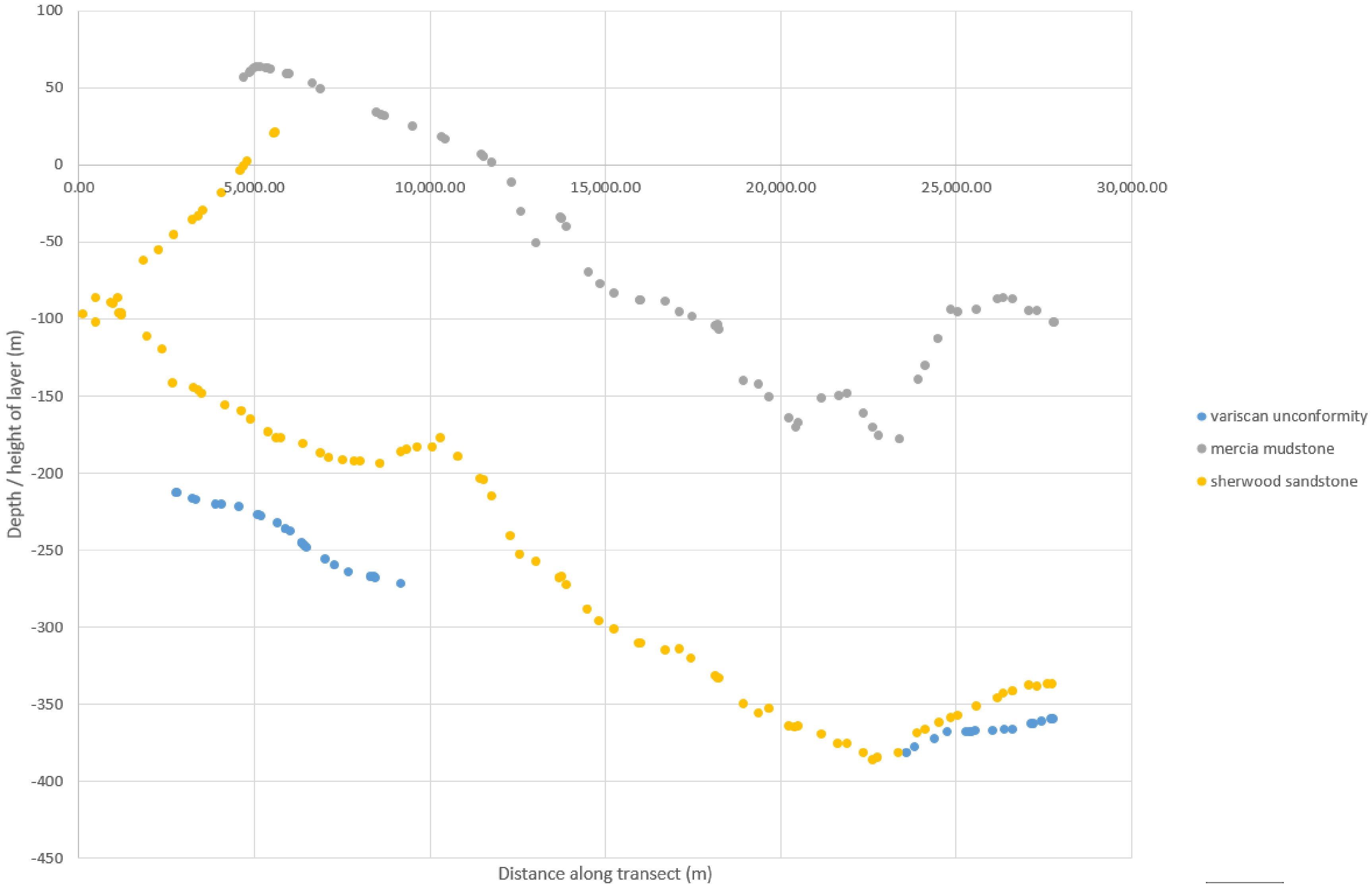
To make a graph in Excel, open up Excel and select file…open then next to the file name box, select *text files* rather than *all excel files*. The *text import wizard* should start. Leave the file type set to *delimited* and click next, then tick **comma** under *delimiters* and click *next* again, then *finish*. You should now see your data in Excel. If you mark up the data under the 'first_dist' and 'First_z' fields for the Variscan Unconformity rows (the first 140 or so) and then choose *insert* from the menus, you should be able to create a scatterplot of these data:



Right-click on the chart that is created and choose *select data* and then *add.* You can then add further points to this graphic by marking up relevant cells in your spreadsheet to depict the sandstone and mudstone distances and depths in different colours:



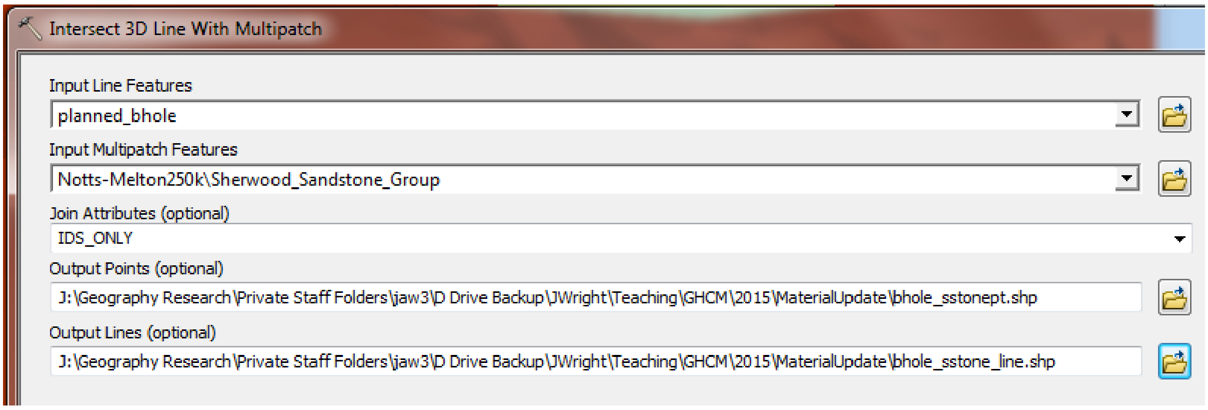
With a little more work in Excel (e.g. choosing *edit* on the above screen and using this to edit the names of each series, and also labelling axes), you should be able to generate output that looks similar to that on the following page:


100
50
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
0.00
5,000.00
10,000.00
15,000.00
20,000.00
25,000.00
30,000.00
Depth / height of layer (m)
Distance along transect (m)
variscan unconformity
mercia mudstone
sherwood sandstone

Analysing multi-patch data

Finally, we will briefly look at an example of one of the 3-dimensional analysis operations in ArcScene – identifying the strata that intersect with our proposed borehole. To do this, open up ArcScene once more and open up the ArcScene document containing the various files for this exercise once more.

Return to the ArcToolBox and select *3d analyst tools / 3d features / intersect 3d line with multipatch*. As your *input line features* select our 3D line '**planned_bhole** and then select the **Sherwood sandstone group** layer as the *input multipatch features* to intersect with this layer. Optionally, ArcScene will create a 3D point indicating the location of the point where the borehole line and sandstone multipatch intersect. Within the table of attributes of this output layer, a *dist_3d* field will be used to store the distance along the line at which the two intersect. Similarly, the output line file will be split at the point where the borehole 3D line intersects with this surface. The lines will have the same *dist_3d* field, but also a *length_3d* field too. Choose an appropriate name and location for both the *output points* and *output lines* created.



After running the tool, take a look at the attributes of the point and line file that you have created.

2. Question: At what depth would the proposed borehole enter the Sherwood sandstone (intersect with the multipatch of this name)? Answer is provided on the following page.

Answers:

1. Caledonian unconformity

2. 148.5 metres – as should be apparent from the attributes of either the point or line file that you created.