An Analysis of Landforms Produced by the Cascadia Orogeny

By Thanh Nguyen

Introduction

The subduction of the Juan de Fuca Plate underneath the North American Plate forms a convergent plate boundary that is known by many in the U.S. Unfortunately, the landforms associated with the tectonic process are commonly overlooked. The anatomy of a collision zone is unique and its landforms are enjoyed by the population of people residing in the zone. Contemporary topography and geology of the Western United States are in part dictated by such landforms. The landforms include oceanic trenches, low-angle thrust faults, volcanoes, basins, batholiths and etc. The volcanic arc and oceanic trench in Oregon is our landform of interest. Oceanic trenches are created from the direct contact between the two colliding plates, while the volcanic arcs are sustained and created by partial melting of the subducting slab.

The focus of this project is to quantify distances between the oceanic trench and volcanic arc produced by the Cascada Orogeny. In addition, a spatial analysis of the Cascadia Trench will be performed. What is the distance between two landforms? What is the slope of the Cascadia Trench?

Data Source

ETOPO1 Global Relief Model:
https://www.ngdc.noaa.gov/mgg/global/global.html

Oregon Department of Geology and Mining Industries:
https://www.oregongeology.org/geologicmap/index.htm

Oregon Spatial Data Library:
https://spatialdata.oregonexplorer.info/geoportal/

Data Files/Collection

Point Shapefile (produced)
Line Shapefile (produced)
Oregon Coast AOI (produced)
Oregon Hill Shade (produced)
Oregon Boundary Shapefile
Volcano Locations Shapefile
Oregon 10m DEM Geodatabase
ETOPO1 Bedrock Raster
Oregon Geology Shapefile

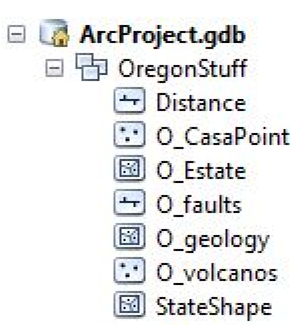
Datum : The North America Datum of 1983
Projection : NAD_1983_Oregon_Statewide_Lambert_Feet_Intl

The datum and projection of all files were identical during the data processing stage.

Data Preprocessing/Processing

Volcano Locations, Oregon Boundary Shapefiles
All shapefiles downloaded online had NAD83 as their datum; therefore, the bulk of the modifications made to the spatial reference involved changing the projection to Oregon Statewide Lambert.

For organizational purposes, a geodatabase was created for the project. Within the geodatabase is a feature class dataset with the same horizontal datum and projection stated above. The feature class dataset did not have a vertical datum(set to "none") since only shapefiles were stored inside the dataset.

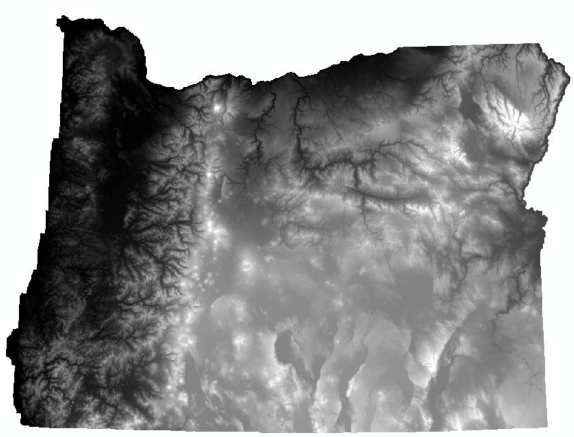


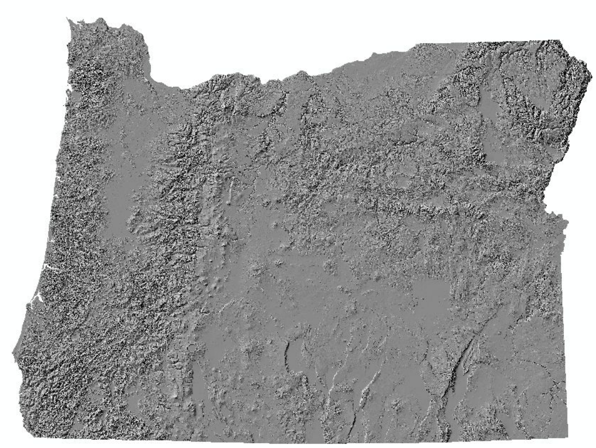
ETOPO1 Bedrock Raster

The bedrock raster is obtained from a bathymetry website and covers the entire conterminous U.S. The datum of the original raster is WGS 1984, so a conversion to NAD83 was needed. The bedrock raster is also clipped using the Oregon Coast AOI shapefile that will be discussed later.

Oregon 10m DEM geodatabase + Oregon Hill Shade

The 10m DEM was downloaded by connecting to the Oregon Spatial Data Library remotely (This folder was not public through their website) using a program called WinSCP. Connecting anonymously to the database via FTP was a viable method to obtain the DEM; however, it should be noted that the folder downloaded is not zipped. The DEM is part of a geodatabase, so the entire geodatabase must be downloaded remotely and in this case required roughly 9 Gbs of storage space. In addition, the folder must be renamed with the .gdb (ie: OR_DEM_10M.gdb) geodatabase extension to be recognized as a geodatabase by ArcMaps. Lastly, the DEM was clipped using the Oregon boundary shapefile.





On the left is the clipped DEM, while on the right is a hill shade raster produced from the DEM with the “Hillshade (spatial analysis)” tool. The hill shade raster is presented with a standard deviation stretch type.

Oregon Geology shapefile

The original polygon shapefile representing the geology of Oregon was too messy and complex. Using the symbology properties of the shapefile, rock ages were condensed.

Table

Dog_geo

GEO_GENL_U	AGE_NAME	TERRANE_GR
volcaniclastic rocks	Miocene	Harney Basin Volcanic Field
volcaniclastic rocks	Miocene	Harney Basin Volcanic Field
volcanic rocks	Miocene	High Lava Plains Volcanic Province
volcaniclastic rocks	Miocene	Harney Basin Volcanic Field
volcaniclastic rocks	Miocene	Harney Basin Volcanic Field
volcaniclastic rocks	Miocene	Neogene volcanic rocks
sediments	Quaternary	Quaternary surficial deposits
volcaniclastic rocks	Miocene	Neogene volcanic rocks
volcanic rocks	Miocene	Columbia River Basalt Group
volcaniclastic rocks	Miocene	Harney Basin Volcanic Field
volcanic rocks	Miocene	Columbia River Basalt Group
volcaniclastic rocks	Miocene	Neogene volcanic rocks
volcanic rocks	Miocene	Columbia River Basalt Group
volcaniclastic rocks	Miocene	Neogene volcanic rocks
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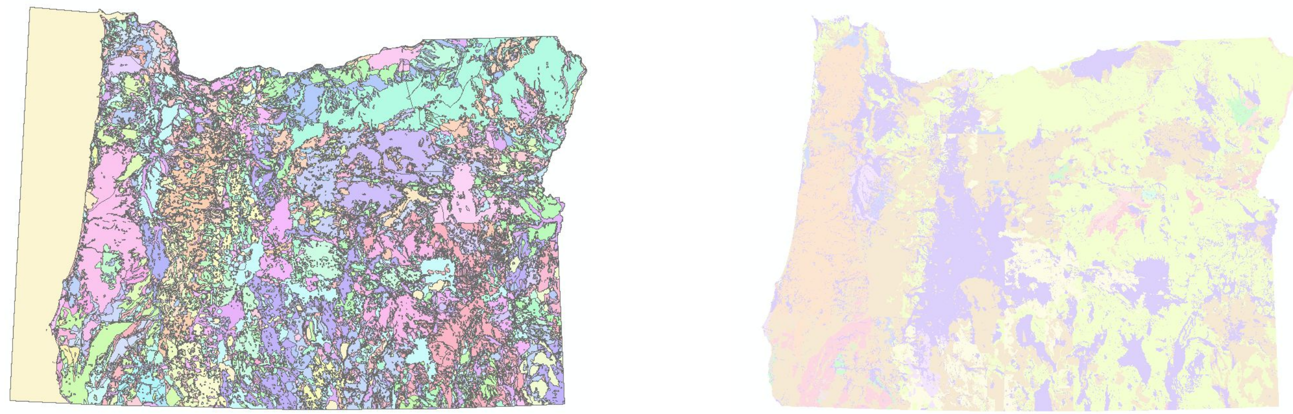
volcanic rocks	Miocene	Columbia River Basalt Group
volcaniclastic rocks	Miocene	Neogene volcanic rocks
volcanic rocks	Miocene	Columbia River Basalt Group
volcaniclastic rocks	Miocene	Neogene volcanic rocks
volcaniclastic rocks	Miocene	Harney Basin Volcanic Field
volcaniclastic rocks	Miocene	Neogene volcanic rocks
sediments	Quaternary	Quaternary surficial deposits

1 (0 out of 120049 Selected)

Shown above is a section of the shapefile’s attribute table. Showing polygons according to specific periods within our “Age_name” column allows ArcMaps to condense all other polygons as one value; as a result, the collection of complex and unique age labels can be condensed.



Overly complex geologic map of Oregon on the left, simplified geologic map on the right

<u>Oregon Coast AOI shapefile</u>

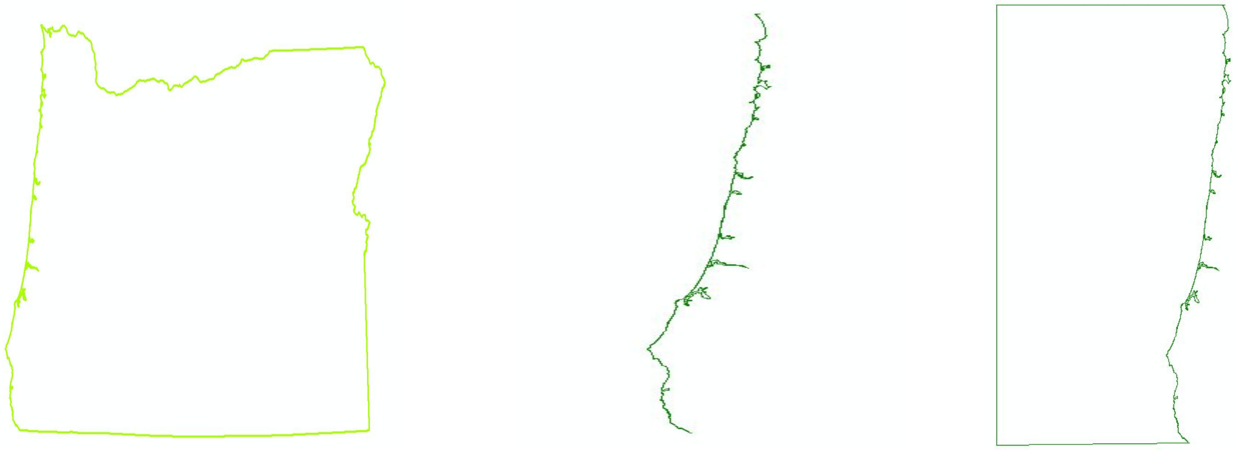
The Oregon boundary shapefile does not encompass the entire area of interest since it only has the land boundary of Oregon. The desired area of interest includes the Cascadia Trench within the ocean and the Cascade Range of volcanoes on land. Therefore, a boundary extending beyond Oregon and including the Cascadia Trench is needed. This process is used to create the mask that the bedrock raster was clipped to.

The first step is to convert the pre-existing Oregon boundary from a polygon feature class to a line feature class using the “Feature to Line” tool.

The second step is to edit the line feature class with a specific tool called the “Split Tool” within the editor bar. The tool will allow the user to cut up desired points within the line feature class to obtain a line representing the western boundary of Oregon. Tracing the boundary by mouse is impractical because the process would be inaccurate; thus, the use of the “Split Tool” produces a better boundary to incorporate into our final polygon shape.

The “Split Tool” is shown highlighted in yellow above.

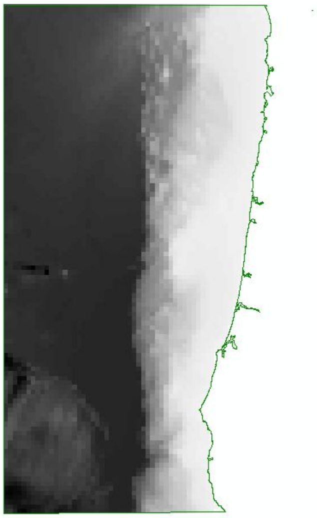
The last step is to create the desired boundary using lines and converting the edited line feature class back into a polygon feature class with the “Feature to Polygon” tool.

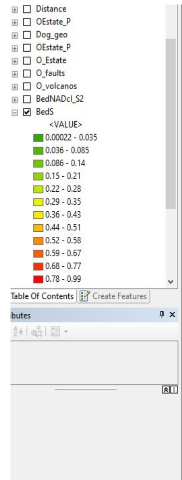


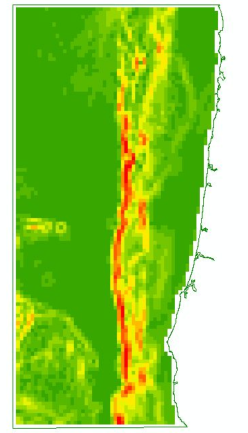
The output from all three steps are shown above. The leftmost image is the first step and the rightmost image is the third step.

<u>Point/Line Shapefiles</u>

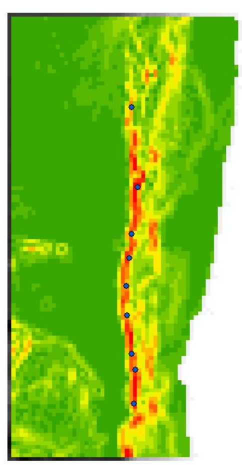
In order to conduct measurements of distance between the volcanic arc and oceanic trench, shapefiles are needed to pinpoint the landform and determine the path between two landforms. Both point and line feature classes are created within the feature class dataset. The point shapefile represents the location of the Cascadia Trench based on a slope analysis.The line shapefile represents the path between two points or two landform locations.



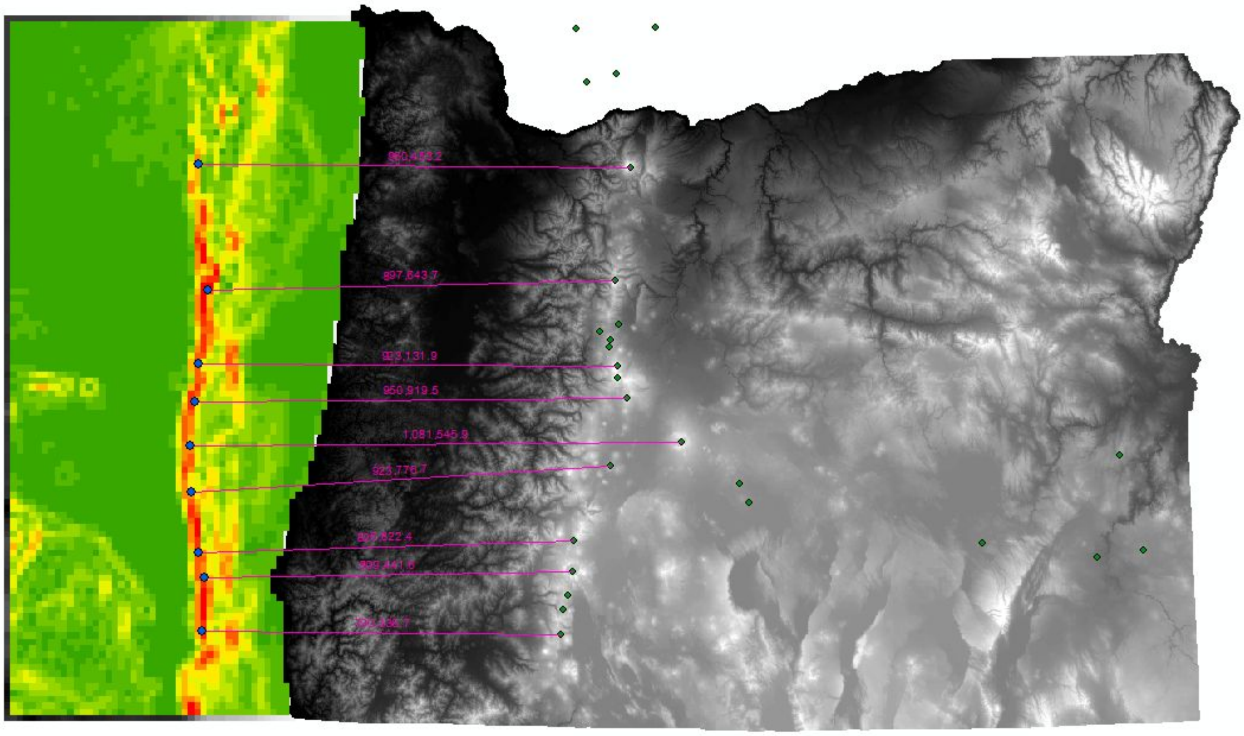




A slope analysis is conducted with the bedrock raster by using the “Slope (spatial analysis)” tool. The z factor within the tool is set to .3048 since the x,y units within the bedrock raster are different compared to the cell unit of the raster. The z factor is the conversion factor from our x,y units(feet) to the cell unit(meters). As seen above, the output raster of the slope analysis yields a colormap of the bedrock raster to which the color indicates slope. The transition between continental and oceanic floor is characterized by the steep slope that represents the Cascadia Trench. Input bedrock raster on the left. Slope analysis output on the right.

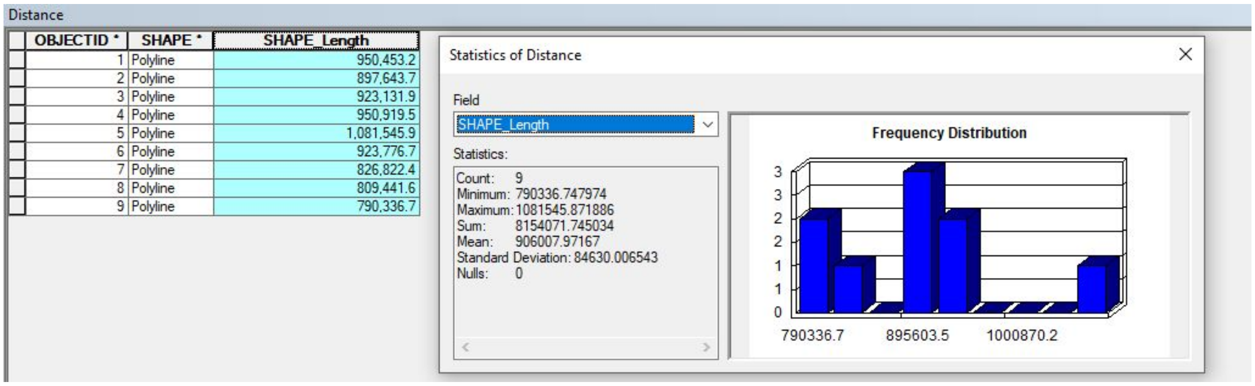


Points can be added into the point feature class to represent the oceanic trench. The blue points in the image above belong to the point feature class.



The process for measuring the distance is fairly simple. Draw a line within the line feature class using the blue points(Cascadia Trench) as the left endpoint and green points(Cascada Volcanos) as the right endpoint. This process yields the purple line shown above with distances labeled in feet. Creating a line within a shapefile automatically measurements the length of the line according to the units of its spatial reference.

Another method to measure the distance between landforms is by using the “Measure” tool shown highlighted in yellow. It can measure distance easily without the need to create a point or line feature class.



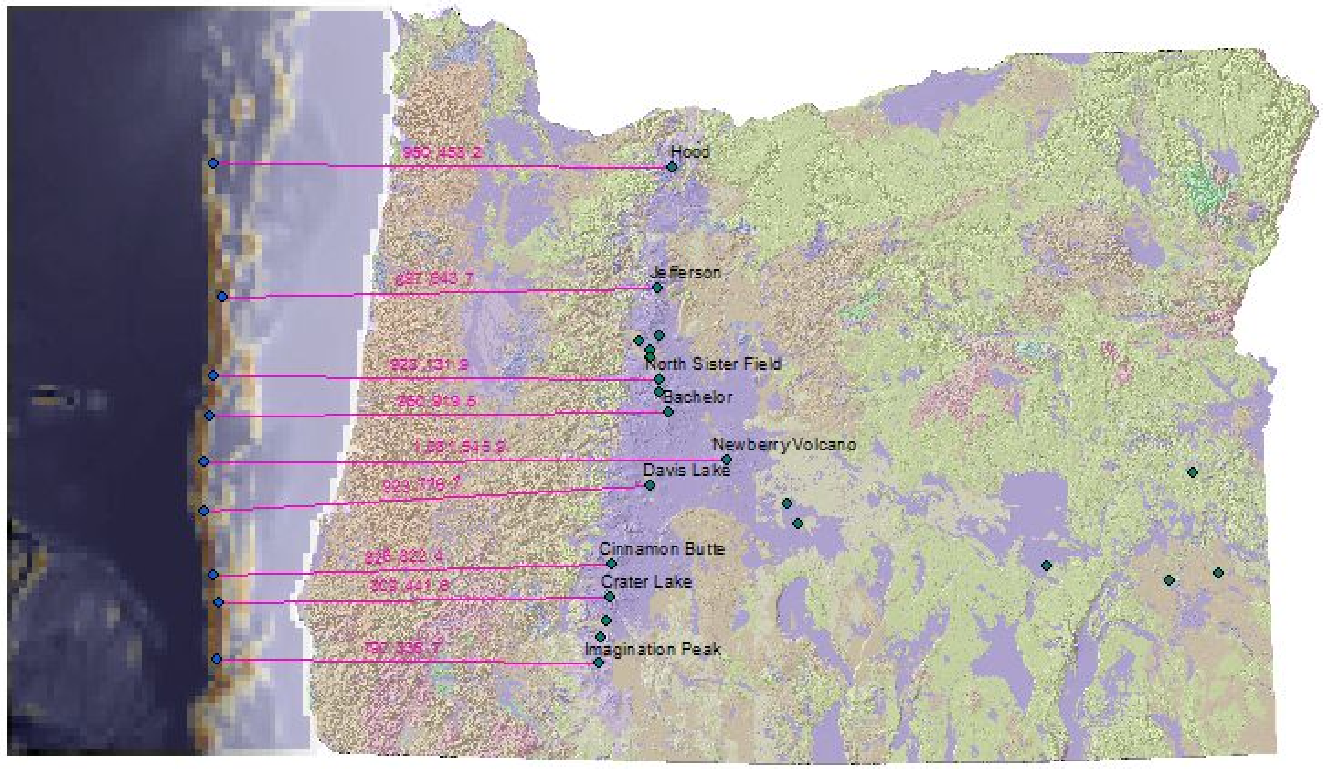
Along with the raw measured values, the attribute table within the line feature class provides basic statistical information about the data.

Ideally, the lines that define the path between each landform should be horizontal. Thus, lines deviating from a straight horizontal path can be considered as an error.

Conclusion

The slope of the Cascaida Trench ranges from 29 degrees to nearly vertical. The average distance between the Cascaida Trench and the Cascade Range of volcanos is 905,607 ft.

Quantifying the Distance between the Cascadia Trench and Casacade Range



Explaination

Volcano Locations

Points within Cascadia Trench

Landform Distance (feet)

Slope

High : 0.987238

Low : 0.000221249

Geology

Other Units	Holocene	Pleistocene
Cenozoic	Jurassic	Pliocene
Cretaceous	Miocene	Quaternary
Eocene	Oligocene	Triassic
	Permian	

Datum: NAD83

Projection: Oregon Statewide Lambert Feet Intl

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