A ‘simple’ guide to ArcGIS map drawing

The aim of this text is to give geology students *just enough* information to be able to create a basic geological map in ESRI *ArcMap (part of ArcGIS 10)*.

Only those functions directly related to this task are shown here. These are mostly the functions I actually used when drawing a map - *www.univie.ac.at/ajes/archive/volume_105_3/rice_et_al_kea_map_A1_hilshade_version_ajes_105_3.pdf*. Like other programs, there are *very* many more specialised functions available, but these are not required to produce a basic geological map.

Possibly some of the ways I have described to do things are not the ‘best’ or the simplest way. But they worked for me. If you have a better suggestion, tell me. Further, some of the methods described here may not work for older (or newer) versions of ArcGIS.

If you cannot find in the text a description of how something is done, particularly if *ArcMap* opens a window with a statement or request you do not understand, use the ‘Find’ option in Word.

The description given here is based on drawing a map of the island of Kythnos, in the Western Cyclades of Greece; hence all files names etc. are based on Kythnos. For your own work, you have to find your own file names.

In this description;

- the ***Project Folder*** is the folder you make in Windows Explorer (or equivalent program) in which *all* the data used and produced in *ArcMap* are saved. Include the date in the title so you know how old the backup file is;
- the ***ArcMap* display** is the area of the screen in *ArcMap* where you draw the map (between the *Table of Contents* and *Catalog*);
- the ***Command Bar*** is the line with *File, Edit, Bookmarks, Insert, Selection…Help* across the top of *ArcMap*. To the right there may be some *Toolbars* open (shown by four vertically aligned darker grey dots at their left end;
- the ***Toolbars*** are the rows of symbols under and to the right of the *Command Bar* in *ArcMap*. Here you should have the *Standard, Tools* and *Editor Toolbars* open. See Section 14 for checking which *Toolbars* are open;
- a ***Feature*** in *ArcMap* is something you have drawn, such as the coastline (or part of it if you draw it in several parts), a road, the shape of a rock unit. There are four classes of *Features (Feature Classes)*: *Points, Polylines (Lines), Polygons* and *Annotations* (i.e. text);
- a ***Shapefile*** is where *Features* with the same format (line width, colour, style, font size etc.) are created;
- a ***Layer*** is a where a *Shapefile* or a satellite image (etc.) is stored. These are listed in the *Table of Contents*.

- the → symbol is used to indicate the options you should select in a sequence of opening windows that are not specifically named (e.g. *Spatial Reference Properties → Edit → Select → Projected Coordinate System).*

I use a left hand mouse, so left click and right click are the other ways around for me. I have tried to write the text as if I were using a right hand mouse, but may have made mistakes. If the text has left click and it doesn’t work, try right click and vice-versa. If you find an error, tell me.

Note that when something is done in *ArcMap*, such as creating a *Layer*, or making a modified version of a satellite image (etc.), several associated files are created in the *Project Folder* (or in a sub-folder) in Windows Explorer, but these are NOT displayed in the list of files in *Catalog*, in *ArcMap*. It is important, therefore, to keep each set of files separate. Hence when georeferencing a map or satellite image or a DEM, keep each version, with all its associated files, either in a separate sub-folder in the *Project Folder* or give them clearly distinct names that indicate what they are (like Kythnos_satimage_raw, Kythnos_satimage_georefd etc.). This enables all parts of unwanted files to be deleted fully, rather than leaving bits of them to clutter up the *Project Folder* and confuse you. However, do not delete files in the *Project Folder* unless you really know what you are doing!

Make a back-up of the *Project Folder* regularly, with the date in the name.

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(01) Getting started in Windows Explorer (the *Project Folder*) and *ArcMap*

01.01. Open a folder in Windows Explorer (or equivalent program) for the project; here, I call this the *Project Folder* - e.g. Kythnos_map_2014_05_05. The date tells you how old your back-up copy is; do a back-up regularly). Eventually, all files with data that are displayed on the map should be in this one folder (or in sub-folders), such as structural data files, sample locations files, metamorphic PT data files, isotopic data files etc. This makes it very simple to copy the complete map (the *Project folder*) from one computer to another.

01.02. Now open the *ArcMap* program. When open, close the *Getting Started* window.

01.03. Then, in the *Command Bar*, select *File* → *New*. The *New Document* window will open.

01.04. In the *New Document* window, select *Blank Map*, then *OK*.

01.05. There should be a range of symbols across the top of the *Arc Map* display. These are the default *Toolbars*; you should have the *Editor*, *Standard* and *Tools Toolbars* open. The name of the *Toolbar* is sometimes given at its left end. Do *Command Bar* → *Customize* → *Toolbars* to open the complete list of *Toolbars* available. Those ticked are already open; tick any of the above given three *Toolbars* that are not already ticked. If other *Toolbars* are open, close them until needed.

01.06. To ensure that all the *Extensions* are open in *ArcMap*, go to *Command Bar* → *Customize* → *Extensions*. This will open the *Extensions* window. Check that all boxes (all *Extensions*) are selected in the list given. Then *Close*.

(02) The *Catalog* window in *ArcMap*

02.01. If there is a window called *Catalog* on the right side of the *ArcMap* display, then read this section, but nothing needs doing. If there is a *Catalog* window floating in the *ArcMap* display, start at 02.03. Otherwise, start at 02.02.

02.02. There are four symbols in the *Standard Toolbar* that look like small computer screens. Click on the one called *Catalog window*. (It looks like it has a pile of gold coins on the right side.)

02.03. The *Catalog* window will open. Left click and hold on the blue bar at the top of this window and move the window. Four blue symbols with white arrows will appear, one at each edge of the screen. Drag the *Catalog* window until the mouse lies over the blue symbol on the right side. Let go of the mouse and the *Catalog* window will attach itself to the right side of the screen. Make the *Catalog* window narrower by clicking and moving the left side. The *Catalog* window may attach itself directly to the left side of the *ArcMap* display when you open it.

02.04. By dragging the thin blue band at the top of *Catalog* to the left, you can make it into a floating window. To replace it, drag it again so that the four blue symbols reappear in the *ArcMap* display and move it to where you want it.

02.05. By clicking the *Auto Hide* symbol (the pin symbol) at the top right of *Catalog*, you can hide the *Catalog* window on the far right side of the screen. To reopen *Catalog*, drag the small, vertically oriented *Catalog* symbol to the left. But when you start drawing again, the *Catalog* window will hide itself again. To keep the *Catalog* window open, click on *Auto Hide* and the pin will rotate from horizontal to vertical; *Catalog* is then pinned in the open position. *Catalog* cannot be made to float when the *Auto Hide* pin is horizontal.

02.06. Use the cross symbol at the top right of *Catalog* to close it altogether. It can be reopened as described in Section 02.02.

02.07. Once *Catalog* is set up, note the *Home - Documents\ArcGIS* folder at the top of *Catalog*; this has a range of folders in it (*AddIn, Packages, Default, Toolbox*, maybe more, or less).

02.08. Now save the project. *Command Bar* → *File* → *Save As*. In the *Save As* window, browse for the *Project Folder*, give the project a *File name* (Kythnos_map) and *Save as Type* → *ArcMap Document* (the only option; this is an *.mxd* file).

02.09. This *Project Folder* will then appear at the top of *Catalog*, as *Home-Kythnos_map*. Essentially this is a shortcut to the *Project Folder*; you can also browse to the folder if you want to, by using the *Folder Connections* folder. Essentially you 'work' with the *Home* folder; it is there every time you open the project.

02.10. F5 is used to refresh *Catalog* (such as after a new folder is added to the *Project Folder* in Windows Explorer).

(03) The *Table of Contents* window in *ArcMap*

03.01. The *Table of Contents* window should be present on the left side of the *ArcMap* display when you open *ArcMap*. If it is not, then select the *Table of Contents window* option from the symbols in the *Standard Toolbar*; it is one of the symbols looking like a computer screen, near the *Catalog window* symbol.

03.02. When the *Table of Contents* window opens, it may attach itself directly to the left side of the *ArcMap* display. If it does not, drag it across there, just as the *Catalog* window was dragged to the right side of the *ArcMap* display. You have the same options for the *Table of Contents* window as with *Catalog* (floating window, *Auto Hide* to the right side or closed).

03.03. There are five symbols at the top of the *Table of Contents* window; four of these list the contents in *ArcMap* in different ways. These five symbols are described here from left to right:

03.04. 1. *List by Drawing Order.* This tells you what is drawn on top of what. So likely you want everything above the satellite image. And structural symbols, for example, above the different rock types. This very simple view of the contents is useful for sorting the information you have created in your map, before printing it. Left click on a *Layer* and drag it up or down the list to change its relative printing position.

03.05. In the *List by Drawing Order* you can click *Layers* on and off, with the ticks. This makes them *Visible/Not Visible*. This is useful if you have a lot of material on the map, but only want to see a few items, to correct or improve or add something; make the unwanted *Layers Not Visible*.

03.06. 2. *List by Source.* This just gives the link back to where the data is kept in the *Project Folder*. You can change the *Visibilty* here also.

03.07. 3. *List by Visibility.* This just shows which layers are *Visible* and which *Not Visible*. This can be useful. You cannot change the *Visibility* here.

03.08. 4. *List by Selection.* Here you can make *Layers Selectable*, so that you can add to or modify them, or *Not-selectable*, so that they cannot be modified. It is best to keep everything in the *Not Selectable* mode except the *Feature(s)* that you are actively working on. This prevents

Features from being accidently moved etc. Very useful, believe me! *Not Selectable Layers* can still be *Visible* or *Not Visible*, as you wish.

03.09. 5. *Table of Contents Options*. If the above are not as described above, then maybe the options here have been changed.

(04) Creating a *Geodatabase (.gdb)*

04.01. A *Geodatabase (.gdb)* is required for some of the operations you do in *ArcGIS* (such as converting *Polylines (Lines)* to *Polygons*, creating a DEM from contours). Some workers prefer to do all the work in *Geodatabases*, and hence have more than one. However, for producing a basic geological map (like the Kea map described in the introduction), only one *Geodatabase* is required.

04.02. In *Catalog*, right click on *Home-Kythnos_map* → *New* → *File Geodatabase*. It will immediately appear in *Home-Kythnos_map*. Change the name to what you want (Kythnos_database). That is all.

04.03. If you change the name of the *Geodatabase*, you may find that the *.mxd* file (the *ArcMap* file) has lost the connection to the data. This can be seen by the red ? symbols in the *Table of Contents* → *List by Drawing Order*. To regain the link, see Section 37.

(05) *Data View* and *Layout View* in the *ArcMap* display

05.01. The *ArcMap* display can be set to two different modes; *Data View* and *Layout View*. These are selected the bottom left of the *ArcMap* display, where there are four symbols; *Data View, Layout View; Refresh; Pause Drawing*.

05.02. *Data View* is used during drawing of the map; enlargement of the (satellite) image does not result in *Features* (like fold axis symbols) becoming larger and *Polylines* do not become thicker. *Data View* is, therefore, not useful in seeing how good the map will look when printed. Details of how to use *Data View* are given in Section 12.

05.03. *Layout View* shows how the map will appear when printed; *Polylines* get thicker and symbols larger when the (satellite) image is enlarged. Further, the *North arrow*, *Scale Bar*, *Legend*, Text and a *Grid* etc. can all be added in *Layout View* (these are not shown in *Data View*, even after they have been constructed in *Layout View). Layout View*, is, therefore, more useful towards the end of the project. Details of how to use *Layout View* are given in Section 31.

(06) Setting the projection and coordinate system of *Layers* in the *Table of Contents*

06.01. In *Table of Contents* → *List by Viewing Order* there is a symbol called ***Layers*** (at the top). All the data you import or create will be stored in a specific *Layer* within this overall list of *Layers*, so the list needs to be in the correct projection and coordinate system.

06.02. Right click on *Layers* → *Properties.* This opens the *Data Frame Properties* window.

06.03. Select *Coordinate System* in the *Data Frame Properties* window. In the *Select a coordinate system* box, look in *Favourites* to see if the one you want is listed.

06.04. If it is not listed, open *Predefined* and select the required system (*Projected Coord. System* → *UTM* → *WGS84* → *N Hemisphere* → *WGS 1984 UTM Zone 35N*, if working on Kythnos).

06.05. Then *Apply* and *OK* to finish.

(07) Importing a (satellite) image or map and giving it the right projection and coordinate system

07.01. Create a folder in the *Project Folder* in Windows Explorer called (for example) Kythnos_satellite_image. Copy the required satellite image or base map (e.g. 'Kythnos_stitched_whole_island') into this folder.

07.02. In *ArcMap*, update *Catalog* using F5.

07.03. Open the folder in *Catalog* with the satellite image. The file will be listed there as a *Raster Dataset*. Left click on this and it expands to show it has three *Bands* (R, G & B, I presume, since later is has these in the *Table of Contents*.)

07.04. Left click on the image file in *Catalog* → *Properties*. This opens the *Raster Dataset Properties* window.

07.05. In the *Raster Dataset Properties* window, you have to select the projection and coordinate system of the map as you have it in the *Project folder*, i.e. as you obtained it. If this is not be the projection and coordinate system you are using for the map you are drawing, you have to change (*Transform*) these when you move the map from *Catalog* to the *Table of Contents* (see Section 11). If you have bought the satellite image commercially, it may be georeferenced already, but if you are downloading it from the internet, likely it will not be georeferenced, but the projection system should be given somewhere in the site. In such a case, you can input the known projection system and give the desired coordinate system. In the *Raster Dataset Properties* window, scroll down to *Spatial Reference Properties* → *Edit* → *Select*…. (For Kythnos, this is *Select* → *Projected Coord System* → *UTM* → *WGS1984* → *Northern Hemisphere* → *WGS 1984 UTM Zone 35N*; otherwise whatever projection and coordinate system you want to use.)

07.06. *Apply* → *OK*. Then *OK* in the *Raster Dataset Properties* window.

07.07. Left click on the satellite image file and drag it across to the *Table of Contents* window. (If the *Table of Contents* window is not present, see Section 03.) Do not worry if a circle with a line across comes up whilst the mouse is in *Catalog*; keep on dragging.

07.08. Choose *Yes* in the *Create Pyramids* window that may open if the satellite image is large.

07.09. In the *Table of Contents*, open the *Layer* with the satellite image file; note it has three layers, R, G & B.

07.10. Right click on the satellite image *Layer* in the *Table of Contents* → *Properties*. This opens the *Layer Properties* window.

07.11. In the *Layer Properties* window, select *Source* → *Set Data Source*. Browse to the image and then *Add*.

07.12. In the *Layer Properties* window, *Apply*, then *OK*.

07.13. **NOW SAVE THE *ArcMap* FILE. *DO THIS REGULARLY!***

(08) Georeferencing the map or (satellite) image

08.01. If the (satellite) image is not automatically georeferenced, then somehow (you can use Google Earth) you have to get the known coordinates of several (at least 10, but more is better) points distributed across all parts your map in the coordinate system you want to use in *ArcMap*. In particular, get data from the most northerly, southerly, easterly and westerly points of the area and somewhere in the middle. With Google Earth, you can save close-up images with a pin in the selected point, for later use. If you have a good quality topographic map you can use the information from the grid lines.

08.02. Go to *Command Bar* → *Customize* → *Toolbars.* Select *Georeferencing*. This opens the *Georeferencing Toolbar*.

08.03. Zoom in to a point for which the coordinates are known on the map/image to be georeferenced. (To zoom in, use the magnifying glass with a cross in the *Tools Toolbar* to drag out the area of interest; use the globe symbol to zoom out fully; more details on zooming and moving about the image are given in Section 12)

08.04. In the *Georeferencing Toolbar*, click on the tool with a green cross linked to a red cross. This is the *Add Control Points* tool.

08.05. Left click with the mouse to make a green cross as EXACTLY as possible on the point for which the coordinates are known; left click again to make a red cross at essentially the same place (this one can be anywhere, really).

08.06. In the *Georeferencing Toolbar*, click the *View Link Table* symbol (this looks like a small table with red and green dots); this opens the *Link Table* window.

08.07. In the *Link Table*, the *X source* and *Y source* are the present coordinate positions of the satellite image (the green cross; it doesn't matter what the numbers are for the first position). In *X map* and *Y map* (the red cross) delete the existing data and input the correct, known coordinates for that position - from, for example, your Google Earth data.

08.08. The satellite image will move so that the selected point lies at the input *X map* and *Y map* position. As no other points have been georeferenced for the satellite image, the whole image will move at the same scale and orientation and may disappear from the area covered by the *ArcMap* display on your monitor screen.

08.09. In the *Table of Contents*, right click on the satellite image *Layer* and select *Zoom to Layer*. The *ArcMap* display will now cover the area of the satellite image. Or just click on the *Full Extent* symbol (the globe) in the *Tools Toolbar*.

08.10. Repeat sections 08.03 to 08.07 for all the points for which coordinates are known. Gradually the satellite image will change into the correct shape/position.

08.11. Do *at least* 10 points. The more the better. For the *Total RMS Error* in the *Link Table* window, a rule of thumb (which is dodgy) says "RMS error should be less than or equal to 1/2 of the side of a cell which make up the total resolution of the image". So it depends on the resolution of your image. I have been told that the *Total RMS Error* should be < 10 for the georeferencing to be generally acceptable.

08.12. In the *Link Table* window, select *Save*. Browse for the place to save the *Link Table* (i.e. the georeferencing data table; save in the folder where the satellite image .tiff file is), give the *Link Table* a name and save it. You can then re-import the original .tiff file and use the *Load* option in the *Link Table* window to immediately georeference the satellite image.

08.13. Then *OK* to close the *Link Table*.

08.14. To remove the red crosses on the map, left click on *Georeferencing* in the *Georeferencing Toolbar* and then click on *Update Georeferencing*. They are not lost, you can display them again by re-opening the *Link Table*.

08.15. Check how well the image is georeferenced when you import your outcrop GPS data.

(09) Saving the (satellite) image as a *Layer File*

09.01. The georeferenced satellite image in the *Table of Contents* can now be saved as a *Layer File*. This can then be added and removed from the *Table of Contents* without the need to redo the georeferencing. This can be important when looking at the map in *Layout View* (see Section 31), for printing, if the areas of some of the base maps (e.g. the Greek Geological Survey map sheet of Kythnos) are bigger than that of the map being produced.

09.02. Right click on the satellite image *Layer* in the *Table of Contents*. Select *Save as a Layer File*. This opens the *Save Layer* window. Browse for the folder in the *Project Folder* where you want to save the *Layer File* (I suggest the same sub-folder that the satellite image is saved in). Then *Save*. Remember to give a distinct name so that the associated files created in Windows Explorer can be identified.

09.03. This creates a *Layer File* of the .tiff, a yellow diamond symbol in *Catalog*. (F5 to update *Catalog*.)

09.04. Delete the *Layer* with the original image from the *Table of Contents*.

09.05. Drag the *Layer File* of the image from *Catalog* to the *Table of Contents*.

09.06. In *Catalog*, KEEP the *Raster Dataset* file (do NOT delete it).

09.07. In the *Layer File*, the image may have an unwanted black (or other colour, apart from white) background. To remove this, right click on the *Layer* in the *Table of Contents* → *Properties*. In the *Layer Properties* window, go to *Symbology*. Here tick *Display Background Value:(R,G,B)* and make sure that *R, G, B* are all set to 0 in the boxes to the right. *OK* to finish.

(10) Saving the (satellite) image as a .img file

10.01. More usefully, you can save the georeferenced satellite image so that the georeferencing is saved with the image in a format that can be used by programs other than *ArcGIS*. That is, you can then directly import the georeferenced image into other software.

10.02. To do this, right click on the *Layer* with the satellite image in the *Table of Contents* → *Data* → *Export Data*. This opens the *Export Raster Data* window. In this:

10.03. In *Extent,* select *Raster Dataset (Original)*. In *Spatial Reference,* select *Data Frame (Current)*.

10.04. In *Location,* browse for the place where you want to save the map. In *Name,* give it a name (like the original but with something like georefd at the end).

10.05. In *Format,* select what format you want (.img is recommended; when I tried a .tiff it did not work properly but .img did work.)

10.06. In *Compression Type,* select *NONE*.

10.07. Select *Yes* in *Output Raster*.

10.08. The new satellite image will appear, but may have an unwanted black (or other coloured, apart from white) background. To remove this, right click on the file in the *Table of Contents* → *Properties.* In the *Layer Properties* window, go to *Symbology*. Here tick *Display Background Value:(R,G,B)* and make sure that *R, G, B* are all set to 0 in the boxes to the right. *OK* to finish.

10.09. Note that the georeferenced satellite image (.img) file size is ca. twice the size of the unreferenced image. When moving the image to another *ArcMap* file or another program, you must take the *.rrd* and *.aux* files in the Windows Explorer folder as well.

(11) Importing a (satellite) image with the wrong projection/coordinate system

11.01. If you drag a satellite image or map (etc.) into the *Table of Contents* that has been previously georeferenced, but in another projection/coordinate system to the one you use (e.g. GCS_GGRS_1987, the local Greek system, rather than GCS_WGS_1984) *ArcMap* will give a warning with the *Geographic Coordinate Systems Warning* window.

11.02. In this window, select *Transformations*. This opens the *Geographic Coordinates System Transformations* window.

11.03. In the *Convert from:* window, select the coordinate system of the map being imported (e.g. GCS_GGCS_1987; it will be listed there, together with other systems already in use in the *ArcMap* project).

11.04. In the *Intro:* window, select the system wanted (*GCS_WGS_1984*).

11.05. In the *Using:* window, select the appropriate transformation option (e.g. *GGRS_1987 to WGS_1984*). If it is not there, browse for it.

11.06. *OK* in the *Geographic Coordinates System Transformations* window.

11.07. Close the *Geographic Coordinate Systems Warning* window. The map should move to the correct position.

11.08. The image can then be saved as a *Layer File* or a .img file so that it does not have to be transformed every time it is re imported.

(12) *Data View* and enlarging/moving around in the image

12.01. Ensure that the *ArcMap* display is set in *Data View* (see Section 05). (Instructions for *Layout View* are given later, in Section 31.)

12.02. In the *Tools Toolbar* select *Full Extent* (the globe symbol - a blue-green circle). The *ArcMap* display will be enlarged to include all material in **all** *Layers* in the *Table of Contents*, whether they are *Visible* or *Not Visible*, *Selectable* or *Not Selectable*. If you have a .tiff of a large base map, such as a geological map with a legend and cross-sections (e.g. the Greek Geological Survey map of Kythos) in the *Table of Contents*, this will be included and hence probably make the area of interest (just Kythnos) seem very small. Converting such base maps to *Layer Files* (see Section 09), so that they can be removed and added to the *Table of Contents* as needed, without re-georeferencing every time, is a good idea.

12.03. Use the *Pan* (hand) tool in the *Tools Toolbar* and hold down the left mouse to move the image about within the *ArcMap* display area.

12.04. Using *Pan* and holding down the middle mouse (scrolling wheel) down for ~ 1 second, changes the hand to a four directional arrow. Then move the mouse in the direction you want to go and it will move the map in the opposite direction (i.e. you go in the wanted direction across the map). Moving the mouse further from the original point will make the movement faster. You can change the direction of movement as the map goes across the screen.

12.05. Use the middle mouse wheel to zoom in and out quickly.

12.06. To get a specific degree of enlargement, give the desired value in the scale box in the *Standard Toolbar*. Left click on the small black triangle to the right to open a list of given standard scales.

12.07. Use the *Zoom In* tool in the *Tools Toolbar* (hand lens with +) to drag out the desired area to enlarge. Use the *Zoom Out* tool (hand lens with -) to zoom out.

12.08. Use the *Fixed Zoom In* and *Fixed Zoom Out* tools (four arrows pointing in and four pointing out) in the *Tools Toolbar* for fixed amounts of zooming in and out.

12.09. Use the blue arrows to the right of the *Fixed Zoom Out* to go back and forwards to previous zoomed extents (*Go Back to Previous Extent, Go to Next Extent* tools).

(13) Creating a *Shapefile* in which to draw a *Feature* and saving it as a *Layer*

13.01. To draw a *Feature* (e.g. a *Polyline* of the coast) you need a *Shapefile* in which to draw it. This *Shapefile* is saved in a *Layer* in the *Table of Contents*.

13.02. In the *Project Folder*, in Windows Explorer, create a folder with the appropriate name, e.g. *Kythnos_coast.*

13.03. In *Catalog*, open *Home-Kythnos_map\ArcGIS* and then the *Kythnos_coast* folder.

13.04. Then right click on *Kythnos_coast* → *New* → *Shapefile*. This opens the *Create New Shapefile* window. In this do the following:

13.05. In *Name* give the *Shapefile* a name, e.g. Coastline.

13.06. In *Feature Type* select the type wanted (likely *Polyline* or *Polygon*. The former draws a *Polyline* which can later be turned into a *Polygon*, so I think these are better; they are more flexible, as one *Polyline* can be used for making the *Polygons* on both sides of it; see Section 17).

13.07. In *Spatial Reference*, if no coordinate system is given, or the wrong one is present, go to *Edit*…This opens the *Spatial Reference Properties* window. In this,

Either: Go to *Select.* This opens the *Browse for Coordinate System* window. Here select *Projected Coordinate Systems* → *UTM* → *WGS 1984* → *N. Hemisphere* → *WGS 1984 UTM Zone 35N* (for Kythnos).

Or: Go to *Import*. This opens the *Browse for Dataset* window. Here browse in *Look in:* for a *Layer* in the same project that has already got the correct *Spatial Reference Properties*.

13.08. After the Either/Or options, click on *Apply* → *OK.*

13.09. Select *Coordinates will contain Z values* in the *Create New Shapefile* window.

13.10. *OK* to close the *Create New Shapefile* window.

13.11. This will create a folder with the *Shapefile* name you gave, in *Catalog*. At the same time, the *Shapefile* will appear as a *Layer* in the *Table of Contents*.

13.12. If it does not appear in the *Table of Contents*, left click on the symbol in *Catalog* and hold, and drag this across to the *Table of Contents*.

13.13. Several *Layers* of similar *Features* (e.g. main roads, minor roads, footpaths) can be combined into a *Group Layer*. Right click on *Layers* in the *Table of Contents* → *New Group Layer*. This can be given a name and then individual *Layers* can be dragged into it. This reduces the length of the *Table of Contents* and allows you to turn on and off a whole group of *Layers* together, although individual *Layers* can still be selected. Note that moving a *Layer* to a *Group Layer* in the *Table of Contents* does NOT affect its position in *Catalog* or Windows Explorer.

13.14. *Shapefiles* can be dragged from one folder to another in the *Home* folder in *Catalog* easily, without loss of data. All the associated files listed in Windows Explorer are moved as well. Similarly, deleting the *Shapefile* in *Catalog* deletes all the associated files in Windows Explorer.

13.15. If a *.sr.lock* file forms in Window Explorer, don't panic. It will likely disappear if you close *ArcMap* (after saving) and then reopen it.

(14) Opening a *Toolbar* and the *Snapping Toolbar*.

14.01. There are many *Toolbars* in *ArcMap* that can be opened when needed. How this is done is described for the *Snapping Toolbar*, which is needed when drawing *Polylines* and *Polygons*.

14.02. To check which *Toolbars* are already open, if they have not already got a name at the left end, do *Command Bar* → *Customize* → *Toolbars.* This opens the list of *Toolbars* available. Those

ticked are already open. When opening *ArcMap*, the *Standard, Tools* and *Editor Toolbars* should be open. If they are not, open them by ticking on them in the list.

14.03. In detail, the list of *Toolbars* can be opened in several ways;
Either: *Command Bar* → *Customize* → *Toolbars*.
Or: In any *Toolbar*, left click on *Toolbar Options*. This is the small grey symbol, part shaded darker grey, with a small black triangle pointing downwards, at the right-hand end of all *Toolbars*. Select *Customize*. This opens the *Customize* window → *Toolbars*. Tick the required *Toolbar* → *Close*. Note the other options (*Commands, Options*) in the *Customize* window.
Or: Right click anywhere in an already opened *Toolbar* (even on the symbols in the *Toolbars*) and the list of *Toolbars* opens.

14.04. *Toolbars* can be dragged into the *ArcMap* display as floating windows by left click and hold on the column of four darker grey dots at the left end of the *Toolbars*. Use the grey bar at the top of the *Toolbar* to drag it back into the top of the screen area if you do not want it as a floating window.

14.05. To close a *Toolbar*, either deselect the *Toolbar* in the *Toolbar* list or, if it is a floating window, use the cross symbol at the top right.

14.06. Open the *Snapping Toolbar*. In this, left click on the small black triangle to the right of *Snapping* to see the options available. Click the area to the left of where it says *Use Snapping* to turn it on (tick shown) or off (no tick). Select what you want to snap to.

14.07. *Snapping* can be turned on and off as you wish whilst drawing a *Polyline* (i.e. you do NOT have to stop drawing to turn it on/off). Just move the mouse to the *Snapping Toolbar* and open the options. Make the change you want, move the mouse back into the *ArcMap* display and carry on drawing the same *Polyline* or *Polygon* as before.

(15) Drawing a *Polyline Feature, Templates* and the *Create Features* window

15.01. If the *Editor Toolbar* is not open, open it (*Command Bar* → *Customize* → *Toolbars*). The *Toolbar* has the word *Editor* on the left side.

15.02. In the *Editor Toolbar*, click on *Editor* → *Start Editing*. This opens the *Start Editing* window. Left click on the *Shapefile* you want to edit (either to modify existing *Features* or draw new *Features*) from the upper list. Note that if you here open one *Shapefile* in a folder in *Catalog*, all the other *Shapefiles* in that folder become available to be edited. *Shapefiles* in other folders in *Catalog* do not become available for editing; this is important to remember. Then *OK*.

15.03. This should automatically result in a *Create Features* window opening below the *Table of Contents*. This has an *Auto Hide* pin that works just like that in the *Table of Contents*, and it can be dragged out to be a floating window.

15.04. The relative positions of the *Create Features* and *Table of Contents* windows depends on how they are placed using the blue arrows when pinning a floating window to the side of the *ArcMap* display. They can be one above the other, so that both are open, or one beside the other, again with both open, or one on top of the other, with the visible one selected by the two small windows at the base of their window space, to the left of the *ArcMap* display.

15.05. When in the *Create Features* window, pull up the base of the window (which may be only a thin horizontal line) until you can see the text *Select a template.*

15.06. In the *Table of Contents*, select *List by Selection* (the symbol looks like an envelope with the left half in pale blue).

15.07. If the *Shapefile* you want to work in is in the *Not Selectable* list, right click on the symbol that looks like an envelope with the left half in grey. This grey will go blue and the *Shapefile* will move up into the *Selectable* list (it may also say *(no features selected)* at the top, but that means no *Feature* has been activated, so ignore this).

15.08. In the *Create Features* window, click on the *Shapefile* you want to work in (Coastline, for example).

15.09. If the *Shapefile* is not listed in *Create Features*, you will have to create a *Template*. In the *Create Features* window, go to *Organize Templates* (the second symbol from the left at the top; it looks like two sheets of paper on top of each other). Left click on this to open the *Organize Feature Templates* window.

15.10. In the *Organize Feature Templates* window, right click on the *Layer* you want to draw in (but couldn't). The window will say *There are no templates to show*.

15.11. Left click on *New Template* in the *Organize Template* window. This opens the *Create New Template Wizard*.

15.12. Select the *Layer* you want to make a *Template* for. Then *Finish*. A symbol and the name of the *Template* will appear in the window of the *Organize Feature Templates* window. Close this window.

15.13. If the *Layer* does not now appear in the *Create Features* window, go to the *Table of Contents* and check it is *Selected*. Then go back to the *Create Features* window.

15.14. At the base of the *Create Features* window, a list of *Construction Tools* will open. Choose the option you want; generally *Line* (*Polyline)*. When you do this, the drawing options to the right of *Editor*, in the *Editor Toolbar*, will become coloured red and green. The active option will have a faint blue box around it. For *Line*, in *Construction Tools*, this should be the one on the far left (i.e. the first one) → *Straight Segment*. If it is not that one, use the mouse (right click) to select it.

15.15. When the mouse is in the *ArcMap* display (where we want to draw), a black cross with a thin white border appears. Left click with this to draw a *Polyline*; a *Vertex* forms at each point you click. The last *Vertex* is red; previous *Vertices* are green.

15.16. Double click to end the *Polyline*; the *Polyline* will go a thicker light blue colour.

15.17. *Save Edits*. Before you save what you have drawn it is important that it is no longer selected. After double clicking to finish drawing, the *Polyline* goes thicker, with a pale blue colour. To remove this (i.e. make the *Polyline* no longer active), select the *Edit Tool* (black arrow tip) in the *Editor Toolbar* and click anywhere in the *ArcMap* display; the light blue colour will disappear and the *Polyline* will be visible in the colour you chose. Then left click *Editor* in the *Editor Toolbar* → *Save Edits*. If you do NOT do this, the *Polyline* you have drawn MAY disappear. The *Undo Delete Feature* tool in the *Standard Toolbar* (the anticlockwise pointing arrow) will not bring it back.

15.18. It's a real bummer, but the *Feature Construction* window will open and get in the way all the time you are drawing. You can move the black cross (the mouse) onto the window and drag it out of the way of where you want to draw (above/below/left/right) and then continue drawing.

15.19. If you are drawing a long *Polyline* (e.g. a coastline) that may take hours to draw, it is best to stop and *Save Edits* regularly, in case the computer crashes or you make a mistake and lose everything. That the *Polyline* is made of several *Features* (segments) is not a problem when later creating a DEM or *Hillshading* from the contours combined with your coastline.

15.20. When restarting to draw a *Polyline* already part drawn, you may have to go back to the *Construction Tools* (in *Create Features*) and select the correct type of *Feature* (*Polyline, Polygon* etc.). It is very important to use *Snapping* to ensure the new bit of *Polyline* is properly joined to the end of the previous part.

15.21. To change the properties of a *Polyline* or *Polygon* or of a structural symbol, go to the *Table of Contents* → *List by Drawing Order* and open the relevant *Layer*, so that the symbol to be changed can be seen in the *Table of Contents* (i.e. click on the cross symbol to the left), and make it *Visible*. Then right click on the symbol and a colour chart will open. Select the required colour; the chart will automatically close. If you left click on the symbol, the Symbol Selector Window will open. Here you can change the colour and width of the *Polyline*. The symbol can be changed by clicking on *Edit Symbol.* This opens the *Symbol Property Editor* → *Style,* or in more detail by opening the options in *Type:*.

15.22. In the *Symbol Selector* window, more symbols can be added to the window by clicking on *Style References*. This opens the *Style References* window. Here scroll down the list until you find an option that may have the symbol you want, tick the box to the left of it, and *OK*. This will close the Style References window. If the symbols do not appear in the list in the *Symbol Selector* window, you have to use *Add Style to List.*

(16) Editing a *Polyline* and joining/breaking *Polylines*

16.01. When editing *Polyline*, it is very useful to have the *Snapping Toolbar* open.

16.02. Editing should be done in *Data View* (see Section 12).

16.03. To activate (pick up) a *Feature* so that you can modify it, drag the *Edit Tool* over part of the *Feature*. This will make it go to a thick pale blue colour. It is not necessary to drag the *Edit Tool* over the whole *Feature*, just a part. If the *Edit Tool* goes over more than one *Feature*, they will all be activated. However, you can only activate one *Feature* at a time to modify (move the vertices, cut the *Feature*, reshape it).

16.04. Once the *Feature* is activated, select which of the tools you want to use in the *Editor Toolbar* (*Edit vertices, Reshape Feature Tool, Split Tool*); these are in red and green to the right of *Editor*. This will make the *vertices* appear; the red *vertex* is where you ended the *Polyline*.

16.05. If you find that you can activate a *Feature* but the *Vertices* do not appear when a tool is selected in the *Editor Toolbar*, so you cannot modify it, this is likely because:

- Either it is not *Selectable* (so go to the *List by Selection* window in the *Table of Contents* and make it *Selectable*);
- Or it is not listed in the *Create Features* window. This can be corrected by doing in sequence *Editor* → *Save Edits; Editor* → *Stop Editing; Editor* → *Start Editing*. Select the *Feature* you want to edit in the *Start Editing* window.

16.06. To join two *Polyline* (or more). Right click and drag the *Edit Tool* over part of the two or more *Polylines* to activate them (they will go blue). Then left click on *Editor* → *Merge*. A window will open with the segments listed. Click *OK* and they join to form one *Polyline* (but they are still separate in CorelDraw, just ungroup them). If you want to join several segments that cannot be activated in one go, press and hold down Strg (on the keyboard) and drag the *Edit Tool* over each segment in turn. These will turn blue. Then *Merge* them, as described above.

16.07. To break a *Polyline*. Pick up the *Polyline* using the *Edit Tool* and then select the *Split Tool* (to the right of the *Edit Vertices* tool; it looks like a green line dipping to the left with a red spot in the middle). Move the mouse over the *Polyline* to be split until the symbol changes and left click. Again, it is not necessary to be exact where you split the *Polyline* because you can move the *Vertices* later.

16.08. To move a *Vertex* in a *Polyline* or *Polygon*. Drag the *Edit Tool* over the *Feature* so that it goes blue. Then select the *Edit Vertices* tool (to the right of the *Edit Tool*; it looks like a square defined by four green spots with a line going to a single red spot on one of the edges of the square). This will make the *Vertices* visible. Place the mouse over the *Vertex* to be moved and when it changes to a diamond shape, right click and drag it to the required point. (You may want to turn *Snapping* off when doing this if you are only moving the *Vertex* a very short distance).

16.09. To delete a *Vertex*. Do as in 16.07 to activate the *Polyline* and see the *Vertices*. But when the mouse symbol changes shape, right click and select *Delete Vertex*.

16.10. To add a *Vertex*. Do as in 16.07 to activate the *Polyline* and see the *Vertices*, but bring the mouse close to the *Polyline* at the point where the vertex is needed (not important to be exact, because you can later move the *Vertex* to the right position). When a symbol like a headset appears next to the mouse arrow, right click and *Insert Vertex*.

16.11. To move a whole part of a *Polyline* (i.e. several *Vertices* together). Do as in 16.07 to activate the *Polyline* and see the *Vertices*. Then,

Either left click and hold and drag the mouse over the vertices to be moved. Use the Shift key if you want to drag the mouse over several areas;

Or hold down Strg and the Shift button and click on the *Vertices* making the segment of the *Polyline* to be moved. Release the buttons.

Then move the mouse to any part of the selected *Polyline* until the headset symbol appears. Left click and hold and move the segment.

16.12. To delete a *Polyline*. Drag the *Edit Tool* over a part of it; it goes blue. Then press Delete (=Del or = Entf) on the keyboard. You cannot delete a *Polyline* or *Polgon* in *Layout View*.

(17) Converting *Polylines* to *Polygons*

17.01. To do this, the *Polylines* to be converted must all lie in the same *Layer* in the *Table of Contents*. So, for the coastline, if you want to convert this to a *Polygon*, the data are likely already in the right set-up. However, if the data are in several different layers (e.g. if you are making a *Polygon* out of a bit of the coast and some sections of road), then first create a new *Shapefile* in *Catalog* called, for example, Line_to_Polygon, and drag it to the *Table of Contents*. Then copy all the *Polylines* to the Line_to_Polygon *Layer*. (Use *Copy* and *Paste*, working in the *Table of Contents;* this may involve changing the active *Layer* using the *Editor Toolbar* → *Start Editing* → *Stop Editing*.) Use *Snapping* to ensure that the *Vertices* of the *Polylines* are properly aligned. You can create several *Polygons* at the same time (thus with

the coastline, both the main outline of Kythnos and all the small islands around it were converted to *Polygons* at the same time).

17.02. Having done the above, it is not necessary to have *Start Editing* on or for the data to be *Selectable* in the *Table of Contents* or even for the *Layer* to be *Visible*.

17.03. Note that doing this conversion does not affect the original data; *ArcMap* will create a copy of the *Polyline* data set to merge into the *Polygon*. The original *Feature* (*Polyline*) data will still exist in the same *Shapefile/Layer* as before; that is, the *Polyline* data will still be present in your original *Polyline Layer*.

17.04. In the *Standard Toolbar*, select the *Search window* (this is one of the four 'TV screen' like symbols).

17.05. This opens the *Search* window. Ensure that *Local Search* is the top line (if not, select this). Write *to polygon* in the search space near the top, then click search (magnifying glass symbol).

17.06. In the list of possible items returned, select *Feature to Polygon (Data Management)*. This opens the *Feature to Polygon* window.

17.07. In the *Feature to Polygon* window, use the folder symbol far to the right of *Input Features* to open the *Input Features* window and browse for the *Layer* required in *Name* (the Line_to_Polygon *Layer)*. Then *Add*. What you select will come up in the area below the *Input Features* space. Or just drag (right click and hold) the *Layer* from the *Table of Contents* to *Input Features.*

17.08. In the *Output Feature Class* space, use the folder symbol far to the right to open the *Output Feature Class* window. The *Output Feature Class*, by default, has to be in a *Geodatabase* (*.gdb*). If you do not have a *Geodatabase* in the *Project Folder*, create one; see Section 04).

17.09. In the *Output Feature Class* window, click on *Go to Home Folder* (the house symbol at the top). Browse until you have the project *Geodatabase* in the list and double left click so that it appears in *Look in*:. Give the name of the *Output Feature* in *Name* (e.g. greenschists). *Save as Type* can only be *Feature Classes*. Then *Save* to close the window.

17.10. Ignore *XY Tolerance*. Make sure *Preserve Attributes* is selected (especially if Z data is included). Then *OK* in the *Feature to Polygon* window.

17.11. A small *Feature to Polygon* window may open (or may not, depending on how big the conversion is), showing the progress of the conversion. *Completed* comes up in this when it is done.

17.12. Similarly, blue text may scroll continuously round in the bottom right of the *ArcMap* display saying *Feature to Feature* and, when finished, a small window may appear down there, with a hammer and a tick, indicating the conversion has been done. *Close* this window.

17.13. The *Feature* created will appear as a *Layer* in the *Table of Contents* and also as a *Feature* in the *Geodatabase* in the *Home* folder in *Catalog*.

17.14. The *Layer* can then be dragged to a *Group Layer* in the *Table of Contents* if you wish to, or the data can be transferred to the required *Layer*.

17.15. If you wish, you can export the *Feature* in *Catalog* to another folder. Right click on the file in the *Geodatabase* in *Catalog* → *Export* → *To Shapefile (single)*. This opens the *Feature Class*

to *Feature Class* window. The *Feature* to be exported will be listed in the *Input Features*. In *Output Location*, browse for the folder where the *Feature* will be saved and *Add*. In *Output Feature Class*, give the name of the *Feature* (e.g. greenschists). Ignore *Expression (optional)* and leave *Field Map (optional)* with the defaults listed. Then *OK*.

17.16. A small window will appear in the bottom right of the computer screen, indicating the conversion has been done. At the same time, a new *Layer* with the given name will appear in the *Table of Contents* and the new *Feature* will be listed in the folder in *Catalog* to which it was exported. Thus there will be two copies of the *Layer*, one still in the *Geodatabase* and the one exported from the *Geodatabase*.

17.17. Now delete the *Feature* from the *Geodatabase*; right click on the *Feature* → *Delete*. *Confirm deletion*. At the same time, the *Layer* will be deleted from the *Table of Contents* (but the exported copy will not be deleted from anywhere).

17.18. If the *Features* do NOT convert to a *Polygon*, it almost certainly means that somewhere in the loop of *Vertices* formed by the *Features*, there is a break or gap, i.e. the *Vertex* of one *Feature* is not properly snapped (linked to) a *Vertex* on the next *Feature*. Or if the *Polyline* is only one *Feature* (note that two *Polyline*s merged are not one *Feature*), the *Vertices* at the start and finish of the *Polyline* do not overlap. This has to be corrected before a *Polygon* can be made.

17.19. Fixing this is difficult: it can be done in *Topology*, but this is complex. A simple, but slow way to find the error is to export the *Features* to CorelDraw (see Section 39) and systematically check the junction between each segment (ungroup the merged segments in CorelDraw). You can then look in the *Layer* in *ArcMap* to correct the error, using *Snapping*.

17.20. Note that depending on the geometry of the *Polylines* involved, more than one *Polygon* may form. All possible *Polygons* will form. Those not needed have to be deleted.

(18) Tracing a *Polygon* from intersecting *Polylines*

18.01. A *Polygon* can be traced over a previously existing set of *Polylines*. Suppose you have defined the area of a unit of rock by several intersecting *Polylines*; by tracing around the *Polylines*, the *Feature* is directly drawn as a *Polygon*.

18.02. Make all *Layers* that are not to be traced *Not Visible*. (The trace can go along any visible *Polyline*, so 'steering' the trace is easier if only the *Polylines* needed are *Visible*.)

18.03. Make sure that all *Layers* are *Not Selectable* (*Table of Contents* → *List by Selection*). This ensures that you cannot accidently edit or delete anything during tracing.

18.04. Create a new *Polygon Shapefile* and *Layer* (right click *Home* → *New* → *Shapefile* → *Type/Polygon* etc; see Section 13). Only this *Layer* should be *Selectable*.

18.05. In the *Editor Toolbar*, *Start Editing*. Select the *Polygon Layer* in the *Start Editing* window. *OK*.

18.06. In the *Create Features* window (see Section 13), select the required *Polygon Shapefile* and in *Construction Tools* select *Polygon*.

18.07. Turn *Snapping* on. (If you trace without *Snapping*, the start point will not be exactly on the *Polylines* being traced, but the rest of the *Polygon* will be on the *Polylines*. You can later use the *Edit Vertices* tool to put the starting point in the correct place.)

18.08. In the *Editor Toolbar*, select the *Trace* tool; this is the third red/green symbol from the left, with a cloud of fine black dots at the base. The mouse symbol will become a black cross.

18.09. Place the mouse near a *Vertex* in one of the *Polyline*s where you want to start the trace. A black cross within a square symbol will appear directly on that *Vertex* and the name of the *Layer* in which the *Polyline* lies will appear, with the word *Vertex*. (e.g. *Minor_Roads: Vertex*). Left click to start the trace.

18.10. Now drag the mouse along the *Polyline*. You do not have to move exactly on the *Polyline*; the simpler the *Polyline*, the less accurate you can be. If you drag the mouse close to the *Polyline* a black box will appear every time you reach a *Vertex* and a triangle symbol at mid-points, with an *XXXX: Vertex* or *XXXX: Mid-point* label.

18.11. Close the *Feature Construction* window if it opens. This will not reappear.

18.12. You can use the middle mouse to enlarge the *ArcMap* display at need.

18.13. At the end of the loop, (i.e. when you get back to the starting point), the cross within a square symbol re-appears. You can go on, beyond the 'end point' but this is not recommended. A single right click shows the completed *Polygon* with the *Vertices*. Double right click and the *Vertices* disappear. Click on the *Edit Tool* to deactivate the *Polygon* and then *Editor* → *Save Edits*.

18.14. If the size of the *Polygon* is too large to get into the *ArcMap* display, you can single right click to stop tracing. The *Polygon* will appear with most *Vertices* in green and the last one in red. Then use the middle mouse to move the *ArcMap* display so that the next part to trace comes into view. Then move the mouse back to the red *Vertex*; the box with a cross symbol appears on it. Left click and carry on tracing.

18.15. Once the blue line appears, you cannot go back and carry on tracing. You can, however, add *Vertices* if you have stopped too early etc.

18.16. If the *Polyline* is complex, with isoclinal curves, you have to move the mouse about in the correct direction to get it 'around the corner' and to drag the trace back. Zoom in to make this easier. However, for very complex and long *Polylines*, tracing the outline to make a polygon is too difficult and the *Convert Feature to Polygon* method should be used (see Section 17).

(19) Drawing a *Polygon* and modifying it

19.01. Create a *Polygon Layer* file (see Section 13, but select *Polygon* in *Feature Type*).

19.02. In the *Editor Toolbar*, select *Start Editing*. In the *Start Editing* window, select the polygon *Layer* wanted. In the *Create Features* window, select the *Layer* wanted and the *Polygon* option in *Construction Tools*.

19.03. In the *Editor Toolbar*, select the *Straight Segment* tool.

19.04. Right click at the required point to make the first *Vertex* and then again to make the next *Vertex*. The last *Vertex* made is always red.

19.05. Close the *Feature Construction* window. It will not come back.

19.06. You can use the middle mouse at any time to move the area shown in the *ArcMap* display and then continue drawing the *Polygon*.

19.07. Double click to end drawing the *Polygon*. The outline goes blue. Deactivate the *Polygon* (click the *Edit Tool* anywhere in the *ArcMap* display) and *Save Edits*.

19.08. You can only change the shape by adding/deleting/moving the *Vertices*, as with editing a line (see Section 16).

(20) Converting *Polygons* to *Polylines*

20.01. This works for all combinations of intersecting *Polylines* and *Polygons*, i.e. (a) two or more intersecting *Polylines*; (b) two or more overlapping *Polygons*; (c) one or more *Polylines* with one or more *Polygons*. The result will be a whole series of small *Polylines*; wherever *Polylines* or *Polygons* intersect, they will be broken.

20.02. In the *Standard Toolbar*, left click on *Search window*.

20.03. This opens the *Search* window. Ensure that *Local Search* is the top line (if not select this). Type *to polyline* in the search space near the top, then click search (magnifying glass symbol).

20.04. In the list of possible items returned, select *Feature to Line (Data Management)*. This opens the *Feature to Line* window.

20.05. In the *Feature to Line* window, either use the folder symbol far to the right of *Input Features* to open the *Input Features* window and browse for the *Layer* required in *Name*. Then *Add*. What you select will come up in the area below the *Input Features* space. Or just drag (right click and hold) the *Layer* from the *Table of Contents* to *Input Features.*

20.06. In the *Output Feature Class* space, use the folder symbol far to the right to open the *Output Feature Class* window. The *Output Feature Class*, by default, has to be in a *Geodatabase* (*.gdb*). If you do not have a *Geodatabase* in the project, create one (see Section 04).

20.07. In the *Output Feature Class* window, click on *Go to Home Folder* (the house symbol at the top). Browse until you have the project *Geodatabase* in the list and double left click so that it appears in *Look in*:. Give the name of the *Output Feature* in *Name* (e.g. roads). *Save as Type* can only be *Feature Classes*. Then *Save* to close the window.

20.08. Ignore *XY Tolerance*. Make sure *Preserve Attributes* is selected (especially if Z data is included). Then *OK* in the *Feature to Polygon* window.

20.09. A small *Feature to Polygon* window may open (or may not), showing the progress of the conversion. *Completed* comes up in this when it is done.

20.10. Similarly, blue text may scroll continuously round in the bottom right of the *ArcMap* display saying *Feature to Feature* and, when finished, a small window may appear down there, with a hammer and a tick, indicating the conversion has been done.

20.11. The *Feature* created will appear as a *Layer* in the *Table of Contents* and also as a *Feature* in the *Geodatabase* in the *Home* folder in *Catalog*.

20.12. The *Layer* can then be dragged to a *Group Layer* in the *Table of Contents* if you wish to, or the *Features* required can be cut and pasted to the required *Layer*.

20.13. If you wish, you can export the *Feature* in *Catalog* to another folder. Right click on the file in the *Geodatabase* in *Catalog* → *Export* → *To Shapefile (single)*. This opens the *Feature Class* to *Feature Class* window. The *Feature* to be exported will be listed in the *Input Features*. In *Output Location*, browse for the folder where the *Feature* will be saved and *Add*. In *Output Feature Class*, give the name of the *Feature* (e.g. greenschists). Ignore *Expression (optional)* and leave *Field Map (optional)* with the defaults listed. Then *OK*.

20.14. A small window will appear in the bottom right of the computer screen, indicating the conversion has been done. At the same time, a new *Layer* with the given name will appear in the *Table of Contents* and the new *Feature* will be listed in the folder in *Catalog* to which it was exported. Thus there will be two copies of the *Layer*, one still in the *Geodatabase* and the one exported from the *Geodatabase*.

20.15. Now delete the *Feature* from the *Geodatabase*; right click on the *Feature* → *Delete*. *Confirm deletion*. At the same time, the *Layer* will be deleted from the *Table of Contents* (but the exported copy will not be deleted from anywhere).

(21) Importing structural orientation data into the map (or outcrop locations etc.)

21.01. Open a folder in the *Project Folder* for the Excel files with the structural data (e.g. Kythnos_structure). I find it simpler to have a separate Excel file for each data type (lineation, fold axes, S surfaces etc), but this is not actually necessary. The orientation data must be in separate columns for dip, dip direction, strike or plunge and trend. The GPS coordinates of the data must be in the same coordinate system as the map. Label these as Easting and Northing (or something similar). And it is useful to have location numbers or some other way of identifying data points (useful if you want to find anomalous data in the Excel file).

21.02. In *Catalog*, do F5 to update the list.

21.03. In *Table of Contents* go to *List by Source* (that is the table with the grey drum symbol).

21.04. Right click on *Layers* → *Add Data*. This opens the *Add Data* window.

21.05. In the *Add Data* window, browse for the data in the *Project Folder* and double click on the data file wanted.

21.06. In the *Add Data* window, this brings up a small symbol looking like two columns of text on a page and then a filename ending with a $ sign. Right click on this so this name comes up in the *Name* window and then select *Add*.

21.07. This creates a folder in *Table of Contents* → *List by Source* with a symbol looking like three columns of data.

21.08. Right click on this symbol → *Display XY* data.

21.09. The *Display XY Data* window comes up. In the *X Field* window, select *Easting*; in the *Y Field* window select *Northing*. The coordinate system should be already there (WGS1984 → UTM Zone 35N for Kythnos); if not, use *Edit*… to put in the coordinate system. Then *OK*.

21.10. *OK* to the window *Table Does Not Have Object ID Field*.

21.11. In the *Table of Contents* → *List By Drawing Order*, a file called *Kythnos$ Events* is created. Change the name to whatever the structural data is (e.g. Crenulations).

21.12. Right click on the *Layer* → *Properties* to open the *Layer Properties* window.

21.13. In the *Layer Properties* window, open *Symbology* and, in the *Symbol* box, left click on whatever symbol is visible. This opens the *Symbol Selector* window.

21.14. In the *Symbol Selector* window, scroll down to the symbol you want. If you cannot find geological symbols, open *Style References* in the *Symbol Selector* window, scroll down to *Geology 24K*, tick the option and then select *Add Style to List* → *OK*. Now you will find some geological symbols in the *Symbol Selector* window.

21.15. Select the required size and colour in the *Symbol Selector* window. Then *OK*.

21.16. In the *Layer Properties* → *Symbology* window, click on *Advanced* → *Rotation*. This opens the *Rotate* window.

21.17. In this, select *Geographic* → *OK* (i.e. 0° is north).

21.18. In the *Rotate Points by Angle in this field* box, select <*expression*>.

21.19. Click on the calculator symbol to the right of <*expression*>. This opens the *Expression Builder* window.

21.20. In the *Expression Builder* window, select the data to be plotted in the *Fields* box. This then comes up in the *Expression* box. Use the calculator to create the formula [whatever azimuth data you have]+X°. This must be done because the arrow points do not point north in the *Symbol Selector* window. You have to calculate how much needs to be added (X°) to rotate the arrow to north before doing the rotation to the angle you measured in the field (e.g. if the arrow points down, X=180). The same is true for plotting plane symbols. The angle varies between symbols, so be careful. Then *OK*, *OK* to close the windows down to *Layer Properties*.

21.21. In *Layer Properties* → *Symbology*, left click on the structural symbol in the box next to *Symbol*. This opens the *Symbol Selector* window. Double click *Edit symbol* to open the *Symbol Property Editor* window.

21.22. In the *Symbol Property Editor* window, the symbol you have chosen is displayed at the top right under crossed dashed lines. Where these lines intersect is the GPS point of the data. To move the tip of the arrow so that it lies on the GPS point (i.e. on the position where you actually measured it; that is, on the outcrop, and not crossing over each other), change the *X:* and *Y:* values in the *Offset:* boxes on the right side of the *Symbol Property Editor* window. The symbol will move under the crossed lines as you change the values. Then *OK*, *Apply*, *OK* to finish.

21.23. Then *OK* in the *Layer Properties* window.

(22) Showing a value (dip/plunge/outcrop number, isotopic age) next to a symbol

22.01. To add a value (dip angle, plunge angle, outcrop number etc.) next to a symbol, right click on the layer in the *Table of Contents* → *Properties*. This opens the *Layer Property* window.

22.02. In the *Layer Property* window → *Labels*.

22.03. Click on *Label all features in this layer* (top left of window).

22.04. *Method* → *Label all features the same way*.

22.05. In the *Text String* box, select which column the values should come from in the original Excel file in the *Project Folder*.

22.06. In the *Text Symbol* box, select the font and size required. (This can be changed in CorelDraw, later).

22.07. In the *Other Options* box, *Placement Properties* allows you to define where the number should be placed. Select the position you want, but you will almost certainly have to move things about a bit in CorelDraw, so that values from different symbols do not overlap. Do nothing with *Scale Range*.

22.08. Do nothing in the *Predefined Label Style* box.

22.09. Note that to turn the labels off, you only have to go to *Properties* → *Labels* and then deselect *Label features in this layer*.

22.10. When you have exported the map to CorelDraw, you will have to go over the map making sure that the numbers do not lie on other symbols and likely delete some symbols if there are too many at one outcrop etc.

(23) Creating contours from a scan of a printed topographic map

23.01. The addition of contours, from which *Hillshading* can be derived, is much more difficult to describe, because the data may be in a range of formats.

23.02. If it comes in a simple .tiff or .jpeg file (such as a scan of a topographic map) you can import and georeference it like a satellite image (see Section 08). Use the confluence points of rivers or crossing points of roads/tracks as well as the coastline as known locations for georeferencing.

23.03. The contour lines then have to be redrawn as *Polylines* in *ArcMap*. This is very tedious and is just about OK for a small map area. For large maps, it is impossible. For reasons given in Sections 27 and 29, draw the contours to cover an area ca.0.5 - 1 km larger in all directions than the area of the final map.

23.04. When creating the *Shapefile* for redrawing the contours, be sure to click on the *Coordinates will contain Z values. Used to store 3D data* option. During drawing, have the *Attribute Table* open (right click on the layer in *Table of Contents* → *Open Attribute Table*) and add the altitude of each segment of a contour line as you draw it (a contour does not have to be one continuous line). You can then use this data to create a DEM and thence *Hillshading*.

23.05. Z data *can* be added later to the contours if you forget to do it initially (see Section 38).

(24) Getting contours as a *Shapefile (Polylines)* and the *Spatial Adjustment Toolbar*

24.01. If the data comes directly as a georeferenced *Shapefile*, it can be simply dragged from *Catalog* to the *Table of Contents*. If not you have to georeference it (see Section 08).

24.02. The shape/distribution of the contours should then be compared with the satellite image to check their positioning is correct (assuming the coordinate system is correct). For example, the 0 m contour should be compared with the coastline that you have already drawn; the former is unlikely to be as detailed as the latter, but the overall fit should be good. Contours should fit with river valleys etc.

24.03. If the fit is not good, it can be adjusted using the *Spatial Adjustment Toolbar* (see Section 24 for opening a new *Toolbar*).

24.04. To do the *Spatial Adjustment*, activate the contour *Layer* in the *Table of Contents* (*Editor* → *Start Editing* → select the contour *Layer* in the *Start Editing* window).

24.05. Make sure that the contour *Layer* is the only *Selectable Layer (Table of Contents* → *List by Selection)*. Select all parts of the *Layer* by right click on the contour *Layer* in the *Table of Contents* → *Selection* → *Select All.*

24.06. In the *Spatial Adjustment Toolbar*, take the *New Displacement Link* tool (the one with the green cross linked to a red cross) and click on (for example) the 0 m contour in the contour layer and then on the equivalent position on the coastline you have drawn; this will result in a black arrow appearing, pointing in the direction the 0 m contour (and the whole data set essentially) will be moved and how far.

24.07. Do this as many times as you can (for Kythnos, I used ~150 points around the coast for a contour data I was sent; the more points the better). If you do not have any coastline, use other things like river confluence points, lakes etc.

24.08. Try to get an even distribution of arrows. Make an arrow even in places where no adjustment is needed, so that no movement is made in that place.

24.09. You can use the middle mouse to enlarge the image and to move the image about whilst making the adjustment arrows.

24.10. If you make a mistake placing an arrow (i.e. it is in the wrong position), go immediately with the mouse to the *Spatial Adjustment Toolbar*. Select the *View Link Table* option (the symbol that looks like a table), scroll down the list of points that appears and left click on the lowest point (the last point you made; it should get a blue background in the list). The black arrow in the *ArcMap* display will go green, confirming you have the correct line in the table. Then, in the table, right click → *Delete link*. If you see that you made a mistake later, then finding the line to delete in the table might take some time, it but must be done.

24.11. When enough points have been made, open the *Spatial Adjustment* options list (small black triangle next to *Spatial Adjustments*, in the *Spatial Adjustment Toolbar*). Select *Adjustment Method* → *Rubber Sheet*. Then, in the same options list, select *Adjust* (if it has a coloured symbol to the left, everything is set up correctly and should work). The whole contour set will

be adjusted (deformed) to the correct position. Check the quality of fit and do more adjustments if necessary.

24.12. Then save it as a *Layer File* (see Section 09).

(25) Converting a DEM to contour data.

25.01. It is possible that you will have to derive the contour data from a DEM.

25.02. Getting a high quality DEM may be the most difficult (and expensive) part of drawing the map. You need a DEM not only for the contours (which you might get elsewhere) but also for *Hillshading* effects, although this is not absolutely necessary.

25.03. Some DEM data is available free online. For example, the USGS has loads of data; but this is mostly at a 90 m grid (i.e. there is a known altitude for all points on a fixed 90 m spaced horizontal grid). Contour levels are then obtained in *ArcMap* by a linear interpolation on the grid. For Kythnos, the results were useless; contour 'valleys' did not lie in topographic valleys (out by 50 m or more), contours went uphill etc.

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25.04. Once you have a good DEM, import it and georeference it (if necessary) into *ArcMap, Table of Contents*.

25.05. Select the *Arc Toolbox window* in the *Standard Toolbar* (it is the one with the red box in). Open *3D Analyst Tools* → *Raster Surface* → *Contour*. This opens the *Contour* window.

25.05. Drag the DEM *Layer* into the *Input raster* box in the *Contour* window.

25.06. In the *Output Polyline features* box, browse for the *Home* folder, select the *Geodatabase* (*.gdb*) and input the file name wanted.

25.07. In *Contour interval*, give the contour spacing wanted.

25.08. In *Base contour (optional),* input the height of the first contour level wanted. You can here leave out the 0 m (coastline) contour, since you have already drawn this in greater detail than the contours from a DEM will be, i.e. input 20 m if you are having 20 m spaced contours.

25.09. Leave *Z factor (optional)* on the default value (1).

25.10. Then *OK* to start. *Contours...* scrolls around at the bottom right of the *ArcMap* display until finished. The *Layer* will then be shown in the *Table of Contents* and listed in the *Geodatabase* folder. It can be exported from here to another *Layer*, if required.

25.11. If you made a DEM from the contours, it is a useful exercise to remake the contours from the DEM, just to see the difference; a *lot* of detail is lost.

(26) Removing the 0 m contour level and separating the 100 m and 20 m contour levels

26.01. If your contour data has a 0 m level (a crude coastline) then it must be deleted. Further, maps generally differentiate the 100 m spaced contour lines from the 20 m lines (or 1000 m from the 100 m etc.) by different colours, line thickness or line style.

26.02. In *Catalog*, make a back-up copy of the complete contour file and keep it; never delete it. (See Sections 35 & 36 for how to copy a *Layer* or *Shapefile*).

26.03. Make another copy of the complete contour file in *Catalog*, name this 100m_contours and drag it across to the *Table of Contents*.

26.04. Make sure that the 100m_contours *Layer* is the only *Selectable Layer (Table of Contents → List by Selection)*.

26.05. Click on the 100m_contours *Layer* in the *Table of Contents*. Then *Editor → Start Editing →* select the 100m_contours *Layer* in the *Start Editing* window. In the *Create Features* window, you may have to make a new *Template* for the 100m_contours *Layer*.

26.06. In *Table of Contents → List by Drawing Order*, right click on the 100m_contours *Layer → Open Attribute Table*. This opens a *Table* window showing all the *Features* in that *Layer*, with their attributes.

26.07. In the *Table*, go with the mouse to the *ELEVATION* column. A small black downward pointing arrow appears. One left click and the column is marked with a blue background. Then double left click and the whole table is sorted, based on the *ELEVATION*.

26.08. Then go with the mouse to the far left and right click in the topmost row of the 0 m elevation data. Hold the right mouse down and drag it down through all the 0 m elevation data. It is not necessary to keep the mouse in the far left column whilst doing this. All the 0 m elevation data will get a blue background and the 0 m elevation line in the *ArcMap* display will go blue as well.

26.09. Then click on the black cross (which will also have a blue background) at the top of the *Table*. This will delete all the 0 m elevation data and the *Polylines* will be gone from the *ArcMap* display.

26.10. Repeat this process (24.08 to 24.09) for all data except the 100 m, 200 m, 300 m etc. data. All that will be left is the 100 m contour levels. Then close the *Table* (cross in top right corner).

26.11. Save another copy of the back-up file in *Catalog* (see 26.03) called 20m_contours. Then repeat the whole process in this, including deleting the 0 m contour, but this time delete the 100 m contour intervals and leave the 20 m intervals.

26.12. If the coastline you drew and the 0 m contour level did not match perfectly, go around the coastline and check that the 20 m and 100 m contours do not go outside the coastline you drew (i.e. into the sea). If they do, manually move the *Polylines* so that they are inside the coastline. This is a ‘fudge’ but it is the best you can do.

26.13. In the *Table of Contents* make the two different interval contour *Layers* (20 m and 100 m) different (different colours/different line thicknesses or line styles (see Section 15.21).

(27) Converting contours to a DEM

27.01. If you are making a DEM from contours, note that your coastline is most unlikely to be exactly the same as the 0 m contour of the contour data set. However, you can delete the 0 m contour level (see Section 26) and add your coastline data to the remaining contour data in the *Table of Contents* (see Sections 35 & 36 for combining data from different *Layers*). Check the

coastline *Layer* you drew has Z (*Elevation = 0 m*) data; if it does not, add the *Elevation* (see Section 38).

27.02. Even then, some gaps will occur between the DEM created and the coastline, and these will be carried into the *Hillshading*. To ensure that there are no gaps, draw a very crude *Polyline* with as few segments as possible ca. 0.5 km offshore from the coast (I call this the 'offshore line'), with an *Elevation* of 0 m, in the coastline/contour *Layer* that is to be used to make the DEM. This will force the DEM (and so later the *Hillshading*) to be extended to well offshore from the coastline. The excess material, lying outside the coastline then has to be masked with a white overlay (see Section 30). If you are working inland, extend the contours for ca. 0.5 - 1 km beyond the map area you are interested in to ensure the DEM/*Hillshading* covers the whole area you are interested in.

27.03. If the contour data you obtained is not in the same coordinate system as the map you are drawing (i.e. you have to do a *Transformation* every time you drag it into the *Table of Contents*) then you have to create a data set with the correct coordinate system. This is done easily, by making a copy in *Catalog* of your coastline *Layer* and pasting the contour data into this, in the *Table of Contents.*

27.04. Open the *Arc Toolbox* window. Go to *3D Analyst Tools* → *Raster Interpolation* → select *Topo to Raster*. This opens the *Topo to Raster window*.

27.05. In this window, drag the combined contour + your coastline + offshore line *Layer* into *Input feature data*. This will then come up in the *Feature layer* column. For this data set, set the *Type* to *Contour* (click in the box in that row and a window will open → tick on the small black triangle to get the options). Similarly, set the *Field* to *Elevation*.

27.06. Drag the offshore line (alone) as a ***Polygon*** into *Input feature data*. It will come up in the *Feature layer* column. For this data, set the *Type* to *Boundary*. There is no *Field* input for *Boundary*; leave it blank. (See Section 17 for converting *Polylines* to a *Polygon*.).

27.07. In *Output surface raster*, browse for the project *Geodatabase* (use the *Go to Home Folder* symbol) and input the *Name:*. *Save* to close the window.

27.08. In *Output cell size (optional)*, give the spacing of the contours.

27.09. Leave *Margin in cells (optional)* on the default.

27.10. Set *Smallest z value to be used in interpolation (optional)* to 0.

27.11. Then *OK* to start the conversion. In the bottom right corner of the *ArcMap* display, *Topo to Raster*… will scroll around with a percentage showing how much has been done.

27.12. When finished, it will appear in the *Table of Contents*. Depending on what image appears, some adjustments may be necessary. Right click on the DEM *Layer* in the *Table of Contents* → *Properties*. In the *Layer Properties* window, check the following are set properly:

27.13. In *Symbology* → *Show*, select *Stretched*.

27.14. This should automatically change the *Color Ramp* in *Symbology* to a white to black gradational scale. If it does not, use the small black triangle in the *Color Ramp* box to open the options. Take the second one down from the top.

27.15. In *Display → Resample during display using:*, check it is on *Bilinear Interpolation (for continuous data)*. This smooths the data, so that the pixels are not seen.

27.16. In *Display*, adjust the *Contrast* and *Brightness* to show the topography best. Note that you can input negative numbers to reduce the contrast or brightness.

27.17. If the DEM comes out as a uniform grey colour, right click on the file in the *Geodatabase* in *Catalog*. Select *Properties*. In the *Raster Dataset Properties* window, scroll down to *Statistics*. If none are there, open the *Options* and select *Build Statistics*. This will open the *Calculate Statistics* window. The file name should already be in *Input Raster Dataset*. *OK* to build statistics.

27.18. If that does not work, right click on the DEM *Layer* in the *Table of Contents → Properties*. In the *Layer Properties* window → *Symbology*. Here, in *Stretch → Type:* select *Standard Deviations*. Click *Yes* in the *Compute Statistics* window. Then *Apply* in the *Layer Properties* window. Then *OK* when the conversion is finished.

27.19. Ensure that the DEM fills the whole area inside the coastline. If it does not, move the 'offshore line' farther offshore where necessary (or extend the contours further in an inland area).

(28) Converting contours to a TIN and then to a DEM

28.01. If you cannot make a DEM directly from the contours, you can make a *TIN* (*Triangular Irregular Network*) first and convert that to a DEM.

28.02. Use the combined contour+coastline *Layer* described in Section 27. It is not necessary to make an offshore line.

28.03. To make the TIN: *ArcToolbox → 3D Analyst Tools → TIN Management → Create TIN*. This opens the *Create TIN* window.

28.04. Left click and drag the combined contour+coastline *Layer* into the *Input Feature Class (optional)* box in the *Create TIN* window.

28.05. In the *Spatial Reference (optional)* box click on the symbol on the right. This opens the *Spatial Reference Properties* window. *Select* or *Import* the correct spatial reference (check you have the right one). Then *Apply*, *OK*.

28.06. In the *Output TIN* box, browse for the location folder where you want to store the TIN.

28.07. Click on *Environments*, in the *Create TIN* window. This opens the *Environment Settings* window. Here click on *Raster Analysis*. Click on the small black triangle by *Cell Size*. The smaller the *Cell Size*, the better the quality of the TIN and hence the DEM and finally the *Hillshading*. From the list, select *As Specified Below* and input the number you want in the box below. 10 or less is generally fine. Then *OK* to close the *Environment Settings* window.

28.08. Then *OK* in the *Create TIN* window. In the bottom right of the *ArcMap* display, the words *Create TIN...* will scroll through continuously, until a box with a tick showing the TIN has been created will appear briefly.

28.09. The TIN will build (literally) itself in the *ArcMap* display. Scroll in and out to see the triangles as the TIN reforms. Now *Save*.

28.10. The output TIN *Layer*, when opened in the *Table of Contents* will have a series of boxes of different colours with numbers beside them, representing elevation ranges. If these values are all 0 (zero) it means that there is an error in the data and hence the DEM and *Hillshading* will not work. This is especially likely if the data was derived from more than one original source, such as drawn coast and imported contours. For Kythnos, the only solution was to delete the coastline that I had copied into the contour data set and trace the entire coastline into the contour data set. This then worked.

28.11. To make the DEM from the TIN, do *Arc Toolbox* → *3D Analyst Tools* → *Conversion* → *From TIN* → *TIN to Raster*. This opens the *TIN to Raster* window.

28.12. In the *TIN to Raster* window, left click and drag the TIN file from the *Table of Contents* to the *Input TIN* box.

28.13. In the *Output Raster* box in the *TIN to Raster* window, use the browse symbol to open the *Output Raster* window. Click on the *Go to Home Folder* symbol (the house). In the *Home* folder, double left click on the *Geodatabase* (Kythnos_database.gdb). Leave other options on the default.

28.14. In the *Sampling Distance (optional)* box, click on the small black triangle. Select *Cell Size*. Then in the box, correct the text *Cellsize* to a value < 10. Maybe the same size as used in making the TIN. Then *OK* in the *TIN to Raster* window.

28.15. In the bottom right of the *ArcMap* display, *TIN to Raster*… scrolls around and then a box with a tick, showing that the conversion has worked, appears. The DEM (the Raster) will open in the *Table of Contents*.

28.16. You can remove the black background by right click on the DEM layer in the *Table of Contents* → *Properties* → *Symbology* → tick on *Display Background Value* → and then in *as* choose white.

(29) Creating *Hillshading* from a DEM

29.01. Open the *Arc Toolbox* window. Then, *3D Analyst Tools* → *Raster Surface* → *Hillshade*. This opens the *Hillshade* window.

29.02. In the *Hillshade* window, left click and drag the DEM raster into the *Input raster* box.

29.03. In the *Output raster* box, use the folder symbol to open the *Output raster* window. Browse for the project *Geodatabase* (Kythnos_database.gdb), double click on it, so that this lies in the *Look in*: box. Give the DEM a *Name:* e.g. Kythnos_TIN_DEM_hillsh. *Save* to close the *Output raster* window.

29.04. *Azimuth* and *Altitude* (the direction from which the sun shines to make the shade effect) can be changed later (see 29.10).

29.05. Click on *Environments* in the *Hillshade* window. This opens the *Environment Settings Window*. Open *Raster Analysis*. In *Cell Size*, use the small black triangle to open the list of options. Select *As Specified Below*. In the box below, specify the same value as used in making the DEM. *OK* to close the *Environments Settings* window.

29.06. *OK* in the *Hillshade* window.

29.07. *Hillshade*… scrolls around with a percentage value that increases. Then a box tells you the *Hillshading* is finished. The finished *Hillshade* will appear in the *ArcMap* display.

29.08. In *Table of Contents*, right click on the *Hillshade Layer*. Click on *Properties* to open the *Layer Properties* → *Display*. In *Transparency* set a value of ca. 70 %. This makes the *Hillshading* transparent. You will have to test this to see which value is best for you. Then *Apply*, *OK*.

29.09. Then in *Layer Properties* → *Symbology*. In *Resample during display using:* select *Bilinear Interpolation (for continuous data)*. This removes the pixelated effect and makes the shading smooth. In the same window, increase the *Contrast* to 50% and set the *Transparency* to 80%. You will have to vary these numbers to see what is best for your map and personal style. You can press *Apply* in the window to see the effects of the change, without closing the window. Then *OK* to finish.

29.10. To change the direction the light is shining from in the *Hillshade*, right click on the map in the *ArcMap* display → *Properties*. This opens the *Data Frame Properties* window → *Illumination*. Here click on the sun symbols and move the *azimuth* and *altitude* of the sun to change the illumination direction.

29.11. The *Hillshade* effect will extend into the sea; this will be more extensive if a TIN was used earlier in creating the DEM for the *Hillshade*. This can be hidden by placing a white mask over the *Hillshade* (see Section 30).

(30) Putting a white mask around the map to hide excess DEM/*Hill-shading*

30.01 Making a DEM and *Hillshade* that covers fully the area wanted inevitably leads to the DEM/ *Hillshade* extending into areas outside the map area (into the sea, for an island such as Kythnos). This can be hidden by using a white mask. In CorelDraw, this takes 15 seconds to do.

30.02. Making a white mask in *ArcMap* takes a bit longer, but is worth doing, as having the DEM/ *Hillshade* extending beyond the map area (the coast) look bad in the *ArcMap* display.

30.03. Make a copy of the coastline *Layer* in the *Table of Contents* (e.g. coastline_whitebox). Then, in coastline_whitebox, draw a box around the island, as small as possible, but containing all the unwanted DEM/*Hillshade (Start editing* etc. and if necessary make a *Template*). Use the *Rectangle* tool in *Construction Tools* in the *Create Features* window.

30.04. Convert the coastline_whitebox *Layer* to a *Polygon* (see Section 17). This will make two *Polygons*. One will be the island defined by the coast; delete this. The other will be the area of the box with the shape of the island inside, cut out; keep this. (Note you will have to *Save Edits* → *Stop Editing* → *Start Editing* and select the output file from the *line to polygon* conversion before you can do the deletion. Also, check the layer is *Selectable*.) In *Layer properties*, convert this to having a white colour and a white boundary line. Place it above the DEM/*Hillshade Layer* and below the coastline *Layer*. The unwanted DEM/*Hillshade* material will now be hidden.

30.05. Delete the now unneeded original coastline_whitebox *Layer*.

(31) *Layout View* and enlarging/moving around in the image

31.01 This is the view of the map as it will be printed on whatever page size is defined. Page size is defined in *Command Bar* → *File* → *Print and Page Setup*. Best to set up the page size using the Adobe PDF as the printer unless you are connected to the plotter.

31.02. At the bottom left of the *ArcMap* display, there are four symbols; *Data View, Layout View; Refresh; Pause Drawing*. Up to now, you should have been drawing and constructing everything using *Data View* (see Section 12).

31.03. Select *Layout View*. If the *Layout Toolbar* is open the symbols will now be in colour (rather than grey) and can be used. Otherwise, open the *Layout Toolbar*. Although its use is described below, it is best not to use the *Tools Toolbar* when in *Layout View*; either drag it to one side or close it.

31.04. In *Layout View*, when the tools from the *Layout Toolbar* are used, symbols get larger and *Polylines* thicker when you zoom in: it is thus useful for seeing if your structural symbols etc. are the right size. *Polyline* thicknesses (of roads, coast etc.) can be changed in CorelDraw, but structural symbols cannot be.

31.05. Depending on the magnification set, opening *Layout View* will result in a frame with a black border appearing, containing whatever portion of the map was on view in *Data View*.

31.06. If you do not get the complete frame, then right click inside the frame in *ArcMap* display → *Zoom Whole Page*, where *Whole Page* means the complete area of paper to be printed, not the whole area of the map. Or click on the *Zoom Whole Page* symbol in the *Layout Toolbar* (fourth symbol from left).

31.07. If the whole map is not visible inside the frame, then right click inside the rectangle in *ArcMap* display → *Full Extent*. Or click on the *Full extent* symbol (the globe) in the *Tools Toolbar*.

31.08. If some of the base maps are too big in size, they should be converted to *Layer Files* (see Section 09) and then deleted from the *Table of Contents*.

31.09. *Pan* tools (the hand symbols). For both the *Tools* and *Layout Toolbars*, using the middle mouse with the *Pan* tool results in the whole map being moved at the same scale. If the middle mouse is held down without moving, arrows appear to show the direction of movement.

Layout Toolbar: With left click and hold, the *Pan* tool moves the whole page (map and frame) about within the *ArcMap display*.

Tools Toolbar: With left click and hold, the *Pan* tool moves the map about within the frame.

31.10. *Zoom in/Zoom out* tools (hand lens symbols). For both the *Tools* and *Layout Toolbars*, left click and drag out the area to be enlarged.

Layout Toolbar: This enlarges the whole page (map and frame) within the *ArcMap display*. Symbols get larger and *Polylines* thicker when you zoom in: it is thus useful for seeing if your formatting is good.

Tools Toolbar: This enlarges the map within the frame, but as in *Data View*, this does not result in *Polylines* becoming thicker etc.

If you mix the use of these two sets of *Zoom in/Zoom out* tools, strange magnifications of symbols and *Polylines* can occur.

31.11. Using the middle mouse wheel, you can zoom in and out. This enlarges the map and the frame. It makes no difference if you use the symbol in the *Tools* or *Layout Toolbar*.

31.12. To get the map to the required size in the box (to fit the box, i.e. the paper size), change the scale as shown in the *Standard Toolbar*.

31.13. Left click on the frame and it becomes a dashed line with blue boxes at the corners and in the middle of the edges. You can use the blue squares to make the margin fit the map better, i.e. to centre the map. Centring the map will then use this new frame shape.

(32) Adding a *North arrow, Scale Bar, Legend* and text in *Layout View*

32.01. To add a *North arrow* (this can be modified in CorelDraw later if needed), go to *Command Bar* → *Insert* → *North Arrow*. This opens the *North Arrow Selector* window.

32.02. In the *North Arrow Selector* window, scroll down and select the symbol you like best. The size, font etc. and even the symbol are best modified later in CorelDraw; all we need here is an accurate way of showing where North is on the map.

32.03. Similarly for a *Scale Bar*. *Command Bar* → *Insert* → *Scale Bar*. This opens the *Scale Bar Selector* window. Here select the *Scale Bar* you like best, since significantly changing it in CorelDraw is tedious. *OK* to close the window.

32.04. Then left click on the *Scale Bar* to activate it *Layout View;* a dashed blue line forms around it. Then right click on the *Scale Bar* in *Layout View* → *Properties*. This opens the *Properties* window for the selected type of *Scale Bar*. Ensure that the *Scale Bar* has a sensible length, with the desired number of subdivisions and the correct units. Getting the text correct here is not so important, as this can be done quickly in CorelDraw. Then *Apply, OK* to finish.

32.05. Similarly for a *Legend*. *Command Bar* → *Insert* → *Legend*. This opens the *Legend Wizard*. Here transfer across the data you want in the *Legend*. Then *Next* to do the font size etc., then *Next* to do a frame around the *Legend*, etc. etc. Then *Finish*.

32.06. In the *ArcMap* display, right click on the *Legend* → *Properties* to reopen the *Legend Properties* window if you want to change the layout.

32.07. Only *Visible Features* are shown on the *Legend*.

32.08. The *North arrow, Scale Bar* and *Legend* are not seen in *Data View*.

32.09. Add geographical text (towns, rivers etc.) in CorelDraw; it is very much easier there.

32.10. To add text in the *ArcMap* display, *Command Bar* → *Insert* → *Text.* If the text lies on the map, a white background can be placed underneath, if required. To do this, open the *Draw Toolbar*.

32.11. In the *Draw Toolbar*, use the small black triangle to open the fifth symbol from the left (a square or circle or ellipse etc.; it depends how it was left after the last use) and select the style you want.

32.12. With the cross that forms in the *ArcMap* display, drag out the frame shape you want over the text. Right click the frame → *Properties* to open the *Properties* window. Here select *Fill Colour* and *Outline Color* and *Width*. Then *OK*.

32.13. The frame will now lie above the text. Right click in the frame → *Order* → *Send to back*. The frame may now lie under the *Grid*, so right click on the *Grid* → *Order* → *Send to back*. This puts the *Grid* below the frame, which is now visible, under the text.

32.14. Close the *Draw Toolbar*.

(33) Adding a *Grid*

33.01. A *Grid* is important and must be included.

33.02. Right click on *Layers* at the top of *Table of Contents* → *List By Drawing Order* → *Properties.* This opens the *Data Frame Properties* window. Select *Grids.*

33.03. Select *New Grid*. This opens the *Grids and Graticules Wizard* window.

33.04. In the *Grids and Graticules Wizard* window and further on, it is a matter of a wide range of options that reflect personal style as much as anything else.

Graticule gives you degrees, minutes, seconds.

Measured Grid gives you UTM coordinates; this is generally best since the grid lines are spaced at regular (km or fraction of a km) based intervals.

Reference Grid gives a non-georeferenced grid which is not useful for most geological maps (but good for very detailed local mapping using quadrats).

Give a *Grid name*; make it descriptive if you have more than one *Grid*. Then *Next.*

33.05. In the *Create a measured grid* window (assuming you chose *Measured Grid* in 33.04):

Appearance: Choose what you want. For *Tick* marks and *Labels* you get a cross where the grids intersect (this does not always appear on the example map).

Coordinate System: By default this should be on the one you are using. Change it if you want to show a different one. Use *Properties* to change the system.

Intervals: This is the spacing of the *Grid* in metres.

Then *Next*.

33.06. *In the Axes and labels* window:

Select *Major Division Ticks* and *Subdivision Ticks* as wanted. To open the *Symbol Selector* window click on the line to the right, under *Symbol Selector*. Here you can set colour and line thickness. Click *Edit Symbol* to open the *Symbol Property Editor* window. In some of the options in *Properties* → *Type, a Template* option is given. This controls the spacing between dashes in a dashed line. Then *OK, OK* to get back to the *Axes and labels* window. Note that you can have a dashed line in the *Simple Line* option (click on the small black triangle), but you cannot control the spacing. *OK, OK* to get back to the *Axes and labels* window.

Click on the *AaBbCc*…in *Labelling* → *Text Style* to open the *Symbol Selector Window*. Select as required. Select font, font size, bold etc. Click *Edit Symbol* to open the *Editor Window*, to get more options. *OK, OK* to get back to the *Axes and labels* window. Then *Next*.

33.07. In the *Create a measured grid* window:

Choose a *Measured Grid Border* (you can add a *Neatline* later; see Section 34).

In *Grid Properties,* select *Store as a fixed grid that updates*….

Then *Finish*.

33.08. Having done this, you have to modify the *Grid.* In the *Data Frame Properties* window → *Grids*. Tick the *Grid* to be altered → *Properties*. This opens the *Reference System Properties*

window. (Similarly, if you later want to modify a *Grid* later, open the *Data Frame Properties* window → *Grids*.)

Axes: Decide how many *Subdivision Ticks* you want. Select where you want the ticks at the border (*Top, Left* etc. of the frame), if you want ticks inside or outside the frame and the tick size. Click on the lines beside *Symbol* to open the *Symbol Selector* windows. Here you can define the line/tick thicknesses. Set the *Tick size* in both *Major Division Ticks* and *Subdivision Ticks*.

Labels: Again define where you want the numbers, and the *Grid Label* font, the font size etc. In *Label Style* → *Mixed Font*. *Label Offset* controls how far the text is from the margin of the map. The value should be bigger than the length of the *Major Division Ticks* (in *Axes*).

In *Labels*, click on *Additional Properties.* This opens the *Grid Label Properties* window. Make the font, colour and size the ones you want. Then click on *Number Format.* This opens the *Number Format Properties* window. In *Numeric*, set the *Number of decimal places* to the number needed. (Otherwise you get a grid number 4173823^{000000} where the superscript numbers are the decimal places. Since the grid is every whole kilometre or a part of a kilometre, not all these decimal values are required.)

Then OK, OK.

Lines: Here you can set the style of line (continuous, ticks where the lines cross, or no line). Click on the line by *Symbol* to open the *Symbol Selector* window. Here set the *Grid* colour and line thickness. *OK* to close the *Symbol Selector* window.

System: This controls the coordinate system.

Intervals: Here you can set how far apart the grid lines should be and also define the origin of the lines.

Apply, *OK* to close the *Reference System Properties* window.

Then *Apply* in the *Data Frame Properties* window. Then *OK* to finish.

33.09. Note that *Grids* can be deleted in the *Data Frame Properties* window → *Grids*. Select the *Grid* and then *Delete*.

33.10. The lines of the *Grid* cover the whole area of the sheet. This cannot be avoided. To remove *all* unwanted (by me anyway) parts of the *Grid*, you can shorten them in CorelDraw.

33.11. You can draw a white box around text that overlies the *Grid* and underlies any text you have; see Section 32.11.

33.12. Or you can have white *Grid*.

33.13. The *Grid* is not seen in *Data View*.

(34) Adding a Neatline

34.01. A *Neatline* (just a border around the map) is a matter of taste.

34.02. In *Layout View*, go to *Command Bar* → *Insert* → *Neatline*. This opens the *Neatline* window.

34.03. Here follow the very simple instructions to put a *Neatline* around the map.

(35) Copying a *Layer* or *Shapefile*

35.01. A *Layer* can be copied and pasted in the *Table of Contents* → *List by Drawing Order*. Just select the *Layer*, right click → *Copy*. Then right click on *Layers* or on a *Group Layer* → *Paste Layers*. You do not have to paste to the same *Layer* you copied from. This is essentially the same as dragging the *Shapefile* from *Catalog* to the *Table of Contents* again. The new *Layer* will not appear as a *Shapefile* in *Catalog*. With this method, however, any *Edits* made in the copied version of the *Layer* will also appear in the original version.

35.02. A proper copy can be made in *Catalog*. Right click on the *Shapefile* in *Catalog* → *Copy*, then right click on the folder where it is to be pasted in *Catalog* → *Paste*. The *Shapefile* can then be dragged to the *Table of Contents*. If you make the copy in the same *Shapefile*, it will automatically be called XxxxCopy. Note that you can copy a *Shapefile* in *Catalog* even if the *Shapefile* is active in the *Editor* but it cannot be deleted whilst the original *Shapefile* is still active in the *Editor*, so *Save Edits* → *Stop Editing* first.

(36) Copying *Polyline (Line)* or *Polygon* data from one *Layer* to another *Layer*

36.01. Copy and paste can also be used to transfer or add data from one *Layer* to another in the *Table of Contents*. But remember that if you make a copy of the *Layer* into which you want to copy data, this should to be done at the *Shapefile* level, in *Catalog*.

36.02. Copy and paste will only work if the data are the same (the *Target Geometry type* must be same as that of the source of the data). That is, you cannot copy and paste data that have different data in their *Attribute Tables* (like orientation data and contour data).

36.03. The *Merge* function can be used to combine lines with different data in their *Attribute Tables*, with the output formed in the project *Geodatabase*. *Command Bar* → *Geoprocessing* → *Merge*. This opens the *Merge* window. Here drag into the *Input Datasets* box the files to be merged. In *Output Dataset*, click on the folder symbol to the right and in the *Output Dataset* window browse for the project *Geodatabase* in *Look in*. Then give the output data a *Name*. In the *Field Map (optional)* you can decide which data you want in the *Merge* dataset. Then *OK*.

36.04. A *Merge* window will open with the percentage of the *Merge* done. When finished, it will say *Completed*. Close this. The *Merge* file will appear in the *Table of Contents* and in the *Geodatabase*. The *Attribute Table* will show a complete range of data, but many will be empty or have <*Null*> in them.

(37) Finding the data (e.g. after copying the *Project Folder* to another folder/computer)

37.01. If you open the Project and find that one (or more) *Layer* has a red exclamation mark (!) to the right of the box in *Table of Contents* and cannot be seen in the *ArcMap* display, it means that the Project has lost the connection to the data. This may happen if you move the *Project Folder* within your computer and will happen if you copy it to another computer.

37.02. Right click on the *Layer* in the *Table of Contents* → *Properties*.

37.03. In the *Layer Properties* window → *Source* → *Set Data Source*. This opens the *Data Source* window.

37.04. In the *Data Source* window → *Go to Home Folder* (the House symbol). Double click on the folder with the data. This will go to *Look in:* and all the *Shapefiles* (.shp) in that folder will appear in the box below.

37.05. Click on the required *Shapefile* in the box. It will appear in *Name:*.

37.06. Then *Add*, and the *Data Source* window will close.

37.07. *Apply, OK* in the *Layer Properties* window. The red mark should have gone from the *Table of Contents* and the data should be visible in the *ArcMap* display.

(38) Adding a new *Field* (column of data) to the *Attributes* of a *Layer* (in the *Attribute Table*)

38.01. *Save Edits* and *Stop Editing*. New *Fields* cannot be added when the *Editor* is on.

38.02 Right click on the *Layer* in the *Table of Contents* → *Open Attribute Table*.

38.03. In this *Table*, left click on the small black triangle by *Table Options* (the symbol on the far left). In the list, click on *Add Field*.

38.04. In the *Add Field* window, give the name of the data in *Name:*. Make sure this is the correct one for the data type you want to add; look in another *Attribute Table* to check this.

38.05. In *Type:* select the data type (for Elevation, *Short Integer* is correct).

38.06. In *Field Properties*, leave the *Precision* at 0 unless you understand this option better.

38.07. Then *OK* to close the *Add Field* window.

38.08. In the *Attribute Table*, you can now manually type in the values you want in the new *Field*.

38.09. Then close the *Attribute Table*.

(39) Exporting *ArcMap* to CorelDraw and then to PDF to print the map

39.01. This is tedious but easy. Before doing it:

A. Ensure that every *Layer* in *ArcMap* has an obviously different colour, since the data will later be separated into layers in CorelDraw using the symbol colours. (Or ensure alternate *Layers* have obviously different colours.)

B. If you have drawn a white mask around a DEM/*Hillshading* (see Section 30), give it a visible colour so you can see it during the reorganisation of the data in CorelDraw.

C. Draw a *Polyline* (I call this a *Positioning line*) in *ArcMap* that lies just outside the maximum size of all parts of the project map (including a white mask), in both the N-S and E-W direction; one diagonal *Polyline* is OK. Draw this in a new *Layer* in *ArcMap*. The *Positioning line* is used in combination with the Snap to Guidelines (Hilfslinie) in CorelDraw to ensure that each layer is positioned in exactly the same place relative to the other layers. This is especially important if you later add more

layers to the CorelDraw figure; they will be in the correct position relative to the earlier exported layers. Do NOT trust the coastline (or anything else) to be copied from *ArcMap* to CorelDraw in exactly the same way each time you export it (i.e. you cannot use the coastline to do this accurately).

D. Get the image set up and centred in *Layout View* (see Section 31) with the *North arrow*, *Scale Bar*, *Legend* and *Grid* included (see Sections 32, 33).

39.02. In *ArcMap*, in *Layout View* → *File* → *Export Map*.

39.03. This opens the *Export Map* window. In *Save in:* select where the map is to be saved (in the *Project Folder*). In *File Name:* give the name of the file to be saved (Kythnos_map). *Save as type EPS*. (Don't worry about the text *No items match your search*.)

39.04. In *Options* → *General*

Resolution: To get a good resolution on complicated *Polylines* (coast, rivers), use *2,400* dpi. Check how well these come out in CorelDraw, later.

Output Image Quality → *Best.*

Ratio 1:1.

39.05. In *Options* → *Format.*

Destination colourspace → *RGB* or *CMYK* as you wish.

Image Compression → *None*.

Picture Symbol → *Vectorize layers with bitmap marker fills*.

Leave the other options on the default.

39.06. Ignore *Advanced Options*. Then *Save*.

39.07. In CorelDraw → File → New.

39.08. In CorelDraw → File → Import. Browse for saved map → Import.

39.09. In CorelDraw, in Import Options, select Import as Editable, Import Text as: - Text. OK.

39.10. In CorelDraw, open the Object Manager (found under Tools).

39.11. Of the three Icons at the top of the Object Manager window, select the one on the right (Layer Manager View).

39.12. In the now opened Layer Manager View, In Page 1, open Layer 1 and then open the layer with the map (Kythnos_map). This will list separately *every single object on the map*; each structural data symbol will be separately listed.

39.13. In the Object Manager window, right click on the layer map name (Kythnos_map) In CorelDraw → Ungroup. The map name layer will disappear and everything will be in Layer 1.

39.14. Then select all the objects of one type (one colour), then cut them from that Layer 1 (use Strg_X to cut). My suggestion is to start with complex *Polylines* (rivers, roads, coastline) to see if they come out well. If not, do the whole export again using a higher dpi.

39.15. Create a new layer in CorelDraw (bottom left Icon in the Object Manager window).

39.16. Paste the objects you cut to the new layer and give the layer its proper name (Fold axes, coastline etc.).

39.17. Repeat until all the data have been moved from Layer 1. Save regularly during this process.

39.18. Check all *Positioning lines* (see Section 39.01 C) are correctly placed using the Guidelines in CorelDraw.

39.19. Now check that data symbols (fold axes, current ripples etc.) are not overlapping and that the numerical data (dip angle) are also not mixed up. If there is too much data at one outcrop, decide what is best and copy the excess to another, not printed layer in CorelDraw.

39.20. When the map is finished in CorelDraw, save it with Fonts Embedded and then print it to Adobe PDF. The plotter processes and prints a PDF much faster than a CorelDraw file.

39.21. Print the map first at A3 size (use the Fit to Page option in the printer) to get an overall impression of the layout before printing a large (perhaps A0) version.