Ocean Basin Profile
March, 2014

EAPS 10000 Y01 *Planet Earth* online course
Homework Assignment #4 (30 points)

Ocean Basin Depth Profile
(Trans-Atlantic Ocean Depth Profile –
Cape Hatteras, North America to Cape Blanc, Africa) and Interpretation

Name: Yinglai Wang

Part I – Ocean basin depth profile – Atlantic Ocean basin

Objective: Plot a bathymetric (ocean depth) profile across the Atlantic Ocean to examine the typical shape of the ocean basins. This exercise also provides experience with graphing and concepts of scale.

Procedure: The table given on the next page contains depth data for a profile across the Atlantic Ocean from Cape Hatteras, North America to Cape Blanc, Africa. Plot the 61 distance and depth points on the attached graph, then connect the dots to form a ***bathymetric*** profile or ocean basin topography profile. (If you wish to plot by computer, you can obtain the data at: http://web.ics.purdue.edu/~braile/EAS100online/OceanProfileDataTable.xls. You can produce an Excel plot, or use other software, to paste into your Hwk 4 submission. If you plot by computer, please be sure to make the graph look similar to that shown on page 3.) Note that the distance scale is in **kilometers** and the depth scale is in **meters**. Thus, the depth data are **vertically exaggerated** (by a factor of 200) which enhances the subtle features of the ocean basin topography. A plot at true (1 to 1) scale will be provided later to show the actual topography. Vertical exaggeration is useful to display profile data when the horizontal extent of the data is very large and when the profile is relatively smooth. The data that are given in the table are sampled at a large interval (100 km between data points) and, thus, the bathymetric profile is only a rough approximation of the true ocean basin topography. However, the main features of the ocean basin are visible on the graph. A similar graph is shown in **Figure 9.15** of **L&T, 2014** and L&T, 2011. For additional information, refer to **pages 302-312, Lutgens & Tarbuck, 2014** (pages 265-270 of L&T, 2011; pages 250-257, L&T, 2008).

Questions:

1. On the graph, label the following features of the ocean basin: **continental slope, abyssal plain, mid-Atlantic ridge**.

2. What is the approximate ocean **depth** at the mid-Atlantic ridge and the **relief** of the ridge (difference in depths, or elevations, between the top of the ridge and the adjacent, relatively flat ocean bottom)?

   Ocean depth at mid-Atlantic ridge 2500 meter

   Relief (difference in ocean depth between the ridge and the abyssal plain) of the mid-Atlantic ridge (6000−2500) = 3500 meters

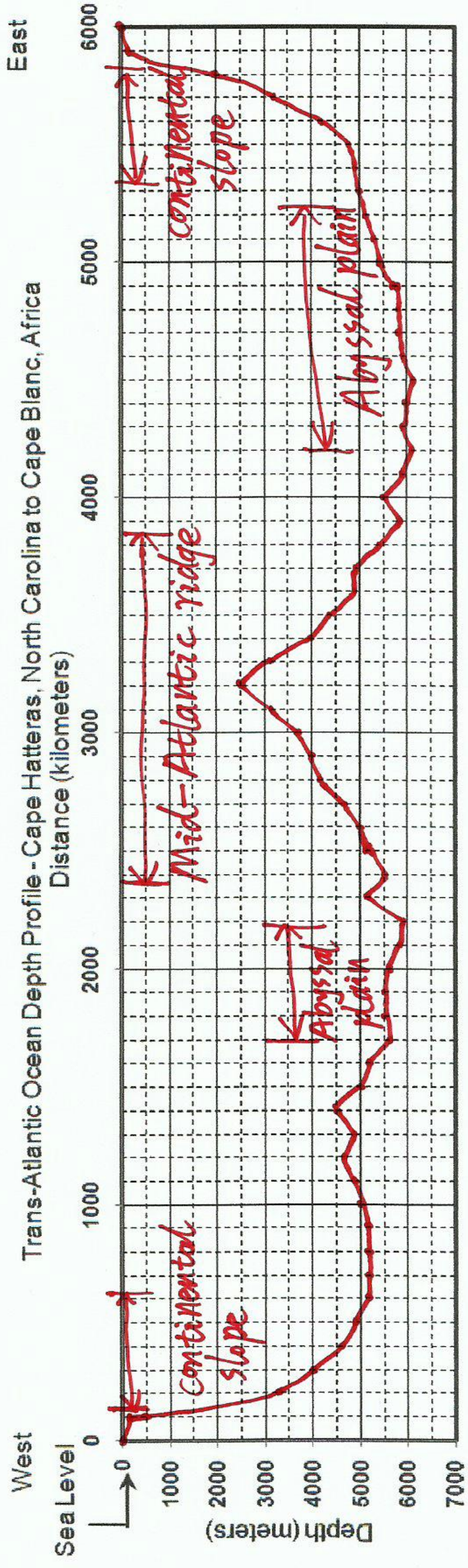
3. What is the approximate **slope** of the west flank of the mid-Atlantic Ridge (measure the difference in ocean depth along the profile between about 2200 km and 3200 km distance and divide by the difference in distance, 3200-2200 or 1000 km. Be sure that both measurements, differences in depth, and distance, are in the **same units**, either km or m. The resulting number will be the slope expressed as a ratio. The slope can also be given as a percent or as an angle. (**Information (review) on calculating the slope of a line: http://web.ics.purdue.edu/~braile/eas100/Slope.pdf.**)

   Approximate slope of the west side of the mid-Atlantic ridge 0.0102.

$$\frac{5200-100}{600000-100000} = 0.0102$$

Dist. (km)	Depth (m)
0	0
100	100
200	3300
300	4000
400	4600
500	4900
600	5200
700	5200
800	5200
900	5200
1000	5000
1100	4900
1200	4700
1300	4900
1400	4500
1500	5000
1600	5200
1700	5600
1800	5500
1900	5500
2000	5600
2100	5800
2200	5900
2300	5200
2400	5500
2500	5100
2600	5000
2700	4700
2800	4200
2900	4000
3000	3700

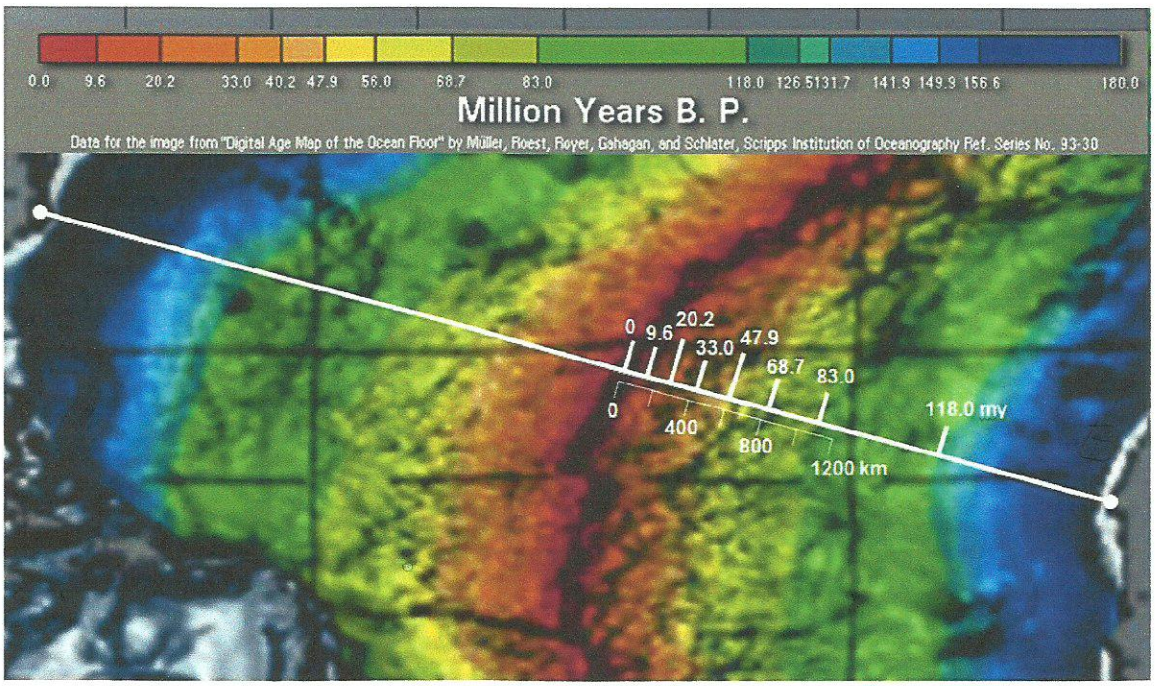
Dist. (km)	Depth (m)
3100	3100
3200	2500
3300	3100
3400	4000
3500	4400
3600	4900
3700	4900
3800	5400
3900	5800
4000	5500
4100	5900
4200	6100
4300	5900
4400	6000
4500	6200
4600	5900
4700	5800
4800	5800
4900	5700
5000	5400
5100	5300
5200	5100
5300	5000
5400	4900
5500	4800
5600	4200
5700	3200
5800	2000
5900	100
6000	0



Dots can be copied and pasted to plot points.

Part II – Analyzing the ocean depth and age adjacent to the Mid-ocean ridge.

In Part I of this exercise, we examined the depth of the Atlantic Ocean basin and observed the prominent mid-ocean ridge (MOR) near the center of the ocean basin. The MOR is also known to be an area of shallow earthquake and volcanic activity and is interpreted as a spreading center where new oceanic lithosphere is formed. The newly formed oceanic crust and uppermost mantle then moves away from the ridge as part of the plate tectonic processes. The uplift of the MOR is interpreted to be due to rising hot material that forms the new ocean lithosphere. As observed in the ocean profile, the ocean depth increases away from the MOR. This subsidence of the oceanic lithosphere could be cause by cooling of the lithosphere as it moves away from the ridge and area of rising hot material. We can examine this process using ocean crust age and depth data. In the figure below, the age of the oceanic crust for a part of the North Atlantic Ocean is shown by the colors. The bold line is the Atlantic Ocean profile used in Part I. The numbers above the profile to the east of the MOR are interpreted age boundaries in millions of years. The ocean age information is derived from radiometric dating of ocean crust samples from deep drilling, dating of index fossils in sediments overlying the newly-formed crust, and the paleomagnetic reversals time scale. A color version of this map is available at http://web.ics.purdue.edu/~braile/eas100/OceanAge2.pdf.



Ocean crust ages for a portion of the North Atlantic Ocean (from http://www.ngdc.noaa.gov/mgg/image/crustageposter.gif).

In the Table on the next page, the first two columns show distance from the ridge and ocean depth. The ocean depth data are the average of the depths on the two sides (west and east of the ridge) of the MOR. Using the distance scale on the OceanAge.pdf image (http://web.ics.purdue.edu/~braile/eas100/OceanAge2.pdf, zoom to 130% so that a metric ruler can be used with a scale of 1.0 cm = 200 km), estimate by interpolation the ocean crust age at 100 km increments out to 1200 km from the ridge and record the results in the Table. Then, take the square root of the age data and record the results in the last column. The first two age and square root of age data points, for 0 and 100 km distance, have already been entered in the Table. (If you wish to plot the graphs on pages 5 and 6 using your computer, you can obtain the data [see data Table on page 5] at: http://web.ics.purdue.edu/~braile/EAS100online/OceanFloorAgeData.xls. You can produce an

Excel plot, or use other software, to paste into your Hwk 4 submission. If you plot by computer, please be sure to make the graphs look similar to those shown on pages 5 and 6.)

Dist. from MOR (km)	Depth (m)	Age (my)	SQRT Age $(my)^{1/2}$
0	2500	0	0.00
100	3100	5	2.24
200	3850	11	3.32
300	4200	20.2	4.49
400	4550	30	5.48
500	4800	40	6.32
600	5200	46	6.78
700	5450	55	7.42
800	5500	65	8.06
900	5550	72	8.49
1000	6000	75	8.66
1100	5850	81	9
1200	5800	89	9.43

MOR = Mid-ocean ridge

m = meters, km = kilometers

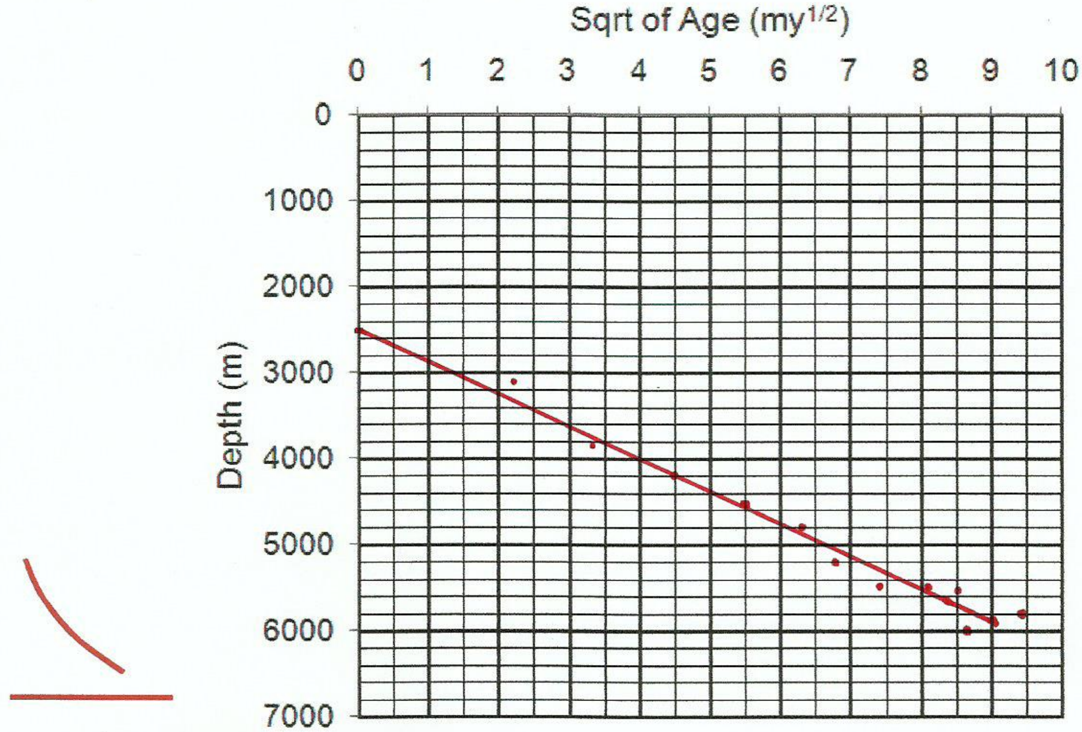
my = millions of years

Next, plot the ocean crust age and depth data on the graph below. Use a dot (•) for each age vs. depth data point. How does the depth change with increasing age?

Depth increases as the age increasing. Increase rate slows down as age increasing.

●●● ← Dots, straight and curved lines can be copied and pasted on graph. Lines can be stretched, etc.

On the graph below, plot the square root of age and depth data. Use a dot (•) for each SQRT (age) vs. depth data point. How does the depth change with increasing SQRT (age)? Depth increases in an approximately constant rate as SQRT(age) increasing.



●●● ← Dots, straight and curved lines can be copied and pasted on graph. Lines can be stretched, etc.

A theoretical cooling model of the oceanic lithosphere can be derived from the theory of the flow of heat through solids. The theory indicates that the ocean depth should increase away from the ridge approximately following the equation: **Depth = slope • SQRT (age) + y-intercept**. The theory is further explained by the following:

"Newly formed oceanic lithosphere moves away from the mid-ocean ridge and cools as it is removed from underlying sources of heat. Cooling has two effects: 1. lithosphere contracts and increases in density; 2. the depth of the lithosphere/asthenosphere boundary is controlled by temperature and cooling causes the lithosphere to increase in thickness away from the mid-ocean ridge. Cooling and contraction of the lithosphere cause a progressive increase in the depth to the top of the lithosphere away from the ridge. This is accompanied by a decrease in heat flow." (from: http://www.noc.soton.ac.uk/soes/teaching/courses/oa405/GY405/handouts/Bending.htm)

Draw a **"best fit"** straight line through the data points in the SQRT (age) vs. Depth graph (above). Calculate the slope and intercept coefficients of the line and record them here (the form of this equation is **y = bx + a**, where **y** is depth, **b** is the slope, **x** is SQRT(age), and **a** is the y-intercept). (**Information on calculating the slope of a line: http://web.ics.purdue.edu/~braile/eas100/Slope.pdf.**) $\frac{5900-2500}{9-0} = 377.78$

Depth = 377.78 **• SQRT (age)** + 2500 (**Depth** is in **m**, **age** is in **m.y.**; put **b** in the 1st space, **a** in the 2nd)

The **SQRT (age)** vs. **depth** data display a **straight line relationship** that is consistent (in shape and values of the coefficients) with the ocean lithosphere cooling model (and the physics of heat conduction), and thus provides strong evidence supporting the sea floor spreading process and plate tectonics theory. A classic research paper by Parsons and Sclater (1977) first described this relationship. You can view the paper at: http://www.earth.ox.ac.uk/~johne/teaching/pdfs/parsons-sclater77.pdf.