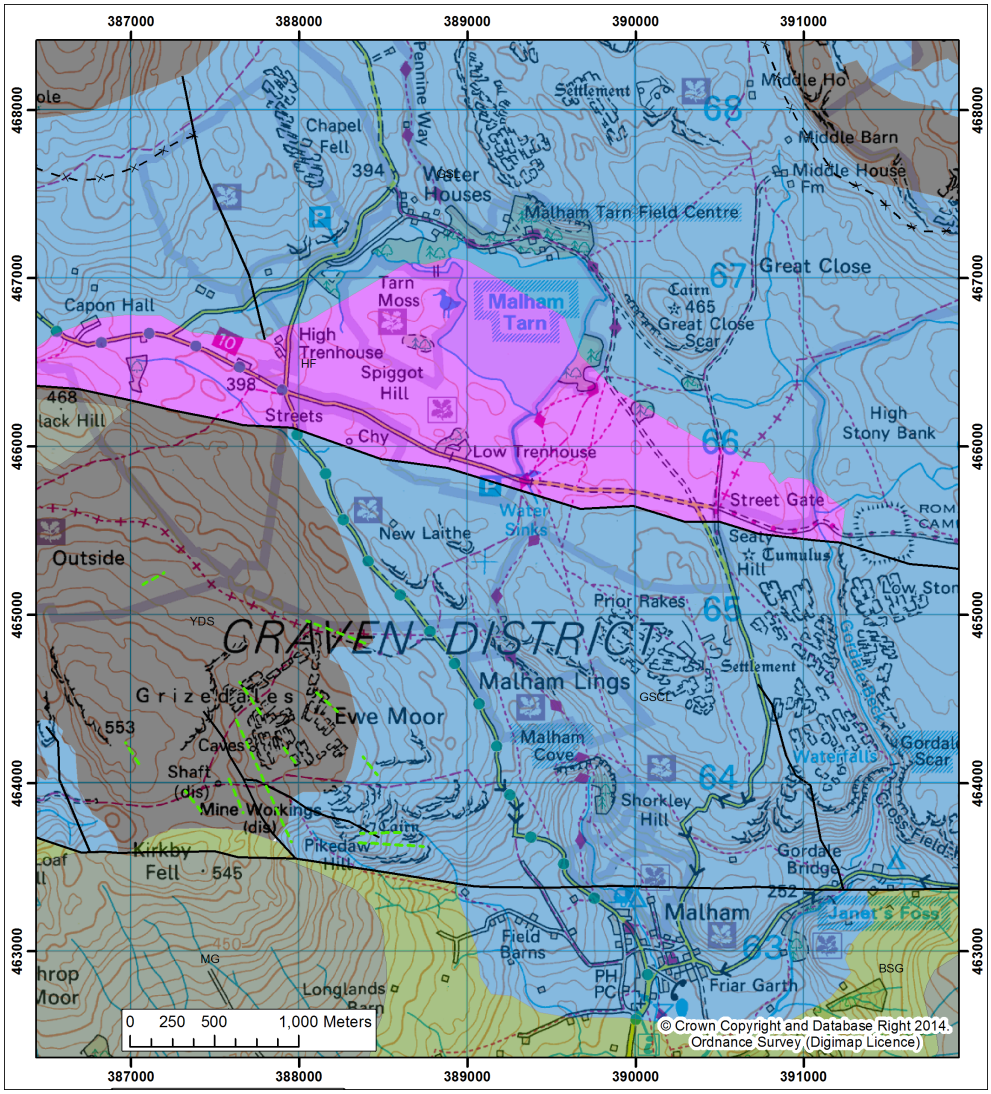
GIS for Geologists:
an introduction



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For ArcGIS version 10.4 and up
18th October 2019

Contents

Major changes to workbook

Major changes to the workbook with the date on which they were made are listed here. If you have been using an older version of the workbook, please check to see which sections have been changed. The date of the workbook will always be shown on the front cover.

Table 1: Major changes to workbook. Newest first.

Date of change	Section no.	Summary of change
18th October 2019	Section 8.6.3, page 102	Updated instruction for exporting png images from Inkscape to create transparent backgrounds.
3rd January 2019	Appendix B, page 156	New appendix on workflow for converting Leeds convention strike and dip measurements to right hand rule for use in GIS.
23rd August 2018	Chapter 4, page 27	Instructions updated for new versions of Roam and Data Download in all collections.
26th January 2018	Chapter 5, page 53	Instructions changed to producing greyscale base map as recommended for dissertation, rather than full colour.

Chapter 1

Introduction to ArcMap

1.1 Learning outcomes

When you have completed this section of the workbook you should be able to

- demonstrate how to open a map in ArcMap
- select appropriate tools to navigate in a map document
- use layers to organise and display information on a map
- add information to a map layout and prepare it for printing or display

1.2 Obtain the sample map

We'll start by loading a map that has already been created and exploring it in ArcMap.

- download the **malham.zip** file from Minerva and save it on your M:/ drive.
- Unzip the file to a folder called **gis** on your M:/ drive (see table 1.1 if you need instructions for unzipping files).

NOTE: for the purposes of this module always navigate to your M:/ drive directly via your username, then create a folder called **gis** at the top level, and use that for all of your GIS projects. Even though you end up in the same place as **My Documents**, for some reason Arc recognises this route as not having any spaces in the path, something to which it objects. You'll find out more about Arc's file management peculiarities in chapter 2

1.3 Open the sample map

- Search for **ArcMap** from the Windows start menu and click to open it. Be patient - Arc opens slowly!
- From the splash screen (figure 1.1) select to Browse for more... on the left-hand side. If you don't have the splash screen use File > Open....
- Navigate to the folder in which you unzipped the downloaded file and open **MalhamGeology.mxd**.
- Your ArcMap window should look similar to figure 1.2, though the layers probably won't be opened out.

Unzipping files
Zipping files is a way of compressing them to save space and make it easier to store and download them. You'll frequently need to extract or unzip files during this module. Zip files may have extensions of either `.zip` or `.7z`, both will extract or unzip if you use the instructions here. • In **My Computer** right-click on the zip file. • 7-Zip ⟩ Extract files... select the location to save the files to OK Right-click and **Extract all** (which is the unzip utility provided by Windows) will usually work on `.zip` files, but occasionally doesn't extract **all** of the files in the archive. 7-zip seems to be more reliable and works for `.7z` too. 7-zip is also open-source so if you want to install a copy on your own computer you can - just download it from `http://www.7-zip.org/`

Table 1.1: Unzipping files

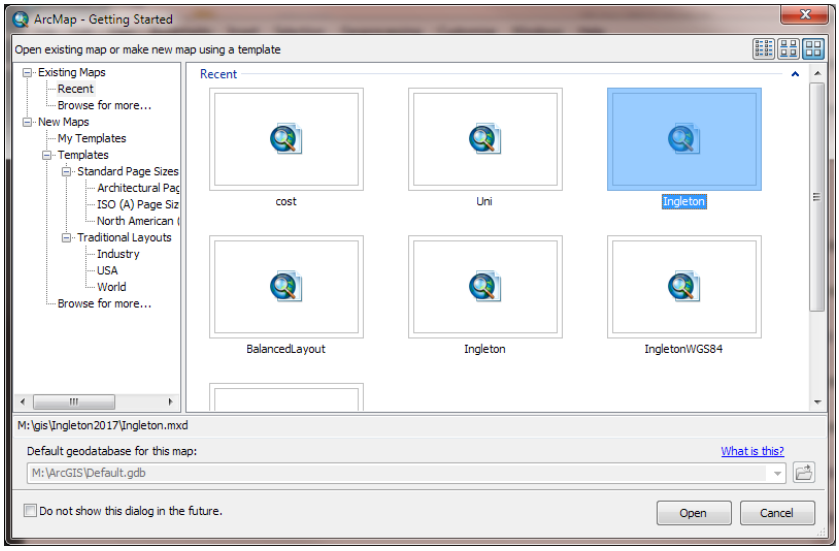


Figure 1.1: ArcMap splash screen. At this stage you won't have any recent maps showing in the area on the right.

1.4 Navigation

The Tools toolbar (figure 1.3) gives you the tools to move around your maps and zoom in and out. Hover over the buttons to see the tooltips that explain what each button will do.

Question 1.1. Try out each tool in turn and see what it does. Make notes for yourself in table 1.2 on page 2.

(Remember that the possible answers to questions in the workbook are given in section E starting on page 164)

Table 1.2: Navigation tools in ArcMap

Tool	What it does
Zoom in (also try using the mouse wheel to zoom in and out)	
Zoom out	
Full extent	
Zoom to layer (this one isn't on the tools toolbar. Right-click on the title of a layer in the table of contents Zoom to layer)[1]	
Pan (also try holding down the mouse wheel and panning - useful when you're using another tool)	
Select features (try clicking on the map, and click and hold then drag and let go)	
Identify	
Find (try searching for **Craven** in the **Features** tab. Once you have a result, right-click a record and have a go with the commands from the menu, e.g. **Flash**)	

NOTE: For numbered questions, such as question 1.2 above, have a go at them first for yourself, but then the answers are given at the back of the workbook in appendix E on page 164 and following pages, for you to check that you have understood what you are doing. If you can't see why a question has a particular answer please ask staff or demonstrators to explain.

Video Clip available in Minerva - Using the "Find" button to find features in ArcMap. Direct link: `http://bit.ly/2h5hWeC`

1.4.1 Change scale

To change to a particular scale, e.g. 1:100 000, simply use the drop down box at the top of the window (figure 1.4) to select the scale you want. You can also type a scale in this box particu-

[1] **Zoom to layer** is a very useful tool. It can be particularly useful if you have zoomed in or out too far and can no longer see your map properly. Zoom to layer and you'll usually be able to see enough to find the bit of the map that you really want to see.

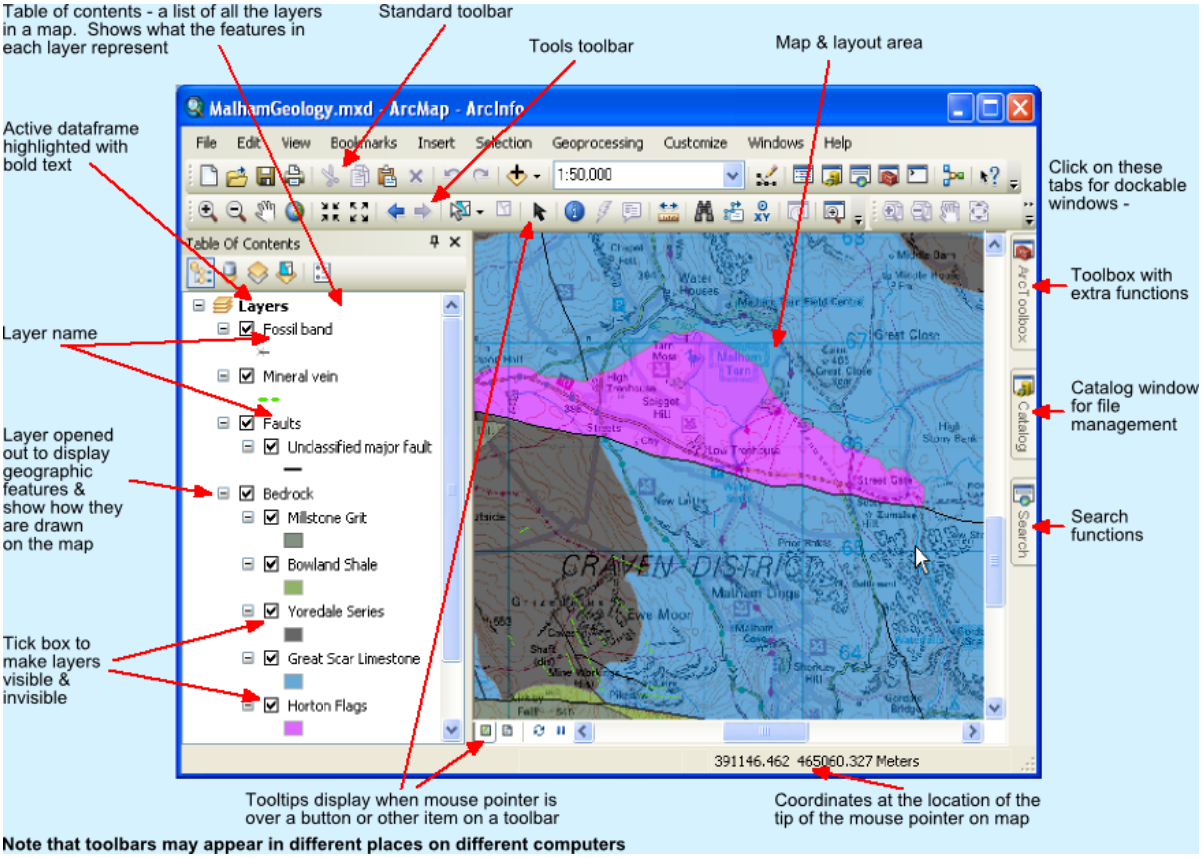


Figure 1.2: The ArcMap window

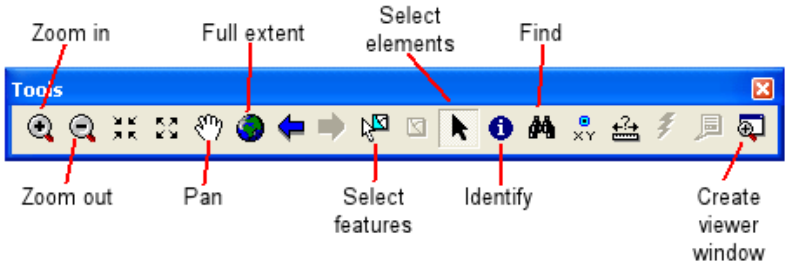


Figure 1.3: The tools toolbar

larly if the scale you want isn't in the list, e.g. 50000 (note no punctuation), and it will change to that when you press ↵.

1.4.2 Catalog window

There is a separate component of ArcGIS called ArcCatalog, but with version 10 most of the functions of this have been incorporated into the Catalog window within ArcMap.

- Click on the **Catalog** button at the right-hand side of the map window. (If the button isn't there go to Windows > Catalog to open it.)
- Clicking on the "pin" at the top of the Catalog window allows you to decide whether to keep it open or let it auto-hide.

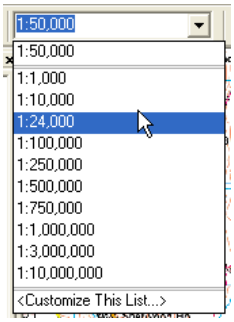


Figure 1.4: Scale dropdown box

- Explore the tree in the Catalog window - you should be able to see a heading such as **Home - Malham** which is the folder where you opened this map from. Look at the other files in the folder. Some of them should be the files that go with the layers in the table of contents.

1.4.3 Overview window

If you have zoomed right in, but still want to know where you are in relation to the rest of your map you can use the Overview window.

- Windows > Overview.
- The Layers overview will open as a new window (figure 1.5 and the area you are viewing will show up as an outline on the overview window.

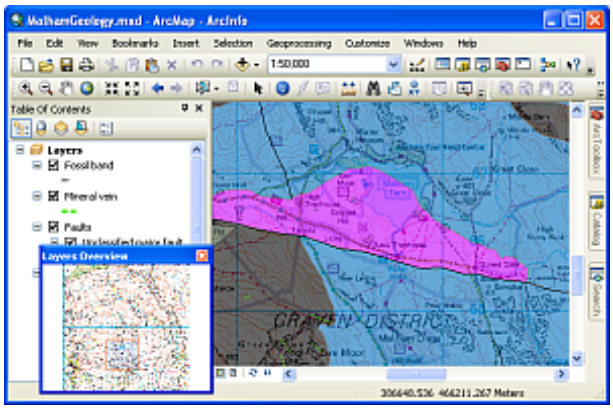


Figure 1.5: Overview window

- Use the overview window to move around your map by dragging the selected square.

1.4.4 Spatial bookmarks

Spatial bookmarks enable you to go back to a view you have set up earlier. The map of Malham has a bookmark set up for the correct scale and location for printing.

- Bookmarks > For printing.

To set up your own bookmarks

- Bookmarks > Create... type a name for your bookmark OK.
- The bookmark should be visible when you click on Bookmarks again.
- Change the scale of the map and pan to a different view, then go the bookmark that you have just set.

Video Clip available in Minerva - Spatial bookmarks in ArcMap. Direct link: `http://bit.ly/2eQmVPA`

Question 1.2. Change the scale of the map and pan to a different view, then go to the bookmark that you have just created and check the scale again. How has the bookmark affected the scale?

1.5 Working with map layers

Layers are an essential part of any GIS. Each layer is a reference to a particular data source. In the Malham map file the layers include

- Bedrock
- study-area
- sd86.tif

Question 1.3. What are the names of the other layers in the Malham map?

Layers are controlled from the table of contents to the left of the map window.

Go to this module in Minerva and watch the video clip on "Working with layers in ArcMap". Then get used to working with layers by following the instructions below.

Video Clip available in Minerva - Working with layers in ArcMap.
Direct link: `http://bit.ly/2ttzfdJ`

1.5.1 Viewing contents of layers

- Click on the little cross symbol next to a layer to open the layer out and view the contents.
- Click on the little minus sign next to a layer to close an open layer.
- The table of contents also acts as a key to your map and shows the symbols for map features.

1.5.2 Turn layers on and off

You may not want to be able to see all of your layers all of the time, for example, if you turn off a layer which has lots of features it can save time each time you move the map.

- Click in the box next to the **Bedrock** layer title to turn the bedrock geology off.
- Once a layer is in the table of contents you can turn the layer on and off to view other data without removing it.
- Turn other layers on and off and see what the map looks like. If you turn off **sd86.tif** while all the other layers are on, you can get an idea of what information you will be creating yourself in future sessions.
- Finish with all of the layers visible.

1.5.3 Add new layers

There are two simple ways to add new layers.

Video Clip available in Minerva - Adding new layers to ArcMap from a local disk. Direct link: `http://bit.ly/2sueGtH`

Add data command

- File > Add data... navigate to the folder in which you unzipped the map. Go to the **field-geology** folder and add **YSS 2 Malham Area Geology.png**. (Note that if you double-click on a png, jpg or tif file in Arc you are shown three or four apparently separate files called something like **Band_1, Band_2, Band_3 etc** - you don't want to add these individually, they are just parts of the main file. Go back one step and add the single png, jpg or tif file.)
- When you add png, tif or jpg files to ArcMap as a layer it will ask you whether you want to create pyramids. It's your choice! Pyramids can save time when you are zooming in and out of your map but take a while to create when you first load the file.[2]
- If you can't find the folder to add the image follow the instructions in the **Connect to a folder** tip box (table 1.3).

[2] If you want more information about how pyramids work, search for **raster pyramids** in the Desktop Help.

Drag and drop

- Alternatively simply find the file in the **Catalog** view and drag and drop it onto the map area.
- If you can't find the folder to add the image follow the instructions in the **Connecting to a folder** tip box (table 1.3).

This is the map that was used as a base to trace the geology. You should be able to see that the outlines of the bedrock geology layer follow the sketch map.

Connecting to a folder
If you can't see your M:/ drive or USB device in the list of folders when adding data or viewing the catalog you need to **Connect to folder**. • Click on the **Connect Folder icon** (figure 1.6) and select your top level gis folder then click OK. • Now select your files from the folders that you can see. On cluster machines you'll probably find that you have to repeat this each time you start work in Arc, unfortunately.

Table 1.3: Connecting to a folder

Figure 1.6: Connect to Folder button

Video Clip available in Minerva - Connect to Folder. Direct link: `http://bit.ly/2sp6mA3`

1.5.4 Make layers transparent

Now we can't see the base map underneath the scanned map - we need to make the scanned map layer transparent.

- Right-click on **YSS 2 Malham Area Geology.png** in the table of contents Properties > Display > Set transparency.
- 0% is fully opaque, 100% is fully transparent. Try several steps between 30 and 60% and see what difference it makes.

1.5.5 Change the order of layers

Changing the order of layers is simple once you remember that they "stack up" in the order in which they appear on the table of contents.

- To change the order of layers so that the **YSS 2 Malham Area Geology.png** layer is below the **sd86.tif** layer, simply use the mouse to drag the layer to where you want it to lie in the table of contents.

Using the above instructions move the layers around in the table of contents and change transparency for various layers, just to see what the possibilities are.

1.5.6 Grouping layers

The geology layers are related to each other and could be grouped together to organise the map. Amongst other advantages this would make it easier to turn all of the geology layers on and off together.

- Right-click on the word **layers** in the table of contents. New Group Layer click on the New Group Layer that appears and give it a name such as **Geology** that tells you what the group is. Now use the mouse to drag the geology layers so that they appear indented underneath the layer name.
- Try turning off the Geology group layer to check that all of your layers are actually together. Don't forget to turn them back on again!

1.5.7 Remove layers

Perhaps we don't need the **YSS 2 Malham Area Geology.png** layer in our map after all.

- Right-click on the layer Remove.

Note that this doesn't delete the data from your disk, it just removes the link to it from your map.

1.6 Viewing an attribute table

Data for GIS is stored in tables as **feature attributes**. You can view the attribute tables to get an overview of your data, and to carry out some useful operations.

Video Clip available in Minerva - Working with attribute tables in ArcMap. Direct link: `http://bit.ly/2s9y1k9`

- Right-click on the **Millstone Grit** layer under **Bedrock** in the table of contents Open Attribute Table.

You should have a window similar to figure 1.7.

Have a look at the structure of the table -

- Each row contains one record - the details for one **feature** on the map.

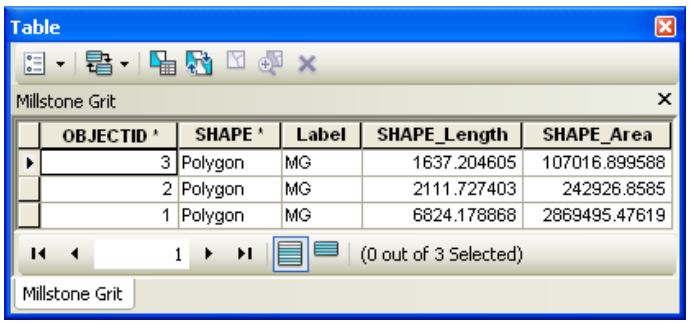


Figure 1.7: Attribute table

- Each column is one field - or **attribute**. That is, related information for each feature, such as Label.
- If you are working with polygon features in a geodatabase the **SHAPE_Length** and **SHAPE_Area** fields will automatically be created and filled in with the length of the outline and the area of the polygon.
- If you are working with line features in a geodatabase the **SHAPE_length** field will automatically be created and filled in with the length of the line.

The measurements will be in **map units** - find out what these are set to by going to View > Data Frame Properties > General in the main ArcMap window. Look at the **Units - Display field**.

Question 1.4. What are the map units of the current map? Make a note in the box below. This information will be useful later.

Map units:

Video Clip available in Minerva - Selecting features with the attribute table. Direct link: `http://bit.ly/2fb3j8T`

- In the attribute table click on the little grey area to the left of the one of the records. The feature will be selected in the table, and will also be selected on the map. Move the attribute table to one side if you need to, to check this on the map.
- Use the **Select Features** tool from the tools toolbar to click on a feature from the Millstone Grit layer in the map and notice that this selects the same feature in the attribute table.
- In the attribute table click on the first of the features. Now hold down the Ctrl key and click on the third feature. In this way you can select more than one feature at a time.
- To view only your selections click on the Selected button at the bottom of the window. To view all records again click on Show all records.
- To clear selections click on the Options button (figure 1.8) Clear Selection.
- Right-click on the **SHAPE_Area** column heading Sort Ascending. This will reorder the table from low to high by the area of the polygon.
- Play around with the attribute table and explore what else you can do.

Figure 1.8: Attribute table options button

1.7 Saving a map

IMPORTANT: Save your maps at regular intervals. ArcMap can crash when carrying out some operations and you don't want to lose all of your work. Crashes can also corrupt data files, so copy the whole of your gis folder to another location or drive at frequent intervals (i.e. create a **backup** copy).

- File » Save.

1.8 Creating data in ArcGIS

Now it's your turn to add some features to the map and create data. We'll go into more detail about this in later sessions when you'll set your own project up, but for now let's add fossil bands to the Malham map.

- Start by adding the **YSS 2 Malham Area Geology.png** layer back into your map again. This is the sketch map that was used to trace the geology layers that you've been looking at.[3]
- Open the Editor toolbar - Customize » Toolbars » Editor.
- Click on Editor » Start Editing select **Fossil band** from the list of layers OK.
- Zoom to the extent of the Study area layer.

If you look at the sketch map there are some lines with little crosses on them (—x—x—x—x—). You can probably see these most clearly at the top of the area. These are fossil bands in the limestone and haven't yet been added to the digitised map.

- In the **Create Features** area which should be open to the right of your window (see figure 1.9, select the layer that you want to edit - in this case **Fossil band**.

- In the area below Create Features select the correct **Construction Tool**, e.g. **Line**. See figure 1.10.

- The **Straight Segment** tool (figure 1.11) should automatically select on the Editor Toolbar, if it doesn't then click on it now. Alternatively select another tool at this stage, and try it out.
- Click on the map to start drawing a line. Trace along the line of the fossil band on the map, clicking each time you want to change direction. Each click creates a **vertex** which is similar to a node in CorelDraw.
- If you want to **undo** the last vertex that you drew, press Ctrl + Z.

[3] NOTE: this is an old sketch - 1924/30 - don't assume that it shows the current thinking on the geology around Malham.

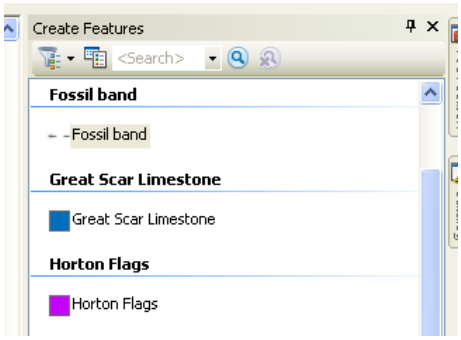


Figure 1.9: Create Features area

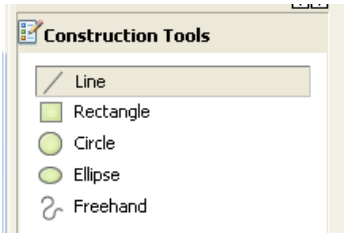


Figure 1.10: Construction Tools area

Figure 1.11: Straight segment tool

- Double-click when you finish your line or press F2.
- You can easily delete features within an edit session, so just have a go and don't worry if your shapes don't work first time.
- **IMPORTANT:** Save your edits at regular intervals - Editor > Save Edits.
- When you've finished stop editing (i.e. come out of the edit session) - Editor > Stop Editing.

Congratulations, you've just created new data in ArcGIS. Turn off the **YSS 2 Malham Area Geology** layer and have a look at the lines that you have just drawn. They should appear in the style shown in the table of contents.

1.9 Layout view - printing a map

So far we have been using the **Data view**. If you print the map from the data view you have little control over it's appearance. To produce a professional looking map you need to use **Layout view**.

- View > Layout View.
- Go to the bookmark "**for printing**" to select the predetermined location and scale.

The layout window (shown in figure 1.12) looks similar to the data window, but shows the layout as it will appear when printed. You still have the table of contents on the left of the screen, and the tools toolbar visible, but you now also have the **layout toolbar** available. (If the layout toolbar isn't visible go to Customize > Toolbars > Layout toolbar to activate it.)

- Explore the layout toolbar. Use the buttons to zoom in and out of the layout and move around it.

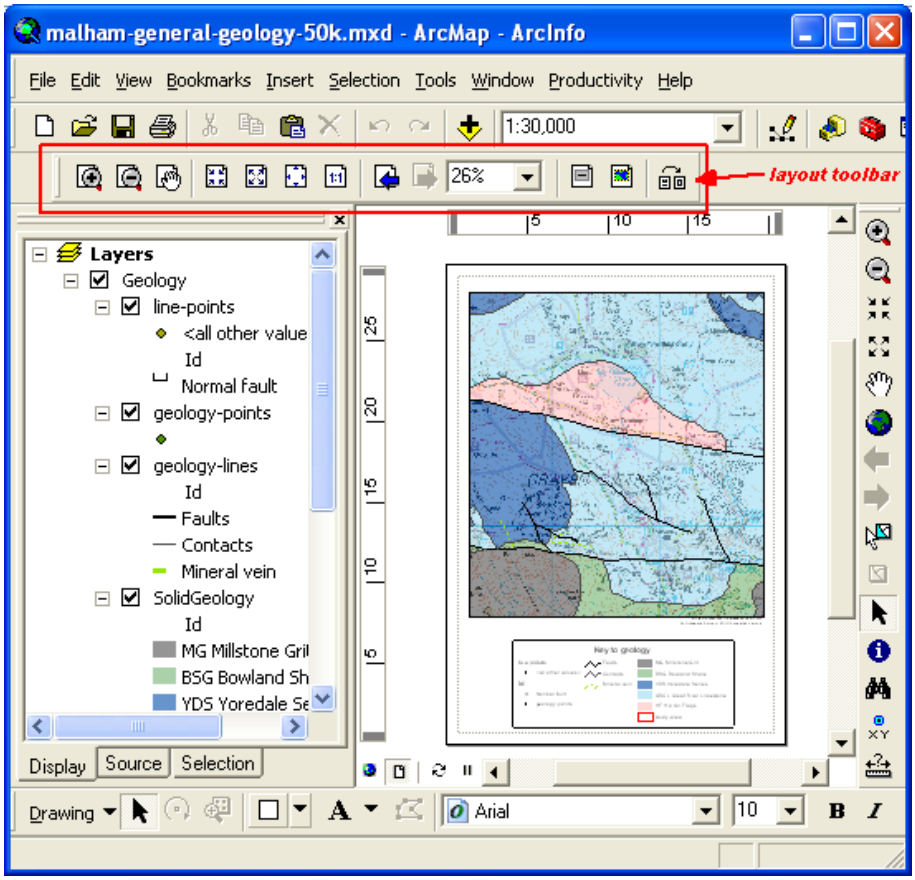


Figure 1.12: Layout view and toolbar

- The final button on the toolbar changes the template. Try this out, but you probably won't want to save the end result!
- Try the tools on the tools toolbar in this view too.

Question 1.5. What is the difference between zooming with the layout toolbar and with the tools toolbar in layout view?

1.9.1 Adding objects to the layout

Most of the maps that you create will need to be printed out with additional content such as a title, a key or legend, a scale bar and some text. These can all be added in layout view.

To add a title

- Insert > Title type your title, e.g. "Geology of Malham" then press ↵.
- Use the **Select Elements** tool (the black arrow head) from the tools toolbar to move the title to the top of the page where it doesn't overlap the map.

To add a scale bar

- Insert > Scale bar... Select a format from the examples available OK.
- The scale bar will be added to the centre of your view. Use the **Select Elements** tool to move the scale bar to the space just below the map.
- You can resize the scale bar by dragging the blue boxes around the edges when it is selected (figure 1.13). Note that as you resize it, the scale stays the same as the map scale.

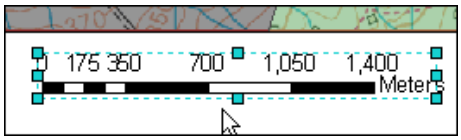


Figure 1.13: Changing the size of the scale bar

To add text

Use the **Insert** menu to add the following text to the remaining space at the bottom right of the map, replacing **(yy)** with the current year. (See the box below for how to add the copyright symbol.)[4]

> ***© Crown copyright and database rights 20(yy). Ordnance Survey (100025252)***

Adding the copyright symbol to your text
To add the **copyright symbol** - ©- to your text • check that the Num lock is on on the keyboard • hold down the Alt key • use the number pad to type 0 + 1 + 6 + 9 • release the Alt key

Table 1.4: Adding the copyright symbol to your text

- Double-click on the text once you have added it and use the **Change Symbol** button to change the font to **size 8**.

Copyright acknowledgement is important! You will all have agreed to the Digimap terms of use when you registered. Every map that you produce using data from Digimap should have the copyright statement printed on it as above. If you are using data from another source check the terms and conditions for that source.

[4] You can check the current form of the copyright text via the Resources link on the Digimap homepage. Under **Popular Resources** on the right, look for **Digimap Licence Agreements** and look for the appropriate dataset. In each case the recommended statement is part of the way down the page under **In return, You must:** (April 2019)

There is more information about adding text and copyright acknowledgements in section 10.4.2 on page 122.

Adding a basic legend to a layout

We will cover adding a legend / key in more detail later in this module. For now we'll add a legend using default options.

- In layout view - Insert > Legend...
- The legend wizard should open (figure 1.14). ArcMap will probably add all of your layers to the right-hand box automatically. Use the arrow keys to remove and add layers and to order them as you want them to appear. See the example key (figure 1.15) for the list of layers to add to the Malham map.

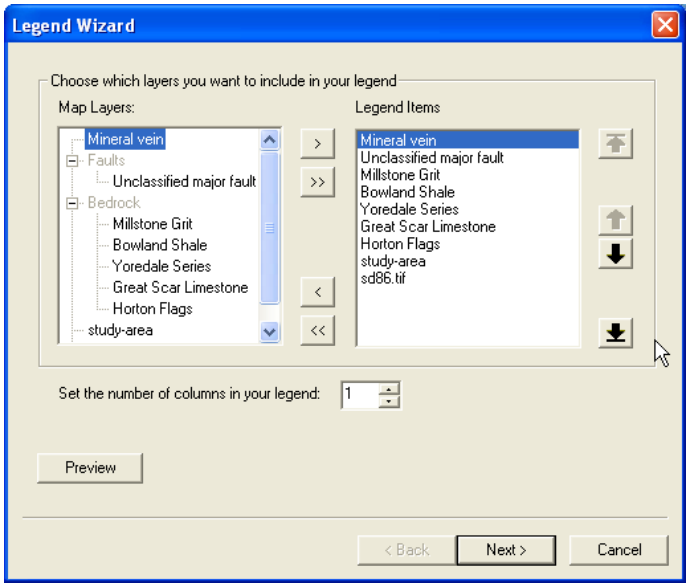


Figure 1.14: Creating a legend with the legend wizard

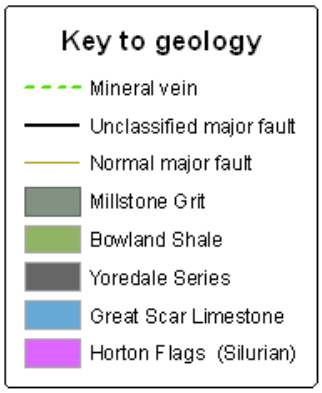


Figure 1.15: Example of a legend for the Malham map

- Set the number of columns
- Next change the legend title to something appropriate Next.
- If your legend will be overlapping your map set the background to white. If you want to, try giving it a border.

- Next > Next > Finish.
- Move your legend to an appropriate position on your map.

You can double click on the legend to change its properties and settings. Experiment to see what you think looks best - it doesn't matter if your legend looks different from mine as long as it is clear and gives all of the information that it needs to.

Try the following -

- Double-click on the legend to open the Legend Properties > Items.
- Make sure that the **All items** check box is checked, then click on the Symbol... button.
- Use the **Options** to change the colour, font, size and style or text.

Adding a description to a legend item

Sometimes you need more text in the legend than you have in the table of contents. You will lose descriptions if you **Add values** to your symbology again, so make sure that you are happy with the list of values before you start adding descriptions.

To add extra description -

- Open the **Layer Properties** for the **Horton Flags** layer in the table of contents.
- Symbology > Description...
- Type "**(Silurian)**" into the description box then OK > OK.

The description should appear next to the Horton Flags layer in the legend. If not:

- go into the Legend Properties select the layer Style...
- Choose a style which includes the Label and Description.

To add a measured grid

Measured grids add labelled grid lines to a layout. If you are using Ordnance Survey data then you can easily add National Grid lines and numbers making it easy to read grid references from your map. The O.S. raster tif files already have grid lines marked, but adding a measured grid allows you to include coordinates around the edge of your map.

- View > Data Frame Properties > Grids > New Grid > Measured Grid.
- Select the appearance that you prefer. Check that the coordinate system is set to <**Same as data frame**>, and check that the Intervals are suitable to the scale and units - in this case set both of the axes to **1000**.
- Next > Next > Finish > OK.

1.10 Printing or exporting a map

To **print** your layout:

- Change paper size and direction using the File > Page and Print Setup... dialog.

- To print - File > Print... then select the correct printer.
- Check the image at the bottom right of the print dialog to make sure that your map fits properly onto the paper you have selected. If you need to make any changes click on the Setup... button next to the printer selection box. Then click on OK to print.

To **export** a map to pdf or an image:

- Change paper size and direction using the File > Page and Print Setup... dialog.
- To export - File > Export Map...
- Select the format that you wish to export and give your file a name. Check the other options and change as appropriate (you may find that the defaults are OK) and then Save

1.10.1 Suggested layout

Your final map could look something like figure 1.16. It is unlikely to look identical as you should make your own decisions about where to place elements and how to display your map.

Print your final layout and bring it to the next class. I will try to speak to all of you individually during the course of the practical and will give you feedback on this exercise.

1.11 Recommended reading: Introduction to GIS

Many of the books in the reading list[5] have a general introduction to GIS which explain what it is and how it is used. Suggestions include the following:

- Chapter 1: *What is GIS?* IN Heywood, I., Cornelius, S. and Carver, S. (2011), pp. 2-30.
- Chapter 1: *Systems, Science, and Study* IN Longley, P.A. et al. (2011), pp. 3-37.

In addition have a look at the other books under **Geography K-13** on level 9 in the Edward Boyle Library.

The Ordnance Survey has a very useful page of information explaining what GIS is, and how it can be used - `http://bit.ly/1PWKE5T`

For more information about basic use of ArcMap, ArcCatalog and Arc Help look at the book by Kennedy, M. (2013). He specifically covers using ArcCatalog and ArcHelp - use the index to find the sections that you need.

1.11.1 Videos online

If you find videos helpful then search online for specific tasks in ArcMap and you will find plenty. Make sure that you are viewing videos for ArcMap rather than ArcOnline, though.

Examples include:

`http://bit.ly/1C08CKj` - from University of Toronto Library

`http://bit.ly/1u3RWk4` - longer videos from Cornell University which cover a lot of the basics

[5] Reading list available from Minerva and from the module catalogue at `http://webprod3.leeds.ac.uk/banner/dynmodules.asp?M=S0EE-1470`

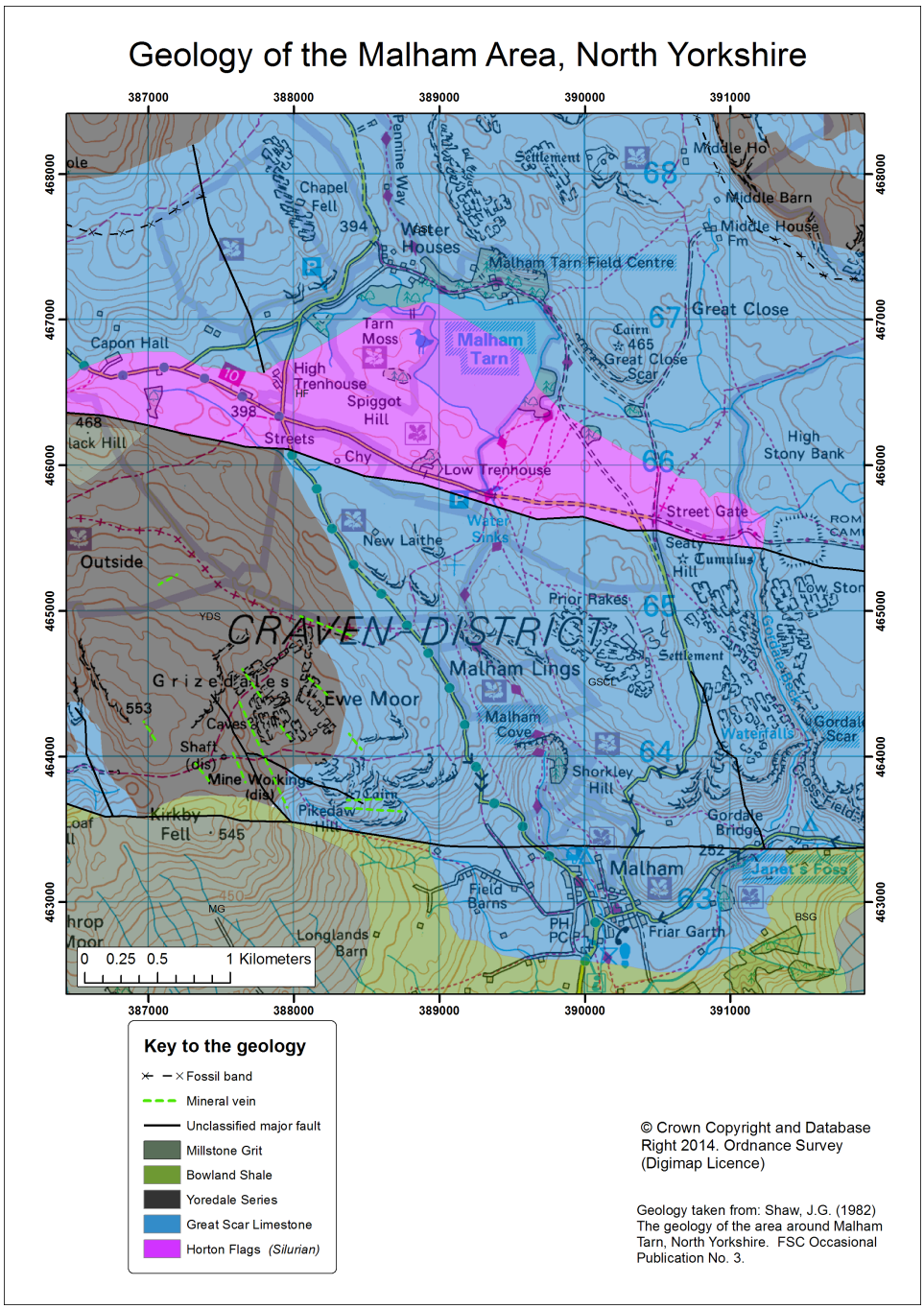


Figure 1.16: Possible layout for Malham geological map

Chapter 2

Introduction to the Catalog

Use the **Catalog window** in ArcMap and **ArcCatalog**, which is a separate program, to manage your GIS data, and particularly for tasks such as moving and deleting files, where you would usually use My Computer. Changes to GIS layers often affect several other files and tables and ArcCatalog and Catalog maintain the correct relationships.

2.1 Learning outcomes

When you have completed this section of the workbook you should be able to

- understand the basic principles of file management for GIS
- identify when to use ArcCatalog or Catalog to manage GIS data
- use the catalog to preview GIS files and find out more information about data

2.2 *****Warnings about file management*****

Boring, but **essential!**

You don't want to spend lots of time creating a map only to find that it won't open when you come to print it, or that you can't find the files that go to make up your map. A lot of students have wasted a lot of time because they didn't follow the file management rules which are laid out in table 2.1 on page 20.

The table summarises the rules, more detailed information was given in the lecture segment. See the presentation slides and the video in Minerva.

Video Clip available in Minerva - File management for ArcGIS. Direct link: `http://bit.ly/2gNqFBN`

2.3 Absolute and relative paths between maps and data

Arc layers **reference** datasets rather than contain them.

Summary of file management rules - ignore at your peril!

If you have problems with a project in ArcGIS check that you have followed the rules below before you ask for help.

- Keep your files organised - create a folder for each project and keep all the files for that project in that folder. Make sure that you remember where you are saving files. If you forget you'll probably have to waste time downloading the files and processing them again.
- Don't use spaces or non-standard characters in folder or file names - these can cause problems for ArcGIS. Stick to alpha-numeric characters.
- Keep file paths short but informative - that is the whole list of folders and the file name. The total should be less than 256 characters. Make sure you use names that mean something to you for future reference!
- If you have problems opening / moving / unzipping files - check disk space! Remember GIS data needs a lot of space and can quickly fill your M:/ drive.
- Don't save files to **My Documents** or **Documents and Settings** because of the spaces in their pathnames. On the University system start at the root of your M:/ drive (your username rather than your full name) and navigate from there.
- Don't save files to the **Desktop, the harddisk of a cluster machine** or any **temp or temporary** folder. The files will have disappeared by the next time you look for them.
- Don't save zip files to a temp or temporary folder or open them without saving them first - you may be refused permission to unzip them.
- Use ArcCatalog or the Catalog window in ArcMap to move and delete gis files, not Windows Explorer or My Computer. ArcCatalog is specially set up to handle gis files with more than one part without breaking them.
- If you are having trouble carrying out an operation in ArcMap check that ArcCatalog is not open too - and the reverse if you are having problems in ArcCatalog.
- Keep a backup copy. Arc does crash and can damage datafiles as well as your map.

Table 2.1: Summary of file management rules

By default layers link to datasets through their source property using **absolute** paths. This means that once you have saved a file created in ArcMap or ArcScene to a particular drive, e.g. your M:/ drive, if you then move it to a different drive, e.g. a USB stick, you will lose the **links** to your data. This is not a problem if you always use the map from your M:/ drive, but if you want to work on it in a different environment or save it to a memory stick it can become a problem. It is advisable to change paths to relative and instructions for this are given in section 5.4.1 on page 55.

2.4 Opening Catalog

Most of the operations below will work in ArcCatalog too, but sometimes in a slightly different manner.

- Open ArcMap if it isn't already open
- You may have a tab on the right-hand side which says **Catalog**, if you have just click on it

- Otherwise, Windows > Catalog will open the Catalog which should look something like figure 2.1.

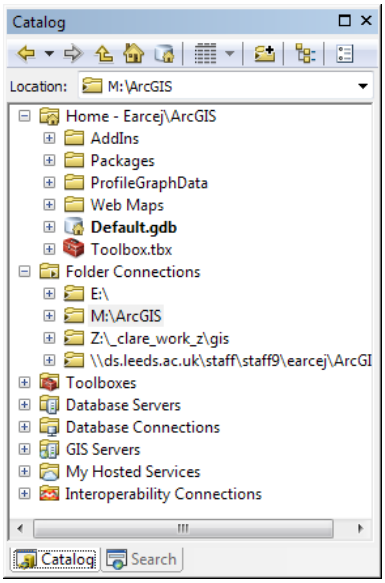


Figure 2.1: The Catalog window in ArcMap

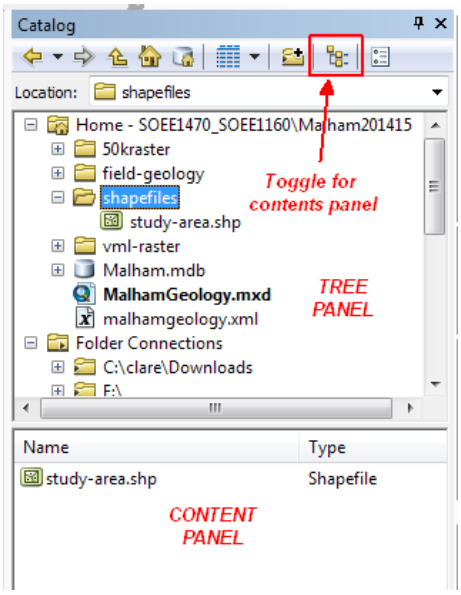


Figure 2.2: File tree and contents panel in Catalog

In section 4 on page 8 you added a new layer to ArcMap by dragging and dropping it from the table of contents. In the default **Tree view** you can only do this, or delete files, one file at a time. To be able to add or delete multiple files open the **Contents panel** as follows:

- Open and close the contents and tree panels by toggling the button at the top right of the tree view - shown in figure 2.2.

2.5 Navigation

- Use the catalog table of contents to navigate to the folder in which you saved the downloaded files, using **Connect Folder** if necessary (see table 1.3 on page 8). You should be able to see the files listed in the right-hand window of figure 2.1.
- Open out the **shapefiles** folder by clicking on the **+** sign next to the folder name. The contents should look something like figure 2.2.

Open My Computer from your desktop and have a look at the shapefiles folder.

Question 2.1. What is the main difference between the contents of the folder in ArcCatalog and the contents of the same folder in My Computer? (Apart from the different icons!)

Displaying file extensions in Catalog
You may not be able to see the file extensions such as "**.shp**". The exercises in this section will assume that you can so make them visible as follows - • To turn file extensions on click the **Options** button at the top right of the Catalog window • Make sure you are on the **General** tab and click to remove the tick in the box next to Hide file extensions > OK.

Table 2.2: Displaying file extensions in ArcCatalog and Catalog

Shapefiles are a specifically GIS format which can be read by many GIS programs. The exercise above should show you why it is best to move files around in the catalog rather than the usual file manager.

Question 2.2. In a similar way open out the Malham.mdb file in ArcCatalog and have a look at the contents, then look at the same file in My Computer. This is a database file. What is the difference this time?

This is a geodatabase [1]. Geodatabases like this one are a specific Arc format, though more GIS programs are starting to use them. They are useful as a much more efficient method of storage than shapefiles. You will need to be familar with both geodatabases and shapefiles for future exercises.

2.6 Viewing files and file information

It is possible to use Catalog to preview GIS files.

Video Clip available in Minerva - Viewing file properties and information in ArcCatalog. Direct link: `http://bit.ly/2h49Z9s`

- Open out the **Malham.mdb** file and the **Bedrock** folder inside it. Right-click on **Great_Scar_Limestone**, then click on Item Description. You can then click on the **Preview** tab at the top of the window.

Your screen should look similar to figure 2.3.

[1] if you're not sure what a database is then you can find a brief definition by searching at `http://support.esri.com/en/knowledgebase/GISDictionary/search`

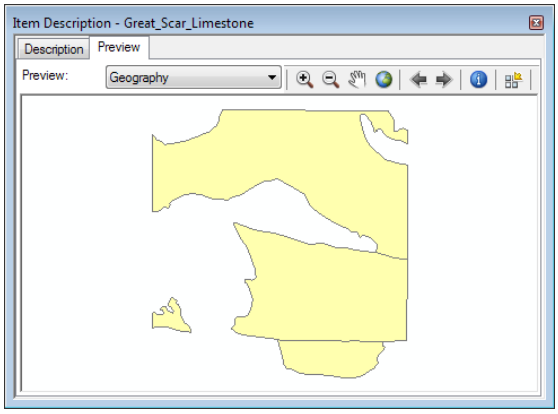


Figure 2.3: Previewing a feature class in Catalog

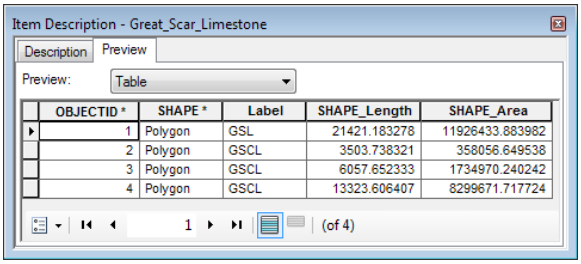


Figure 2.4: Viewing the attribute table of a feature class in Catalog

- This view is useful for quickly checking the contents of layers. Click on other headings in the same folder and preview them. Also open the **50kraster** folder and preview **sd86.tif**.
- Return to the **Great_Scar_Limestone** feature class and this time select **Table** from the preview drop-down box at the bottom of the window. Now you can look at the details of your data in the **attribute table** (figure 2.4).
- Finally, have a look at the **Description** tab. This area gives you background information, or **Metadata**[2] , In this case the metadata doesn't actually include much information so you need to use the following method to find out more about the file that you have selected.
- Close the Item Description window, right-click on **Great Scar Limestone** again, but this time select Properties.
- Have a look at what information is available to you. You will need to click on the various tab headings to see everything.
- Look for the **XY Coordinate System** heading. This section tells you whether the file uses a Projected or Geographic Coordinate System. You will be able to see the projection and the geographic coordinate reference for the data. The feature classes and datasets in the Malham database should be set to the usual systems for spatial data from the Ordnance Survey.

Question 2.3. Make a note below of the coordinate information for the Great Scar Limestone layer. You will find out more about coordinate systems as the module progresses.

Projection name:

Geographic Coordinate Reference name:

[2]**Metadata** is data about data. It is important because it helps to organise information. Think of the library catalogue.

Chapter 3

ArcGIS Desktop Help

ArcGIS Desktop Help is actually very helpful - unlike some software help information. There are detailed instructions and tutorials on how to do all sorts of useful things in ArcGIS.

3.1 Learning outcomes

When you have completed this section of the workbook you should be able to

- use ArcGIS Desktop Help to answer your questions about using ArcGIS.
- demonstrate different ways of finding information in ArcGIS Desktop Help.

3.2 Where to find ArcGIS Desktop Help

The same information is available either from within the program, or on the web.

3.2.1 From within Arc

- Help > ArcGIS Desktop Help on the menu bar in either ArcMap or ArcCatalog, or just press the F1 key (figure 3.1).

3.2.2 On the web

If you find that some of the links don't work via Arc, or for some reason it appears in a language other than English (it does happen in the computer cluster, for some reason!) Desktop Help is also available on the web (figure 3.2) at

`http://desktop.arcgis.com/en/arcmap/`

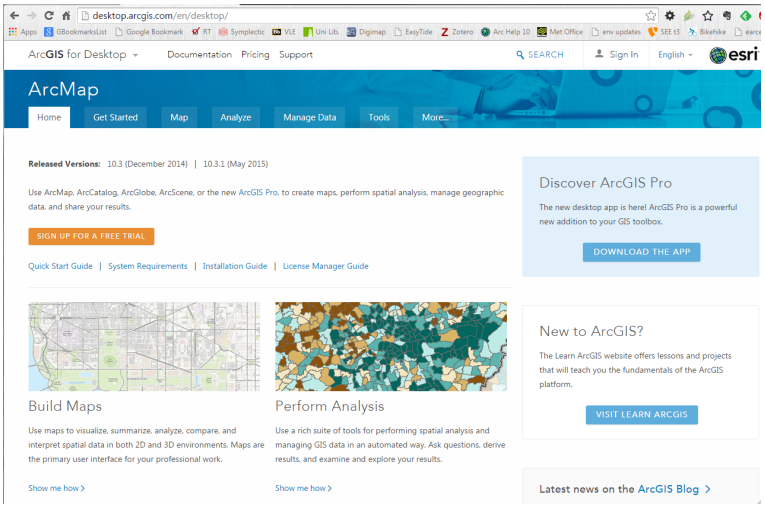


Figure 3.1: ArcGIS Desktop Help

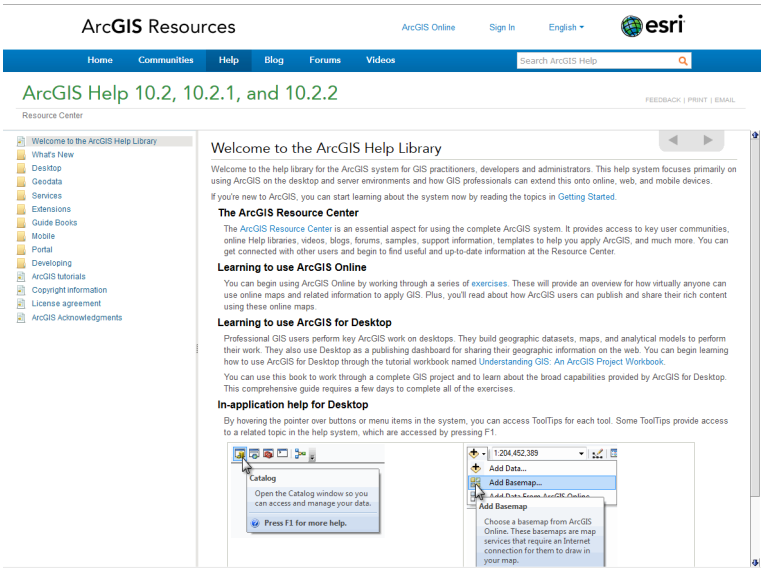


Figure 3.2: ArcGIS Desktop Help on the web

3.3 Using ArcGIS Desktop Help

- Browse by using the **Contents** tab or search by using the **Search** tab.
- There is an extensive **glossary** which can be very useful when you are wondering what a particular term means. Look for **GIS glossary** on the contents tab in the program version, or go to `http://support.esri.com/en/knowledgebase/Gisdictionary/browse` on the web.
- Look under Essentials Library » Getting Started with ArcGIS » ArcGIS Tutorials to find detailed tutorials for all sorts of tasks. (This is an area that often works better in the web version than in the local version.)

Practice using ArcGIS Desktop Help by completing the exercises below.

"Raster" and "Vector" are the two main types of data structure used in ArcGIS.

Use the ArcGIS glossary to find out what "Raster" and "Vector" mean and write definitions in the boxes below using diagrams if it will help you to remember the difference.

Question 3.1. Raster:

Question 3.2. Vector:

Video Clip available - See a video on YouTube by the Ordnance Survey about raster and vector data - `https://youtu.be/aKdRiHezuk0` (this video has sound)

Use the search (on the web) or Search tab (locally) to look for "Go To XY" and click on "Using the Go To XY Tool". This is a technique that you will find useful in future exercises. Follow the instructions there to navigate to

x = 391052
y = 463529

on the map of Malham and draw a callout at the location. (Note: measurements should be in meters).

Question 3.3. What is the name of the bridge at that location?

Chapter 4

Digimap

4.1 Introduction

Digimap is a service provided to Higher Education in the U.K. by EDINA at Edinburgh University. Digimap provides a front end to digital maps and data of Great Britain from the Ordnance Survey and the British Geological Survey. As a member of the University of Leeds you have access to maps and data for use as part of your studies.

4.2 Learning outcomes

When you have finished this workbook you will

- be aware of the UK data available to you through the Digimap service
- understand how to use the Roam browser in the Digimap Collections to make a digital map displaying a selection of features
- know how to download images and pdf maps from the Digimap Collections for printing and use in other programs
- know how to use Data Download to download data from Digimap Collections for use in GIS programs

4.3 Logging in to Digimap

4.3.1 Registering

If you have not used Digimap before you will need to register using your University id, that is the username and password that you use to access University systems. Full instructions for registering and logging in are on the Digimap help pages at

`http://bit.ly/1yQusPx`

Start by selecting **University of Leeds** and logging in with your usual University username and password. Please do not use any other email address to register - it will only cause you problems when it comes to obtaining data later.

You need to register for each collection separately, but can do it in one go. For this workbook you won't need to use all collections, but it is worth registering for all that are available to you so that you can explore them for yourself. The University of Leeds does not subscribe to Marine or Global Digimap[1].

In the **Purpose** dropdown select **Academic Works (coursework, projects, dissertations etc.)**

[1] as of September 2018

4.3.2 Logging in

To log in go to the Digimap Collections page (figure 4.1) at

`http://digimap.edina.ac.uk`

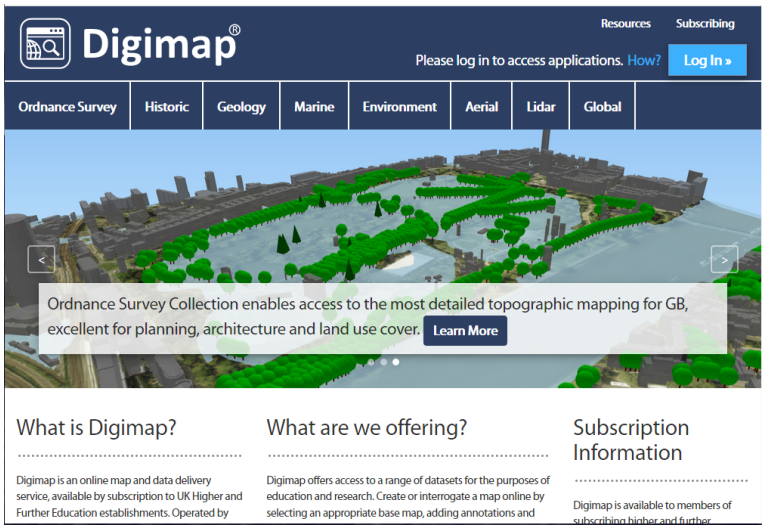


Figure 4.1: Digimap initial page

- Click the **Login** button at the top right of the screen and type **Leeds** in to the box and select the **University of Leeds** from the list of available institutions
- You should get the familiar University of Leeds login page, so type your **University username and password** into the appropriate boxes and then click the **Log in** button. If you are already logged in to Minerva you may find that you don't have to enter your login details again.

You should be taken to the Digimap initial page again (figure 4.2), but this time with your name at the top right.

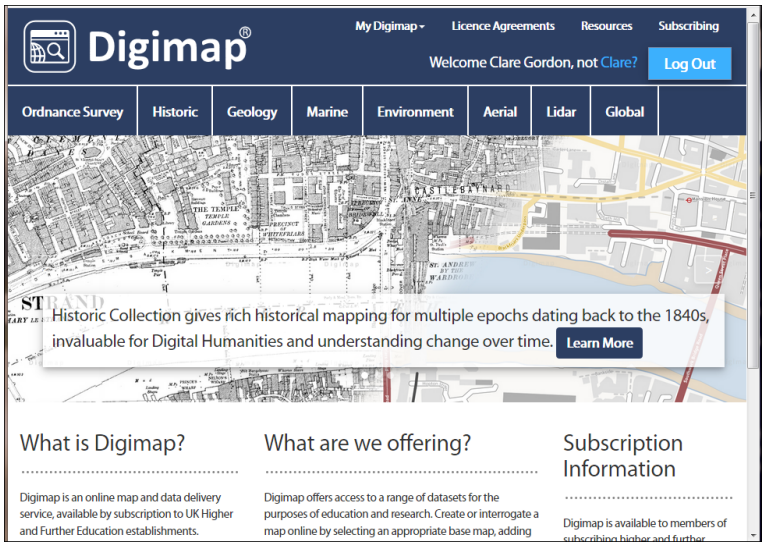


Figure 4.2: Choosing a data collection

The list includes options for a large number of collections. In this workbook we'll only be looking at the collections that are most relevant for creating the maps you'll need during your course, but if you are interested in any of the others feel free to explore them. Edina have worked to make all of the tools similar across each collection so just have a go!

4.4 Ordnance Survey Collection

We are going to start by looking at the **Digimap - Ordnance Survey Collection**. (Figure 4.3.) Click on the Ordnance Survey heading at the top of the screen and you'll be shown which services are available to you and information about the collection.

Figure 4.3: Ordnance Survey Collection

The list includes links to **Roam** and **Data Download**. We'll look at both of these in the sections below.

Roam and Download are fairly standard across all collections in Digimap (making allowances for the differences in the data) so once you've used them in the OS Collection you'll have a good idea of how they are likely to work for Geology, Aerial etc.

4.4.1 Digimap Roam

In this section you will learn how to use Roam to view and create maps using Ordnance Survey data.

- Click on the **Roam** heading.
- You may be presented with the copyright statement page.
- Read the copyright notice carefully and click on the **copyright terms and conditions link**. This launches the "Digimap: Ordnance Survey Data Sub-licence Agreement" page which shows the full terms and conditions. You signed up to these terms and conditions when you registered so make sure that you follow them. Click your browser's **back** button to return to the copyright notice, then click on the green button to acknowledge your agreement to the copyright statement.

Video Clip available - The Digimap video on Digimap Roam is available at `https://youtu.be/kSdO-2lnRGc` (this video has sound). Note that this video shows the beta version of Roam so there may be some differences.

Overview

Digimap Roam enables you to view and print maps using Ordnance Survey data at various predefined scales. PDF prints can be created in A4 or A3 size and landscape or portrait orientation. See figure 4.4 for an annotated overview of the Roam window.

Figure 4.4: The Digimap Roam window

The service is being actively developed at the moment so keep an eye open for new buttons or headings and try them out.

1. = **Map window** - Where the maps are displayed
2. = **Home** - return to the Digimap home page
3. = **Search** - enter a place name, postcode or map coordinates here to search for them
4. = **Print** - produce a printable PDF file of your map
5. = **2 up** - open a second map window - allows you to look at two different maps of the same area side-by-side
6. = **Click and drag to zoom in** - as it says!
7. = **Zoom slider** - use to zoom in and out
8. = **Zoom to max extent** - Click to zoom out to full G.B. view
9. = **current view** and **scale bar** - shows current view type and the scale on the map
10. = **Overview map** - when you're zoomed in use this to show where in the country you are
11. = **Map content** - view map legend and customise map content when possible

12. = **My Maps** - previously saved map views and content
13. = **Overlays** - Enables hill shading at certain levels of zoom
14. = **Drawing tools** - Tools to create annotations, import your own data, or export data in various formats
15. = **Measurement tools** - Tools to measure distance and area
16. = **Map information** - current map product, data licence, date of map and other essential information
17. = **Basemaps** - Enables different map styles at certain levels of zoom
18. = **Opacity** - slider to change the transparency of the basemap

Searching for a location

You can search for a location in Roam by using a place name, postcode or grid reference.

To search using a **place name**:

- Type the place name (for this example type **Leeds**) in the search box and press Enter or click on the magnifying glass button.
- If there is more than one match for your place name the search results will be displayed below the search box - see figure 4.5. Click the place name that you are interested in to view it in the map window - in this case click on **Leeds (Leeds)**.

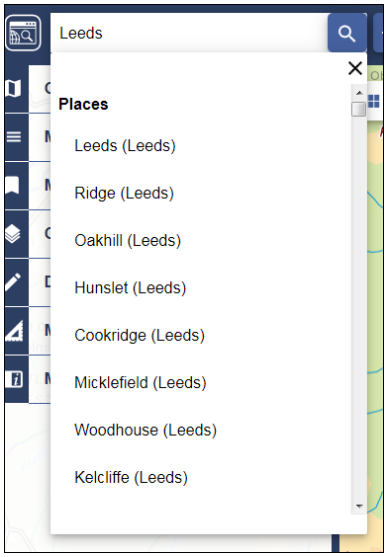


Figure 4.5: Search box and results of a search for “Leeds”

You’ll need to click on the cross on the search results to close the list but when you do you’ll lose the marker showing the centre of your search area.

To search using a **full postcode**:

- Try searching for the University postcode - **LS2 9JT**. Roam should take you straight to the centre of this postcode area.

To search using a **Grid Reference**:

- Type the grid reference, e.g. **SE4435** in the **Grid Reference** box and click **Find**. Roam will automatically navigate to that location.

Navigating in Roam

You can navigate in Roam by panning (moving the map in any direction by dragging it with the mouse) and by zooming in and out of the map.

To zoom in/out of the map you can:

- Double click to zoom in
- Use the zoom slider bar to zoom in or out either by clicking on the **+** and **-** signs or dragging the blue marker on the bar.
- Or click anywhere on the slider bar to zoom to that scale.

Map views

Roam has at least 13 pre-defined map scales, called **views**. The views consist of different Ordnance Survey map products which are appropriate for each view's scale (e.g. the Street view uses the VML (VectorMap Local) raster). once you have found your location of interest you can zoom in and out to find the appropriate view for your map.

The name of the view you are looking at appears in the bottom right of the map window, e.g. **City view**.

Search for the postcode LS2 9JT (The University).
Question 4.1. What view does Roam take you to when you click on "Find"?

Zoom in and out and notice the way that the map content changes between views. Pan around and explore an area of your choice.

Controlling map content and basemaps

In some of the views in Roam it is possible to customise which features are displayed on the map - e.g. display only A class roads and/or railways.

To customise the map view:

- Zoom to **Neighbourhood view** - the type of view is shown in the bottom right of the map.
- Click on **Basemaps** (top left of the map window) and select **VML Streetview**[2] See figure 4.6
- Click the **Map Content** tab in the task menu panel. The map content panel contains a list of the feature types that are included in the map so it can also function as a key.
- Switch features or groups of features (such as all roads) on and off by checking or unchecking the tick box next to the feature name.
- All features can be switched off by unchecking the **Clear/select all layers** tick box. **N**B: clearing all layers will result in a blank map, so remember to switch at least one layer back on!

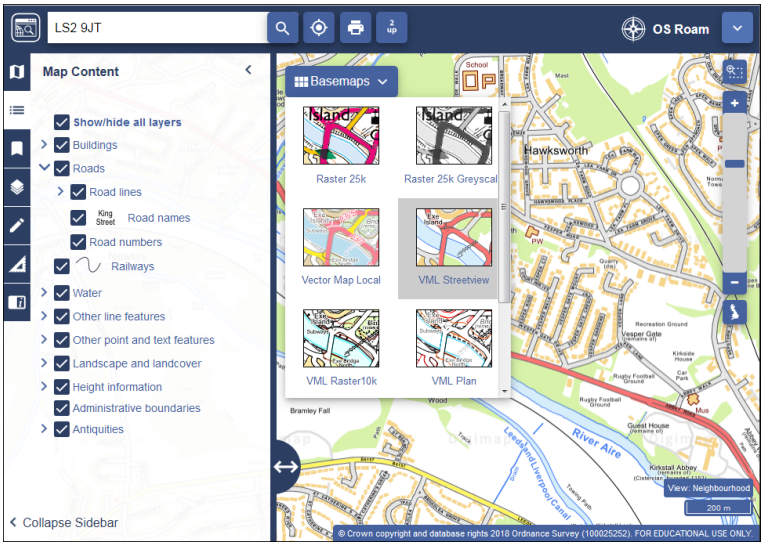


Figure 4.6: Choosing a basemap in Neighbourhood view in Roam. Note the tickboxes next to the features for the VML Streetview basemap.

Note: Many other views cannot be customised because the Ordnance Survey data used in these views are in raster data format which do not allow selection of features. You will still be able to see the features listed in the map content control panel but there won't be tick boxes next to them.

Question 4.2. Name some other view and basemap combinations besides Neighbourhood >> VML Streetview that allow you to select content?

Using the measuring tools

Roam provides tools for measuring distance and area.

- Click on Measurement Tools on the sidebar to open them (figure 4.7).
- Click on the first button - **Measure Distance**.
- Click on the map to start measuring, click for each corner, then double-click to stop measuring. The measurement in metres will appear on the toolbar as well as on an overlay on the map.

Question 4.3. Use the Measure Distance tool to measure your route to the University. How far away do you live?

[2]VML stands for VectorMap Local and refers to a particular Ordnance Survey product which is used in many of their web mapping applications.

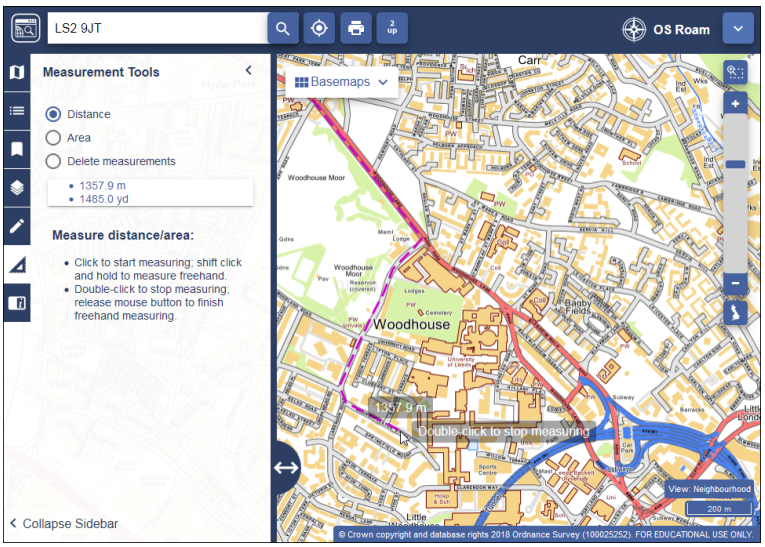


Figure 4.7: Measurement tools - click on the map to start measuring, double-click to stop

In a similar way try out the **Measure Area** tool.

Try very roughly to measure the area of Woodhouse Cemetery (now disused and known as St George's Fields) which is just north of us here in Earth and Environment.

Question 4.4. What is the area of Woodhouse Cemetery?

Using the drawing tools

Roam has a set of drawing tools that allow you to draw on a map and add labels. This is particularly useful for marking up maps for reports or to show people where you are working.

Video Clip available - The Digimap video on Annotating maps with Roam is available at `https://youtu.be/GeFa2Er1Z9M` (this video has sound)

- Click on Drawing Tools on the sidebar - the Drawing Tools panel should open (figure 4.8).
- Explore the tools and scribble all over your map! There is a **Delete All** button so you can clear everything when you have finished, or you can toggle visibility so that you can turn the annotations off without losing them.

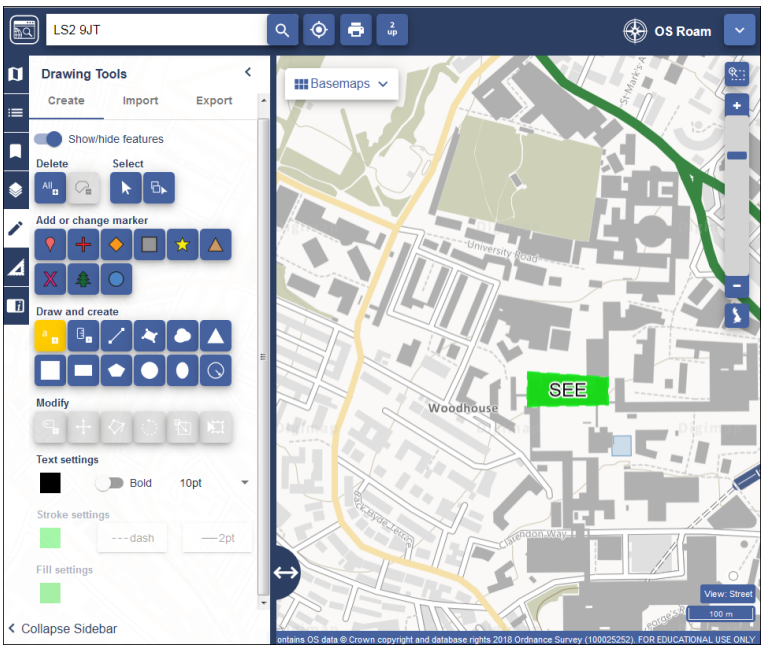


Figure 4.8: The Drawing Tools panel

Return to the University (LS2 9JT) and check that the view is set to Street View.

Use the drawing tools to draw a box with a red line around the Earth and Environment building (i.e. this building!) and label it "SEE" in bright green.

Exporting annotations

It is possible to save your annotations or drawings to file. This is particularly useful as one of the options is Shapefile which can be directly opened in ArcGIS, and another is kml which can be opened in Google Earth.

- Click on Export on the Drawing Tools panel, (figure 4.9) give your file a name that will help you identify it again later and select a file format:
  - **Shapefiles** can be opened in most GIS software
  - **KML** will open in Google Earth
- Then click on Export to save the file to disk

Printing from Roam

Roam allows you to create printable PDF (Portable Document Format) maps or export jpg or png images in A4 to A0 size and in portrait or landscape layout. The image formats make it possible to import maps into Word or Powerpoint.

You won't be printing directly from Roam, really this is more of an **export** function.

Using the map that you were looking at in the previous exercise create a pdf map which you'll save to your M:/ drive. You don't need to print it unless you particularly wish to.

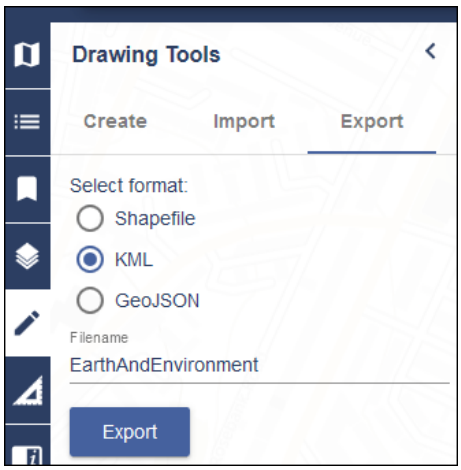


Figure 4.9: Saving annotations to file in Roam

Video Clip available - The Digimap video on Printing Roam maps is available from `https://youtu.be/mPZOyGp75h0` (this video has sound)

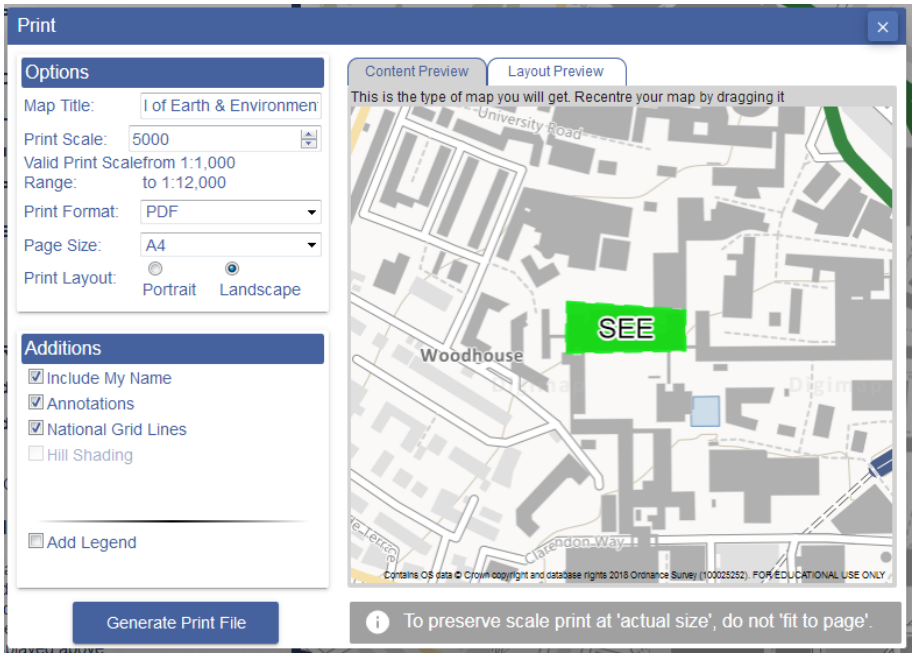


Figure 4.10: Printing to pdf or image file from Roam

- Click the **Print icon** at the top right to open the print options in a new browser window (figure 4.10).
- Enter a map title in the appropriate box.
- Click to add National Grid Lines.
- Select the page size and layout using the drop down menus.
- Look at the **Layout Preview** tab to check that the area that you want will be printed and move the map, or rescale it if you need to
- Click **Generate Print File**, depending on your choice this will either produce a PDF file which

you can save or print, or an image file that you can include within other documents.

See section 4.7 on page 50 for information on how to print and edit PDF files.

Saving map views for future use

Once you have set up a view and, maybe, added annotations, Roam allows you to bookmark it so that you can go back to it later.

- Click on My Maps on the sidebar
- Click on Save and give your map a name that will help you to identify the map later then click Save on this screen.
- Next time you want to use that map click on Open and open it from the list that appears there - figure 4.11.

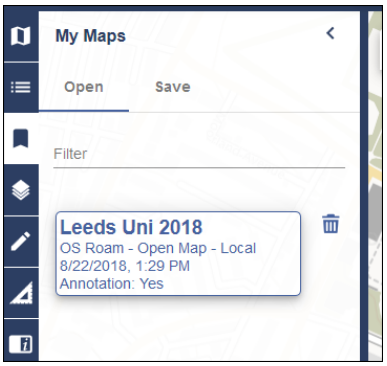


Figure 4.11: My Maps

4.4.2 Data Download

Data Download is a tool for downloading Ordnance Survey data for use in GIS or CAD software. The format that the data is delivered in will determine whether you will be able to open it directly in a software package or whether you will need to convert it.

We'll be using data from Digimap in ArcGIS later in the module so you need to know your way around this section. Instructions for converting, importing and viewing file types that need it will be given during the ArcGIS part of the course.

Selecting your Ordnance Survey data

- Go to the Digimap home page
- Click on **Ordnance Survey** in the menu at the top of the page
- From the Ordnance Survey page choose **Data Download** (Figure 4.12.)

Data download takes you to a map that looks very similar to Digimap Roam but with some important differences.

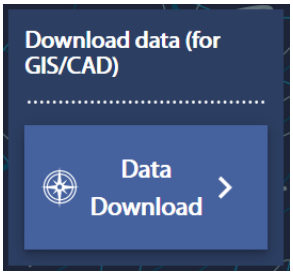


Figure 4.12: Data Download

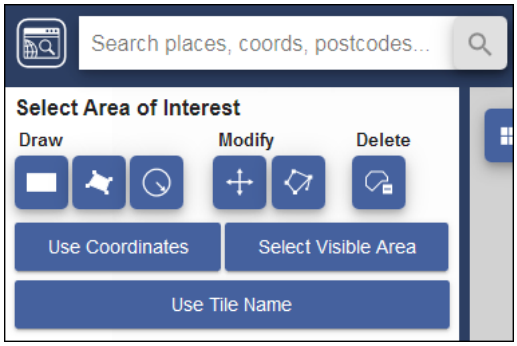


Figure 4.13: Search for & select an area

Selecting an area

On the left there is a menu panel with options for selecting an area with a search box above it (figure 4.13).

- Click in the **Search** box and type **University Road, Leeds**, then press Enter or click on the magnifying glass to search.
- When you get the results click on **Roads (100+)** then select **University Road (University - Leeds)** to zoom in then close the search results.
- Under **Draw** click on the rectangle and use the mouse to draw a box around part of the University, clicking to start and finish the box. (Figure 4.14)

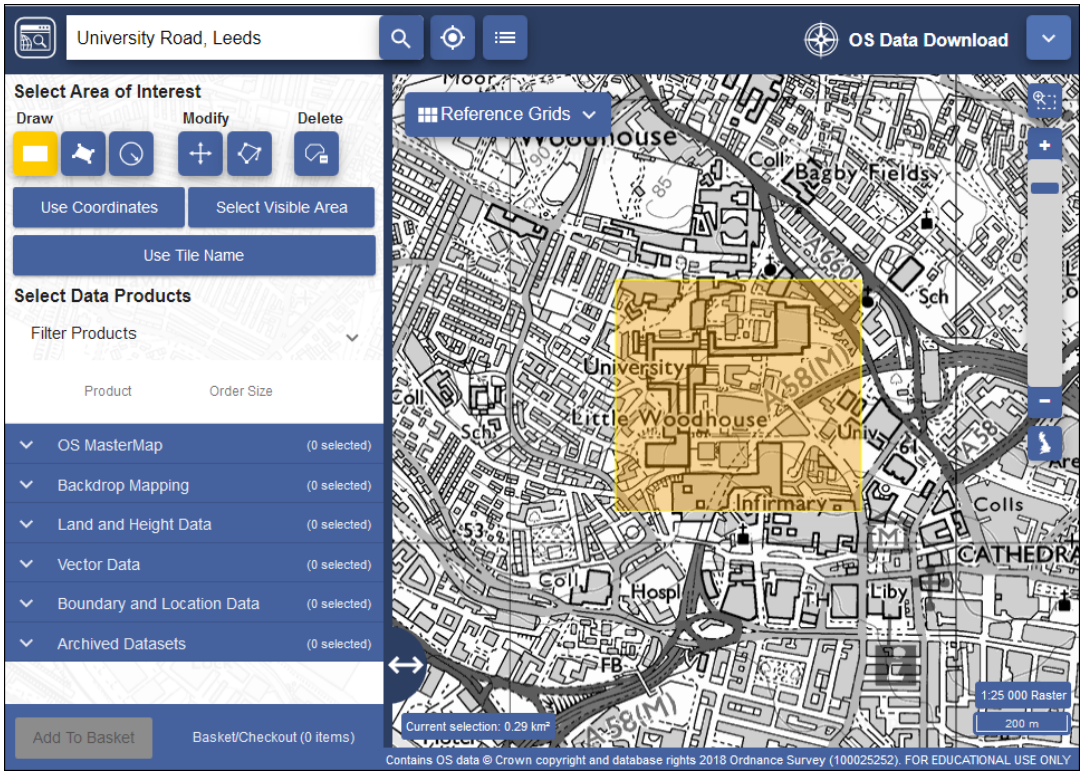


Figure 4.14: Selecting an area in Digimap Download

Note: The map that you see on the screen only shows the area that you will be downloading data for, **not** the actual data that you'll be downloading. You'll select the data separately so don't worry what it looks like for now.

Selecting data sets

Now that you've selected an area you have to select the data that you need.

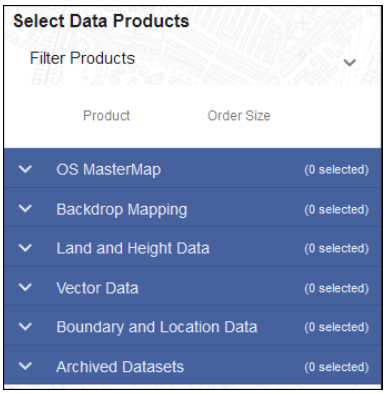


Figure 4.15: Select products from the list

- Back in the panel on the left, under **Select Data Products**, drop down each of the headings in turn. (Figure 4.15.)
- There are a lot of different data sets here and most of them won't mean anything to you. For now select the following datasets when you find them by putting a tick in the box next to them.

> ***Backdrop mapping: VectorMap Local Raster***
> ***Land and Height data: OS Terrain 5 Contours***

You can get more information about the datasets by clicking on the arrow next to them. This includes information on licences.

The figure on the right in brackets under **Order Size** shows how many tiles your selected area uses out of the maximum downloadable number.

- When you have selected the data you require click on **Add to Basket**. (Don't worry - despite the Shopping Basket and Checkout you won't be charged. The University has already paid the subscription!)

Your basket should appear with details of your order. (Figure 4.16.)

- Some datasets will give you an option to change the format (highlighted in yellow). In this case click on **Select Format** next to the contours. The choices are **Shape**, **GML3** or **DWG**. Choose **Shape** in this case.
- You may also need to select a theme - for the VectorMap Local Raster there is a choice of themes - pick whichever one you like this time!

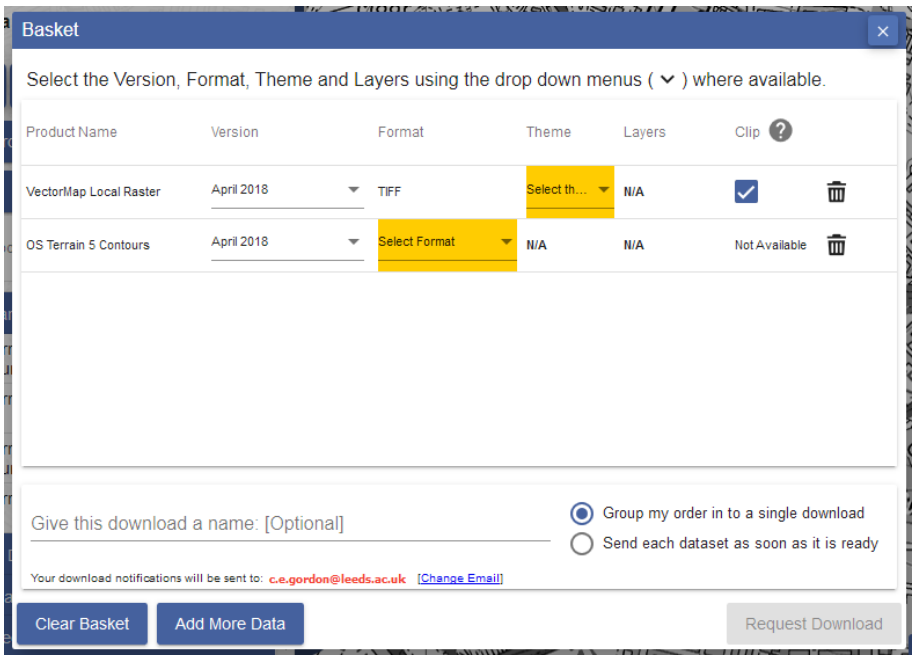


Figure 4.16: Details of your order in the Basket

- Some items will have a **Clip** option. This means that the data will be sent to you clipped to the area outline that you requested. If you are really short of disk space this could be useful, but it doesn't usually hurt to have extra data around the outside of your study area. I prefer to untick this box and download full map tiles.
- Give the order a name, e.g. **Leeds**. This will be part of the file name of the zip file that you download so try to make it short but helpful!
- Click on **Request Download**.

Downloading your data

You'll receive an email confirming your order, then another with a download link. Make sure that you are still logged on to Digimap before you click on the download link (figure 4.17).

Figure 4.17: The download link in the email - click on this not on any of the other links in your email!

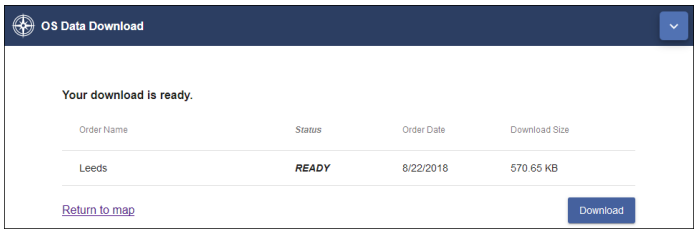


Figure 4.18: Order ready to download

Once you have clicked on the link a window should open telling you that your order is ready to download (figure 4.18).

- Click on **Download**.
- You'll download a zip file. **NOTE:** Don't run or open the file directly from your browser, and make sure that you **DON'T** save your zip file to a **temp** folder where you will probably be unable to unzip it.

Make sure that you remember where you have saved the zip file.

Now open **My Computer** and navigate to the location where you saved the zip file. Right-click on the compressed map data file that you downloaded and choose 7-zip ⟩ Extract files... . Select where you want to save the extracted files, and make a note of where you save them to. You should end up with a folder for each dataset that you requested.

Viewing your data

In this case the files that you have downloaded are either tiff graphics files or shapefiles. Navigate to the downloaded folder called something like `vml-raster_746810▸se` (your order number will be different) and look at the contents. Open one of the .tif files from the VectorMap Local Raster download by double-clicking on it. These files should open in a graphics program. In future classes we'll be using these in our own maps. Try opening one of the .shp files too. It's unlikely that you will be able to. These are a specific format for use in Arc and other GIS programs and we'll look at that in the ArcGIS sessions[3].

The download facility includes a lot of different formats and products, but the basic method of download is the same for all of them. The challenge tends to be in knowing how to use them once you have downloaded them and you'll be looking at that in future sessions.

4.5 Geology Digimap

Geology Digimap gives you access to British Geological Survey (BGS) data, if you use Geology Roam it is on a background Ordnance Survey maps.

4.5.1 Geology Roam

Geology Roam works in a similar way to the Digimap Ordnance Survey Roam so you may find that some of this seems familiar.

Video Clip available - The Digimap video on Geology Roam is available at `http://bit.ly/1y191L7` (this video has sound). Note that this refers to an older version of Geology Roam.

If you are already in the Ordnance Survey section find the **Digimap home page** by clicking on **Digimap Home** at the top left of the screen.

From the Digimap home page click on the Geology heading and click on **Geology Roam**.

The Geology Roam map window (figure 4.19) is basically the same as the Ordnance Survey Roam window.

Geology Roam is very similar in functionality to the Ordnance Survey Roam, so the buttons and task menu should be familiar to you from the previous sections.

- Open the **Search** menu and enter the University of Leeds postcode - **LS2 9JT** - into the postcode search box, then click on **Find**.

[3] Note that there may also be other files in the VectorMap Local folder with a **.tfw** extension. These won't open in any program but, if present, are essential for using the tif file in GIS programs such as ArcGIS, so make sure that you keep this together with the tif file.

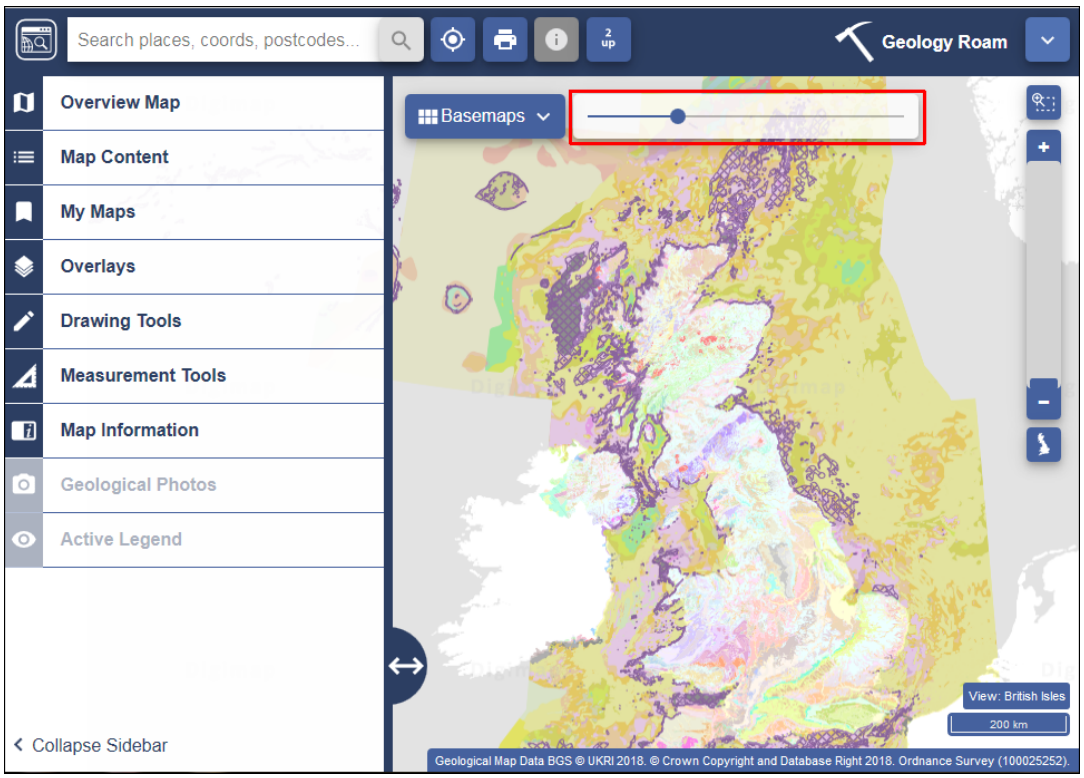


Figure 4.19: Geology Roam map window

- As in OS Roam use the controls to change scale and level of detail.
- One feature that is different from OS Roam is the slider at the top of the map window (outlined in red in figure 4.19). Try sliding it and see its effect on the transparency of the geology over the topography.
- use the Basemaps menu to load different geology layers, for example, in the more zoomed in views try changing the 1:50 000 geology so that it shows **rock types** instead of **rock units**.

Controlling map content

- Once you have a geological map of the area you require click on the **Map Content Control** tab (figure 4.20). This will give you a key to the area shown in the current map and a way to control the visible layers.
- Try turning off the **Superficial Deposits** by unticking the box next to that heading and see what difference it makes to the map. You may have to be patient if you can't see the geology at all for a minute or so - it should return eventually! Try the same with **Artificial Ground**
- To find out what geology is present in a particular area click on the button for the **Feature Information** tool on the toolbar at the top...
- ...then click on the unit on the map that you want to find out more about. A box will appear showing basic details for all of the layers underneath the cursor (figure 4.21), plus the National Grid coordinates. The features selected in the list at the left of the box will be outlined on the map.

Question 4.5. What is the Bedrock geology underneath the School of Earth and Environment?

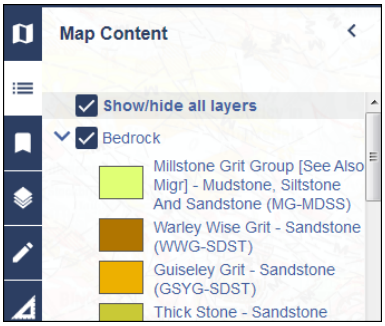


Figure 4.20: Map Content Control

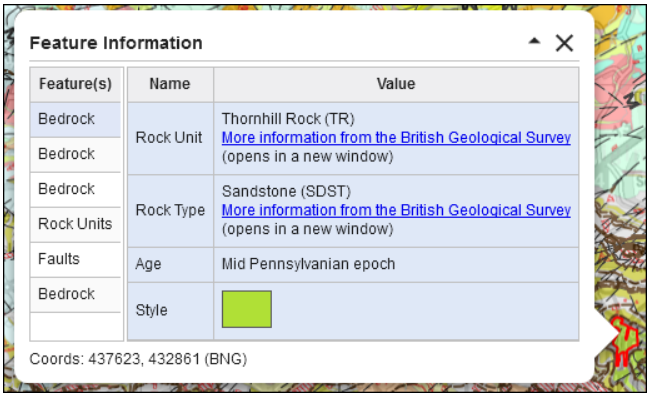


Figure 4.21: Feature information

Geological photographs

The geological photos panel adds icons that open photographs from the BGS photo archive. These include a caption with information about the geological features that they show.

Currently there are no geological photos available for the Leeds area. Search for and go to **Malham Cove** on the map and then click on Geological Photos in the side panel.

You should see lots of “camera” icons appearing on your map - figure 4.22.

Click on one of the icons to see a thumbnail. Click on that to see the large photo and more details (you may need to scroll down to see explanatory text).

Alternatively open out the **Geological Photos** list on the left-hand side of the screen and click on items in the list there.

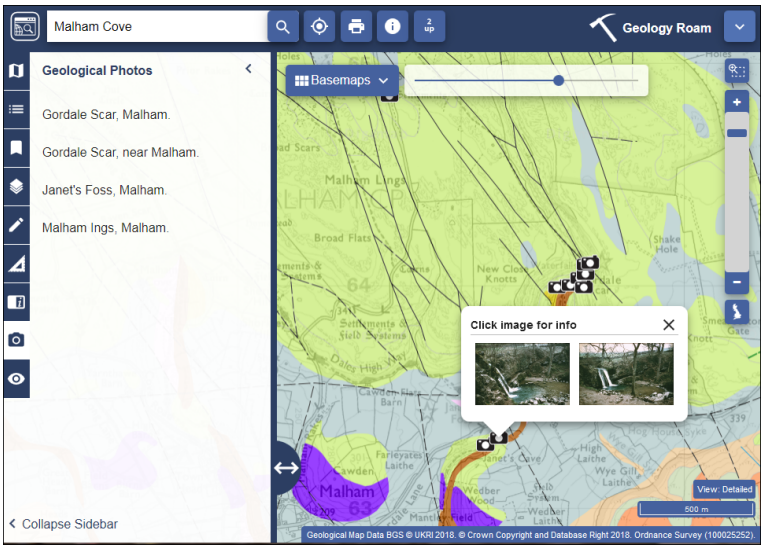


Figure 4.22: Viewing geological photographs

Printing from Geology Roam

Printing from Geology Roam means that you produce a file which you can save to print later if you wish, or include in another document.

- Click on the **Print** icon. The print dialog will open in a new window (figure 4.23).
- Fill in a map title
- Select the **print format** that you require - pdf for printing, png or jpg for importing into other documents - and whether you want to print in portrait or landscape format.
- Select the **Page Size** that you require.
- Note that the extent shown on the preview will not necessarily correspond with the extent that will actually print out - you can check that on the **Layout Preview** tab.
- Select whether you wish to include **National Grid lines** or **Rock Code Labels** (the labels are useful if you add a legend, but are rather obvious on the map).
- Select **Add Legend** if you want to generate a separate legend. If you choose this then your output will be two files inside a zip file.
- Click on **Generate Print File**, this will produce a file which you can then save or print.
- See section 4.7 on page 50 for information on how to print and edit PDF files.

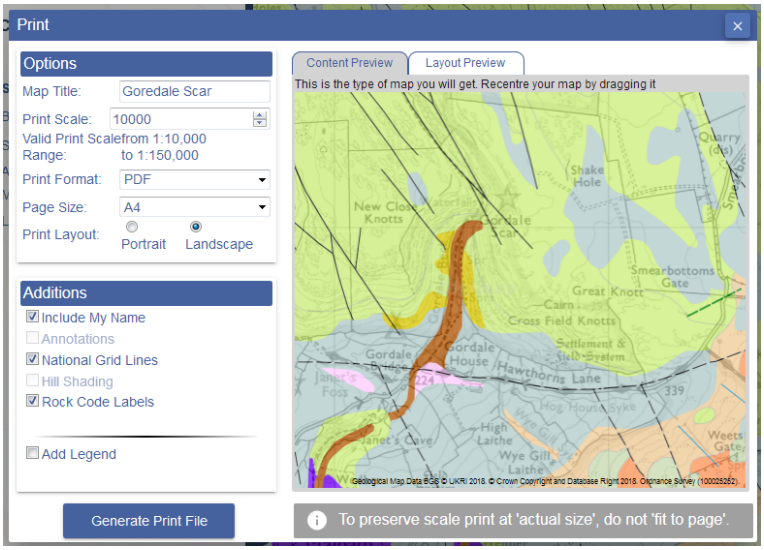


Figure 4.23: Geology print dialog

Other features of Geology Roam

In addition to the features listed above Geology Roam allows you to make annotations, measure distance and area, save and open maps, and save annotations to file in exactly the same way as Ordnance Survey Roam. See the notes in section 4.4.1 from page 29 for more information.

4.5.2 Geology Download

Geology Digimap also gives you the opportunity to download tiles of geological data to add to your own maps. We'll download some data now, but it is delivered in a format that has to be opened in a GIS program and you'll find out how to do that later in the workbook.

Video Clip available - The Digimap video on Geology Download is at `http://bit.ly/1xssnUC` (this video has sound), again, this refers to the older version.

- Click on the **Home** button in the top left-hand corner of the screen to return to the Digimap home page.
- Click on **Geology** in the menu at the top, then on **Geology Data Download** to bring up the map for selecting downloads.

Geology Download works in the same way as Ordnance Survey download, but of course, you have a different selection of layers to download. So start by selecting the area you require - using **search** and then the rectangle tool under **Draw** to outline the correct area.

Search for "Malham Cove" and outline a small area around that.

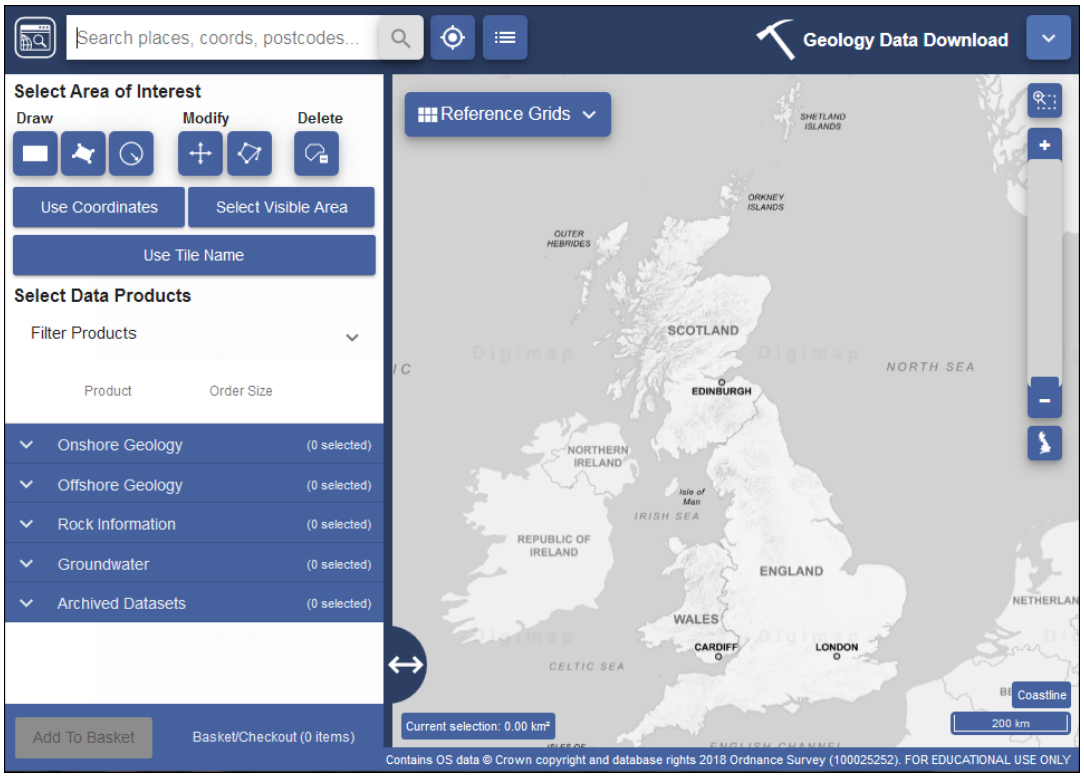


Figure 4.24: The Geology Download interface

You then need to select the data sets that you are interested in from the panel on the left. Usually you'll want layers from the **Onshore Geology** section.

To find out whether there is 1:10 000 or 1:25 000 coverage of the area that you are interested in click on the grid symbol next to the layer in the Selection panel.

If there is data available the tiles will then be highlighted and you'll be able to see the tile names too. If you've zoomed to Malham Cove there won't be anything visible.

Click on the grid icon next to 1:50 000 Geology, then zoom out. You should reach a point where you can see the outlines of the tiles of data.

Question 4.6. What is the Tile Name for 1:50 000 data at this location?

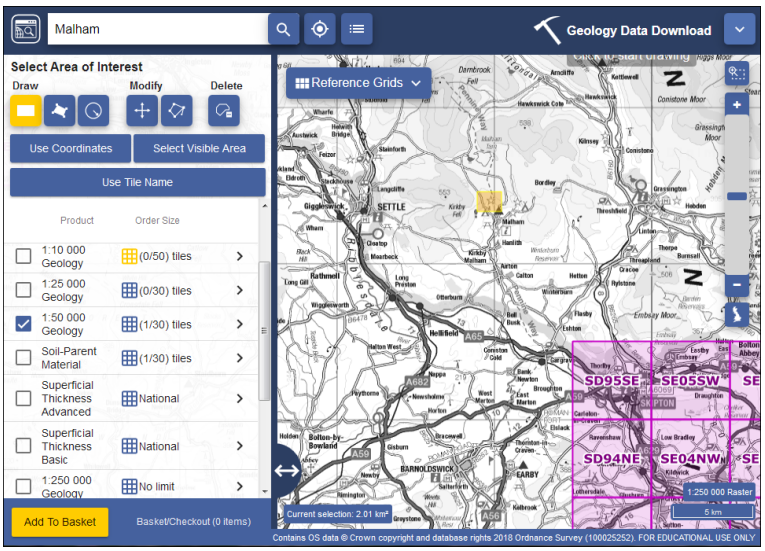


Figure 4.25: Finding out the availability of geological data: the shaded areas in the south east of the area around Skipton show 1:10 000 tiles which are available for this area. There is by no means full coverage of either 1:10 000 or 1:25 000

In this case

Select 1:50 000 Onshore data and don't forget to add it to your Basket. Once you've done that go to Checkout where you will be able to choose the format for your data, and when appropriate, the layers (figure 4.26).

The format choices will be either **SHAPE**, **MIFMID** or **TAB**. Shapefiles are opened in ArcGIS (and many other GIS programs) so once you have completed the rest of this module you will have the knowledge to open the downloaded files in Arc, but for now just be aware that the data is available. Mid/mif format opens in MapInfo - another GIS program which is also available within the university but which we won't be covering here.

4.5.3 Geological maps in the School of Earth and Environment

The geological maps that are available through Digimap are also available in paper form by speaking to Clare Gordon in the Kennedy Library (C.E.Gordon@leeds.ac.uk).

The paper geological maps still provide more information than the digital service, such as cleavage and bedding, and complete legends.

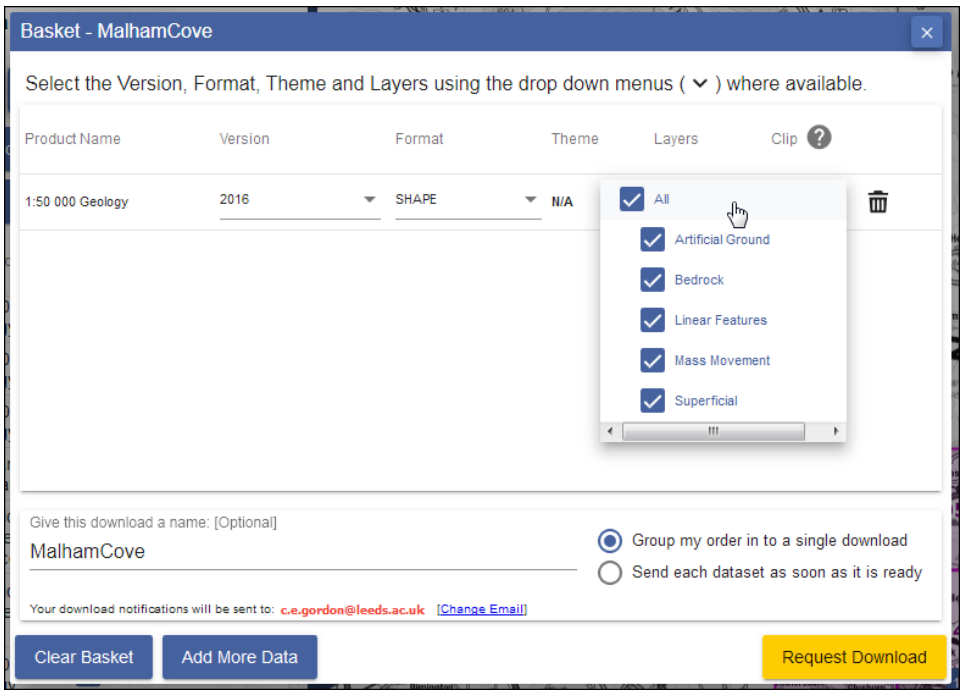


Figure 4.26: Format and layer options for downloading geological data

4.6 Aerial Digimap

Since 2016/2017 Digimap has given access to 25cm resolution aerial imagery from Getmapping. This is a fantastic resource and enables you to see a great deal of detail. It's well worth downloading imagery for your field areas. As in other collections in Digimap, you have a choice of Roam or Data Download and these work in a similar way, so refer back to the previous sections if you need a reminder, but there are inevitably some differences because of the different nature of the data.

4.6.1 Aerial Roam

From the Digimap home page click on the **Aerial** heading and then on **Aerial Roam**

The Aerial Roam map window is basically the same as the Ordnance Survey Roam window and the functionality is very similar so I won't go through it all here.

- Open the **Search...** menu and enter the University of Leeds postcode - **LS2 9JT** then click on **Search**
- You should be taken to a view which looks something like figure 4.27

Note that the imagery isn't available to browse at all zoom levels. Look at the bar on the right of the window (figure 4.27) and you'll see that the most zoomed out levels are labelled **OS**. As you zoom in closer the map will change to imagery.

Zoom in and out and move around the map to see what is available.

Opacity and viewing place names and roads

You can use the opacity slider at the top of the screen (above the zoom control) to allow the map to be shown through the aerial photograph.

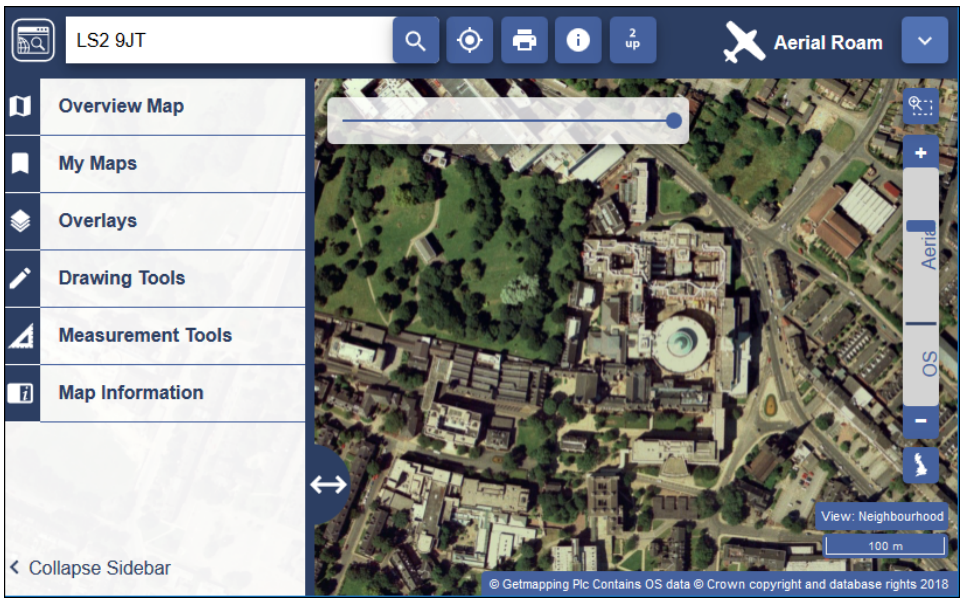


Figure 4.27: The Aerial Roam window

If you don't want to make the aerial layer transparent, but do want to be able to see the names of places and the roads, click on Overlays > Road/Place names in the sidebar. This is a toggle, so do the same again to switch the names off.

Finding the date of the imagery

If you have searched for **LS2 9JT** and are looking at a view of the University, move the map so that you can see the SEE building. There is a lot of building work going on around the University so it would be useful to know when the imagery was taken to have some idea of how much is likely to have changed since. To find out the date it was flown do the following:

- Click on the **i** for information button at the top of the screen (next to the Overlays)
- Now click somewhere on the map, close to the SEE building.
- You should be shown a panel with the Tile name, Date Flown and the eastings and northings of the location that you clicked - see figure 4.28

In 2000 the company Getmapping flew aerial imagery for the whole of the UK - which is extremely impressive given that they were obtaining high resolution, cloud-free data. For how many days in the year is the UK completely cloud free?

Most of the data available in Aerial Digimap has been flown much more recently.

Note that when you click on the map for information you are also shown a red outline for the tile that you have clicked on. You may need to zoom out and move the Tile Name dialog out of the way to see this.

Search for the following British National Grid easting and northing using the search box:

- ***289576, 812418***

Question 4.7. What is the Tile Name at this location, and on what date was the aerial imagery at this location flown? As a bonus, what town is this point within?

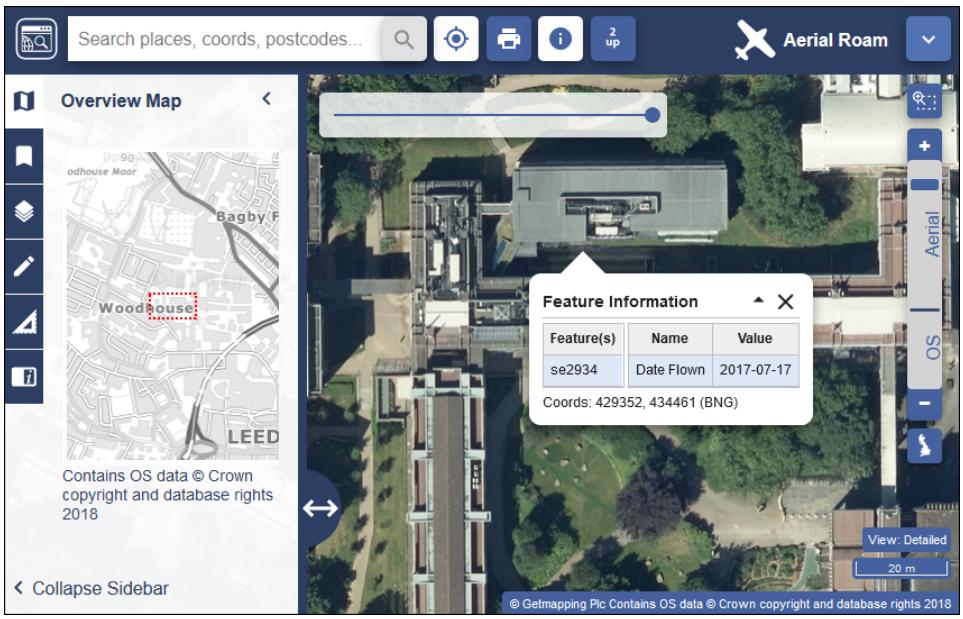


Figure 4.28: Information about the tile of aerial imagery, including the date that it was flown

4.6.2 Aerial Download

Return to **Digimap Home** and now select

- **Aerial** and **Aerial Data Download**

As with the other download interfaces the map that you see on the screen is only an indicator of the area that you will be downloading, it is not the actual data.

Use **Search** to go to British National Grid coordinates **254042, 271408**. You'll see that this is a coastal area of Wales with a rocky foreshore. Use the **Rectangle** tool to draw a rectangle around a small part of the rocky coast. These imagery downloads can be very large so for now just pick a very small area, at the bottom right of the map you can see the size of your current selection in km^2, try to go for something of about 0.25 km^2.

- Go to **Aerial Imagery (Latest)** in the panel on the left and put a tick in the box next to **High Resolution (25cm)**
- The number in brackets after this shows how many tiles you have selected to download out of the maximum of 100. If you have selected to download more than 4 files then I'd suggest that you outline a smaller area just for the purposes of this exercise.
- If you click on the arrow next to the dataset you are given more information about it, including the recommended copyright acknowledgement. Make a note of this and add it to any document or map that you create with this data.
- Now click on **Add To Basket** and give your download a name, then **Request Download**

This works in exactly the same way as OS and Geology download, so having requested the data you need to wait for an email which contains the download link. Once you have this, download the data, move it to your M: drive and **unzip it** (Right-click on the zip file - 7-zip > Extract here).

View the files in ArcGIS

You can open the jpg files in a graphics editor if you want a quick look at them, but for our purposes it makes more sense to add them to a map.

- Open ArcGIS, set up a new map and add the jpg file(s) that you have downloaded.
- You should be able to zoom in on an area of the rocky coast and have a look at the amount of detail that is available
- The files are georeferenced so can be used alongside map tiles from Digimap Ordnance Survey download
- If you are using this in a map for coursework or your dissertation, or indeed for showing to anyone else, don't forget to add the correct copyright acknowledgement.

Using aerial imagery for fieldwork

If you are setting up a map for geological fieldwork in an area of the UK it is well worth downloading this data and creating a set of aerial images too. Data may be available for other countries but it won't be downloadable via Digimap. If you can't find any aerial imagery for your area try searching for **World Imagery** in ArcGIS Online or the basemaps and add that to your map. It won't be as detailed as 25cm resolution, but will be better than nothing.

4.7 Printing and editing PDF files

4.7.1 To print

PDF files can be viewed and printed in any PDF reader, such as Adobe Acrobat Reader.

- From **My Computer** double-click on the pdf file and it should open automatically in the default reader.

For your own computer there are a lot of different programs that will read PDF files. See the list at

`http://en.wikipedia.org/wiki/List_of_PDF_software#Viewers_4`[4]

4.7.2 To edit

PDF files can be edited in Adobe software such as Photoshop and Illustrator, and in CorelDraw. It is also possible to edit files in Inkscape. Open the file as follows -

- File » Open » OK.

[4] Last accessed: 17th September 2019.

4.8 Copyright acknowledgements for Digimap data

Copyright is important. Remember that most data providers ask you to sign up to conditions that include an obligation to add a copyright acknowledgement to your map. Check what that copyright statement is and add it.

e.g. when you signed up to use the Digimap collections you agreed to add copyright acknowledgements whenever you created a map with the data. These do change from time to time so it's worth knowing how to check it for yourself.

- To find these copyright acknowledgements go to the **Digimap Resource Centre** (**Resources** at the top of the main Digimap page)
- Look for a link to **Digimap Licence Agreements** and click on it.
- Click on the End User or Sub-licence agreement for the data that you've used
- then look for the information under **In return, you must:** - that gives you the acknowledgement text.

For example, as of April 2019 when you use Ordnance Survey data obtained from Digimap you are expected to add the following text to your map.

> ***© Crown copyright and database rights*** `year`***. Ordnance Survey (100025252).***

Where *year* is replaced by the current year.

Remember that you do have to acknowledge each different dataset that you use and will have signed up to that when you registered.

Adding the copyright symbol to your text
To add the **copyright symbol** - ©- to your text • check that the Num lock is on on the keyboard • hold down the Alt key • use the number pad to type 0 + 1 + 6 + 9 • release the Alt key

Table 4.1: Adding the copyright symbol to your text

If you are *not* using U.K. Ordnance Survey data this is **not** the correct copyright acknowledgement to use, for example if you are using data for Spain or the United States, or indeed UK data that you haven't downloaded from Digimap. You'll need to find the correct copyright acknowledgement for yourself. The web page[5] at `http://bit.ly/1ZSifnd` gives some information about how to cite GIS materials - including the software as well as the data. Have a look at that and follow the suggestions to cite non-Digimap data.

Advice on citing Digimap data, as opposed to the copyright acknowledgement is at `https://digimap.edina.ac.uk/webhelp/resources/citation/services.html`

[5] Last viewed: 18th September 2018

4.9 Further help with Digimap

4.9.1 Additional Digimap collections

This booklet has only covered the basic collections from Digimap. The University of Leeds also subscribes to Geology, Aerial, Historic and Environment collections.

All of the collections have a Roam and a Data Download interface which work in a similar way to the examples you have used.

You have access to all of these collections, feel free to have a look at what is available and make use of any of the data or maps in your work.

4.9.2 Digimap Collections online help

Digimap help is available from both the Digimap Ordnance Survey and Geology home pages. Click on the links in the left hand menu for more information about how to use the services and file formats.

Alternatively use the Help links from within Roam or Download or use the videos that Edina have uploaded to YouTube at -

`http://www.youtube.com/user/EDINADigimap`[6]

If you want more detailed information Edina provide e-learning units which are linked from the main Digimap home page.

4.9.3 School of Earth and Environment

Clare Gordon can provide help and advice on using Digimap. Contact her in room 10.140b at the back of the Kennedy Library or on **c.e.gordon@leeds.ac.uk**.

The most up to date edition of this workbook will be available in Minerva for those modules on which it has been used.

[6] Last accessed: 29th August 2019

Chapter 5

Creating a topographic base map

Now that you've been introduced to the basic concepts of using ArcGIS you are going to start putting together your own map from scratch. You'll start by downloading data from Digimap and finding out how to process some of it so that you can open it in ArcMap.

5.1 Learning outcomes

When you have completed this section of the workbook you should be able to

- Use the conversion tools provided with ArcGIS to prepare Ordnance Survey data for further use.
- create a 1:10 000 topographic base map that is suitable to use for geological field mapping and as a base for adding data to ArcMap
- demonstrate how to update symbology and add basic labels to layers in your map

5.2 Data to download

You will need to download topographic data from Digimap before you can create a base map in ArcMap. For a 1:10 000 map we have to download the raster topographic maps and the vector contour files separately as Digimap does not provide these as one file.

- Create a folder called **ingleton** within your gis folder.
- Use that folder to store all of the data you download for this exercise, as well as any files that you create yourself.

Download the following datasets from Digimap using the Ordnance Survey download service.

You'll need the data for at least the area shown in figure 5.1 - search for Ingleton (North Yorkshire). If you need a reminder of how to download OS data from Digimap refer back to section 4.4.2 on page 37.

Note on colour choices for background
• When you download the raster topographic maps for the UK from Digimap the basket gives you a choice of colour formats between black and white; faded; and full colour. It's worth downloading and trying them all. You may also have choices for mapping areas outside of the UK. • If you are creating a field slip to take into the field and map onto then you can choose which will be the best background for your markings, colours etc. It varies from area to area so you may want to discuss this with your mapping supervisor (show them examples!) • For your final top copy map with the digitised geology on top use the **black and white** version so that the geology shows clearly. On a BGS published map the topography is a grey layer behind the geology. You can "fade" a background that is too dark by making the layer transparent.

Table 5.1: Note on colour choices for background

- VectorMap Local Raster - TIFF, Black and White (chose this under **Theme** in the basket).[a]
- OS Terrain 5 contours (*NOT 50*) - SHAPE (*NOT GML*)

[a] See table 5.1 on page 54 for hints on which colour backgrounds to use when. I recommend black and white for this exercise because you will be going straight on to digitise the geology but if you were creating a map to take out into the field you might prefer to use a colour background.

WARNING: be careful not to download DTM files instead of the contour files. Check that you have the correct dataset before you add it to your basket.

WARNING 2: be careful that your contour files are **SHAPE** format NOT **GML**. It's worth checking the options to change the format before you request download.

5.3 File types for ArcGIS

You will be using a variety of file types, i.e. ways of storing geographic data. The two basic categories are raster and vector - look back at your notes in the previous section if you need to remind yourself of what each of them are. The tif files you downloaded are **raster** files, the Terrain 5 contours are a **vector** dataset.

5.4 Opening a new map

- Open ArcMap. If you get a splash screen select to open **A new empty map**. The splash screen will disappear but you won't notice much else! If you don't get a splash screen a new empty map will have opened by default.

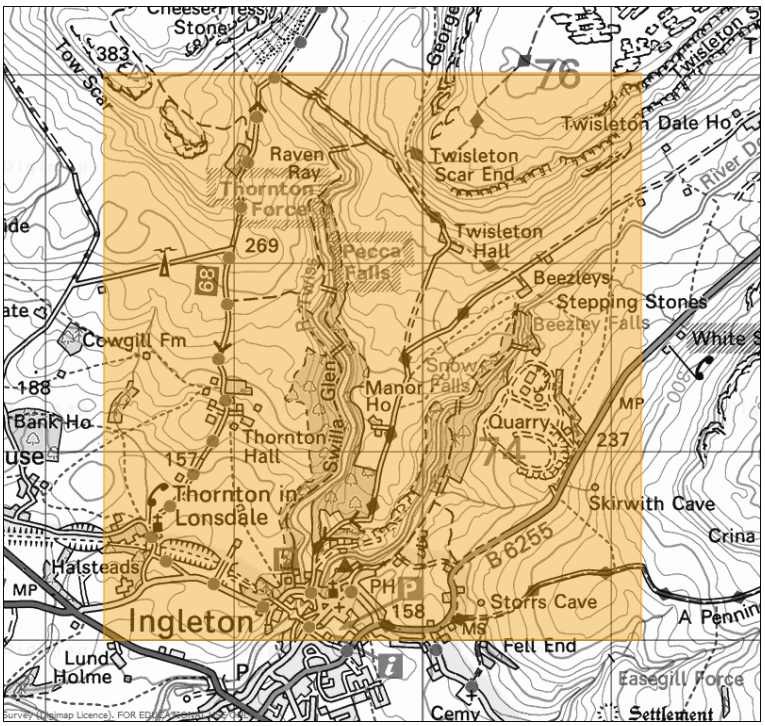


Figure 5.1: Minimum area to download for Ingleton exercise (it doesn't matter if you download for a larger area, but try not to download for smaller.)

5.4.1 Changing links to data files to relative

ArcMap layers reference datasets rather than contain them. By default layers link to datasets through their source property using ***absolute*** paths. This means that if you save a map file to a drive, e.g. your M: drive, if you then move the folder containing all of your files to a different location you will lose the links to your data. It is advisable to change paths to ***relative*** before you start creating a map, then as long as your files remain in the same relationship to each other between folders it doesn't matter if the drive letter changes.

- Customize › ArcMap Options › General tick next to Make relative paths the default for new map documents › OK › OK.
- Now check that the setting is correct for this map File › Map Document Properties › General and check that **Store relative pathnames to datasources** has a tick next to it.

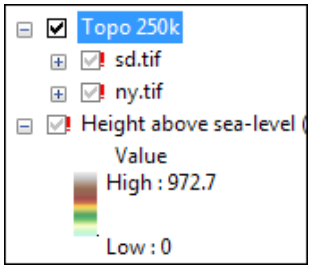


Figure 5.2: The red exclamation mark showing that the links to the data for these layers is broken

Repairing broken file links

If you use absolute file paths and you have to move the files from one location to another you will find that the broken links are marked by a red exclamation mark next to the layer name (as in figure 5.2).
To check the file name and repair the links

- Open the layer properties and go to the Source tab
- Under **Data Source** you will see which file Arc is looking for
- To repair the link click on Set Data Source... and look for the missing file - which won't be in the location that is listed
- Once you find it, select it and click Add and then OK

If you are really lucky any other missing layers will appear too, but if not, repeat as necessary.
If you already know which files you need to look for, do the following to repair the links:

- Right-click on the layer
- Data > Repair Data Source...
- Navigate to the file Add > OK.

Table 5.2: Repairing broken file links

Video Clip available in Minerva - Repairing broken file links. Direct link: `http://bit.ly/2h2X1J3`

5.5 Adding data

If you need a reminder of how to add layers/data check back to section 1.5.3 on page 7.

The Data Frame will be set to the coordinate system of the first files that you add to the map. The contour files should already have a coordinate system set, so adding these first (as shown in the instructions below) will save you time later.

5.6 Using OS Terrain 5 Contour files in ArcGIS

If you have followed the download instructions correctly, once you have unzipped your download you should have a folder containing shapefiles for the contours. Probably point feature classes containing spot heights and line feature classes containing contour lines. Add the contour **line** feature classes to a new map. The point feature classes are spot heights and you don't usually need to add these. This dataset gives you contours suitable for a scale of 1:10 000.

If you are creating a 1:50 000 map then download the Terrain 50 contours which can be dealt with in a similar way to the Terrain 5 contours.

5.6.1 Merging multiple feature classes

You'll probably find that you have more than one shapefile for the area of your map and they will show up with each tile being a different colour. It will make it much simpler if you merge them into one feature class as then you can symbolise them as one and do any further analysis much more simply too. Note that when merging, all of the feature classes need to be of the same type - so merge all of the line feature classes into one line feature class, or all of the point feature classes into one point feature class.

When merging feature classes you can either save the result in a shapefile or as a geodatabase feature class. The instructions here show the latter as it then makes some tasks easier later on. If you've not come across a geodatabase before don't worry about it now - you'll get more information in future. For now just follow the instructions below.

Setting up a new geodatabase

- In the catalog window on the right-hand side of ArcMap select the folder in which you want to set up your **file geodatabase**, e.g. the **ingleton** folder you created earlier.
- Right-click on the folder New > File Geodatabase.
- The geodatabase should appear in your file tree. Give it a name such as the area covered by your map, e.g. `Ingleton`. You'll be adding more data to this geodatabase later, so don't just call it **contours**.

Things to check if you have problems setting up geodatabases
• Make sure that you are in a folder, not directly on the root of a drive, e.g. in the C: drive. • Check your disk space!

Table 5.3: Things to check if you have problems setting up geodatabases

Merging contour line feature classes

Video Clip available in Minerva - Creating a base map with OS data:
1. Merging contour shapefiles. Direct link: `http://bit.ly/2gNjJ7N`

- On the menu bar at the top of the map window select Geoprocessing > Merge... to bring up the dialog in figure 5.3
- Fill in the **Input Datasets** with the files that you want to merge (in this case that should just be the files ending in `_line.shp`) - if they are already in your map document you can use the dropdown arrow at the top, otherwise browse using the folder button on the right.
- Fill in the **Output Dataset** by clicking on the folder button, navigating to the geodatabase that you have created, and giving the new feature class a name, e.g. `Contours`. Check that the **Save as type:** is **Feature classes** then click to Save.

- Don't forget to make a note of where you have saved the output dataset - you'll need to know this later
- Click OK

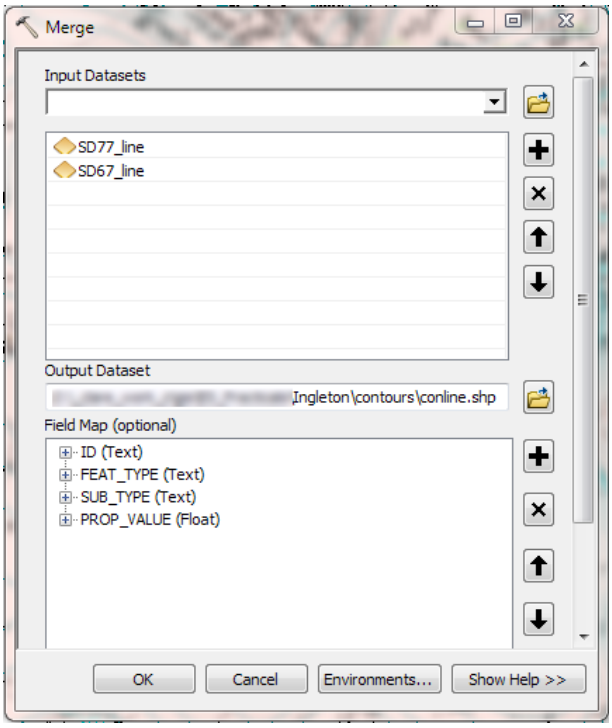


Figure 5.3: Merging two feature classes into one

ArcGIS should run the tool and then add the resulting new layer to your map. Once it has done this, if you had added the original feature classes to your map, remove them from the table of contents to keep things tidy[1].

- Save your map to your M: drive.

5.7 VectorMap Local raster tif files

These image files do not need to be processed or merged. They should be added to ArcMap as they are. Do make sure that the file extension is **.tif** though, NOT **.tiff** or they may not open in Arc.

Video Clip available in Minerva - Creating a base map with OS data: 2. adding raster background maps. Direct link `http://bit.ly/2gNkldB`

- You can add more than one file at a time by holding down the control key while you click on file names.

[1] If you need to save space on your M: drive you can also delete the folder containing the original shapefiles. You should still have the zip file that you downloaded so you can unzip them again if you need to go back to them.

- When you add tif or jpg files to ArcMap as a layer it will ask you whether you want to create pyramids. It's your choice! Pyramids can save time when you are zooming in and out of your map but take a while to create when you first load the file.[2]
- Ignore any error message about not being able to project data. Usually I wouldn't advise this, but for this purpose the files should be fine.

5.8 Checking that your layers have been added correctly

If you can't see any of your files follow the instructions on Coordinate Systems in section 5.8.1 below.

If your files are visible check that your contours match the tiff files correctly by zooming in and having a close look. Note that the data layers may be different sizes - that doesn't matter. Look to check that the valleys and hills in the contours match the details on the raster tiff map. If they don't match or you can't see either layer try the following suggestions.

- Rearrange the layer order - check that the contours are not below the tif files in the table of contents. If they are, drag them to above the tif layers.
- If the contour and the tiff files don't line up it can mean that for some reason the georeferencing of the tiff files has been altered. Note that this doesn't mean that they should be the same size, they might not be, but that obvious features in the landscape should appear in the same place. If features don't line up, delete the existing tiff files, download them again, and try adding them to your map again.

5.8.1 Coordinate System

Check the coordinate system of your data frame by doing the following

- Select **Layers** in the table of contents.
- View » Data Frame Properties » Coordinate System.

The top half of the tab allows you to select a coordinate system. The lower half shows you what coordinate system is set (figure 5.4).

Question 5.1. If the coordinate system has been set write down the name below, or make a note if it hasn't been automatically set and just says "No coordinate system".

Setting the coordinate system of the data frame

If the coordinate system is **not** British National Grid (for Ordnance Survey data[3]), or if there is no coordinate system set, don't worry, you can change or set it as follows.

- From the coordinate system window
- Projected Coordinate Systems » National Grids » Europe » British National Grid » OK[4].

[2] If you want more information about how pyramids work, search for **raster pyramids** in the Desktop Help.

[3] If you are creating a base map for an area outside of the UK check what the coordinate system of the data you are using should be, and check for that rather than British National Grid.

[4] Instead of clicking through the tree you can just search for "British" in the search box at the top. You'll still need to open the tree out, though!

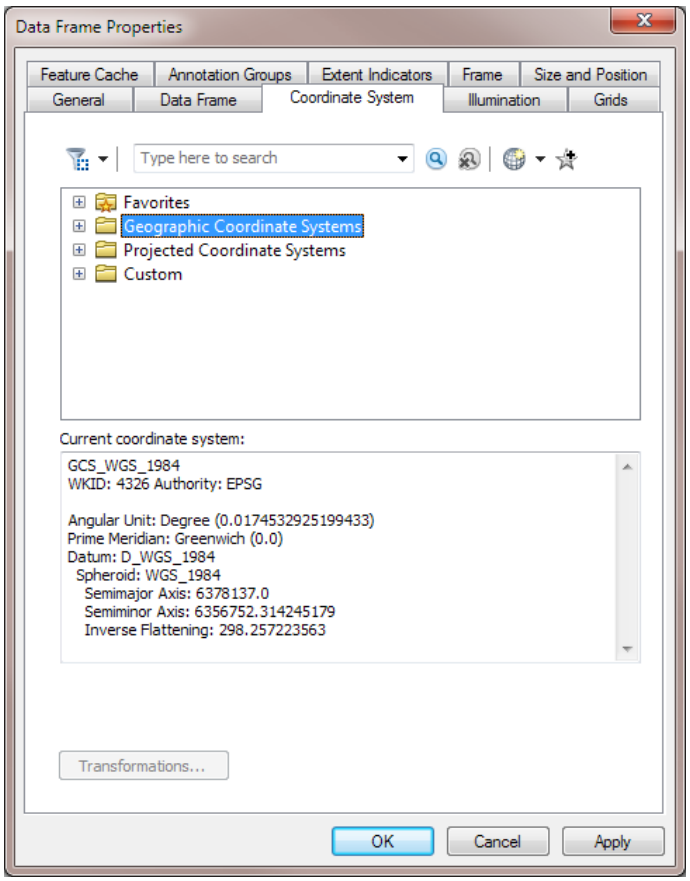


Figure 5.4: The Coordinate System tab in Data Frame Properties. This one shows that the data frame coordinate system is a Geographic Coordinate System called WGS 1984. Yours should show something different.

5.8.2 Save your file

Remember to keep saving your file. This will be the final reminder in this workbook!

5.9 Format and label contours

Contours will have been imported and drawn in a random colour and all in the same style. They will also be lacking in height labels, which are essential. We'll reformat and label the contours now.

5.9.1 Changing colour and width (updating symbology)

If you are using coloured background maps the colour of the contours can be changed to match the standard one used by the Ordnance Survey on their published maps. If you are using a black and white background layer then make the contours greyscale to match (look at a BGS published geological map to see an example). Whichever you do try to make both the index/-master contours and the ordinary contours the same colour.

We'll also make the ordinary and index/master contours slightly different widths as that makes them a bit easier to read.

Video Clip available in Minerva - Symbolising contours in ArcMap.
Direct link: `http://bit.ly/2h5iiBA`

- Right-click on your contours layer in the table of contents.
- Properties » Symbology tab » Categories » Unique Values.
- Value field should be set to **SUB_TYPE**.
- **Add all values**.

This adds a list of feature codes, probably only **master** and **ordinary** for Ingleton as there is no coastline, but **meanHighWater** and **meanLowWater** are also possible in coastal areas - see figure 5.5.

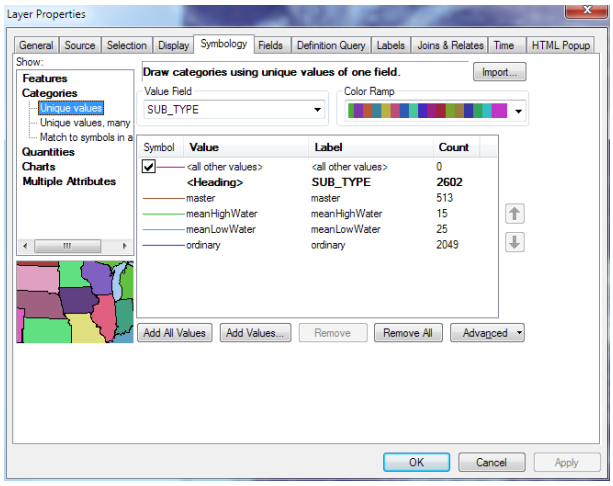


Figure 5.5: Setting contour lines in the symbology tab

Again, lines will be symbolised with random colours - click **Apply** and see what your map looks like now.

To choose appropriate colours:

- Double-click on the symbol next to the line you want to change, e.g. **master**.
- The **Symbol selector** will open (figure 5.6).
- Choose a **colour** by clicking on the colour box - e.g. something like Gray 50% for a greyscale map. (If you're producing a colour map, a deep orange (Seville Orange) matches contours on an OS printed map.) (Hovering over a colour with the mouse pointer shows a tool tip of the colour name.)
- Choose a line width - try **1.00** for feature code **master** (index contours) and **0.40** for feature code **ordinary** (normal contours). The difference in width may not show on screen but it will when you print your map.
- Click OK » Apply to check the results.
- Click to remove the tick from the box next to <**all other values**> to prevent it from appearing in your table of contents and keys.
- You can also use **transparency** to make the contours less obvious if necessary - section 1.5.4 on page 8.

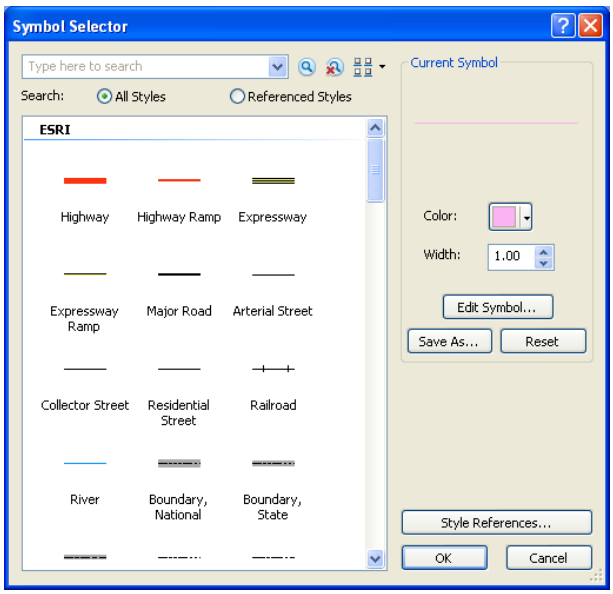


Figure 5.6: The symbol selector

- When all the lines are formatted to your satisfaction, click **OK**.

If you are in a coastal area and are using VectorMap Local Raster, or similar, as a background, you probably still won't want to include the lines for meanHighWater and meanLowWater as they will already be there. To get rid of them:

- Open the layer properties and go to the symbology tab
- Select the symbols that you **don't** want
- click on Remove then on OK

5.9.2 Labelling contours

Video Clip available in Minerva - How to add labels to layers in Arc.
Direct link: `http://bit.ly/2h2vtDs`

To add height labels to the contours so that you can tell which direction the slopes are going:

- First switch on the Labeling toolbar - Customize > Toolbars > Labeling
- Then start by checking that the Maplex Label Engine is active - Labeling > Use Maplex Label Engine. This allows more useful automatic label settings to be used.
- Right-click on your **contours** layer in the table of contents.
- Go to the Properties > Labels tab then click in the box next to **Label features in this layer**. If you forget this your labels won't show at all.
- **Label field = PROP_VALUE**
- Change **colour** to the colour you selected for the contours themselves.

- Click on Placement properties > Label Position tab. Drop down the dropdown box under **General** which says **Regular Placement** by default, and select Contour Placement
- OK > Apply to check the result. OK again when you are satisfied with the labels.

Figure 5.7 shows examples of symbolised and labelled contours in both colour and black and white versions.

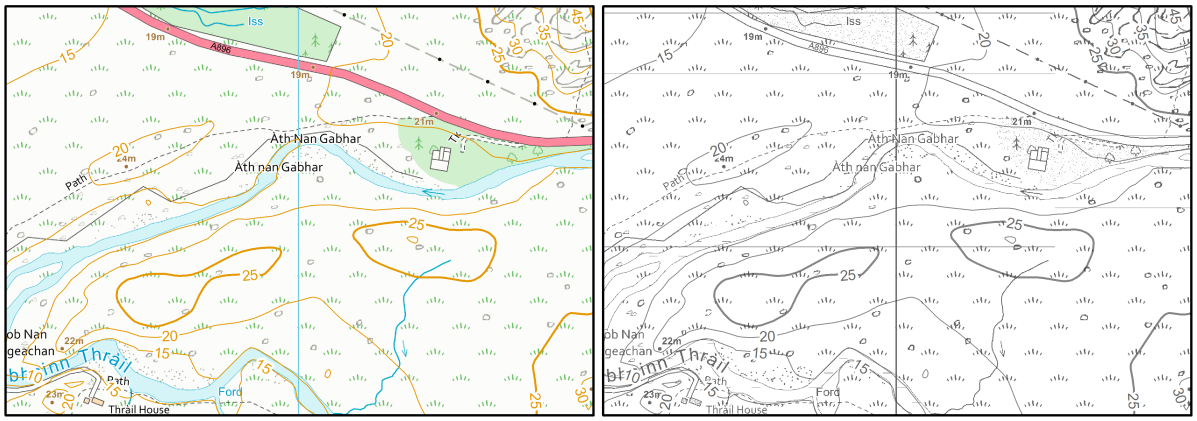


Figure 5.7: An example of symbolised and labelled contours. Full colour on the left, black and white on the right.

Try out some of the other options in the label dialog as well and see what effect they have on your labels.

5.9.3 Data frame reference scale

> ***Question 5.2. Zoom in to 1:1 000 and then zoom out to 1:25 000. What happens to the size of the labels you have just created when you zoom in very close or zoom out?***

When you print your map you will want the labels to be a particular size at a particular scale. If you set a **data frame reference scale** to the scale at which you are intending to print the map then you can set the size of the labels at this scale.

Figure 5.8: Scale dropdown

- Scale the map to the scale that you will be printing it at by using the **scale drop down** on the standard toolbar. In this case set the scale to **1:10 000**.
- Right-click on the **data frame title** (Layers) in the table of contents.
- Reference Scale > Set reference scale. Arc will set the reference scale to the current map scale.

Question 5.3. Zoom in to 1:1 000 again - what happens to the size of the labels now? And what happens to them when you zoom out to 1:25 000?

When you use the labels dialog to set the size of your labels now, you will be setting the size that they print out at your reference scale.

- To remove the reference scale completely use Reference Scale > Clear Reference Scale.
- To change a reference scale set your map to the correct scale then use Reference Scale > Set Reference Scale again.

5.10 Laying out and printing your map

When you need to print out a topographic base map use the instructions in section 1.9 on page 12. For the purposes of this exercise print out a **greyscale, A4** map of the area of the Ingleton Waterfalls Walk at **1:10 000**. This is useful experience as in the future you'll need to be sure that your field slips are exactly the scale specified.

If you don't have the correct area already showing try centering the map on **x = 369987 meters : y = 474659 meters**. Remember that you found out how to use the **Go to xy tool** to do this in section 3.3 on page 26.

For your layout include a **measured grid** (section 1.9.1 on page 16). And don't forget to add the **copyright acknowledgement** (see section 1.9.1 on page 14).

By the time you have finished you should have something that looks like figure 5.9. Your map probably won't look identical to this one as you'll have made your own decisions, but it should look similar.

Once you've printed your A4 map check that it is the correct scale by measuring the distance between two 1000 m grid lines. There should be exactly 10 cm between the two lines.

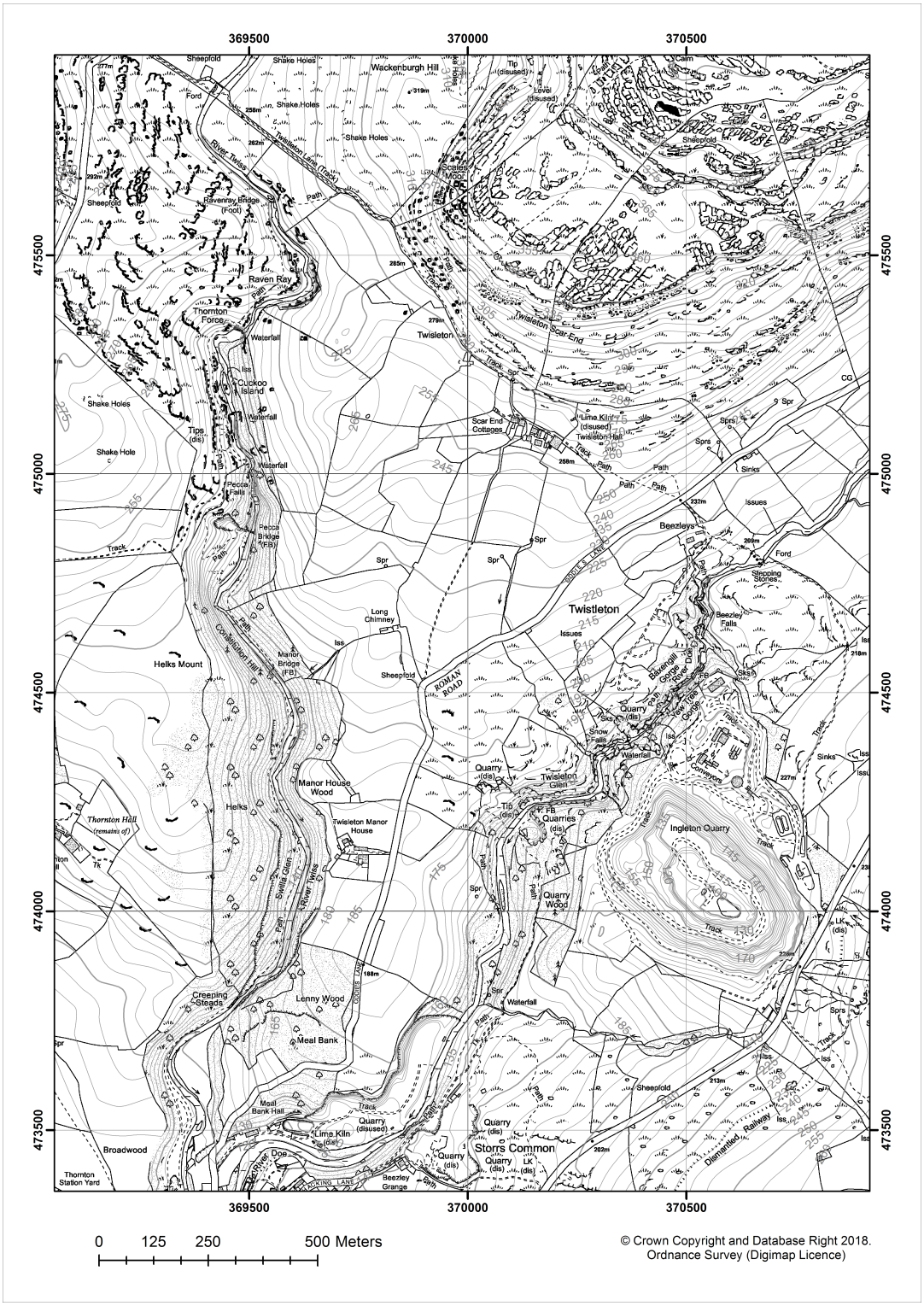


Figure 5.9: Basemap for the Ingleton waterfalls walk

Chapter 6

Georeferencing a scanned map

Having created a base map, printed it out, and used it to collect data in the field, you will then have returned with hand drawn markings on the printed map.

In this exercise you will be creating a geological map of the Ingleton area based on a scanned copy of a sketch map which you will have imported to ArcMap. The sketch map is merely a picture. It has no information in the file which tells Arc whereabouts in space the map belongs. So you will need to **georeference** the scanned map so that it occupies the same geographical space as the Ordnance Survey base map you created in section 5 beginning on page 53, Creating a base map from Ordnance Survey data.

6.1 Learning outcomes

When you have completed this section of the workbook you should be able to

- understand what is meant by georeferencing
- show how to import a scanned map into ArcMap and use georeferencing tools to place it in the correct geographical relation to your base map.

6.2 What is georeferencing?

You will be using the scanned field slip of Ingleton to trace the geology, but at the moment the scanned map has no information with it that tells ArcMap how the field slip relates to the base map. Georeferencing will add that information by stretching and locating the field slip so that when you trace the geology it will appear in the correct place on your base map.

6.3 Scanning your field slip

For this exercise you are given a scanned copy of the field slip, but in future you will need to scan your own.

All of the printers in clusters around the University will also scan. The default appears to be pdf, which won't open in Arc. Either change the settings so that the output is **tif** or **jpg**[1], or use the website at `http://smallpdf.com/` to convert the pdf to jpg.

[1] Tif, jpg and png are all acceptable formats for georeferencing. Tif will be the best quality, but also the largest file sizes. Jpg will have smaller file sizes, but may loose some quality.

6.4 Import a scanned map into ArcMap

The first stage is to get the scanned map into Arc without worrying about its location.

- Open in ArcMap the base map of Ingleton that you created previously (if it isn't already open).
- Save the file as **IngletonGeology.mxd** - this ensures that you will still have a copy of your base map.
- Download the file **ingleton.tif** (figure 6.1) from Minerva (ensure that the file extension remains as .tif, not .tiff) and then add it to Arc as a layer. As in section 4 on page 7, it's your choice whether you add pyramids or not.
- ingleton.tif has no geographical information with it so you won't be able to see it in the map window, only in the table of contents. Don't worry about it!

6.5 Setting up georeferencing

Now we'll start adding the location data.

- Make the **Georeferencing** toolbar (figure 6.2) visible - Customize > Toolbars > Georeferencing.
- **IMPORTANT:** Make sure that the drop-down box on the georeferencing toolbar is set to the correct layer - **ingleton.tif**. **If you have the wrong layer selected, e.g. one of the Ordnance Survey maps, you'll reset the georeferencing of that and give yourself major problems later**.

6.6 Georeferencing with known grid references

If you are georeferencing an image that has known grid references for particular points, e.g. if you are georeferencing a map with marked British National Grid squares as you are for this exercise, then you can type in the figures rather than having to look for identical points on the base map.

If the map or image that you are georeferencing does not have known grid references then go straight to section 6.7 on page 71 for instructions on how to georeference using identifiable points.

Video Clip available in Minerva - Georeferencing a scanned map in ArcMap: 1: using grid intersections. Direct link: `http://bit.ly/2eKj4DB`

Video Clip available - The YouTube video at `http://bit.ly/1AiharF` shows the process of georeferencing and goes into more detail than the notes here or the previous video. (This video has sound)

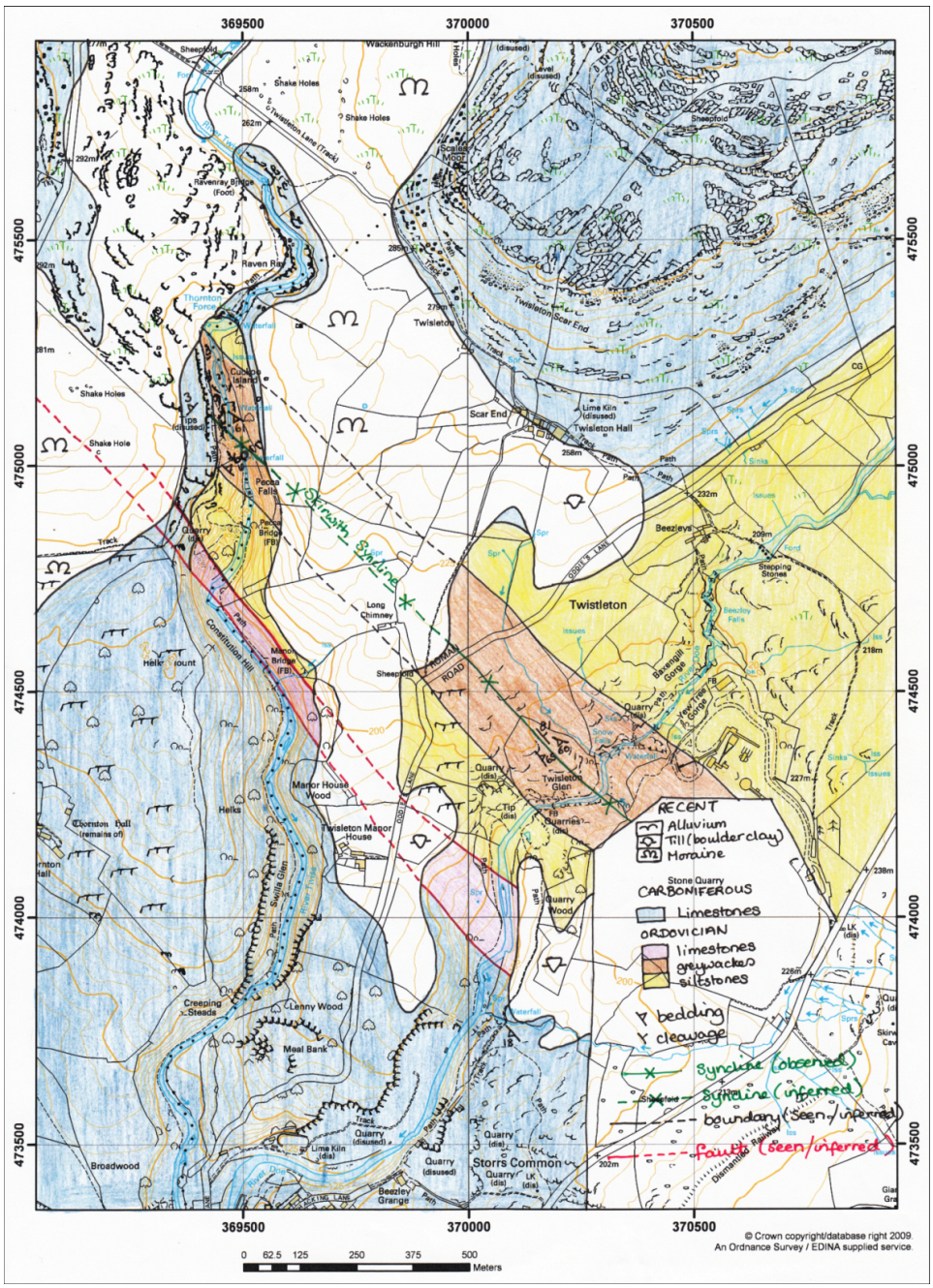


Figure 6.1: The Ingleton field slip

Figure 6.2: Georeferencing Toolbar set to correct layer

You'll be adding **control points** and typing in the grid reference for each point, so it may help if you start by marking some points at corners of grid squares on a print out of the field slip, e.g. figure 6.1 on page figure 68, or the base map in figure 5.9 on page 65, and write down the full 12 figure grid reference, being very careful to get the x and y coordinates the correct way round[2].

[2] A useful way of remembering can be "Along the corridor and up the stairs" - so start with the numbers along the bottom (or top) for x, then the numbers on the sides for y.

Figure 6.3: Add control points tool

- Right-click on Ingleton.tif in the table of contents and **Zoom to layer**. Ingleton.tif should now show in the map window but is still not georeferenced, and won't be in the same place as your base map.
- Click on the **Add Control Points** tool on the georeferencing toolbar (figure 6.3). Now zoom in and use the tool to click on a point on the scanned image for which you know the grid reference, e.g. the corner of a grid square. Try to do this as accurately as possible.
- Now right-click, select **Input X and Y** (figure 6.4) and enter your grid coordinates in the box that opens (figure 6.5).

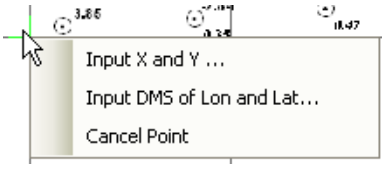


Figure 6.4: Input X and Y

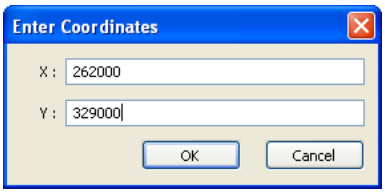


Figure 6.5: Enter your grid coordinates

- **OK**. If you have **Auto Adjust** switched on your image should shift to the correct point, which probably means that at this stage it disappears. **Don't panic!**
- **Zoom to layer** on Ingleton.tif again, and it should zoom to an area within your base map. Arc now nows vaguely where your field slip belongs, but it doesn't know how big it should be, so it will probably be completely the wrong scale. Things should start to look better once you've added a second control point.
- Repeat this process for at least three more points (minimum total of four) spread out across the whole image. First making a note of a grid reference, then clicking on it, right-clicking and entering the coordinates.

Errors caused by georeferencing to a grid

One of the potential problems with georeferencing to a grid is that you can reach a point where control points are too evenly lined up and Arc thinks that there is a problem. When this happens you'll see a warning message about **The control points are collinear or not well distributed** (figure 6.6).

Sometimes when this happens it is fine to continue and your scan will still line up correctly. Other times it isn't fine, and once you click OK your scan will disappear or smear across the screen. If this happens don't panic! Just use the instructions in section 6.6.1 below to use the link table to remove the control point which is causing the problem.

6.6.1 Using the link table

The **link table** is a useful way of checking the points that you have entered.

Figure 6.6: Warning message about distribution of control points

Figure 6.7: Link table icon

- To check your points open the link table - click on the **Link Table** icon on the georeferencing toolbar (figure 6.7).
- The link table gives you an overview of your points so far with a useful indication of Residual Error (right-hand column). If you are having problems with your image stretching in odd directions - AFTER you have added at least 4 points - then you can see which is the most problematic point and try deleting it.
- You can edit your grid references via the link table (figure 6.8), or add them this way if you wish. Click on the entry under **X Map** and type in the correct grid reference. Repeat for **Y Map**. If you have **Auto Adjust** switched on your image should shift to the correct point. Note that you can't edit the **X Source** and **Y Source** fields in this way.
- To delete a point, select it in the table and click on the cross symbol to the right of the list. If you change your mind - don't use **Undo** or Ctrl + Z to get the point back - add it again yourself. Undo can have drastic results when georeferencing!.

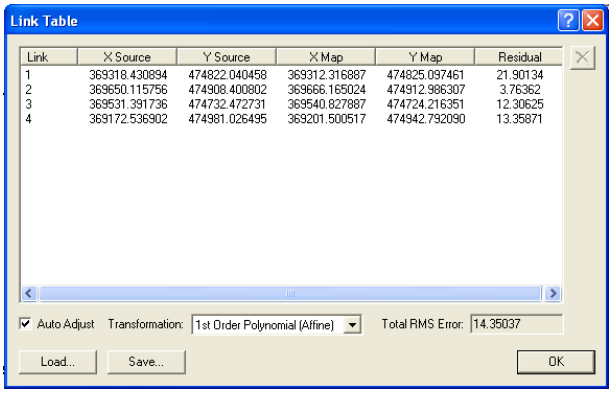


Figure 6.8: The link table

6.6.2 Saving your georeferenced scan

The most crucial step. Forget this and you'll have to go through it all again!

- IMPORTANT: Once you are happy with the match -
- Georeferencing > Update Georeferencing.

- Don't click on Update Georeferencing more than once or your georeferenced image may be reset - which usually means that you have to start again from scratch.

Failure to do this step will mean that you have lost your carefully added links next time that you open the map and the scanned image probably won't show.

Once you update georeferencing Arc will add extra files to the same folder as the scanned map - rather like those in figure 6.9. These files contain the world information for geographical location, the equivalent of the tfw files with the O.S. tif files. Make sure that you keep these files and the scanned map together.

Figure 6.9: The original tif file and the extra files resulting from georeferencing and creating pyramids

6.6.3 Solving georeferencing problems after updating

If you have problems with your georeferenced image after you have updated georeferencing you will probably have to start again from scratch. In this case, remove the layer from your map, then delete all of the extra files that have been created such as .tfw, .jgw or .aux. That is, anything with the same name as your original tif or jpg file, except for the tif or jpg file itself.

Then add the image back to your map as a layer and start the georeferencing process again.

6.7 Alternative method: georeferencing using identifiable points

Identifiable points here means that you will be using, for example, corners of field boundaries and road junctions as landmarks to add your georeferencing points.

If you have been able to georeference your scanned map using grid lines, as in the previous section, then you don't need to use this section now. Just be aware that it is possible as you may need this in the future.

Video Clip available in Minerva - Georeferencing a scanned map in ArcMap: 2: Using identifiable points. Direct link: `http://bit.ly/2eLOEm2`

I strongly recommend that you view the video clip that shows how to georeference a scanned map before you start this section. It can be a difficult concept to grasp at first, but once you know what you are doing it becomes fiddly rather than difficult.

This method of georeferencing is more fiddly than using known grid references but you may find that you need to use it if you don't have a grid on your scanned map. This should be an extra incentive to you to make sure that you remember to put one on your base map for field work!

You need to be able to spot identifiable points on the background map of the scanned map and relate them to the base map in ArcMap.

- **IMPORTANT:** Make sure that the drop-down box on the georeferencing toolbar is set to the correct layer - **ingleton.tif**. **If you have the wrong layer selected, e.g. one of the Ordnance Survey maps, you'll reset the georeferencing of that and give yourself major problems later.**
- Navigate to the approximate area of your scanned map. For this map (Ingleton), using the screens in the SEE computer cluster, set the scale to 1:12 000 and make sure that you are centred on **x = 369987 meters: y = 474659 meters**. That should take you to approximately the right area.
- Click on Georeferencing > Fit to display. Ingleton.tif should now show in the map window but is still not georeferenced. If you closed your map now, the tif file wouldn't show in the right place the next time that you opened it.
- On the georeferencing toolbar select the control points tool (figure 6.3)

You always link points by clicking on the **scanned image first**, then on the base map.

- Click **once** on an identifiable point on the scanned map - see tip box 6.1 for hints.
- Turn off the scanned map in the table of contents
- Click on the same identifiable point on the base map
- The layers will immediately adjust. Switch the scanned map back on.

Suggestions for identifiable points to look for when georeferencing
You need to look for features that you can spot and click on accurately on both maps. Look for features such as • Look for features such as – road junctions – corners of buildings – fence/wall junctions – bench marks • If you are using two different editions of a map, be careful to choose points that are unlikely to have changed between the two maps. E.g. streams tend to move around over time! You can still use the zoom and pan tools, so zoom in close to be as accurate as possible.

Table 6.1: Choosing identifiable points when georeferencing

Repeat the process at least three times more for different points on the map, preferably more, and on points as widely spread as possible.

- If you make a mistake you can cancel the previous point by pressing <**esc**>.
- To check the accuracy of the georeferencing, in addition to making a visual check, use the link table - see section 6.6.1 on page 69.

6.7.1 Saving your georeferenced scan

The most crucial step. Forget this and you'll have to go through it all again!

- IMPORTANT: Once you are happy with the match -
- Georeferencing > Update Georeferencing.
- Don't click on Update Georeferencing more than once or your georeferenced image may be reset - which usually means that you have to start again from scratch.

Failure to do this step will mean that you have lost your carefully added links next time that you open the map and the scanned image probably won't show.

Once you update georeferencing Arc will add extra files to the same folder as the scanned map - rather like those in figure 6.9. These files contain the world information for geographical location, the equivalent of the tfw files with the O.S. tif files. Make sure that you keep these files and the scanned map together.

6.7.2 Solving georeferencing problems after updating

If you have problems with your georeferenced image after you have updated georeferencing you will probably have to start again from scratch. In this case, remove the layer from your map, then delete all of the extra files that have been created such as .tfw, .jgw or .aux. That is, anything with the same name as your original tif or jpg file, except for the tif or jpg file itself.

Then add the image back to your map as a layer and start the georeferencing process again.

6.8 Further information

The YouTube video from Texas A&M University which you can find at `http://bit.ly/1AiharF` (which was also referenced earlier) shows the process of georeferencing and goes into more detail than the notes here.

Search for **Fundamentals of georeferencing a raster dataset** in Arc Desktop Help to find how-to information and plenty of background on the different types of transformations.

Chapter 7

Getting ready to create data in ArcGIS

Once you have your base map set up, and have the scanned map ready to trace, you need to set up files to contain the data that you have been creating. These instructions will show you how to set up both geodatabases and shapefiles, and give you some suggestions on how to organise your data.

7.1 Learning outcomes

When you have completed this section of the workbook you should be able to

- plan the structure of your data
- demonstrate how to use the tools in the Catalog Window and/or ArcCatalog to create files to contain your data

7.2 Planning your data

Before you start creating features you'll need to spend a bit of time thinking about the structure of the data that you will be storing. Doing this now can save a lot of time in the long term.

You will be creating a **geodatabase**. This will contain **feature datasets** which each contain a number of **feature classes**. Each feature class will include many individual items, called **features**. See figure 7.1 for a graphic view of this using the Malham exercise as an example.

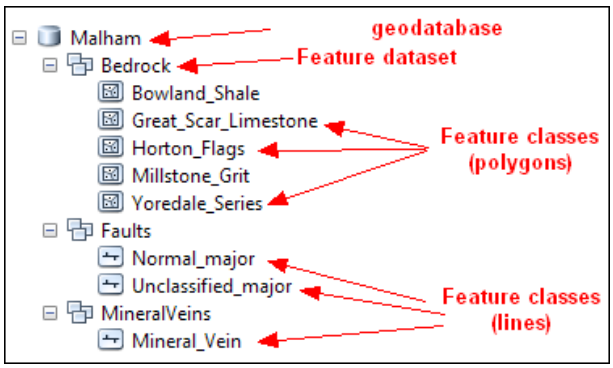


Figure 7.1: Structure of a geodatabase

Each feature in your file will include **attributes**. Some of these, such as FID (Feature ID) and SHAPE, will be automatically generated by Arc. Some will be set by you, e.g. label text, strike.

You will also set up a **shapefile** to contain the outline of the area in which you will be working. You could include this in your geodatabase, but we'll use a shapefile here to demonstrate an alternative file type.

Look at the field slip for Ingleton, particularly the key, and think about the potential feature datasets and feature classes (or layers) that you will need.

Question 7.1. Use the space below to draw a possible tree structure of your geodatabase. Include the geodatabase name itself, the feature datasets and the possible feature classes.

Remember to label which feature types are polygons, which are lines, and which are points.

For the purposes of the rest of this exercise I'm going to suggest a structure to you. Once you have more experience with GIS you can select the storage method that makes most sense to you, but the suggestions below will give you a selection to choose from.

7.3 Setting up a file geodatabase

Note that we will be using the Catalog window in ArcMap for these steps, but all will work in ArcCatalog too.

Video Clip available - The YouTube video at `http://bit.ly/1zR2WBY` shows the process of creating a geodatabase, feature dataset and feature class. It also carries on to show how to add data to a feature class - we'll cover this in the next chapter. (This video has sound)

A geodatabase is effectively a container that holds lots of other datasets. You'll set one up and then use it to store the data that you create by digitising geological features. Note that there are two types of geodatabase, Personal and File. We'll be using a File Geodatabase for this exercise but either will work. File geodatabases are considered by ESRI to be a more modern and efficient form of GIS data storage.

You may have already set up a geodatabase to hold your contour data when you were merging multiple feature classes, as shown in section 5.6.1 on page 57. If this is the case then you can use that geodatabase to hold your geological data too, so skip straight to section 7.3.1 to start setting up a feature dataset. Otherwise:

- In the catalog window on the right-hand side of ArcMap select the folder in which you want to set up your geodatabase, e.g. the **ingleton** folder you created earlier.
- Right-click on the folder New > File Geodatabase.
- Give your geodatabase a name, e.g. **Ingleton**.

Things to check if you have problems setting up geodatabases
• Make sure that you are in a folder, not directly on the root of a drive, e.g. in the C: drive. • Check your disk space!

Table 7.1: Things to check if you have problems setting up geodatabases

7.3.1 Set up a feature dataset

Setting up a feature dataset to hold your data has the advantage of setting the coordinate system in a single place. If you then store all of your feature classes inside the dataset they will all be set correctly.

Still in the catalog window or ArcCatalog

- Right-click on your geodatabase
- New > Feature Dataset…
- Enter a name that describes the information that it will contain, for this example call the feature dataset: **Geology**. Next.
- Set your coordinate system, for this example set it to the projected coordinate system (PCS) British National Grid - double-click on Projected Coordinate Systems > National Grids > Europe > British National Grid.
- Next > Next > Finish.

A database can hold multiple feature datasets, each set up in the same way.

7.3.2 Set up a feature class

Still in the catalog window or ArcCatalog

- Right-click on the feature dataset that you've just created (i.e. **Geology**) New > Feature class…
- Give your feature class a name that describes what it's contents will be, to start with here create one called **Carboniferous_limestone** and an alias, e.g. **Carboniferous limestone**. The alias will be a readable name that will appear in ArcMap etc., so it can include spaces. Notice the underscore in the middle of the feature class name.
- Select the type of feature class to be stored - for this class it will be **Polygon Features**.
- Next > Finish.

Getting around problems with adding feature datasets and feature classes to a geodatabase
Sometimes when you try to add feature datasets or feature classes to a geodatabase you'll get an error message saying that the database is already in use or is locked. This will prevent you adding anything else. The first thing to check is that you are not in an edit session. If you are sure that you are not and it still isn't working, try the following. • If you are using the Catalog Panel in ArcMap then close ArcMap completely. • Open ArcCatalog and, in the table of contents, go to the geodatabse to which you want to add a feature dataset or feature class. • Right-click and add the feature dataset or feature class here If you are having problems with creating feature datasets and feature classes in ArcCatalog, then do the reverse - close ArcCatalog, Open ArcMap, and use the Catalog panel to add new datasets or classes.

Table 7.2: Getting around problems with adding feature datasets and feature classes to a geodatabase

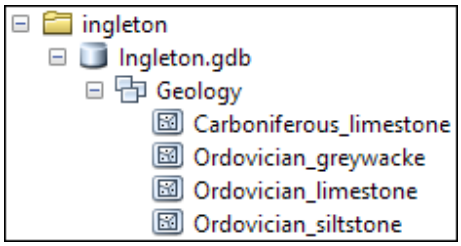


Figure 7.2: Structure of the geodatabase for Ingleton bedrock

Set up further feature classes for the bedrock geology, making sure that there is a feature class for each of the bedrock types in the key and remembering to change the type of feature class as appropriate, make sure in this case that the type is set to polygons. WARNING: Always double-check this. The only way to change the type later is to delete the feature class and create it again.

The structure of your geodatabase should look something like figure 7.2 in the Catalog panel.

Don't worry about setting up feature classes for the lines and points yet - you will be given more instructions about these later.

7.4 Set up a shapefile to define the edge of your study area

It can be very useful to set up an outline of your study area. Not least because it gives you a layer to which you can **Zoom to layer** and stay in the right area of your project, but also to give an outline to your traced shapes. You probably won't want to print it when you've finished your map, though. You'll set this up as a shapefile rather than a geodatabase feature class as that prevents problems with clipping later in the exercise.

- In Catalog right-click on the **folder** in which you want to store the shapefile (this will **not** be

inside your geodatabase).

- New > Shapefile.
- In the **Name:** field type **study_area**.
- Change the **Feature Type** to **Polygon**.
- Under **Spatial Reference** click on the **Edit...** button and select the British National Grid projected coordinate system as you did for the geodatabase feature classes Add. The details for the British National Grid should appear in the window. (See figure 7.3)
- Click **OK** and a shapefile called **study_area** should be created.

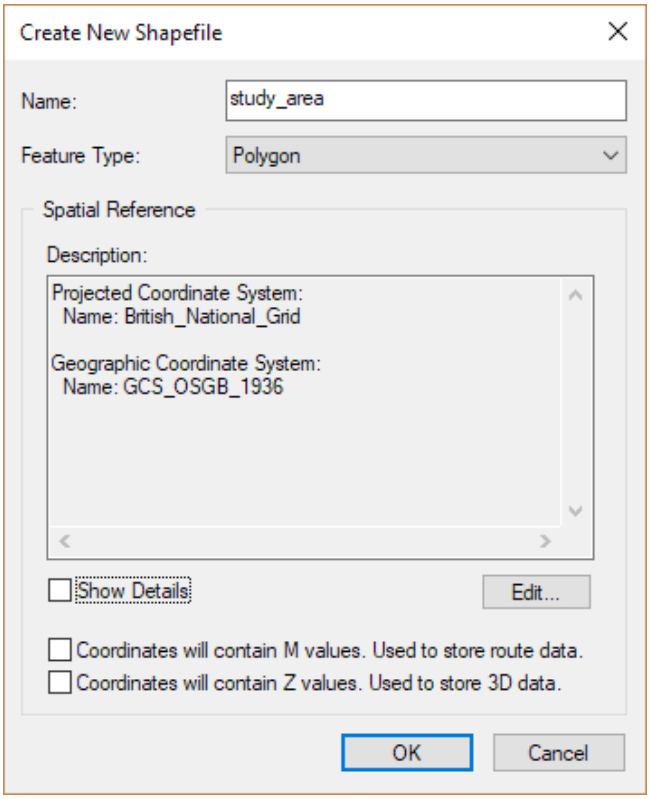


Figure 7.3: Setting up the study area shapefile

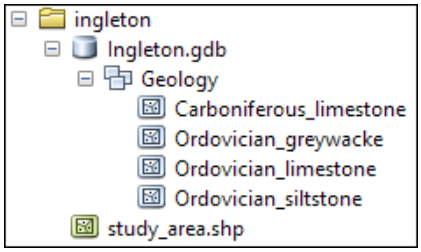


Figure 7.4: The structure of your folder in the Catalog panel once the geodatabase and the shapefile have been created

Once you have set up your study area shapefile and the bedrock feature classes, your data folder should look something like figure 7.4.

7.5 Summary

This section has shown you how to set up geodatabases and shapefiles as **containers** for your data. Next we'll start adding data to those containers.

Chapter 8

Digitising in ArcMap

This section of the workbook shows you how to create your own data by tracing the scanned-in field map.

8.1 Learning outcomes

When you have completed this section of the workbook you should be able to

- use the tools in ArcGIS to create and edit map features
- demonstrate how to add appropriately located labels to the features on your map
- explain how to symbolise a map so that it displays the data clearly

8.2 Introduction

Digitisation is the process of creating data in a GIS such as Arc by tracing or drawing points, lines and polygons. The techniques explained here for creating geological maps with ArcGIS are of necessity more generalised than the previous sections of the workbook. Each map that you create will have different requirements, e.g. you may not wish to add symbols or lines.

Try out the techniques listed here and use the ones that you need. Experiment. You may well find better ways of doing things. As ever in computing there is more than one way to do most things and you may find that a different way gives you better results or seems simpler to you.

This section shows you one possible plan for digitisation - starting with the bedrock polygons and building the rest of the map up from there. Is is also possible to start by digitising all of the geological boundaries, then use a tool in Arc to create the bedrock polygons from those. This sounds relatively simple, and can be much easier on some maps, but can also give you problems with gaps between lines and too many or too few polygons being created. The instructions are provided in appendix **??** on page **??**, try them out when you've worked through the instructions below, and see whether you think that this is an alternative you'd prefer to use.

8.3 Setting up a map document

First you need to add feature classes to your map document.

- Open ArcMap and open the document you saved as **IngletonGeology.mxd** when you imported the scanned map. It should already contain the georeferenced field map.

- If necessary add your new feature classes to the map document as new layers. Remember to add the **study_area** shapefile too.
- Organise your map by grouping your layers, e.g. put all the bedrock geology layers into a group layer called **Bedrock**. If you keep things tidy then it makes it easier to find things later!

8.4 Editing in ArcMap

8.4.1 Open the Editor toolbar

All of your creating and editing will take place within an **Edit Session**. The drawing tools will create an **edit sketch** which will modify the feature in the feature class when you stop editing.

- Open the **Editor toolbar** (figure 8.1) (if it isn't already open) - Customize > Toolbars > Editor.

Figure 8.1: The Editor Toolbar

8.4.2 Check your features are available to edit

Sometimes when you create a feature class it appears in the table of contents, but doesn't appear in the list of layers that you can edit. Check that as follows -

- Start an edit session by right-clicking on a layer in the table of contents and selecting Edit Features > Start Editing and check that each geodatabase feature class appears in the list of layers that you can edit.

If you created a feature class but it doesn't appear in edit choices in the right-hand panel there are two things to check:

1. Have you selected the correct geodatabase or shapefile folder? Stop editing and start editing again, being very careful to select the correct geodatabase or shapefile folder.
2. If the feature class or feature still isn't visible you need to set up **feature templates** - see the next section.

8.4.3 Feature templates

Feature templates show the symbology of the layers that you are editing. Usually they are created automatically when you add a layer, but in some circumstances they are not. In that case you need to create them manually.

- Open an edit session and select the correct geodatabase or shapefile folder.
- Click on the Organize Templates button on the **Create Features** panel (figure 8.2).
- In the **Organize Feature Templates** dialog box click on **New Template**.

Figure 8.2: The organize templates button

- Tick the check boxes next to the layers that you need to create templates for Finish.
- There should be a symbol for each of the layers that were missing Close.

Your feature classes or features should now appear in the **Create Features** list and you should be able to select that layer to edit.

If you have set symbology categories for a layer, you can also add the symbology as templates in exactly the same way and select them directly when you are editing and creating data.

8.4.4 Outline the area to be digitised

To start with we'll create a simple outline for the area we are digitising by drawing a polygon. This isn't essential for every map, but it can be useful to define the area you are working on. Not least it allows you to use **Zoom to layer** on your whole study area, but it can also help to keep the outside edges of your bedrock polygons tidy.

- Start an edit session by right-clicking on the study_area layer Edit Features » Start Editing.
- In the **Create Features** area which should open to the right of your window, make sure that the study_area layer is selected.
- In the area below select the correct **Construction Tool**, e.g. **polygon**.

Figure 8.3: Straight Segment tool

- The **Straight Segment** tool (figure 8.3) should automatically select on the Editor toolbar, if it doesn't then click on it now. Alternatively you can select another tool at this stage.
- Click on the map to start drawing a polygon. Trace along the edges of the map area on your scan by clicking once at each corner.
- Each click creates a **vertex**, which is similar to a node in CorelDraw or Inkscape.
- If you want to **undo** the last vertex that you drew, press Ctrl + z.
- Double-click when you finish your polygon, or press F2.

You can easily delete features within an edit session, so just have a go and don't worry if your shapes don't work the first time.

- **IMPORTANT:** Save your edits at regular intervals - Editor » Save Edits.
- To stop editing - Editor » Stop Editing.

You have created a solid polygon which means that you won't be able to see your scanned map. Symbolise the polygon so that it becomes just an outline.

Video Clip available in Minerva - Digitising in ArcMap Part 1: Starting and finishing, and creating polygon features. Direct link: `http://bit.ly/2gNhDVw`

- Double click on the coloured box underneath the **study_area** layer title.
- Set **Fill Color** to *No Color*.
- Set **Outline width** to 2, and **Outline Color** to bright red OK.

We'll start digitising the geology by creating a shape (polygon) in a feature class.

- Start editing.
- Select the layer that you are going to add the **Carboniferous Limestones** to and make sure that it is ready to edit.
- Zoom in to the blue patch of Carboniferous Limestone in the north west corner of the scanned map (as in figure 8.4).

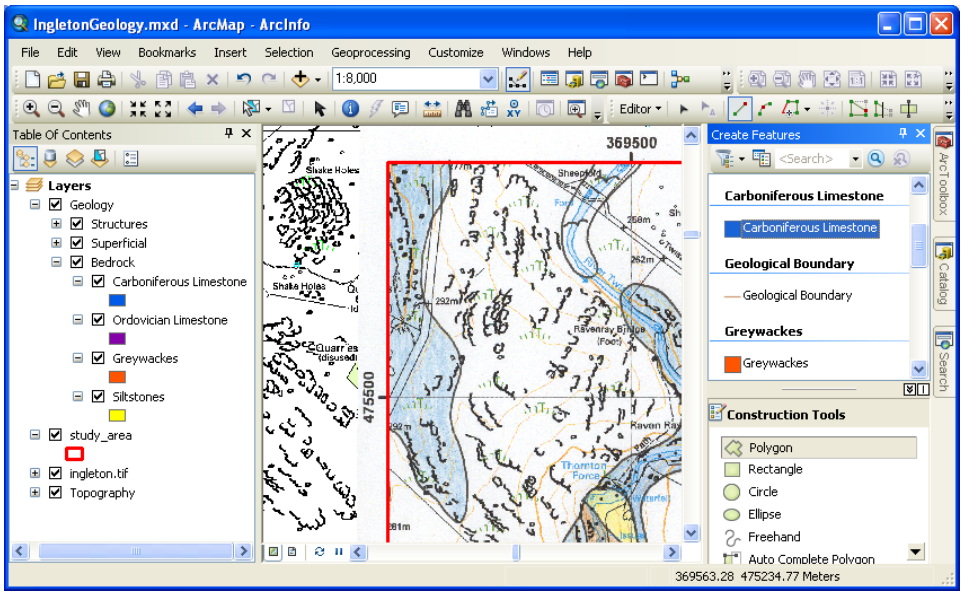


Figure 8.4: Carboniferous Limestone in north west corner of scanned map

- Start with the **Straight Segment** tool (figure 1.11 on page 12) - which should automatically be selected on the Editor Toolbar. You can also experiment with other options such as **Freehand**.
- Click on the map to start drawing a line. Trace along the outline on the map, clicking each time you want to change direction. Each click creates a **vertex** which is similar to a node in CorelDraw or Inkscape.
- An outline can have as many vertices as you need to get around corners and curves. The tighter the curve, the more vertices you will need to prevent it from looking too square.
- If you want to **undo** the last vertex that you drew, press Ctrl + z.
- Double-click when you finish your line or press F2.

- You can easily delete features within an edit session by selecting them and hitting the delete key, **so just have a go and don't worry if your shapes don't work first time**.
- **IMPORTANT:** Save your edits at regular intervals - Editor > Save Edits.
- When you've finished stop editing (i.e. come out of the edit session) - Editor > Stop Editing.

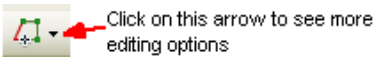


Figure 8.5: Finding more edit options

- Try the other tools available by clicking on the little arrow next to the trace button on the Editor Toolbar (figure 8.5). There are options such as **Arc Segment** and **Bezier Curve Segment** which you may find helpful with a bit of practice, though most don't have quite the same functionality as they do in a full drawing program such as CorelDraw or Inkscape.

8.4.5 Editing features

If you want to edit a polygon or line to change it once you have created it, start by using the black arrow, i.e. the **edit tool**, from the Editor Toolbar to select the feature that you want to edit...

Video Clip available in Minerva - Digitising in ArcMap Part 4: Editing features. Direct link: `http://bit.ly/2gNddyO`

Figure 8.6: Edit Vertices button

- click on the **Edit Vertices** (figure 8.6) button on the Editor toolbar.
- You can then move the existing vertices, or use the small toolbar that appears to add or remove a vertex.
- You'll be editing the **Edit sketch**, not the actual line or edge, so the feature itself won't change until you finish editing by clicking F2 on your keyboard.

8.4.6 Transparency

Don't forget that you can make layers transparent. As you draw your geology polygons you'll gradually be covering up the layers underneath and it can be useful to see through the top layers. Instructions for setting transparency are in section 1.5.4 on page 8.

8.4.7 Suggestions for avoiding gaps and overlaps

You should continue in the same way to add the other bedrock and superficial polygon features on the map. Remember to change the layer for each different formation. If you create a feature on the wrong layer it is difficult to move it to the correct one later.

Some of the polygons that you need to add share edges with others and you'll need to use techniques to make sure that these polygons neither overlap or have gaps between them. Gaps and overlaps between polygons and lines that don't follow the edges of polygons make your map look as if you haven't taken care with your digitising. GIS instructions often refer to these techniques as topological editing, or topology.

Try the following suggestions to make it easier to avoid gaps and overlaps while efficiently digitising the shapes.

The trace tool

This tool can be used successfully with both polygons and lines. It can be a little difficult to use at first, but once you've got used to it can make tracing a lot easier and quicker.

Figure 8.7: The Edit tool

Figure 8.8: Palette with edit tool choices

Video Clip available in Minerva - Digitising in ArcMap: Avoiding overlaps and gaps Part 1. the trace tool. Direct link: `http://bit.ly/2gNoHBr`

- From within an edit session click on the edit tool (figure 8.7 and click on the existing polygon that you want to trace (use as a guide) to select it.
- Click on the little black down arrow to open the palette with other edit choices (figure 8.8).
- Hovering over each tool will give you a tooltip that tells you what it does.
- Select the **Trace Tool**.
- Click on the selected polygon for the first vertex of the edge that you want to draw, then, without clicking, follow around the edge of the selected polygon. The edge you are drawing should appear along the line that you are tracing.
- If you want to continue a line or edge away from the edge that you are tracing simple click to create a vertex, then click back onto the **Straight Segment Tool** (or which ever you are using) on the edit toolbar and continue as usual.
- To finish your line double-click or press F2 as usual.

Clipping

Clipping will remove the portion of one polygon that overlaps another. Note that clipping has no effect on line features.

- Start by preventing the study_area layer from being selectable, otherwise it is easy to clip the study_area by mistake. At the top of the table of contents click on the List by Selection button (figure 8.9) and look down the list for **study_area**. Next to **study_area** click on the Click to toggle selectable button (figure 8.10). The study_area layer should move into another list headed **not selectable**.
- Return to the **Display** tab by clicking on the List by Drawing Order button (figure 8.11).

Video Clip available in Minerva - Selection tools and stopping layers from being selectable. Direct link `http://bit.ly/2fbGgee`

Figure 8.9: List by Selection button

Figure 8.10: Click to toggle selectable button

Figure 8.11: List by Drawing Order button

Now to actually clip a polygon

Video Clip available in Minerva - Digitising in ArcMap: Avoiding gaps and overlaps Part 3. clipping. Direct link: `http://bit.ly/2gNnXwh`

- Select the feature you want to use to clip, i.e. the one that is the correct shape.
- Editor > Clip.
- Leave the buffer value as **0**.
- Click Discard the area that intersects > OK.

Your polygons should now match rather than overlap. Click each polygon to view the selection outline, or change their order in the table of contents to check.

You will find that you often need to clip against more than one polygon.

Merging features

If you have drawn two separate polygons which overlap each other and want to join them together as one you need to **merge** them. The polygons must be from the same layer, e.g. both Carboniferous Limestone.

This can be useful if you are tracing a large or complex shape and want to create it in small portions, or if you get interrupted.

- Select the polygons that you want to merge by using the black arrow tool from the Editing toolbar to click on both polygons while holding down the ⇧ key.

Video Clip available in Minerva - Digitising in ArcMap: Avoiding overlaps and gaps Part 4: merging. Direct link: `http://bit.ly/2gNsAGA`

- Editor » Merge » OK.

Using the techniques in the sections above trace all of the bedrock and superficial geology polygons to your map. Remember to click more frequently around curves to make good shapes; use the trace tool, clipping and merging to make sure that your polygons neither overlap or have gaps between them.

Practice!

8.4.8 Adding fields to a feature class

At the moment your feature classes only contain the fields that Arc adds by default. You will almost certainly find that you want to add some more information, for example, some text that you can use as a label for each feature on the map or some other data describing the feature. The first step is to add fields to the attribute table.

- With editing off and ArcCatalog closed…
- Right-click on the layer title - e.g. **Carboniferous Limestones**.
- Open Attribute Table click on the Table Options button in the top left of the attribute table window Add Field…
- Fill in the form (see figure 8.12) by typing **Label** in the **Name** field; change the **Type** to **text**; change the **Length** (i.e. how many characters the field will be able to hold) to 75 » OK
- Close the attribute table.
- Repeat this for the other **bedrock** layers.

8.4.9 Adding feature attributes to a feature class

Now you're ready to add information, or attributes, to your new field.

- Start an edit session
- Click on the **attributes** button on the Editor toolbar (see figure 8.13). This will open the **Attributes** window.
- Use the black arrow on the Editor toolbar to click on a **Carboniferous Limestones** feature and select it, the attributes window will show the current layer and the fields (properties) available - figure 8.14.
- Enter an appropriate label in the **Label** field that you've set up. In this case enter **CL** as a code for Carboniferous Limestones. Later we'll set this up so that it shows on the map legend.
- Keep the attributes window open and use the black arrow to click on another polygon, not necessarily from the same layer. Enter a label in the same way. For each Carboniferous Limestones polygon use CL as the code, but for the other layers make up your own (logical) short codes.
- Repeat adding the label text for all of the bedrock polygons on your map. When you've finished save your edits and stop editing.

Figure 8.12: Add Field dialog

Getting around problems when adding fields to feature classes
Sometimes when you try to add a field to a feature class you'll get an error message saying that the field is already in use. This will prevent you adding a field. The first thing to check is that you are not in an edit session. If you are sure that you are not and it still isn't working, try the following: • If you are using the Catalog Panel in ArcMap then close ArcMap completely. • Open ArcCatalog and go to the feature class to which you want to add a field. • Right-click and open **Properties** • Go to the **Fields** tab. • Use the boxes there to add as many new fields as you need to add. If you are having problems with creating fields in ArcCatalog, then do the reverse - close ArcCatalog, Open ArcMap, and use the Catalog panel to add new fields.

Table 8.1: Getting around problems with adding fields to feature classes

Figure 8.13: Attributes button

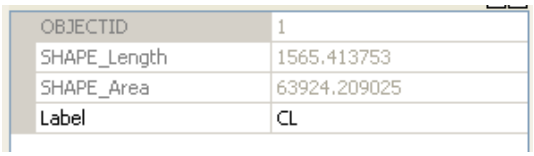


Figure 8.14: The attributes window

8.4.10 Labelling features

Now that you have label text in your attribute table you can label the features on your map.

- Right-click on the **Carboniferous Limestones** layer in the table of contents Properties › Labels
- Click to put a tick in the **Label features in this layer** box and set the **Label** field to Label › OK

Video Clip available in Minerva - Digitising in ArcMap Part 4: Editing features which also shows how to add attributes to the attribute table. Direct link: `http://bit.ly/2gNddy0`

- The code CL should appear in the middle of each of your Carboniferous Limestones polygons. Repeat this for each bedrock geology layer.

8.4.11 Setting a single symbol for a layer

You have already used **symbology** to change the format of the contours on your base map (section 5.9.1 on page 60) but we'll spend more time on changing symbols now so that the geological features that you have created will look just as you want them to.

You'll cover setting multiple symbols for a layer in section 8.5.4 on page 92 but here we'll concentrate on layers that can be symbolised with a single symbol.

You have added bedrock geology as several individual layers, so applying symbology is a simple case of selecting the chosen colour for each layer.

Choosing colours for polygons
There is a lot of advice in the books on the reading list about choosing colours for maps. In addition try the Color Brewer web site at `http://bit.ly/1OiBt3w` - it lets you play with colour combinations and is specifically aimed at people creating maps. Note that if you are going to be making a layer transparent then you will probably find that it is best to choose strong colours, such as Steel Blue, for your polygons. They will fade when you apply transparency. *(If you hover over a colour in the Symbol Selector a tool tip will tell you the name of that colour.)*

Table 8.2: Choosing colours for polygons

- Right-click outline the layer heading for **Carboniferous Limestones** in the table of contents Properties > Symbology. OR double-click on the symbol that you want to change in the table of contents.
- Click on the block of colour labelled **Symbol** to bring up the **Symbol Selector**.
- Use the options to select the fill and outline colours that you want to use for that particular symbol OK.

8.5 Adding line features

To digitise a line feature you can basically use the same instructions as you did for digitising polygons, but of course you won't have to "close" lines or clip them. Use the instructions on **snapping** in section 8.5.3 below to ensure that the ends of the lines join each other where necessary, and that the lines follow the edges of polygons where appropriate. The **trace tool** (see section 8.4.7 on page 84) can also be very useful when a line needs to follow the edge of a polygon.

Video Clip available in Minerva - Digitising in ArcMap Part 2: Creating line features. Direct link: `http://bit.ly/2gNchJY`

8.5.1 Setting up feature classes

Start by using the instructions from section 7.3.2 on page 76 to create a new feature class (type should be **line**) called **GeolLines** with an alias of **Geological lines** and make sure that the class is added to your map.

As you create the feature class also create extra fields for adding attributes (see figure 8.15 for the dialog for adding new fields). The field names and types should be as follows:

Field name	*Type*	*Length*
Type	text	50
Label	text	75

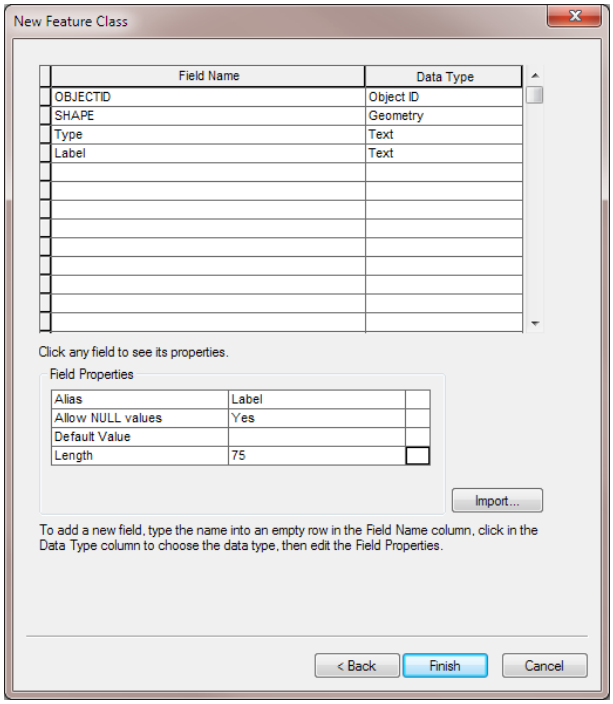


Figure 8.15: Adding fields whilst creating a feature class

Adding further fields to existing feature classes

If you don't add the fields when you are creating the feature classes it is still possible to add them later.

If you're editing, make sure that you stop the edit session first then the instructions for adding fields when you have already created feature classes are in section 8.4.8 on page 86).

You'll see how to set the symbols for the line classes in a later section.

8.5.2 Digitising line features

- Select your **Geological lines** layer and start to digitise the **Skirwith Syncline** by digitising the solid syncline line overlying the greywacke in the middle of the map. Don't carry on to digitise the dashed portion of the line as the same line but double-click or press F2 to finish the edit sketch.
- Open the **Attributes** window (figure 8.16) by clicking on the Attributes button on the Editor toolbar (figure 8.18)
  - Fill in the **Type** field with `Fold - syncline - observed`
- Now digitise the dashed part of the line, and again, don't carry on to the next solid part but double-click or press F2 to finish the edit sketch. Don't be tempted to create each dash as a separate line - you'll see later how to make a solid line dashed.
- Again, open the **Attributes** window
  - Fill in the **Type** field with `Fold - syncline - inferred`
  - Fill in the **Label** field with `Skirwith Syncline`
- In the same way digitise the final, solid, part of the line and fill in the attribute table as follows:
  - Fill in the **Type** field with `Fold - syncline - observed`

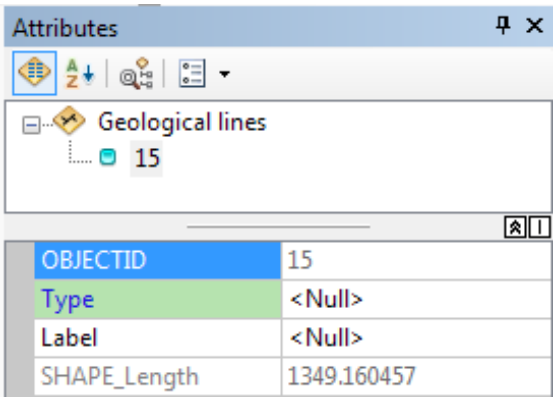


Figure 8.16: The attributes window. While you are in an edit session you can add attributes to whichever feature is currently selected by filling in this form.

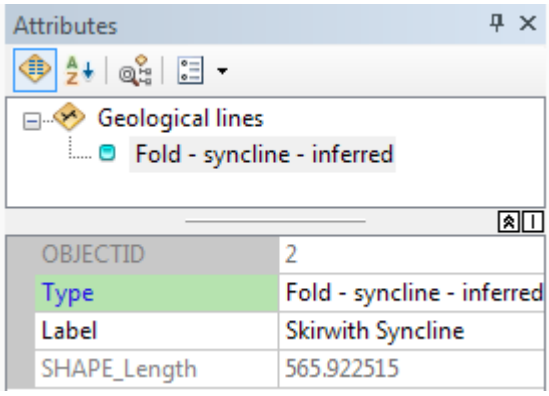


Figure 8.17: The new attributes entered in the attributes window.

Adding attributes to existing features

If you have already digitised lines but then want to add attributes later, start the edit session again and add attributes to the line layer as follows:

- Use the Edit tool (black arrow on the Editor toolbar) to select the feature whose attributes you wish to edit
- If the attributes window (figure 8.16) isn't open either select it from the right-hand side of the screen, or click on the Attributes button on the Editor toolbar (figure 8.18) then enter the attributes in the relevant fields (figure 8.17).
- Add the **Type** to each line being careful to be consistent.

- You will only need to add a label to the central part of the Skirwith Syncline (as shown on the field slip). Don't add labels saying just "fold" or "fault".

Figure 8.18: Attributes button on the Editor toolbar

Figure 8.19: The Snapping Toolbar

8.5.3 Snapping

Snapping allows new edits to connect exactly to existing lines and edges. You may find this particularly useful if you want lines such as faults to line up with the edges of geological formations. Note that this will work with polygons and points as well as lines.

It is worth being aware of snapping, even if you decide you don't want to use it, as it can cause you issues when digitising. In particular, it can be useful to switch off contours, as those can become very irritating when you are digitising.

Video Clip available in Minerva - Digitising in ArcMap: Avoiding overlaps and gaps Part 2. snapping. Direct link: `http://bit.ly/2gNtt1R`

To set snapping -

- Start an edit session then Editor > Snapping select **Snapping Toolbar**.
- The toolbar will open (figure 8.19) - if it doesn't, check that it is also turned on under Customize > Toolbars.
- **Snapping > Use Snapping**. Use the buttons on the toolbar to set what type of snapping you are using. There are times when you will find snapping useful, and others when it will just get in the way. **Experiment!**

Snapping tolerence

Snapping tolerence sets how close the pointer has to be to an edge, end or vertex before it **snaps**, or jumps, to it.

- Snapping > Options... > Snapping tolerance.
- Start by setting this to **10 pixels**. This is quite large and may stop you from putting vertices where you want to, but you can then experiment to get this set to your satisfaction once you start editing.

Continue to digitise the lines on the map using the line types below to distinguish them. If you are digitising around the edges of an existing feature, e.g. the bedrock polygons, you can again use the trace tool (section 8.4.7 on page 84) or snapping (section 8.5.3 on page 91) to make sure that your lines match.

- ***Fault - inferred for the dashed red lines***
- ***Fault - observed for the solid red lines***
- ***Geological boundary - observed for the solid black and the lines around the rest of the bedrock units.***
- ***Geological boundary - inferred for the dashed black lines.***

You should end up with multiple line features in one feature class: **don't create the dashed lines for the inferred faults by digitising lots of short segments** - I'll show you how to create the dashes automatically later.

8.5.4 Setting multiple symbols for a layer

If you only need to set a single symbol for all lines in a layer then you can use the same technique that we used for polygons - see section 8.4.11 on page 88. Here we'll look at layers that contain more than one type of line, but this technique will also work when you have more than one type of polygon, or point.

The **Geological lines** layer needs a different line symbol for each line type, e.g. folds, faults, geological boundaries, in the same way as you set the contour layer to use more than one symbol in section 5.9.1 on page 60.

Video Clip available in Minerva - Symbolising a layer by categories in ArcMap. Direct link: `http://bit.ly/2ePRqVG`

To add multiple categories do the following:

- Right-click on the layer heading in the table of contents and go to Properties > Symbology > Categories > Unique Values (figure 8.20).
- Set the **Value Field** to **Type** (this is the field that you want to categorise your data by).
- Add all values.
- Arc will assign random colours / symbols to each value. You can change these by double-clicking on the symbol next to each category.
- If you add a new value later you will also need to add that to the list of categories, to do this without reassigning symbols to all values click on the Add values... button and select the value you wish to add then click OK.
- When you have added all values and have finished editing, click in the tick box next to <**all other values**>, then this won't appear in legends. Be careful if you continue to edit once you have done this as it can appear that your new features are not being drawn.
- When you are happy with the result click OK.
- The table of contents will list the categories as the ones that you have set. These descriptions are fine, but if you need to change them you can do so by clicking twice slowly on the text in the Table of Contents that you want to change (or select it and press F2).

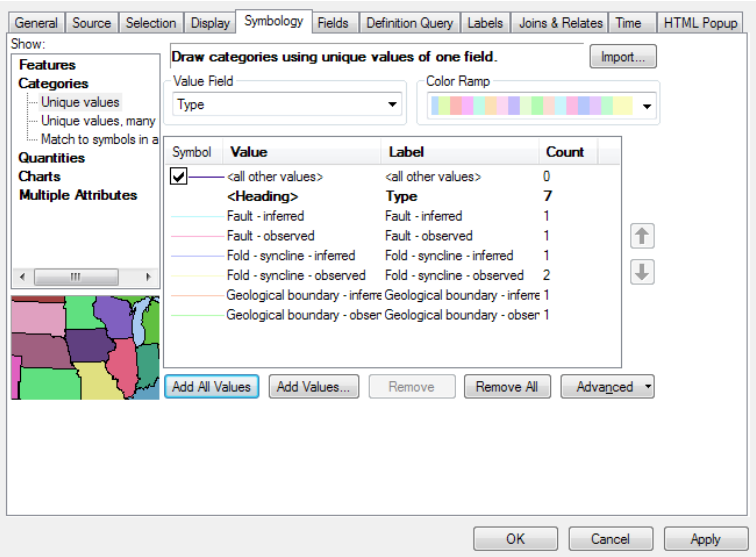


Figure 8.20: Adding multiple types of line to symbolise by category

8.5.5 Symbolising dashed lines

In this example the type **Fault - inferred** is shown as a dashed line on the field slip. You should have drawn it as a continuous line and the default symbology will not be dashed. To symbolise the line as dashed:

- Open the **Symbol selector**
- Browse the choices on the left of the selector to find **Dashed 4:4** and select it.
- You can use the symbol as it is shown, and in this case that is probably fine, but you can also change the colour and width as usual, or change the spacing of the dashes as follows:
  - Click on Edit Symbol...
  - Go on to the Template tab - figure 8.23.
  - On this tab you can change the distance between the dashes and the width of the dashes. Try moving the grey square on the line to the far right. Then click somewhere on the line to place a couple of black squares - that should add another symbol. You can remove the original location by clicking on the first black square. Keep checking the result in the **Preview** pane.
  - Once you're happy with your line symbol click OK until you get back to your map and check it there.

8.5.6 Symbolising lines with "decoration"

You can use existing styles within Arc to symbolise lines with "decoration" e.g. ticks on the downthrow side of a fault. Arc includes the U.S.G.S. geological symbols in the Geology 24k symbol set. These are not the standard UK symbols, but you may still find them useful.

Alternatively you can "build" your own line styles using the **Symbol Property Editor** as shown here, or just add point symbols to a line and rotate them as necessary as shown in section 8.6.5 on page 104.

- In the table of contents double-click on the style that you want to change to bring up the **Symbol Selector**

- From the Symbol Selector click on the Edit Symbol... button (figure 8.21) to bring up the **Symbol Property Editor**

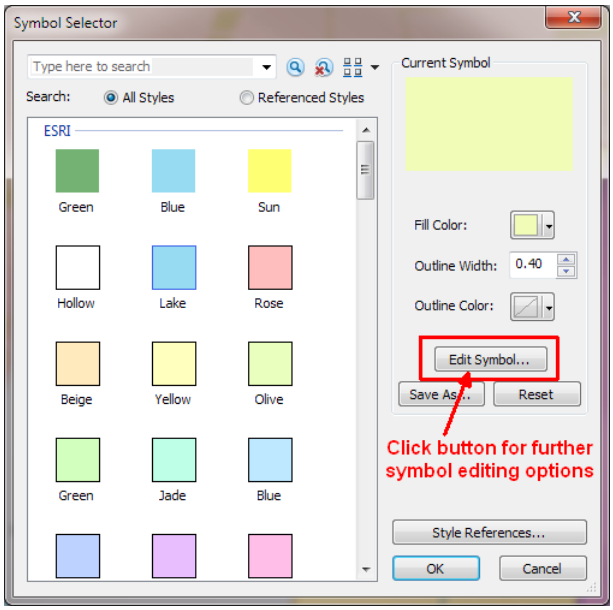


Figure 8.21: The Symbol Selector showing the button to click to bring up the Symbol Property Editor.

For this example we'll add a syncline symbol to a fold axis line feature. The syncline symbol looks like two arrows pointing in towards the line. In effect what we need is a cross on top of a line, so start by looking at the **Layers** area of the Symbol Property Editor (figure 8.22).

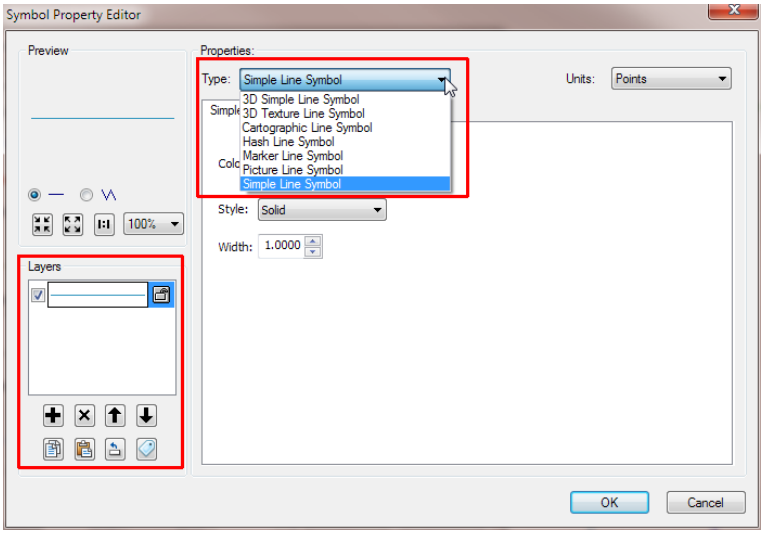


Figure 8.22: The Symbol Property Editor showing the Layers and Type areas

- Click the plus sign underneath the **Layers** box to add a new layer
- Now click on the **Type** dropdown and select **Marker Line Symbol**. The result will look dreadful to start with, but now click on the Symbol... button on the **Marker Line** tab.
- From there you get the familiar symbol selector. Scroll down through the choices and select the **X**. You can also change the colour to green in the usual way, and change the size of the symbol.

- Click OK. On the left you should be able to see a preview of your line. It will look a bit of a mess at the moment but keep going!
- Go on to the Template tab - figure 8.23. On this tab you can change the distance between the symbols. Try moving the grey square on the line to the far right. Then click somewhere on the line to place a black square - that should add another symbol. You can remove the original location by clicking on the first black square. Keep checking the result in the **Preview** pane.
- Once you're happy with your line symbol click OK until you get back to your map and check it there.

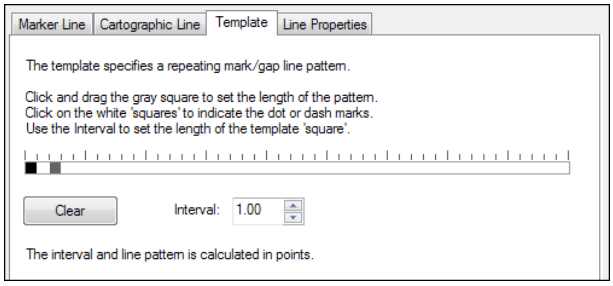


Figure 8.23: The Template tab of the Symbol Property Editor

Keep trying out different settings, sizes, intervals etc until you are happy with your line.

Note that there are sometimes issues with the location of symbols on lines. This is particularly noticeable when you try to put thrust barbs onto a line with a lot of bends. Some of the symbols become detached from the line, and others may even turn around completely. So far we haven't been able to find a solution for this beyond making the symbols small and spread out.

Use the techniques above to finish symbolising all of the lines on the map. The symbology dialog should look something like figure 8.24 by the time you have finished.

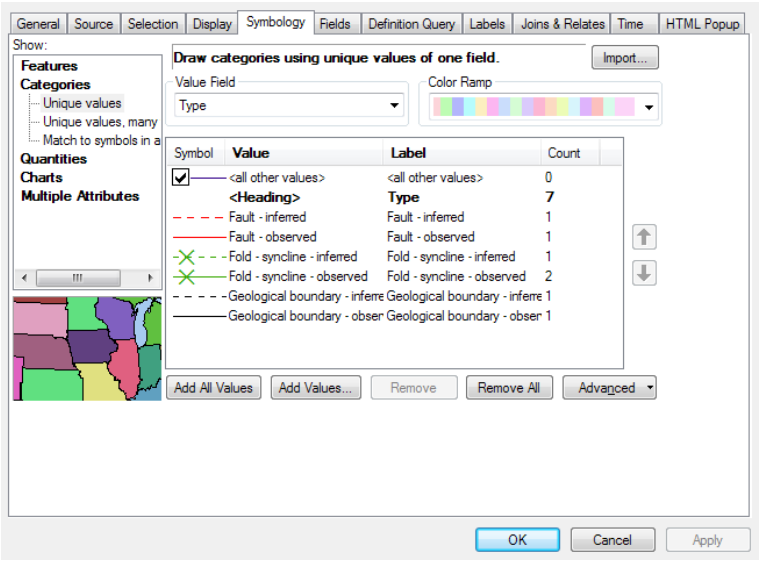


Figure 8.24: The symbology properties dialog with all of the lines symbolised appropriately

8.5.7 Flipping line features

If you are adding a symbol to a line and it appears on the wrong side, you need to change the direction of the line by **flipping** it. This means that, rather than having a line that, for example, starts on the left and goes to the right, you flip it so that it starts on the right and goes to the left.

Video Clip available in Minerva - Flipping line features. Direct link:
`http://bit.ly/2vnPCqM`

- Start an edit session and use the Edit Tool to double-click on the line you want to flip
- the vertices should become visible - note that the final vertex that you created is red.
- Right-click on the line and select Flip

The red vertex should change ends, showing that your line is now the opposite way round from how you digitised it. Don't forget to save your edits.

8.6 Adding point features

Points on maps can include symbol markers to show types of lines, such as anticlines and synclines (useful if you can't find a line symbol with appropriate "decoration"), direction of dip and strike for field observations, locations of particular features, or a way of adding symbols for particular rock types. You can also use points to create labels that aren't attached to any other particular feature. Figure 8.25 shows some examples of uses of point symbols.

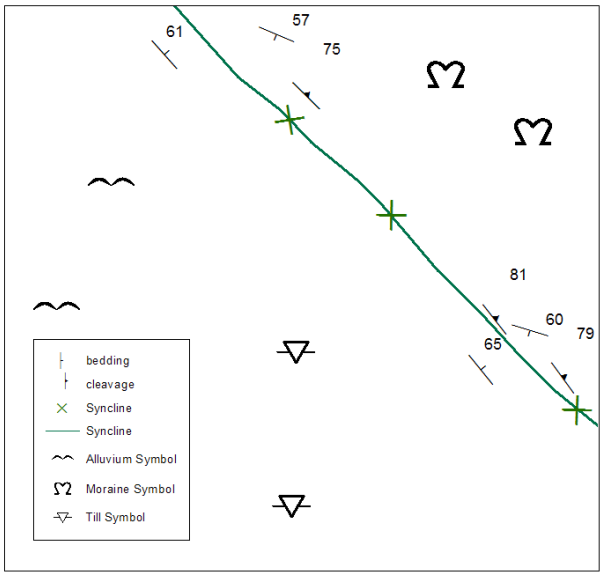


Figure 8.25: Examples of the uses of point symbols on maps

We'll use two different ways of adding points to a map - for the marker symbols on lines, and the symbols for superficial deposits we'll add points in an edit session in a very similar way to that in which we added polygons and lines. For the bedding and cleavage we'll use a spreadsheet and import the values. When it comes to adding your own data in future it will be up to you which method you decide to use for which types of point data. If you have bedding, cleavage, etc on your fieldslip, the simplest way will probably be to add the points in an edit session.

8.6.1 Adding points in an edit session

You add points in a similar way to adding lines and polygons, but this time by selecting a point layer. Of course, for points you only need to click once on the map.

Video Clip available in Minerva - Digitising in ArcMap Part 3: Creating point features. Direct link: `http://bit.ly/2gNlHoI`

If you haven't done so already, use the instructions from section 7.3.2 on page 76 to create new feature datasets and classes (type should be point) for the following layers according to the plan that you made in section 7.3 on page 75 and make sure that the classes are added to your map.

You'll see how to set the symbols for these in section 8.6.3 on page 101 but for now you just need to add the basic data to your geodatabase.

Then use the scanned map to add point features to the appropriate classes :

- ***alluvium symbol***
- ***moraine symbol***
- ***till symbol***

8.6.2 Adding points by importing

Point data can be added either by editing the map, as in the section above, or by importing it from a spreadsheet or text file. When you are working with your own data you will have all of these measurements on your field slip and in your notebook - not in a table format like you have been given here. So the first step would be to collate the measurements that you want to include in your top copy map into a table. For this reason you may find it much simpler just to digitise the measurements in an edit session using the instructions in the previous section.

It is completely up to you which method you use but have a go at both before you decide.

Xyz files can be either comma separated value text files or Excel spreadsheets. They contain point data which includes coordinates for a geographic location either in two dimensions (x and y) or three (x, y and z). The example we'll use is an Excel spreadsheet. When you are creating your own maps you could either create the file for yourself from a field notebook or create from GPS-related data.

Creating xyz files and preparing for import

In Excel open the **strikedip.xls** file that you can download from Minerva and have a look at the data (Figure 8.26). We're using bedding and cleavage data as an example, but the same techniques will apply to any point data, such as lead concentrations in soil samples, gravity measurements, rainfall totals etc.

Note that Arc doesn't appear to open files from the latest versions of Excel so make sure that you save the file as Excel 97-2007 and that it has an **xls** extension rather than **xlsx**. If you have trouble importing an excel file, try saving it as .csv instead.

I6

	A	B	C	D	E	F	G
1	site	100kgrid	eastings	northings	type	strike	dip
2	1	SD	69388	75125	bedding	220	3
3	2	SD	69487	75103	bedding	122	61
4	3	SD	69471	74991	bedding	310	60
5	4	SD	70171	74404	cleavage	322	81
6	5	SD	70207	74392	bedding	107	60
7	6	SD	70168	74356	bedding	321	65
8	7	SD	70101	73749	bedding	137	18
9							

Figure 8.26: Excel file containing x and y point data

strikedip.csv

```
site,100kgrid,eastings,northings,type,strike,dip
1,SD,69388,75125,bedding,220,3
2,SD,69487,75103,bedding,122,61
3,SD,69471,74991,bedding,310,60
4,SD,70171,74404,cleavage,322,81
5,SD,70207,74392,bedding,107,60
6,SD,70168,74356,bedding,321,65
7,SD,70101,73749,bedding,137,18
```

Figure 8.27: The same file containing x and y point data, this time saved as .csv and opened in a text editor

Arc can also import xyz data from **.csv** (comma-separated value) files either saved from Excel or created in a text editor such as Notepad++ (Not Word!) see figure 8.27.

IMPORTANT NOTE: Column headings must be short and contain no spaces or non-standard characters - so text and numbers only.

Plotting structural geology data in GIS: Leeds method vs Right hand rule
When you take structural readings you will be recording them using the Leeds method as (for example) 010/18NW, with the strike being between 0 and 180, but when you then plot them in GIS, which uses the right hand rule, the tick mark will be in the wrong direction for some of your measurements. The problem isn't with your measurements, but with the way that Arc is able to handle them. Have a look at appendix B on page 156 for more information on how to deal with this. **Once you have imported the points into Arc have a close look to make sure that they agree with your symbols on the field slip.** **The data you have been provided with for Ingleton is already converted so that you don't need to worry about this step.**

Table 8.3: Plotting structural geology data in GIS

Notice the **eastings** and **northings** columns - in effect x and y. These are in **British National Grid 1m coordinates**. We'll need to do some work to make these suitable for importing into Arc, though. Note the column headed **100kgrid** - that tells you which 100km grid square the references are in, **SD** in this case. Unfortunately Arc won't read these, and if you import the eastings and northings as they are your data will end up in the wrong place.

British National Grid 100km squares

British National Grid references are most commonly given in the form NN60052674, with grid **letters** at the start to give the 100km grid square. These letters need to be replaced by numbers if the grid references are to be read by ArcGIS.

If you are given a reference that does not include the grid letters but consists entirely of numbers it is worth checking whether the grid numbers make sense. Of course, it may just mean that the person who created the references forgot about the letters, in this case the reference could refer to any of the 100km squares covering the UK - not helpful!

The instructions with figure 8.28 show you how to convert from grid letters to numbers. Study this and then practice using the examples below.

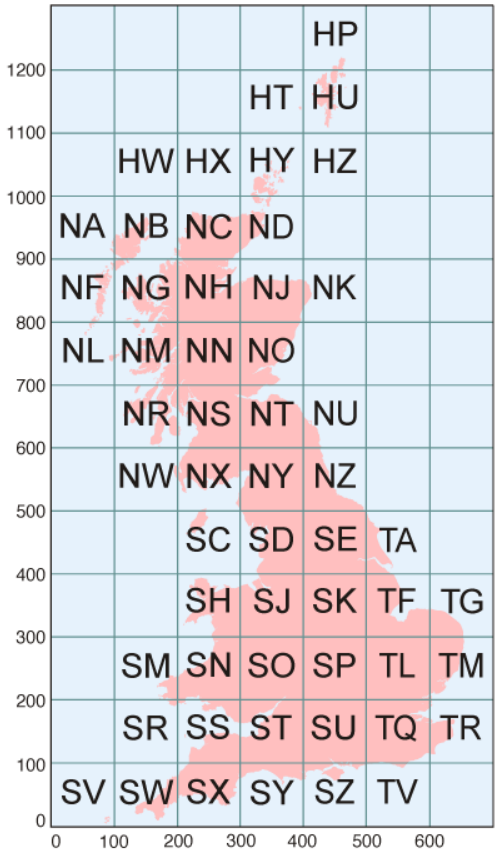


Figure 8.28: British National Grid 100 km squares

To replace grid letters with numbers as is required when importing British National Grid coordinates into Arc:
Using the example **NN 6005 2674** (This is not Ingleton!)

- find the number of the line **to the left** of the grid square (i.e. one of the numbers from the line at the bottom) in figure 8.28 - for **NN** this is "2".
- This number will apply to all of the references in the eastings column of the spreadsheet.
- then the number of the line **below** the grid square (i.e. one of the numbers to the left) - in this case "7".
- This number will apply to all of the references in the northings column of the spreadsheet.
- So in this example, grid reference **NN 6005 2674** would become **26005 72674**.
- In addition, x and y numbers all need to be six figures to appear in the correct place in Arc, so if, as in the example, there are fewer digits then add zeros to the end of each so make it correct.

Finally the grid reference above will become **260050 726740** and at this point will be ready to enter into Arc.

Try replacing grid letters with numbers

Question 8.1. Starting from a grid reference NG 344 576 what will be the grid reference with NG converted to figures?

If you look at the corners of a published hardcopy Ordnance Survey map such as the Landranger (pink covers) or Explorer (orange covers) series you'll be able to see these numbers as small figures on the labels of the grid lines - only at the corners, though, not right around the edges. The grid letters will appear in the corner of the published maps too.

Try replacing grid numbers with letters

Try doing a similar exercise in reverse:

Question 8.2. Starting with grid coordinates 5433 2433 what will be the grid reference with the figures converted to letters?

Have a look at the data that you have been given for Ingleton and work out what numbers you need to add to the eastings and northings columns to make the numbers correct for grid square SD.

Edit the spreadsheet so that all of the eastings and northings have the correct number at the beginning. Every number should consist of 6 figures when you have finished.

Converting .xls or csv to a feature class

In the Catalog panel in ArcMap:

For an Excel spreadsheet (if you are using a csv file use the instructions below) -

- click on the plus sign next to the Excel file to show the contents (figure 8.29)
- You should be able to see a layer with a name which ends with with a **$** sign.
- right-click on that layer (if you can see more than one use the first in this case) and click to Create Feature Class » From XY Table... (figure 8.30)
- Fill in the X and Y Fields using the spreadsheet columns which show the coordinates in British National Grid
- Click on Coordinate System of Input Coordinates... and select **British National Grid**
- Choose a location and name for the output, then OK

This also works for csv (**c**omma-**s**eparated **v**alue) files. Indeed, **if you are having trouble loading an Excel file**, try saving it as csv in Excel[1], then import it to Arc using the instructions below. It often works much better than the Excel file.

For a csv file -

- just right-click on the file name, it won't have a plus sign like the Excel file does
- select Create Feature Class » From XY Table....
- Fill in the X and Y Fields using the spreadsheet columns which show the coordinates in British National Grid
- Click on Coordinate System of Input Coordinates... and select **British National Grid**
- Choose a location and name for the output, then OK

The output shapefile should appear in Catalog in the location that you chose to save it. Add it to your map in the usual way.

[1] Save from Excel to csv as follows: File » Save As choose a location then under **Save as type:** choose **CSV (Comma delimited) (*.csv)**.

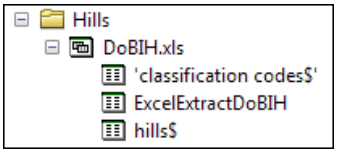


Figure 8.29: Excel file in Catalog opened out to show contents

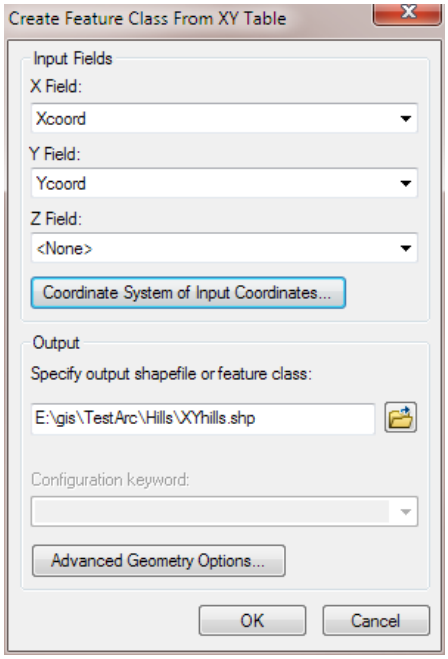


Figure 8.30: Creating a feature class from an XY Table (your field and file names probably won't be the same as this)

8.6.3 Symbolising points

The techniques for symbolising points are basically the same as those that you used for polygons and lines, so look back at sections 8.4.11 setting a single symbol for a layer on page 88 and 8.5.4 setting multiple symbols for a layer on page 92 if you need a reminder. For some of the points on our Ingleton map we need to use slightly more complex symbols and need to create them ourself but we'll start by using existing symbols.

Using symbols provided

If you are lucky the symbols that you'll need to use have already been provided in ArcGIS.

- In the table of contents double-click on the symbol that you want to edit, to bring up the **Symbol Selector** (figure 8.31.
- Make sure that **All Styles** is selected and then try searching for **bedding**.
- If searching doesn't work (it doesn't always in clusters) click on Style References... in the Symbol Selector. Tick next to Geology 24k > OK then browse the list. There should be various entries for bedding under the Geology 24k heading, choose the most appropriate.
- You can hover the cursor over the symbols that appear to see exactly what each one is. When you find the symbol that you want to use select it, and check the settings on the right, e.g. color, size. (If you want to make any more advanced changes to the symbol click on Edit Symbol... and have a go!)
- Note that in figure 8.31 the **Angle** is set to `270 degrees` in the symbol selector. This ensures that the symbol is at the correct angle to rotate according to your measurements. If you choose a different symbol check that it appears vertical and with the "tick" or mark on the right-hand size. If not, change the angle so that the symbol does appear like that.

- OK

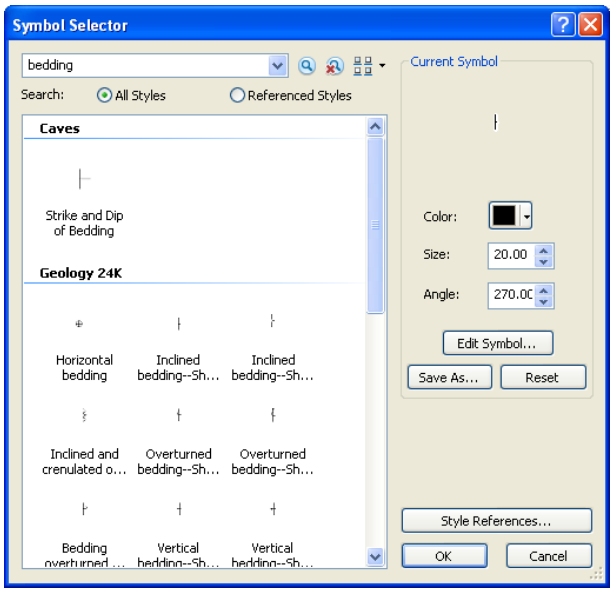


Figure 8.31: Finding point symbols in the symbol selector

Creating your own symbols

If you can't find the symbols that you need, then you can create your own. Use Arc Desktop Help to search for **Creating New Symbols**. There are various options including altering existing symbols and creating your own from images (picture marker symbols).

To create your own picture marker symbols:

- On this occasion I've created the png files for you, so download them from Minerva and unzip to your M:/ drive - **GeolSymbols2018.7z**[2]
- You'll usually have to start by using Inkscape or CorelDraw to create the symbol you need
  - Set the page or drawing size as **512 X 512 pixels** and use the whole space.
  - if using Inkscape do File > Export PNG Image... and export as a **.png** file. This will export the symbols with transparent backgrounds.
  - if using CorelDraw **export** the symbol as a **.png** file.
- We'll start by setting up the symbol for **till** but other symbols will be created in the same way.
- In the Table of Contents double-click on the symbol that is current being used for Till - probably just a coloured dot. The **Symbol Selector** should open.
- Edit Symbol... in the **Type** dropdown box select **Picture Marker Symbol**. Use the dialog that opens to browse for the png files that you just downloaded from Minerva and select TIL_till.png > Open.
- In the **Symbol Property Editor** (figure 8.32) make any changes that you need to size etc (you probably won't be able to change the colour), then OK. The new symbol should now be available to use on your map. Note that the symbol is **linked** from your map, not embedded in it, so ensure that you keep it in the same folder now and don't delete it.

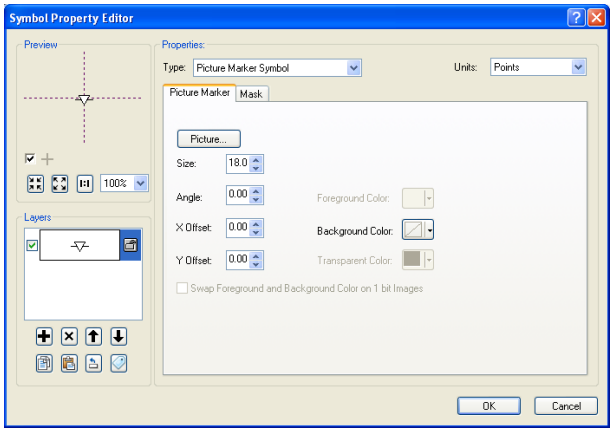


Figure 8.32: The symbol property editor

To save the symbol so that you can use it again in Arc:

- From the Symbol Selector click on Save As...
- Give the symbol a name and click on Finish. It should now be available in your default style which is stored in your profile.

Repeat for the Alluvium and Moraine symbols, again using the png files downloaded from Minerva.

8.6.4 Rotating point symbols

Some symbols need to be rotated, for example, if the angle of the symbol shows something about the data that symbol represents such as the strike for bedding symbols, or if a symbol should be at a particular angle on a line such as a fold axis. Symbols such as moraine and till don't need to be rotated.

Video Clip available in Minerva - Rotating point symbols in ArcMap.
Direct link: `http://bit.ly/2eNvRF8`

Preparing to rotate

If you are adding bedding, foliation etc measurements, there should already be a field for strike and you will use this as the rotation field.

If you wish to rotate symbols which don't have strike you will need to set up a **short integer** field in your feature class to hold the rotation information, e.g. you could create a field called **Rotation**. See section 8.4.8 on page 86 for instructions on how to add a new field/column and don't forget that it must be **Short integer** data type.

[2] I have based these symbols on the BGS Symbols Index v.3 which can be downloaded from `http://www.bgs.ac.uk/reference/symbols/home.html` (Last accessed: 5th October 2017). The codes in the filenames refer to this document.

Setting the rotation field

Once you have symbolised a point feature class you need to tell ArcMap which field to use to hold information about rotation. **If you don't do this your symbols won't rotate.**

- Right-click on the **bedding** layer in the table of contents.
- Properties > Symbology tab > Advanced > Rotation.
- From the drop-down list, click on the field that will contain the rotation angle - in this case **strike**. Values should be in degrees and in the range of 0-360.
- Click the **Geographic** rotation style.
- Click OK on all dialog boxes.

Rotating symbols in an edit session

Within an edit session you can change the values in the rotation angle field in two ways:

Figure 8.33: The rotate tool

- You can update the rotation angles values by interactively rotating individual point symbols with the **Rotate tool** on the Editor toolbar (see figure 8.33) - here you can use this method for symbols on a line. **If you rotate your symbols but they just flick back to where they started check that you have remembered to set a rotation field in the symbology tab of the layer properties, as instructed above.**
- or by typing new values in the attribute table or the Attributes dialog box. So if you have a measured strike angle then you can add that to the field for accuracy. By importing the bedding and cleavage points you should already have the strike in your table so the points should have rotated automatically when you set rotation - check that they have.

What if rotation doesn't work?

Troubleshooting: If rotation doesn't work, the first thing to check is that you have remembered to set **Rotation** in the symbology tab of the layer properties, as instructed above.

If you can't select the correct field for rotation under **Advanced**, check that the field type is **Short Integer**. If it isn't you will have to create another field that is!

8.6.5 Adding point symbols to lines

Adding points to a line and then symbolising the point is an alternative way to add symbols to lines. You have already symbolised the **Syncline** layer to indicate the type of fold in section 8.5.6 on page 93, so you don't need to do this now, but it's worth knowing that it's a possibility. An alternative way to add the syncline symbol would be as follows:

- Set up a new point feature class called **Fold Symbol**. Use that feature class to add points on the syncline where you want the symbols to appear.

- Add **Rotation** (short integer type) and **Type** (text type) fields to the attribute table (use the instructions in section 8.4.8 on page 86), possible attributes for the Type field will be **Syncline** or **Anticline**. In an edit session add **Syncline** to the Type field for the points that you have just created.
- Add the symbology as described in section 8.6.3 on page 101. In this case look for a cross symbol for the syncline and a diamond for the anticline (though you won't need that on this map).
- You'll need to rotate the symbols individually **after** you have symbolised them so that they are at the correct angle on the line by following the instructions in section 8.6.4 on page 103 for rotating point symbols.

8.7 Advanced labelling

You can label any layer in the same way that you labelled the base map contours (section 5.9.2 on page 62), but once you have done this there are ways to have more control over the placement and occurrence of your labels. Start by checking that the Maplex Label Engine is activated.

- Open the Labelling toolbar (Customize > Toolbars > Labeling).
- Labeling > Use Maplex Label Engine.

This immediately improves the placement of your labels but it also gives you many new options but it also gives you many new options which mean that you have more control over label placement.

Figure 8.34: Labeling toolbar with Label Manager button

You can edit label properties by opening the Layer Properties and clicking on the **Labels** tab as you did in section 5.9.2 on page 62, but it is also possible to use the **Label Manager** and I'll show you how to do that in this section.

- Click on the Label Manager button (figure 8.34).
- The Label Manager should open (figure 8.35). Notice the list of label classes on the left which should equate to your current layers.

You have already labelled the Skirwith Syncline on your map, so we'll modify that so that it looks a little better.

- Look for the **Geology: Geological lines** layer (or whatever you called it!). Make sure that there is a tick in the box next to the layer and then click on **Default** underneath the heading (there should also be a tick in the box next to that).
- Using the options on the right untick **Stack label**. Stacking means that the label will be "Stacked" onto more than one line. Useful if it is particularly long, but you don't always want this - particularly if you want the label to follow a line.

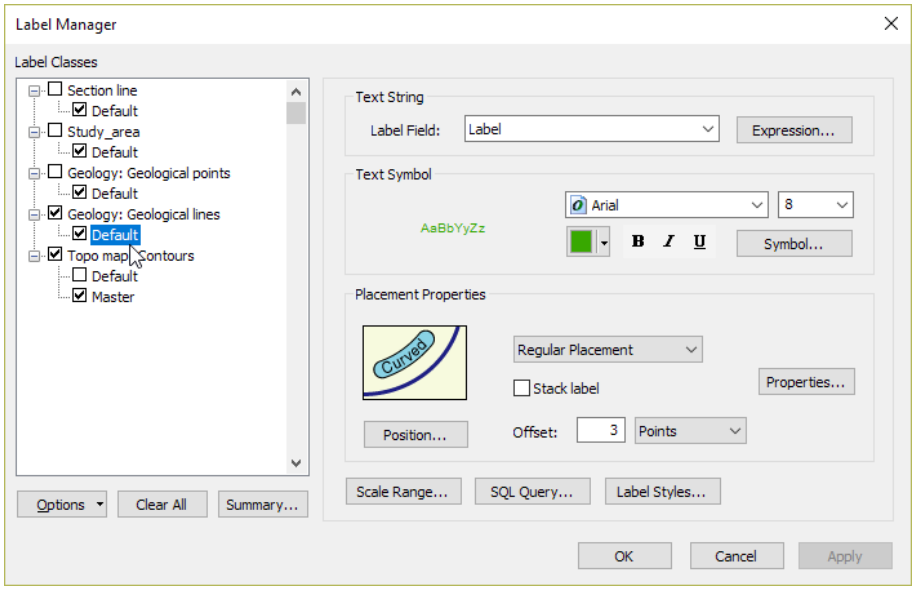


Figure 8.35: The Label Manager

- Set the **Offset** to **3 Points**. This means that the label will be slightly further from the line.
- Click on Position > Offset Curved > OK.
- Double-check that the **Label Field:** is set correctly
- Click Apply to check the results on your map. If you are happy with them click OK to close the Label Manager.

> ***There are too many options to go through one by one here. Try out different settings and try them on different layers. Aim for a setting that doesn't look crowded but provides useful information for the audience of your map.***

8.7.1 Using label classes

Label classes make it possible to only label some types of features in a layer, or to label different types in different ways, in a similar way to being able to use multiple symbology for features in the same layer.

Here we'll use the example of the contours feature class. In an area with dense contours, labelling all of them can become confusing. Instead it is possible to only label contours every 25 metres, for example. For the OS Terrain 5 contour data which your are using for the Ingleton map, you've already seen that there is a field called **SUB_TYPE** which categorises contours as either **master** or **ordinary**. You can now use this to set up **label classes**.

- In the **Label Manager** (selected from the Labeling toolbar as above) click on the entry for your contours
- The label manager should look something like figure 8.36.
- Untick any categories apart from **master** in the lower box then click Add next to the box. In the next dialog which opens click on No so that you don't overwrite the default class.
- There should now be a new class for **master** in the **Label Classes** box on the left (figure 8.37). Make sure that this class is ticked and the **Default** class isn't.

- If you click on the **master** class it should still have the styles that you have set previously. Change them if you wish to, otherwise click Apply to see the difference.

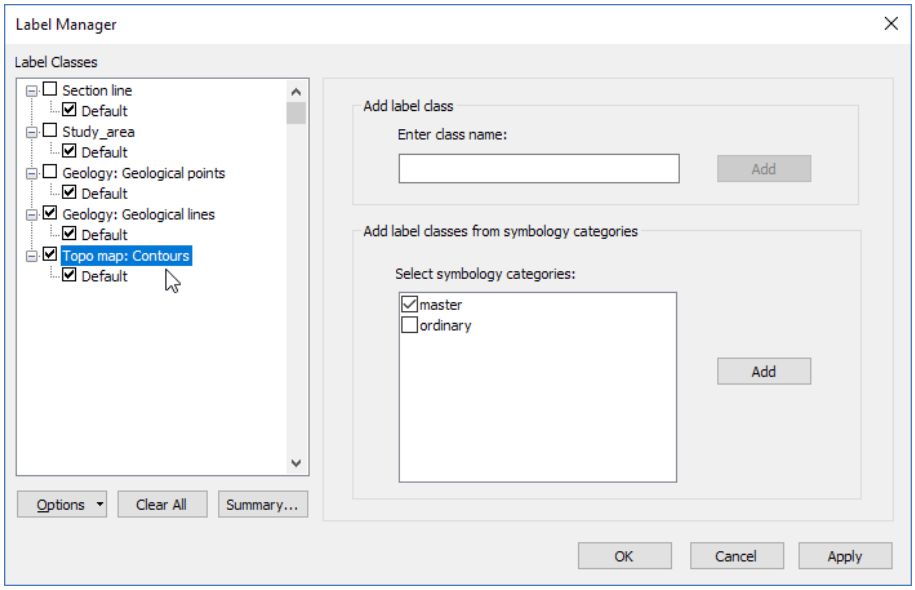


Figure 8.36: Adding new label classes in the Label Manager

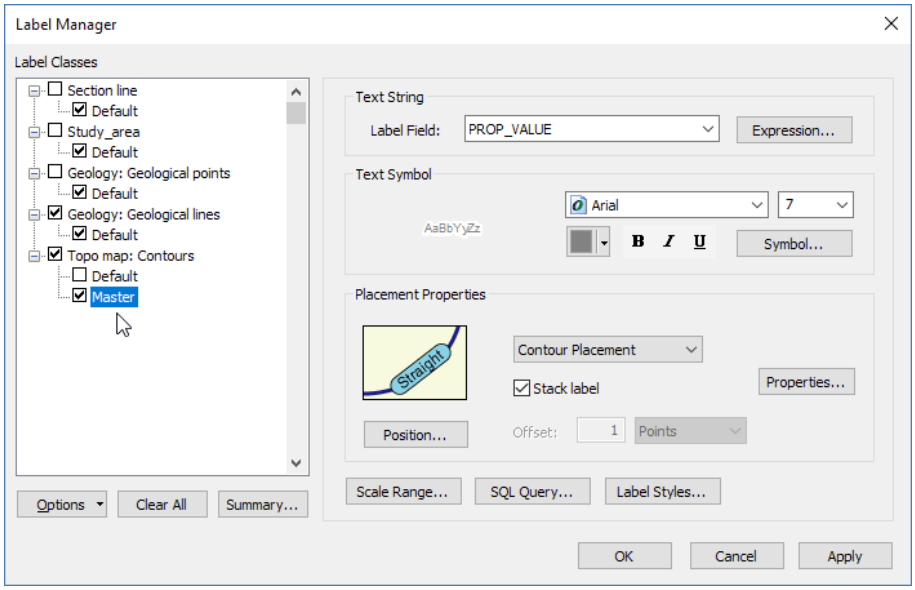


Figure 8.37: Selecting label classes to display - only the master contours will be labelled

See figures 8.38 and 8.39 to see the difference. Of course, this technique can also be used if, for example, you wish to label different features with labels of different colours or sizes of font.

8.7.2 Convert labels to annotation

You will convert the contour labels to annotation so that they can be treated like any other layer and moved around manually. This gives you a way to neaten your map by placing the contour labels underneath the geology layers in the layer order, rather than on top of them. This gives a neater finish so that the labels are still visible but not dominant.

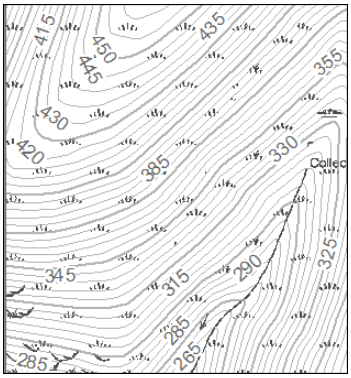


Figure 8.38: An area of steep contours with all contours labelled - it isn't always clear which label belongs to which contour, and because the labels are so close together some of them are "pushed" out of the way

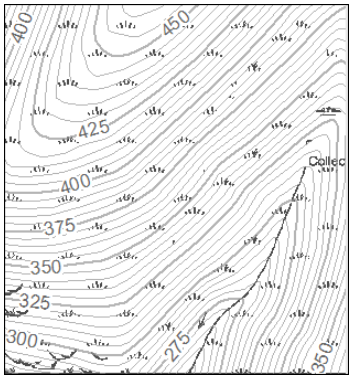


Figure 8.39: An area of steep contours with contours only labelled at 25 metre intervals. It is much easier to see which label belongs to which contour, and it isn't difficult to work out the heights of the intermediate contours

Annotation also means that if you are not happy with the automatic placement of the labels on any layer you can convert them to annotation and then move them around individually in an edit session.

IMPORTANT: This step can crash ArcMap. Make sure that you have your map saved and backed up BEFORE you do this!

- Right-click on the contour layer in the table of contents Convert Labels to Annotation (figure 8.40).
- **Store Annotation - In a database**.[3]
- **Create Annotation For - all features**.
- Check that the correct layer is selected.
- Click on Convert and wait patiently. This could take a while to finish processing.

The new annotation layer will be added to the table of contents and a new feature class will be created in your geodatabase. Move the annotation layer so that it is grouped with your contour layer and make sure that both layers are beneath your geology polygons but above the OS base map tiles. If you find that most of your labels have disappeared during the conversion try the tip in box 8.4

8.8 Digitised and symbolised geology

The techniques in this chapter should allow you to digitise and symbolise all of the geology on the original fieldslip. By the time you have finished you should have something that looks like figure 8.41 (if you turn off the base map and the field slip). Your map probably won't look identical to this one as you'll have made your own decisions, but it should look similar.

[3] Note that if the layer that you are converting labels to annotation for, is stored as a shapefile rather than a feature class in a geodatabase you will only have the option to save annotation to the map. This doesn't allow you to change the order of the layers, though it does still allow you to move individual labels around. You may want to return to section 5.6 on page 56 and merge your contours into your geodatabase.

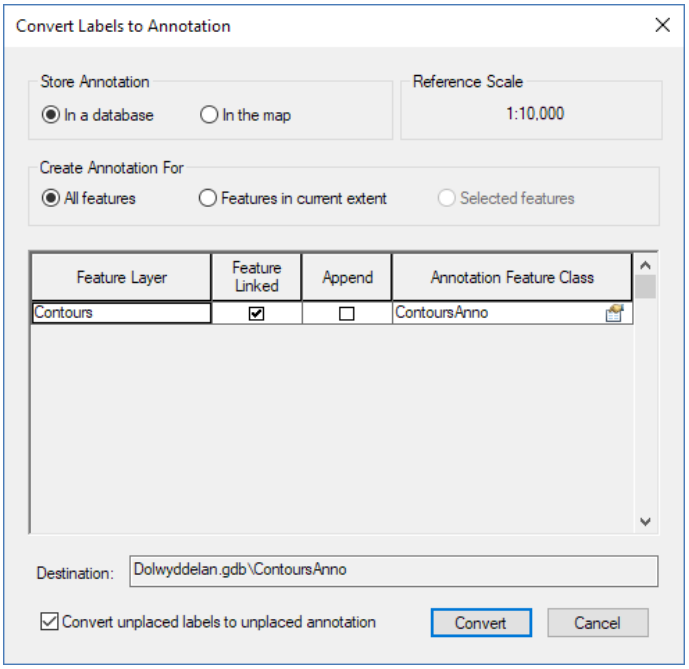


Figure 8.40: Convert Labels to Annotation. If you don't have the option to Store Annotation in a database then you probably saved your contours in a shapefile when you merged them. In this case annotation won't work well and you may want to return to section 5.6 on page 56 and merge your contours into your geodatabase.

Converting to annotation: Disappearing labels
Sometimes you might find that when you convert labels to annotation some of, or even most of, your labels just disappear. If that happens **try turning off all other layers, apart from your contours, before you set up the labels and then convert them to annotation.** It seems that Arc gives priority to other layers and removes contour labels that clash with them.

Table 8.4: Converting to annotation: Disappearing labels

8.9 Recommended video clips: digitising

The YouTube video at `http://bit.ly/1CasAjt` is a detailed look at creating points, lines and polygons, using the example of tracing features from a satellite view. The video has sound and is about 14 minutes long.

There are a lot of other videos on YouTube which may help you - just do a search on **digitising** or **digitizing**.

8.10 Recommended reading: digitising

For more detailed information have a look at the following references from the module reading list[4].

[4] Reading list available from Minerva and from the module catalogue at `http://webprod3.leeds.ac.uk/banner/dynmodules.asp?M=SOEE-1470`

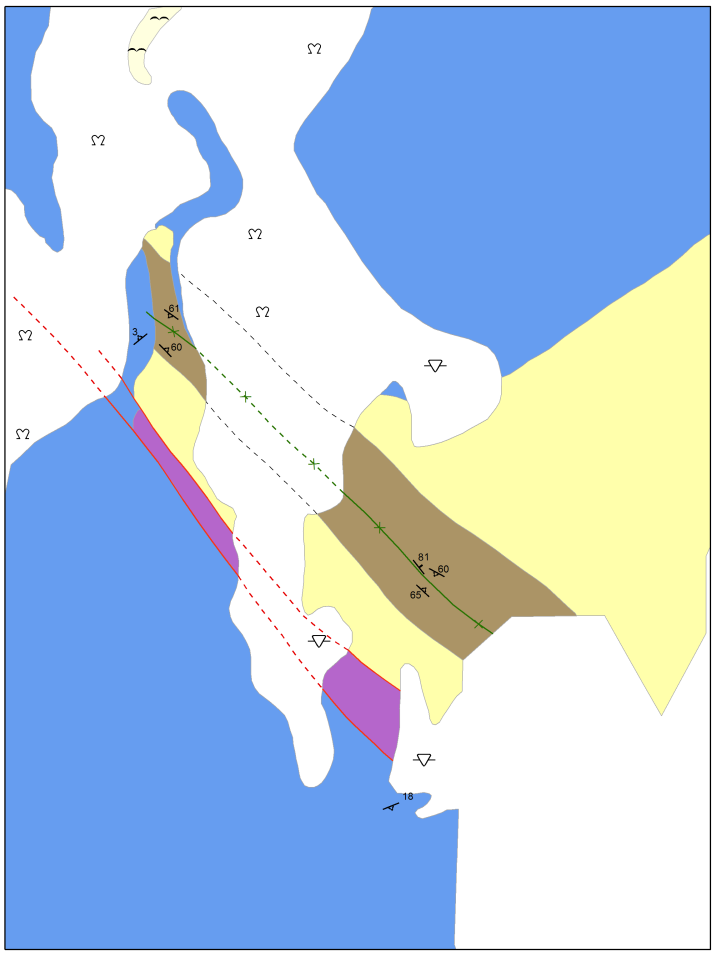


Figure 8.41: Digitised and symbolised geology - ready to add to a layout to make a “proper” map

Chang (2016), Section 5.4. on creating new data includes information on various ways of digitising.

Kennedy, M. (2013), Chapter 5 includes information and exercises which look at data storage structures and digitising.

For help with specific tools don’t forget to search in Arc Desktop Help - there is a lot of helpful information in there.

Chapter 9

Viewing your data in 3D in Google Earth

Once you have created features and data in Arc you can export your map from ArcMap and import it to Google Earth as an overlay. Arc does have some 3D facilities but in this chapter we'll look at how Google Earth gives you a simple way to overlay a map on the terrain of any part of the Earth. You can then view the map in 3D and see how your data relates to the topography. One big advantage is also that by saving your map as a kmz file you can then share it with anyone else who has Google Earth but not necessarily Arc.

9.1 Learning outcomes

When you have completed this section of the workbook you will

- be able to export the layers from a map and open them in Google Earth
- be able to view and explore the map in 3D
- save the view and share it with other Google Earth users

9.2 Prerequisites

This chapter assumes that you have

- a map with vector and/or raster layers in ArcMap
- Google Earth version 4 or higher.
- experience of navigating in Google Earth (Instructions are available at `http://tinyurl.com/6wot7ez` if you want help).

9.3 Exporting your map from Arc

9.3.1 Preparing your map

You'll need to make a few changes to your map to enable it to export smoothly.

- Open your map and Save as… to create a new copy to work on. I suggest that you add **WGS** to your new file name as you'll be changing it to that coordinate system.
- **Remove** any layers that you don't want to include, e.g. base map and contours, field slip.

- If you have an outline for your study are then make sure that you keep it on your map - it is essential for ensuring that your exported data appears in the right place in Google Earth
- If you don't have an outline check whether you have a single vector layer which covers the whole of the area that you want to export. If not you'll need to create one - use the instructions in section **??** on page **??** to create a new feature class and add a polygon to surround your study area.

Now you need to change the coordinate system of your map so that it is the same as the one Google Earth uses (WGS84) and at the moment your map should be in OSGB1936 (British National Grid).

- Working on your WGS file - View > Data Frame Properties > Coordinate System.
- In the **Select a Coordinate System** box - Geographic Coordinate Systems > World > WGS1984 > Apply.
- Click Yes to get rid of the warning that appears. You should see your map change shape.
- Now we need to apply a Transformation to the layers - in the Data Frame Properties click on the Transformations... button.
  - **Convert from:** GCS_OSBG_1936
  - **Into:** GCS_WGS_1984
  - **Using:** OSGB_1936_To_WGS_1984_Petroleum
- OK > Yes > OK

Save your map. It should look a different shape now - as an example figures 9.1 and 9.2 show a map of the Lake District National Park before and after the transformation. (Hopefully now you see why you should be working on a copy! This is good practice anyway.)

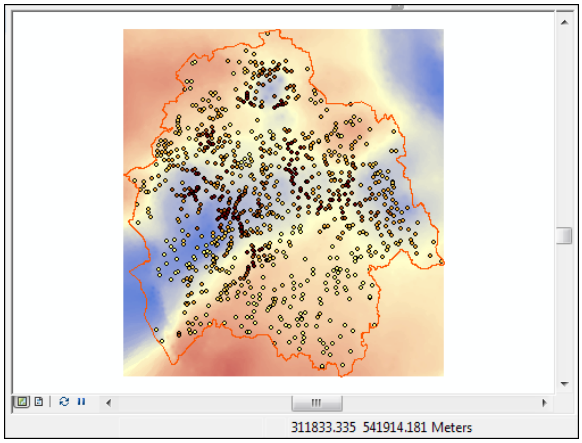


Figure 9.1: A map of the Lake District National Park set to British National Grid projected coordinate system

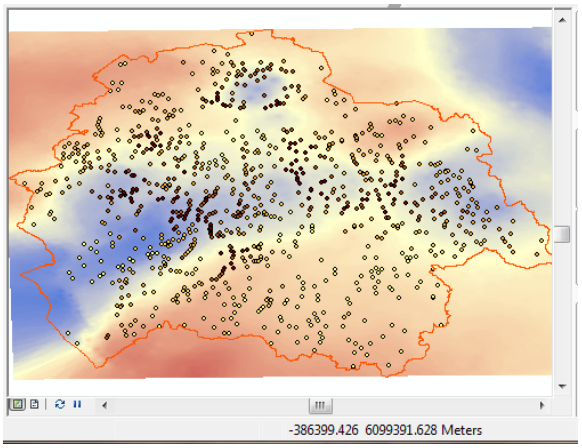


Figure 9.2: A map of the Lake District National Park after transformation to WGS84 geographic coordinate system. The ArcMap window size is identical to that in figure 9.1

9.3.2 Exporting kmz using ArcToolbox

Arc includes tools for exporting either a whole map or individual layers as kmz files which can then be opened directly in Google Earth, ArcGIS Explorer or ArcGlobe. This works best for vector layers. Raster layers, such as the scanned field map, usually end up as very low resolution but there are ways around that.

Note that kml and kmz files both work with Google Earth, but the kmz is a zipped file type and **includes** any images etc, so is the more advanced and comprehensive.

Video Clip available in Minerva - Exporting a map to kmz. Direct link: `http://bit.ly/2vnR7Fh`

- Open ArcMap and click on the button to open the toolbox (figure 9.3)
- Within the Toolbox Conversion Tools » To KML double-click on **Map to KML**.
- In the Dialog box that opens (figure 9.4) select your **Map document** - i.e. the ArcMap file that contains your map.
- Click on the folder icon next to **Output File** and select where to save your kmz file and what to call it (note that the tool won't overwrite pre-existing files). **Remember where you are saving your file.**
- Enter a **Map Output Scale**, e.g. 10000 (numbers only).
- Under **Data Content Properties** tick next to **Return single composite image**.
- Under **Extent Properties** select **Same as layer** and select a layer which covers the whole area you want to view in Google Earth, e.g. your study area outline. This is important - if you don't select a layer you will probably find your map floating somewhere off the coast of Africa when you open it in Google Earth! This is the location where the Greenwich meridian crosses the Equator and therefore the grid coordinates are **0,0** [1]
- Finish by clicking OK

Wait for processing to finish - it can take a while. Arc will eventually notify you that it is complete. Once this happens you can close the dialog box. (If the tools are running in the background, you won't be able to see much happening but you will eventually be notified by a discrete little pop up in the bottom right of your screen!)

Arc may automatically add the kmz to your map and it will appear in your Table of Contents as lots of layers grouped under the name you chose for your output. **Remove** this to keep your map tidy.

Improving image quality

If, once you have viewed your map in Google Earth you are not satisfied with the quality of the image, try changing the settings under the **Output Image Properties** heading. See figures 9.5 and 9.6 for the difference in output quality that is possible.

[1] This is such a current occurrence when having projection issues with data in GIS that the location has been nicknamed "Null Island". It even has its own web site - `http://www.nullisland.com/` - which isn't bad for a fictitious island. See more about the background to this at `http://www.vicchi.org/2014/04/05/welcome-to-the-republic-of-null-island/`

Figure 9.3: Toolbox button

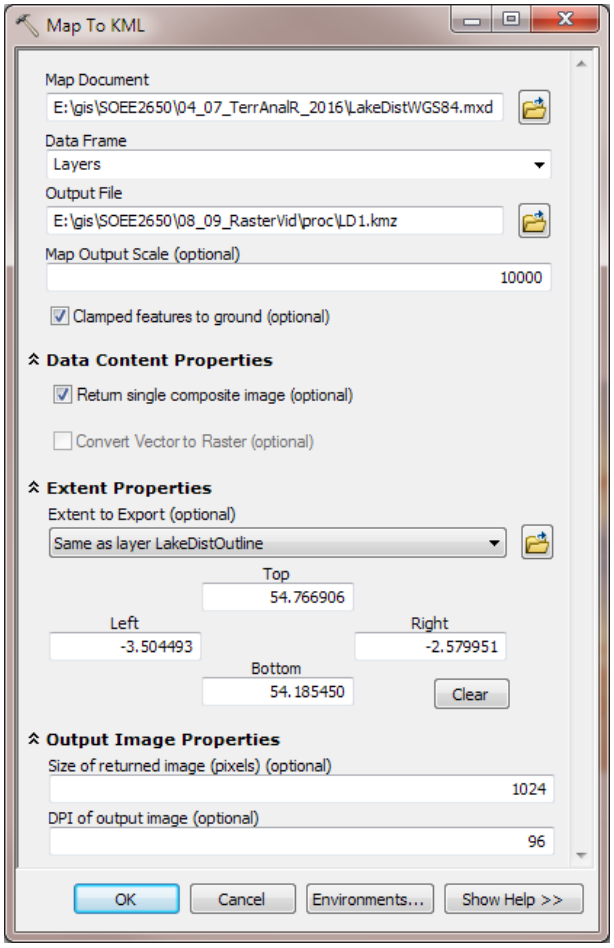


Figure 9.4: The Map to KML dialog box

Video Clip available in Minerva - Solving problems with exporting to Google Earth: output quality. Direct link: `http://bit.ly/2ePNmVe`

For example, changing the **dpi of output image** to **300, 600** or even **1200** should increase the resolution.

You can also increase the setting under **Size of returned image (pixels)** - try doubling the default figure that appears there to start with.

Increasing the size seems to have more effect than just increasing the resolution. Be careful, though, increasing these settings will also increase the file size.

9.4 Viewing your map in Google Earth

- Use Google Earth to open the resulting KMZ file (Open Google Earth then Open and select your kmz file).
- Check that your map is correctly aligned. If it isn't go back to your original map, check that the coordinate system is correct, then export it again being careful to select a suitable extent layer.

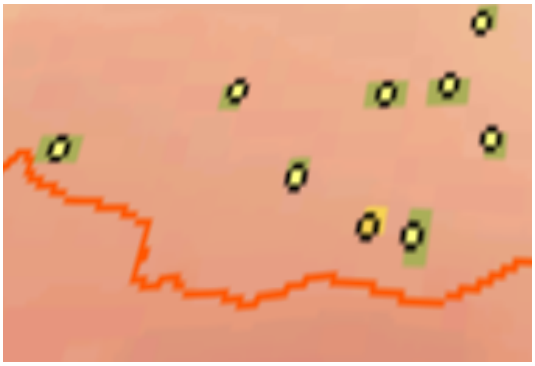


Figure 9.5: Output from ArcMap to KMZ using default Output Image Properties

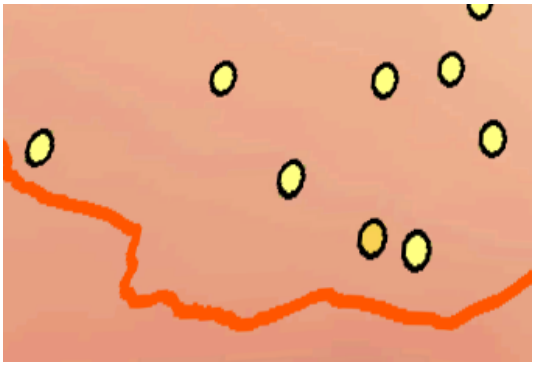


Figure 9.6: Output from ArcMap to KMZ with Output image size increased to 4096 and resolution to 600

9.4.1 Other settings in Google Earth

- The overlay should have been saved to the **My Places** folder in Google Earth. If not, you should find it in the left hand panels, maybe under **Temporary Places**. It will probably be called the same name as your data frame in ArcMap. If you haven't changed that the default is **Layers**. Right click on the overlay layer and select **Save to My Places**
- If necessary zoom to your overlay. Double-clicking on the layer name in **My Places** can be the easiest way to do this, though it isn't always reliable!
- Use the **transparency** slider at the bottom of the **places** panel to make the topography visible underneath the overlay. (You may need to click on an **Adjust Opacity** button to make this slider visible.)
- You can make further edits to the layer, e.g. location and transparency, by right-clicking on it in the **My Places** panel and selecting **Properties**.

Run the Map to KML tool again in ArcMap. This time don't select Return single composite image, but leave it unticked.

Add the resulting kmz file to Google Earth again and compare the two. This time if you click on the little arrow next to the layer you should see that the layers that you had in Arc have been exported as layers to Google Earth and can be individually turned on and off and made transparent. This is very useful if you want people to be able to explore your data further and click layers on and off.

9.4.2 Viewing 3D terrain

- Google Earth instructions for viewing 3D terrain are at `http://support.google.com/earth/bin/answer.py?hl=en&answer=148186`. For instructions on how to tilt the view look for the section on **Tilting and viewing hilly terrain**.
- Elevation exaggeration can be altered by going to Tools > Options...

9.4.3 Saving the Google Earth view to My Places

If you save a layer to My Places it should open again the next time you open Google Earth.

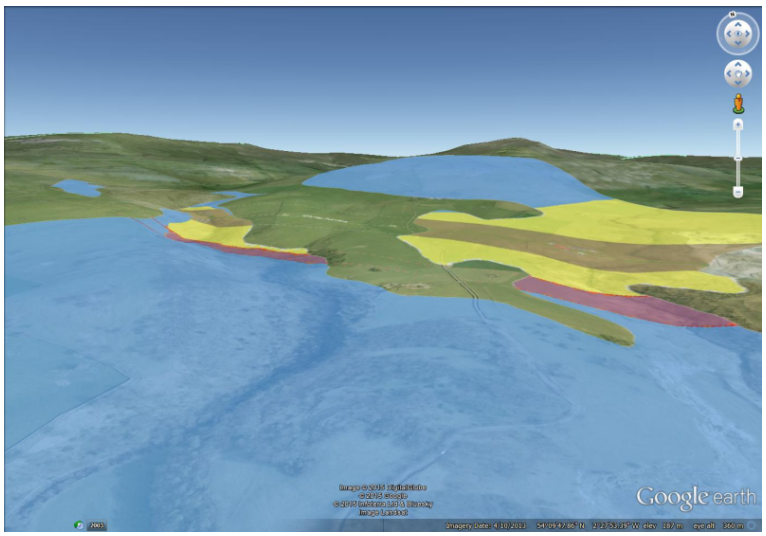


Figure 9.7: Viewing 3D terrain in Google Earth

- Right-click on the layer name in **Temporary Places**.
- **Save to My Places**

9.4.4 Sharing your map

You can share the kmz file that you have created in Arc with any other Google Earth user just by sending it to them. They can then just Open it in Google Earth as usual.

You can also save a view as a jpg image which can then be used in other programs, e.g. if you want to add a particular view to a Word document or an ArcMap layout.

- Open the file in Google Earth by using File > Open
- File > Save... > Save Image...

9.5 Exploring your map in 3D

Now you can have a closer look at how the features and layers in your map area relate to the topography.

9.5.1 Adding a grid lines layer

If you are exploring a map of the UK it can be easier to look at and refer to it if you can use British National Grid coordinates.

The Google Earth Grid lines layer is available from `http://nearby.org.uk/google.html#9` - look for **GB & Ireland Grid-Lines Layer** [2] Click on the link and open the kml file in Google Earth. Right-click on the layer to save to **My Places**. You should see British National Grid lines on the map which change frequently as you zoom in and out (it can be a bit slow sometimes).

[2] Last accessed: 3rd November 2016. It's worth looking at the other tools/layers available on this page too.

Chapter 10

Layout and presentation

Once you've put in all of the hard work to produce a map of your field area or project, it is worth making the extra effort to ensure that you lay it out clearly and print it, or export it in a professional fashion. Make sure that you allow the time to do this. Care and patience can make the difference between a scruffy, unimpressive map that loses you marks, and a clear, professional map that gives a good first impression.

Don't underestimate the time that the final details can take and don't leave this until the last hour before a deadline!

You won't need to use all of the elements and features outlined here for every map. Equally, this is not an exhaustive list of possible elements. You should already have some idea of what elements are useful, and should be able to make a decision for each case based on your existing knowledge of maps. If you think that you need to add something that is not listed here, e.g. a report based on a table, then use the extra information available in the bibliography, further information and on-line to find out how to add it.

This chapter also includes some information on map evaluation and a useful checklist which should help you to think about how maps are used and what needs to be included.

So this chapter isn't necessarily for working through in order. Make sure that you are aware of the contents and of what Arc is able to do, and then make your own decisions and further investigations.

10.1 Learning outcomes

When you have completed this section of the workbook you should be able to

- layout a map in such a way that it effectively communicates the content and purpose of your work to a user
- select map elements to include in a layout and set their properties to match the requirements of your map
- print or export your map to show it to it's best advantage
- evaluate your maps and maps by other people or organisations based on a checklist

10.2 Viewing a map layout

In ArcMap **Layout view** allows you to control the format and scale at which you print your map, and lay out additional elements to complete the final product.

- Open the map that you created in the previous chapter in ArcMap
- Go to layout view by clicking on View > Layout View or by clicking on the Layout view button - see figure 10.1

In this view you will see your map laid out as it will be when it is finally printed or exported with the page outlined on screen and the content on top of it - figure 10.1.

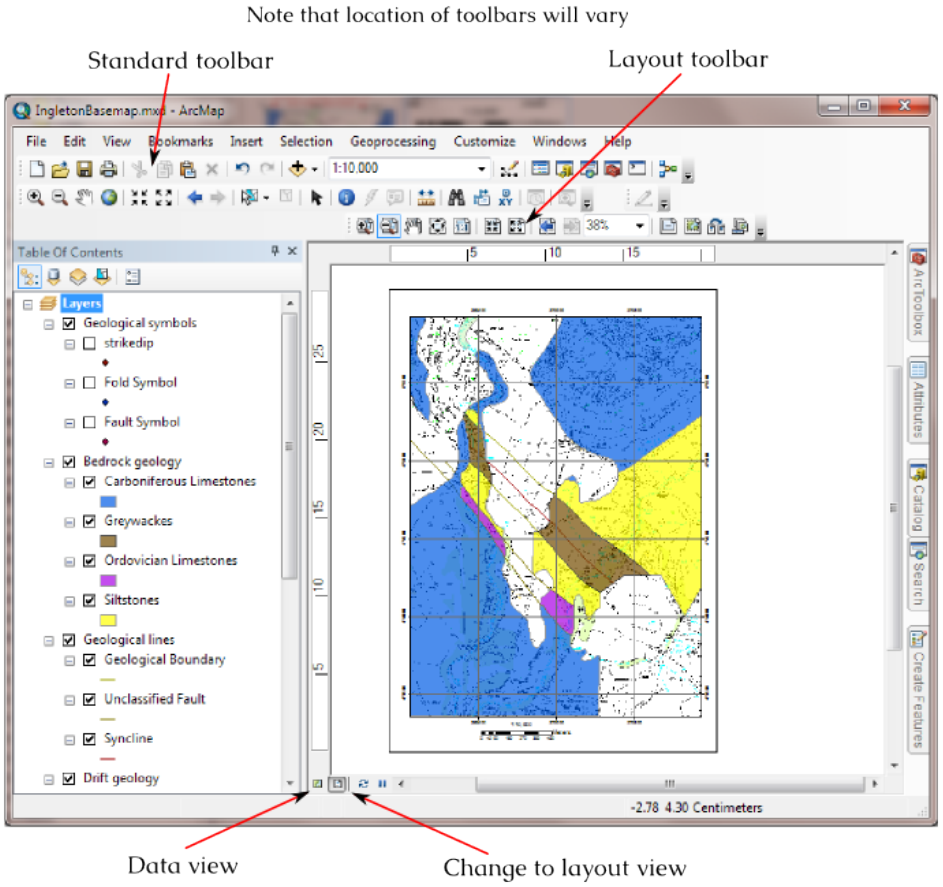


Figure 10.1: Layout view

10.3 Size and scale of a layout

10.3.1 Page size and scale

Changing the size of the page can also change the scale, so each time you alter this check the scale of your map again!

Video Clip available in Minerva - Setting the size and scale of a map layout. Direct link: `http://bit.ly/2h33WSu`

- File > Page and Print Setup... - see figure 10.2.

- Check whether **Use Printer Paper Settings** is ticked or not.
  - If it is the settings used are those in the **Paper** area above
  - If it isn't then the settings used are those in the **Page** area below.
- If you want a standard paper size such as A0 or A4
  - Select the size in the dropdown list in the **Page** or **Paper** area
  - Select the correct orientation (portrait or landscape)
- If you need a non-standard paper size
  - Choose **Custom** in the dropdown box
  - type your required measurements into the **width** and **height** boxes
  - select the orientation if necessary (portrait or landscape)

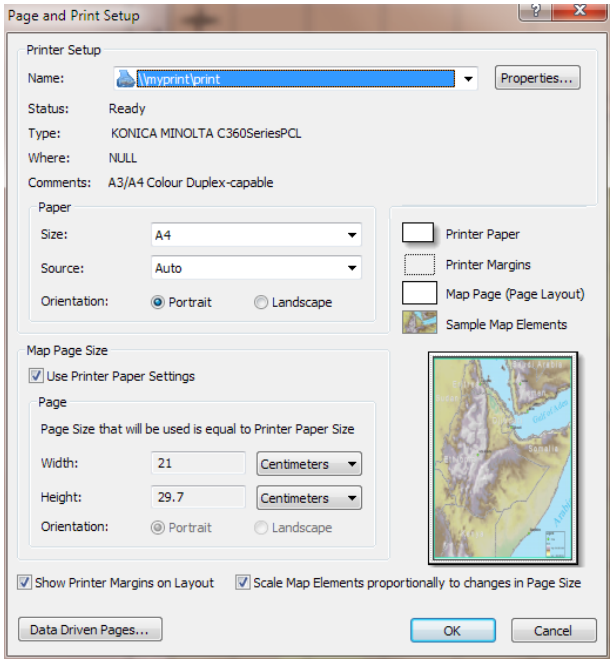


Figure 10.2: Page and Print setup: Choosing page size

Start with the paper size as A4 in Page and Print setup; set the map scale to 1:25 000. Next set the paper size to A3 and tick the Scale Map Elements proportionally to changes in Page Size box. Now click ***OK***
Now what scale is your map?

The scale will probably change almost every time you change anything else! **KEEP CHECKING AND RESETTING IT!**

Repeat the above steps as necessary until the layout looks right and is at the correct scale.

10.3.2 Resizing the data frame in a layout

When you first change to layout view the area of the map that you see in the data frame will not necessarily be the area that you want to show. Changing the size of the data frame is easy, but can take a little experimentation. You will also need to look at this in conjunction with the instructions on changing paper size in the previous section.

Video Clip available in Minerva - Resizing the data frame in a layout.
Direct link: `http://bit.ly/2h2YQWp`

- Click once on the data frame (that is the main map area)
- When the data frame is selected you should be able to see that it is outlined by a dashed line with small turquoise boxes at the corners and on each side - see figure 10.3.
- Use the boxes as "handles" to resize the data frame by dragging
- Keep an eye on the scale dropdown! You may need to put this back to your required scale and then resize the data frame again
- Remember that you can use the pan tool on the layout toolbar to move your map within the data frame.
- Keep repeating this until the size/extent and scale of your map are correct

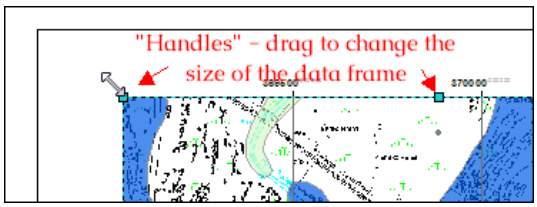


Figure 10.3: Using the "handles" to resize a data frame in layout view

Printing a map at the correct page size, area and scale
Printing a map at the correct page size, area and scale can be a bit like "juggling jelly". You just have to keep trying and change it a little bit at a time until it looks right. • Start by setting the correct paper size • Then use the black arrow tool to set the data frame to the size you want compared to the paper size • Now check the scale of your map and change it if necessary • Check the coverage - does your map show the area you need? • keep repeating these steps (sometimes several times) until your map shows the right area at the right scale, and fits on the page!

Table 10.1: Printing a map at the correct page size, area and scale

10.3.3 Setting a fixed extent

It is possible to set the view to show a particular extent, but be warned that if you do this it then becomes impossible to change the scale of your map in either map or layout view, and you won't be able to resize the data frame in layout view or pan your map in map view. If you've been asked to produce a map at a particular scale this won't be a good idea!

- Go to Data Frame Properties > Data Frame
- Under **Extent** use the dropdown box to select Fixed Extent
- Enter the coordinates you require in the boxes or click on Specify Extent... to choose a layer or view.
- Apply > OK
- If you wish to undo this just set Extent back to Automatic

It is also possible to set the dropdown to Fixed Scale, which can be useful, but does mean that if you are still working on your map it isn't possible to zoom in and work on details.

10.4 Adding elements to a layout

The information below includes details on adding many different elements to a layout. Not all of these will be appropriate to every layout, it is up to you to decide which elements to use depending on the purpose and audience of your map and any guidelines specified for assessments or reports.

Remember that **Arc Desktop Help** will provide you with plenty of extra information on how to add map elements to a layout.

Most elements are added to a layout in a similar way to each other using the Insert menu. In most cases you'll then be presented with a properties dialog which allows you to make changes to the element.

Once they have been inserted you can move the elements around. If you need to change properties then double-click on an element.

Video Clip available in Minerva - Adding a scalebar, title and text to a layout. Direct link: `http://bit.ly/2s9iMYO`

10.4.1 Scale bar and text

Some indication of scale should always be added to both printed and screen maps. A scale bar is a useful convention for both. Scale text (e.g. 1:50 000 or 1cm = 1km) is only relevant for printed maps, not for maps on screen where someone can zoom to any scale.

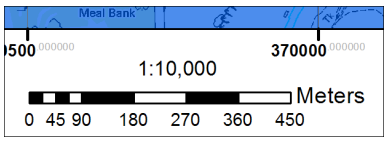


Figure 10.4: Scale bar and scale text on a map layout

10.4.2 Title and text

Adding a title

Maps need an informative title so that people looking at them know what they are supposed to show. You can add a title by going to Insert > Title. This gives you a dialog in which to add the title which will then appear on your map. If you want to change the font size etc double-click on the title then click on Change Symbol... . Doing it this way sets the title in the **Map Document Properties** for the whole map - change the title text by going to File > Map Document Properties.

Adding text

You should use the insert text command to add further text, such as your name (or for an assessment your student ID) as creator of the map, a copyright statement, acknowledgements, and further explanation.

Copyright acknowledgements Copyright is important. Remember that most data providers ask you to sign up to conditions that include an obligation to add a copyright acknowledgement to your map. Check what that copyright statement is and add it.

e.g. when you signed up to use the Digimap collections you agreed to add copyright acknowledgements whenever you created a map with the data. These do change from time to time so it's worth knowing how to check it for yourself.

- To find these copyright acknowledgements go to the **Digimap Resource Centre** (**Resources** at the top of the main Digimap page)
- Look for a link to **Digimap Licence Agreements** and click on it.
- Click on the End User or Sub-licence agreement for the data that you've used
- then look for the information under **In return, you must:** - that gives you the acknowledgement text.

For example, as of April 2019 when you use Ordnance Survey data obtained from Digimap you are expected to add the following text to your map.

> ***© Crown copyright and database rights*** `year`***. Ordnance Survey (100025252).***

Where *year* is replaced by the current year.

Remember that you do have to acknowledge each different dataset that you use and will have signed up to that when you registered.

If you are *not* using U.K. Ordnance Survey data this is **not** the correct copyright acknowledgement to use, for example if you are using data for Spain or the United States, or indeed UK data that you

Adding the copyright symbol to your text
To add the **copyright symbol** - ©- to your text • check that the Num lock is on on the keyboard • hold down the Alt key • use the number pad to type 0 + 1 + 6 + 9 • release the Alt key

Table 10.2: Adding the copyright symbol to your text

haven't downloaded from Digimap. You'll need to find the correct copyright acknowledgement for yourself. The web page[1] at `http://bit.ly/1ZSifnd` gives some information about how to cite GIS materials - including the software as well as the data. Have a look at that and follow the suggestions to cite non-Digimap data.

Advice on citing Digimap data, as opposed to the copyright acknowledgement is at `https://digimap.edina.ac.uk/webhelp/resources/citation/services.html`

If you want to add formatted text try adding it via a Word document using the instructions in section 10.4.9 on page 131.

10.4.3 Adding a key / legend to your layout

You'll have added various data to your map, and it is necessary for you to explain to anyone looking at your map what those layers and symbols show. To do this you'll need to add a legend or key.

Start by using the default options to create a legend. Once you have the basic legend it is possible to make alterations later

Video Clip available in Minerva - Adding and editing a map legend.
Direct link: `http://bit.ly/2urgYuF`

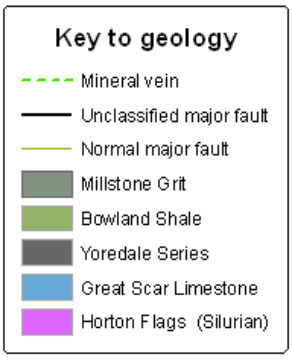


Figure 10.5: An example of a basic legend or key

[1] Last viewed: 18th September 2018

- In layout view - Insert > Legend...
- The Legend Wizard should open. ArcMap will probably add all of your layers to the right-hand box automatically. Use the arrow buttons to remove and add layers and to order them as you want them to appear - referring back to the list that you just made.
- Next then change the legend title if you wish and click Next again
- Decide whether you want to add a background or border to your legend then Next > Next > Finish
- Move your legend to an appropriate position on your map.

You can double-click on the legend to change its properties and settings. At this stage if you make changes to the layers in the table of contents, those changes will automatically be reflected in the legend.

As an aside - the ESRI blog has a short discussion at `http://arcg.is/2eD2Kk2` about the use of singular and plural nouns for legend items which you might find informative.[2]

It is very likely that you will want to change the legend in some way to make it clearer. Once you have all the basic information in your legend you can convert it to a graphic and you will have more flexibility to rearrange items. Note that once you have converted a legend to a graphic it will no longer change automatically if you change symbology or layers on your map, you will have to generate a new legend. So leave this step until you are happy with everything else on your map.

Converting a legend into a graphic

- In Layout view use the **Select elements** tool (black arrow) to select the legend.
- Right-click on the legend Convert to Graphics.
- Right-click on the legend again Ungroup.
- Repeat the last step again

Now you should be able to select individual parts of your legend and move them around or delete them.

> ***For example if you have lines with symbols that have been added as points: in your legend move the point symbol so that it is positioned on top of the appropriate line then delete any text that was associated with the symbol.***

Use the tools on the **Draw** toolbar (figure 10.6) to add extra text.

Figure 10.6: The Draw toolbar

> ***The default legend styles in Arc will not necessarily group features in a way that is most helpful for your map. You can add headings yourself using the Text tool and then rearrange the entries under those headings manually.***

[2] Last viewed: 18th September 2018.

Make sure that your key covers all of the information that you have added to your map, but doesn't include any symbology that doesn't appear on your map. (Do you want a viewer to sit there wondering where that symbol is on your map?)

10.4.4 Adding a measured grid

Measured grids add labelled grid lines to a layout. If you are using Ordnance Survey or other UK data projected in British National Grid then you can easily add National Grid lines and numbers to your map. The O.S. raster tiff files already have grid lines marked, but adding a measured grid allows you to include coordinates around the edge of your map - making it possible to read grid references.

Video Clip available in Minerva - Adding a measured grid to a map.
Direct link: `http://bit.ly/2uruf6q`

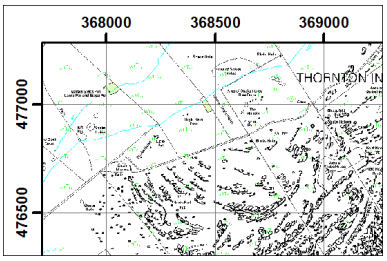


Figure 10.7: A map with a measured grid that shows British National Grid references on a 500 m grid

- View > Data Frame Properties > Grids > New Grid > Measured Grid
- Choose the style that you want. Check that the coordinate system is set to **Same as data frame**, and check that the intervals are suitable to the scale of the map, e.g. 500 meters for a 1:10 000 scale map. *Note that being able to set this relies on having the correct co-ordinate system set for your data frame.*
- Next > Next > Finish > OK

Once you have set the grid up you can make further changes to the properties by going to View > Data Frame Properties > Grids and double-clicking on the grid that you have already created.

Note that the grid that Arc adds is fully numeric, you may be more used to seeing grid letters for 100 km grid squares, e.g. our current grid reference is similar to SE 2934 3444, our current grid coordinates are similar to 42934 43444. It is the latter that will appear on a measured grid generated by Arc. For more information on this and a diagram to help you to change from one to the other, see section 8.6.2 on page 98.

10.4.5 Adding north arrows

Before adding a north arrow to your layout stop and think about how you need to indicate north on your map. If you look at the technical information on an Ordnance Survey Landranger (1:50

000) map you'll see a diagram showing Grid north, True north and Magnetic north. The information given there shows how to plot the difference of magnetic north from grid north. Adding this to your own maps can also be useful.

If you are taking strike and dip measurements in the field you should have corrected your compass-clino for declination (the horizontal angular difference between true north and magnetic north) anyway. When you plot the measurements on your map it isn't worth worrying too much about whether you are plotting against grid or true north as the difference on any grid, not just the British National Grid, is unlikely to be that big. Figure 10.8 shows the different types of north and the declination.

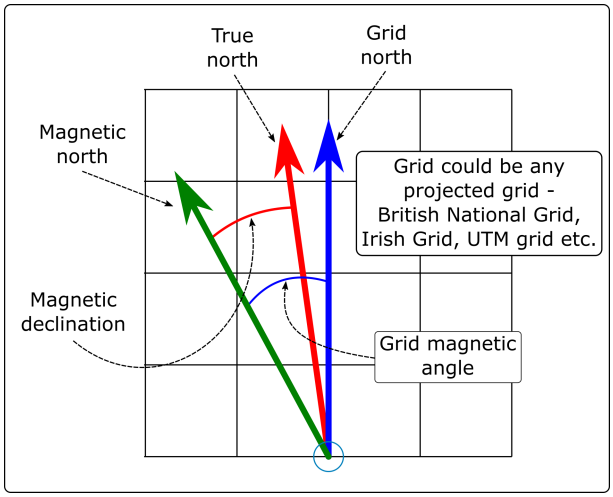


Figure 10.8: The different types of North that you'll find on a map set to a projected coordinate system, such as British National Grid

If you add north arrows to your layout do remember to label them in some way which shows which version of north each one is showing.

Video Clip available in Minerva - Adding north arrows to a layout.
Direct link: `http://bit.ly/2hohEQa`

North arrow: Grid north

If a map is in a projected coordinate system ArcMap will automatically lay it out aligned with the grid. So for example, any map set to British National Grid will be aligned to grid north.

In this case it isn't strictly necessary to add a north arrow to show grid north if you also include a measured grid on your map, but it doesn't hurt.

In layout view:

- Insert > North Arrow...
- select an arrow style (it's usually better not to go for something too fancy!)
- Click on Properties... and check that **Align To:** is set to **Data Frame Rotation**
- OK > OK

If you check this against your measured grid lines you should find that it matches exactly.

North arrow: True north

True north is the direction from the area of your map to the North Pole. In the east/west centre of a grid, such as that set for the British National Grid, it may well be the same as grid north, e.g. in Leeds the difference is extremely slight. As you go further east or west towards the edges of an area covered by a grid the difference becomes more noticeable, e.g. at Lands End in Cornwall, or in Norfolk.

In layout view:

- Insert » North Arrow...
- select an arrow style (it's usually better not to go for something too fancy!)
- Click on Properties... and check that **Align To:** is set to **True North**
- OK » OK

If you check this north arrow against your measured grid lines you may well find that the north arrow is slightly tilted.

North arrow: Magnetic north

Magnetic north is the direction from the area of your map to the magnetic North Pole. This changes with time so the first thing you need to do is to find out what the **declination** is in your area at the moment[3]. To do this you can use the page provided by the BGS Geomagnetism Group at `http://bit.ly/2uGMfdp`[4]

Use the map to select your area and click to retrieve the data. Make a note of the figure shown as **degrees east** and round it to the nearest whole number. The key to the table you are given is underneath the map.

In layout view:

- Insert » North Arrow...
- select an arrow style (it's usually better not to go for something too fancy!)
- Click on Properties... and check that **Align To:** is set to **True North**
- Set the **Calibration Angle** to the figure you found above. The arrow on the preview should change to reflect this (see figure 10.9).
- OK » OK

This magnetic north arrow should now appear tilted the appropriate number of degrees from the true north arrow that you added above. It would be useful to also add text to your layout (Insert » Text...) showing the date that you added magnetic north, and the declination figure.

10.4.6 Adding extra data frames

It can be very useful to be able to place more than one map or map view on a single layout, either so that you can show a different area, or a different zoom level for the same area. You can also use this to set up an automatic extent indicator which marks your study area on a larger map. To do all of this you need to add extra data frames.

[3] **Declination** is the angle between true north and magnetic north at a particular location. **Grid Magnetic Angle** is the angle between north on the grid and magnetic north. To find Grid magnetic angle for Great Britain use the calculator at `http://www.geomag.bgs.ac.uk/data_service/models_compass/gma_calc.html` on the BGS pages. This is the number that is given on the corner of OS maps and the one you need for setting your compass-clino in the field so it would be worth making a note of this on your map too.

[4] This should work for anywhere in the world.

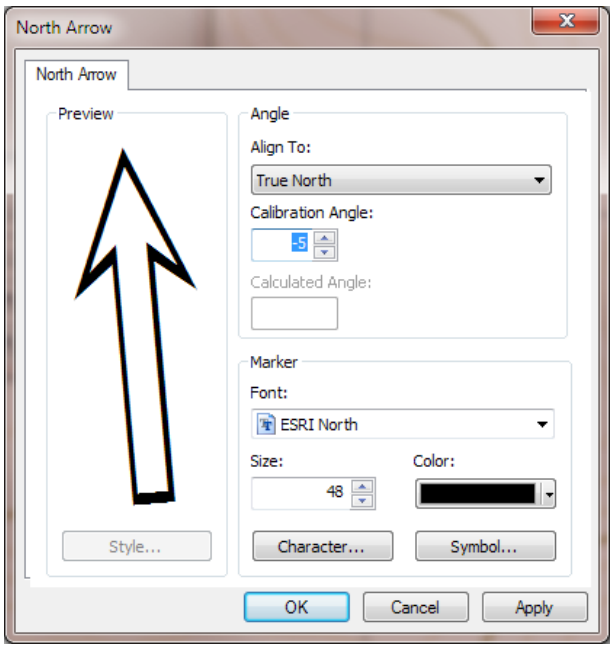


Figure 10.9: The properties for a north arrow to show magnetic north

Video Clip available in Minerva - Adding extra data frames to a layout. Direct link: `http://bit.ly/2spjXqZ`

Create a new data frame

- In either data or layout view Insert > Data frame
- A new data frame should appear in your table of contents and the map area will become blank if you are in data view, or show a new data frame on the page if you are in layout view (see figure 10.10). If the new data frame doesn't appear in layout view, use the cursor to drag the data frame title from the table of contents to the layout.
- Make sure that the data frame title in the table of contents is bold - that means that it is **active** (see figure 10.11). If you need to make a data frame active right-click on it and select **Activate**.

Add data and set the projection

- Add map data to the new data frame, either by adding it from the Catalog, or by dragging and dropping it from an existing data frame.[5]
- You may need to alter the data frame properties to set the Coordinate System - don't forget to check that it has been set correctly! Note that it is possible for data frames within the same map to have different coordinate systems.
  - Right-click on the data frame title (probably **New data frame**) in the table of contents

[5] Occasionally if you are dragging and dropping from another data frame Arc will lose the link to some layers and you'll see the dreaded red exclamation mark. If this happens just follow the instructions in table 5.2 on page 56 to repair the links.

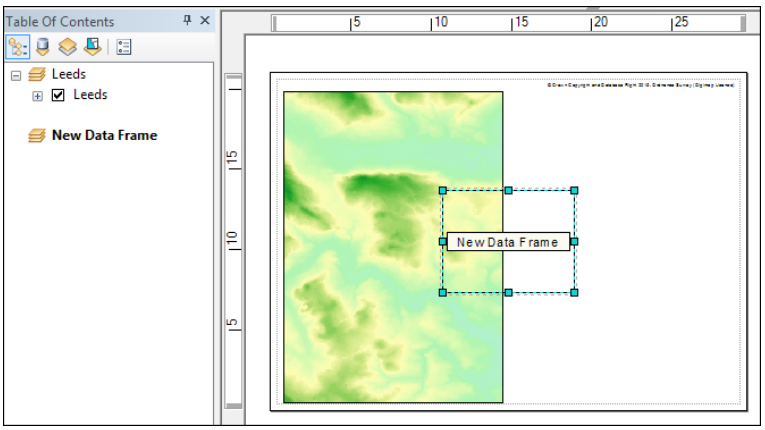


Figure 10.10: Layout view showing the newly added data frame. You can now move and resize this as you wish, and add data to it as required

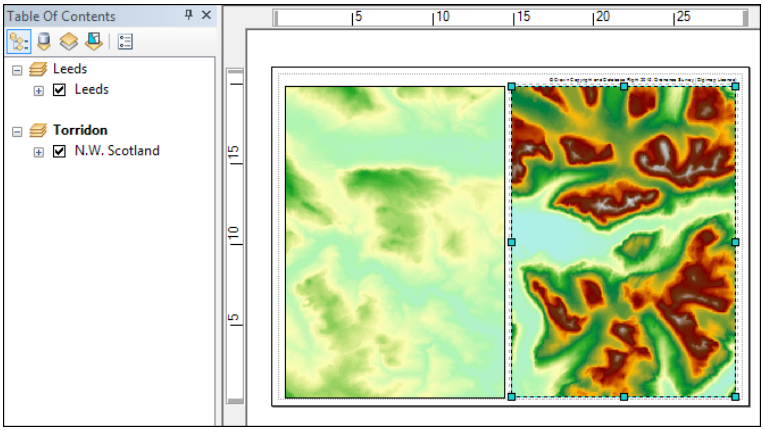


Figure 10.11: Layout view showing the activated data frame - note the data frame title in bold in the table of contents, and the selection lines around the data frame on the layout

– If it hasn't already been set, set the coordinate system as required by your map, e.g. for British National Grid - Properties... > Coordinate System > Projected Coordinate Systems > National Grids > Europe > British National Grid > OK

10.4.7 Adding an extent indicator

For some maps, particularly large scale maps of very small areas, it is useful to show a small scale map of the general area with the area of the main map marked (see figure 10.12). To do this you need to obtain small scale data and then add it to a second data frame in ArcMap. For Great Britain investigate the more general scale basemaps from Digimap, such as MiniScale or GB Overview, or use the national outlines from the boundary layers. It's up to you to select data which is readable/clear at the scale you are going to display it.

For areas outside of Great Britain you may need to search for suitable data, or use data from Natural Earth[6].

Note that using a screenshot from Google Maps or Google Earth (or similar) with a marker on it doesn't look good, and should be avoided.

Start by adding a new data frame to your map as shown in section 10.4.6 on page 127 and add your choice of map layers to the new data frame.

[6]Download from `https://www.naturalearthdata.com/` Last visited: 16th May 2019.

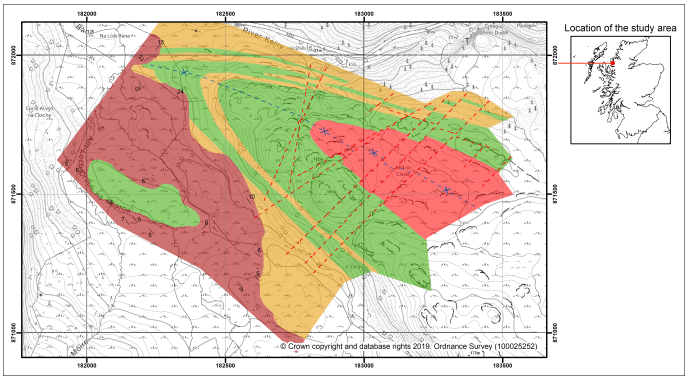


Figure 10.12: An extent indicator on a layout: using a smaller map to show the general area of the main map

Set up the extent indicator

- Resize and relocate the data frame and set it to an appropriate scale (e.g. start with 1:1 000 000) and the area around the location of your main map.
- Right-click on the data frame title in the table of contents Properties > Extent Indicators add the main data frame (probably called "**layers**" to the right-hand box and tick the **Show Leader** box then click OK.

You should now have a map with a red box showing the outline of the area covered by your main map and with a line leading to it as in figure 10.12 on page 130.

> ***Try moving and rescaling both maps - the box should resize and relocate to reflect your changes.***

You can change the style of the box and the leader line by going back into the **data frame properties**.

10.4.8 Showing a profile on a layout

If you have created a profile graph for your map you may wish to include it in the final layout.

- If the profile that you created earlier is still open:
  - Right-click on the graph Add to Layout
- If the profile is closed - whilst in layout view:
  - Views > Graphs > Manage... right-click on your graph in the list Add to layout
- Once your profile graph is on the layout:
  - Move the graph to the required permission
  - Change properties by selecting the graph, right-clicking and going to **Properties**

10.4.9 Adding sections, diagrams and photographs to a map layout

You will probably want to add extra items to your map layout, in particular cross sections and diagrams created in vector drawing packages such as Inkscape, CorelDraw or Adobe Illustrator and maybe some photographs.

When it comes to creating a full map presentation, such as the Geological Sciences A0 dissertation map, which includes elements other than just a map, you have a choice:

- You can either use ArcMap to set up the full layout by importing photographs and also sections, diagrams, etc created in other programs such as Inkscape or CorelDraw - **instructions for importing elements from other programs are in this section**.
- *or* you can export your completed map (and other map elements) from ArcMap and import them into Inkscape, CorelDraw or a similar vector package. (Word, Powerpoint etc are **not** recommended for creating a full layout.) **In this case go to section 10.6.3 on page 134 and look at the instructions for exporting a layout from ArcMap.**

Video Clip available in Minerva - Adding diagrams, images and formatted text to a layout. Direct link: `http://bit.ly/2t8CHbs`

Adding objects: CorelDraw diagrams and Word documents

You should use these instructions to include any text and CorelDraw diagrams that you need to include in your layout. These instructions also work for Excel spreadsheets. Inkscape diagrams should be exported to png and then imported to ArcMap as images - see section 39 below.

Note that CorelDraw files may not display correctly if you have gradient fills. You may find that you have to export images from CorelDraw as png (Portable Network Graphics format) and then insert them into Arc as images - see section 39 below.

- In Layout view - Insert > Object... to open the dialog (figure 10.13)
- Click to **Create from File** and browse to find the file that you want to insert
- Check that Display as icon isn't checked
- then click OK
- Move and resize the file on the page as required.
- If you wish you can right-click on the object to get a dialog that allows you to add a background or border.

If you are likely to want to make changes to your diagram or document later then you can click so that you **link** the file rather than insert it, but that does mean that you need to keep it in the same location relative to your Arc mxd file. This is particularly useful if you want to add formatted text as the tools are so limited in Arc. Write your text in Word and then include it as an object and you can still edit it by double-clicking on the object in Arc.

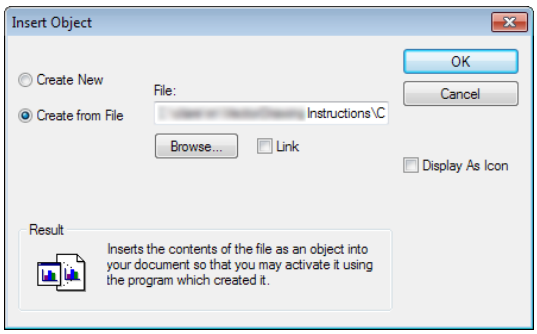


Figure 10.13: Inserting an object such as a CorelDraw file into a layout

Inserting photographs and images

Very similar to above but use this method for including jpg, bmp, png etc files in your layout.

Following some experimentation I would recommend that if you are including diagrams produced in either CorelDraw or Inkscape you **export/save as...** your diagram as **png** format and then insert the result into Arc. It may not look quite right on screen (gradients can be a bit odd and the image can look very pixelated/blurry) but looks fine when actually printed. Jpg files tended to have problems with colours changing when they are exported from CorelDraw.

- In Layout view... Insert > Picture... and browse for the image you require OK
- Move the image as required. Try not to resize it unless you absolutely have to. You'll get better quality if you resize vector images in Inkscape/CorelDraw before you export them, rather than resizing them in Arc once they've been saved as rasters.

Remember, if the image doesn't look quite right, try exporting to pdf or printing a copy before you worry about it (see section 10.5.1 on page 133). What you see on screen isn't always how the final result will look.

NOTE: double-check that images inserted in this way print! If they don't then, if all else fails, it is possible to add them to a Word document then insert the Word document as an object - see section 39 above.

10.5 Checking your map

A very important stage but one that can easily be forgotten if you are in a hurry!

In addition to the points below have a look at Darkes (2017) which gives lots of quick tips on map layout and presentation. On pages 92 and 93 Darkes includes a section with quick wins for improving your map before publication if you have 5, 15 or 50 minutes. In addition, check the reading list for other references - there is plenty of information available to help you to present better maps.

- ***Check spelling. Even better - get a helpful (and reliable!) friend to proof-read your text for spelling mistakes. It's very easy to miss something obvious in your own work. In particular check geological and geographical names and any technical terms.***
- ***Check that you have included everything that you need to include - if this is an assignment reread the instructions and check that you haven't forgotten to do anything.***
- ***Check that your map doesn't include anything that you don't want to include! Did you add some experimental polygons when you were editing, then forgot to delete them? Have you clicked on the Add text button too many times, but then not removed the resulting text?***
- ***Look at the article on the ESRI blog at*** `http://bit.ly/SZyDiC` [a]***. Read about what makes a map great, then click on the link to the checklist and use the questions there to evaluate your own map. Have you included everything you need to include, or do you have a good reason if something is not on your map? Have you taken care with your presentation?***

[a] Last viewed: 18th September 2018

10.5.1 Printing a copy to pdf to check

Inevitably you'll notice something not quite right with your map after you have printed it. To minimize the chances of this happening when the (expensive) big version is printed it is a good idea to print your map at A3 and have a close look at it first! (This isn't such an issue if your map is only A3 or A4 when full size.)

- Export your map as a pdf file following the instructions in section 10.6.2 on page 134.
- Open your pdf map file in Acrobat reader, or your usual pdf program (instructions below are for Acrobat).
- File > Print...
- Choose your printer and use the printer properties to set the paper size to A3 then choose to print in colour.
- In the **Page Handling** section set **Page Scaling** to **Fit to Printable Area**. In Acrobat this should show you a small preview of how your file will print.
- When you are happy with the settings - OK

10.6 Printing and exporting maps from ArcMap

When you have finished creating your map in ArcGIS you will usually need to export it to pdf for printing. The following instructions should help to ensure that your map is the correct size and scale.

10.6.1 Printing a map from ArcMap

The best quality output is obtained by printing directly from ArcMap, though this isn't always possible. If it is, print as follows:

- Start by checking that the page size and scale are correct in **Page and Print Setup...** (section 10.3 on page 118)
- Whilst in Layout view - File > Print...
- Select your printer with the Setup... button and choose paper size and colour printing as you usually would (this is system specific so I can't include exact instructions here)
- Set **Output Image Quality** to **Best**
- Click on OK to print

10.6.2 Exporting a map for printing

These instructions show you how to export the map to pdf - the format that is usually required by print shops etc. There are other options in the dropdown list if you need to export an image or another format and the instructions are very similar.

- From within layout view - File > Export Map...
- Select **PDF(*.pdf)** in the **Save as** type. **(Do not select the 'Production PDF' option, if you have it - it causes all sorts of problems.)**
- Set the resolution - minimum 300dpi for printing. Higher is better, but too high and it will be impossible to export the file, particularly if it is a large map.
- Set **Output Image Quality** to **Best**.
- Give your file a name and choose where to save it (checking first that you have enough disk space - some exported maps can be very large[7]).
- Save - be patient! For a large map this can take a long time.

Important note on printing your final copy

If you are printing your final copy from pdf double-check that the **Page Scaling** or **Zoom** is set to **Actual Size...** or **None** (the actual terminology depends on which pdf application you are printing from). This is important to ensure that your map is printed at the scale at which you intend it to be printed. Major problems can be caused by the tiny amount that your map will be reduced by otherwise.

10.6.3 Exporting a map to import to other programs

As explained in section 10.4.9 on page 131 you can either import items into an ArcMap layout, or export the ArcMap layout to include in programs such as Inkscape, CorelDraw, Word or Powerpoint. The instructions here show how to do the latter.

- To start with set up your ArcMap layout as required
  - check that the page size, and the scale/size of the data frame are correct - you'll lose quality if you resize them outside of Arc
  - If you want to include a legend in the final layout it is a good idea to create it in Arc and export it with the map as then the colours and sizes of the symbols will match the map.

[7] If you think that you may be short of disk space you can save the export to the c: drive or the desktop of the computer in the first place, but do make sure that you then move the file to your m: drive or a USB stick. Forget and you'll lose it.

  - add a measured grid and a scale bar
  - optionally add an automatically generated extent diagram

- File > Export Map...
- Choose the appropriate output format (see below) and set the resolution - to **600 dpi** if you have the disk space
- Choose a location then Save

If you basically want a good quality image to import into Word, Powerpoint, CorelDraw, Inkscape etc, then **png** or **jpg** are both fine. Be aware that if you import png or jpg and then resize them you are likely to end up with blurred final result - double-check before printing.

You can also import **pdf** or **svg** into Inkscape and CorelDraw and do some limited further editing.

Whichever format you choose, if your map is going to be part of a bigger presentation where scale is important, such as the Geological Sciences final dissertation map, import to either Inkscape or CorelDraw without changing scale/size/proportions (check instructions for those programs) and then double-check the scale of the main map by drawing a horizontal line of known length and checking it against the lines of the measured grid. For example, for a map at 1:10 000, a line of 10 cm will be the same length as the space between the 1000 m (1 km) grid lines.

10.7 Recommended reading: layout and presentation

The module reading list[8] includes a full section on layout and presentation. In particular have a look at “Designing better maps” by Cynthia Brewer, but for a quick overview look at the article by Frye (2001) or the small book by Darkes and Spence (2017). For examples and ideas look at Brewer (2008) and the ESRI Map Book Gallery.

[8] Reading list available from Minerva and from the module catalogue at `http://webprod3.leeds.ac.uk/banner/dynmodules.asp?M=SOEE-2650`

10.8 Suggested final map layout

Figure 10.14 shows a suggested layout for your final map. Once you have finished working through chapter 10 you will be able to pick the most appropriate elements to add to your maps. This is the stage where you present your map in the clearest possible way so that your audience can “read” the information that you are trying to give to them.

Your map should not look identical to this as you will have made your own decisions as to what to include and where to put the elements. For example, you could add an extent indicator to this to show where Ingleton is located within the UK; you could add a north arrow (remember to give the details if you do); you should include your name, or at least Student ID, as the creator of the map.

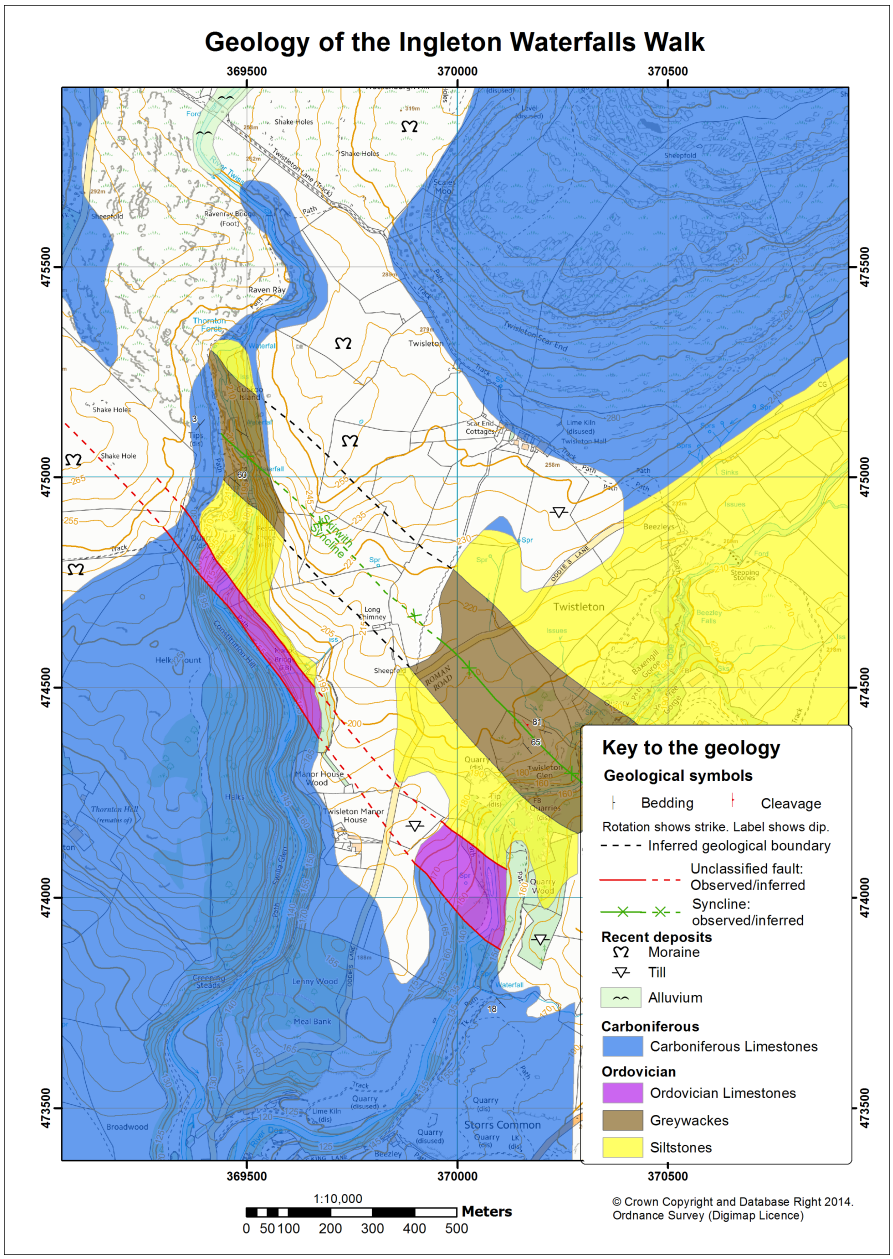


Figure 10.14: Suggested final layout for the Ingleton geological map

Appendix A

Creating data for GIS: Point data and GPS

A.1 Learning outcomes

When you have completed this section you should be able to

- collect your own spatial data for use in GIS
- discuss the problems that can affect data for GIS
- suggest ways in which to minimize error and uncertainty in spatial data

A.2 Introduction

The previous chapters should have given you some idea of the variety of data that is available for you to use, but there is nothing to replace going out and collecting your own data and it is very likely that you will be using GPS units for fieldwork at some point.

In this chapter you will collect waypoints using a GPS unit. Once you have collected waypoints you will look at how to import the data from the GPS units into ArcMap.

Waypoints collected using a GPS receiver can be downloaded and opened in ArcGIS in a variety of ways depending on the software provided with your receiver. Instructions in this section will of necessity be vague in places as it is impossible to know about every combination of hardware and software. You may need to use instruction booklets and help files provided with your setup.

If you are new to GPS and would like to find out more about the background and technology there are beginners guides at:

Garmin:

`http://www8.garmin.com/aboutGPS/index.html`[1]

Ordnance Survey:

`http://bit.ly/1cPJkCw`[2]

A.3 Prerequisites

- GPS receiver with cables to connect to computer
- **OR** GPS enabled mobile device either with cables to download data or wifi connection.
- Base map - these instructions will show you how to use ArcGIS Online as a base, but use the most suitable base map for your area.

[1] Last visited: 18th September 2018
[2] Last visited: 18th September 2018

A.4 Collecting data with a GPS

You will be divided into small groups. Each group will have a GPS unit (probably a Garmin eTrex 10), a brief quick start guide and a fieldslip (see section A.12). The official Quick Start manual for the Garmin eTrex 10 is available online[3] at

`http://static.garmincdn.com/pumac/etrex_10_QSM_EN.pdf`

A.4.1 Setting up the GPS

This is best done once you are outside and the gps can find satellite signals. Wait for me at the location I tell you, and we will check that you all have a gps which works, and know how to do the basics before you continue with the exercise.

You will be given a quick reference sheet which you can take outside with you to use during the exercise.

Take a short while to familiarise yourself with the GPS and work out how to add waypoints (use the quick reference leaflet to see how to do the basics). Please ask if you can't work anything out.

- Start by turning the GPS on!
- Use the thumbstick to navigate the menu. Press it to select.
- Use the **Waypoint manager** to delete all existing waypoints (hint: use the **Menu** button!)
- Use the **Track manager** to clear the current track
- For this exercise go to Setup » Position Format and check that the format is as follows:
  - **Position format:** British Grid
  - **Map Datum:** Ord Srvy GB
  - **Map Spheroid:** Airy
- If the position format isn't correct, reset it.[4]
- Check that you know how to record a **Waypoint**

Now you should be ready to go.

A.4.2 Collecting data: warnings

Accuracy

It is possible check how many satellites your GPS receiver can see (**Satellite** in the initial menu). The more satellites there are within view, the more accurate your readings will be.

When you get outside, keep an eye on this from time to time.

[3] Last visited: 18th September 2018

[4] It is often best to have the coordinate system set to the same as a paper map that you are using in the field. If this isn't possible set the format to WGS84, which is a standard geographic coordinate system and can be **transformed** into another system later:

- **Position format:** hddd.ddddd degrees
- **Map Datum:** WGS84
- **Map Spheroid:** WGS84

Figure A.1 shows the satellite information screen on the eTrex 10. In this case it is showing that it has picked up four of the satellites that it is expecting, although it only has a full-strength signal from three of them. The accuracy is +/- 34 m, hopefully yours will be better than that!

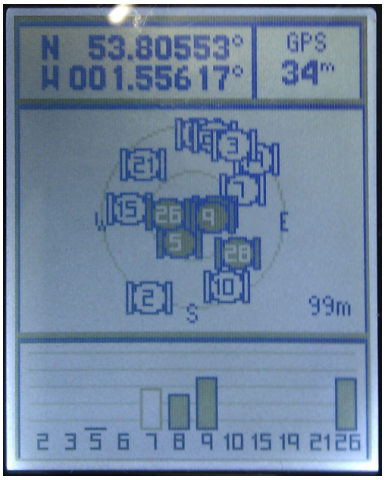


Figure A.1: Garmin eTrex 10 satellite information screen

Make a note on your sheet of the number of satellites that there are in view when you first switch on the GPS and of the stated level of accuracy which should be in metres (ask for help if it is in feet).

The general advice is to turn on your GPS well in advance of starting to work, and leave it on for the whole of the working day. This gives it a chance to find and track the maximum number of satellites. Even under ideal conditions, when your receiver has found several satellites, due to the nature of the system accuracy still won't be 100%. Under **Satellite** you should be able to find out what the current level of accuracy is - it will be a measurement in metres. Be aware of this when using the readings. According to the O.S. website "Positional accuracy with a single receiver, to civilian users approximately equals 5 m to 10 m, 95% of the time." [5]

It is particularly worth noting that GPS data can give an *illusion* of extreme accuracy. The readings tend to show figures with lots of decimal points which could lead you to assume that a reading is accurate to 1 m or less. Given the statement above that is very unlikely to be the case.

For this reason it is still important to know how to locate yourself accurately on a paper map without the use of GPS, and most navigation experts will say that with practice you can be far more reliable and accurate than a GPS unit. Not least, you should have the intelligence to recognise when the point where you are standing is at the top of a cliff, not off it!

Elevation

Don't use elevation measurements from your GPS. For various reasons obtaining accurate height readings with GPS is much more difficult than obtaining accurate horizontal readings. The OS website has an explanation of how best to do this, but it involves specific equipment and readings taken over at least 24 hours.

A.4.3 Data to collect

Go out to the area indicated in the class (probably Chancellors Court or St Georges Fields) taking a copy of the data sheet or map with you and collect a series of point readings. You will be

[5] `http://bit.ly/1cPJkCw` [Last accessed: 18th September 2018]

given a time limit - try quickly to collect points which are spread out across a fairly wide area. When you are doing field work you will collect data in your field notebook and/or on a field slip but for now mark items on the field slip provided.

Suggested features to take a reading for are: Trees; Seats; Rocks; Rubbish bins; Memorials; Sign posts; Planters; Maps. But add any other features that you think are appropriate.

Fill in the fieldslip with the number of the waypoint, and the type of feature, e.g. seat.[6]

Make sure that every member of the group has a turn with the GPS and try to work quickly and efficiently.

Once you have at least the recommended number of points, return to the computer cluster and continue following these instructions to download the data.

A.5 Downloading files from the GPS

Start from here once you get back into the cluster from collecting data.

To download data directly from the GPS unit you will have a USB lead (if you're in class you should sign one out from the demonstrator).

- Connect the USB lead to a USB port on the computer.
- Lift the "weather cap" from the port near the top of the back of the gps unit and plug the other end of the USB lead in to that
- The gps unit should appear as a removable drive in **My Computer**
- navigate to `Garmin`▸`GPX` and download the gpx (gps exchange format) file - `Waypoints_`*`current_date`*`.gpx`

You won't be able to open the file directly, but **copy it to your working folder** so that you don't lose it when you remove the gps.

Make sure that every member of your group has a copy of the gpx file on their own drive so that you can all work through the remaining exercises independently.

When you've finished make sure that the gps is turned off - the batteries are not rechargeable!

A.6 Converting gps files for ArcGIS

Before you start this exercise check that you have set the links from ArcMap to datafiles to relative - see section 5.4.1 on page 55 for a reminder on this and how to deal with broken links (the little red exclamation mark).

Video Clip available in Minerva - Converting gps files to display in ArcMap. Direct link:`http://bit.ly/2fY3bd7`

A.6.1 Converting with the Conversion tools

Methods of converting gpx files in Arc appear to change with each version. This method should work with version 10.4 and above. If it doesn't, or if you are on version 10.3 or another lower version try the instructions in section A.6.2 on page 142 instead.

The simplest way to convert gpx to feature class is to use the **From GPS** tool.

- Open ArcMap and begin by having a look at the properties of the gpx file in the Catalog panel - right-click on the file and select Properties
- In particular check the XY Coordinate System and make a note of how it is set in the box below.

gpx file coordinate system:

If the XY coordinate system is `<unknown>`, which it probably is, you'll need to work out what the coordinate system actually is.

Open the gpx file in a text editor such as Notepad or Notepad++ (right-click on the file in the windows file explorer and Open with... . You may need to set the text to wrap around if the whole thing appears on a single line - in Notepad++ go to View > Word wrap.

It will look rather confusing - this is a form of xml - but don't panic! Look for a line that begins `<wpt lat= ...` (see figure A.2). This line shows the **latitude** and **longitude** of a waypoint and demonstrates that, even if your gps unit was set to British National Grid, for example, a gps unit will still **store** the data in a coordinate system called **WGS84**.

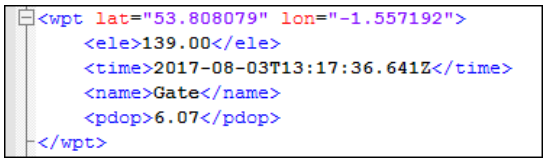


Figure A.2: This is how a waypoint looks in Notepad++ - note the line beginning **<wpt lat=** . Also note that the coordinates will be in lat and long even if you had the GPS unit set to British National Grid.

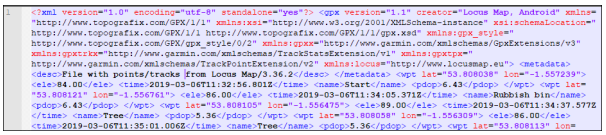


Figure A.3: This is the same file as figure A.2 but with all of the data on one line. It's harder to see what is happening, but the information is the same. Just look for **<wpt lat =** still.

So if the coordinate system of your file was `<unknown>`, write **WGS84** in the box above where you wrote the gpx file coordinate system previously.

You'll use one of the tools in **ArcToolbox** to convert the gpx file. ArcToolbox gives you the opportunity to do a lot of very advanced processing tasks without needing to use a command-line interface.

[6] It is possible to use the GPS unit to add notes, such as the type of feature, to each waypoint, but the GPS doesn't have a touch keyboard and entering text is very long-winded and fiddly. It is much easier to collect the points on the GPS, make notes on paper, then add the notes to the data on computer.

- If the toolbox isn't already open find it by going to Geoprocessing > ArcToolbox. Be patient, it can be slow to open - it should look something like figure A.4 once it does.
- Open Conversion Tools > From GPS and double-click on GPX to Features to open the tool (figure A.5).
- Fill in your **Input GPX File** and then click on the folder symbol next to **Output Feature class** (remember - never try to save to the Default geodatabase - it almost always crashes)
- You can either just navigate to your folder and then type in a name such as `Waypoints` or you can add the data to an existing geodatabase
- Click Save > OK

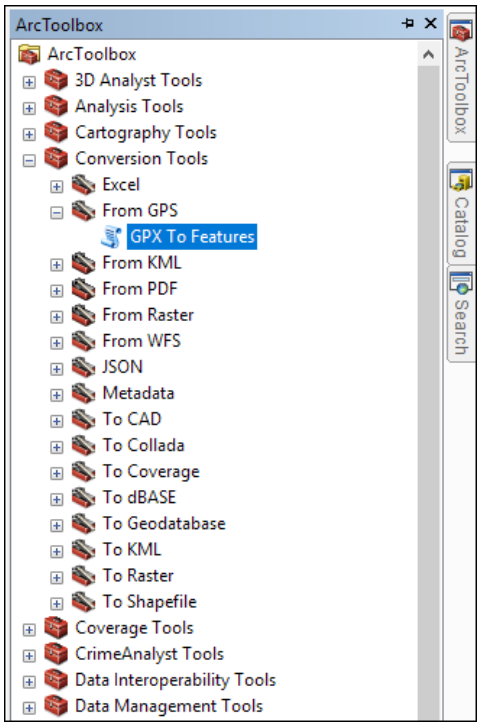


Figure A.4: ArcToolbox - showing GPS to Features selected

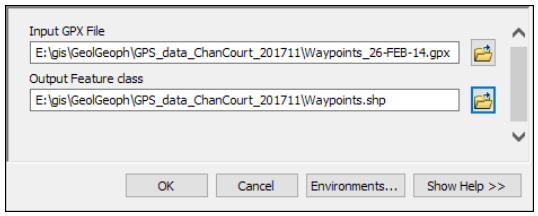


Figure A.5: The filled in GPS To Features tool

The tool should run and add a point feature class to your blank map.

A.6.2 Converting with the Data Interoperability tools

> ***If you have already converted your gpx files in section A.6.1 on page 141 go straight to section A.7 on page 144.***

Methods of converting gpx files in Arc appear to change with each version. This method should work with version 10.3.1. If it doesn't, or if you are on version 10.4.1 try the instructions in section A.6.1 on page 141 instead.

The simplest way to convert gpx to feature class is to use the **Data Interoperability Quick Import tool**.

- Open ArcMap and begin by having a look at the properties of the gpx file in the Catalog panel - right-click on the file and select Properties
- In particular check the XY Coordinate System and make a note of how it is set in the box below.

gpx file coordinate system:

NOTE: If the XY coordinate system is actually `<unknown>` you'll need to know the system that the gps was set to - in this case it should be **WGS1984**.

You'll use one of the tools in **ArcToolbox** to convert the gpx file. ArcToolbox gives you the opportunity to do a lot of very advanced processing tasks without needing to use a command-line interface.

- If the toolbox isn't already open find it by going to Geoprocessing > ArcToolbox
- Once in the toolbox double-click on Data Interoperability Tools > Quick Import
- Click on … next to **Input Dataset:**
  - Set format to gpx by clicking on … next to **Format** and searching for **gpx** in the box at the bottom left, then selecting **GPS eXchange Format(GPX)**.
  - Click on … next to **Dataset:** to navigate to your gpx file and open it
  - Click on … next to **Coord. System** to set it to WGS84 (or whatever coordinate system your gps was set to - see the note you made above) - For WGS84 look for Geographic Coordinate System > World > WGS1984
  - OK - see figure A.6
- OK
- Now click on the folder symbol next to **Output Staging Database** to set where you want to save your data. **Don't save it to the default location as it will almost inevitably crash!**

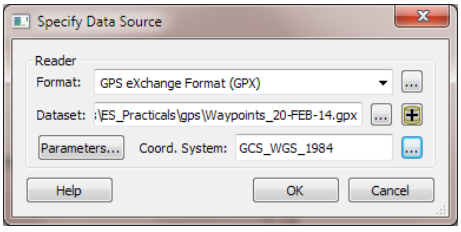


Figure A.6: Selecting the data source to import

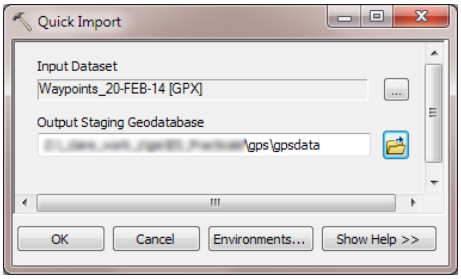


Figure A.7: The Quick Import dialog

Your input dialog should look something like figure A.7.

- Click OK to run the conversion.

Check in the Catalog panel to make sure that you have a new geodatabase with the name that you gave it under **Output Staging Database**, and which contains a feature class which will probably be called something like **Waypoints**.

A.7 Add waypoint data to ArcMap

Before adding your data to a map you need to stop and think about coordinate systems - the coordinate system of your data needs to match the coordinate system of your map.

If you followed the instructions for converting your gpx file with the Conversion tools or the Data Interoperability tools then the coordinate system will be **WGS1984** (you should have made a note of it in section A.6.2 on page 142). We'll start by adding the data to a map with that coordinate system.

- Add your converted Waypoints feature class to the map, if it hasn't been added automatically.
- Check the coordinate system of the data frame (double-click on the data frame title (usually **Layers**) to open the properties, then go to the **Coordinate System** tab) - it should be WGS84. If it isn't, set it to that now (`Geographic Coordinate Systems▸World▸WGS84`)
- also check that the waypoints are set to WGS84 by going to the layer properties and looking for the **Geographic Coordinate System** heading under **Data Source**. If that says `<unknown>` you'll need to set the projection:
  - use the toolbox to **Define** the projection of the Waypoints feature class to WGS84. (Toolbox » Data Management Tools » Projections and Transformations » Define Projection and set the **Coordinate System** to `Geographic Coordinate Systems▸World▸WGS84`)

A.7.1 Adding a background map from ArcGIS Online

As a quick way of setting up a background map we'll use a dataset provided by ArcGIS Online. There are a lot of maps available this way and although they have some limitations it can be a useful way of creating a map.

Warning: adding online data can slow Arc down significantly, or cause it to crash completely. If you are having trouble with a map try removing any online layers.

Video Clip available in Minerva - Adding data from ArcGIS Online.
Direct link: `http://bit.ly/2sp41oY`

- File » ArcGIS Online...
- Search for **Imagery** in the box at the top and from the layers that appear choose **World Imagery**. Make sure that you choose the layer package (see figure A.8) - if the button for the layer says Open rather than Add then look for another similar layer! **Add** the layer to your map.

Be patient while the layer loads. If it won't load and complains of lack of memory you will need to close ArcMap and open it again - the previous operations will have been fairly memory intensive!

Because the map uses the coordinate system WGS84, which is also the coordinate system for data in ArcGIS Online, you shouldn't get any error messages or warnings.

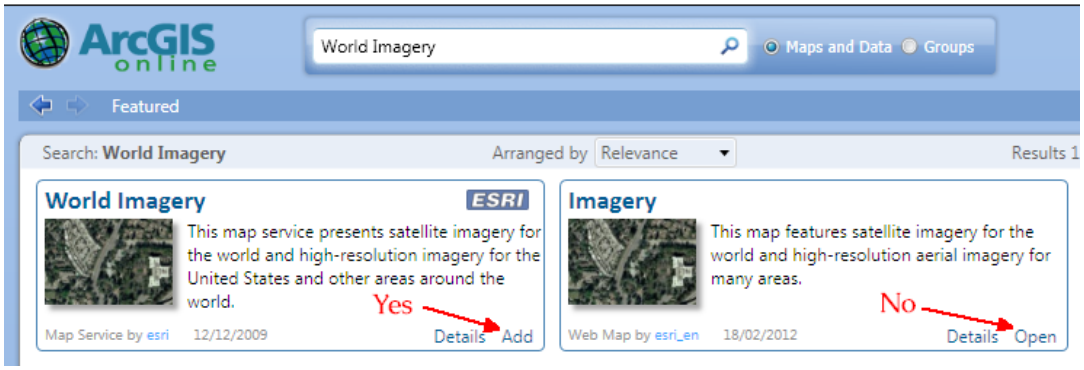


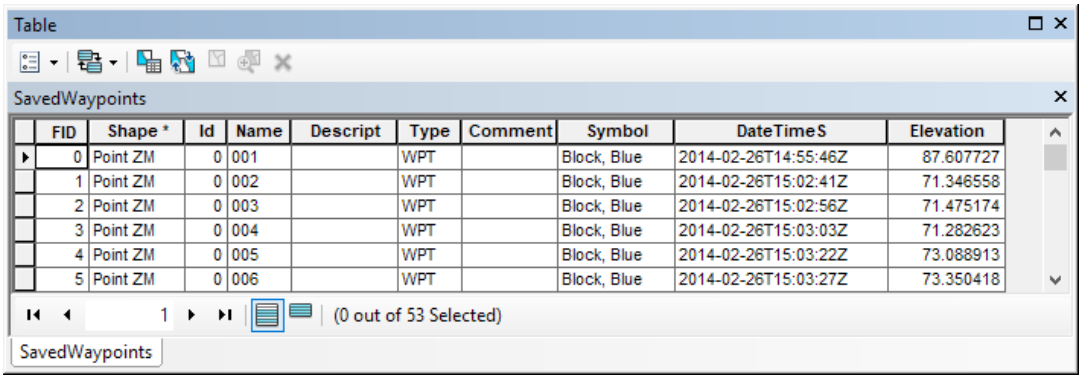
Figure A.8: Adding imagery from an ArcGIS Online layer package

Have a look at your map and zoom in and out a bit. Take particular note of where your gps points are. How accurate do you think the locations are? What problems can you spot based on your memory of collecting the data? How do you think you could increase accuracy of data collection?

A.7.2 Adding extra data to feature classes

Have a look at the attribute table of the new layer

- right-click on the layer in the table of contents
- select Open Attribute Table. It should look something like figure A.9



FID	Shape *	Id	Name	Descript	Type	Comment	Symbol	DateTimeS	Elevation
0	Point ZM	0	001		WPT		Block, Blue	2014-02-26T14:55:46Z	87.607727
1	Point ZM	0	002		WPT		Block, Blue	2014-02-26T15:02:41Z	71.346558
2	Point ZM	0	003		WPT		Block, Blue	2014-02-26T15:02:56Z	71.475174
3	Point ZM	0	004		WPT		Block, Blue	2014-02-26T15:03:03Z	71.282623
4	Point ZM	0	005		WPT		Block, Blue	2014-02-26T15:03:22Z	73.088913
5	Point ZM	0	006		WPT		Block, Blue	2014-02-26T15:03:27Z	73.350418

Figure A.9: The attribute table for the converted gps data

Amongst many other attributes there should be one for **Name** which should include the label or name of each waypoint as stored by the GPS unit. There is a set of important information missing from this file, though. What do you think it is?

Hopefully you spotted that you still need to add the details of each feature to the shapefile, i.e. what type of feature it is, such as seat or signpost. You should still have a copy of this information. This is the point at which you add that information to the attribute table but first you need to add a new field.

Adding a new field to a feature class

This can also be referred to as adding a new column or a new attribute field.

Video Clip available in Minerva - Adding a new field to a feature class.
Direct link: `http://bit.ly/2fYVbZE`

- Within ArcMap, with editing off and ArcCatalog closed...
- Right-click on the layer title - e.g. **Waypoints**.
- Open Attribute Table click on the Table Options button in the top left of the attribute table window Add Field...
- Fill in the form (see figure A.10) by typing **FType** in the **Name** field[7]; change the **Type** to **text**; change the **Length** to 75 OK
- Close the attribute table.

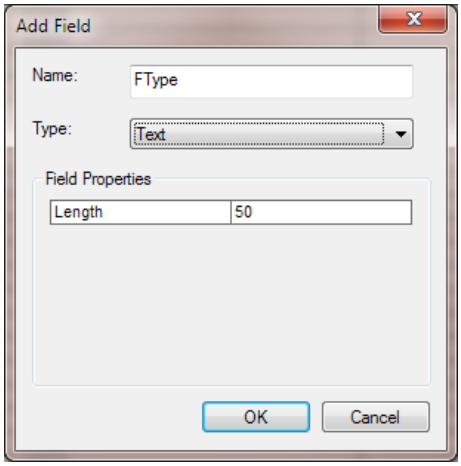


Figure A.10: Add Field dialog

Problems with adding fields to feature classes crop up rather regularly, usually it is possible to get around them by using the tips in table A.1 on page 147.

A.7.3 Adding feature attributes to a feature class

Now you're ready to add information, or **attributes**, to your new field.

- Start an edit session by doing the following
  - open the Editor toolbar by going to Customize Toolbars and clicking so that there is a tick next to **Editor**
  - right-click on the waypoints layer in the Table of Contents and select Edit Features Start Editing
- Open the attribute table for the waypoints feature layer (right-click on the layer then Open Attribute Table)

[7] Field names are restricted to 8 characters and cannot have any spaces. `FType` is a contraction of `Feature Type`

Getting around problems when adding fields to feature classes
Sometimes when you try to add a field to a feature class you'll get an error message saying that the field is already in use. This will prevent you adding a field. The first thing to check is that you are not in an edit session. If you are sure that you are not and it still isn't working, try the following: • If you are using the Catalog Panel in ArcMap then close ArcMap completely. • Open ArcCatalog and go to the feature class to which you want to add a field. • Right-click and open **Properties** • Go to the **Fields** tab. • Use the boxes there to add as many new fields as you need to add. If you are having problems with creating fields in ArcCatalog, then do the reverse - close ArcCatalog, Open ArcMap, and use the Catalog panel to add new fields.

Table A.1: Getting around problems with adding fields to feature classes

- Click in the first box - check that the `Name` field matches the number in your notes, and add the type of feature. Try to be consistent, so all features of the same type have exactly the same text - check spelling and if you use upper case to start one, use it for all.
- go through the list and add all the feature types, see figure A.11.
- then save your edits and close the edit session - using the Editor toolbar Editor > Save Edits then Editor > Stop Editing.

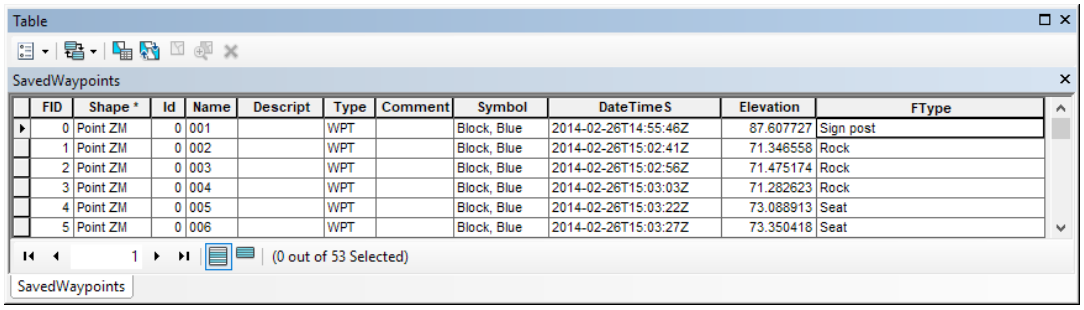


Figure A.11: The attribute table for the converted gps data with the feature type added manually

Video Clip available in Minerva - Adding feature attributes to a feature class. Direct link: `http://bit.ly/2fYFMZ5`

A.8 Symbolising a layer

So far you have a single coloured dot representing every point. Your map would be much more informative if each type of feature had it's own symbol.

Open the attribute table for your new point feature layer again and have another look at the data that it contains. In the previous section you created a column called **FType** or something

similar and added attributes to show what type of feature each record contained. In Arc it is easy to colour, or **symbolise** the features so that you can differentiate what they refer to.

- Close the attribute table.
- Right-click on your point layer and click on **Properties**
- Go to the **Symbology** tab

Video Clip available in Minerva - Symbolising a layer by categories in ArcMap. Direct link: `http://bit.ly/2ePRqVG`

At the moment the layer is symbolised as a single symbol - a single random colour which is used for all features.

- Select **Categories** in the list on the left of the properties dialog
- then select **Unique Values**
- in the **Value Field** box that appears select **FType** - or whatever you called the field that you added attributes to.
- click on Add All Values

You should find that you get a list of the values of FType to which Arc will have assigned random coloured symbols - figure A.12.

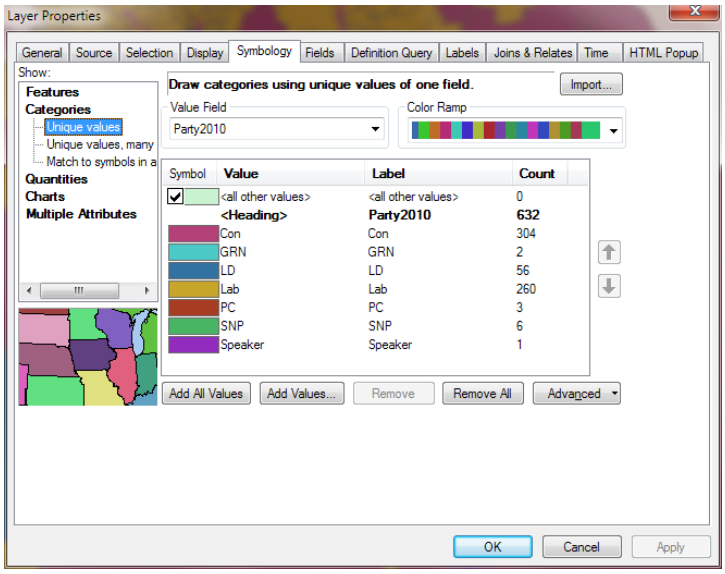


Figure A.12: Setting symbols for a layer with multiple categories

- You can change the symbols by double-clicking on each symbol in turn - have a go now. If you search through the possible symbols in the symbol selector you may find appropriate symbols for rocks, plants etc.[8] Use the Style References button to add further selections of symbols.
- Click on Apply to see the result and OK when you are happy with it.
- You may find it easier to see what you are doing if you turn off the base map layers.

[8] Note that the search facility doesn't always work in cluster machines - you may have to browse the possibilities instead.

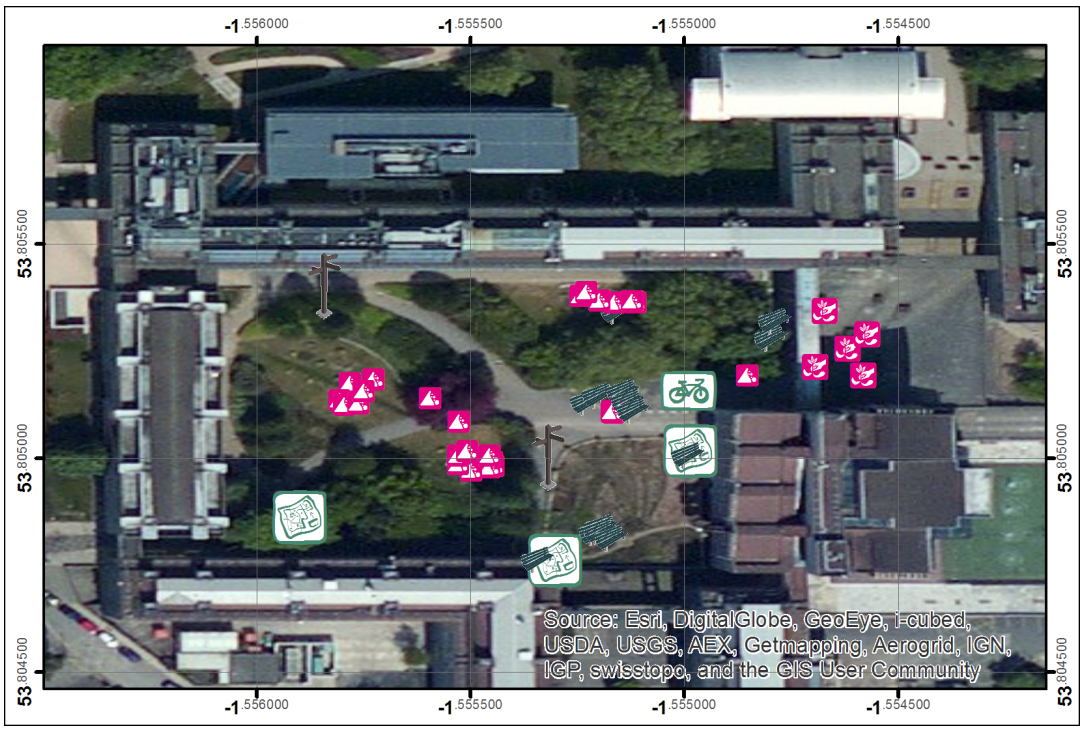


Figure A.13: An example of symbolised waypoints for Chancellors Court (WGS84 coordinate system)

A.9 Data frame reference scale

When you print your map you will want the symbols and labels to be a particular size at a particular scale. If you set a **data frame reference scale** to the scale at which you are intending to print the map then you can set the size of the symbols and labels at this scale.

Question A.1. Zoom in to 1:500 and then zoom out to 1:25 000. What happens to the size of the symbols you have just created when you zoom in very close or zoom out?

- Scale the map to the scale that you will be printing it at by using the **scale drop down** on the standard toolbar. In this case set the scale to **1:1 000** (you can just type **1000** into the box).
- Right-click on the **data frame title** (Layers) in the table of contents.
- Reference Scale > Set reference scale. Arc will set the reference scale to the current map scale.

Question A.2. Zoom in to 1:500 again - what happens to the size of the labels now? And what happens to them when you zoom out to 1:25 000?

When you use the symbology settings to set the size of your symbols now, you will be setting the size that they print out at your reference scale. You may find that you do need to resize the symbols so that they don't look to crowded once you have set this.

- To remove the reference scale completely use Reference Scale > Clear Reference Scale.
- To change a reference scale set your map to the correct scale then use Reference Scale > Set Reference Scale again.

A.10 Changing the coordinate system of data

The GPS data that you have collected is in the WGS84 geographic coordinate system, but often you will need to use the data in a local projected coordinate system. The obvious example is if you are using Ordnance Survey maps from Digimap in the same project. This is the example that we'll use now, but the same situation can arise if you are, for example, mapping in Spain or Eire.[9]

- Open a new blank map in ArcMap and add the **LocationBNG** shapefile that you can download from Minerva as **Week06Data.zip**. Remember that the first layer that you add to a data frame automatically sets the coordinate system.
- Add the **se2934.tif** layer from the downloaded data to your map.
- Now try adding your **Waypoints** layer. What happens?

You should get a warning which looks something like figure A.14.

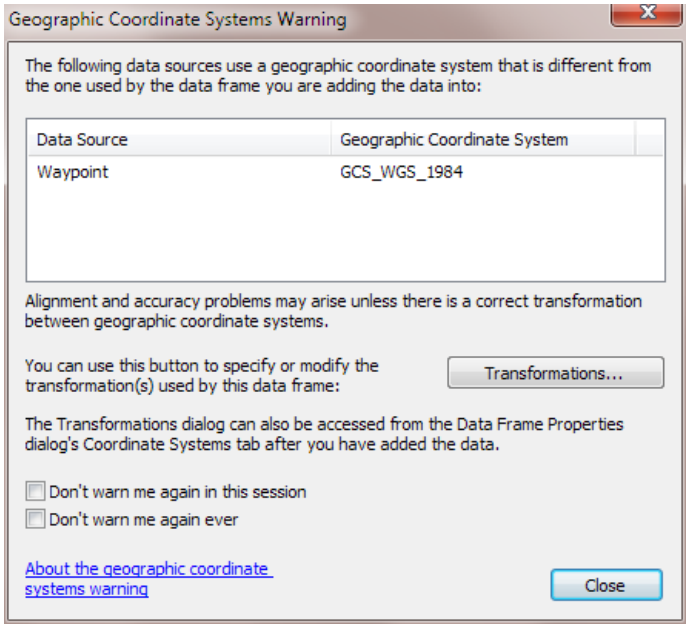


Figure A.14: Geographic Coordinate System Warning

This is telling you that the data that you are adding to the map is not in the same coordinate system as your map, so Arc can't add it in the correct location without some extra information from you. You need to tell ArcGIS that you want to **project on-the-fly** so that the WGS layer appears in the same space as the map and data that has already been projected to British National Grid.

[9] If you want to find out more about coordinate systems and projections have a look at Heywood (2006) pp. 44-51 for a general introduction. The books in the Coordinate systems and projections section of the module reading list give more detailed information.

Video Clip available in Minerva - Transforming the projection of data "on-the-fly". Direct link: `http://bit.ly/2fYQtLg`

- Click on Transformations...
- Set the Transformations dialog so that your selections are as in figure A.15 with the top box being the GCS to convert from[10].
  - **Convert from:** GCS_WGS_1984
  - **Into:** GCS_OSGB_1936
  - **Using:** OSGB_1936_To_WGS_1984_Petroleum
- OK > Close

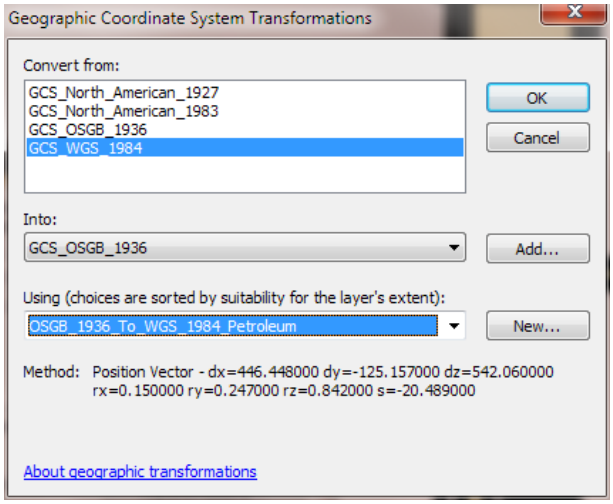


Figure A.15: Transformations dialog

Even if you don't get a warning, don't assume that all is well! The **Location** feature class should outline an area around where you collected data. If it doesn't you need to check that transformations are set up correctly.

The layer should be added to your map and appear in the correct position. This method of projecting a layer is only temporary.

- Open the data frame properties
- Go to the **Coordinate System** tab and click on the Transformations... button
- from there select to transform WGS84 to OSGB1936 using the Petroleum option as in the previous instructions.

If you want to project a layer permanently, particularly if you want to do analysis on it, you have to use the **Project** tool which you find from Toolbox > Data Management Tools > Projections and Transformations. There are separate tools for feature classes and raster layers, in this case you would select Feature > Project

[10] If you want more information about what you are doing here try clicking on the **About geographic transformations** link at the bottom of the dialog.

Video Clip available in Minerva - Reprojecting a feature class with the toolbox. Direct link: `http://bit.ly/2fYCPYv`

A.10.1 Adding data from ArcGIS Online

Once again add an Imagery layer from ArcGIS Online as you did in section A.7.1 on page 144. You should find that you get the Geographic Coordinate System warning again, and again you'll need to **Transform** the layer to British National Grid to be able to use it on your map.

Be aware that adding layers from ArcGIS Online can slow ArcGIS down a lot. If Arc crashes because of this all you can do is remove the ArcGIS Online layer. In this case - speak to staff or demonstrators to obtain an alternative dataset.

Look at both maps in turn and it should become obvious that changing the projection doesn't just have an effect on how your layers line up with each other, but also on the "shape" of your data.

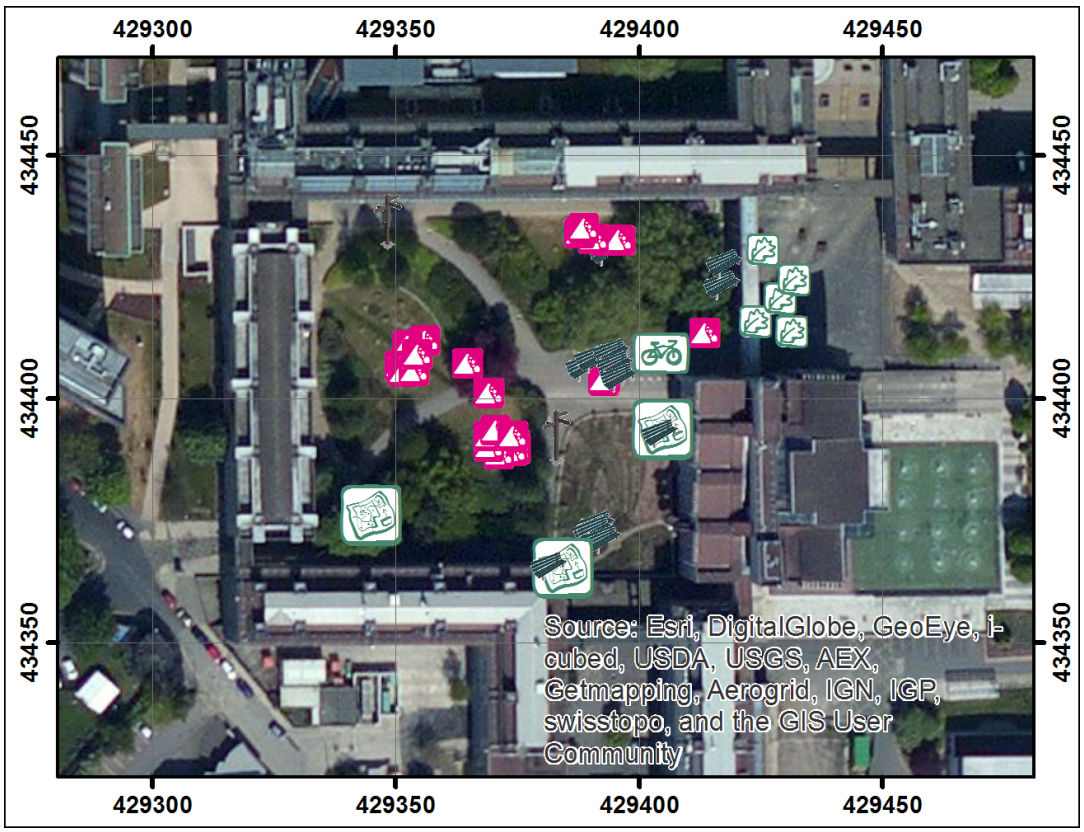
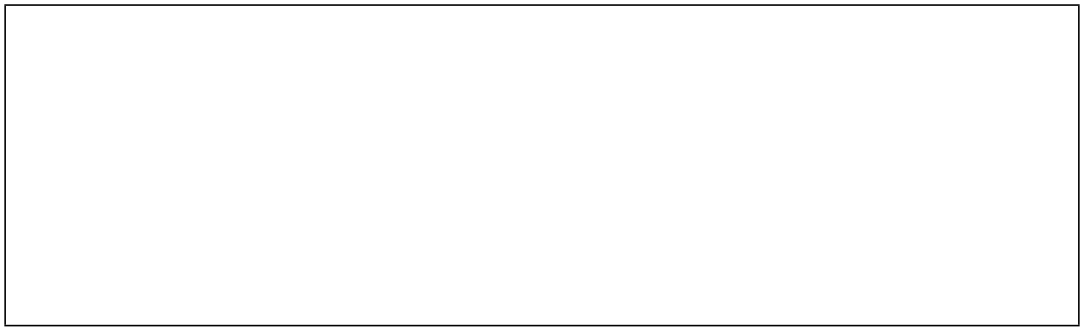


Figure A.16: An example of symbolised waypoints for Chancellors Court (British National Grid coordinate system)

A.11 Finally...

Question A.3. Have another close look at the gps layer. How accurate do you think the locations of the points are? What problems can you spot based on your memory of collecting the data? Compare the points you collected with the base imagery that you've added. How do you think that you could increase accuracy of data input?



When you are mapping in the field you can use a gps receiver to locate your measurements and keep a record in your field note book. But remember the issues with accuracy (section A.4.2 on page 138) and make sure that you can also locate yourself accurately using a paper map. The advice of professional mappers is often to check the location given by your gps unit against a map every time that you take a reading!

A.12 Recommended reading: collecting data with GPS

For more detailed information have a look at the following references from the module reading list[11].

Chang (2016), Section 5.4. on creating new data includes information on GPS.

The Ordnance Survey has a lot of information about GPS on their website[12], including a Beginners Guide to GPS. Start at `http://bit.ly/1C5XMST`

Heywood, I. (2011), Chapter 10 covers data quality issues, including accuracy.

[11] Reading list available from Minerva and from the module catalogue at `http://webprod3.leeds.ac.uk/banner/dynmodules.asp?M=SOEE-2650`

[12] Last visited: 18th September 2018

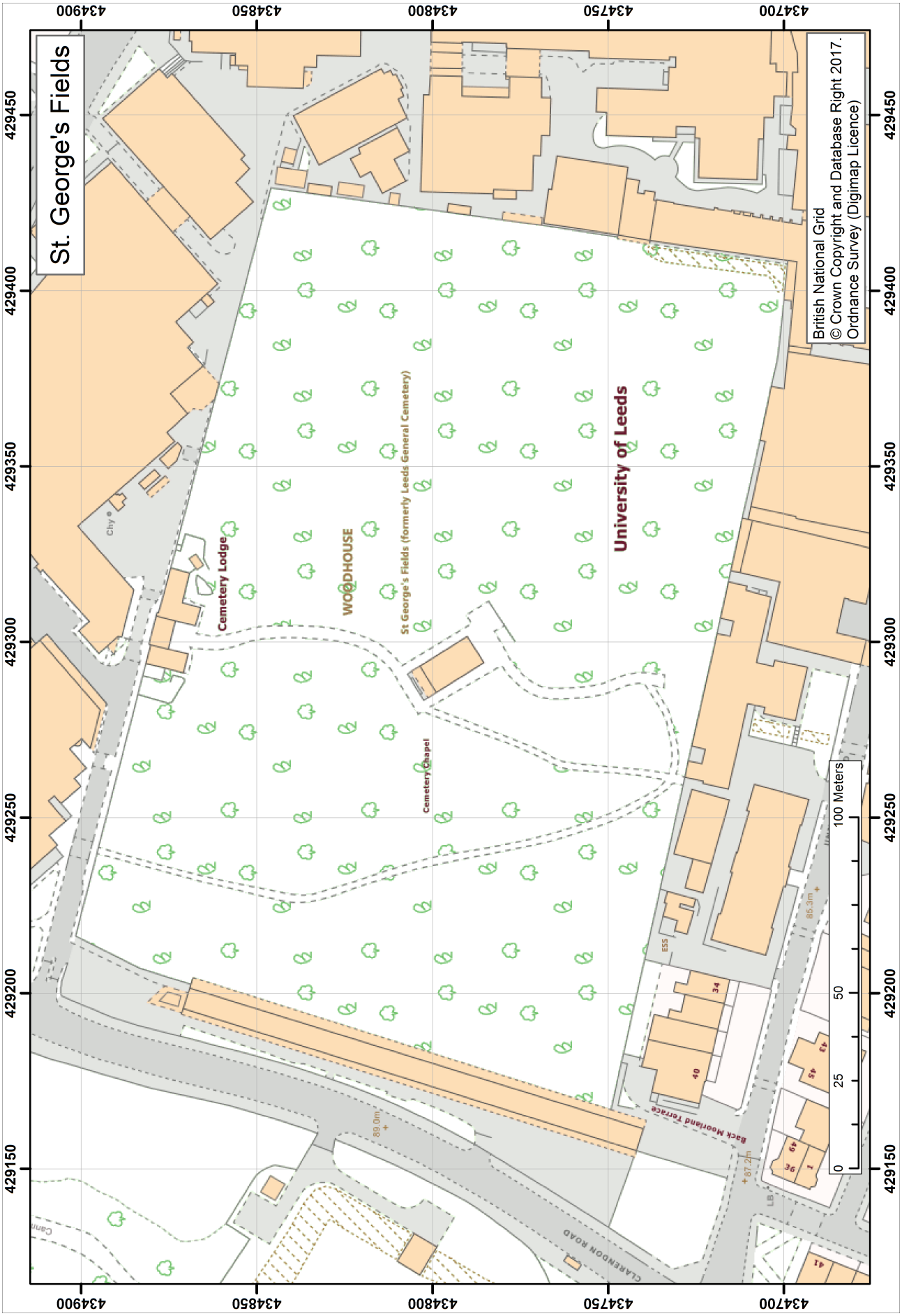


Figure A.17: Field slip for St George's Fields

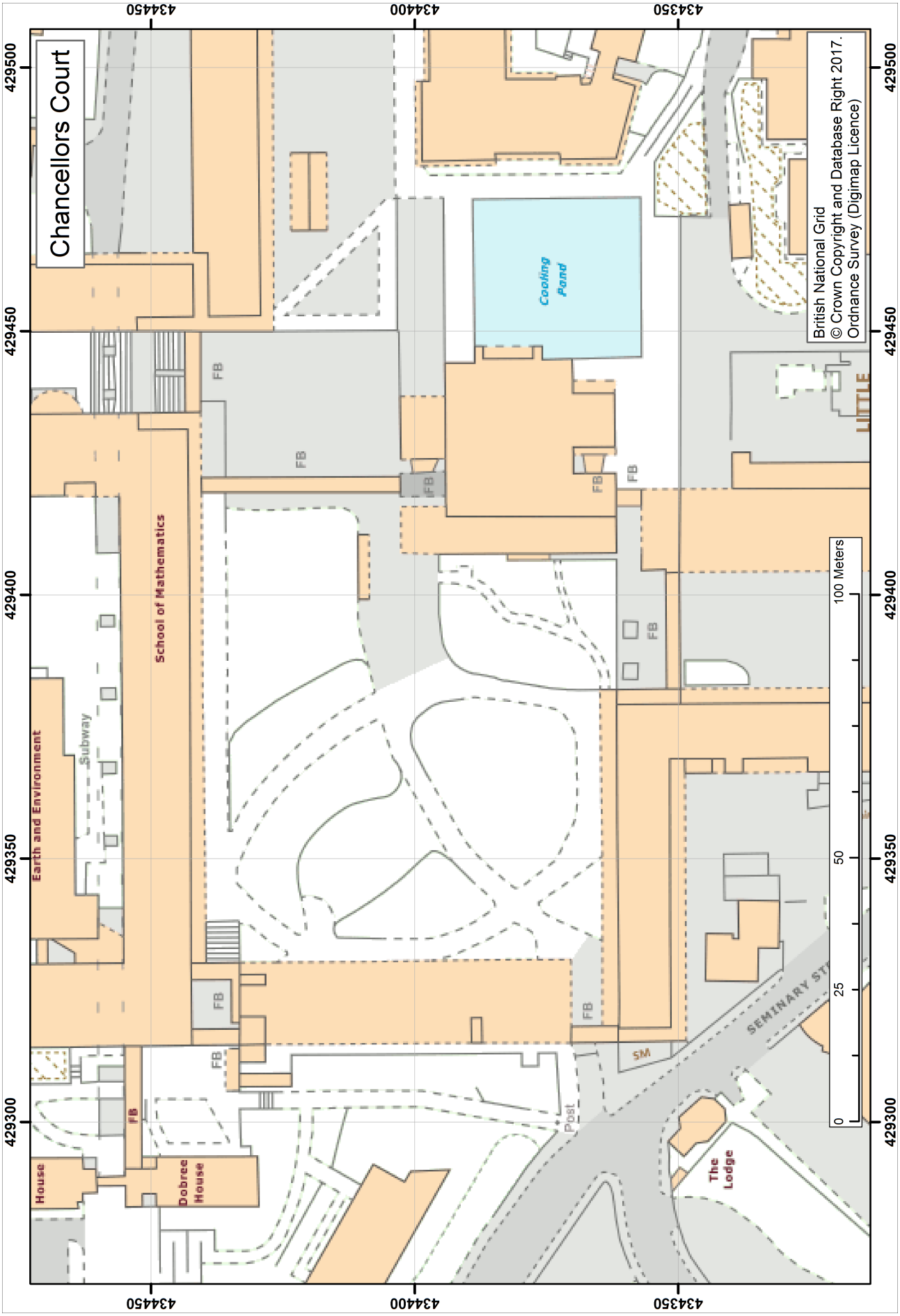


Figure A.18: Field slip for Chancellors Court

Appendix B

Changing Leeds method strike and dip to the Right Hand Rule for GIS

The information in this appendix was provided by Ph.D. student Josh Wolstenholme, to whom many thanks.

Remember that you can also add strike and dip measurements to your map by digitising the points directly from your fieldslip. You do not have to add them via a spreadsheet.

B.1 Introduction

The right hand rule (RHR) is a notation for geological measurements adopted by some of the geological world, including software such as ArcGIS and Stereonet 9. The right hand rule essentially states that the 'dip tick' (using bedding strike and dip as an example) must always be on the right of the strike line as in figure B.1.

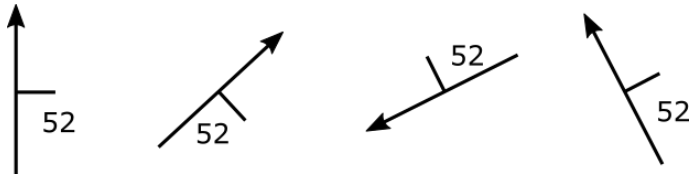


Figure B.1: Right hand rule vs Leeds Notation

In figure B.1, an indicator arrow has been placed along the strike as a reference to keep the dip on the right hand side of the strike. You may find it easier to comprehend by drawing a strike and dip on a piece of paper and rotating it yourself. This helps to visualise what is happening.

B.2 Data preparation in Excel

When importing any data into Excel it is always a good idea to make it clear what each row/-column represents. For example, when working with large datasets it's worthwhile adding in a 'Type' column alongside a unique 'ID' and any 'Notes' you may have. This is helpful when referring back to data and when importing it into software such as ArcGIS and Stereonet 9.

a		b		c		d	
Leeds	**RHR**	**Leeds**	**RHR**	**Leeds**	**RHR**	**Leeds**	**RHR**
000/52E	000/52	048/52SE	048/52	063/52NW	243/52	153/52NE	333/52

B.2.1 Converting dip direction into RHR

Essentially if your dip direction is between just above west (271°) and just below east (089°) you will need to create a new strike. If you refer back to figure B.1, measurements a and b have a dip direction between 090° and 270°; whereas c and d are between 271° and 089°.

In Excel, a simple (but complex looking!) formula can calculate this all for you. It utilises the operators `=IF` and `=OR` [1] to determine whether your measurement needs converting or not. **N.B. It is always worth double checking your measurements are displaying how you would expect them to.**

The formula we will use is as follows (note code should all be on one line):

```
=IF(OR([@[Dip Direction]]="
    N",[@[Dip Direction]]="NE",[@[Dip Direction]]="NW",[@[Dip Direction]]="NNE",[@[Dip
    Direction]]="NNW",[@[Dip Direction]]="E"),[@[Strike/Azimuth]]+180,[@[Strike/Azimuth]])
```

This essentially states that if any of the values within the Dip Direction column are equal to any of the following: "N","NE","NW","NNE","NNW","E" there will be 180° added to the Strike/Azimuth in a new cell. If condition is not met (i.e. Dip Direction does not equal any of the aforementioned), then the original strike is preserved and placed in a new cell. An alternative way of doing this is to use an actual dip direction in degrees. This is more accurate and a quicker formula to write, however requires more data collection or processing:

```
=IF(OR([@[Dip
     Direction]]>270,[@[Dip Direction]]<90),[@[Strike/Azimuth]]+180,[@[Strike/Azimuth]])
```

This takes the reading from the Dip Direction column (i.e. the direction the dip is pointing), and tests if it is either >270 (North West → North) or <90 (North East). If so, 180° is added to the Strike/Azimuth in a new cell. If condition is not met then the original strike is preserved and placed in a new cell.

N.B. The `[@[Name]]` notation refers to a column within a formatted table. It is perfectly fine to use an individual cell reference such as `G38` (for example).

B.3 Excel document with examples

There is an associated Excel document with this workflow, which makes use of the first example of code with arbitrary data which can be found at this link:

`http://homepages.see.leeds.ac.uk/~earcej/downloads/RHR_Example.xlsx`

[1] see `https://support.office.com/en-gb/article/if-function-69aed7c9-4e8a-4755-a9bc-aa8bbff73be2` and `https://support.office.com/en-us/article/or-function-7d17ad14-8700-4281-b308-00b131e22af0` for more information respectively

Appendix C

GIS: Bibliography

GIS basics

Heywood, I., Cornelius, S. & Carver, S. (2011) *An Introduction to Geographical Information Systems.* 4th ed. Harlow, Essex, Prentice Hall. (available online)

A good general guide which isn't tied to one particular GIS application. Data for these exercises is available on the book's website and there are also questions to test your understanding.

Longley, P.A. et al. (2015) *Geographic Information Science & Systems*, 4th ed. Chichester: Wiley. (Available online)

Another useful general book about GIS.

Chang, K. (2016) *Introduction to Geographic Information Systems*, New York, USA: McGrawHill, 8th edition.

General book that goes into more detail than some of the others. Sets tasks which run in ArcGIS.

Kennedy, M. (2013) *Introducing Geographic Information Systems with ArcGIS*. 3rd ed. New Jersey, Wiley. (available online)

A detailed work book rather than a straightforward reference guide - intended to be a complete course. Useful if you want to get more involved in GIS.

Newsletters

ArcUser - `https://www.esri.com/about/newsroom/arcuser/`

Freely accessible on-line magazine from ESRI with articles and examples on how to use ArcGIS.

ArcNews - `https://www.esri.com/about/newsroom/arcnews/`

Freely accessible on-line magazine. Lots of technical articles giving real-world examples of the use of ArcGIS.

Journals

I haven't listed specific articles here, but all of the following journals are available online through the University Library and if you browse the latest articles in any of them you will see how GIS is being used by scientists in a range of disciplines. These are just suggestions, there are plenty of other GIS and cartography journals out there, and plenty of GIS-related articles in discipline-specific journals.

- Cartography and geographic information science
- GIScience & Remote Sensing
- International Journal of Digital Earth

GIS for geology and environmental science

Note that some of these books will also include useful basic information about GIS in general.

Tian, Bai. (2016) *GIS Technology Applications in Environmental and Earth Sciences*, Boca Raton, Fla: CRC Press.

Available online via the University Library. Includes lots of relevant case-studies and examples of how environmental and earth scientists can use GIS.

Scally, R. (2006) *GIS for Environmental Management*, Redlands, California: ESRI Press.

A book of case-studies, e.g. wetland preservation; habitat conservation; reclaiming industrial land.

ESRI (2011) ESRI Conservation Map Book `http://www.esri.com/library/books/conservation_mapbook.pdf` (Last viewed: 20th July 2016)

Another book of case-studies and example maps.

Brimicombe, A. (2010) *GIS, environmental modeling and engineering*, Boca Raton, Fla; London: CRC Press. 2nd edition. (available online)

Uses environmental examples. Shows in detail the process of planning a project as well as basic information about GIS.

Bonham-Carter, G. (1994) *Geographic Information Systems for Geoscientists: Modelling with GIS*. New York, Pergamon.

Uses geological examples but plenty of ideas on how GIS can be used in a scientific context. Probably too much detail but gives an impression of what is possible!

Bettinger, P. and Wing, M.G. (2004) *Geographic Information Systems: Applications in Forestry and Natural Resources Management*, New York, USA: McGrawHill Higher Education.

Basic GIS techniques and information applied to a specific area.

Most articles demonstrating the use of GIS are in other subject-specific journals rather than specific GIS journals. Try searching Scopus (`http://search.library.leeds.ac.uk/iii/encore/record/C__Rb3205248`) or Web of Knowledge (`http://search.library.leeds.ac.uk/iii/encore/record/C__Re1000528`) using the keyword **GIS** and other keywords for your specific interest.

Layout and presentation: or How to draw a better map!

As well as the technical skills involved in creating a map you should have some awareness of the principles necessary to produce a map that communicates information to your viewers in the best way possible, otherwise known as cartography. The references below will give you some ideas to start you off.

Darkes, G. & Spence, M. (2017) *Cartography: an introduction.* 2nd edition. London, The British Cartographic Society.

Short guide to basic principles. Available from the British Cartographic Society at `http://www.cartography.org.uk/product/cartography-an-introduction-second-edition-2017/` for £12.99 (plus £2 postage). (Last viewed: 24th January 2018).

Frye, C. (2001) Making maps that communicate. *ArcUser*, (October - December), pp.38-43.

A brief but useful guide to how to communicate with maps. Well worth a look if you want to pick up some ideas quickly. Available on-line at `http://www.esri.com/news/arcuser/1001/files/bettermaps.pdf`. (Last viewed: 15th January 2015)

Peterson, Gretchen N. (2009) *GIS cartography: a guide to effective map design*, Boca Raton, Fla. : CRC Press. (available online)

More detailed guide to cartography and design which is very accessibly written. Possible to download pdf of the book and keep it handy for reference.

Brewer, Cynthia A. (2016) *Designing better maps: a guide for GIS users*, Woodlands, California: ESRI Press. 2nd edition.

The classic book on cartography for GIS. A lot of information but very clearly presented.

Brewer, Cynthia A. (2008) *Designed maps: a sourcebook for GIS users*, Woodlands, California: ESRI Press.

Lots of examples of maps with comments about how they were designed.

ESRI Map Book Gallery at `http://www.esri.com/mapmuseum` (Last viewed: August 2019)

Examples of maps produced with ArcGIS - from volume 28 Transforming Our World, the books are fully available on-line. Have a browse and see examples of maps that ESRI considers are “best practice”. If you would rather have a look at a printed copy I have some editions in my office, just come and ask.

ESRI UK has an online showcase of “Maps we love” at `http://www.esriuk.com/products/maps-we-love` where they also suggest the steps to reproduce some of the maps.

Coordinate Systems and Projections

Maher, M.M. (2013) *Lining up data in ArcGIS: A guide to map projections*. 2nd ed. Redlands, California: ESRI Press.

A practical guide to coordinate systems and projections in ArcGIS. As well as background information it gives step-by-step instructions for how to identify unknown coordinate systems and how to solve problems in Arc. In addition to the copies in the Edward Boyle Library there is a copy of the first edition available for reference in room 10.140b in SEE. See Clare Gordon if you wish to consult it.

Snyder, J.P. (1983) *Map projections used by the U.S. Geological Survey*. U.S. Geological Survey Bulletin 1532, Washington D.C., U.S.A.; U.S.G.S. 2nd edition. Available online from: `http://pubs.er.usgs.gov/publication/pp1395`

A classic! Anyone who works regularly with map projections will know this book. Detailed, but has useful information about map projections in general; the terminology; and specific map projections.

Monmonier, Mark. (2004) *Rhumb lines and map wars: A social history of the Mercator Projection*, Chicago; London: The University of Chicago Press.

A readable look at map projections taking the "war" between the Mercator and Peters projections as a starting point.

Raster surface models and 3D Analyst

Kennedy, K.H. (2010) *Introduction to 3D data : modeling with ArcGIS 3D Analyst and Google Earth*, Hoboken, N.J. : Wiley. (available online)

Clear information on the use of ArcGIS and Google Earth for exploring data in 3D. A how-to guide.

Appendix D

GIS: Further information and help

D.1 Digimap

See the section at the end of the Digimap workbook.

D.2 ArcGIS

D.2.1 ArcGIS Desktop Help

The help provided with ArcGIS is very extensive and also includes in-depth tutorials. If you are wondering how to do anything - look here first!

From within any ArcGIS application just press **F1** or **Help** >> **ArcGIS Desktop Help On-line**

Alternatively, to access help on the web go directly to

http://desktop.arcgis.com/en/arcmap/

D.3 GIS in general

D.3.1 ESRI

ESRI (the producers of ArcGIS) provide gis.com, a site with lots of general information about GIS. Look particularly at "What is gis?" which doesn't just tell you what it is, but also why you should use it and what you can do with it.

http://www.gis.com/whatisgis/index.html

D.3.2 Ordnance Survey: GIS files

The Ordnance Survey GIS files provide a guide to GIS concepts and how the O.S. uses the technology.

http://www.ordnancesurvey.co.uk/oswebsite/gisfiles/

D.4 Map Projections and Coordinate Systems

D.4.1 Ordnance Survey and British National Grid

The O.S. provides an on-line guide to coordinate systems in Great Britain which includes information on how to change from one to another.

http://www.ordnancesurvey.co.uk/oswebsite/gps/information/coordinatesystemsinfo/

D.4.2 General information from ESRI

ArcGIS Desktop Help gives general information about map projections and coordinate systems starting from basics.

http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/What_are_map_projections/003r00000001000000/

D.5 GPS

D.5.1 Garmin: basic information

If you are new to GPS and would like to find out more, Garmin have a beginners guide which you can download from http://www8.garmin.com/aboutGPS/manual.html. There is also information on how to use a GPS to complement paper mapping and potential problems. The same page includes a general guide to using a Garmin GPS unit.

D.6 Google Earth

The Google Earth user guide is available on-line and gives information on many of the advanced features as well as the basic information such as how to navigate. Instructions include using image overlays and drawing lines, points and polygons.

http://www.google.co.uk/intl/en_uk/earth/learn/

Appendix E

Answers to questions in text

These are suggested answers to the questions asked in the text. Check your answers against them but be aware that in many cases there is more than one correct answer. If you don't understand why a particular answer has been given please ask module staff or demonstrators for more information.

Chapter 1: Introduction to ArcMap

Question 1.1: Try out each tool in the tools toolbar in turn and see what it does.

Tool	What it does
Zoom in	*Moves the view closer in to the map so that you are viewing a smaller area in more detail*
Zoom out	*Moves the view out from the map so that you are viewing a larger area in less detail*
Full extent	*Zooms right out so that all of the data in your map is visible.*
Zoom to layer (this one isn't on the tools toolbar. Right-click on the title of a layer in the table of contents zoom to layer)	*Zooms to the extent of the data in the layer you clicked on*
Pan	*Move the area of the map that you are viewing by dragging it*
Select features	*Select particular features, or items from the selected layer*
Identify	*Find out more information about the features at a particular point on the map*
Find (try searching for **Cutting** in the **Feature** tab. Once you have a result, right-click a record and have a go with the commands from the menu, e.g. **Flash**)	*Search for features that match a particular term and view the features in the map*

Question 1.2: How has the bookmark affected the scale of the map?

The scale should have returned to the scale that had been set when you created the bookmark.

Question 1.3: What are the names of the other layers in the Malham map?

*The other layers are **Fossil band; Mineral vein; Faults**.*

Question 1.4: What are the map units of the current map?

The map units should be set to meters[1]

Question 1.5: What is the difference between zooming with the tools in the layout toolbar and with the tools in the tools toolbar in layout view?

You should find that the zoom on the layout toolbar changes the zoom of the layout so that you are zooming on the "sheet of paper", while the zoom on the tools toolbar changes the zoom level of the map itself without changing the size of the paper.

Chapter 2: Introduction to the Catalog

Question 2.1: What is the main difference between the contents of the shapefiles folder in the catalog window in Arc, and the contents of the same folder in My Computer?

The main difference should be that in Arc you can only see one version of the study-area file and that has a file extension of .shp. In My Computer there are multiple versions of each file with different file extensions.

These are examples of shapefiles. A specifically GIS format which can be read by many different GIS programs.

Question 2.2: What is the main difference between the contents of the Malham.mdb folder in the catalog window in Arc, and the same file in My Computer?

The main difference should be that you can clearly see your individual layers in the Catalog view, but in My Computer the file opens in Microsoft Access and looks rather different. Just close Access and don't make any changes to the file.

Question 2.3: What are the coordinate details for the Great Scar Limestone layer?

Your answers should be similar to the below:

Current coordinate system: British National Grid

Projection: Transverse Mercator

Linear unit: Meter (1.0)

Chapter 3: ArcGIS Desktop Help

Question 3.1: A possible definition of raster format.

A file format consisting of cells of data with each cell defined by x and y coordinates.

Question 3.2: A possible definition of vector format.

A file format consisting of paths and points which are located by x and y coordinates, and which can be joined to create lines and polygons.

Question 3.3: What is the name of the bridge at GR 391052 463529?

The bridge is Goredale Bridge

[1] The spelling of words such as metres and colour are Americanised in Arc.

Chapter 4: Digimap

Question 4.1: What view does Roam take you to when you click on "Find"?

Street View - look in the bottom right of the map view to see which view you are looking at.

Question 4.2: Name some other view and basemap combinations besides **Neighbourhood** >> **VML Streetview** that allow you to select content?

Possible combinations include the following:

- Street >> Vector Map Local
- Street >> VML Plan
- Detailed >> Full Colour
- District >> Mid-scale (2016)
- City >> Strategi (2016)

There are other combinations which also allow you select. Note that none of the basemaps marked as Raster allow you to select, neither do the most zoomed out Views.

Question 4.2: Use the Measure Distance tool to measure your route to the University. How far away do you live?

Of course, I can't tell you the answer to this one. Make sure that you include the units of the measurement in your answer - which should be either metres or kilometres.

Question 4.4: What is the area of Woodhouse Cemetery?

The area is approximately 36450 m^2

Question 4.5: What is the bedrock geology underneath the School of Earth and Environment?.

You'll probably need to click on the Bedrock tab to see that the bedrock unit is Pennine Lower Coal Measures Formation, and the rock type is Mudstone, Siltstone and Sandstone. The Age is listed as Langsettian Sub-Age.

Question 4.6: What is the Tile Name for 1:50 000 data at this location?

Once you've zoomed out a fair way, you should be able to see that Malham Cove is covered by a tile called "EW060". This means that it is covered by the map sheet for England and Wales with the number 60 - which matches the paper maps produced by the British Geological Survey.

Question 4.7: What is the Tile Name at this location, and on what date was the aerial imagery at this location flown? As a bonus, what town is this point within?

*This point is in Aviemore (switch on Overlays - Road/Place Names to be able to see this) and the Tile Name is **nh8912**. The date that the imagery was obtained was **2015-10-01** (as of 1st August 2018).*

Chapter 5: Creating a topographic base map

Question 5.1: If the coordinate system has been set - what is the name of it?

The coordinate system should be British_National_Grid - the coordinate system of the first layer that you added to a blank map, which in this case should have been the contours. If it isn't set, don't worry, just continue with the next section.

Question 5.2: What happens to the size of the labels that you have just created when you zoom in very close or zoom out?

The labels should stay the same size on the screen, so if you are zoomed in close they are small compared to the rest of the map. If you zoom out they will be large compared with the rest of the map.

Question 5.3: What happens to the size of the labels now that a reference scale has been set?

The labels should stay the same size relative to the rest of the map. So when you zoom in close they look very large, but when you zoom out they look smaller.

Chapter 7: Getting ready to create data in ArcGIS

Question 7.1: Draw a tree for the structure of your geodatabase.

To a large extent the structure of your geodatabase is up to you, though for this exercise I'll suggest one so that you can have a go with several techniques. Make sure that you include the following layers in your plan, but then arrange them as you think may be helpful.

- Polygons
  - Carboniferous limestone
  - Carboniferous sandstone
  - Ordovician limestone
  - sandstone
  - siltstone
- Lines
  - Fault - inferred
  - Fold - anticline
  - Fold - syncline
  - Geological boundary
- Points
  - Bedding - inclined, overturned and vertical
  - Quaternary symbols - alluvium, moraine and till

Chapter 8: Digitising in ArcMap

Question 8.1: Starting from a grid reference **NG 344 576** what will be the grid coordinates with NG converted to figures?

The grid coordinates will be 1344 8576

Question 8.2: Starting with grid coordinates **5433 2433** what will be the grid reference with the figures converted to letters?

The grid reference will be TL 433 433

Chapter A: Creating data for GIS: Point data and GPS

Question A.1: What happens to the size of the symbols when you zoom in to 1:500 and then out to 1:25 000?

You should be able to see that the text and symbols stay the same size on the screen, which means as you zoom out they look larger in comparison to the rest of the map. This means that at a smaller scale the symbols overlap.

Question A.2: Once you've set a data frame reference scale, what happens to the size of the symbols when you zoom in to 1:500 and then out to 1:25 000?

This time you should be able to see that the text and symbols become larger or smaller on the screen depending on the zoom, but they remain in the same proportion to each other - and don't overlap more at a smaller scale than they do at a larger.

Question A.3: How accurate do you think the locations of the points are? What problems can you spot based on your memory of collecting the data? How do you think that you could increase the accuracy of data input?

Your results may be very different to mine, but based on the readings that I took I would say that the accuracy is variable. The data sheet should enable you to quantify this for each point. In relation to the base imagery my points vary between very accurate and up to a couple of meters away.

Ways to increase accuracy include using GPS in areas with a clear view of the sky, so away from buildings, trees, mountains, etc. Turn on your GPS well before you start to use it and give it plenty of time to connect to multiple satellites. Read the instructions for your GPS! Some models have additional ways of increasing accuracy.

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