Field Maps of the Beypazari Granitoid north central Turkey

Pamela Speciale
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Contents

Introduction

Background

The Beypazari Granitoid is a crystallized magma chamber emplaced in a Late Cretaceous volcanic arc in north central Turkey (Billur 2004). This pluton is of specific interest because it records collisional processes during the closure of the NeoTethys Ocean (Sengor et al. 1981), a major event in Earth history. The granitoid pluton crops out in the Sakarya Zone, a lithospheric sliver that trends from east to west for approximately 1500 km and extends 200 km from north to south (Okay and Tuysuz 1999).

During the summer of 2011, my supervisor (Dr. Elizabeth Catlos), graduate mentor (Karen Black), and Okan Yildiz (a Turkish undergraduate student from Middle East Technical University) collected samples of the Beypazari Granitoid. Zircons from these granites were dated in rock thin-section using an ion microprobe. The ages range from Late Cretaceous to Early Eocene (102.8±16.8 Ma to 48.9±2.7 Ma). This represents a significant age range within a single pluton, and may be related to pulses of magma within the chamber. In addition, two ~6 Ma zircons were dated in one of the samples, a considerably younger and unexpected result. These zircons are located within a cross-cutting aplite dike. They are not likely related to emplacement of the pluton, and may represent metamorphic ages related to a change in tectonic regime associated with the activation of the North Anatolian Fault.

The Problem

The purpose of my Undergraduate Honors Thesis project is to explore the problem of the origin of the ~6 Ma zircons. Resolving this issue will provide an opportunity to develop ideas about the nature and influence of strike-slip deformation. The Beypazari Granitoid can not only provide useful insights into the tectonic processes of collision that consolidated the Turkish Anatolian Plate, but also constrain the tectonic influence of the North Anatolian Fault. This strike-slip fault system presents a major seismic hazard in Turkey as the Anatolian Plate migrates to the west relative to the Eurasia Plate. The M7.4 Izmit Earthquake of 1999, for example, resulted in the deaths of tens of thousands of people and rendered millions homeless (Ucarkus et al. 2011).

My central hypothesis is that the ~6 Ma zircons represent metamorphic ages related to motion along the North Anatolian Fault, and the range of Late Cretaceous ages relates to pulses of magmatism during crystallization of the Beypazari Granitoid pluton. The long-term goal of this research is to improve our basic comprehension of the tectonics of north central Turkey, with a focus on the Beypazari granite. This will lead to a better understanding of the influence of extension, extrusion tectonics and strike-slip faulting in the region.

This Report

This report describes the development of a series of ArcGIS maps generated for my use in the field. The final three maps include: 1) a Geologic Map of the Beypazari Granitoid, 2) an Outcrop map with sample locations, towns and roads, and 3) a HillShade Map with outcrops of the Beypazari Granitoid to aid in finding and confirming faults or other structures in the field. I also calculated the outcrop area of the granitoid and the length of roads that coincide with the outcrop to get a better idea of accessibility to the pluton.

Data Collection

Existing Data

Dr. Mark Helper provided a wealth of ArcGIS data collected from a variety of sources such as the USGS. These data include shapefiles of cities, rivers and roads, and an outline of Turkey.

ASTER DEM

ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) is an Earth-orbiting remote sensing device that generates high-resolution digital elevation data of the Earth's surface. An ASTER DEM (digital elevation model) can be obtained free of charge on the USGS Land Processes Distributed Active Archive Center (LP DAAC) website. I ordered a DEM of my field area in geographic coordinate system WGS1984 using the following procedure:

- Visit the LP DAAC website at https://lpdaac.usgs.gov/get_data (Figure 1).
- Obtain the required username and password to order the free DEM.
- Click on Launch Reverb.

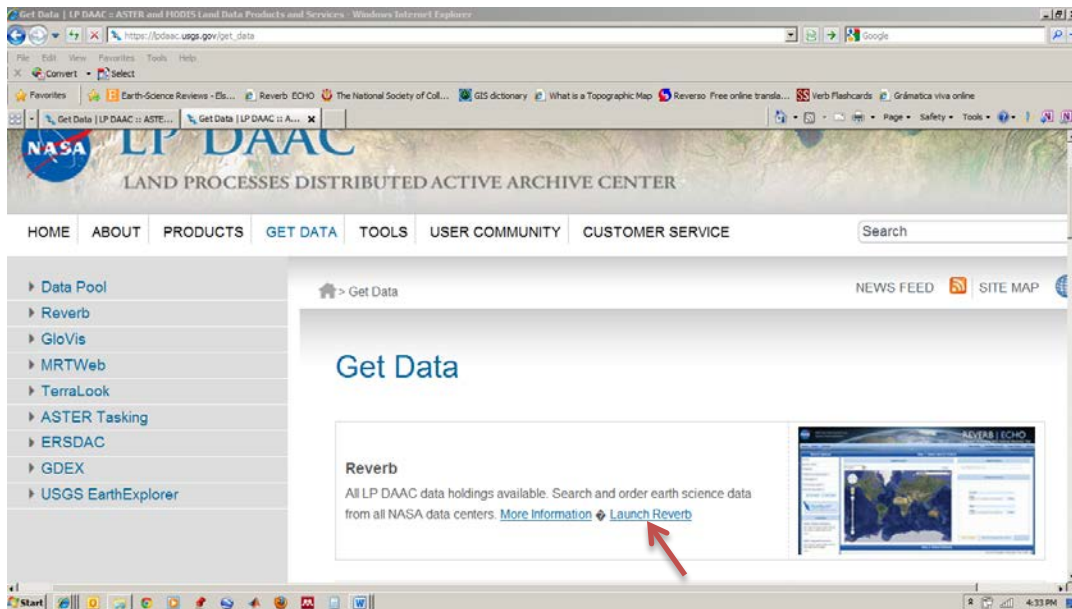**Figure 1. To download ASTER DEM, visit LPDAAC website and click on Launch Reverb.**

- Enter the geographic coordinates (lat/lon) bounding the area of interest (Figure 2).

The order takes a few days to process, and a link to an ftp site is provided via email to retrieve the DEM in TIFF format.
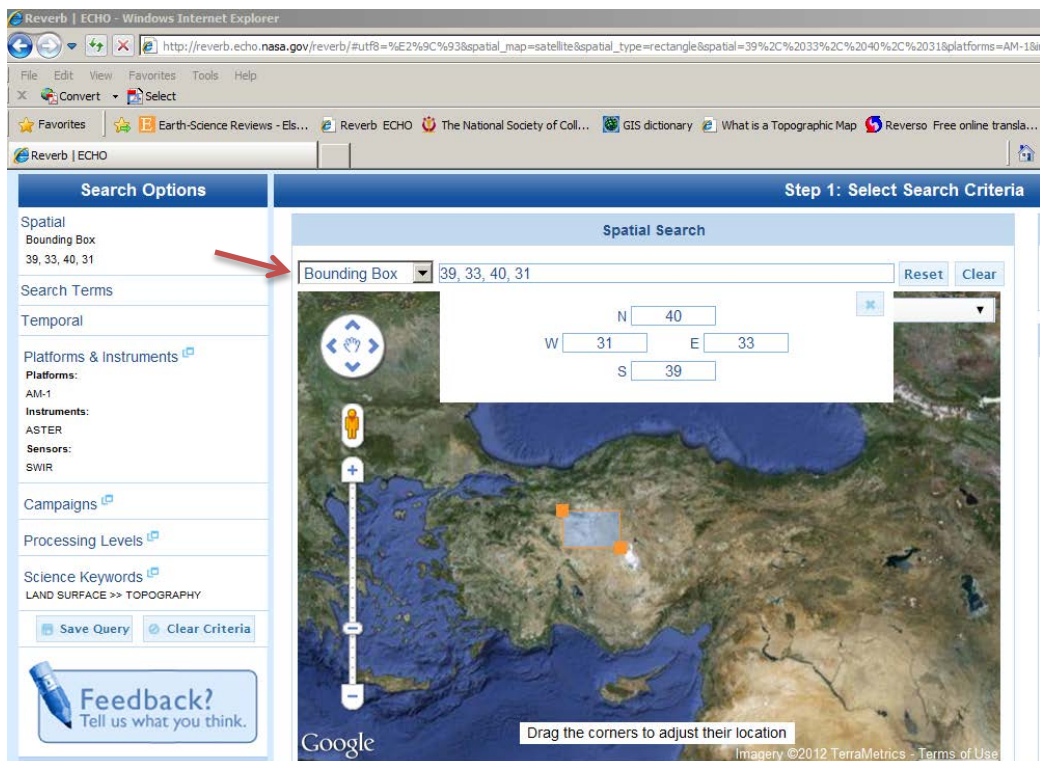

Figure 2. Click drop-down Bounding Box and enter the geographic coordinates bounding the area of interest.

ArcMap Data Generation

In order to develop my field maps, I needed not only to import the data provided by Dr. Helper and LP DAAC, but also create new data in ArcGIS. Below is my process:

- Starting with a blank ArcMap document, click the File drop-down menu and click the Map Document Properties and check the Pathnames box near the bottom to Store Relative Pathnames to Data Sources. This is a helpful initial step ensures that the software can find the appropriate files for the map regardless of which computer is used (Figure 3).
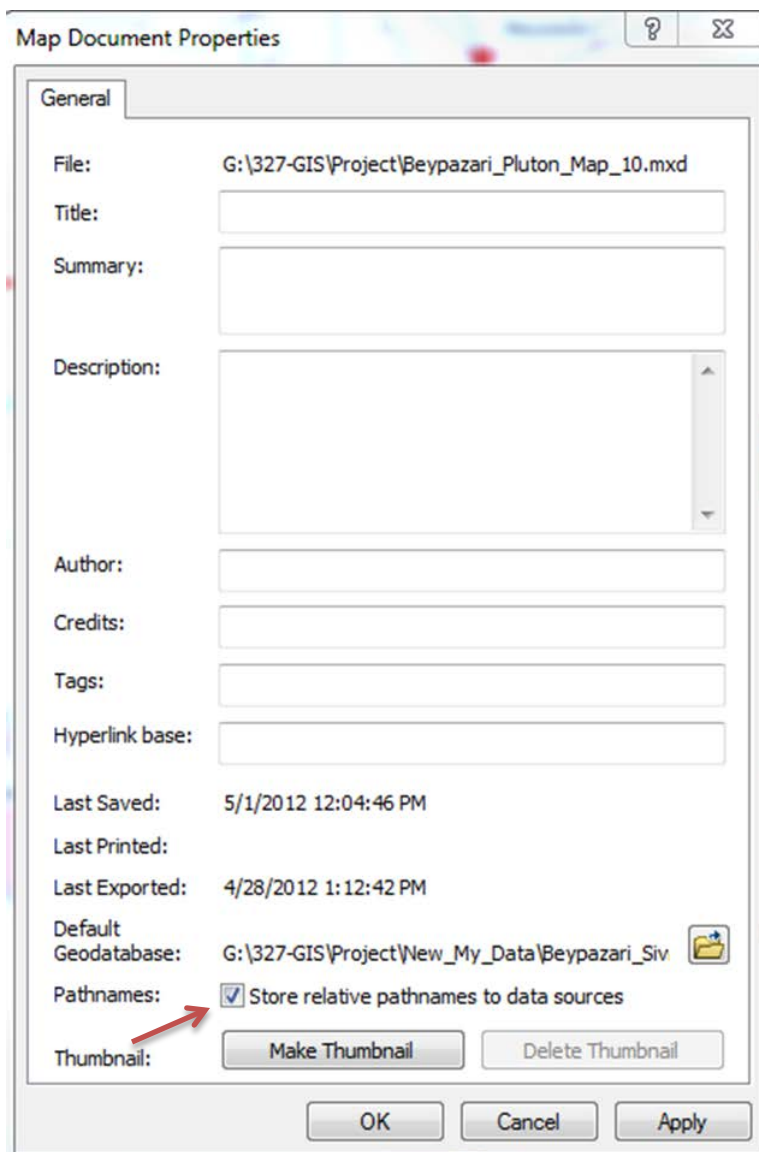

Figure 3. Store relative pathnames to enable the map to find data from any computer. (File→Map Document Properties)

- Create a project folder (Project) and a subfolder (My_Data) to serve as the central storage folder for the geodatabase, shapefiles, and other data specific to the map.

Extract and Import TIFFs

When the ASTER DEM data arrived, I needed to extract the zipped files in Windows Explorer and import them into an ArcGIS map.

- In Windows Explorer, create a subfolder (Extracted_zips) under the Project folder for downloading zipped ASTER DEM files.
- Right-click and select Extract All to unzip these files into the same folder for later processing (Figure 4). ASTER files are conveniently named with the latitude and longitude of the bottom-left corner of the square image.
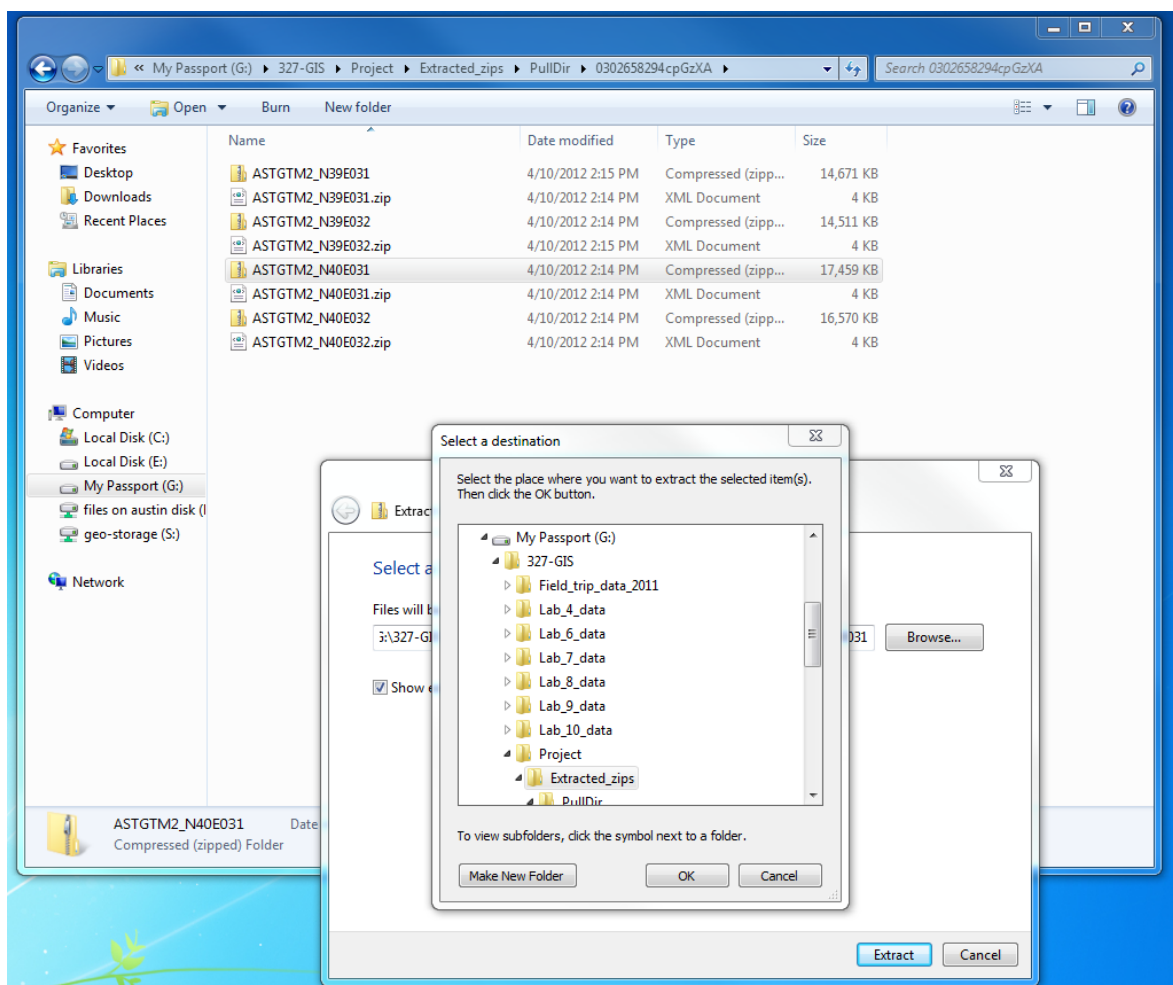- From ArcCatalog, drag and drop each DEM.tif into the TOC.

Figure 4. Extract TIFF files in Windows Explorer.

Mosaic DEM

The spatial reference of the DEM was GCS_WGS_1984, and it did not need to be projected. It is very important to maintain the spatial reference that comes pre-defined in a dataset because it is the known spatial reference against which all other data are referenced.

- From ArcCatalog, browse to the Extracted_Zips subfolder.
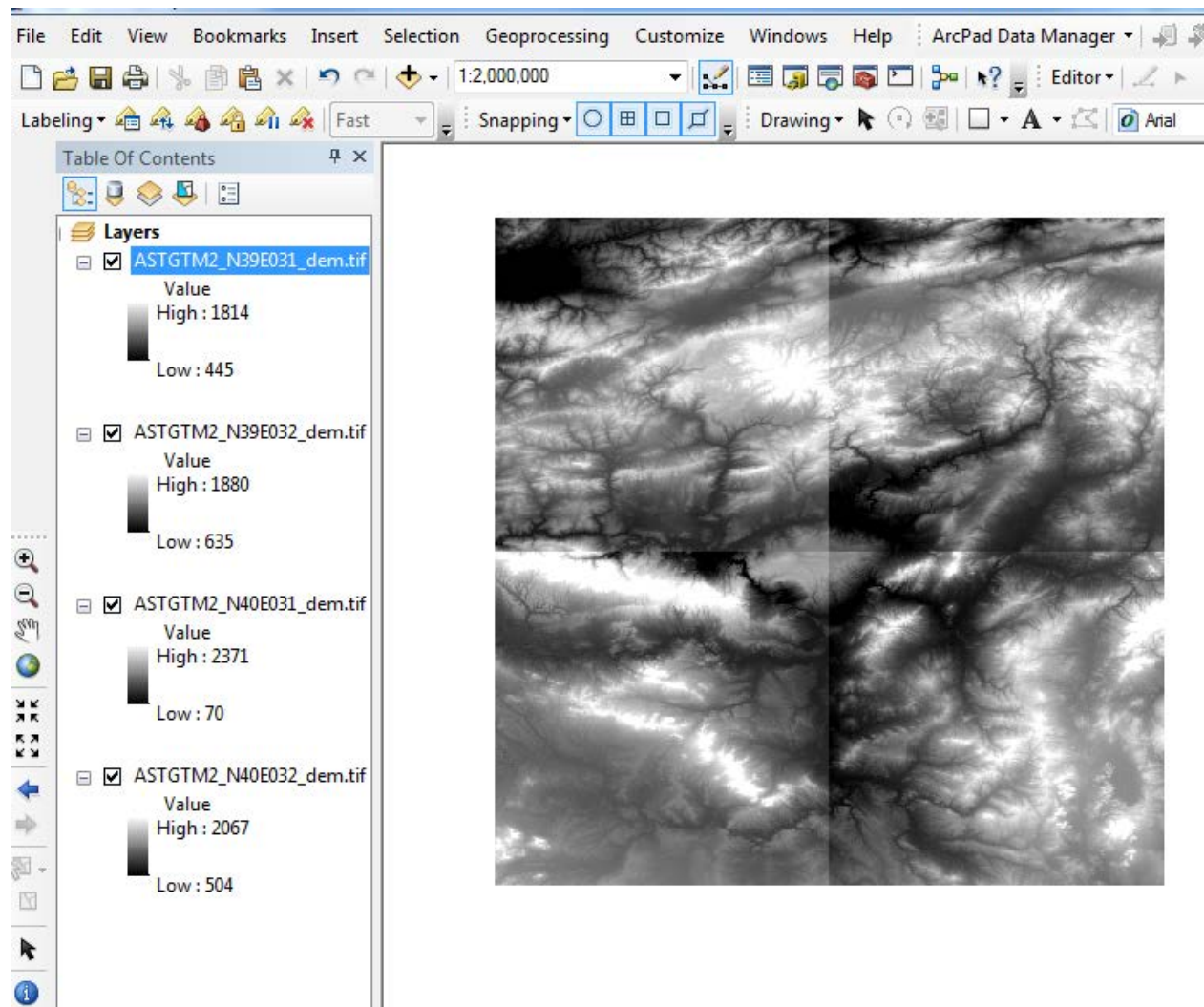- Drag and drop each *dem.tif file into the map (Figure 5).

Figure 5. Drag and drop the DEM image(s) into the map from the central storage folder in ArcCatalog.

The DEM was in four square rasters with differing minimum and maximum elevations. To combine them into a seamless image, I converted them to a new single raster using the Mosaic function in the ArcGIS toolbox (Figure 6):
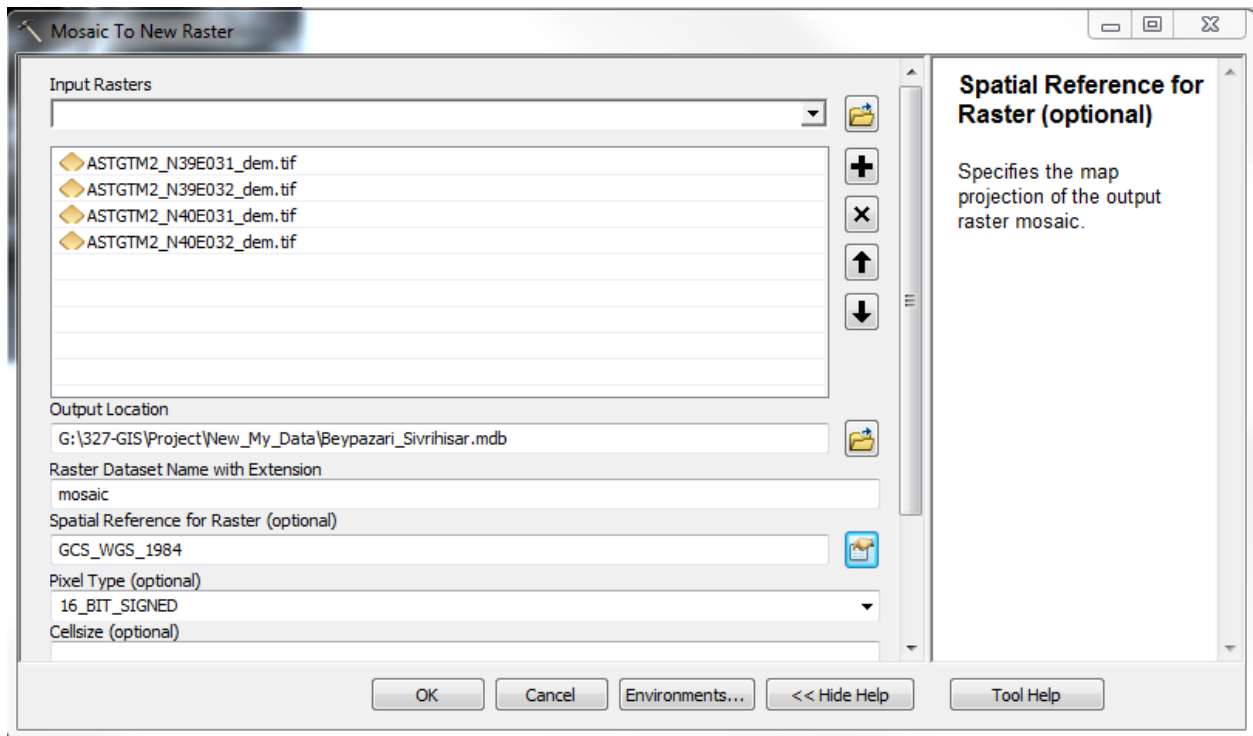
Figure 6. Create a single raster file from the DEM(s). (Data Management→Raster→Raster Dataset→Mosaic to New Raster)

- Open ArcToolbox from within ArcMap. (NOTE: For ease of use, always click first on Tool Help at the bottom of all toolbox screens.).

- Click on Data Management Tools, Raster, and Raster Dataset.

- Double-click Mosaic to New Raster.

- From the Input line drop-down, select the four rasters.

- In the Output line, designate the destination of the new raster by clicking the file icon and browsing to the central storage folder.

- Name the new mosaic raster, set the pixel size, pixel depth and cell size to match to original raster files. Number of bands should be 1.

- Click OK. A single raster image of the combined DEM raster is generated and added to the map.

- Right-click the four original ASTER rasters in the TOC and click Remove. They are no longer needed on the map.

Create HillShade

A HillShade raster generates a shaded relief image that assumes an infinite illumination source like the Sun. I generated a HillShade from the new single mosaic raster, which I will use in the field to identify and locate potential faults and other structures at the surface (Figure 7).
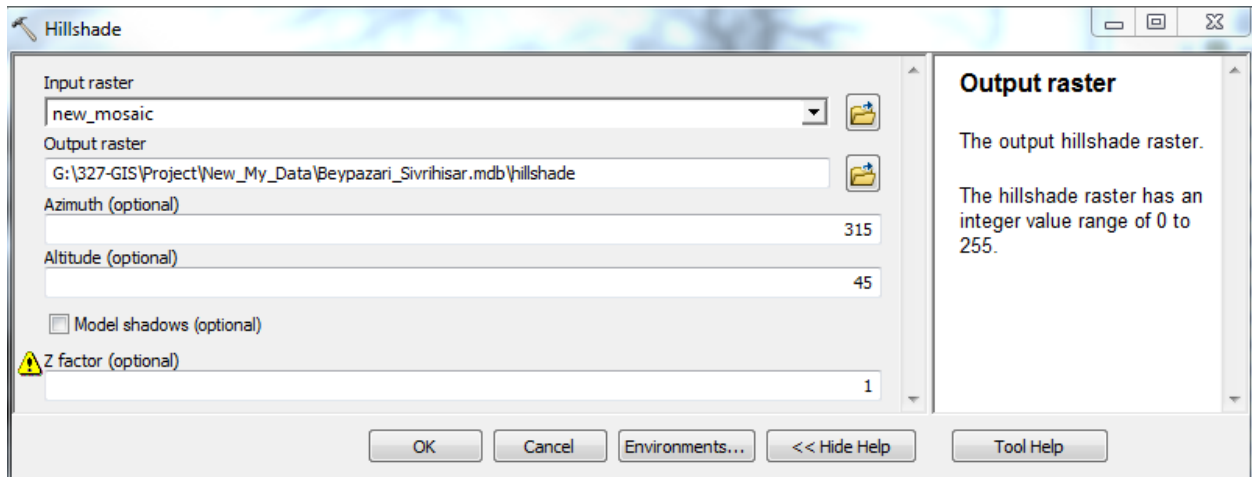

Figure 7. Generate Hillshade raster. (Spatial Analyst→Surface→Hillshade)

- In ArcToolbox, click on Spatial Analyst, and Surface.
- Double-click on Hillshade.
- In the input line, select the mosaic DEM file.
- In the output, designate the central storage folder and name the hillshade raster.
- Click OK. The HillShade is added to the map.

Create Elevation Contours

Contours are lines of equal elevation on a map. I added contours for every 100 meters on my Geologic Map to help me see elevation differences on the pluton and surrounding area (Figure 8).
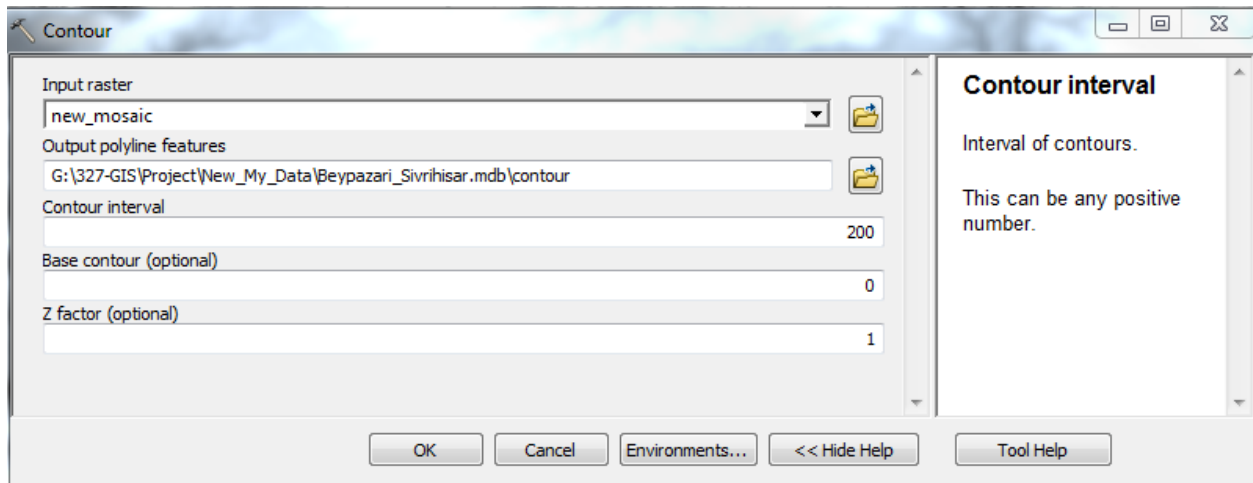
Figure 8. Generate Elevation Contours. (Spatial Analyst→Surface→Contour)

- In ArcToolbox, click on Spatial Analyst and Surface.
- Double-click Contour.
- Select the mosaic DEM raster as the input. The output is the central storage folder.
- Name the output shapefile (Contour) and designate the contour interval (100).
- Click OK. The contour is generated and added to the map.
- Right-click on the shapefile in the TOC and click Properties then the Symbolize tab to select the appropriate line colors and weights to be drawn on the map.
- To select specific elevations from among the complete list of 100-m contours in the Symbology tab, click Add Values.

Scan Geologic Maps

To generate a geologic map of the Beypazari Granitoid, I scanned the Zonguldak and Ankara sections from the Geological Map of Turkey in the Walter Geology Library. I imported the scanned maps into Adobe Photoshop and combined them, aligning the lines of latitude and longitude. I saved the Photoshop image as a TIFF image so it could be imported into ArcGIS (Figure 9).
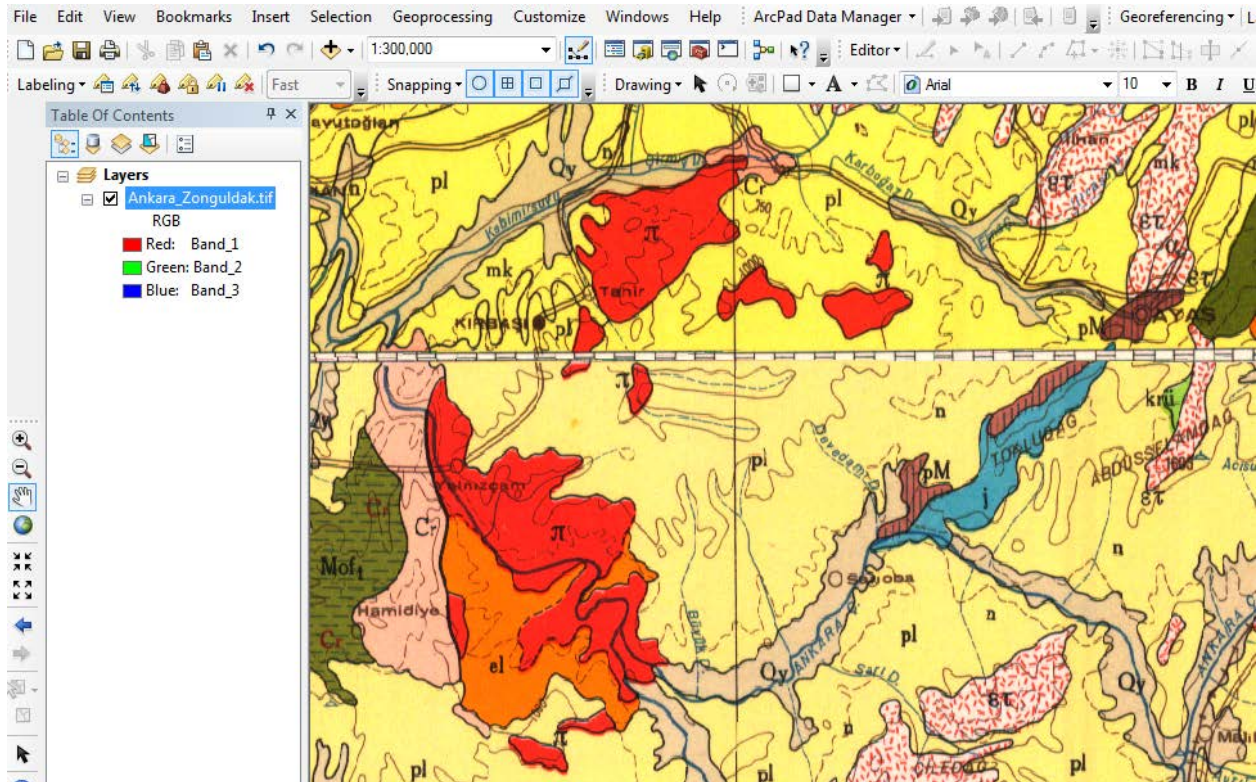
Figure 9. Scan paper maps, align in Adobe Photoshop, save as TIFF. Drag and drop into ArcMap TOC.

- From ArcCatalog, drag and drop the image.tif file into the top of TOC. The imported TIFF is lacking a spatial reference.
- In ArcCatalog, right-click the image.tif again and click Properties.
- Click Edit beside Spatial Reference and Import to select the reference frame of the mosaic raster (Figure 10).
- Click OK. This will set the appropriate Spatial Reference of the image.tif. (NOTE: Select Yes for a dialogue box asking to build a Pyramid).

Figure 10. For a raster file lacking a spatial reference, set it to match the mosaic of known spatial reference. (ArcCatalog→Properties→Edit (Spatial Reference)→Import→browse to select mosaic raster)

Georeference Scanned Image to Mosaic DEM

Using the known lines of latitude and longitude from the scanned image.tif, I
georeferenced the image to the corners of the DEM (Figure 11).

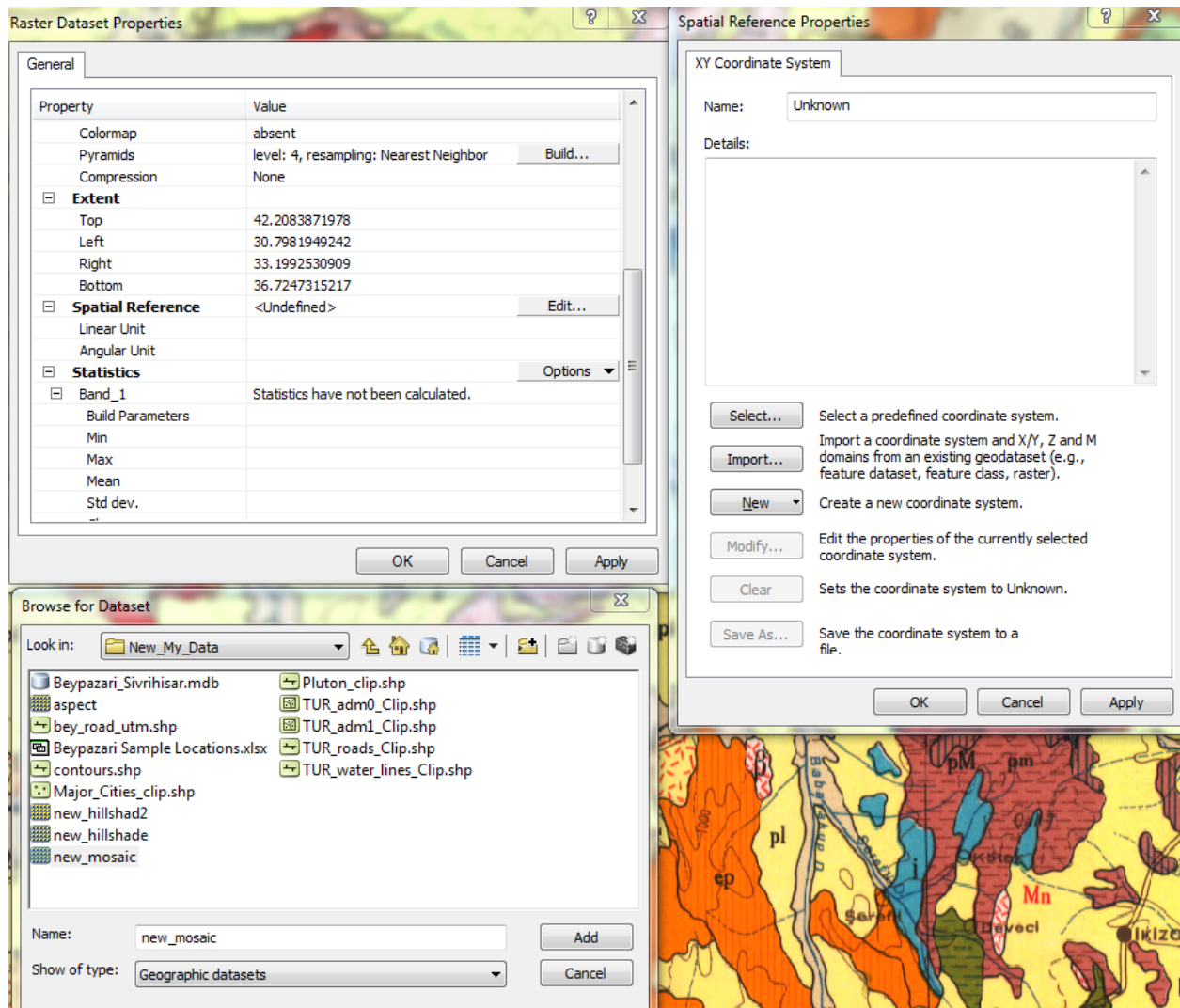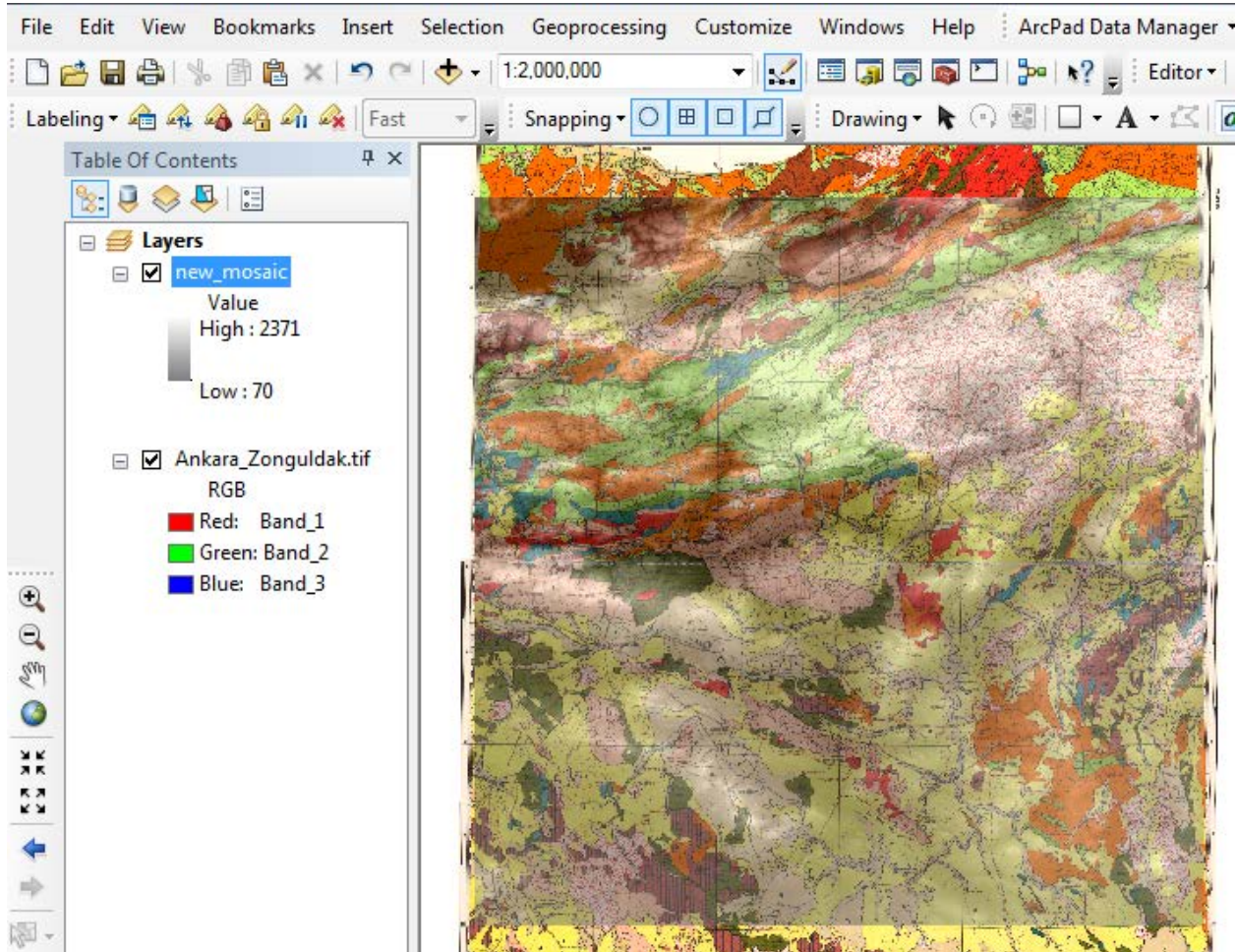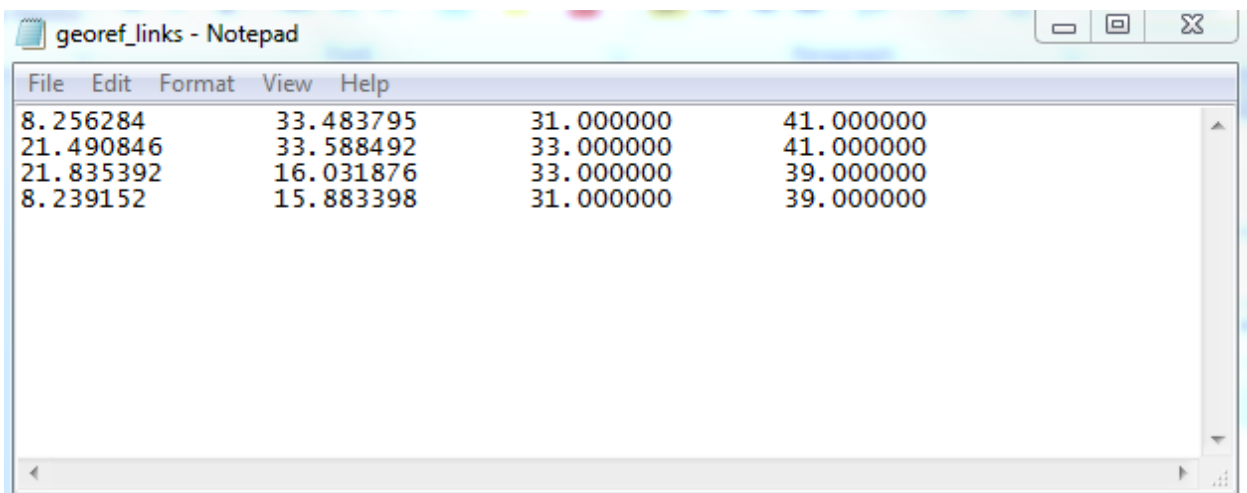**Figure 11. Georeference by clicking the same corner of each map sequentially.**

To georeference, I used the following procedure:

- On the Georeferencing Toolbar drop-down menu, select the scanned image.tif.
- Click View Link Table, then Add Control Points.
- The first point to click is the top left intersection of latitude and longitude on the image.tif
  that will correspond to the same intersection on the mosaic.
- Next, right-click on the mosaic raster in the TOC and click Zoom to Layer. Click the
  same intersection to connect that point to the image.tif. Do the same for the bottom left
  intersection, and bottom right intersections of both image and raster.

- Important: The final top right intersection should be *double-clicked* to complete the links.

- In the Links table, four sets of data are listed. If exact coordinates are known, in the X-Map and Y-map columns, manually change the inputs to the known values of latitude (Y-Map) and longitude(X-Map). Save this table to the central storage folder (Figure 12).

- Click Save and name the file for storage in the central storage folder.

- Now the scanned image lies directly on top of the single DEM and can be used for digitizing. Right-click on the scanned image and select Display to change the transparency to 50% so that digitized lines will be easier to see.

Figure 12. In the Georeferencing Links Table, edit to add exact lat/lon values in x-map and y-map. Save to central storage folder.

Create Personal Geodatabase

In ArcGis, a personal geodatabase is used to organize and store data such as point, lines and polygons for use in the map.

- In ArcCatalog, right-click on the central storage folder and click New and Personal Geodatabase, and name the geodatabase appropriately.

Create Feature Dataset

The Feature Dataset holds all Feature Classes (Point, Line and Polygon shapefiles) used in the map and attaches fields in each shapefile with the appropriate data stored in the geodatabase (Figure 13).

- Right-click on the new geodatabase.
- Hover over New and click on Feature Dataset.
- Name the new Dataset (mine was named Geology).
- Click Next and select the appropriate Coordinate System.
- There is an option to select a vertical coordinate system, but I did not specify one.
- Click Next, to set the appropriate XY tolerance (often the defaults are OK).
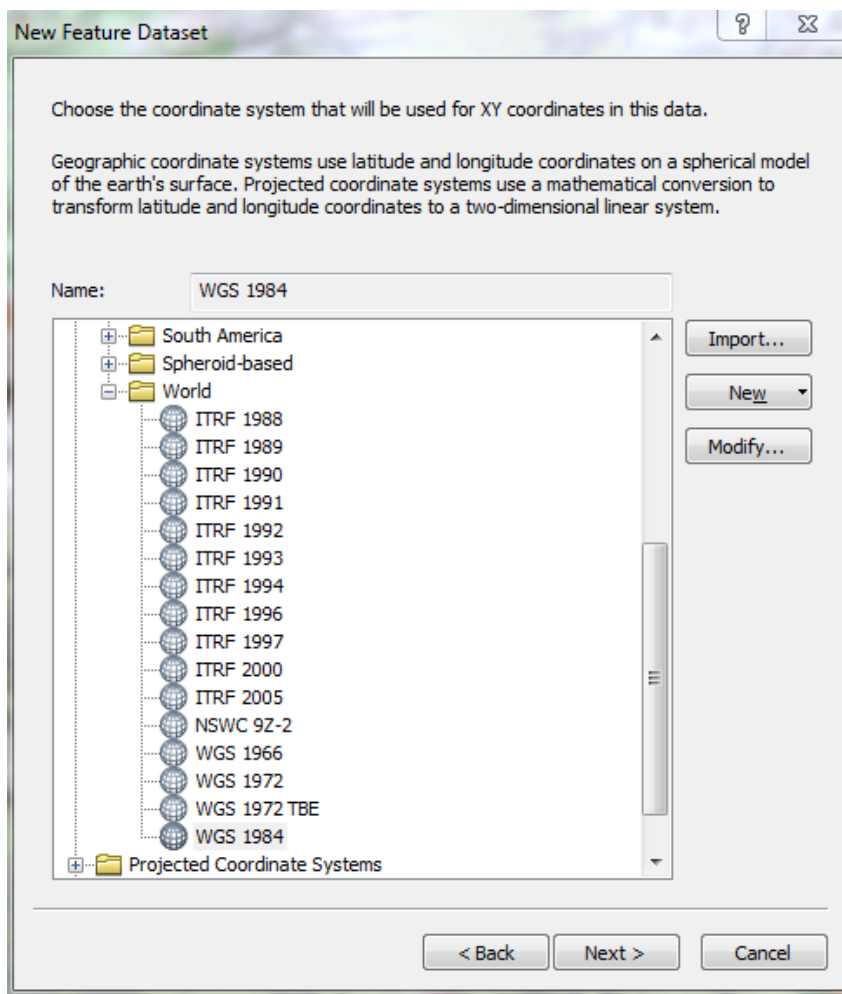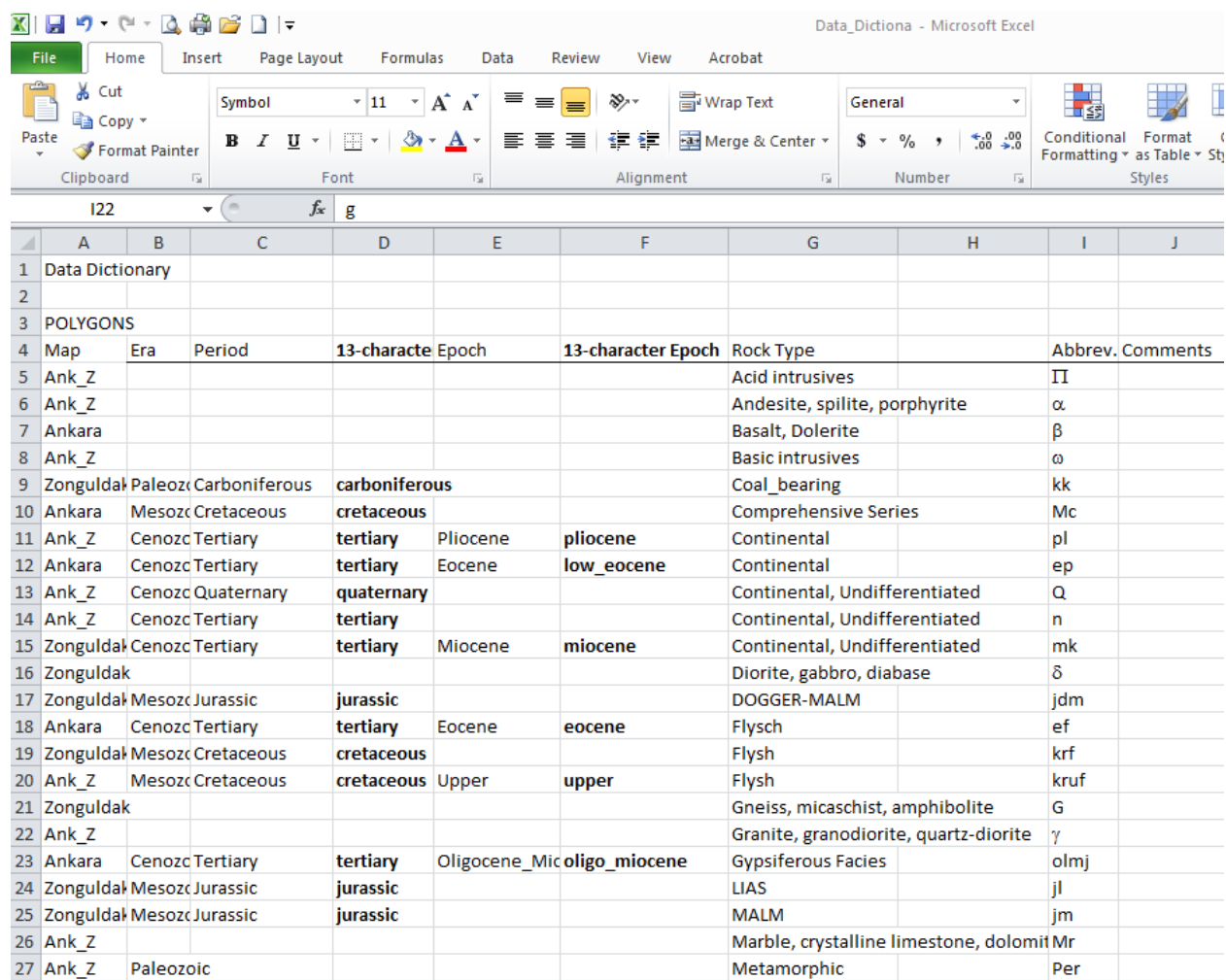- Click Finish to create the New Feature Dataset.

Figure 13. Create Feature Dataset. (Right-click geodatabase→New→Feature Dataset)

Develop Data Dictionary

Before I digitized the rock units based on the complex scanned Zonguldak and Ankara maps, I created a Data Dictionary (Figure 14) using MS Excel. The data dictionary includes the rock units and names, unit abbreviations, and ages found in the legend of the scanned maps. I used the information in the spreadsheet for creating domains to attribute points, lines and polygons.

	A	B	C	D	E	F	G	H	I	J
1	Data Dictionary									
2										
3	POLYGONS									
4	Map	Era	Period	13-characte	Epoch	13-character Epoch	Rock Type		Abbrev.	Comments
5	Ank_Z						Acid intrusives		Π	
6	Ank_Z						Andesite, spilite, porphyrite		α	
7	Ankara						Basalt, Dolerite		β	
8	Ank_Z						Basic intrusives		ω	
9	Zonguldak	Paleoz	Carboniferous	carboniferous			Coal_bearing		kk	
10	Ankara	Mesozc	Cretaceous	cretaceous			Comprehensive Series		Mc	
11	Ank_Z	Cenozc	Tertiary	tertiary	Pliocene	pliocene	Continental		pl	
12	Ankara	Cenozc	Tertiary	tertiary	Eocene	low_eocene	Continental		ep	
13	Ank_Z	Cenozc	Quaternary	quaternary			Continental, Undifferentiated		Q	
14	Ank_Z	Cenozc	Tertiary	tertiary			Continental, Undifferentiated		n	
15	Zonguldak	Cenozc	Tertiary	tertiary	Miocene	miocene	Continental, Undifferentiated		mk	
16	Zonguldak						Diorite, gabbro, diabase		δ	
17	Zonguldak	Mesozc	Jurassic	jurassic			DOGGER-MALM		jdm	
18	Ankara	Cenozc	Tertiary	tertiary	Eocene	eocene	Flysch		ef	
19	Zonguldak	Mesozc	Cretaceous	cretaceous			Flysh		krf	
20	Ank_Z	Mesozc	Cretaceous	cretaceous	Upper	upper	Flysh		kruf	
21	Zonguldak						Gneiss, micaschist, amphibolite		G	
22	Ank_Z						Granite, granodiorite, quartz-diorite		γ	
23	Ankara	Cenozc	Tertiary	tertiary	Oligocene_Mic	oligo_miocene	Gypsiferous Facies		olmj	
24	Zonguldak	Mesozc	Jurassic	jurassic			LIAS		jl	
25	Zonguldak	Mesozc	Jurassic	jurassic			MALM		jm	
26	Ank_Z						Marble, crystalline limestone, dolomit		Mr	
27	Ank_Z	Paleozoic					Metamorphic		Per	

Figure 14. Develop a Data Dictionary to help organize information in the geodatabase domains.

Enter Data into Geodatabase Domains

Using information from the data dictionary, I populated the fields of my geodatabase domains (Figure 15).

- Right-click on the geodatabase and select Properties and click Domains.

- Enter appropriate information, such as Rock type, Unit Name, and Unit Abbreviation, in the Domain Name and Description to identify the types of features that will be attributed during the digitizing process.

- For each Domain Name, a Field Type and Domain Type can be specified. I used Text Field Types and Coded Value Domain Types. Under Coded Value, I entered the information from my Data Dictionary.

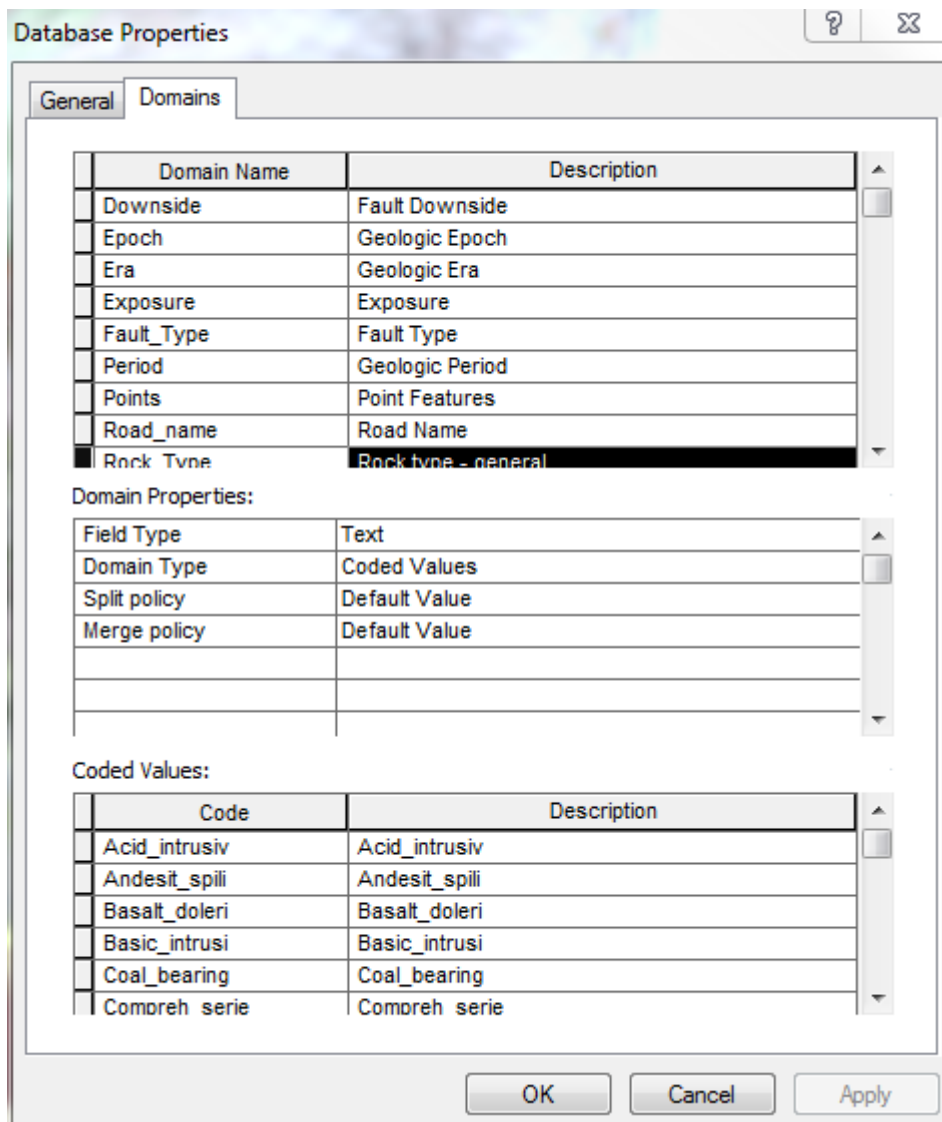- When the Database Properties have been created, click OK.

Figure 15. Create Domains in the geodatabase to add drop-down definitions for Feature Class attributes. (Right-click geodatabase→Properties→Domains)

Create Feature Classes

Feature Classes used in digitizing can contain points, lines, or polygons that are added to the map.

- Right-click on the Feature Dataset (Geology).
- Hover over New and select Feature Class (Figure 16).
- Name the Feature Class (Contacts, for example) and select the Type (point, line, or polygon) appropriate for what will be digitized. I digitized lines and later converted them to polygons.
- Click Next and click on Field Name to name the type of feature to be digitized.
- Click the Data Type drop-down menu and select the type of information to be attributed.
- Under Field Properties below, click the Domain drop-down menu to attach coded values of the same name as those stored in the domain of the geodatabase.
- Define the permitted length of characters in Field Properties.

Figure 16. Create New Feature Classes. (ArcCatalog→Right-click Feature Dataset→New→Feature Class)

Digitize features

To digitize my geologic map, I first digitized my Contact Line Feature Class creating a box around the borders of my DEM for use in snapping rock unit contact lines using the following procedure:

- In the TOC, make sure the feature class to be digitized is selected (check box).
- Click List by Selection above the TOC and make sure the desired feature class is enabled (disable all others).
- Turn on the Snapping Toolbar and select Vertex.
- On the Editing Toolbar, drop-down select Start Editing and select the appropriate layer to digitize.
- Under Create Features, select the line tool and begin digitizing. The first click is in the top left, the next click is the bottom left, then the bottom right, the top right, and finally double-click snap back to the top left.
- On the Editing Toolbar drop-down, click Save and Stop Editing and the Save the map with the Save icon on the Standard Toolbar.
- Turn on the Snapping Toolbar and select End and Edge in addition to Vertex.
- After digitizing the outline, digitize other relevant lines following the visible (but 50% transparent) lines of the existing scanned map image, and snapping to ensure each line segment is connected to another (Figure 17). This is an important step for lines that will be converted into polygons.
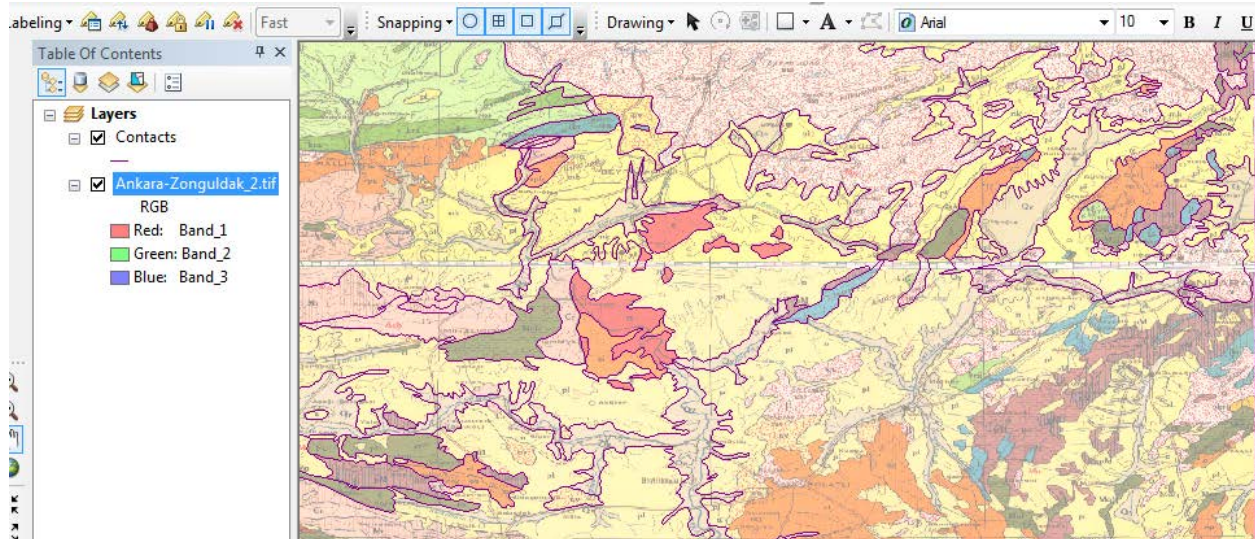
Figure 17. Set scanned map to 50% transparent, and digitize Contacts.

- In the TOC, right-click on the Feature Class and select Symbolize to choose the line color and weight for each type of feature that will appear on the map and in the Legend during map final formatting.

- Point feature classes (such as Towns and Sample Locations) are created, digitized, and symbolized using the above procedure.

- Save edits frequently, both in the Editing Toolbar and the map in general!

Create a Topology

In ArcGIS, topology rules define how points, lines and polygons share geometry. The rules are set by the user to prohibit, for example, lines from self-intersecting or dangling. Areas not completely enclosed by snapped lines cannot be converted into polygons. To ensure that all Contact lines were properly snapped during editing, I created a Topology as follows:

- Right-click on the Feature DataSet.
- Hover over New and select Topology (Figure 18).

Figure 18. Create a Topology to define rules for points, lines and polygons. (Feature Dataset→New→Topology)

- Click Next on the Topology Wizard and name the topology. (The Cluster Tolerance default value often does not need to be changed.)

- Click the boxes beside the Feature Classes that will be included in the Topology. In my Topology, I had only a single Feature (Contacts), so it was ranked 1. Otherwise, select a rank for each feature to determine how much it moves during validation of the topology.

- Click Next. Click Add Rule and drop-down select the Feature Class and Rules, such as Must Not Overlap, Must Not Self-Intersect, and Must Not Have Dangles (Figure 19).

New Topology

Specify the rules for the topology:

Feature Class	Rule	Feature Class
Contacts	Must Not Overlap	
Contacts	Must Not Have Da...	
Contacts	Must Not Self-Inte...	

Add Rule...

Remove

Remove All

Load Rules...

Save Rules...

< Back   Next >   Cancel

dd Rule

Features of feature class:

Contacts

Rule:

Must Not Self-Intersect

Feature class:

Rule Description

A line feature from one layer must not intersect itself.

Any line where the feature overlaps itself or any point where the feature intersects itself is an error.

☑ Show Errors

OK   Cancel

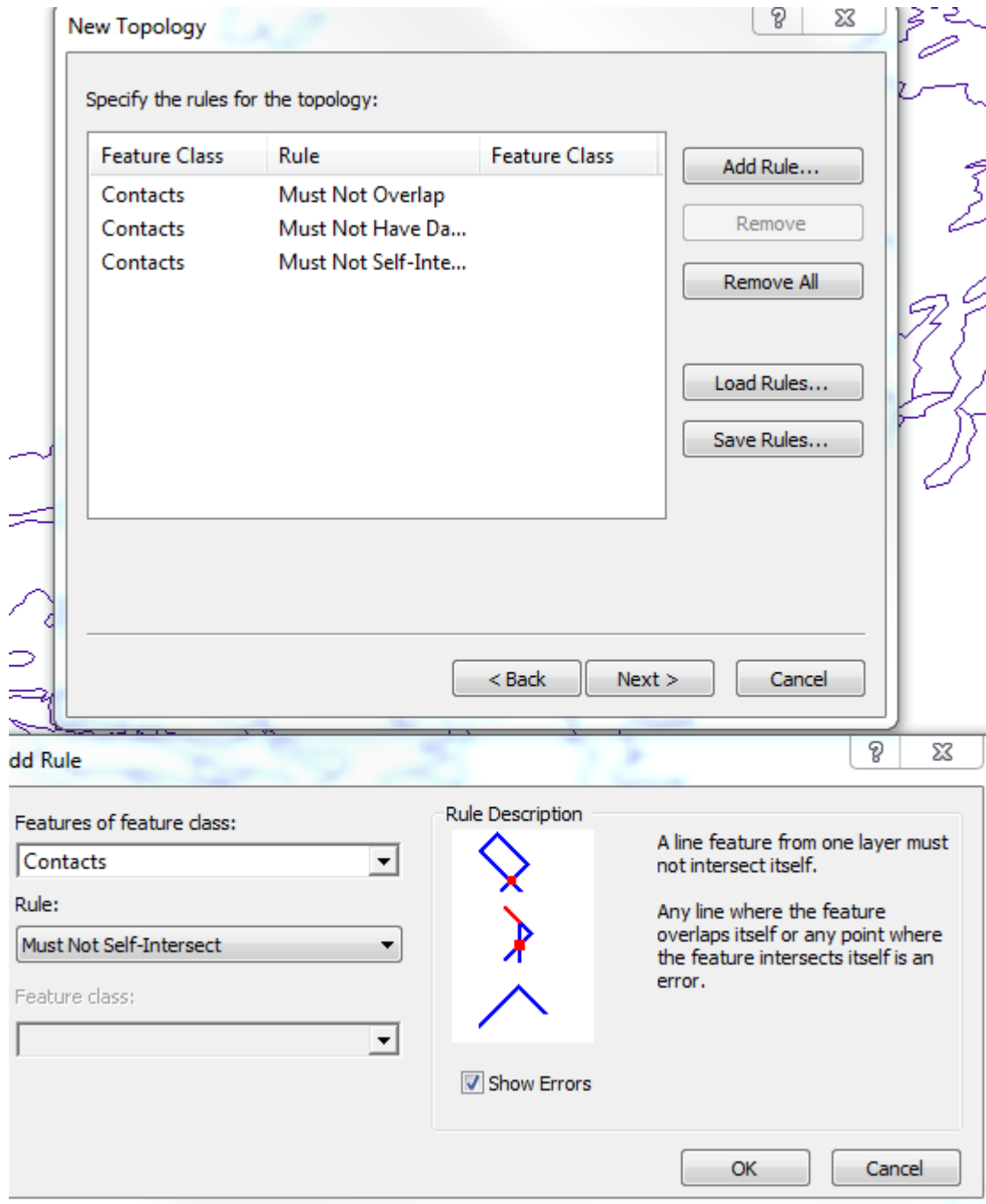**Figure 19. Topology Rules ensure that lines do not overlap or self-intersect. (Feature Dataset→New→Topology)**

- Click Next and then Finish to generate the new Topology.

- Click Yes in answer to the dialogue box Would you like to validate now? (Every time topology errors are corrected, re-validate.)

- Right-click on the newly created Topology located under the Feature Dataset in ArcCatalog.

- Click Properties, then click Errors and Generate Summary. A table will list the errors by category (Figure 20).

Topology Properties

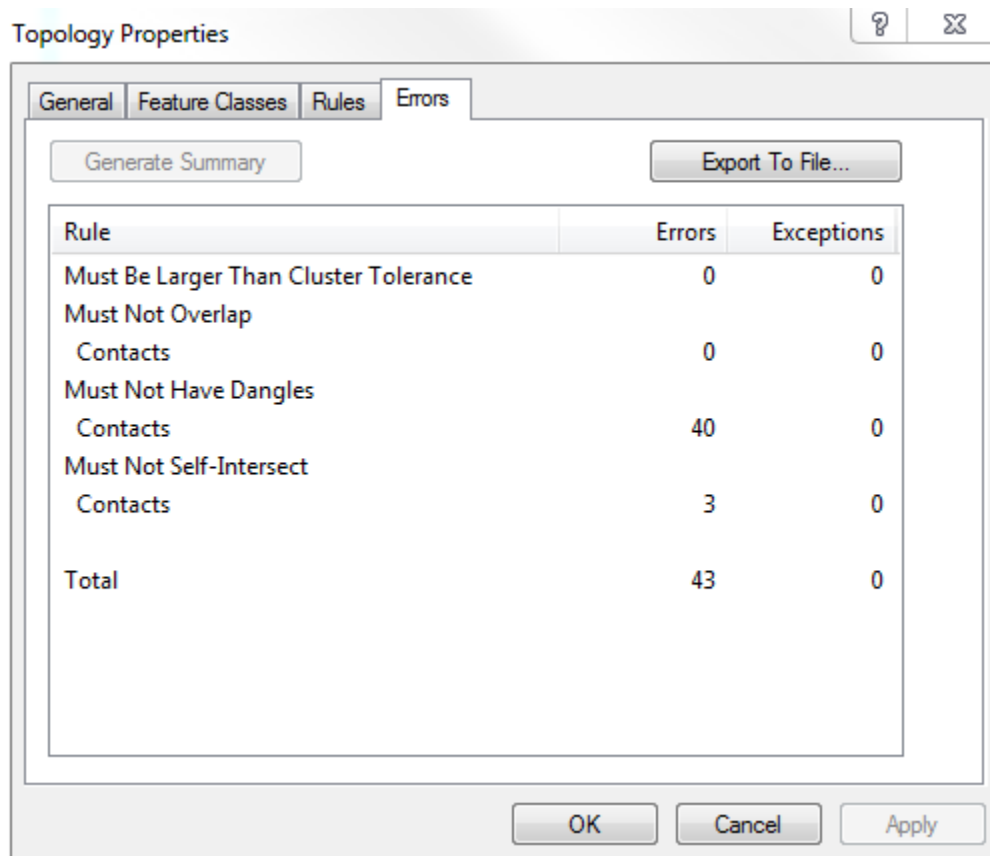| Rule	Errors	Exceptions
Must Be Larger Than Cluster Tolerance	0	0
Must Not Overlap		
Contacts	0	0
Must Not Have Dangles		
Contacts	40	0
Must Not Self-Intersect		
Contacts	3	0
Total	43	0

Figure 20. The Topology Error Summary identifies problems for correction.

- Right-click on the Topology again, and click on Item Description and Preview. Answer No to the dialogue box Do you also want to add all feature classes that participate in the Topology? This just adds digitized lines, but only the errors are important. A screen with pink error squares will appear showing any violations of the Topology rules (any dangles or self-intersects).
- From ArcCatalog, drag and drop the Topology into the top of the TOC.
- From the Editor toolbar, drop-down select the Feature class to be corrected. This activates the Topology toolbar.
- In the Topology toolbar, click on Error Inspector and click Search Now to view and zoom to each error (Figure 21).
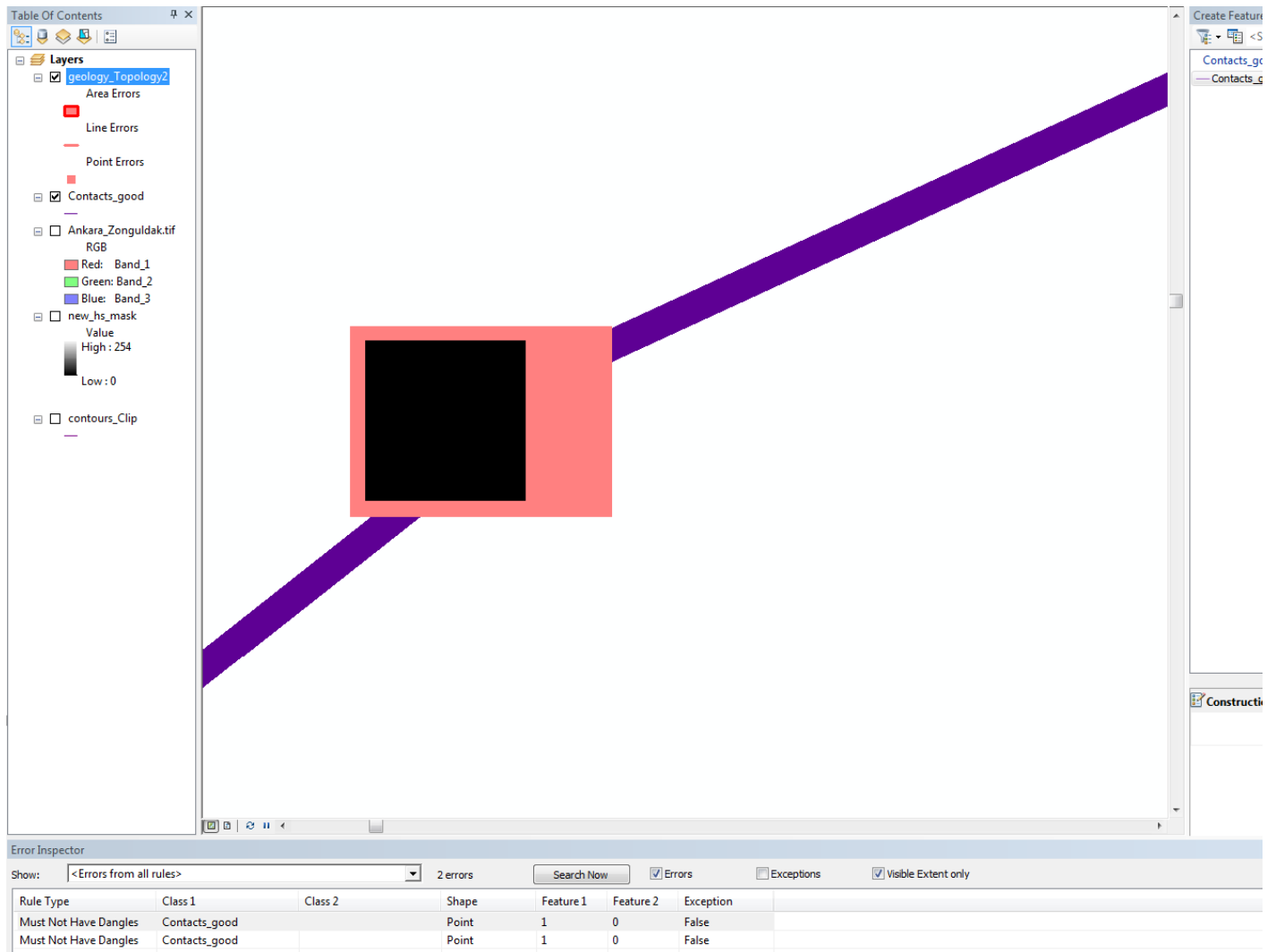
Figure 21. Correct Topology errors before converting lines to polygons.

- After zooming into the error, right-click the Data Frame in the TOC and set the Reference Scale. This will make the error visible.
- Use the editing tools to correct Dangles by adding or snapping to vertices together. Correct Self-Intersects by deleting or moving vertices, as appropriate.
- When all vertices are properly snapped, run the Topology rules again (as above), clicking on Errors to Generate Summary until all pink squares are gone (Figure 22).
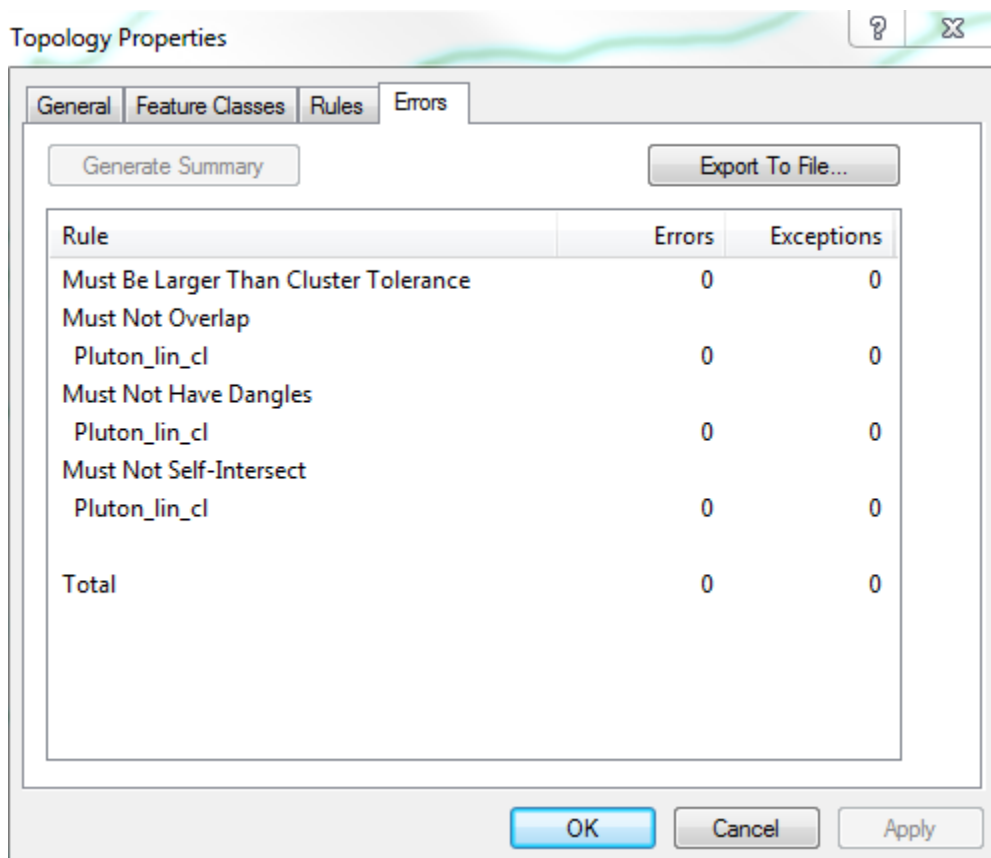
Topology Properties

| General | Feature Classes | Rules | Errors |

Generate Summary   **Export To File...**

Rule	Errors	Exceptions
Must Be Larger Than Cluster Tolerance	0	0
Must Not Overlap		
Pluton_lin_cl	0	0
Must Not Have Dangles		
Pluton_lin_cl	0	0
Must Not Self-Intersect		
Pluton_lin_cl	0	0
Total	0	0

OK   Cancel   Apply

Figure22. The Topology Error Summary confirms all errors were corrected.

Convert Line Feature to Polygon

   To create fully enclosed rock units that could be symbolized with colors and attributed with rock unit names and unit abbreviations, I converted my Line Feature (Contacts) to Polygon (Rock Units), as follows:

- In ArcToolbox, click on Data Management, Features, and Feature to Polygon (Figure 23).
- The input is the Line Feature Class to be converted.
- Save the Output Feature Class to the central storage folder with appropriate name.
- Click OK. The new Polygon Feature Class is added to the map. The Line Feature Class can now be removed from the map.
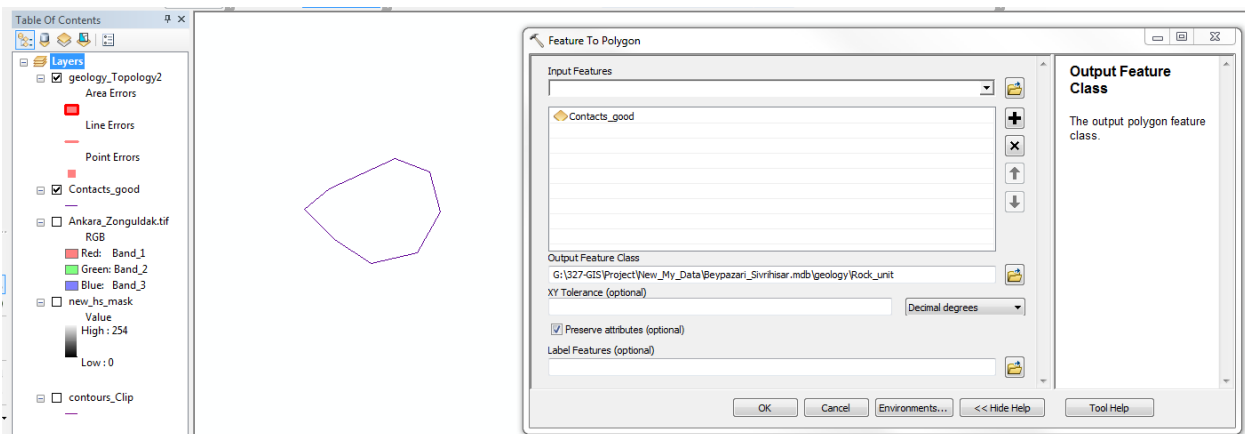

Figure23. Convert Line Feature Class to Polygon Feature Class. (Data Management →Feature→Feature to Polygon)

- Open an editing session for a Polygon Feature Class, right-click on a polygon and select Attribute to choose from domains in the geodatabase that are attached to the Polygon Feature Class. Attribute all polygons (Figure 24).
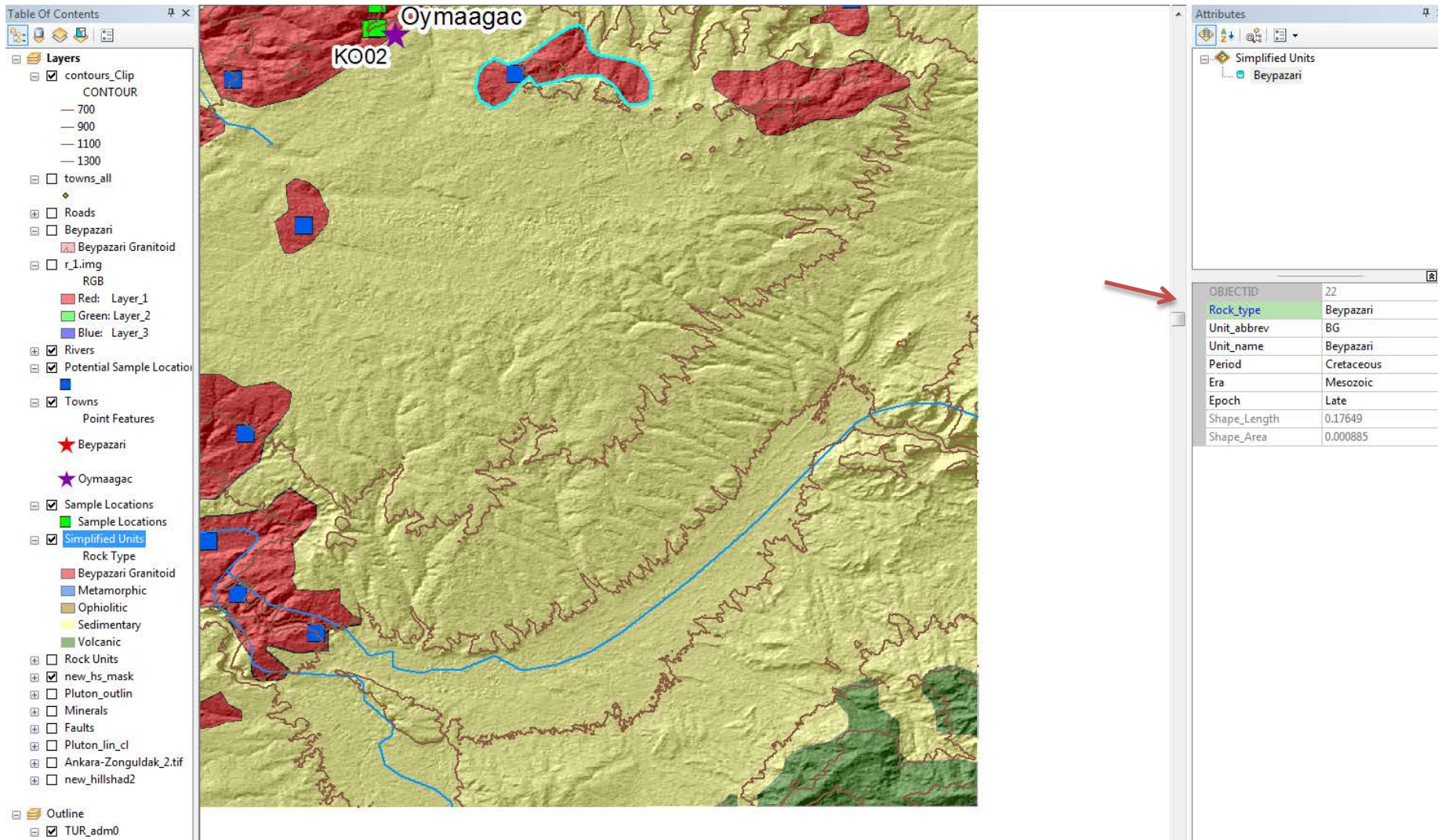
Figure 24. Attribute all polygons in an editing session to assign values from the drop-down connected to geodatabase domains.

- Point (Towns) and Line (Roads) Feature Classes are also attributed in editing sessions. I attributed my Road Line Feature Class as shown in Figure 25.
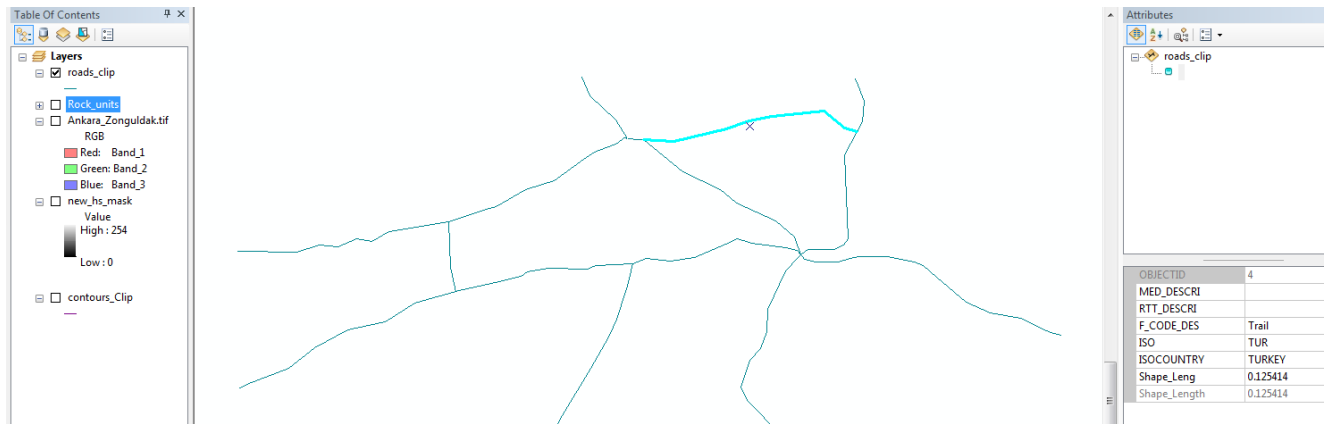

Figure25. Attribute all points and lines similar to the process for attributing polygons.

- In the TOC, right-click on the Polygon Feature Class and select Properties and Symbolize to choose the appropriate symbology, colors and line weights for points, lines, and polygons (Figure 26).
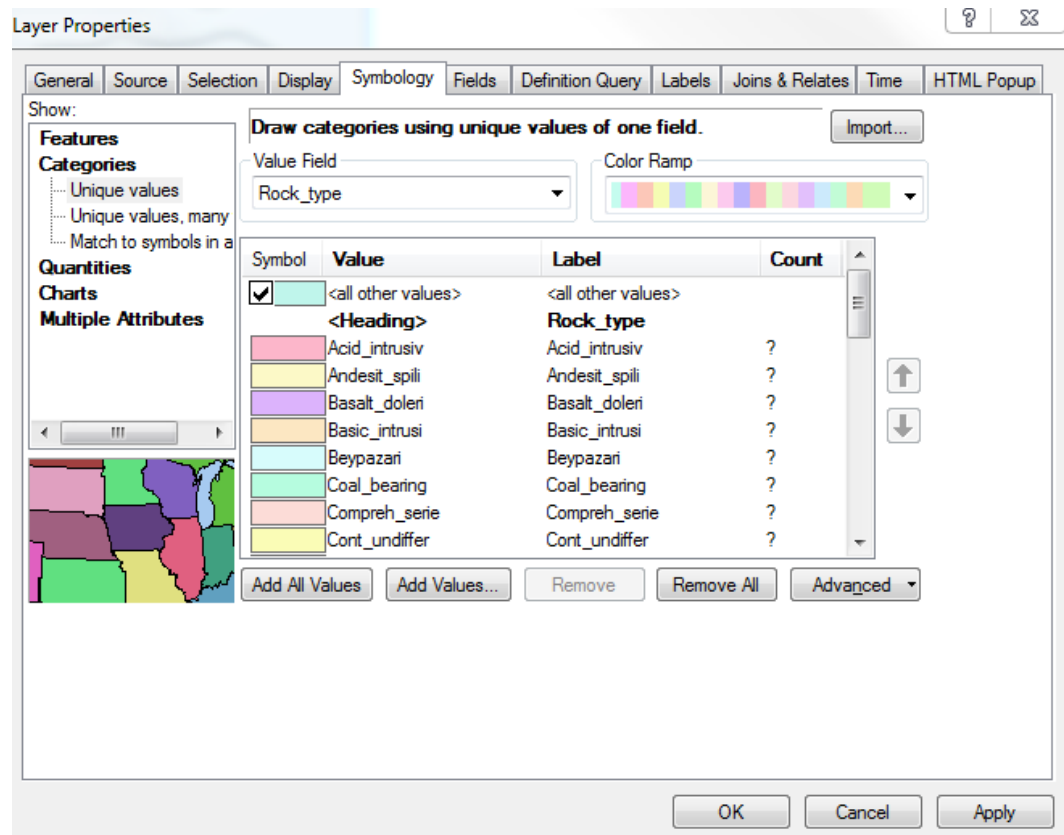

Figure 26. Symbolize Polygon Feature Class. (TOC→right-click Feature Class→Symbology)

- While in Layer Properties, click Display and change Transparency to 50% so the texture of the Hillshade will be visible from beneath.

Clip Layers to the Map Outline

I realized while digitizing that I needed a more manageable map area so I created a new smaller map outline shapefile (Pluton Outline), and clipped the existing feature classes to clean up the layers, including rock units, contours, rivers, and towns.

- In ArcToolbox, click on Analysis Tools, Extract, and double-click Clip (Figure 27).
- The Input is the Feature Class to be clipped and the Clip Feature is the Pluton Outline.
- Save the Output Feature Class in the central storage folder with appropriate name.
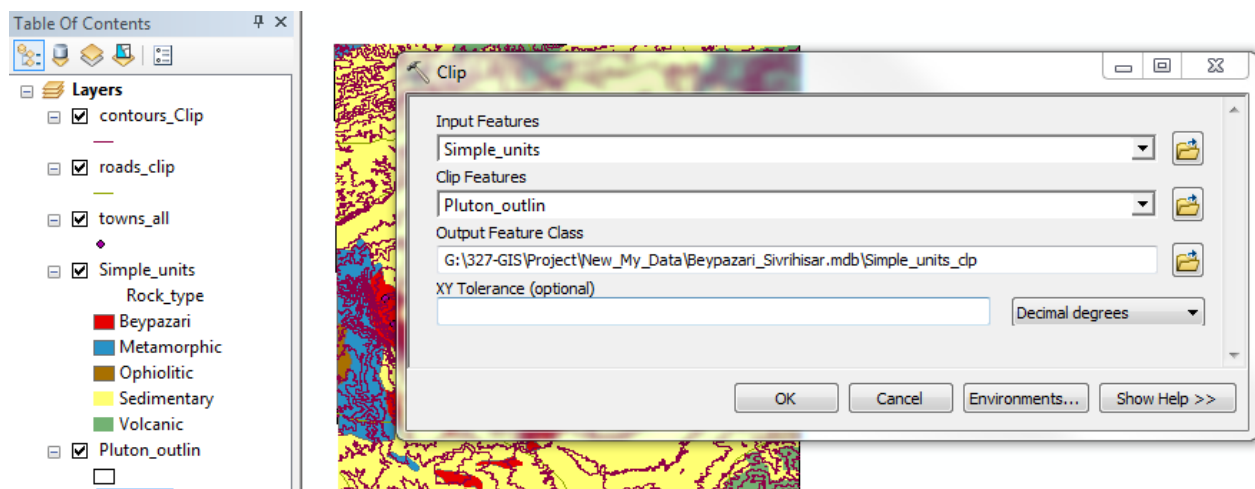
Figure 27. Clip Feature Classes to the Map Outline. (Analyst→Extract→Clip)

Mask Raster Image

To trim my Hillshade raster to the appropriate size, I masked the raster to the smaller new Pluton Outline.

- In ArcToolbox, click Spatial Analyst Tools, Extraction, and double-click on Extraction by Mask (Figure 28).
- The Input Raster is the raster to be masked. The Feature Mask is the Pluton Outline. The Output Raster is the location and name of the new masked raster.
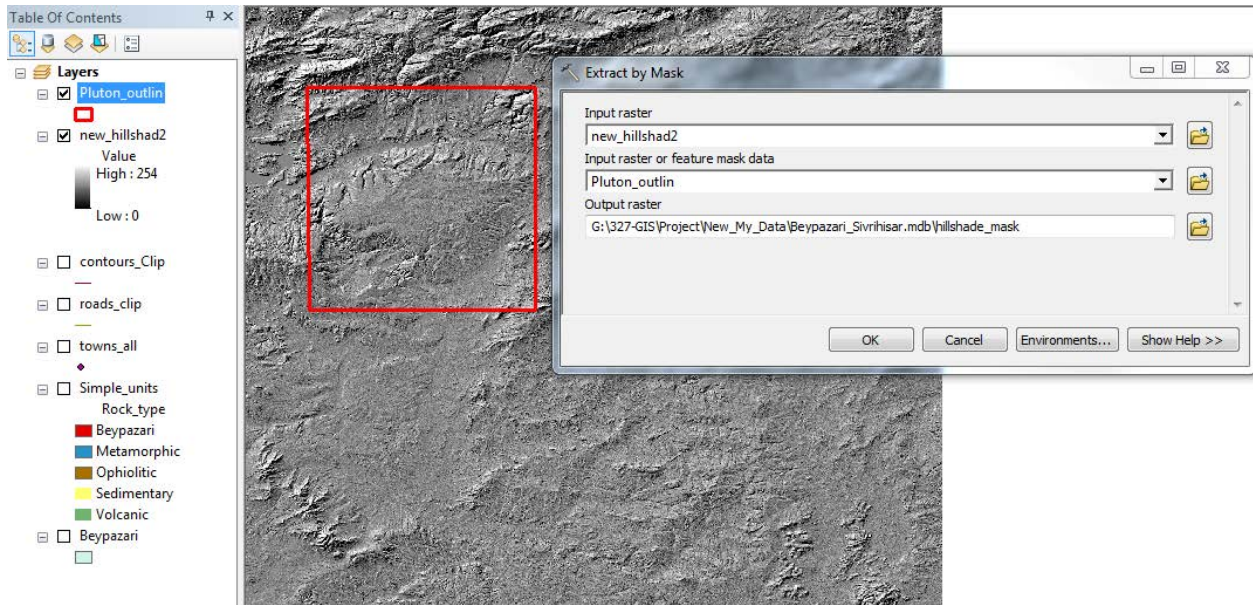
Figure28. Raster images can be Masked to trim them to the desired size (Spatial Analyst→Extraction→Extract by Mask)

Add GPS Sample Locations

When rock samples were collected in the field, GPS latitude and longitude for each sample location were saved to an MS Excel spreadsheet. I added those points to the map, as follows:

- Open MS Excel and save the spreadsheet as a .csv (comma-delimited text).
- In ArcMap File drop-down menu, hover over Add Data and select Add XY Data. (Figure 29).

Figure29. Add data from .csv (comma delimited) file. (File menu→Add Data→Add XY Data→browse to .csv file)

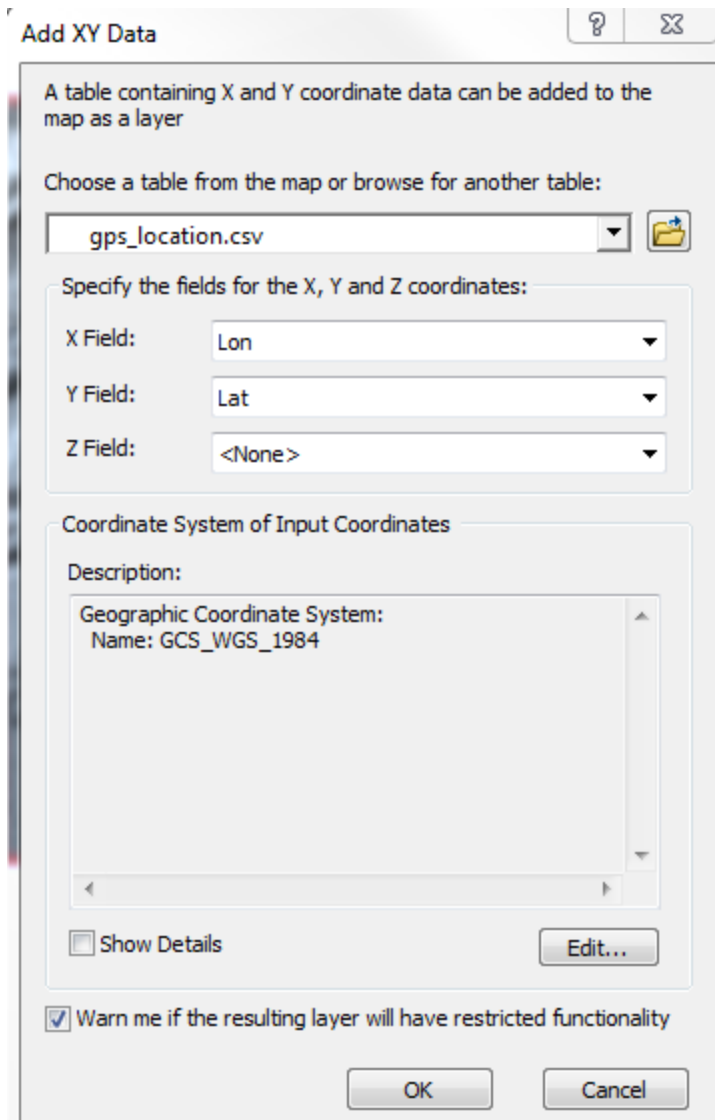- Click the Folder icon to choose a table by browsing to the central storage folder and click Add. The .csv file is added as an Event. A dialog box appears, as shown in Figure 30.
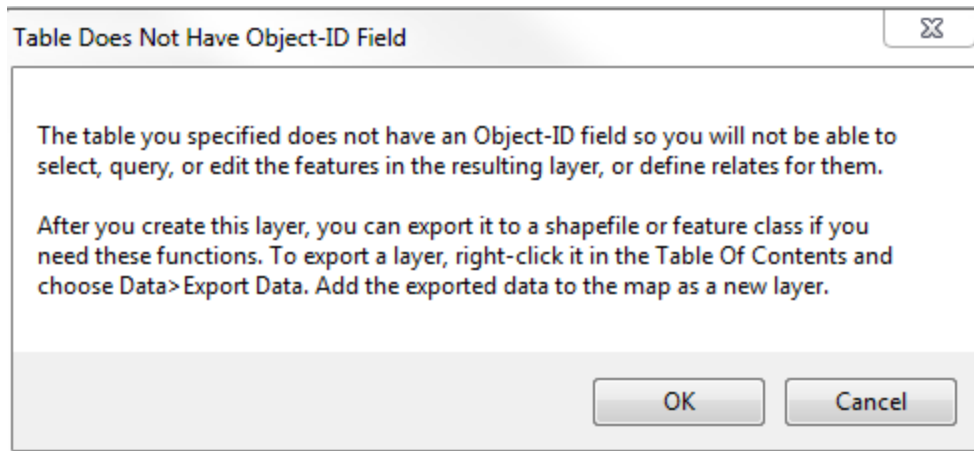
Figure30. Dialog box with instructions for converting the .csv file to a shape file.

- To convert the .csv Event to a Shapefile for use in the map, right-click on the .csv in the TOC, click Data and Export Data, saving the file to the central storage folder with appropriate name (Figure 31).

Figure 31. Convert the .csv file to shapefile that can be Selected, Queried and Edited.

- Symbolize the imported GPS points appropriately for inclusion in the map.

Digitize Additional Points of Interest

When I go to the field, I want to collect additional rock samples for inclusion in my study. To help me find my way to potential outcrops in the field, I edited the Point Feature Class (see Digitizing above) to add towns and promising sample collection sites along roads throughout the pluton, as shown in Figure 32.
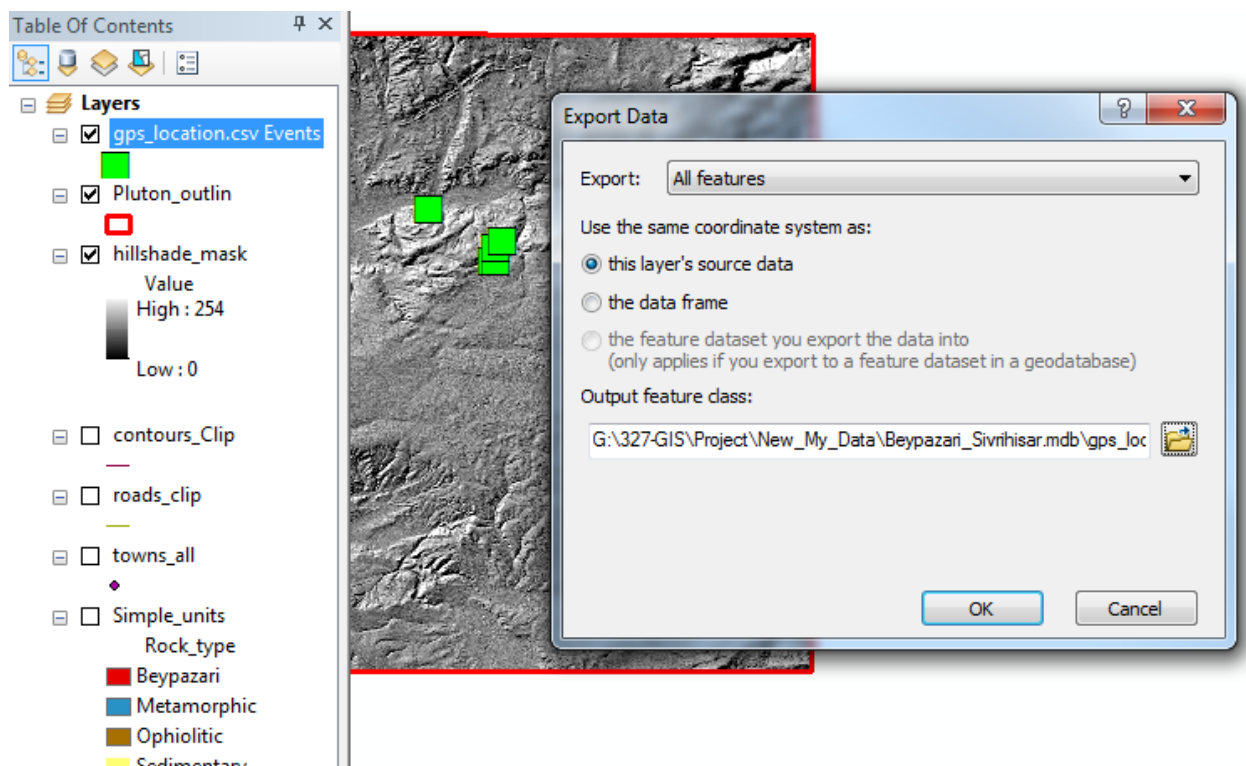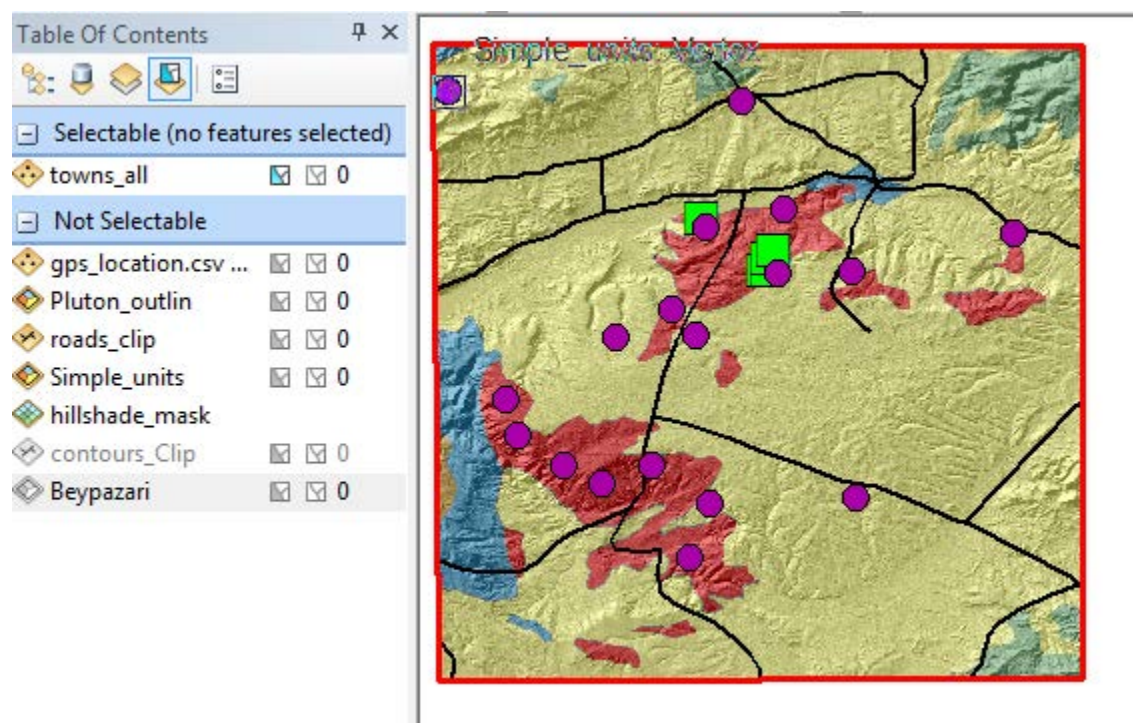

Figure 32. Digitize points (Towns) with the same procedure as Polygons.

Export Feature Class to New Feature Class

I wanted to make another map with the HillShade overlain only by the Beypazari Granitoid rock units for use in analysis and identification of possible faults. The ~6 Ma zircons found in the area may be related to fault motion. To make a copy of the digitized Polygon Feature Class (Simple Units), I used the following procedure:

- In ArcCatalog, right-click on the Polygon Feature Class (Simple Units), hover over Export and select To shapefile (single) (Figure 33).
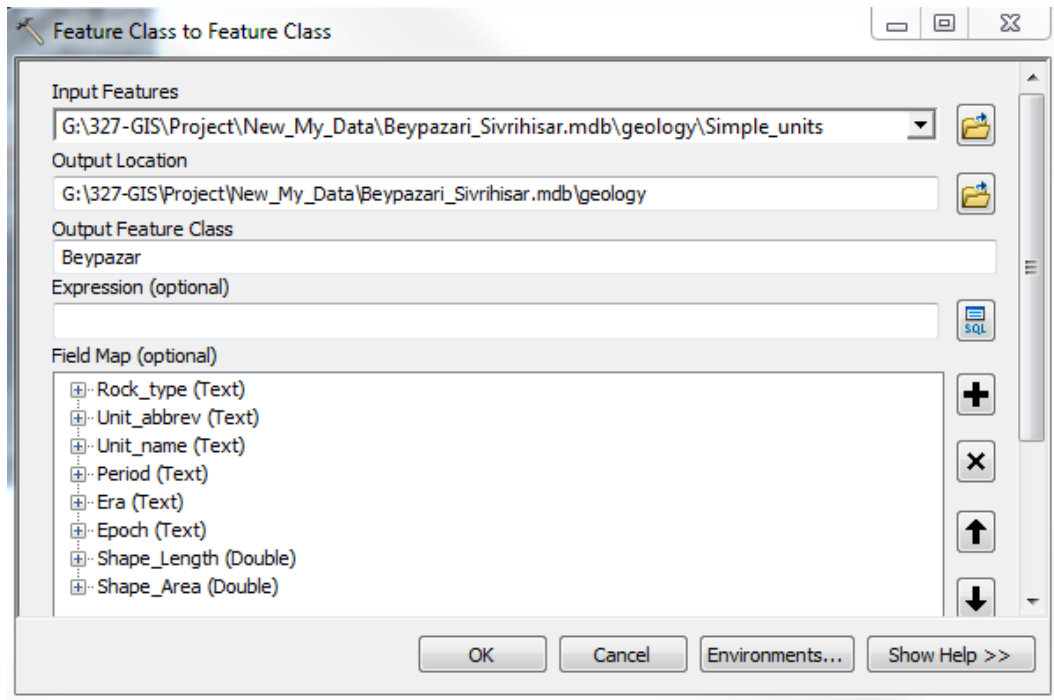
- The Input is the layer to be converted. The output location is the central storage folder, and the Output Feature Class is the name.

In this newly created Polygon Feature Class (Beypazari), I edited to delete all polygons except the Beypazari Granitoid and set transparency to 50% (Figure 34).
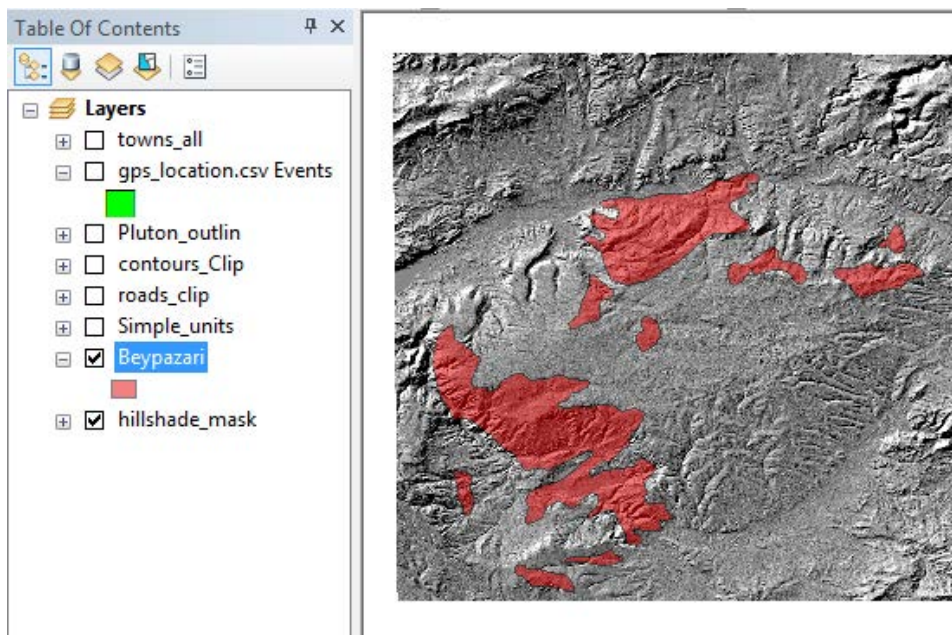
Figure 34. Edit Polygon Feature Set to delete all but the desired polygons.

I also exported the Point Feature Class that included all towns into new a Feature Class (Towns) and changed the symbology to deselect all but the towns of Beypazari and Omaagac. I did the same for the GPS data (Sample Locations), symbolizing each sample name (Figure 35).
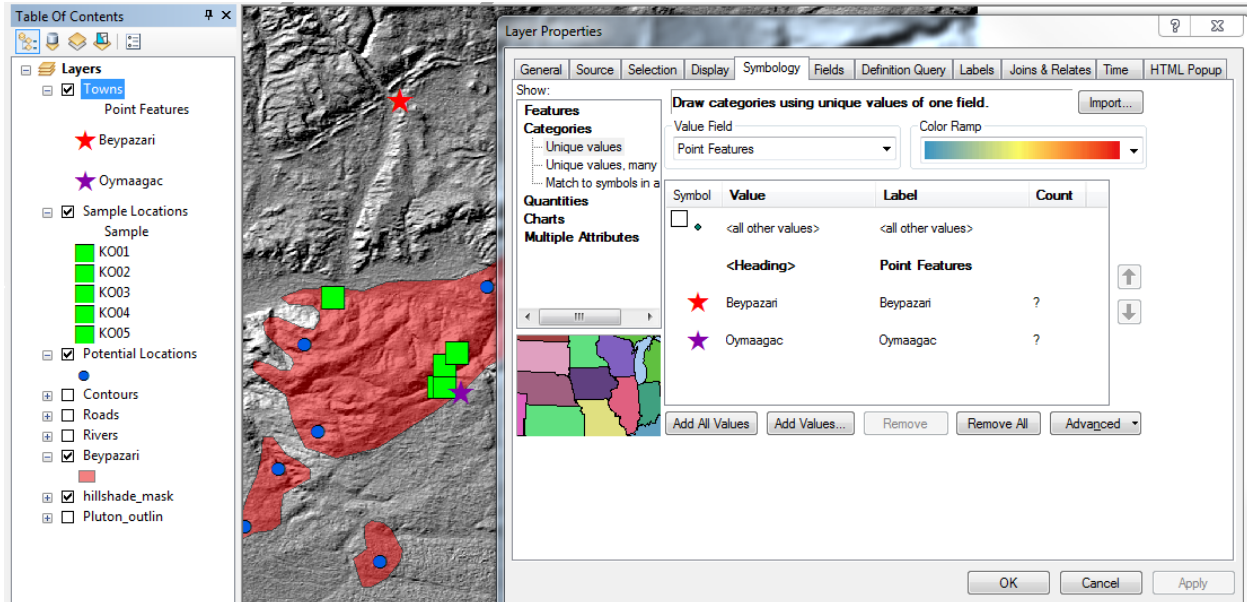
Figure 35. Symbolize point features. (TOC➜Right-click Properties➜Symbology➜Add Values)

Add a Second Data Frame

I wanted to include a reference frame in my printed maps that shows where in Turkey the field area is located.

- From the Standard drop-down menu at the top, click Insert, then Data Frame.
- From ArcCatalog, drag and drop the shapefile of the outline of Turkey into the second Data Frame.
- Export the Town shapefile to a new shapefile (Town2) and delete all towns except Beypazari.
- Drag and drop new Town2 shapefile into the second Data Frame.

Label Features

To ensure that labels would print at the appropriate font size, I set the Reference Scale to 1:250,000.

- Right-click Layer in the TOC, hover over Reference Scale and select Set Reference Scale.

Using the Label Manager Toolbar, I formatted the font size and halo for labels of contours, towns, roads, and sample locations (Figure 36).
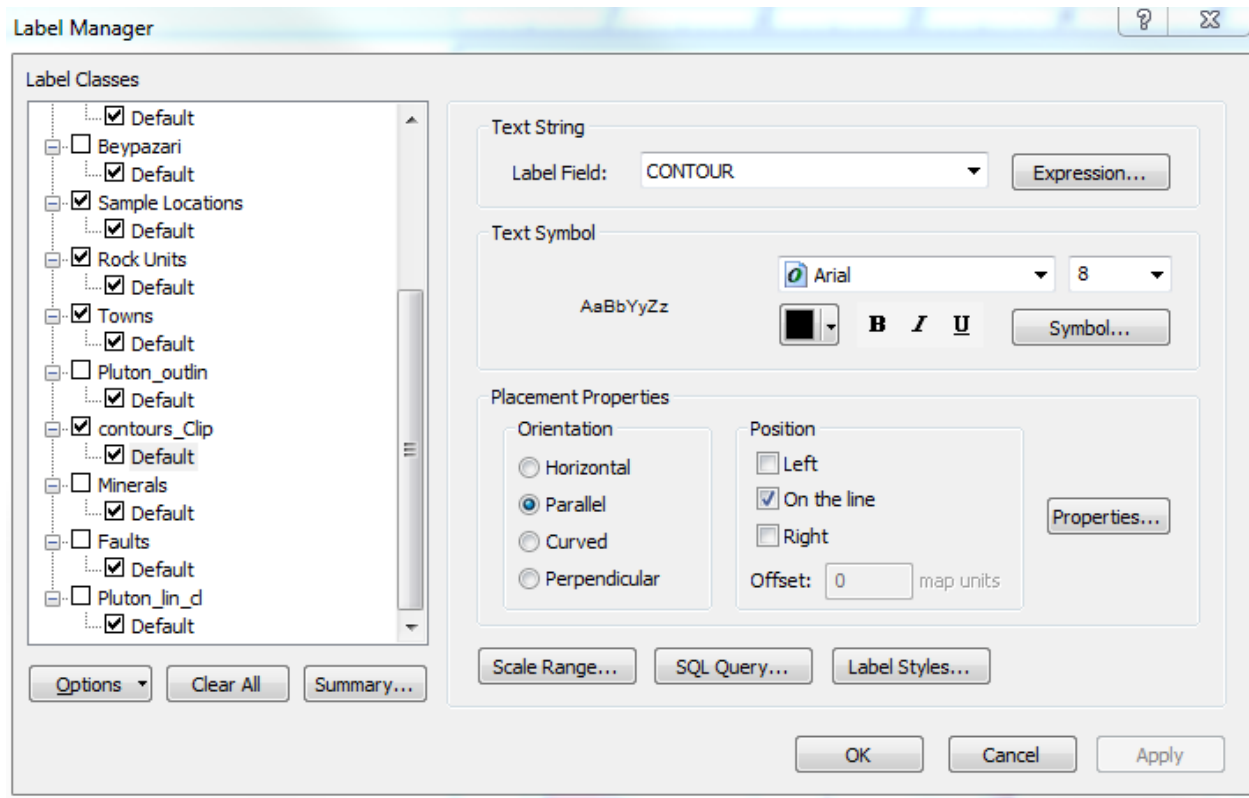
Figure 36. Use the Label Manager Toolbar to designate the size, orientation, and location of labels.

- In the TOC, right-click on each Feature Class and click Label Features, as appropriate for a given map.

ArcGIS Calculations

Area of Beypazari Granitoid Outcrops

With my ArcMap feature elements completed, I was ready to answer the question: What is the footprint of the Beypazari Granitoid outcrop? However, my map is in WGS1984 (decimal degrees) and I want to calculate in square kilometers, so I temporarily projected the reference frame into the UTM36N coordinate system. I calculated an area of ~232 km^2 with the following procedure.

- Right-click on Layer Properties and click Coordinate System then change the Spatial Reference to WGS_1984_UTM_Zone_36N. Click OK.

- Right-click on the Feature Class (Beypazari) and open the Attribute Table.

- In the Table Options drop-down menu, select Add Field. Name it Area and give it Type Double. Click OK.

- Right-click on Area and select Calculate Geometry, using the coordinates of the data frame (UTM) and Units of square kilometers.

- Right-click Area column again and select Statistics for the sum of all shape areas in the Feature Class (Figure 37).
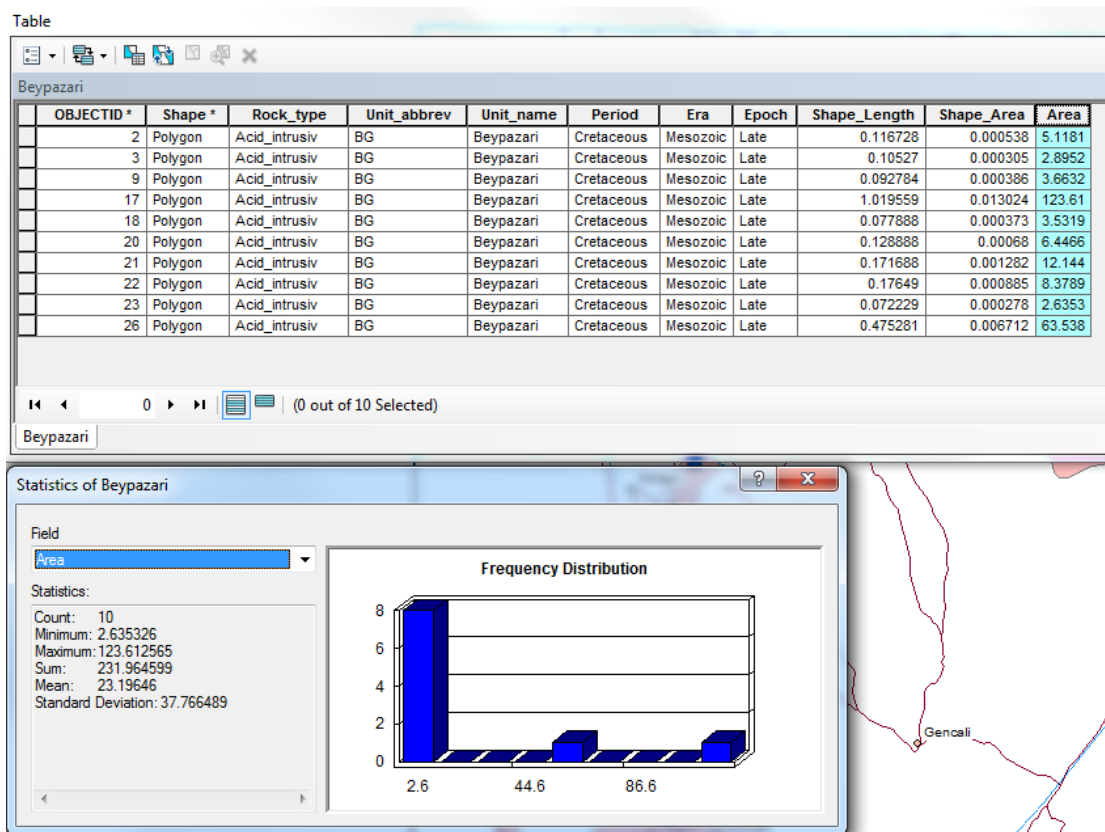
Figure 37. Calculate Areas from a Feature Class Attribute File using Calculate Geometry.

Length of Roads On Outcrops

When looking for rock samples in the field area, I want to know how much of the pluton outcrops are accessible by road. While the Layer was still projected (temporarily) into UTM coordinates I clipped the Roads Feature Class to the Beypazari Feature Class. I calculated a road length of ~81 km.

- Right-click on the Line Feature Class (Roads) and open the Attribute Table.

- In the Table Options drop-down menu, select Add Field. Name it Length and give it Type Double. Click OK.

- Right-click on Area and select Calculate Geometry, using the coordinates of the data frame (UTM) and Units of kilometers.

- Right-click Area column again and select Statistics for the sum of all shape areas in the Feature Class (Figure 38).

- Once calculations are complete, reset the reference frame to WGS_1984 under Layer Properties.

Table

bey_rd_clip

OBJECTID *	SHAPE *	Road name	SHAPE_Length	Length
1	Polyline	<Null>	0.00442	0.398031
2	Polyline	Bey_Kirb_yolu	0.131635	12.126541
3	Polyline	Bey_Kirb_yolu	0.013596	1.489584
4	Polyline	<Null>	0.050757	4.481602
5	Polyline	<Null>	0.013493	1.422218
6	Polyline	<Null>	0.025064	2.609029
7	Polyline	<Null>	0.007419	0.721103
8	Polyline	Bey_Kirb_yolu	0.02291	2.280414
9	Polyline	<Null>	0.027874	2.432484
10	Polyline	<Null>	0.101097	9.539762
11	Polyline	<Null>	0.077126	7.609156
12	Polyline	<Null>	0.064433	5.783325

0 ▶ ▶| (0 out of 20 Selected)

bey_rd_clip

Statistics of bey_rd_clip

Field

Length

Statistics:

Count: 20
Minimum: 0.398031
Maximum: 12.126541
Sum: 81.420953
Mean: 4.071048
Standard Deviation: 3.391842
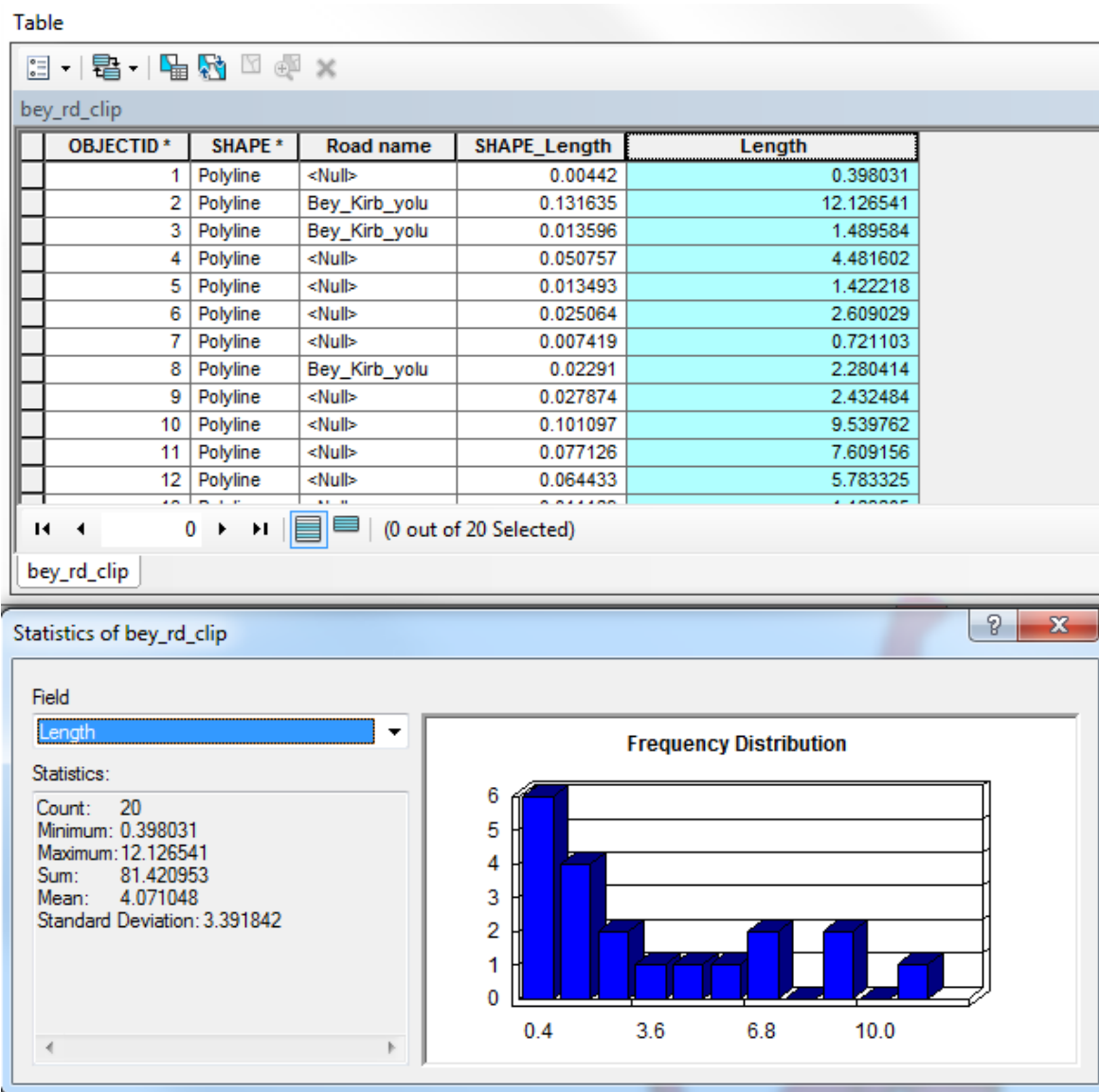
Frequency Distribution

Figure 38. Calculate the length of roads with access to the pluton using Calculate Geometry.

Map Formatting

Map 1 –Geologic Map of the Beypazari Granitoid, north central Turkey

The geologic map is useful for understanding what rock units are found in the area, and their geometric relationships to my field area. The Feature Classes in this map include Simple Units, Contours, Hillshade, and the Towns of Beypazari and Omaagac. The Outline of Turkey Data Frame with a star by the town of Beypazari is provided for reference. By clicking Layout View at the bottom of the screen, I inserted the title, two scale bars, scale text, a north arrow, contour interval and the coordinate system. I added a legend of rock types associated with colors on the map. Finally, I added a Grid to overlay the map with lines of latitude and longitude.

Map 2 – Outcrop Map, with Sample Locations and Potential Locations

The outcrop map will be my field guide as I search for new outcrops for sample collection. The Feature Classes in this map include the Beypazari Rock Unit, Sample Locations, Potential Sample Locations, Roads, Rivers, Towns, and the Turkey Outline with a star to identify Beypazari. A title, scale bars, scale text, north arrow, coordinate system, legend, contour interval and Grid overlay were added.

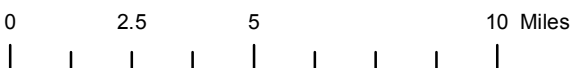### Map 3 – HillShade Map with Beypazari Granitoid and Inferred Fault

The hillshade map can help to analyze patterns, such as faults and other structures. In fact, I was able to infer a possible fault near the town of Beypazari, which I will confirm in the field. The Feature Classes include the Beypazari Rock Unit, Hillshade Raster, Inferred Fault, and Turkey Outline. A title, scale bars, scale text, north arrow, coordinate system, legend, and Grid overlay were added.

I exported all maps to PDF file type using the main drop-down File menu and selecting Export Map to browse to my central storage folder.

References

Billur, B., 2004. Geology and Petrology of the Beypazari Granitoids: Yassikaya Sector. Masters Thesis, Middle East Technical University, Turkey.

Okay, A.I. and Tuysuz, O. (1999) Tethyan sutures of northern Turkey. In: Durand, B., Jolivet, L. Horvath, F. and Seranne, M. (Editors) The Mediterranean Basins: Tertiary Extension within the Alpine Orogen, Geological Society, Special Publications, 156, 475-515.

Sengor, A.M.C. and Yilmaz, Y., 1981. Tethyan evolution of Turkey: a plate tectonic approach. Tectonophysics, 75: 181-241.

Ucarkus, G., Cakir, Z., and Armijo, R. (2011) Western termination of the Mw 7.4, 1999 Izmit earthquake rupture; implications for the expected large earthquake in the Sea of Marmara. Turkish Journal of Earth Sciences, v. 20:4, p. 379-394.

Geologic Map of the Beypazari Granitoid, north central Turkey

★ Beypazari

★ Oymaagac

700
600
800
500
600
1000
900
1000
1000
600
800
700
1300
1200

31.7126 31.799 31.8853 31.9716 32.058 32.1443

40.2057
40.1198
40.034
39.9481
39.8623

0   2.5   5   10   Kilometers
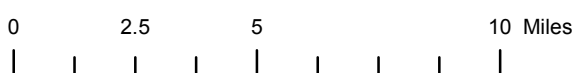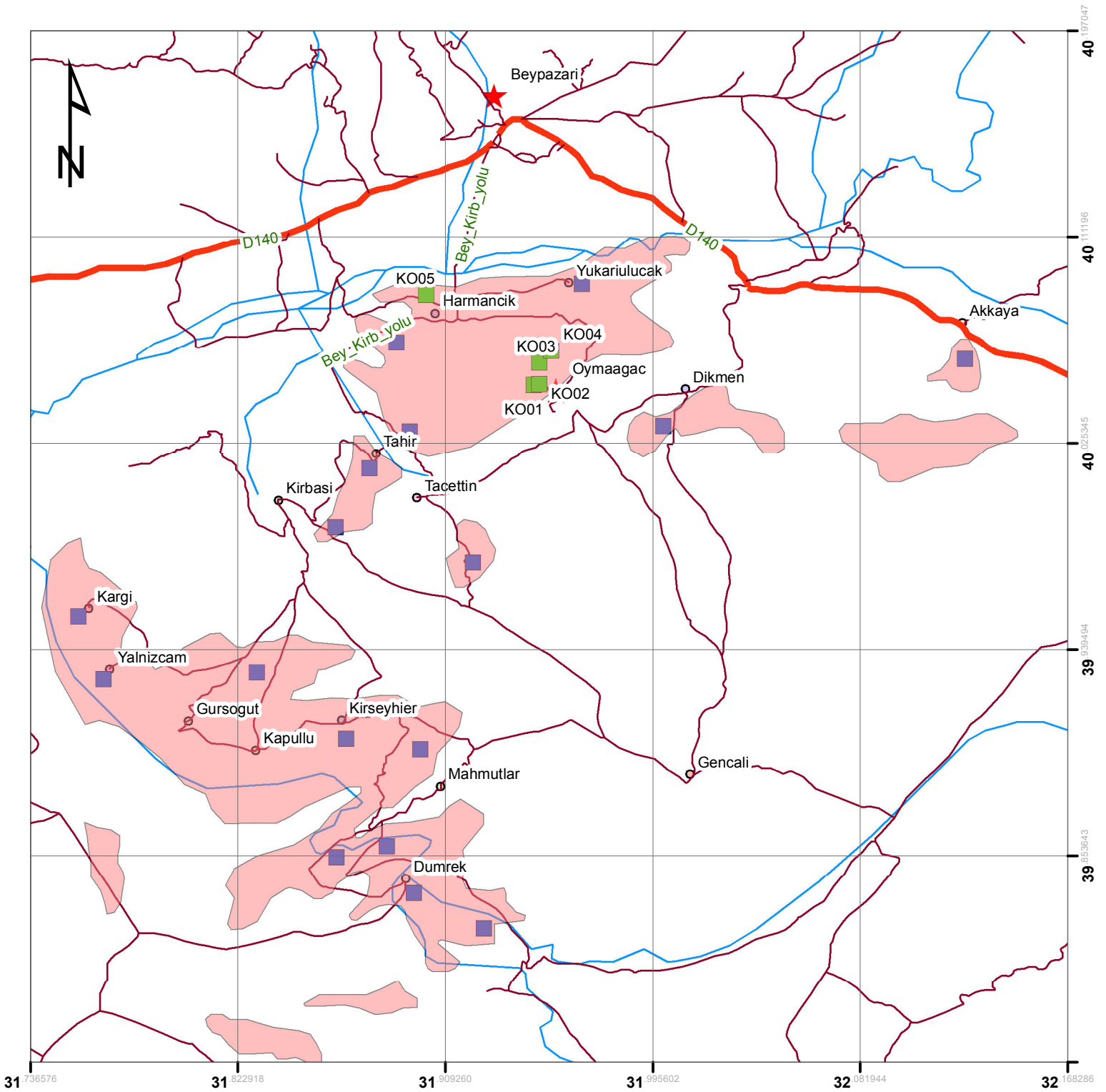0   2.5   5   10   Miles
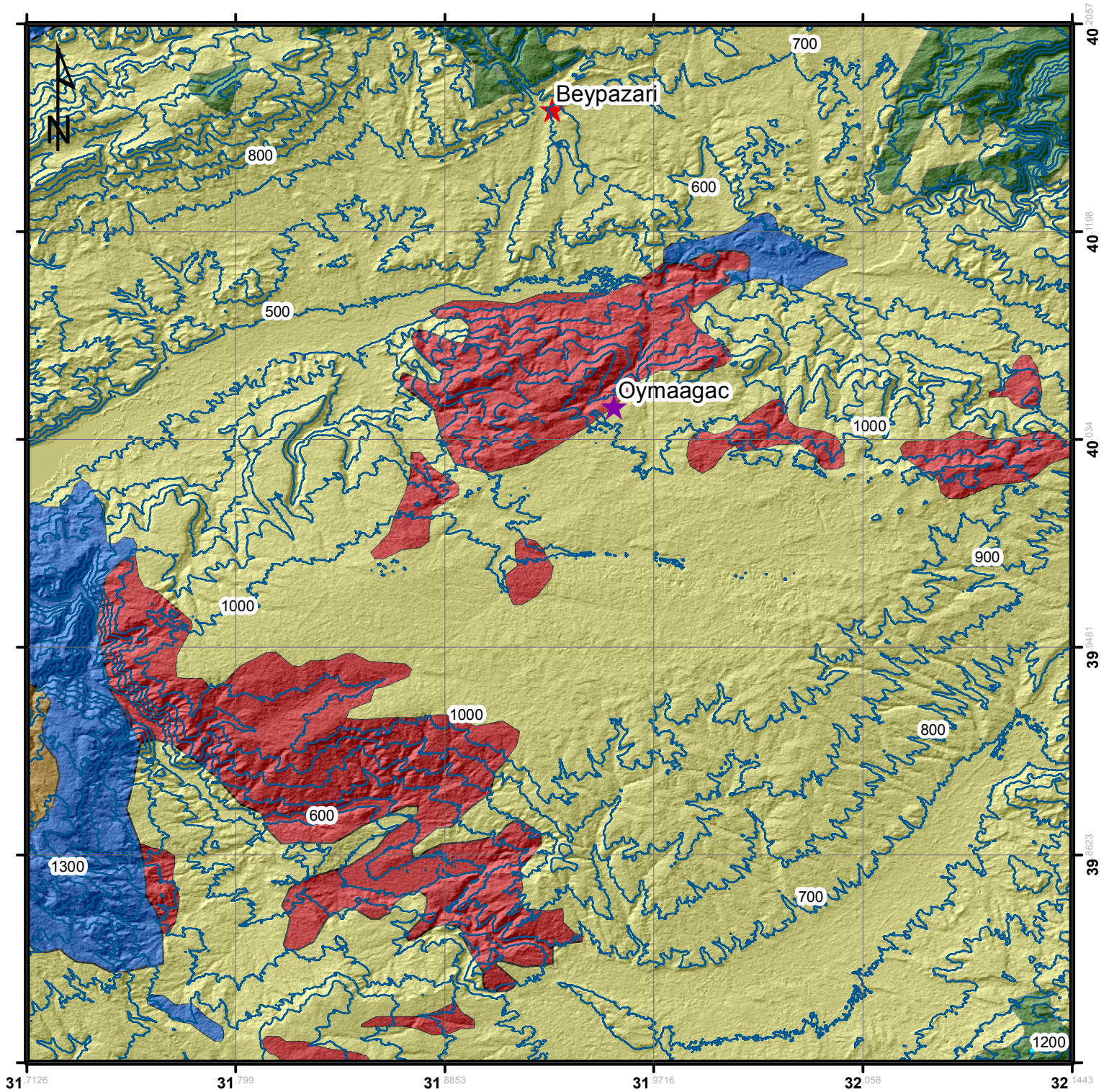
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
1:250,000
100m Contours

Rock Type

- Beypazari Granitoid
- Metamorphic
- Ophiolitic
- Sedimentary
- Volcanic

★ Beypazari

Outcrop Map of the Beypazari Granitoid, north central Turkey, with Sample Locations and Potential Locations

N

40.197047
40.111196
40.025345
39.939494
39.853643

31.736576
31.822918
31.909260
31.995602
32.081944
32.168286

Beypazari

D140

D140

Akkaya

KO05
Harmancik
Yukariulucak

KO03
KO04
Oymaagac
KO02
KO01

Bey_Kirb_yolu

Dikmen

Tahir

Kirbasi
Tacettin

Kargi

Yalnizcam

Gursogut
Kirseyhier
Kapullu

Mahmutlar

Gencali

Dumrek

0   2.5   5   10 Kilometers

0   2.5   5   10 Miles
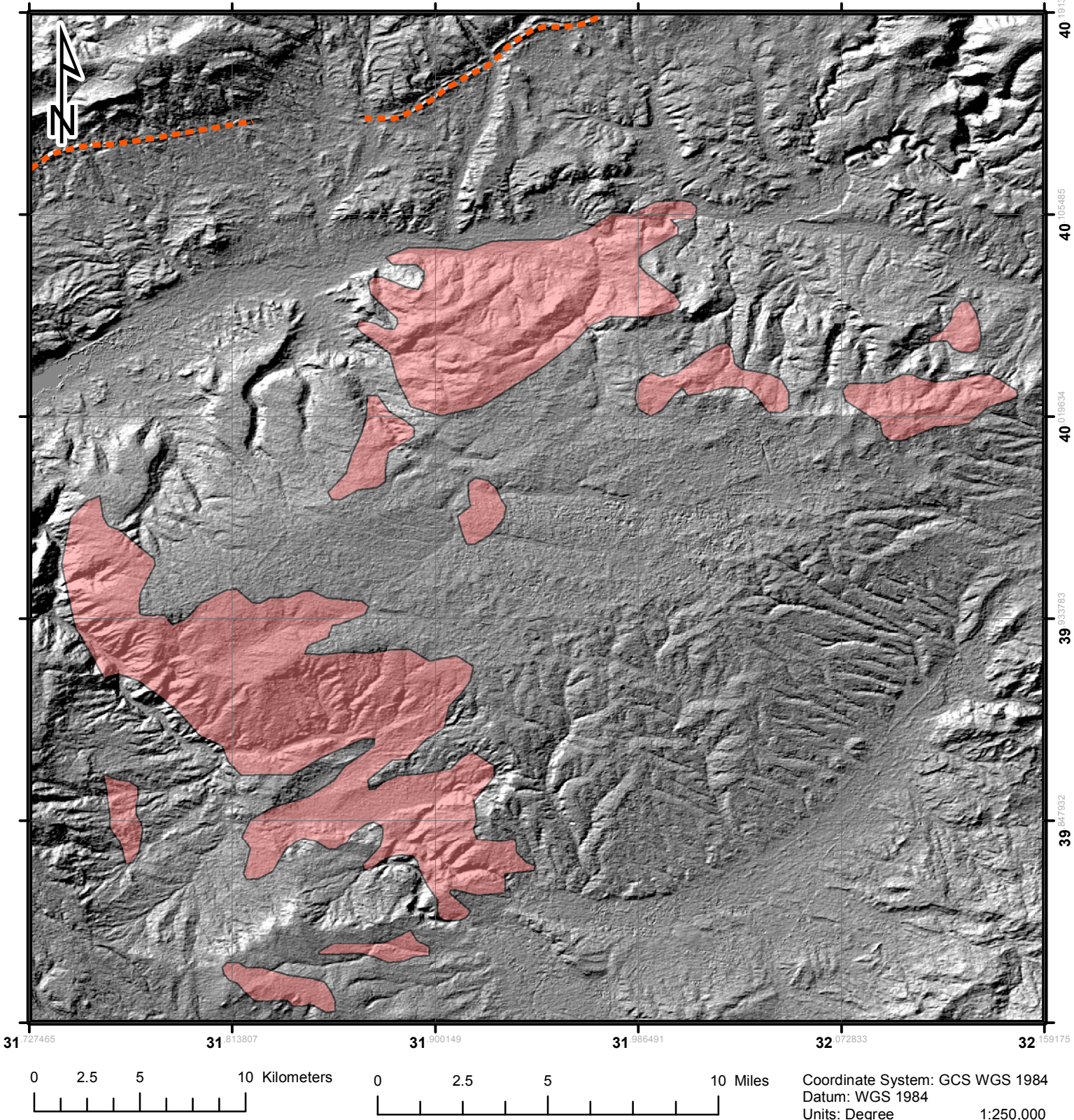
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree   1:250,000

Beypazari Granitoid

Sample Locations

Potential Locations

Rural Roads

Major Road

Rivers

Beypazari

Hillshade Map with Inferred Fault and the Beypazari Granitoid, north central Turkey

40.191336
40.105485
40.019634
39.933783
39.847932

31.727465   31.813807   31.900149   31.986491   32.072833   32.159175

| 0 | 2.5 | 5 | 10 | Kilometers |

| 0 | 2.5 | 5 | 10 | Miles |

Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree   1:250,000

Beypazari

Rock Unit   Faults

Beypazari Granitoid   Inferred