The Woodlark Basin as a Natural Laboratory for the Study of the Geological Sciences

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Figure 1: The Woodlark Basin region (heavy white box) is sandwiched between Papua New Guinea and the Solomon Islands in the southwest Pacific.

The Woodlark Basin is located to the northeast of Australia and between Papua New Guinea and the Solomon Islands (Figure 1). Within this small region active examples of most tectonic processes can be found. We will explore some of these today.

Regional Setting

To the west of the Woodlark Basin, the Papuan Peninsula stretches toward the main part of the island of Papua. Here the tallest mountains east of the Himalayas, formed over the last 60 million years by the construction of a number of volcanic arcs and subsequent continental collisions, reach heights in excess of 4,000 m (~13,000 feet) . Today these mountains support the Earth’s only equatorial glacier. The ruggedness of these mountains has meant that many of the tribes of Papua have developed in almost total isolation. Today almost one-fifth of the world’s human languages (1,100) are found in Papua New Guinea. In the east, the Solomon Islands are mountainous, yet they are far less rugged. This island chain is made up of a series of islands that have has been built up as the Australian, Pacific, and Woodlark plate have subducted beneath them.

About 9 million years ago, for reasons that we do not fully understand, the Papuan Peninsula started to break apart as the region went into a phase of north-south extension. The mountains that we see today extending from the Papuan mainland towards the Woodlark Basin used to extend across much of the region. However, as a result of extension, these mountains have subsided and much of the area is now below sea-level. In the eastern part of the Woodlark Basin there has been so much extension that seafloor spreading started and now extends almost to the modern Papuan Peninsula. Seafloor spreading is now propagating to the west at a rate of about 145 km/m.y. – here the basin is growing. However, in the east, the Woodlark Basin is now subducting beneath the Solomon Islands and the Woodlark Basin is being destroyed.

To the south of the Woodlark Basin is a passive continental margin. Sixty million years ago this was very active: the Australian plate was subducting beneath Papua New Guinea. This stopped when a piece of the Australian continent, which was partially subducted beneath Papua New Guinea, choked the subduction zone. The overriding plate, which was oceanic in origin, was forced upward during the collision forming perhaps the first mountains in the region.

In the west, the Woodlark basin is bordered to the north by the Trobriand Trough, a subduction zone where the oceanic crust of the Solomon Sea is subducting beneath the Woodlark Basin. Many of the volcanoes found along the Papuan Peninsula are arc volcanoes that have formed above the subducting Solomon Sea. Further east, the boundary between the Woodlark Basin and the Solomon Sea is a right-lateral strike-slip fault. To the north of the Solomon Sea, the plate is subducting beneath the islands of New Britain and Bougainville.

Learning Objectives

The exercise has two main learning objectives:

1. Learn how the material covered in class and lab can be integrated and applied to a real-world example.
2. Learn how this material can be presented in terms of a geographical information system (GIS) database.

The Exercise

For today's exercise we will be using ArcReader. This is a freely available computer program that can be used to carry out crude manipulation of databases of geographical and geological information created using ArcGIS. Closely follow the steps and complete the exercises by filling in blanks as necessary.

Starting ArcReader and Loading the Database

1. From the windows desktop select *start – All Programs – ArcGIS – ArcReader*.
2. Once ArcReader window has started from the main menu select *File – Open*. Your TA will direct you to a directory where you will select *Woodlark.pmf*.
3. The ArcReader window should now look like the example in Figure 2.

Bathymetry and Topography

1. Click on the icon. An "*Identify Features on the Map*" window will appear. At the top of the window, next to the word "*Identify from*", there is a drop-down menu. In that menu select *SRTM*. This is the topography layer. SRTM is an acronym for Space Shuttle Radar Topography Mission[1].
2. Click anywhere on the topography (the part of the map that is above sea-level) with the left-hand mouse button. While keeping the mouse button held down note the longitude[2] and latitude[2] in the *Location* box (the longitude is the first number, the latitude is the second). If the phrase *"decimal degrees"* does not appear adjacent to

the longitude and latitude click on the small square adjacent to the *Location* box and select "*Decimal Degrees*". Release the mouse button, and then take note of the elevation in meters ("*Pixel value*"). Repeat this for another nine different locations and write down your results in Table 1.

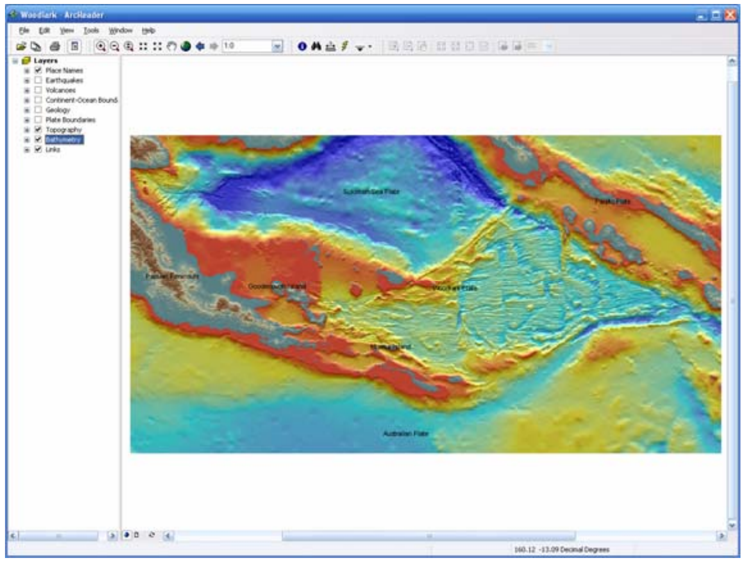

Figure 2: ArcReader window with the bathymetry and topography of the Woodlark Basin region displayed. Topography (above sea level) is shown by blue-gray (lowest) through brown (highest) colors. Bathymetry (below sea level) is shown by red (shallowest) through blue (deepest) colors. Both datasets have been falsely illuminated from the north to emphasize fabric. The panel on the right lists the ArcGIS layers we will be using today.

	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6	Location 7	Location 8	Location 9	Location 10
Longitude										
Latitude										
Elevation										

Table 1: Longitude, latitude, and elevation (in meters) for ten different locations above sea level

3. Click on the icon again. This time select *Regional Bathymetry* from the list of layers. This layer is a compilation of bathymetry data. Some of it is from digitized maps. Much of it is from seafloor surveys that have taken place over the last few years (the most recent being in early 2005).
4. Click on the seafloor (the part of the map that is below sea-level) in ten different locations and again note the depth in meters (*Pixel value*), longitude, and latitude for each point and write down your results in Table 2 below

	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6	Location 7	Location 8	Location 9	Location 10
Longitude										
Latitude										
Depth										

Table 2: Longitude, latitude, and elevation (in meters) for ten different locations below sea level

5. Click on the "+" symbol next to *Bathymetry* in the *Layers* menu. You will now see that this layer actually contains other layers. Click on the check-boxes adjacent to the *1000 m Contours* and *Deepest Points* layers. Contour lines (every 1000 m) are now plotted on the map together with a bright green region that signifies seafloor that is deeper than 8500 m.
    a. Making sure that the ℹ icon is selected and that the *Regional Bathymetry* layer is selected in the *Identify from* drop-down menu on the *Identify Features on the Map* window, click a point within the bright green region and record the latitude, longitude, and depth in Table 3.

	Longitude	Latitude	Depth
Deepest point			

Table 3: The longitude and latitude of one of the deepest points in the Woodlark Basin region

    b. Now select the 1000 m Contour layer in the *Identify from* drop-down menu and click on a contour that is directly adjacent to the bright green region[3]. What is its value (the *CONTOUR* field)?

    ____

    c. What is the name of the geological feature in which the deepest points in the basin are located (you may have to come back to this question later)?

    ____

6. Click on the ✔ symbol next *1000 m Contours* and then on the "-" symbol next to *Bathymetry* in the *Layers* menu. This will turn off the *1000 m Contours* layer and hide the *Bathymetry* layers in the *Layers* window. Click on the "+" symbol next to *Topography* in the *Layers* menu. You will now see the *Topography* layers. Click on the check-box adjacent to the *Highest Points* layer. Additional bright green regions that signify topography that is higher than 3500 m are now plotted.
    a. Select the ℹ icon and the *SRTM* layer in the *Identify from* drop-down menu on the *Identify Features on the Map* window. Now click a point within one of the new bright green regions and record the latitude, longitude, and elevation in Table 3.

	Longitude	Latitude	Elevation
Highest point			

Table 4: The longitude and latitude of one of the highest points in the Woodlark Basin region

Volcanoes

1. Click on the "-" symbol next to *Topography* in the *Layers* menu to hide the *Topography* layers. Currently the only layers that are checked in the *Layers* list are *Topography*, *Bathymetry* (these are the layers that we have worked with so far), *Place Names* and *Links*. Click on the check box for the *Volcanoes* layer. Twelve labeled volcanoes will appear on the map. Click on the 🔍 icon and then click the left-hand mouse button just to the northwest of Koranga Volcano (this volcano is just off the northeast corner of the map). While holding down the left-hand mouse button drag the mouse to the southeast. Make sure that the resultant box includes contains all of the volcanoes and then release the left-hand mouse button. If you select the wrong

area simply click on the icon to return to the previous window. The ArcReader window should now look something like that in Figure 3.

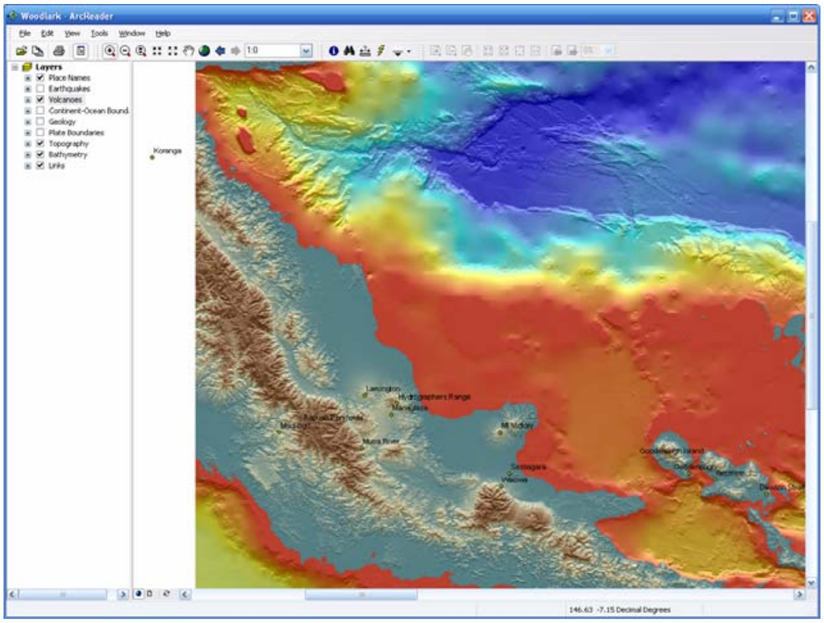

Figure 3: Detailed map of the Papuan Peninsula showing the location of the key volcanoes.

2. Each of the volcanoes is associated with a hyperlink– a link to associated web-page based information. To access this information click on the icon. If multiple links exits a *Hyperlink* window will appear. Highlight a link and then click on *Jump*. Using the information that you gather, fill out the Table 5 as thoroughly as possible for ten of the volcanoes.

Name	Last eruption	Type of volcano	Height	Number of people killed

Table 5: For ten of the volcanoes identified on the Papuan Peninsula find out the date of the last eruption, the type of volcano, its height, and the number of people killed during the last eruption.

Plate Boundaries

1. Return to the previous window by clicking on the icon. We are now going to look at the plate boundaries in the region. Click on check-box for the *Plate Boundaries* layer. Three types of lines will have appeared on your map. Click on the icon and select *Plate Boundaries* from the “*Identify from*” drop-down menu in the “*Identify*

Features on the Map" window. In Table 6 note the name and type of each of the five boundaries and their total length[4]. If the plate boundary consists of multiple segments, sum together the length of them all.

Name	Plate boundary type (convergent, divergent, or transform)	Length in kilometers

Table 6: For each plate boundary note its type (convergent, divergent, or transform) and length in kilometers.

2. The triangles on the lines marking the subduction zones point in the direction of subduction. Answer the following:
   a. Which plate is subducting on two sides?
   b. What type of boundary is the third side?
   c. Given that the sense of motion on the fault in b. is right-lateral, is the Woodlark plate subducting more or less rapidly than the Solomon Sea plate?
   d. At the San Cristobal Trench, under which plate are the Woodlark and Australian plates subducting?
   e. The volcanoes along the Papuan Peninsula are subduction zone volcanoes. Which plate is subducting beneath the Papuan Peninsula to form these?

Earthquakes

1. Click on the check-box for the Earthquakes layer. A large number of small black dots, each representing an earthquake, will appear on your map.
   a. Where are the majority of the earthquakes located?
   b. At what type of plate boundary are most of these earthquakes occurring?
   c. By clicking on the icon and selecting the Earthquakes layer, determine if the earthquakes in general are deeper closer to or further north of the New Britain Trench. Why?

d. In the space below make a sketch of what a cross-section through this boundary might look like.

Figure 4: Draw a cross-section through the plate boundary discussed in 1b, c, and d.

e. There is one more place in the southeastern quadrant of the map (centered on about 155.5^{o}E, 9.5^{o}S) where there is a belt of earthquakes. From what type of plate boundary do they result?

____
____
____

Geology

1. Un-check the earthquake layer. Click on the check-box for the Geology layer. In addition to fault traces, five colored geological units will appear. By clicking on the icon and selecting the *Geology* layer, name the five units and complete Table 6.

	Units Names
1	
2	
3	
4	
5	

Table 6: Name each of the five geological units.

2. Click on the icon and double-click on Geology. If you now move your cursor to the left-hand edge of the map, click the left-hand mouse button, hold it down, and then drag the mouse to the right, the Geology layer will peel back revealing the underlying

topography and bathymetry. Using this technique, determine which two units form the highest mountains in the Papuan Peninsula.

a. ______________________________

b. ______________________________

Why do you think that these two units form the highest mountains?

____

____

____

3. Goodenough Island is made predominantly from one specific rock unit. What is it?

   ____

4. Goodenough Island has been formed as the rock unit named in the previous questions rose in excess of 30 km in the last 4 million years. This very rapid motion has formed an island that is 2,536 m tall. Click on the icon and then click again in approximately the center of the island. A photograph of the island, taken from the south, will pop up. Estimate the average angle of the slopes of the island.

   ____

Natural Resources

1. Papua New Guinea is richly endowed with natural resources. These include gold, copper, silver, natural gas, and oil. These are all directly a result of a very active geological past and present. For what percentage of the Gross Domestic Product (GDP) of Papua New Guinea are mineral resources responsible? You will find a section about mineral resources at http://www.state.gov/r/pa/ei/bgn/2797.htm.

   ____

2. Click on the icon and then in the center of Misima Island. A web page will appear giving some of the detail of mining on Misima Island.
   a. What two minerals were mined on Misima Island?

      ____

      ____

   b. What type of mining took place at Misima Island?

      ____

   c. When did mining stop?

      ____

   d. In Table 7 name five uses for each of the two minerals named in a. above (you can use your text book or resources such as http://www.wikipedia.org)
   e. Name the university from which the co-founder of Wikipedia, Jimmy Wales graduated with an M.S. degree.

      ____

Uses	Mineral 1	Mineral 2
1		
2		
3		
4		
5		

Table 7: Five uses for each of the two minerals mined at Misima Island

[1]The space shuttle mission took place over 11 days onboard the Endeavour in February of 2000 (see http://www2.jpl.nasa.gov/srtm/ for more information). During this mission topography data was collected for most of the surface of the Earth with a pixel size of 30 meters. However, outside of the United States, the data has been degraded and is only available at a pixel size of 90 meters.

[2]Longitude is a measure of the location in the east-west sense. Latitude is a measure of the location in the north-south sense.

[3]It may be easier to zoom into the relevant part of the map for this part of the exercise. To do this, click on the icon, click on the map close to the area where you need to see more detail, and while holding the left-hand mouse button down select a region. Release the mouse button. To zoom back out to the previous image simply click on the icon

[4]To measure the length of a feature on your map click on the icon and then click at one end of the feature. By clicking on the feature whenever it bends you can create a line that mimics it. The total length will be given in degrees. To convert this to kilometers use the conversion 1 degree = 110 kilometers.