

Introduction to Planetary Image Analysis With ArcGIS®

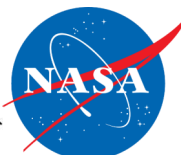
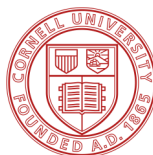
Exercise Workbook

Presented by the

Spacecraft Planetary Imaging Facility (SPIF), Cornell

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All data for the exercises can be downloaded here:
<https://tinyurl.com/SPIFArcGIS-ExerciseData>

Save the “ExerciseData” folder in the “ArcGIS” folder that was created upon installation of the software. Do not change the names of any of the folders or file names.

Please contact SPIF at spif@astro.cornell.edu with any questions or issues.



Workspace basics

Introduction to ArcGIS

Exercise 1A: Working in ArcCatalog

Estimated time: 15 minutes

Exercise 1B: Working in ArcMap

Estimated time: 25 minutes

Chapter 1: Workspace basics

Introduction

In this exercise you will learn the basics of how ArcCatalog™ and ArcMap™, which are two of the applications in the ArcGIS® Desktop suite of software. In ArcCatalog you will see how to create databases, organize data, preview data, and get information about data (metadata). In ArcMap you will see how a map document is structured and how to navigate through map elements in both Data View and Layout View. You will also see how to perform certain functions of ArcCatalog from within ArcMap by using the Catalog Window.

Objectives

- Create a geodatabase in ArcCatalog
- Explore data using previews and metadata in ArcCatalog
- Access ArcCatalog from within ArcMap
- Load a map document
- Explore the map document structure in Data View
- Explore the map document structure in Layout View

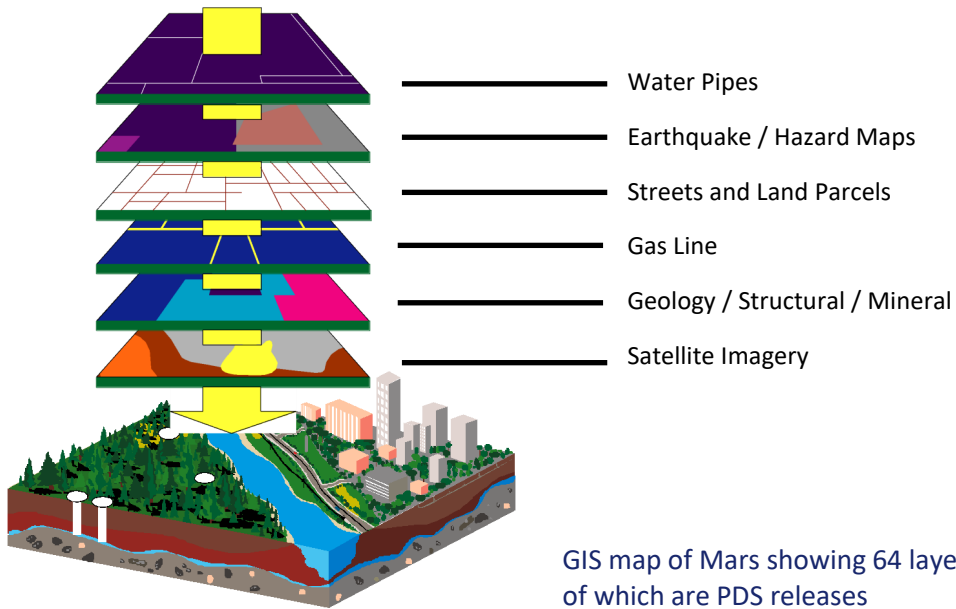
Terms

- Geodatabase
- Feature Dataset
- Metadata
- Map Document
- Data Frame
- Layer
- Data View
- Layout View

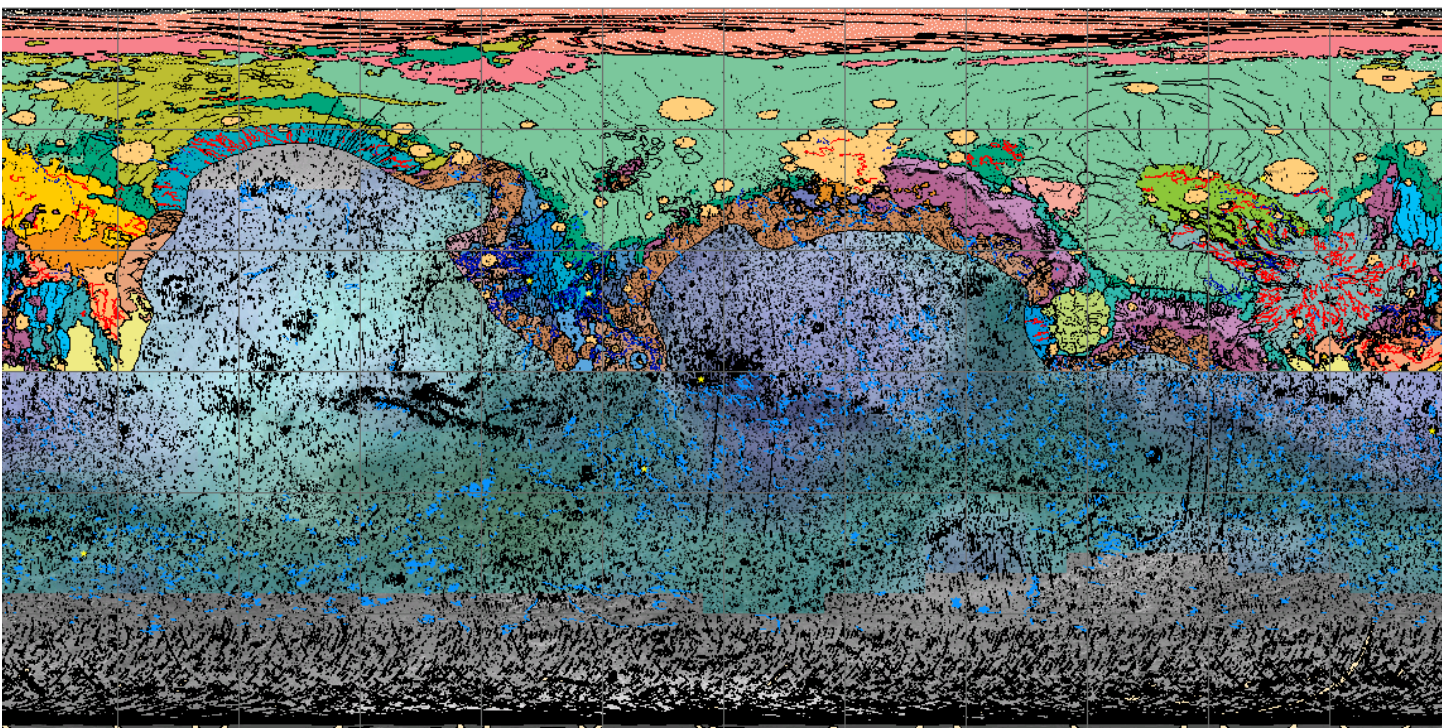
Introduction to ArcGIS

What is ArcGIS?

- GIS stands for Geographic Information Systems
- Tool used for mapping; 2D and 3D Modeling; Geographic Analysis; Storage, Organization, and Processing of ANY spatial data, or data related to location; etc.
- Integrates spatially related information in the form of layers



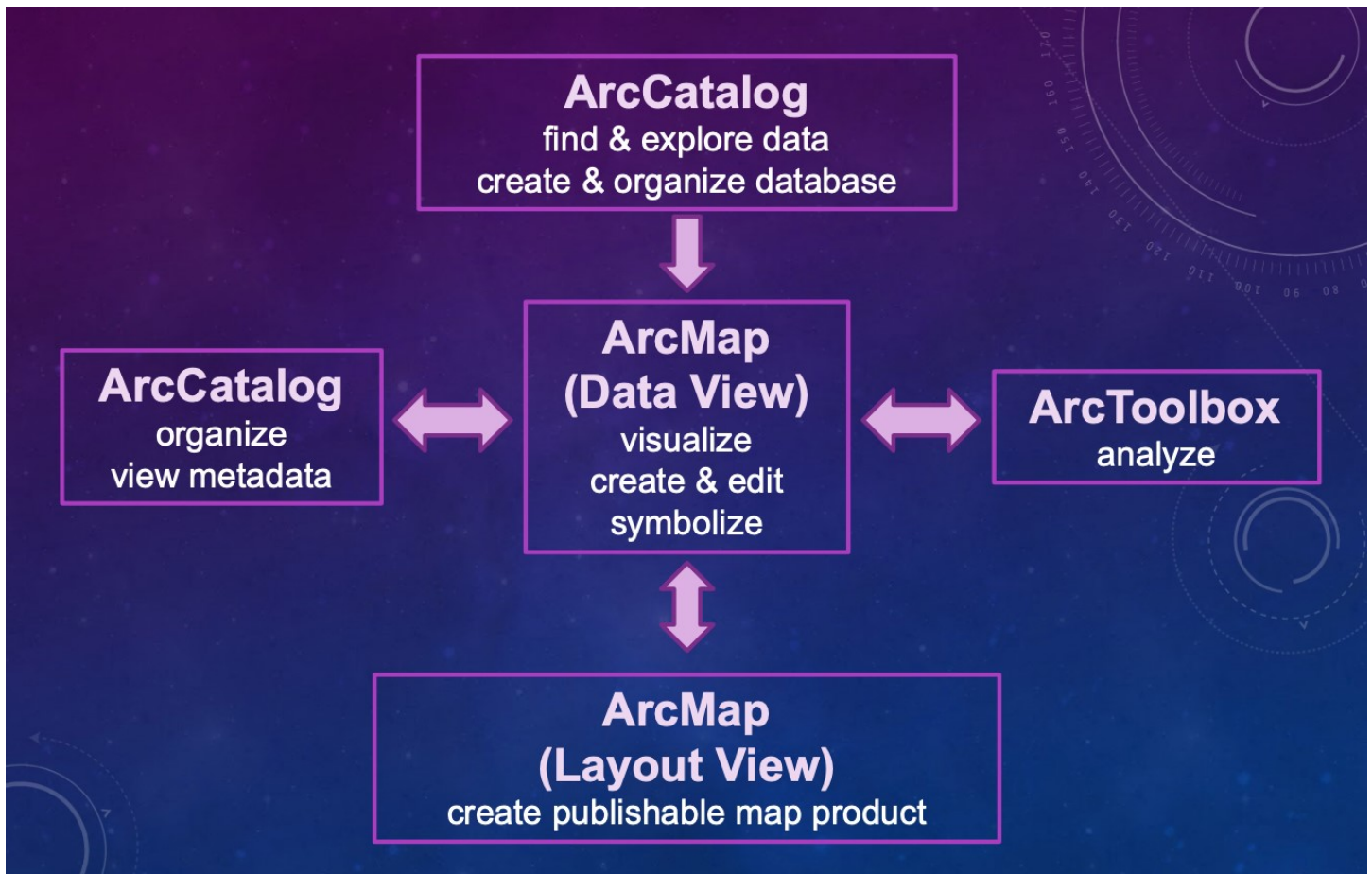
GIS map of Mars showing 64 layers, many of which are PDS releases



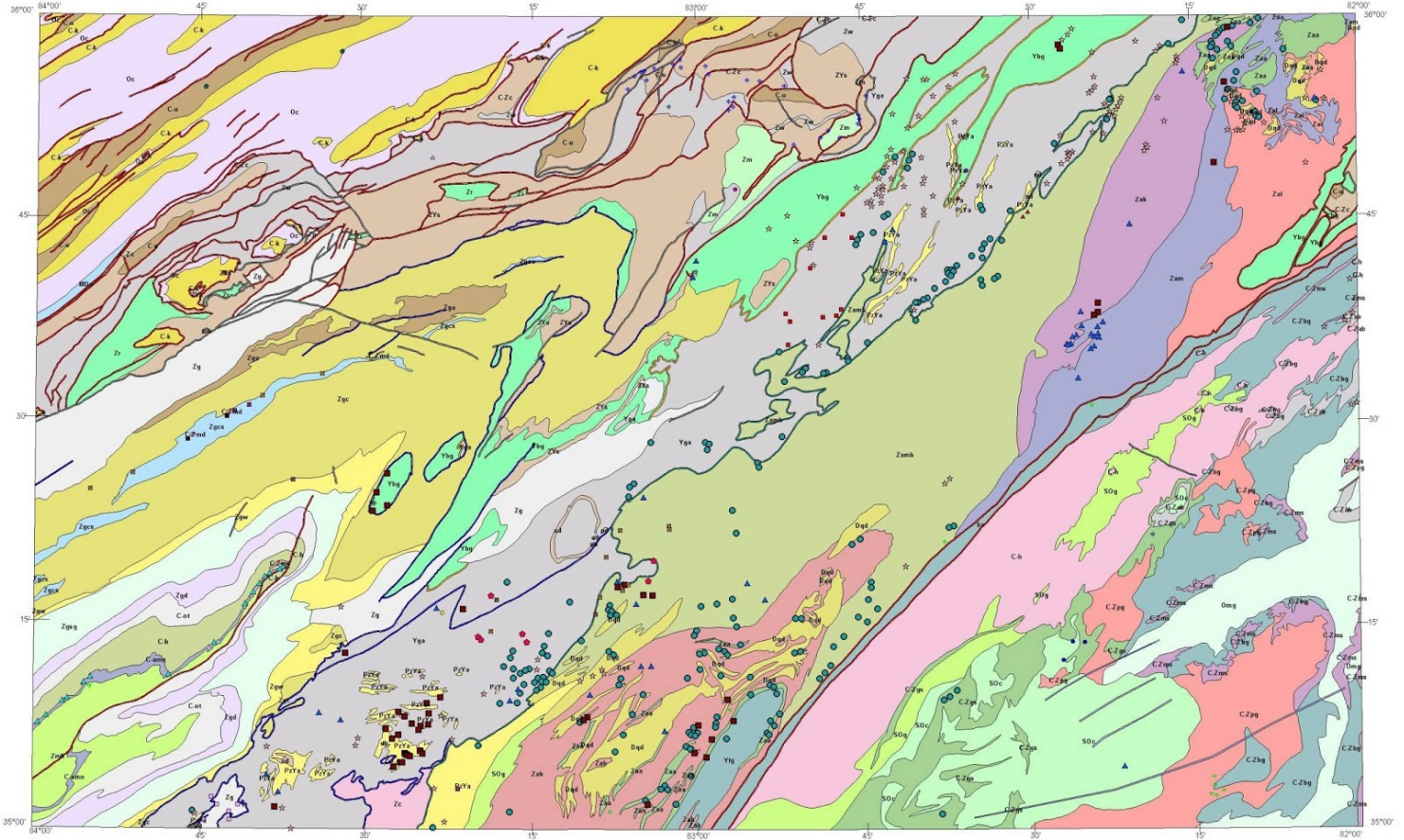
Components of ArcGIS Desktop

- ArcMap
 - Where most of the work is done
 - Used to visualize, explore, and analyze data
- ArcCatalog
 - Similar to Windows Explorer or Mac Finder, but specifically designed for ArcGIS
 - Used to find, explore, and organize data
- ArcToolbox
 - Contains (extra) tools for organizing, displaying, and analyzing data
 - Custom tools can be created using Python
- Others
 - ArcGlobe and ArcScene: used for 3D visualization
 - Model Builder: used to create customized tools and multiple iteration workflows

Typical ArcGIS Workflow



Final Goal: Analysis Results and Publishable Map



LEGEND:

<p>Rock Deposits:</p> <ul style="list-style-type: none"> ● Corundum-bearing rock ● Dunite and peridotite ▲ Metaultramafic rock ▲ Murphy talc ■ Pyroxenite ★ Talc schist 	<p>Mineral Deposits:</p> <ul style="list-style-type: none"> ■ Ag/Au, Cu ■ Ag/Au, Cu, Pb, Zn ● Barite +/- metal/flourite vein ● Base-metal +/- barite vein ■ Cu ● Cu, Zn ● Low-sulfide quartz-Au vein ● Mississippi-Valley type Pb-Zn ■ Pb 	<ul style="list-style-type: none"> ● Rare-earth pegmatite ▲ Stratabound Fe-REE ▲ Stratabound Mn (carbonate) ▲ Stratabound W (scheelite)-Sn ■ Stratabound rutile ● Syenite pegmatite w/ Zr/REE ● Ti-REE veins ● Ultramafic PGE/Au 	<p>Faults:</p> <ul style="list-style-type: none"> ▬ Postmetamorphic thrust/Late Paleozoic ▬ Synmetamorphic thrust/Mid Paleozoic ▬ Premetamorphic thrust/Early Paleozoic ▬ Premetamorphic thrust/Mid-Late Proterozoic ▬ Silicified Breccia ▬ Other
--	---	--	--

0 10 Kilometers

N

Bedrock Lithology Units:
 Bold Lettering: (eg. "Zgc")
 See Table in Report for Unit Descriptions

<p>Valley & Ridge and West Flank Blue Ridge:</p> <ul style="list-style-type: none"> MDu Oc C-k C-u C-Zc 	<p>Central and West Flank Blue Ridge:</p> <ul style="list-style-type: none"> C-b C-nt C-amn Zmb Zw Zg Zgd C-g Zgsg Zgw Zgc Zgcs Zga Zr ZYs 	<p>East Flank Blue Ridge:</p> <ul style="list-style-type: none"> Zal Zam Zak Zamb Zab Zaa Ytg Zc Yga PzYa Dqd SOg ud up C-Zmd Zm 	<p>Inner Piedmont:</p> <ul style="list-style-type: none"> bz C-Zbg C-Zms C-Zab C-Zpg C-Zgs SOc Omg C-h
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Types of Data

- Vector
 - Geometric features such as points, lines, and polygons
 - Stores geometry, spatial data, and unlimited additional information for each feature (numerical, descriptive, images, hyperlinks)
- Raster
 - Image files, or other similar data
 - Array of cells (pixels), each with location in the array and a single numerical value, possibly spatial data (coordinate systems)
- Map
 - Contains information for how to display data
 - Order of layers, symbols and colors, labels, projections

Common File Types (More Information in Quick Reference Guide and Appendix)

- Geodatabase (*.gdb)
 - ArcGIS file structure for storing, organizing, and sharing data with other ArcGIS users
- Image File, Raster
 - Common: TIFF (regular or GeoTIFF), JPEG, JPG2, PNG, BMP, GIF, etc.
 - Dataset specific: SAR, SRTM, DEM, DOQ, LAS, many more
- Shapefile (*.shp), Feature Class
 - Stores spatial and geometric data for features
- Map Document (*.mxd), Layer (*.lyr)
 - Stores information for how to display data
 - Does NOT store any source data
- Packages (*.lpk, *.mpk)
 - Stores both display instructions AND source data
 - Good for sharing with other ArcGIS users who do not have access to your geodatabase

Coordinate Systems and Projections

- Anytime you are modeling a curved surface (planet, moon, etc.) as a flat surface (map displayed on paper or a screen), all cartographic issues are present and must be considered!
- Geographic Coordinate Systems
 - Longitude and latitude measured from a planet's center
 - Requires a defined prime meridian

- ArcMap will display in angular coordinates
- Projected Coordinate Systems
 - Takes latitude and longitude and datum and converts it to a flat array
 - Points are assigned orthogonal positions with a defined origin
 - ArcMap will display in linear units
- Measurements
 - Distortions are UNAVOIDABLE; all measurements are APPROXIMATIONS
 - If data only have a geographic coordinate system, geometric measurements will be inaccurate or not useful (lengths and areas in degrees)
 - If data are projected:
 - Planar measurements assume the surface is truly flat
 - Geodesic measurements assume a curved shape based on the datum

Tips, Tricks, and Quirks

- ArcGIS hates spaces and special characters, so file and folder names must be alphanumeric with no spaces, BUT, aliases (nicknames, shortcuts and labels) can have any characters
- ArcCatalog within ArcMap is not great at refreshing itself, and sometimes even telling it to refresh doesn't work
- It is not uncommon to get the "Not Responding" error message across the top of the window in ArcGIS, however, unlike most programs, ArcGIS tends to recover on its own
- Geodatabases: feature classes must be INSIDE, shapefiles must be OUTSIDE
- Copying and pasting features doesn't always work well, but there are workarounds
- There are usually multiple ways of doing things (menu, button, keyboard shortcut, etc.)
- Sometimes a tool will appear to run but the output is absent or junk, despite not getting an error message (check the Result window)
- Accessing ArcCatalog from within ArcMap has limitations, since file structures in use by ArcMap cannot be altered in the Catalog window
- If the data used in a layer is edited in one ArcMap session, the results are reflected in all other ArcMap documents where that data is used
- Once the projection of a data frame is set, data can be added as layers even if they do not share that projection (ArcMap will "project on the fly" for the sake of display), but working with these layers without re-projecting them can give error messages
- Even within a given coordinate system, there can be inconsistencies in display, such as longitude ranges of -180° to 180° vs. 0° to 360°

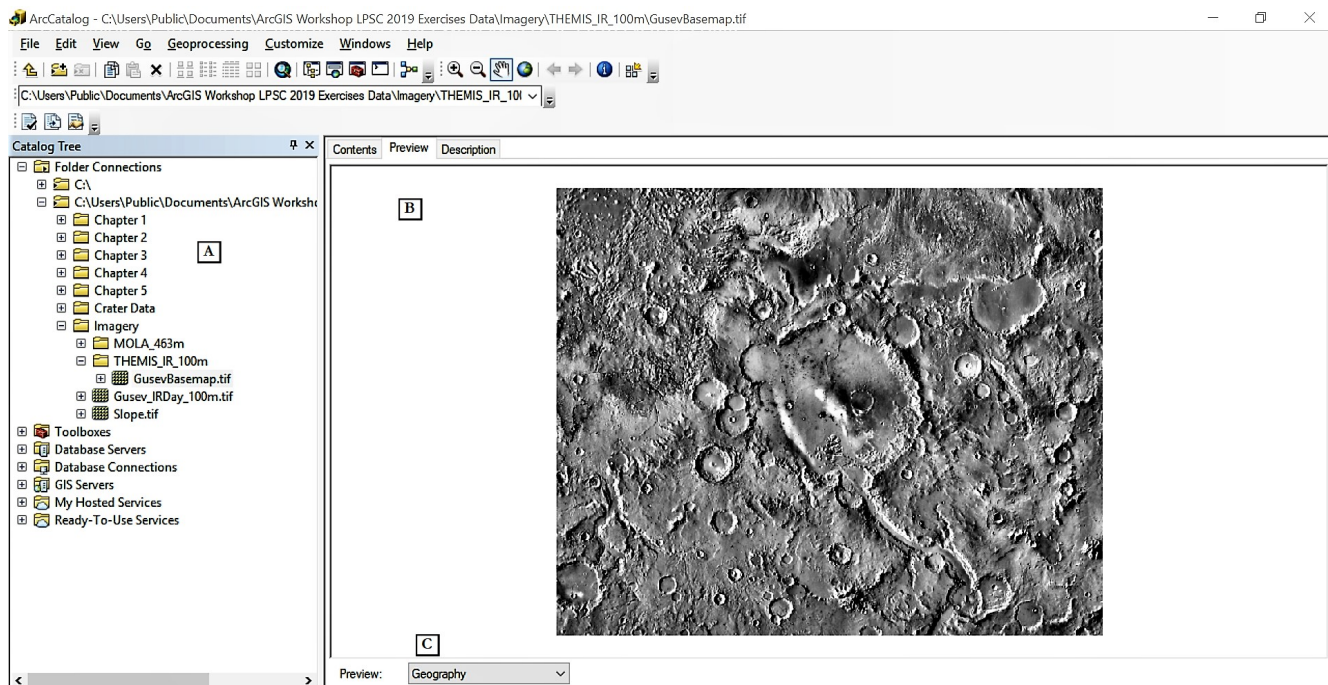
Additional Resources

- ESRI Training: www.esri.com/training/
- Instructor-lead courses: ArcGIS 3, Image Analysis
- Web Courses (requires maintenance subscription)
- Tutorials, Videos, Training Seminars (free)
- Getting To Know ArcGIS Desktop (ESRI book, covers most topics of instructor-lead courses ArcGIS 1 and 2)
- Planetary Usage Support: astrogeology.usgs.gov/facilities/mrctr
- Mastering ArcGIS, by M. Price (workbook-style reference, with links to instructional videos)
- Lining Up Data in ArcGIS

Exercise 1A: Working in ArcCatalog


Estimated Time: 15 minutes

Main components of the ArcCatalog window



- A. The **Catalog Tree** shows files on drive similar to explorer, but recognizes geodatabase elements.
- B. The tabs show different aspects of the data. **Contents** will show you files and ArcMap elements within a selected workspace (folder or geodatabase). **Preview** and **Description** show you information about a specific file or element.
- C. The **Preview** option menu selects whether to view the file or element visually or quantitatively.

Step 1: Create a geodatabase

- Start ArcCatalog.
- Click **Connect To Folder**  in the toolbar near the top of the window.


Building a folder connection makes it easier to access the data you will need for this exercise. This can also be done by right-clicking on **Folder Connections** and clicking **Connect To Folder**.
- Navigate to where you have stored the data and highlight the **Chapter1** folder.
- Click **OK**.

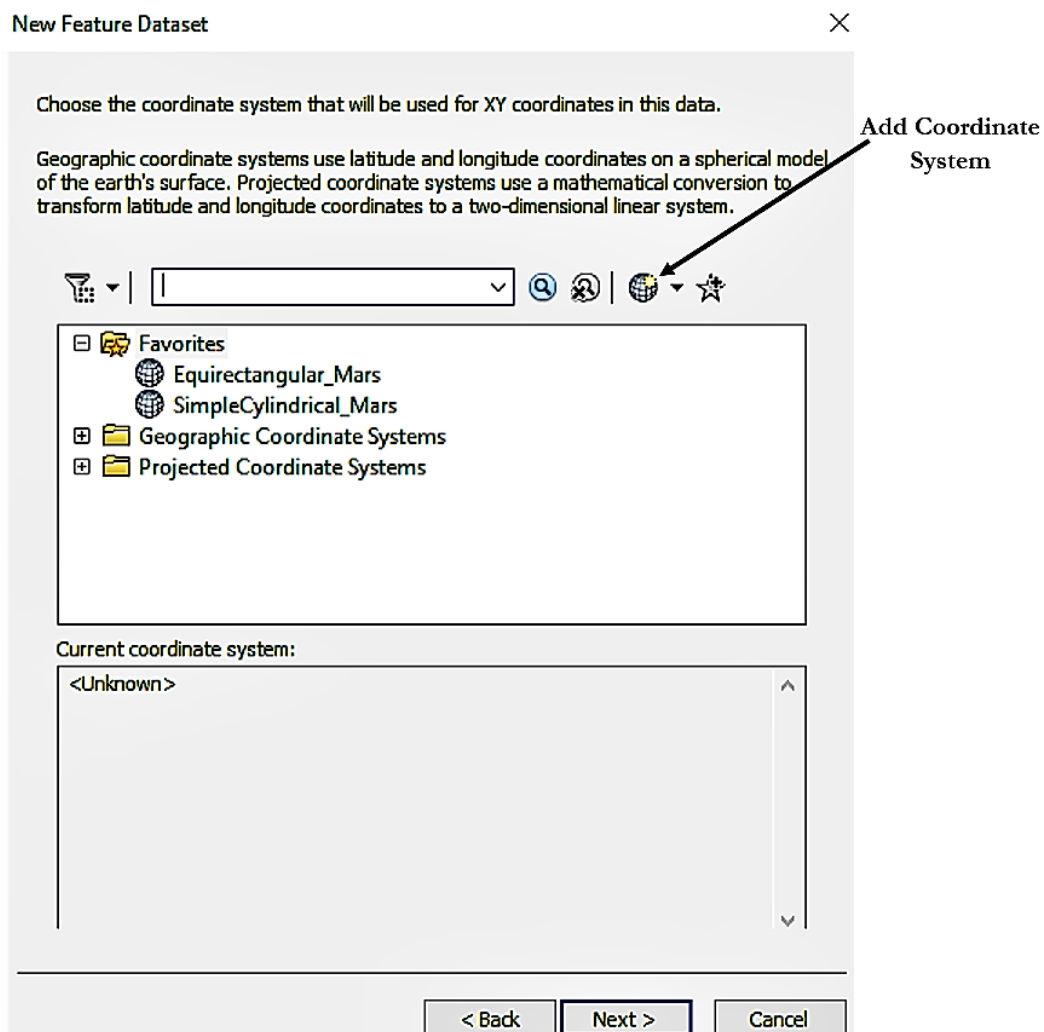
Notice how the folder name in the Catalog Tree shows the folder pathway.
- Make the connection easier to read by right-clicking on the folder name and selecting **Rename**.
- Name it **Chapter 1**.

Note that since this is an alias, it is acceptable to use a space in the name.

- In the **Catalog Tree**, expand the **Chapter 1** folder.
- Right-click on the **Exercise1a** folder in the **Catalog Tree**, and from **New** select **File Geodatabase**.
- Rename the new file geodatabase **GusevCrater**.





Step 2: Create a feature dataset within a geodatabase.

- Right-click on the **GusevCrater** geodatabase in the **Catalog Tree**, and under **New** select **Feature Dataset**.
- Name it **Craters**, and click **Next**.
- Click on **Add Coordinate System**  and select **Import**.
- Navigate to the **Maps** folder in the **Chapter1** folder, select **GusevBasemap**, and click **Add**.
- Click **Next**, then **Next** again, and then **Finish**.



Setting the coordinate system for a dataset

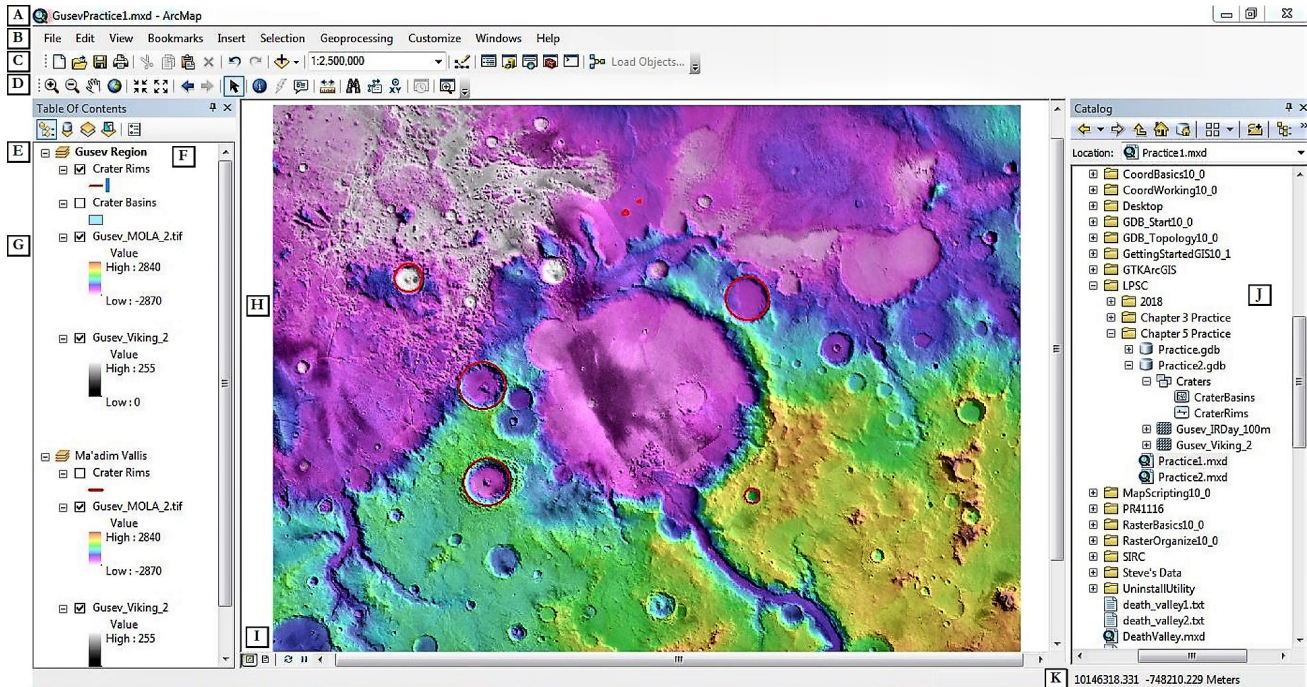
Step 3: Explore an existing geodatabase

- In the **Catalog Tree**, click on the **GusevRegion** geodatabase in the **Exercise1a** folder to view its contents in the **Contents** tab to the right.
- Double-click to expand the feature dataset **Craters**.
- Click once on **CraterRims**.
- Click the **Preview** tab to see what this feature will look like on a map.
- Change the **Preview** option at the bottom from **Geography** to **Table** to see the data stored within the feature.
- Click the **Description** tab.
This shows you the metadata for this feature.
- Scroll through to explore the metadata.
This metadata can be updated by clicking on the **Edit** button under the **Description** tab.
- In the **Catalog Tree**, expand the **Maps** folder in the **Chapter 1** folder and select **GusevBasemap**.
- Go back to the **Preview** tab.
- **Pan** , **Zoom in**  and **Zoom out**  to examine the raster.
If you zoom in too far and are lost, use **Full Extent**  to return to a full view of the data frame.
- Close ArcCatalog.

Exercise 1B: Working in ArcMap

Estimated Time: 25 minutes

Main components of the ArcMap window

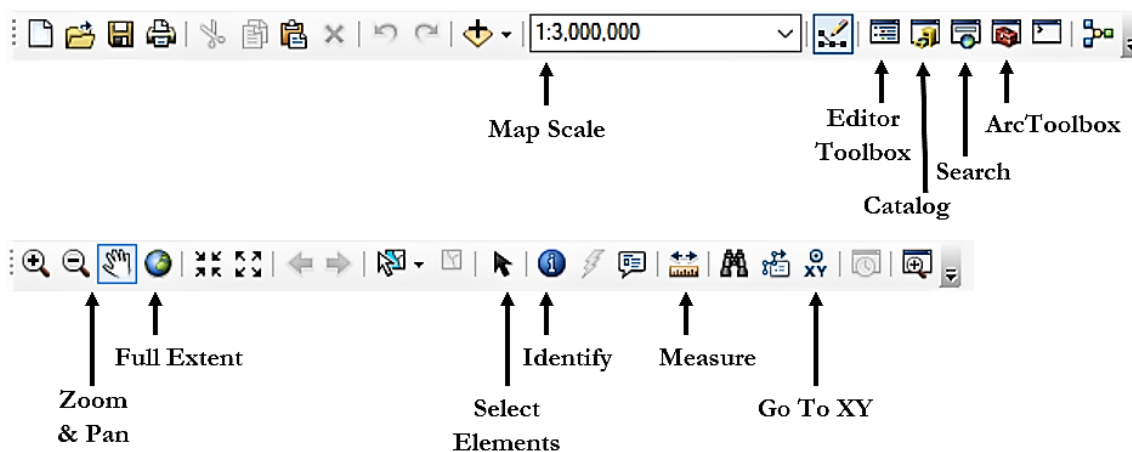


- A. The **Title** bar shows the name of the application, ArcMap, and the name of the map document you are working with.
- B. The top menu bar.
- C. The **Standard** toolbar contains tools for managing the map document and controlling which elements of ArcMap are visible.
- D. The **Tools** toolbar contains key tools and buttons you will frequently use, including most map navigation tools.
- E. A data frame is a container for a map's layers and can be used to organize them. Only one data frame can be active at any time and this determines what you see in the main workspace.
- F. The **Table of Contents** contains a list of all the data frames and layers in the map document.
- G. A layer is an organized set of geographic features with the same type of geometry (point, line, polygon) or a raster (image).
- H. The map display is the main workspace where you can view layers in a data frame and their components.
- I. The map display buttons control whether you are in **Data View**, where you will work on editing the data frames and layers, and the **Layout View**, where you will organize your data frames into presentable documents with elements like titles, keys, and scale bars.
- J. The **Catalog** window allows you to connect to ArcCatalog and perform some of the features of that applications including exploring and organizing data. It also allows convenient loading of data by just dragging and dropping into the map display.
- K. This shows you the position of the cursor in the coordinates of the data frame. You can change the units shown here by going to the **Customize** menu, selecting **ArcMap Options**, and on the **Data View** tab click "**Use these units instead . . .**" and use the dropdown menu to set your desired units.

Step 1: Setting up ArcMap


- Start ArcMap and double-click **Blank Map**.
- From the **Customize** menu, select **Extensions**, and make sure all extensions are selected.
- From the **Customize** menu, go to **Toolbars**, and ensure that **Standard** and **Tools** are the only selections.

You may undock, move, and dock these toolbars. To do so, click and hold the four vertical dots on the left edge of the toolbar, and then drag the toolbar to move it somewhere else. The toolbar can either be a stand-alone window in the interior of the ArcMap window or be docked anywhere on the perimeter of the ArcMap window.



The Standard and Tools toolbars with elements we will be using

- If you do not see the **Catalog** tab on the right side of the ArcMap window, then from the **Windows** menu, select **Catalog**.

You can also click **Catalog**  on the **Standard** toolbar. You can pin the tab by clicking the pin icon in the top right corner of the window.

- Under **Folder Connections**, go to the **Exercise1a** folder and expand the **GusevCrater** geodatabase.
Notice that what you created in ArcCatalog is now accessible from within the **Catalog** window in ArcMap.







Step 2: Build geodatabase structure in ArcMap

- In the **Exercise1a** folder, right-click on the **GusevCrater** geodatabase, and under **New**, select **Feature Dataset**.
- Name it **LandingSites** and click **Next**.
- Notice that the **SimpleCylindrical_Mars** coordinate system is now shown in the **Favorites** folder.
This is because you used it in Exercise 1A.
- Click on it.
- Click **Next**, then **Next** again and then **Finish**.
- Collapse the **Exercise1a** folder.

Step 3: Load and explore a map document

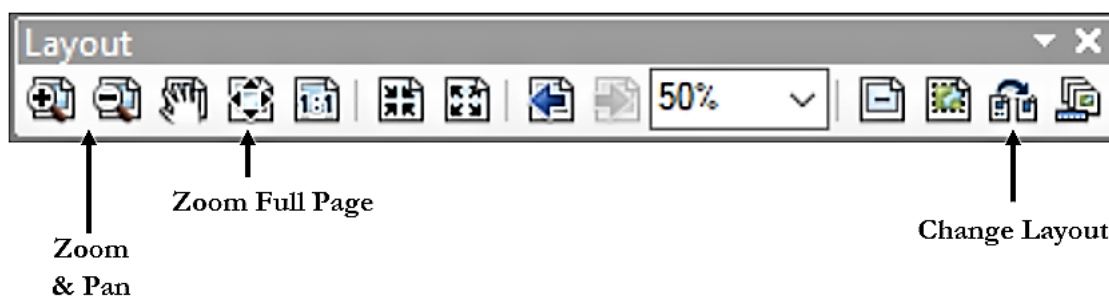
- Expand the **Exercise1b** folder.
- Drag and drop the **GusevRegionLandingSiteAnalysis** map document into the blank workspace.
Notice that the **Table of Contents** window to the left shows you everything in the map document.
- Notice that the **GusevBasemap** layer has a red exclamation mark next to it.
This indicates a broken source path, so the map is looking in the wrong place for the data it needs to display the layer.
- Double-click on the **GusevBasemap** layer to open its **Properties** window.
- Click on the **Source** tab.
- In the **Data Source** frame, look at the **Folder** to see that the map is looking for a folder that does not exist.
- Click **Set Data Source**.
- Navigate to the **Chapter1** folder, and then into the **Maps** folder.
- Select the **GusevBasemap** file there and click **Add**, and then click **OK** to close the **Layer Properties** window.
Now the proper image displays in the map.

Another way to do this is to right-click on the layer name in the **Table of Contents** and from **Data** select **Repair Data Source**. Then navigate to the correct folder and file and click **Add**. This problem can be minimized by clicking on **Map Document Properties** in the **File** menu and at the bottom of the window clicking the **Store relative pathnames to data sources** box each time you create or work with a new map. You can also go to the **Customize** menu and click **ArcMap Options**, and in the **General** tab check **Make relative paths the default for new map documents**.

- From the **Bookmarks** menu, choose **Ma'adim Vallis**.
Notice how this zooms and pans the map display to a specific setting. You can create new bookmarks to easily return to specific views of the map by selecting **Create Bookmark** from the **Bookmarks** menu and naming it. The current zoom/pan will be saved.
- From the **Tools** toolbar, click **Full Extent**  .
This return the map display to zoom/pan settings that show the entire extent of the data frame.
- Explore the map using the **Zoom In** , **Zoom Out** , **Pan** , **Fixed Zoom In** , and **Fixed Zoom Out**  on the **Tools** toolbar. After you have finished, click the **Full Extent** button.
Although spaces and special characters are not allowed in ArcGIS for folder and file names, notice that in the **Table of Contents** the displayed names for data frames, layers, and features do have spaces and special characters. These are “aliases” and are merely part of the way the map is displayed, and so they do not have those restrictions. Changing these aliases has no effect on the names of the files that are the data source.

Step 4: Working with layers

- Right-click on the **Slope & Elevation** data frame and select **Activate**.
Notice that this completely changes what is viewed in the map display, which is now showing within this data frame. **Slope & Elevation** is now in bold in the **Table of Contents**, indicating that it is active, and **Landing Sites** is no longer bold. Only one data frame can be active, and therefore viewed in the map display, at a time.
The **Catalog** window also uses bold to show you which map document you currently have open.



The **Layout** toolbar with elements we will be using

- Right-click on the **Potential Landing Sites** layer in the **Landing Sites** data frame and select **Copy**.
- Right-click on the **Slope & Elevation** data frame and select **Paste Layer(s)**.
- Click and drag the **Gusev Basemap** layer just above the **Combined Analysis** layer.
The order of the layers in the **Table Of Contents** determines what is visible in the map display. Since the basemap is not transparent, the **Combined Analysis** layer underneath it is no longer visible.
- Click to uncheck the box next to the **Gusev Basemap** layer to turn off the layer.
The **Combined Analysis** layer is now visible.
- Move the **Gusev Basemap** layer back to the bottom of the **Slope & Elevation** data frame and turn it back on.
- Right-click on the **Potential Landing Sites** layer in the **Slope & Elevation** data frame and select **Remove**.
Alternatively, click **Undo** until the layer is removed.
- Activate the **Landing Sites** data frame.
This can be done as earlier, or using the short cut of holding down Alt key while clicking on the data frame.

Chapter Summary

Now you have seen some of the basic the capabilities of ArcCatalog in organizing and exploring data, as well as the basic structure of a map document in ArcMap. Feature datasets and raster data sets are not necessary, but they can be useful for organizing large amounts of data. Rasters brought in from downloaded and processed images also do not necessarily need to be stored inside geodatabases, and since these files may be large and you may want to use them in different analyses using different geodatabases, it can be prudent to leave them in a separate folder as is done in these exercises. Rasters produced through analysis should be stored within a working geodatabase and can be exported later to share with others.



Working with rasters

Exercise 2A: Raster Basics

Estimated time: 25 minutes

Exercise 2B: Slope Analysis

Estimated time: 30 minutes

Chapter 2: Working with rasters

Introduction

In this chapter you will learn the basics of loading, symbolizing, and analyzing raster data. Rasters are analogous to image files. They contain an array of pixels, called cells, each with a position and a single value which could represent brightness, elevation, intensity of a quantity, or any other numerical data. A raster basemap is usually the starting point for any map product, and is typically an aerial or orbital image or mosaic of images. Rasters can be organized into datasets within geodatabases, but can also be stored outside of geodatabases. Since rasters are typically the most demanding of storage space among GIS files, we will keep the starting images that were downloaded for use in this workshop in a single file outside the geodatabases we will be working in. Rasters produced from analyzing these images will be stored within individual geodatabases designated for each exercise.

Objectives

- Load downloaded and processed images as rasters in ArcMap
- Utilize the Standard, Tools, and Effects toolbars to investigate and display rasters
- Find locations and take measurements of features in a raster
- Symbolize rasters, both continuous and discrete
- Analyze rasters to produce new raster products
- Perform slope analysis
- Convert continuous rasters into discrete rasters
- Modify labels in preparation for layout mode

Terms

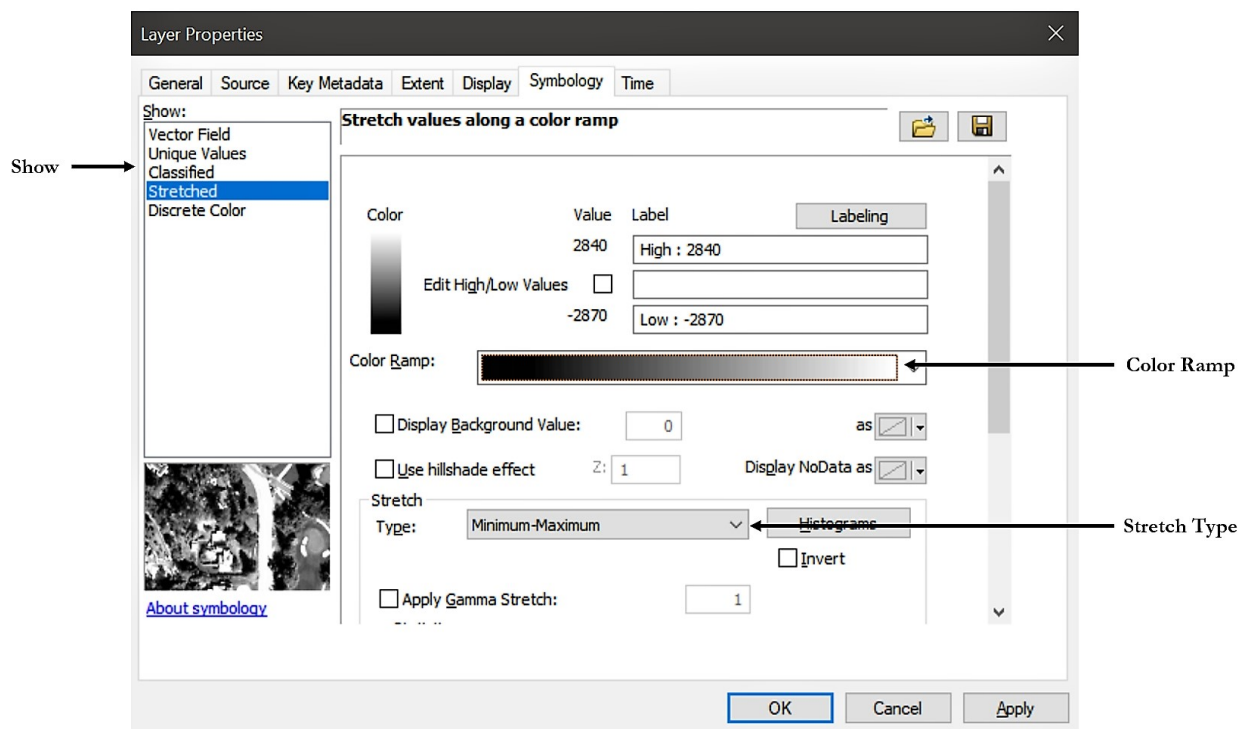
- Raster
- Basemap
- Elevation Map
- Cell Size
- Symbology
- Geoprocessing Tools: Slope, Reclassify
- Toolbars Buttons: Pan and Zoom, Measure, Transparency, Swipe
- Windows: ArcToolbox, Search, Image Analysis
- Hillshade
- Spatial Analyst Toolbar

Exercise 2A: Raster Basics

Estimated Time: 25 minutes

Step 1: Load a raster basemap and elevation map

- Start ArcMap, and click cancel in the **Getting Started** window.
- Create and name a new folder connection in the **Catalog Tree** to the **Imagery** folder.
- Also create a connection to the **Chapter2** folder and name it **Chapter 2** (with a space).
- Collapse the **Home** directory if it has automatically expanded.
- Expand the **Imagery** folder, expand **THEMIS_IR_100m**, and drag-and-drop **GusevBasemap** into the map display area.
- When asked about creating pyramids, set **Pyramid resampling technique** to **Bilinear Interpolation** and click **Yes**.
Pyramids allow the display to adjust to the scale and not display the entire image at small scales, thus speeding up the display.
- Notice that the coordinates in the lower right are in meters, showing that this raster has been projected.
If the image looks dark or all black, that can be fixed in the next step.
- In the **Imagery** folder, expand **MOLA_463m**, and drag-and-drop **GusevElevation** into the map display area.
- Build pyramids with the same settings as the basemap.



The **Symbology** tab with elements we will be using

Step 2: Explore and symbolize a raster

- Double-click on the **GusevElevation** layer in the **Table of Contents** to open the **Layer Properties** window.
- Click on the **Source** tab.

This tells you the location of the source data as well as other information like resolution (cell size), pixel type and depth, and units of measure.

- Click on the **Symbology** tab.

Since this raster is considered continuous (even though pixel values have been restricted to integer values) the **Stretched** option is selected by default for **Show** on the left. If the image is dark or all black, try changing the **Stretch Type** selection from the drop-down menu (default is set to **Percent Clip**). **Minimum-Maximum** usually works well, but try others to see which looks best. You can also do this to your basemap if it has a similar problem.

- Set **Show** to **Classified** (right above **Stretched**).
- If asked about computing a histogram, click **Yes**.

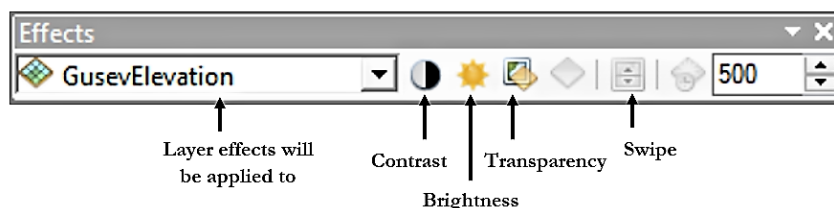
In order for ArcMap to decide how to group the pixel values into a few classes, each with a range of values, it must first perform some standard statistics on the frequency distribution of pixel values among the cells. This is a common message when working with a new raster in ArcMap, and there is generally no reason for refusing.

- Then click **Apply** to see the data displayed discretely.



You can move the **Layer Properties** window out of the way if necessary to see the map display.

- Change back to **Stretched** and click the arrow for the **Color Ramp** drop-down menu to see different color schemes.
- Click outside the menu to collapse it, then right-click on the **Color Ramp** and unclick **Graphic View**.
- Open the drop-down menu again and choose **Elevation #1**, and click **OK** to close the **Properties** window.

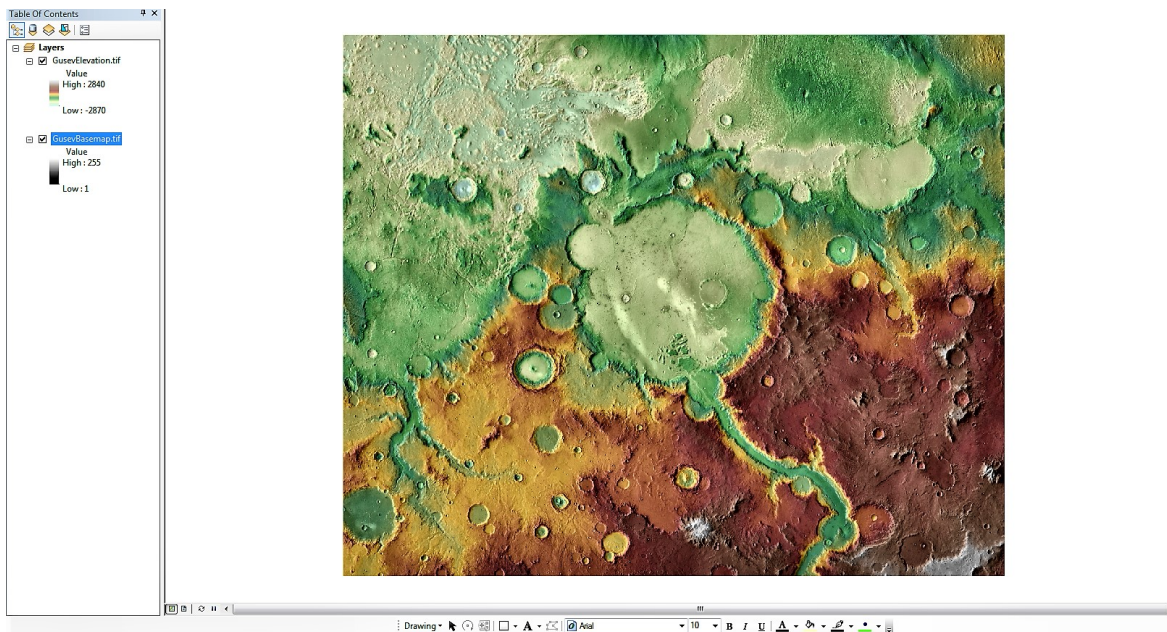
You can quickly access the color ramp by going to the **Table of Contents** and left clicking once on the color ramp under the layer name.



The Effects toolbar with elements we will be using

- Go to **Customize** on the top menu and from **Toolbars** click **Effects**.
Dock this toolbar wherever you like.
You can also add toolbars by right-clicking in any blank gray space around the other toolbars.
- In the **Effects** toolbar, select the **GusevElevation** layer from the drop-down menu.
- Click **Swipe** .
- Click and hold anywhere in the map display and drag the mouse up and down.
- In the **Effects** toolbar, click **Adjust Transparency**  and change the setting to **50%**.
Now the basemap layer can be seen under the elevation layer.

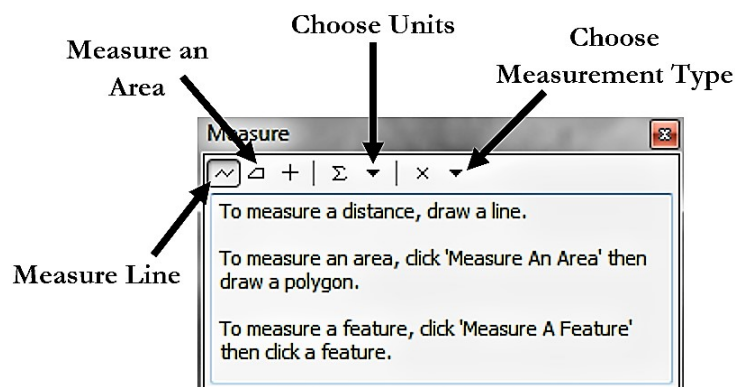
- In the **Effects** toolbar, select the **GusevBasemap** layer from the drop-down menu.
- Experiment with adjusting the display with **Adjust Contrast** and **Adjust Brightness** until you are satisfied with the appearance of the map.



Basemap and elevation layer loaded and symbolized





Step 3: Locate positions on a raster

- From the **Tools** toolbar, click **Go To XY**.
- Click the units drop-down menu and select **Decimal Degrees**.
- Enter **Long: 175.5** and **Lat: -14.5**.
- Click **Flash** to see that this location is the approximate center of Gusev Crater.
- Close the **Go To XY** window.






The Measure window with elements we will be using

Step 4: Measure features on a raster

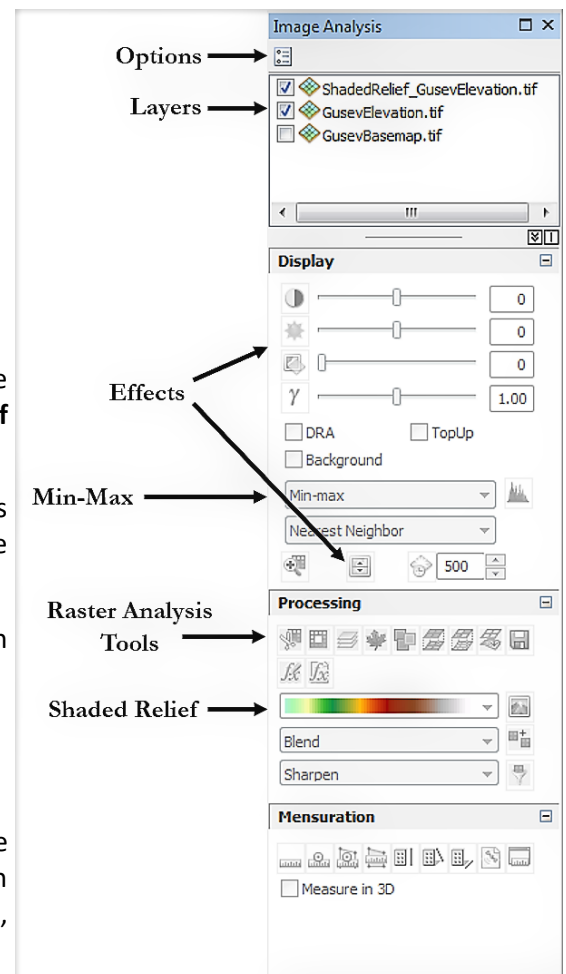
- From the **Tools** toolbar, click **Measure**  .
 - Measure A Distance**  is selected by default.
- Click the **Choose Units**  drop-down menu and set both **Distance** and **Area** to kilometers.
- Click once anywhere on the rim of Gusev Crater, move the mouse to the opposite rim, and then double-click. The **Measure** window displays the approximate diameter of the crater (should be $160 \text{ km} \pm 10 \text{ km}$).
- Pick two very small craters that are far away from each other on the map.
- Measure the distance between them and note the result.
- Click the **Choose Measurement Type** drop-down menu and change from **Planar** to **Geodesic**.
- Make the same measurement again and note the difference.
 - Planar** will calculate a Euclidean distance using the projected coordinates assuming the surface is flat. **Geodesic** takes the curvature of the surface into account.
- Click **Measure An Area**  .
- Click anywhere on the rim of Gusev Crater, then use single clicks periodically as you move the mouse along the rim, and double-click when you have come back to near your starting position.
 - The **Measure** window displays the perimeter and area of the polygon you just specified (roughly 500 km and $19,000 \text{ km}^2$).
- Close the **Measure** window.

Optional: Relief effects


Step 5: Visualize terrain without a basemap

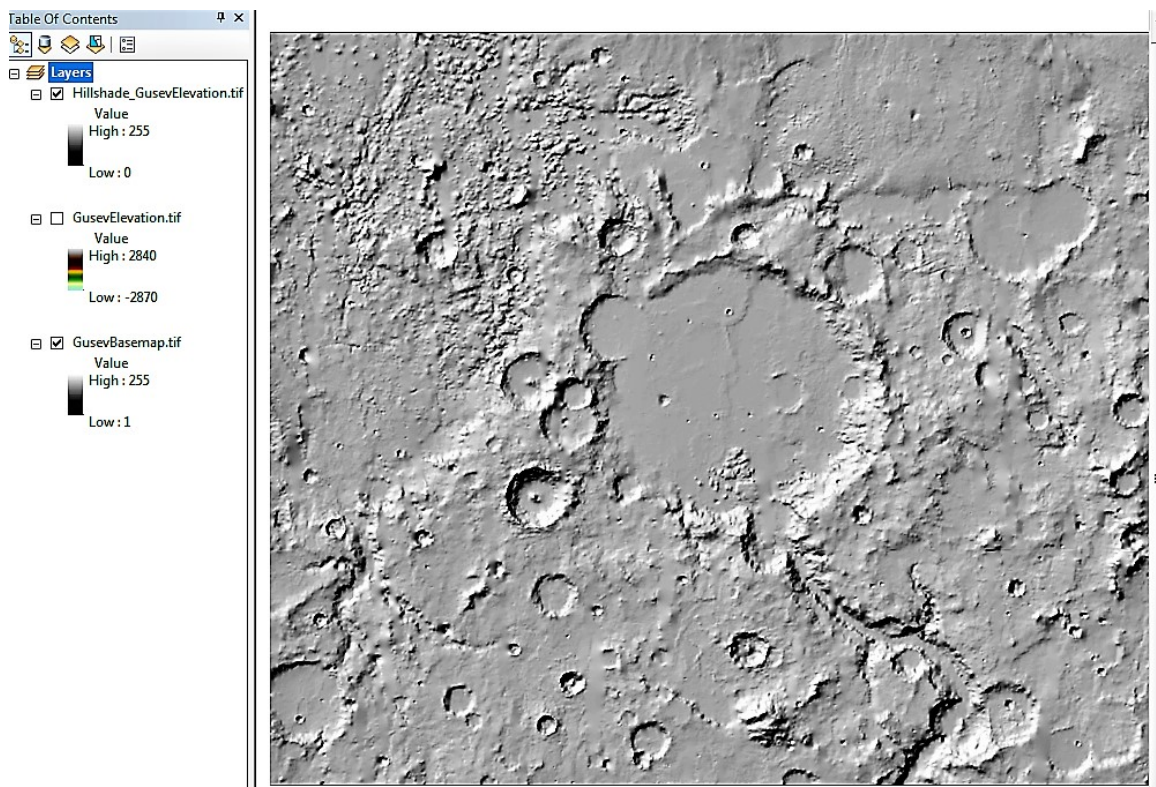
- From **Windows** in the top menu, select **Image Analysis**.
- Turn off the **GusevBasemap** layer by unchecking the box next to the layer name. Notice that this also turns off the layer in the **Table Of Contents**.
- Click on the name of the **GusevElevation** layer to highlight it. This activates it as the layer you are doing analysis on. Set the **Transparency**  to **0%** and change the stretch type to **Min-Max**.
- Click on **Image Analysis Options**  at the top of the window and in the **Hillshade** tab set **Z Factor** to **3** and click **OK**.
- In **Processing**, change the color ramp to one of the grayscale ramps.
- Click on **Shaded Relief**  to the right of the color ramp.

Hillshade can also be added in the **Symbology** tab, but the **Z** value there is normalized and should be set much lower, such as 0.1. In **Image Analysis**, the **Z** value is in the units of the elevation map, which for this map is meters.



The Image Analysis window

- A new layer is added to the map document and a new TIFF file has also been created.
- Click on the new layer at the top of the **Image Analysis** window to highlight it.
- Click the **Save** icon (**Export Raster Data** ) in **Processing** to save this new TIFF.
- Set the **Location** to the **Imagery** folder, name the file **GusevHillshade.tif** and click **Save**.
- Click **No** on the first dialog window and then click Yes on the second.
- Right-click on the **Hillshade_GusevElevation** layer and select **Remove**.
This file was likely stored in a temp folder somewhere, but we want to view the exported one in the map.
- In the **Table of Contents**, turn the **GusevElevation** layer off and turn the **GusevBasemap** layer back on.
- Use the **Swipe** tool (also accessible in the **Image Analysis** window) to compare the basemap terrain to the hillshade terrain. Make sure that the **GusevHillshade** layer is selected as the one to swipe.
- Explore other features of the **Image Analysis** window.
- Close the window when you are done.





Artificial basemap created with Shaded Relief

Exercise 2B: Slope Analysis

Estimated Time: 30 minutes

Step 1: Set up the workspace for analysis

- From the **Catalog** window, navigate to the **Exercise2b** folder and drag and drop the **GusevCrater2b** map document into the display.
- Right-click on the **GusevCrater** geodatabase in the **Exercise2b** folder and select **Make Default Geodatabase**.
This is a very useful thing to do every time you start working in a geodatabase since it will allow you to quickly navigate to this geodatabase when storing any files you create during analysis.
- On the **Standard** toolbar, click **ArcToolbox**  to open the **ArcToolbox** window.
- Dock it wherever you like (typically on the right side) and **Auto Hide** it if you wish by clicking the pin icon in the upper right to turn it from up-down to side-to-side.
If a window is on **Auto Hide**, it will appear as a tab in its dock position. You can open the window by hovering over or clicking the tab.
- Explore the available tools for a few minutes.
Note just how many there are and how confusing it would be to try and remember where all of them are.
- If it is not already open (likely docked on the right), open the **Search** window by clicking **Search**  on the **Standard** toolbar.
Dock and **Auto Hide** as you wish. This window allows you to search for tools and help topics.



Step 2: Find the slope tool

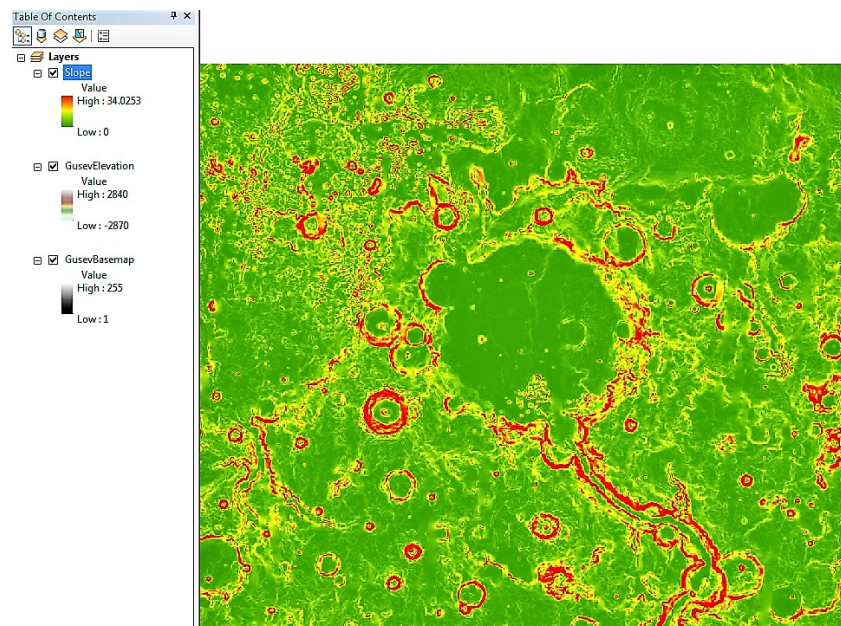
- Type **slope** into the search textbox and hit enter.
Several matches come up, with the main toolbox they belong to in parentheses after their name. We want to use the **Slope** tool from the **Spatial Analyst** toolbox.
Clicking on the first line of this entry will open the tool for use, clicking on the second line will open the help files relating to it, and clicking on the third line will take you to where the tool is in ArcToolbox. You can also see the toolbox path to this tool by hovering over the third line.



Step 3: Use the Slope tool

- Click **Slope (Spatial Analyst)** in the **Search** window to open the tool.
You can also go to where the tool is in ArcToolbox and double-click on it there to open it.
- Click **Show Help** to see information about the tool, and as you click on each field it will show information about it.
If this is already open, it shows up as a white box with a description of the tool to the right of the window. To hide the information, click on **Hide Help**.

- Use the drop-down menu in **Input** raster to select **GusevElevation**.
- For **Output** raster, click **Browse** , click **Go To Default Geodatabase** , and name the file **Slope** and click **Save**.
You can look at the file path in the **Output** raster field and see if you are in the **GusevCrater** geodatabase in the **Exercise2b** folder already, and if so you can just change the file name here without clicking on browse.
- Click **OK** to run the tool.
You will see a scrolling message in the lower right showing that the tool is running, and a window will appear in the corner when it is finished with a green check mark indicating it successfully ran.
If the tool did not successfully run, an “X” in a red circle will appear and clicking on the tool name will open the **Results** window where details of the processes can be viewed, including any errors that occurred.
- The new raster is automatically added as a new layer in the map.
- Open the **Layer Properties** for the **Slope** layer by double-clicking on it and go to the **Symbology** tab.
- Set **Show** to **Stretched** and set the **Color Ramp** to **Slope** (remember to uncheck **Graphic View** to see the names of the color ramps).
- Set **Stretch Type** to **Percent Clip**.
- Click **OK**.



Results of Slope Analysis

Step 4: Export the result


This new image file cannot be accessed outside of ArcMap because we put it inside a geodatabase. The file must be exported to make it available for sharing and use in other programs.

- Right-click on the **Slope** layer and from the **Data** menu select **Export Data**.
- For **Location**, click the browse button, navigate to and highlight the **Imagery** folder.
- Click **Add**.
- Name the output file **Slope**.

- Click **Save**.
- Click **No** to whether to add the output as a map layer.

This image can now be accessed through Windows Explorer and shared for use in other maps. It preserves all the spatial data or the raster.

Step 5: Perform statistics on a raster

- Right-click on an empty space on the toolbar area.
- Activate the **Spatial Analyst** toolbar.
- From the dropdown menu, choose the **Slope** layer.
- Click **Create Histogram** .
- Right-click anywhere on the histogram window, and select **Export** to see a variety of options for saving the data.
- Close the **Export** window, then close the **Histogram** window, and then close the **Spatial Analyst** toolbar.

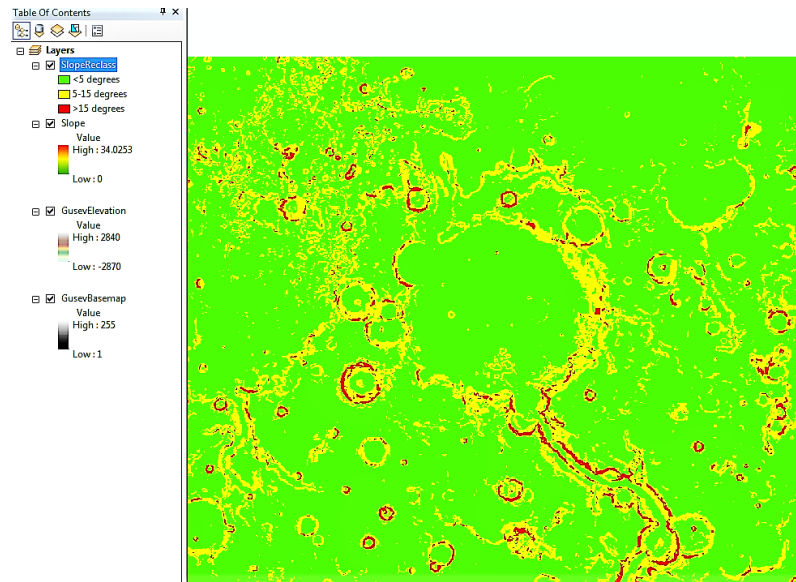
Step 6: Reclassify a raster

When the **Slope** layer first appeared, the **Symbology** was set to **Classified** and the raster was displayed as discrete. However, the source data is still floating point numbers. To create a discrete raster, we must use a tool.

- Use the **Search** window to find the tool **Reclassify (Spatial Analyst)** and open it.
This tool will group pixel values into specified ranges and reassign the pixel values as 1, 2, 3, etc.
- Select **Slope** as the **Input** raster.
- Click **Classify**.
- Set the **Classes** to **3**.
- Set the **Method** to **Manual**.
- Change the first value in the **Break Values** list to **5** and the second to **15** (leave the third number as is).
- Click **OK**.

You can also edit the table directly on the **Reclassify** window by retyping in the **Old Values** column and deleting or adding rows.

- Name the **Output** raster **SlopeReclass**, and click **Save**.
Check that you are in the geodatabase in the **Exercise2b** folder.
- Click **OK** to run the tool.



Results of **Reclassify** and symbolizing the **Slope** layer

Step 7: Symbolize a discrete raster

- Open the **Layer Properties** window for the **SlopeReclass** layer.
- Click on the **Symbology** tab.
- Double-click on the color next to the value **1**.
- Select **Medium Apple** (row 3, column 7).
- Set the color for value **2** to **Solar Yellow** (row 3, column 5).
- Set the color for value **3** to **Mars Red** (row 3, column 2).
- Click on the **1** in the Label column and change it to **<5 degrees**.
- Then change the **2** to **5-15 degrees**, and change the **3** to **>15 degrees**.

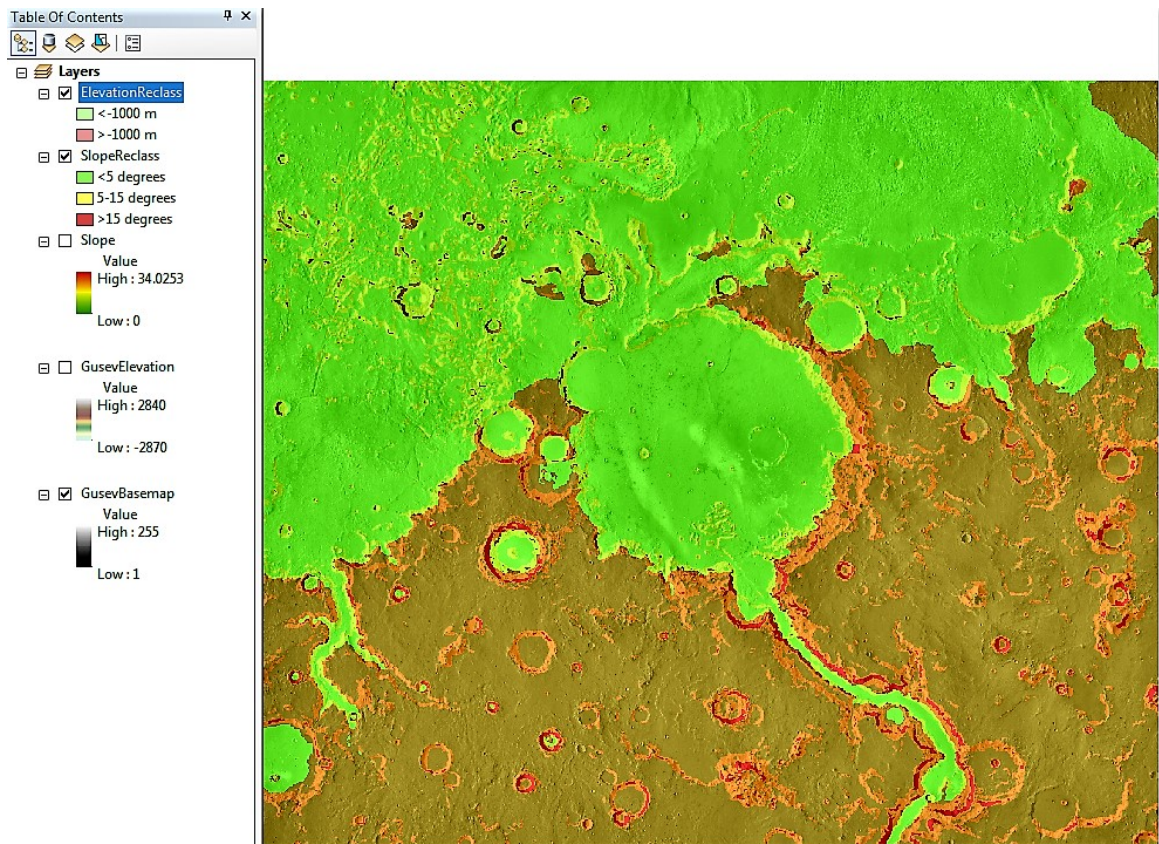
This only changes what is displayed next to each color in the **Table of Contents**. Because these are aliases, spaces and special characters can be used, and it does not alter the actual pixel values, which will remain 1, 2, and 3.

- Click **OK**.
- Close ArcMap or continue to the Optional exercise.

Optional: Reclassify the Elevation raster

Repeat steps 6 and 7 to reclassify the Elevation raster into elevations less than **-1000 m** and elevations greater than **-1000 m**. Symbolize the low elevations with green and the high elevations with red. You can change the colors by going into the **Layer Properties** window as we did before, or by right-clicking on the color you want to change in the **Table of Contents**. Turn off the **Slope** and **GusevElevation** layers and make both reclassified layers transparent. In this view, bright green regions are both low elevation and low slope, whereas bright red regions are both high elevation and high slope. Adjustments like this to display properties can help you do quick by-eye analysis before deciding what tool analysis you would like to do next.

Close ArcMap when you have finished.



Results of Reclassify and symbolizing the **Elevation** layer

Chapter Summary

In this exercise you have learned some of the basic tools for displaying, exploring, and symbolizing rasters. You have also been introduced to using tools from ArcToolbox to analyze rasters, and how to export the results. You have seen how to change the appearance of the Table of Contents, which does not affect anything about the source data and is only saved within the map document. In addition to making your map easier to interpret, these changes will carry over to the map in Layout Mode making your finished product easy to read and understand.



Working with vector data

Exercise 3A: Creating and editing feature classes

Estimated time: 40 minutes

Exercise 3B: Using selection

Estimated time: 25 minutes

Exercise 3C: Tools for modifying and analyzing features

Estimated time: 15 minutes

Chapter 3: Working with vector data

Introduction

In this chapter you will learn the basics of vector data. These are geometric objects on a map, called feature classes, that contain spatial reference data. These objects may be points, lines, or polygons. Unlike rasters, in which each cell can only store one numerical value, feature classes contain geometric information for each feature, such as length and area, and can also store unlimited other values that can be numerical, descriptive, images, or hyperlinks. Creating feature classes to represent objects in rasters, such as craters, valleys, cloud bands, or geologic regions, allows for even more extensive analysis of these objects since so much information can be stored without always needing to create a new file, as with rasters. We will learn how to create feature classes from scratch, which is recommended when conducting your own research, but we will also show how to use and manipulate existing vector data, which is helpful for initial investigation.

Objectives

- Create new feature class
- Work in editing sessions
- Digitize new vector data
- View attribute tables
- Symbolize vector data
- Use selection methods
- Create features from existing features
- Create and calculate new attributes
- Analyze features

Terms

- Vector
- Feature Class
- Polyline
- Editor Toolbar
- Edit Session
- Streaming
- Vertices
- Construction Tools
- Snapping
- Attribute Table
- Query
- Selection
- Fields
- Hot Spot Analysis
- Buffer
- Average Nearest Neighbor

Exercise 3A: Creating and editing feature classes

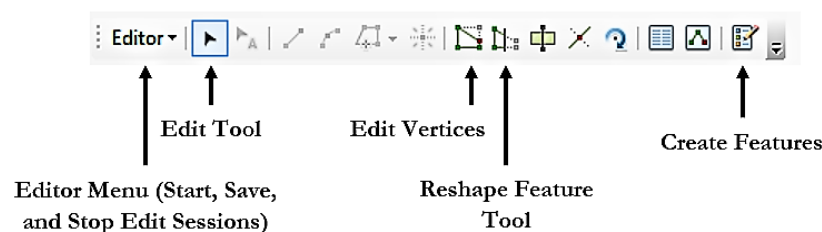
Estimated Time: 40 minutes

Step 1: Open a new map document and add a basemap

- In ArcMap, open a new blank map.
- In the **Catalog** window, add a folder connection to **Chapter3** and name it **Chapter 3**.
- Go to the **Exercise3a** folder and make the **GusevCrater** geodatabase there the default if not already.
- In the **Imagery** folder, expand **THEMIS_IR_100m** and drag and drop the **GusevBasemap** raster into the map display.

Step 2: Create a new feature class.

- Right-click on the **Craters** feature dataset in the default geodatabase, and from **New** select **Feature Class**.
- Name the feature class **CraterRims** with an alias of **Crater Rims**.
The alias is what will be displayed in the **Table of Contents** and the **Layout** mode, and so is allowed to have spaces.
- Select **Line Features** for the type. Click **Next**, accept the default, and click **Next**. Click **Finish**.
Once a geometry type is set for a feature class, it cannot be changed through any editing methods.
- Expand the **Craters** feature dataset in the **Catalog Tree** to see the newly created **CraterRims** feature class.
Notice how the feature class is automatically added as a layer to the map with the alias name. It is turned on but no features are visible, because the feature class has no data.





The Editor toolbar with elements we will be using


Step 3: Digitize a crater rim using a circle

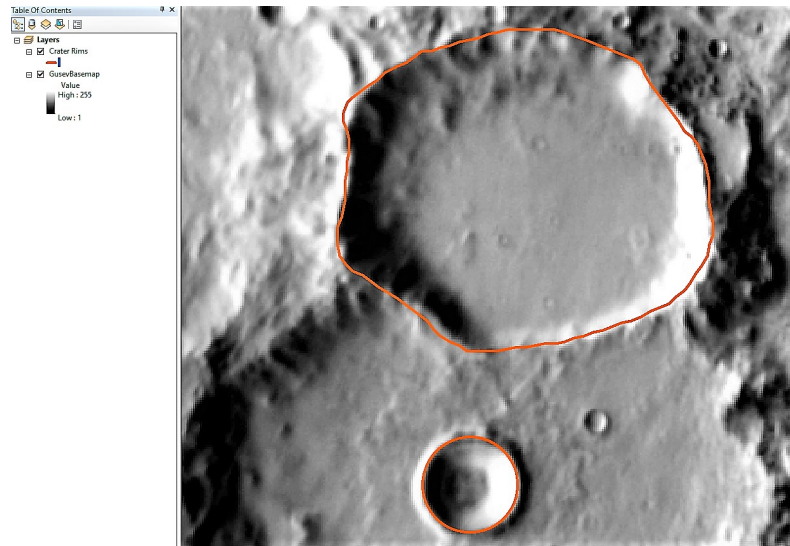
- Activate the **Editor** toolbar and dock it somewhere.
- Choose a crater that looks fairly circular, and zoom in on it (smaller craters work best).
- From the **Editor menu** **Editor** ▾ in the **Editor** toolbar select **Start Editing**.

This starts an Editing Session in which source data can be altered. Within the session, changes can be undone and must be saved regularly and before ending the session. If you are editing a feature class that already contains features, it is highly recommended that you have an original copy of the file stored somewhere.

- From the **Editor** toolbar, click on **Create Features**  .
- Select **CraterRims** by clicking it once.
Even though it may look highlighted, you still need to click on it.
- From **Construction Tools**, select **Circle**.
- Move the cursor to the approximate center of your crater, and click once.
- Drag your cursor away from the center, until the circle closely matches the crater rim.
- Click again to create the circle feature.
Having to start at the center can make it hard to line the feature up with the rim, so if the circle is off center just focus on making it the correct size.
- If your circle is not well aligned to the rim, click the **Edit Tool**  from the **Editor** toolbar.
- Hover over the circle until the four-pointed arrow appears.
- Click and drag the circle until it is better aligned.
When using the **Editor Tool**, the feature needs to be selected to be edited. Selected features will be highlighted in blue. To select a feature, click on it once.
- From the **Editor** menu, click **Save Edits**.

Step 4: Digitize a crater rim using streaming

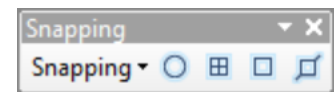
- Using **Pan**  , find a crater with a well-defined rim that is somewhat irregular (non-circular).
- Zoom in on this crater.
- From **Construction Tools**, select **Line**.
- Right-click anywhere in the display and check **Streaming**.
- In the **Editor** menu of the **Editor** toolbar, select **Options**.
- In the **General** tab, set the **Stream tolerance** to **500** (make sure your map units in the lower right are in meters).
This sets the interval between vertices that will be automatically added as you draw.
- Click **OK**.
This tolerance depends on the scale of your map product, but usually 2 to 5 times the map resolution works best so that the line looks curved even though it is made up of many straight segments.
- Click once anywhere on the crater rim.
Once you click, any movement of the mouse will be drawing a line, so be ready.
- Carefully trace the crater rim with your mouse.
If you make a mistake, double-click to stop drawing and click **Undo**, or hit delete. You can also adjust it later using methods described in the next few steps.
- When you have finished tracing the rim and have returned to your starting position, double-click to stop drawing.
- From the **Editor** menu, click **Save Edits**.



Close-up of two digitized crater rims, one using a circle and one using streaming


Alternative Method: Digitize without Streaming turned on



- After you click once to start drawing, you will need to manually click as you move along the rim to place vertices. Some people prefer this.
- Double-click to stop drawing.




The Snapping toolbar

Step 5: Edit an existing feature


- Click the **Pan** tool, and zoom in on the position where you started and stopped your drawing. Notice how the two ends do not meet.
- From the **Editor** menu on the **Editor** toolbar, go to **Snapping** to activate the **Snapping** toolbar. This toolbar can also be added like other toolbars by methods previously described.
- If any of the four snapping buttons is highlighted, click it to turn it off.
- From the **Editor** toolbar, select **Edit Vertices** .
- Click and drag one endpoint to the other end.

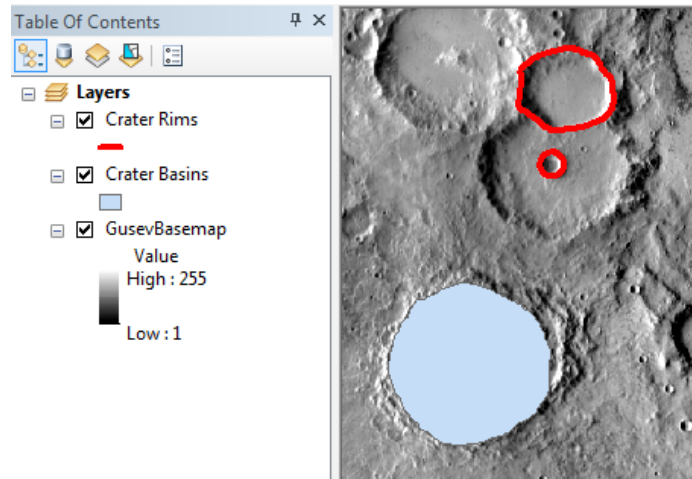
You may also click and drag other vertices to smooth out the line in the vicinity, or use **Add Vertices**  to create additional vertices between existing vertices and move them to improve the feature's shape.
- When you are done, click **Finish Sketch**  in the **Edit Vertices** toolbar to accept the changes.
- Close the **Edit Vertices** toolbar.
- Use the pan tool to zoom in further on the starting/stopping point. Notice the two ends still do not meet.

Step 6: Edit using snapping

- On the **Snapping** toolbar, activate **End snapping**  .
- Select **Edit Vertices** from the **Editor** toolbar.
- Again, click and drag the end of one line to the other.
- Notice how as you hover over the other end, a large square appears at the other endpoint that remains when moving the mouse as long as you are close to this point.
- Release the mouse when this square is visible.
Snapping allows you to connect the two vertices without them needing to be exactly lined up.
- Click **Finish Sketch** on the **Edit Vertices** toolbar and close the toolbar.
- From the **Editor** menu, click **Save Edits**.
- From the **Editor** menu, click **Stop Editing**.


Alternative Method: Digitize a crater basin using a polygon

- Go to the **Catalog** window and follow the instructions from Step 2 to create a new feature class.
- Name it **CraterBasins** with an alias of **Crater Basins**.
- Select **Polygon Features** for the type.
- Click **Next** twice, and then **Finish**.
- Pan and zoom to a crater with a well-defined irregular rim that you did not digitize before.
- Start a new editing session.
- Click on **Create Features**  .
- Select the **CraterBasins** layer and select **Polygon** from **Construction Tools**.
- Turn off all the Snapping buttons.
Since you are creating a polygon, you do not need snapping. You can choose whether or not to use streaming.
- Begin tracing your polygon by clicking once anywhere on the crater rim, and continue along the edge, clicking at regular intervals.
- When your polygon fills the whole crater, double-click to finish it.
- From the **Editor** menu, click **Save Edits** and then click **Stop Editing**.



Close-up of three digitized craters. One is a rim using streaming, one is a rim using a circle, and one is a basin using a polygon.

Additional Tools and Tips

- **Snap to Sketch** (Snapping drop-down menu in the **Snapping** toolbar) will help close polyline shapes by allowing you to snap to a point in a polyline feature you are currently digitizing. Turn on all Snapping options before using this feature.
- If you are drawing features that are close to other features and you want them to remain separate, turn all snapping off. You can also temporarily suspend snapping in the middle of drawing by holding down the spacebar.
- **Reshape**  on the **Editor** toolbar will allow you to redraw portions of the feature without having to individually move vertices. It is best to turn snapping options on. Click once on the vertex where you want to start redrawing, draw a new path to the vertex where you want to stop redrawing, then double-click to finish.

Exercise 3B: Using selection

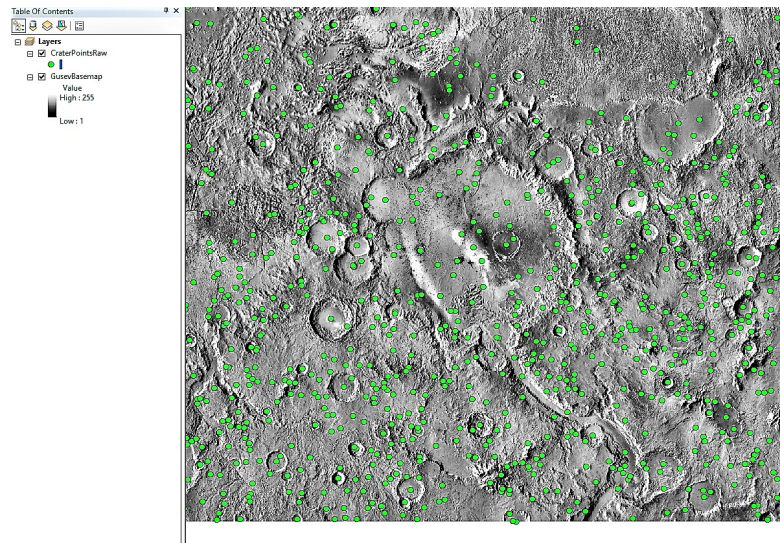
Estimated Time: 25 minutes

Step 1: Import a shapefile

- From the **Catalog** window, open the map document **GusevCrater3b** in the **Exercise3b** folder.
- Make the geodatabase in that folder the default.
- Also in the **Catalog** window, locate the **CraterData** folder (in the Exercises folder) and expand it to find the **RobbinsCraterDatabase_GusevRegion** shapefile.

Since this is a shapefile (not ArcGIS specific) it cannot be simply copied and pasted into a geodatabase. It will need to be converted into a feature class. You can still add shapefiles to the map document, but certain processes can only be done on feature classes.

- Right-click on the **GusevCrater** geodatabase in the **Exercise3b** folder and from **Import** select **Feature Class (single)**.
- For **Input Features**, browse to the **CraterData** folder and select the shapefile.
- The **Output Location** is already set to the default geodatabase.
- Name the **Output Feature Class** **CraterPointsRaw**.
- Click **OK**.
- The new feature class is automatically added to the map as a new layer.




Shapefile of crater centers imported as a feature class

Step 2: Project the new feature class

ArcMap has projected the new layer “on the fly” based on geographic coordinates, but the **CraterPointsRaw** feature class has no projection of its own, and therefore has no sense of linear units for calculating distances. To perform spatial analysis, we need to project it.

- Use the **Search** window to find and open the **Project (Data Management)** tool.
- For **Input Feature Class** choose **CraterPointsRaw**.

- For **Output Feature Class**, navigate to the default geodatabase and name it **CraterPoints**.
- For the **Output Coordinate System**, click the button to the right, and under **Add Coordinate System**  select **Import**.
- Find the **GusevBasemap** raster in the **THEMIS_IR_100m** folder under **Imagery** and select it.
- Click **OK** to run the tool.
- Right-click on the **CraterPointsRaw** layer in the **Table Of Contents** and select **Remove**.
This does not delete the feature class. It only removes it from the map document.

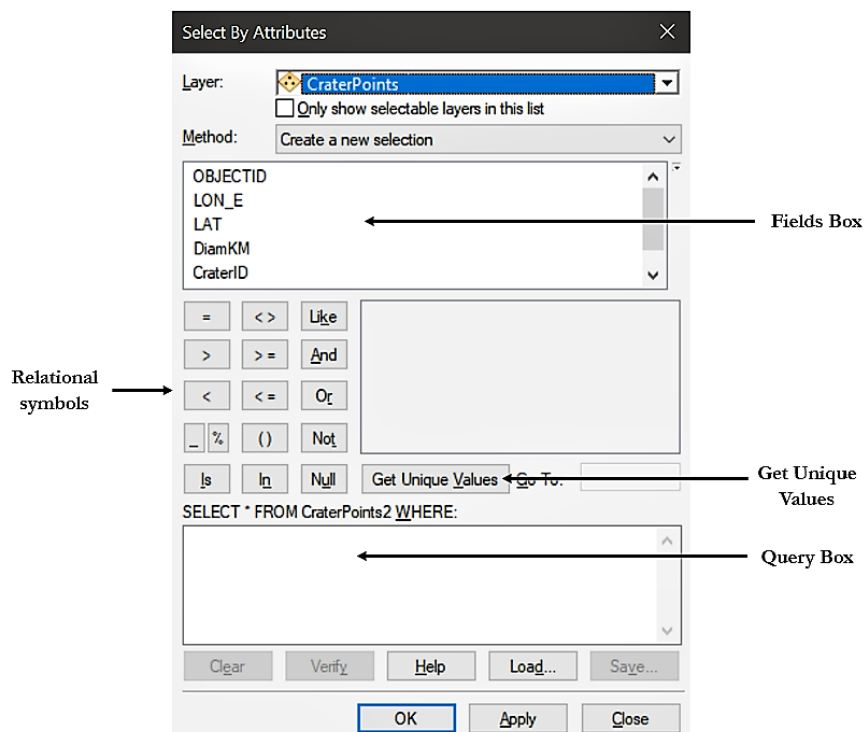
Step 3: Select features by attribute values to highlight small craters

- Click on **Selection** from the top menu and choose **Select by Attributes**.
- Select the layer **CratersPoints**.
- For **Method** keep the default **Create a new selection**, but open the drop-down menu to see the other choices.
- In the fields box, double-click on **DiamKM**. Notice how this text is added to the query box below.
- Click the less than symbol (<).
- Click Get **Unique Values**, and scroll down to **1.5**. Double-click on it to add it to the query. You can also type **1.5** into the query box after the less than symbol.

The query box should now read: **DiamKM < 1.5**

In earlier versions of ArcMap, the query might have quotation marks around **DiamKM**.

- Click **Apply** to see the selected craters highlighted on the map display.
- Click **OK**.



Select By Attributes and the elements we will be using

Step 4: View selected features in the attribute table


- Open the attribute table for the **CraterPoints** layer.

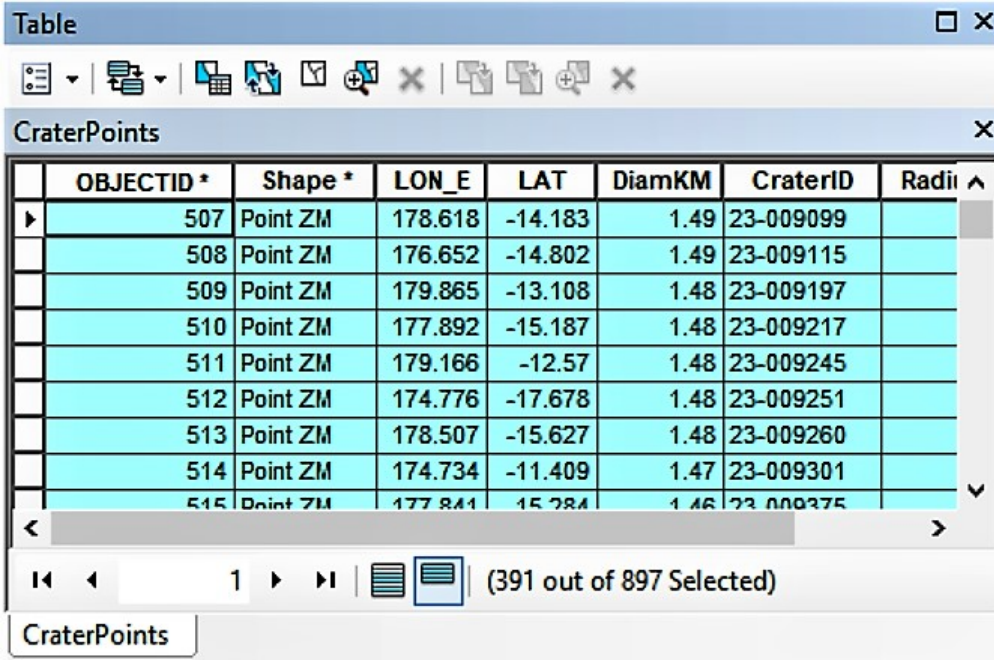
This can be done either by right-clicking and selecting **Open Attribute Table**, or for Windows machines by double-clicking on the layer while holding down the **Ctrl** key.

The attribute table has arranged the craters by decreasing size, so none of the selected features are visible without scrolling down.

- Right-click on **DiamKM** and select **Sort Ascending**.

Now we see that the selected craters are highlighted just like on the map display.

- At the bottom of the attribute window, click **Show selected records** .
- Scroll down to see that only selected features are shown in the table now.
- At the bottom of the window, notice how **391** craters have been selected from a total of **897**.
- Close the attribute window.



	OBJECTID *	Shape *	LON_E	LAT	DiamKM	CraterID	Radius ^
▶	507	Point ZM	178.618	-14.183	1.49	23-009099	
	508	Point ZM	176.652	-14.802	1.49	23-009115	
	509	Point ZM	179.865	-13.108	1.48	23-009197	
	510	Point ZM	177.892	-15.187	1.48	23-009217	
	511	Point ZM	179.166	-12.57	1.48	23-009245	
	512	Point ZM	174.776	-17.678	1.48	23-009251	
	513	Point ZM	178.507	-15.627	1.48	23-009260	
	514	Point ZM	174.734	-11.409	1.47	23-009301	
	515	Point ZM	177.841	-15.284	1.46	23-009375	

CraterPoints (391 out of 897 Selected)

The Attribute Table

Step 5: Create a new layer from selected features

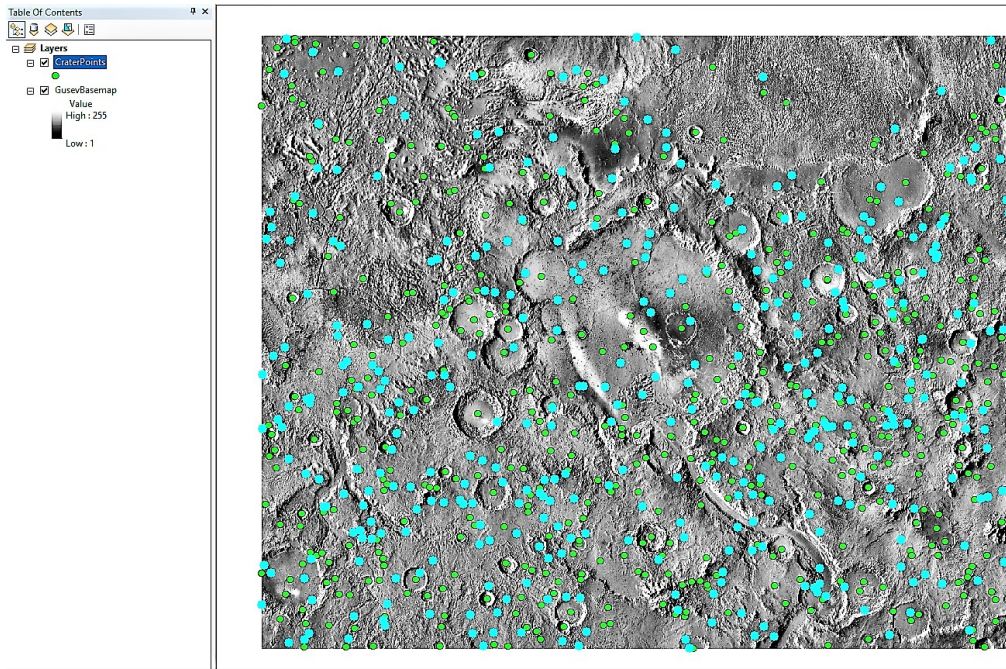
- Right-click on the **CraterPoints** layer, and from **Selection** click **Create Layer From Selected Features**.

A new layer appears just above the original layer.

- On the **Tools** toolbar, click **Clear Selected Features** .

- Turn off the **CraterPoints** layer.

The new layer only displays the craters less than 1.5 km in diameter.



Selection of craters with diameters less than 1.5 km

Step 6: Create a feature class from a new layer

- Look at the **Catalog** window and notice that **CraterPoints selection** does not appear as a new feature class.

It is a layer based on the same source data as the **CraterPoints** layer, and so it only exists in the map document. If you look at the **Source** tab in the **Layer Properties** for this layer, you will see it is still getting its data from the **CraterPoints** feature class, just like the **CraterPoints** layer.
- Right-click on the **CraterPoints selection** layer and from **Data** select **Export Data**.
- Click the browse button for the **Output** feature class.
- Go to the default geodatabase and name the new feature class **SmallCraterPoints**.

Ensure that the file type is **File and Personal Geodatabase feature classes**.
- Click **Save** and then **OK**.
- Click **Yes** to add this feature class to the map display.
- Notice in the **Catalog** window there is now a new feature class named **SmallCraterPoints**.
- Right-click on the **CraterPoints selection** layer and click **Remove**.
- Click once on the symbol for the **SmallCraterPoints** layer in the **Table of Contents** to open the **Symbol Selector** window.
- Symbolize this feature class by changing the fill color to **Electron Gold** (row 3, column 4) and increasing the size to **8**.

Exercise 3C: Tools for modifying and analyzing features

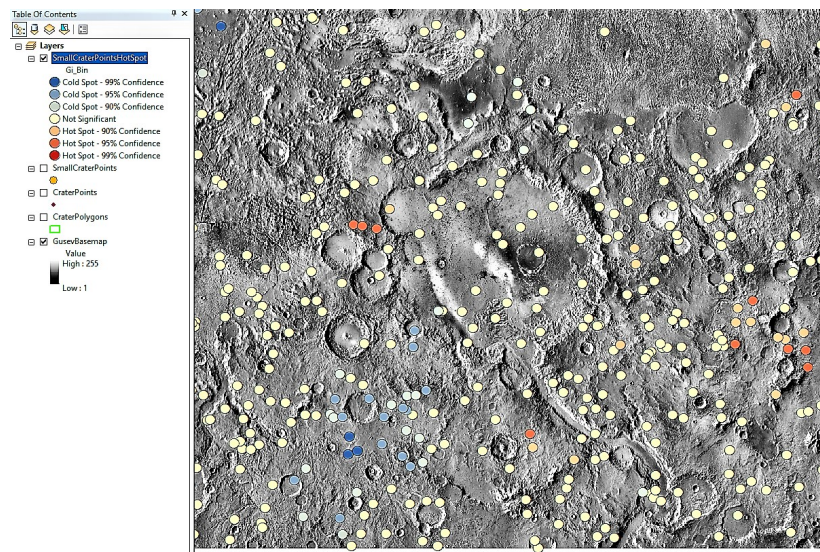
Estimated Time: 15 minutes

Step 1: Analyze crater size distribution

- Open the map document **GusevCrater3c** in the **Exercise3c** folder and make the geodatabase there the default.
- Use the **Search** window to locate the **Hot Spot Analysis** tool and open it.
- For **Input Feature Class** choose **SmallCraterPoints**.
- For **Input Field** choose **DiamKM**.
- For **Output Feature Class**, navigate to the default geodatabase and name the feature class **SmallCraterHotSpot**.
- Keep the other default settings and click **OK** to run the tool.
- Turn off the **SmallCraterPoints** layer and in the **Symbology** tab for the **Hot Spot** layer increase the point size to **12**.
To edit multiple symbols at once, open the **Symbology** tab in the **Layer Properties** window and highlight all the classes. Right-click anywhere in them and select **Properties for Selected Symbol(s)**. Then change the point size to **12**.

The resulting feature class shows places where there are high concentrations of smaller craters in blue and high concentrations of larger craters in red. This can serve as a quick assessment of whether a distribution is random or not.

- Turn off the **SmallCraterHotSpot** layer and collapse it.



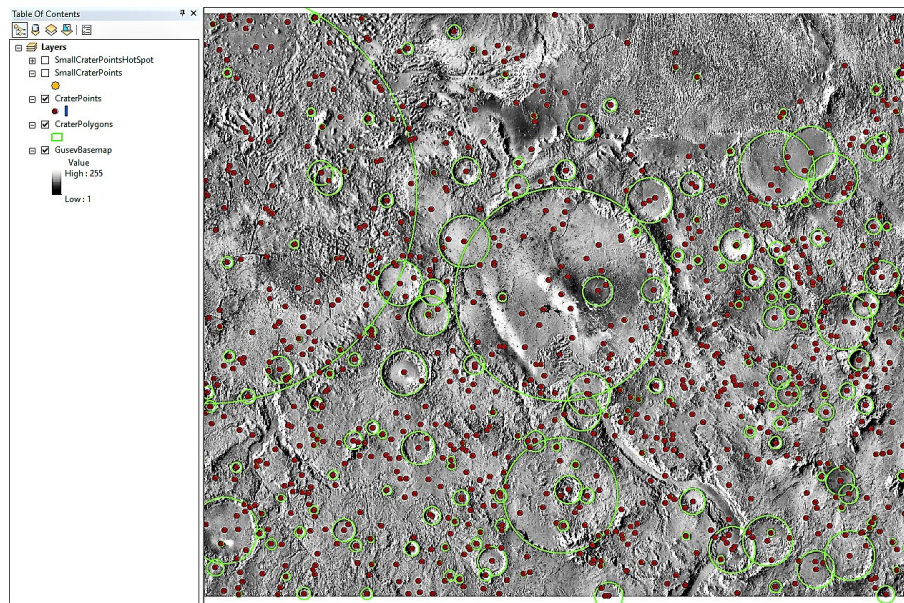
Results of Hotspot Analysis on small craters

Step 2: Buffer the crater points to create approximate polygon features

- Turn on the **CraterPoints** layer.
- From the **Geoprocessing** menu, select the **Buffer** tool to open it.
Some commonly used tools can be quickly accessed from the top menu.
- For **Input Feature Class** choose **CraterPoints**.

- For **Output Feature Class**, click on the browse button and name the file **CraterPolygons**.
- Select **Field** for **Distance** and from the drop-down menu choose **RadiusM**.
This is why we created this field so that we would have a distance in meters on which to base circular buffers.
- Keep all the other default settings and click **OK** to run the tool.
- Symbolize the new polygon layer with no fill color and a **Medium Apple** (row 3, column 7) outline with width **1.5**.
- Pan and zoom to explore these circular approximations of the craters.

The buffer circles work fairly well for larger craters, but zooming in reveals that this crater database is not lined up with our basemap. You can try using the **Measure** tool to see approximately how much the offset is. This is likely due to the database being based on an outdated datum or projection. ArcMap attempts to project new layers “on the fly”, but this does not always work well. You could try performing transformations to the old database to get features to line up better, but this also illustrates the importance of creating your own data from scratch.



Craters modeled by circular polygons

Optional: Calculate circumference and area for the crater points

- Copy the **CraterPointsRaw** feature class from the geodatabase in the **Exercise3b** folder and paste it into the geodatabase in the **Exercise3c** folder.
- Add the new **CraterPointsRaw** feature class to the map.
- As in the demo, create new fields titled **CircM** and **AreaM2** and calculate circumference and area from the radius.
- Open the **CraterPolygons** attribute table and view both tables.
- Compare the **CircM** and **AreaM2** field values to the **Shape_Length** and **Shape_Area** field values.
- Turn off the **CraterPointsRaw** layer.

Optional: Create a new feature with different geometry

Suppose it is preferred that the craters be represented by polylines instead of polygons. There are many tools that can create new features from existing ones with different geometry, including **Feature To Polygon** (polylines must be closed shapes) and **Feature To Point** (can convert either a polygon or polyline feature class).

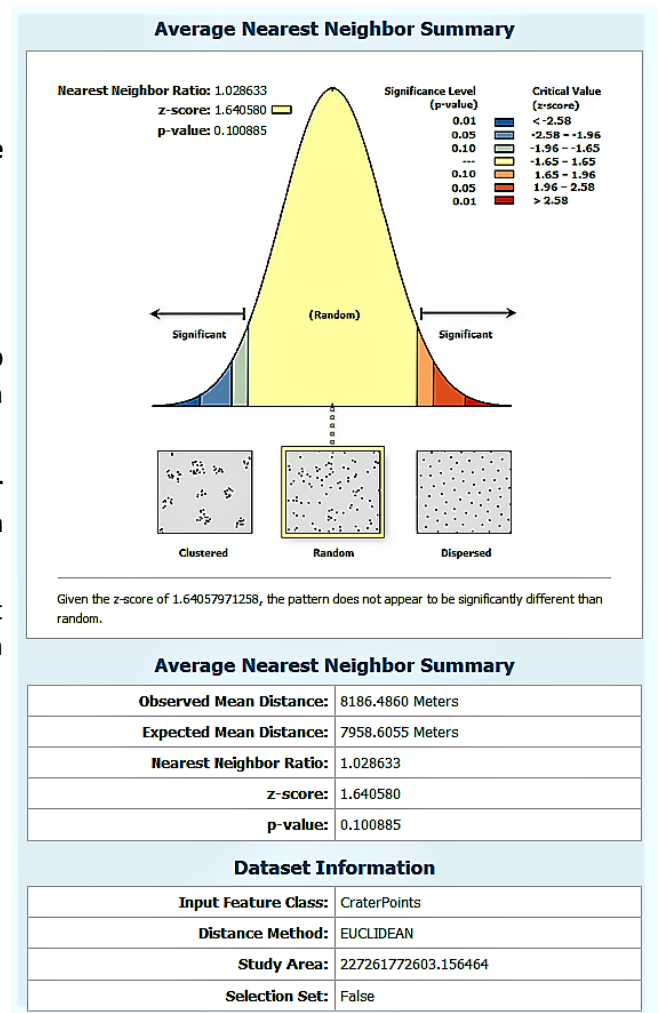
- Use the **Search** window to find the **Polygon To Line** tool and open it.
- For **Input Features** select **CraterPolygons**.
- For **Output Feature Class** click the browse button and name the file **CraterRims**.
- Uncheck **Identify** and store polygon neighboring information.
- Click **OK** to run the tool.
- Turn off the **CraterPolygons** layer.

The new **CraterRims** feature class is a polyline that approximates the rims of the craters.

Optional: Analyze crater distribution

- Use the **Search** window to find and open the **Average Nearest Neighbor** tool.
- For **Input Feature Class**, select **CraterPoints**.
- Check **Generate Report**, and then **OK** to run the tool.
- Open the **Results** window, either by clicking on the pop-up window in the lower right when the tool finishes or from **Geoprocessing** in the top menu.
- If necessary, expand the **Average Nearest Neighbor** heading at the top of **Current Session** and double-click on **Report File**.

An html file opens showing the results of the analysis. It has been saved to the folder you are currently working in (it will not show up in **Catalog**).



Results of Average Nearest Neighbor analysis, indicating that crater positions are randomly distributed

Chapter Summary

In this chapter you have learned the basics of creating, editing, symbolizing, and analyzing vector data. Our end product is a variety of feature classes representing the craters of the Gusev Crater region that could now be used for further analysis. You have also seen how attribute tables show you the data behind the displayed map, and how to manipulate those tables. It is easy to see by comparing the attribute tables of rasters and feature classes how vector data allows for significantly more data storage in a single file.

If you were merely investigating for potential research, using something like Robbins' crater data is a good place to start. However, if you are ready to perform your own analysis for research project, you should make your own data from scratch using the methods in Exercise 3A. It is time-consuming, but it will ensure that the aspects of the data most important to your research are included, and you will be using spatial references that are possibly more up-to-date than those in pre-existing datasets. Though many processes in ArcGIS can be automated for performing large numbers of repeated operations, either through Model Builder or writing a Python script, things like digitizing features generally require a "human touch" and need to be done by hand one at a time. If you have invested a lot of time into a dataset, you should strongly consider sharing it with others in your research group or even in an online forum like ArcGIS Online, so that others can use your data for their initial investigations and as guidance for doing their own research.



Criteria analysis

Exercise 4A: Converting rasters to vector data

Estimated time: 10 minutes

Exercise 4B: Using overlay to find landing site areas

Estimated time: 30 minutes

Chapter 4: Criteria analysis

Introduction

In this chapter you will learn how to prepare data for analysis that involves finding candidate objects, locations, or regions that meet certain criteria through a process of selection and combination. You will be using analysis techniques on vector data including proximity and overlay analysis. Our goal is to identify potential landing sites in the Gusev Crater region for a Mars mission that meet the following criteria:

1. Below -1000 m elevation
2. Slopes less than 5 degrees
3. Able to contain a 12 km diameter landing circle
4. Within 10 km of the rim of a small crater (<1.5 km diameter)

Objectives

- Convert raster data into vector data
- Perform overlay analysis using Union and Intersect
- Perform proximity analysis using Buffer
- Select features based on attributes
- Manage polygon features

Terms

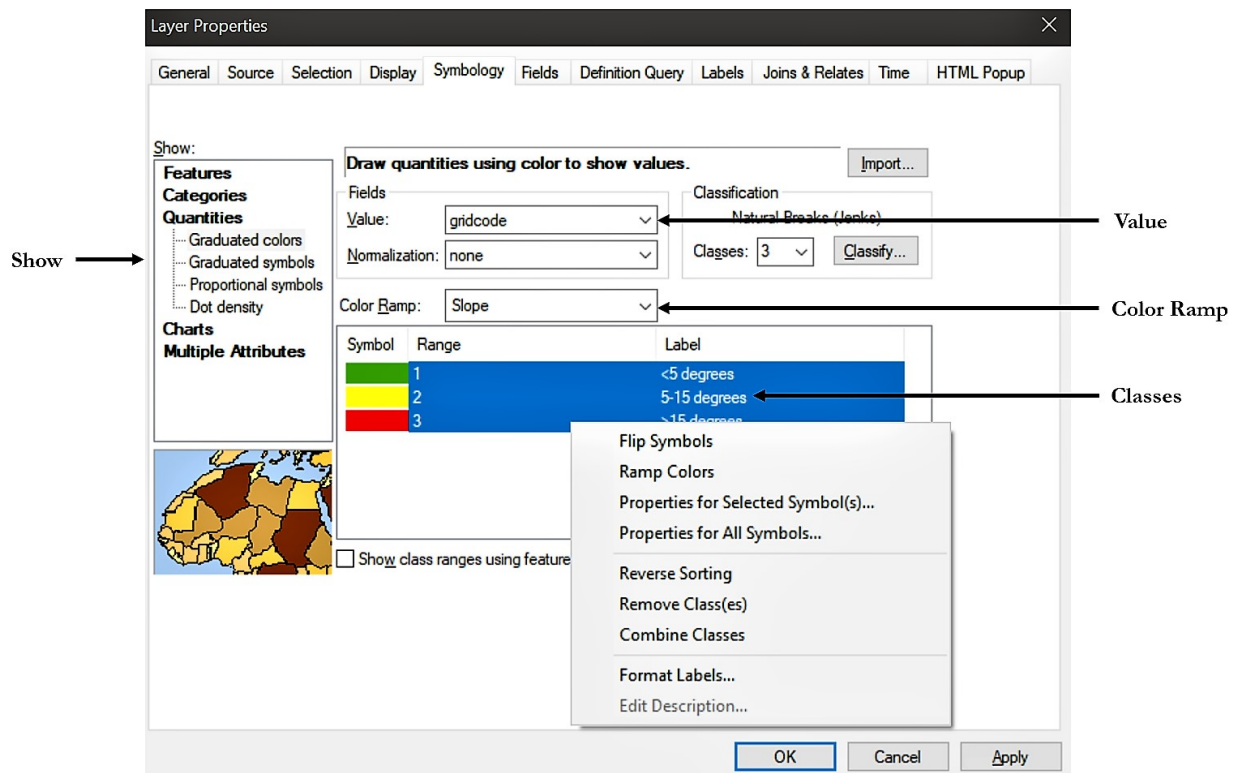
- Raster to Polygon
- Overlay
- Union
- Intersect
- Buffer

Exercise 4A: Converting Rasters to Vector Data

Estimated Time: 10 minutes

Step 1: Convert a discrete raster into a polygon feature class

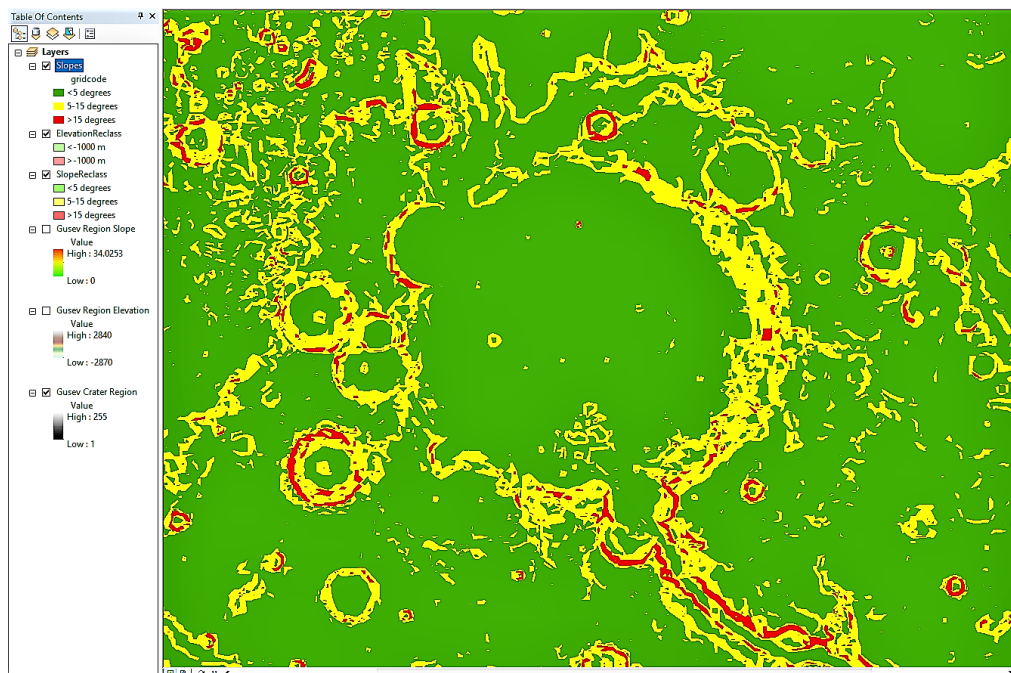
- In the **Catalog** window, add a folder connection to **Chapter4** and name it **Chapter 4**.
- Go to the **Exercise4a** folder and open the **GusevCrater4a** map.
- Make sure the geodatabase in that folder is the default.
- Use the **Search** window to locate and open the **Raster To Polygon** tool.
- For **Input** raster, navigate to the default geodatabase and select **SlopeReclass**.
- For **Output** polygon features navigate to the default geodatabase and name the file **Slopes**.
- Click **OK** to run the tool.



The Symbology tab with elements we will be using


Step 2: Symbolize the polygon feature classes

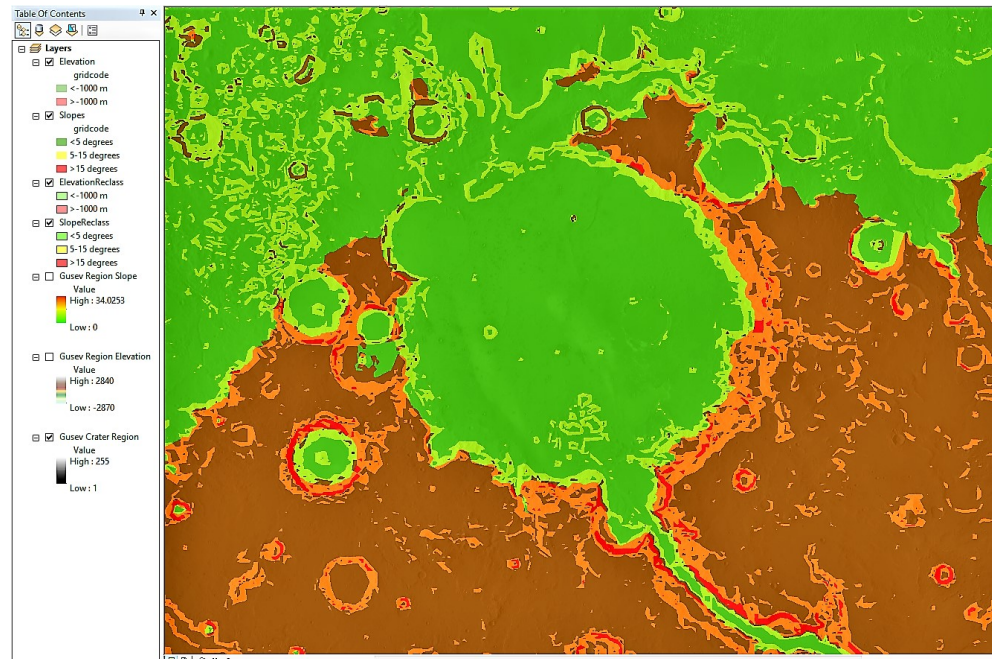
- Double-click on the **Slopes** layer in the **Table of Contents** to open the layer properties window.
- Go to the **Symbology** tab.
- Select **Quantities** in the **Show** table and ensure that it is set to **Graduated colors**.
- Set **Value** to **gridcode**.
- Set **Color Ramp** to **Slope** (turn off **Graphic View** to see the names of the color ramps).
- Change the **Labels** for each class to match those of the **SlopeReclass** layer.
- Highlight all three classes, right-click anywhere in them, and select **Properties for Selected Symbol(s)**.
- Set **Outline Color** to **No Color**.
- Click **OK**, then **OK** again to close the layer properties window.



Results of converting **Slope** raster to a polygon feature class

Optional: Convert the elevation raster

- Repeat the previous steps for the elevation raster, symbolize it, and set the transparencies of the layers as follows: **Slopes to 40%** and **Elevation to 60%**. This can be done by accessing the **Display** tab in the layer properties window, or by clicking on **Adjust Transparency**  on the **Effects** toolbar.



Results of converting **Elevation** raster to a polygon feature class

Exercise 4B: Using overlay to find landing site areas

Estimated Time: 30 minutes

Step 1: Merge feature classes using Union

- Go to the **Exercise4b** folder and open the **GusevCrater4b** map document.
- Make sure the geodatabase there is the default.
- From the **Geoprocessing** in the top menu, select **Union**.
Notice how a few commonly used tools are quickly available from this menu.
- For **Input Features**, choose **Elevation**, and then also choose **Slopes**.
- For **Output Feature Class**, navigate to the default geodatabase and name the file **ElevationSlopesUnion**.
- Click **OK** to run the tool.
- Open the attribute table for the **ElevationSlopesUnion** layer.

There are now more polygons than in either of the original feature classes, subdivided by their combination of attributes from both layers into polygons that now each have all the attributes from the original features. This is because areas of overlap between the two feature classes form new polygons with attributes from both feature classes and areas with no overlap also form new polygons, resulting in an increase in the number of polygons. This ensures that each new polygon has all the attributes from the original features.

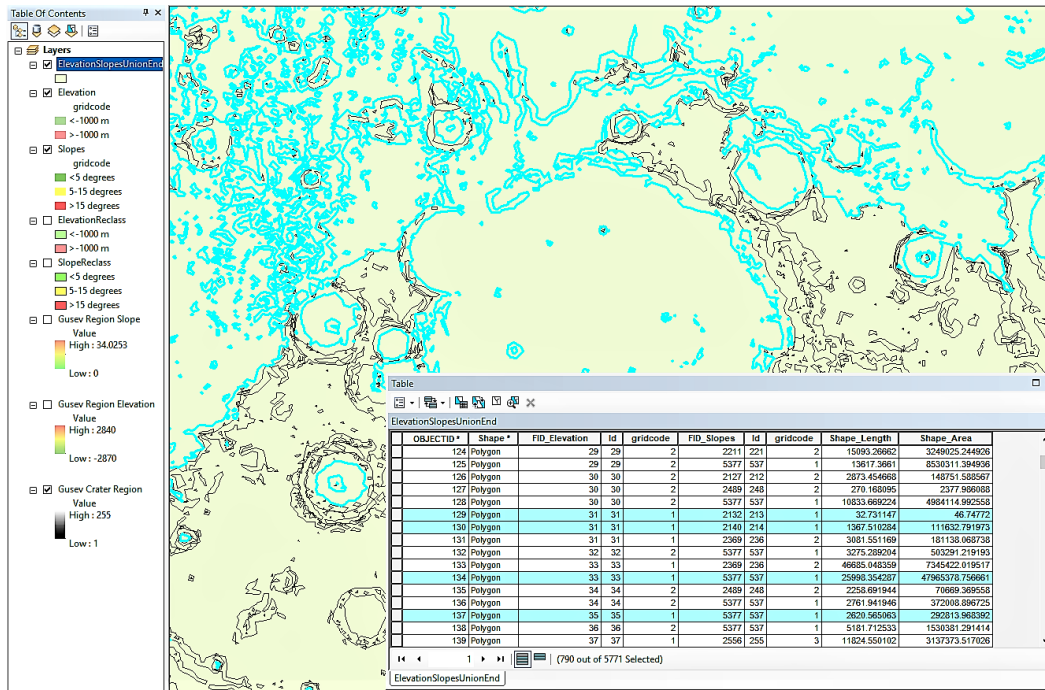
- Close the attribute table.

Step 2: Select potential landing areas

- From **Selection** in the top menu, choose **Select By Attributes**.
- We want the lowest slope and elevation, so we only want values of 1 for each of these fields. Select **ElevationSlopesUnion** layer and build the following query:

gridcode =1 AND gridcode_1 =1


- Click **OK**.
- Open the attribute table for the union layer to see which polygons are selected and how many have been selected (**790** out of **5771**).
- Close the attribute table.



Selection of areas that are both below -1000m elevation and have slopes less than 5 degrees


Step 3: Create a feature class from the layer selection

We want to create a new feature class with only these selected features.

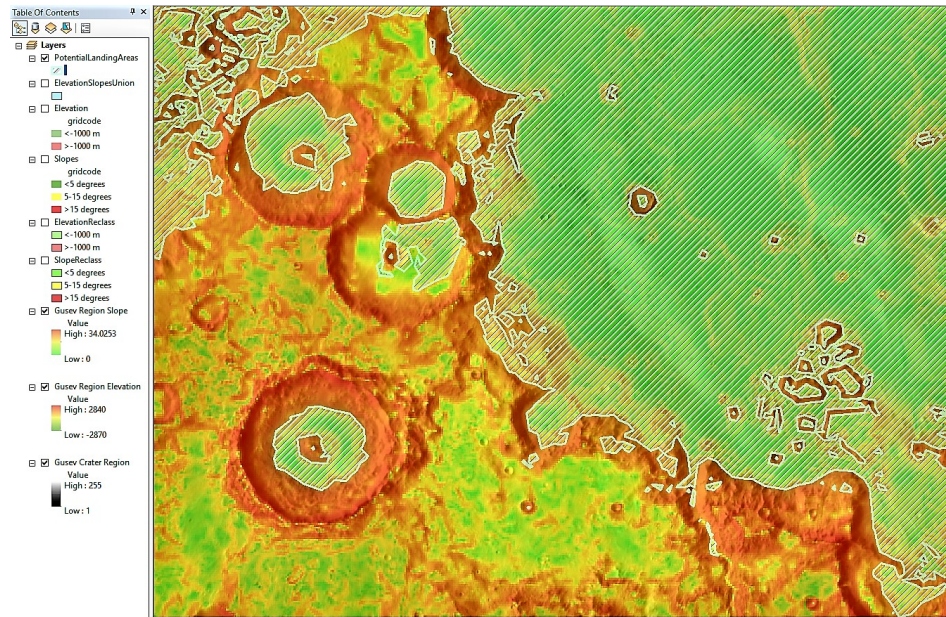
- Right-click on the newest layer and from **Data** choose **Export Data**.
- For **Export** select **Selected features**.
- For **coordinate system**, select **the data frame**.
- For **Output** feature class, navigate to the default geodatabase and name the file **PotentialLandingAreas**.
- Click **Save** and then **OK** to complete the export.
- Click **Yes** to add the new feature to the map.
- Click **Clear Selected Features**  on the **Tools** toolbar.
- Turn the **ElevationSlopesUnion** layer off.

Step 4: Symbolize and explore the results

- Click on the symbol for the **PotentialLandingAreas** layer in the **Table of Contents**.
- In the **Search** box at the top of the **Symbol Selector** window, type **overlay** and hit enter.
- Click on **100 Year Flood Overlay**.
- Change the outline color to **Indicolite Green** (row 1, column 8), and change outline width to **2**.
- Click **OK** to close the **Symbol Selector** window and set the transparency of the layer to **30%**.

This can be done by accessing the **Display** tab in the layer properties window, or by clicking on **Adjust Transparency**  on the **Effects** toolbar.

- Turn off the **Elevation** layer and the **Slopes** layer.
- Turn on the **Gusev Region Slope** layer and the **Gusev Region Elevation** layer.
Their color ramps are the same and their transparencies are set to allow both to be visible.
- Pan and zoom around to notice how the **PotentialLandingAreas** tends to cover greener areas where both the elevation and slopes are low.

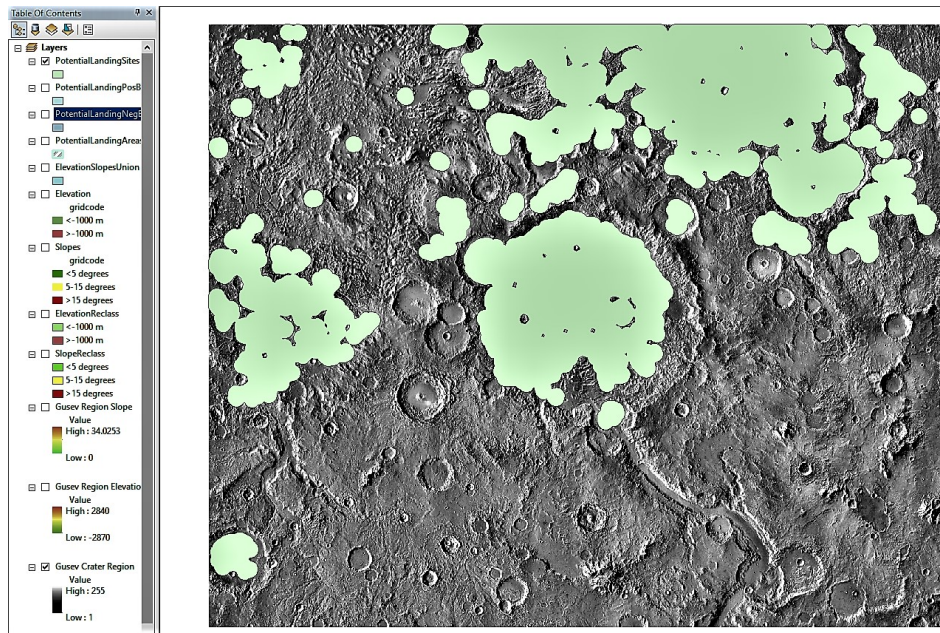


Results of isolating regions suitable in both elevation and slope

Optional: Find potential landing sites by finding large enough contiguous areas

First we will eliminate areas that are not large enough to fit a 12 km diameter landing circle.

- Turn off the **Gusev Region Slope** and the **Gusev Region Elevation** layers.
- From the **Geoprocessing** in the top menu, select **Buffer**.
- For **Input Features**, choose **PotentialLandingAreas**.
- For **Output Feature Class**, navigate to the default geodatabase and name the file **PotentialLandingNegBuff**.
- Select **Kilometers** for **Linear Unit** and enter **-6**.
This will eliminate any polygons that are not large enough to accommodate a 6 km radius landing circle.
- We want to dissolve the result into one polygon, so set **Dissolve Type** to **ALL**.
- Click **OK** to run the tool.
Then we will create regions for potential landing sites.
- From the **Geoprocessing** in the top menu, select **Buffer** again.
- For **Input Features**, choose **PotentialLandingNegBuff**.
- For **Output Feature Class**, navigate to the default geodatabase and name the file **PotentialLandingPosBuff**.
- Set the buffer distance to **6 Kilometers**.



Reduction to areas large enough to accommodate a 12 km diameter landing circle

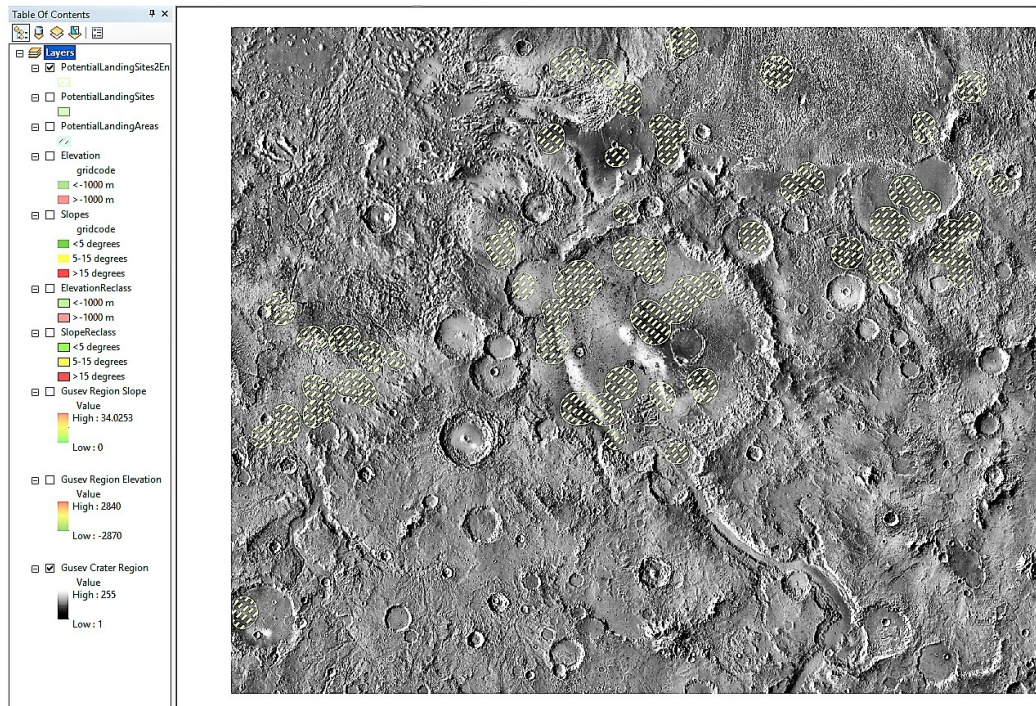
- Click **OK** to run the tool.
- Now, we want to split the one resulting disjointed polygon into multiple contiguous ones. Use the **Search** window to find the **Multipart to Singlepart** tool and open it.
- For **Input Features**, choose **PotentialLandingPosBuff**.
- For **Output Feature Class**, navigate to the default geodatabase and name the file **PotentialLandingSites**.
- Click **OK** to run the tool.
- Open the attribute table for **PotentialLandingSites**.
Notice there are now **25** polygons.
- Remove the buffered layers from the map document in the **Table Of Contents** by right-clicking on the name and selecting **Remove** (this does not delete those feature classes).
- Turn off the **PotentialLandingAreas** layer by unchecking the box next to its name.
- Symbolize this map however you like.

Optional: Use crater data to further refine landing site selections

On your own, bring in data from our crater analysis in Chapter 3 and use the **Buffer** and **Intersect** tools to find suitable landing sites within the **PotentialLandingSites** that are within 10 km of a small crater rim (less than 1.5 km diameter). Since this additional criteria will shrink the areas that are potential landing sites, you will need to repeat steps 4 and 5 after doing the intersection to again eliminate any areas that are too small for the landing circle to fit.

Chapter Summary

In this chapter you learned how to combine raster and vector data to perform analysis based on specific criteria. You converted rasters into vectors so that you could use vector analysis tools, but it is also possible to convert vectors into rasters and use raster analysis tools, though this usually only works well with two-dimensional vectors, i.e. polygon feature classes. Raster Calculator is a general overlay tool that is used to combine data from multiple rasters. It is best to carefully plan out the steps you will take to perform your analysis ahead of time, since there are usually multiple ways to obtain the same results and you must decide which is most efficient for your purposes. For instance, we could



Reduction to areas within 10 km of a crater with a diameter of less than 1.5 km

have created new layers through selection for each of the elevation and slope layers that would only contain the lowest ranges, and then used the Intersect tool to create polygons that fit both requirements. Instead, we first used Union and then a single selection from the resulting layer, which for this exercise was quicker and easier.

For an analysis process that you plan on repeating, the Model Builder function in ArcMap can be used to create a pipeline of tools and outputs to essentially create a new tool that you design. This model can then be saved as a single tool. A similar process can be done with rasters from the Image Analysis window by clicking on the Add Function Template to open the Function Template Editor.

5

Creating map products

Exercise 5A: Working in Layout View

Estimated time: 10 minutes

Exercise 5B: Creating a map product

Estimated time: 15 minutes

Chapter 5: Creating map products

Introduction

In this chapter you will learn how to prepare a finalized map product that is suitable for publishing or sharing online. This is done in ArcMap using the Layout View mode, as opposed to the Data View mode you have been working in while doing analysis and interpretation. Polished map products should have a title, legends, scale bars, and north arrows, which ArcMap refers to as map elements. Elements such as these, that are not spatially related to the data frame are only accessible while in Layout View. Text labels and other elements that are associated with specific locations in the data frame can be added and edited in either Data View or Layout View. Also, while only the active data frame can be viewed in Data View, multiple data frames can be viewed and worked on in Layout View so that a map product can have multiple data frames on it. However, as with Data View, only the active data frame can be worked on while in Layout View.

Objectives

- Explore the difference between Data View and Layout View
- Become familiar with the Layout toolbar
- Add basic map elements
- Work with multiple data frames



Terms

- Data View
- Layout View
- Map Element
- Extent Rectangle

Exercise 5A: Working in Layout View








Estimated Time: 10 minutes

Step 1: Viewing a map in Layout Mode

- In the **Catalog** window, add a folder connection to **Chapter5** and name it **Chapter 5**.
- Go to the **Exercise5a** folder and open the **GusevRegionLandingSiteAnalysis** map.
- In the lower left corner of the map display, change **Data View**  to **Layout View** .

Notice the **Layout** toolbar automatically appears if you do not have it already open or docked somewhere. **Layout View** is where you can combine data frames and add titles, legends, scale bars, etc., to create a publishable map. Changes in the **Table of Contents** will still have the same effects on the appearance of the layers in the data frames. Try turning some layers on and off to see this.

Step 2: Differences between the Layout toolbar and the Tools toolbar

- Explore the map layout using the **Zoom In** , **Zoom Out**  and **Pan**  tools in the **Layout** toolbar. These tools treat the display as a single page.
- Explore the **Landing Sites** data frame using the **Pan** , **Zoom In**  and **Zoom Out**  tools on the **Tools** toolbar. Using these tools will only affect the active data frame. If you wanted to make changes to the **Slope & Elevation** data frame, you would need to activate it first. This can be done by either right-clicking on the data frame and selecting **Activate**, or by holding down the Alt key while left-clicking on the data frame.
- Click **Zoom Full Page**  on the **Layout** toolbar.

Step 3: Map elements

- Change back to **Data View**, and click **Insert** from the top menu.
- Notice how options such as **Title**, **Legend**, and **Scale Bar** are not available, but **Text**, **Picture**, and **Object** are. This is because the location of things like titles and legends are stylistic, whereas things like text labels of a particular feature are location specific.
- Switch back to **Layout Mode**.
- Click **Insert** again, and notice these options are now available.

In the next exercise, you will learn how to create and modify map elements.

Exercise 5B: Creating a map product

Estimated Time: 15 minutes

Step 1: Getting started in Layout View

- Go to the **Exercise5b** folder and open the **GusevCrater5b** map.
- In the lower left corner of the map display, change **Data View** to **Layout View**.
The three data frames are all in the middle of the page, each with a thin, black rectangle around them. The rectangles show the extent of the data frame on the page, and mimics the extent of the map display window when in **Data View**.
- Click the **Pan** tool on the **Tools** toolbar and use it to move the **Landing Sites** data frame around.
Notice how if you move the map display outside of its extent rectangle, it is no longer visible.

Step 2: Arranging data frames

- Activate the **Craters** data frame.
- Select the **Pan** tool.
- Click and drag the **Craters** map display and, without letting go of the left mouse button, try to move the map display to the upper right corner and then move it back to the center before releasing the left mouse button.
The map display disappeared because it was moved outside the data frame's extent rectangle.
- Click on **Select Elements** on the **Tools** toolbar, and then click on the **Craters** map display.
The rectangle around the **Craters** map display is now highlighted and when you move the cursor over it a four-sided arrow appears.
- Click and drag the **Craters** data frame to the upper right corner of the page.
- Use **Pan** and **Zoom** on the **Tools** toolbar to get the map display to fill the data frame's extent rectangle.
Select Elements can also be used to resize the extent rectangle.
- Repeat these steps to move the **Slope & Elevation** data frame to the lower right corner, and then move the **Landing Sites** map display to the upper left, leaving some room on top for a title. Do not resize the **Landing Sites** extent rectangle, but rather use it as a frame around your entire map product.
Note that when you select a data frame's extent rectangle, it is automatically activated. However, unlike the **Pan** and **Zoom** tools, you can resize and move a data frame's extent rectangle without needing to have that data frame active.

Step 3: Adding basic map elements

- Click **Insert** from the top menu bar and select **Title**.
- Name the map **Gusev Region Landing Site Analysis** and click **OK**.
The newly created map element is automatically selected.

- Right-click on the title and select **Properties**.
- Click **Change Symbol**.
- Change the **Size** to **20** and click on the bold symbol for **Style**.
- Click **OK**, and then **OK** again.
- Use **Select Elements** to move the title to the upper left corner of the page, just above the **Landing Sites** map display and inside that data frame's extent rectangle.
- If it is not, make the **Landing Sites** data frame active.
- From the **Insert** menu, select **Scale Bar**.
- Click on **Alternating Scale Bar 2** and then click **OK**.
- Move the scale bar just below the **Landing Sites** map display.

The scale bar created will be based on spatial data from the active data frame and will automatically adjust to any changes in how that data frame is being displayed, such as zooming in or out.

- Right-click on the scale bar and select **Properties**.
- Change **Division Units** to **Kilometers** and click **OK**.
- From the **Insert** menu select **Legend**.
- Click on **GusevBasemap** under **Legend Items** and then click the left arrow (<).
- Then click **Next**.

This is how you can specify which layers you want to be shown in your legend.

- Delete **Legend** from the **Legend Title** field and leave it blank, then click **Next**.
- Continue clicking **Next**, observing all the options available at each step.
- Click **Finish** at the end.
- Adjust the position and size of the legend to fit right below the scale bar.
- Repeat the previous seven steps to create legends for the other two data frames, remembering to activate the frame before selecting **Legend** from the **Insert** menu.

Your map product should now look similar to the one seen in Exercise 5A.

Chapter Summary

In this chapter you learned the basics of working in Layout View, arranging multiple data frames within a map product, and adding map elements. You also saw that there are many more options available for creating map products suitable for publishing. Working with data frames and map elements in Layout View works similarly to a program like MS PowerPoint. The finished map can be exported in several formats. If you click on File in the top menu and hover your cursor over Export Map, you will see the options available for doing this.

Appendix

Common File Types

Toolbars

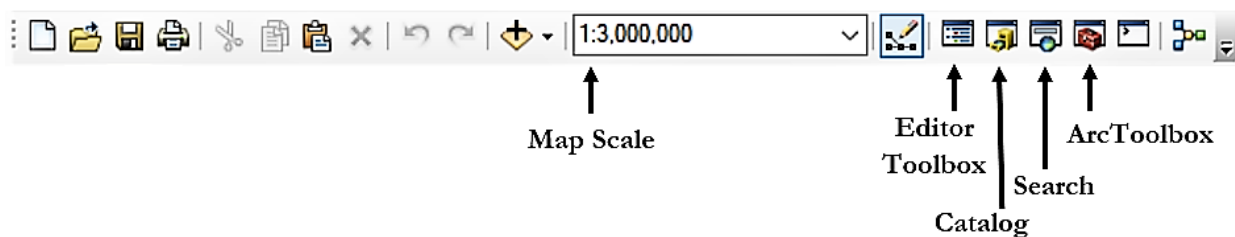
Glossary

Common File Types

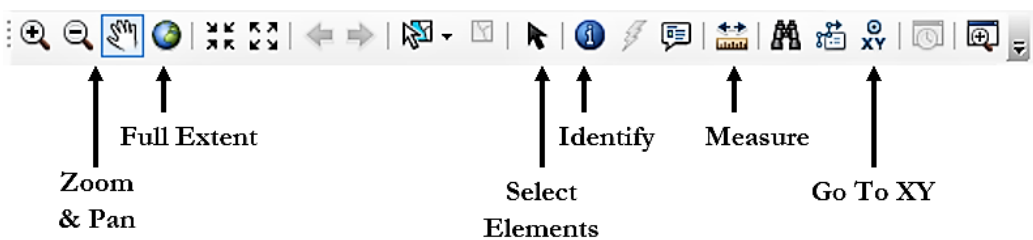
- * **Data frame** 📄
 - * Contains one or more layers, part of the map document structure
 - * Only one data frame can be active at a time, can activate by right-clicking menu of the data frame or by Alt-left-clicking on the data frame
 - * Only the active data frame can be viewed in Data View; in Layout View, only the active data frame can be altered
- * **Feature Class** 🗺️ 📄 🗺️
 - * Similar to shapefile, but with additional files for use in ArcGIS
 - * Can ONLY be used within an ArcGIS geodatabase, can be exported as a shapefile
- * **Feature Dataset** 🗺️
 - * Contains multiple feature classes related by content, must have the same coordinate system
- * **Geodatabase:** *.gdb 🗺️ (default geodatabase: 🗺️)
 - * ArcGIS file structure for storing, organizing, and sharing data with other ArcGIS users
- * **Image Files:** *.tif 🗺️
 - * Common: TIFF (regular or GeoTIFF), JPEG, JPG2, PNG, BMP, GIF, etc.
 - * Dataset specific: SAR, SRTM, DEM, DOQ, LAS, many more
- * **Layer:** *.lyr 📄
 - * Store information for how to display a particular data source or dataset
 - * Does NOT store any source data
- * **Map Document:** *.mxd 🗺️
 - * Stores information for how to display all data in a map
 - * Does NOT store any source data
- * **Packages:** *.lpk 🗺️ , *.mpk 🗺️
 - * Stores both display instructions and source data
 - * Good for sharing with other ArcGIS users who do not have access to your geodatabase
- * **Shapefile:** *.shp 🗺️ 📄 🗺️
 - * Stores spatial and geometric data for features
 - * Used by most GIS software , can be used in ArcGIS but not within a geodatabase, can be imported as a feature class
- * **Table** 📄
 - * Tabular data, can be imported from other formats like MS Excel and then added to the attribute table of a feature class, or can be exported from the attribute table data of a feature class

Toolbars

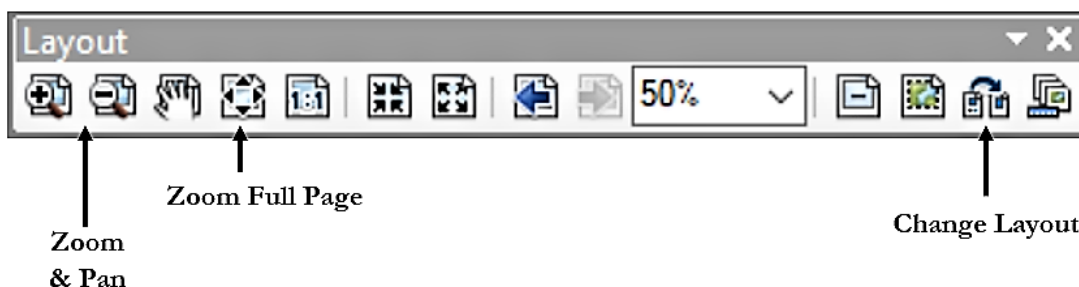
The Standard toolbar



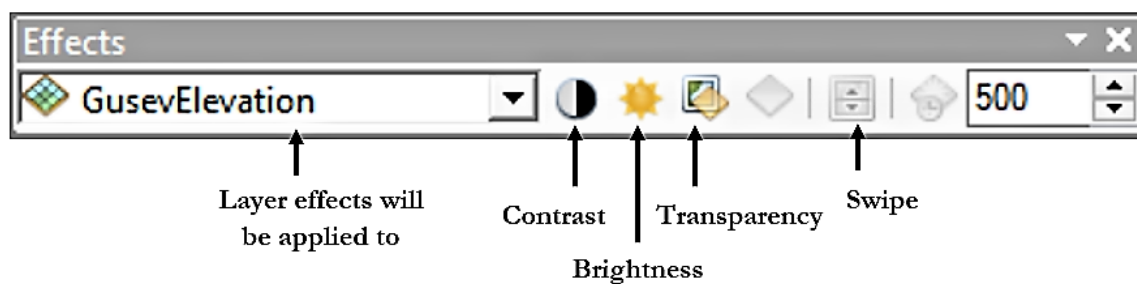
The Tools toolbar



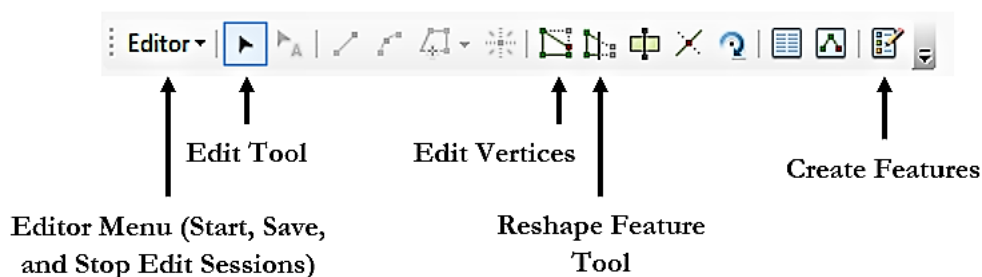
The Layout toolbar



The Effects toolbar



The Editor toolbar



Glossary

- * **Attribute Table:** a table that stores non-spatial information about features in a feature class (or statistics on pixel values in a raster), more columns can be added to associate additional data with features (only for feature classes, not rasters)
- * **Average Nearest Neighbor:** a tool that calculates the nearest neighbor index from the average distance between each feature and its next neighboring feature
- * **Basemap:** a raster depicting background reference information onto which other layers, either from rasters or feature classes, are placed
- * **Buffer:** a tool for creating a zone around a map feature a specified distance from the edge of the feature, output is a polygon feature class, distance can be negative to create a smaller zone within a feature (not available in earlier versions of ArcGIS Desktop)
- * **Cell Size:** the spatial resolution of a raster, i.e. the physical size of a pixel on the surface being viewed
- * **Construction Tools:** specifies the method by which the user will draw a new feature
- * **Data Frame:** a map element that contains one or more layers, all layers in a data frame share a geographic extent and coordinate system, a map may contain multiple data frames but only one frame may be active at a time and only the active frame will be visible in Data View mode in ArcMap
- * **Data View:** one of two possible modes for displaying maps in ArcMap, used during analysis and interpretation, certain map elements with no spatial relationship to the data frame (such as legends, titles, scale bars, etc.) are not shown in this mode and are only visible in Layout View, text labels and other objects associated with specific locations on the map are shown in Data View
- * **Edit Session:** while in an edit session, changes to features and attributes that alter source data can be made and new features can be created
- * **Editor Toolbar:** contains tools used to start and stop editing sessions and edit data during an editing session
- * **Feature Class:** a vector data file used specifically by ArcGIS to store geometric features and attributes associated with them, analogous to shapefiles used throughout GIS platforms but with added features for use with ArcGIS tools
- * **Feature Dataset:** a collection of feature classes stored together that share the same coordinate systems, extent area, and theme; feature classes with different geometries can be stores in the dame dataset
- * **Fields:** the columns in an attribute table which associate a value for a certain property, or other type of information such as a word, thumbnail image, or hyperlink, for all the features in a feature class or shapefile
- * **Geodatabase:** contains a file structure for organizing data such as feature classes, rasters, and tables; the structure can only be properly viewed within ArcCatalog, as its schema and file types are not recognized by other data viewers such as Windows Explorer or Mac Finder
- * **Hillshade:** a feature that uses elevation data from a raster to simulate the terrain with shadows due to a light source
- * **Hot Spot Analysis:** a tool used to visualize statistically significant spatial clusters of high values (hot spots) and low values (cold spots) of a given numerical attribute within a feature class
- * **Intersect:** a tool for creating a new feature class from two or more existing polygon feature classes, which creates

polygon features based on the areas where features in the existing feature classes overlap; attributes from all input features are included in the attribute table of the output feature class' attribute table

- * **Layer:** on a map; layers can also define additional properties, such as which features from the data source are included a component of a map document that provides information on how to display data from a given source file; can be stored as a file and used to display other similar source files; layers appear in the Table of Contents window in ArcMap
- * **Layout View:** one of two possible modes for displaying maps in ArcMap, used after analysis is complete for creating a finished map product for publication; in this mode map elements can be created and modified, such as titles, legends, and scale bars and data frames can be moved and resized on the page; all data frames are visible, but as with Data View only the active frame can be manipulated
- * **Map Document:** a file that contains information for how to display spatial data, such as feature classes and rasters; contains one or more data frames, each of which contain one or more layer; contains no source data, and must be saved as a Map Package in order to include source data in the file
- * **Metadata:** information associated with a data file, such as source, authors/owners, keywords, coordinates, and previous processing; can be edited by any user in ArcCatalog
- * **Overlay:** a set of processing tools, such as Intersect and Union, that create new feature classes from the overlapping of existing features
- * **Query:** a logic expression that describes a subset of features within a feature class by their properties; typically used to select features that make the expression true
- * **Raster to Polygon:** a tool that converts a raster to a polygon feature class by converting areas of equal cell value into polygon features
- * **Raster:** an array of cells (pixels) each possessing a numerical value and a spatial coordinate; image files of all common types can be loaded in ArcMap and spatial data can be added through georeferencing to existing rasters covering the same geographic area
- * **Selection:** a subset of features from a feature class isolated for analysis, often created by using a query but also can be created by hand using the Select Features tool on the Tools toolbar
- * **Snapping:** an adjustable feature of editing that allows for exact matching of position to an existing part of a feature, such as a vertex or edge, when the mouse is moved to within a specified distance, or tolerance, of the object
- * **Spatial Analyst Toolbar:** provides advanced analysis tools for use on both rasters and vector data
- * **Streaming:** a feature used in digitizing (drawing by hand) polylines and polygons in which vertices are added automatically at regular defined intervals as the mouse is moved
- * **Symbology:** controls how the data are displayed in ArcMap, such as color, icon size, line width, continuous vs. discrete, etc.; symbology information is stored in layer files and map documents
- * **Union:** a tool for creating a new feature class from two or more existing polygon feature classes, which creates polygon features based on the areas occupied by any features in the existing feature classes; attributes from all input features are included in the attribute table of the output feature class' attribute table
- * **Vector:** a geometric object, such as a point, line, or polygon, defined by the exact locations and sizes of defining properties, such as end points and lengths; as vectors do not depend on arrays of cells, but rather by pure geometry, they have effectively infinite resolution when being displayed