

Ocean Basin Profile

EAS 100 Homework Assignment #3 Ocean Basin Depth Profile (Trans-Atlantic Ocean Depth Profile – Cape Hatteras, North America to Cape Blanc, Africa) and Interpretation

Name: _____

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 transect 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. 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. For additional information, refer to p. 265-270 of Lutgens and Tarbuck (2011), p. 250-257 of L&T (2008) or p. 239-245 of L&T (2005).

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)?

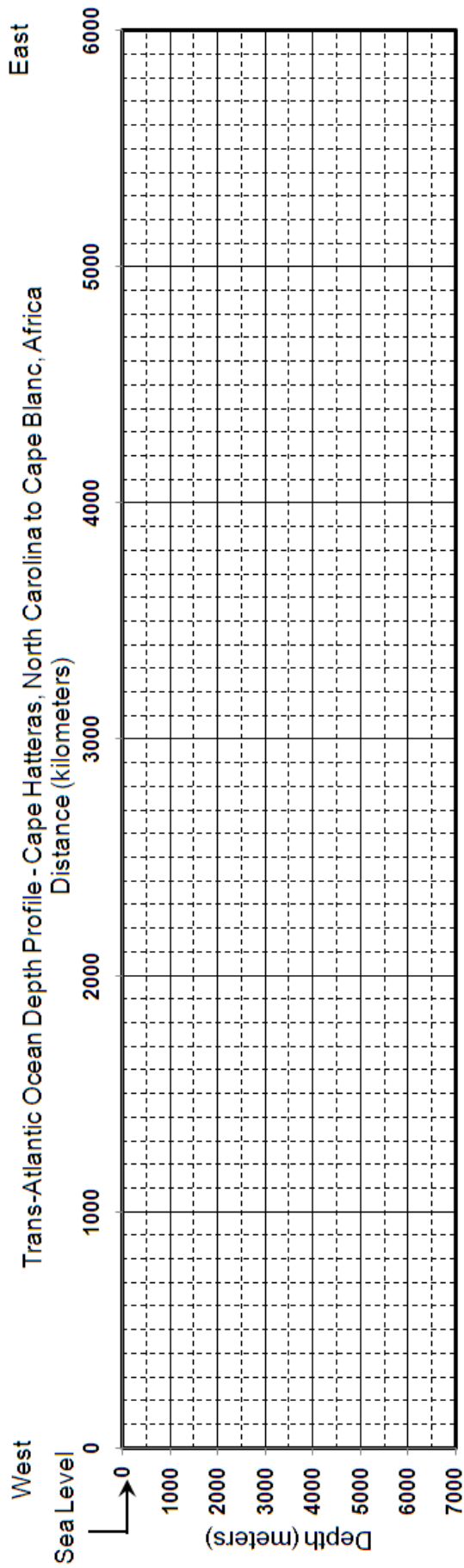
Ocean depth at mid-Atlantic ridge _____

Relief (difference in ocean depth between the ridge and the abyssal plain)
of the mid-Atlantic ridge _____

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.)

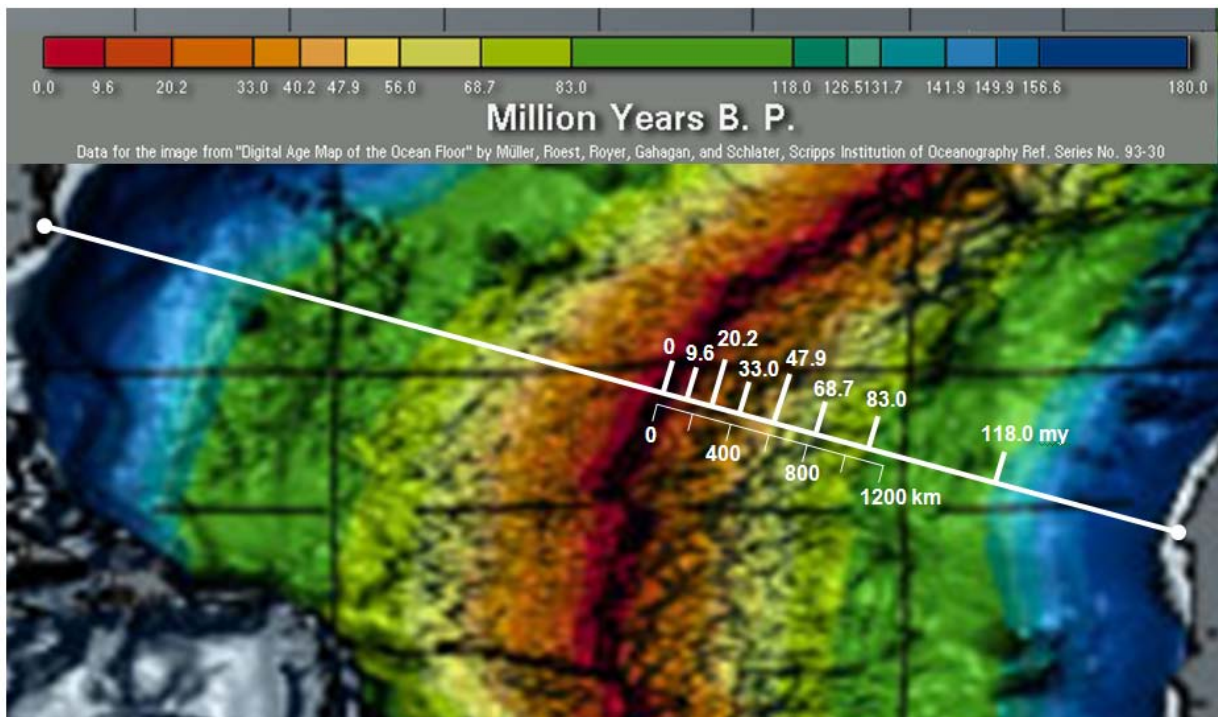
Approximate slope of the west side of the mid-Atlantic ridge _____.

Dist. (km)	Depth (m)		Dist. (km)	Depth (m)
0	0		3100	3100
100	100		3200	2500
200	3300		3300	3100
300	4000		3400	4000
400	4600		3500	4400
500	4900		3600	4900
600	5200		3700	4900
700	5200		3800	5400
800	5200		3900	5800
900	5200		4000	5500
1000	5000		4100	5900
1100	4900		4200	6100
1200	4700		4300	5900
1300	4900		4400	6000
1400	4500		4500	6200
1500	5000		4600	5900
1600	5200		4700	5800
1700	5600		4800	5800
1800	5500		4900	5700
1900	5500		5000	5400
2000	5600		5100	5300
2100	5800		5200	5100
2200	5900		5300	5000
2300	5200		5400	4900
2400	5500		5500	4800
2500	5100		5600	4200
2600	5000		5700	3200
2700	4700		5800	2000
2800	4200		5900	100
2900	4000		6000	0
3000	3700			



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 ocean 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 caused 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 as 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.

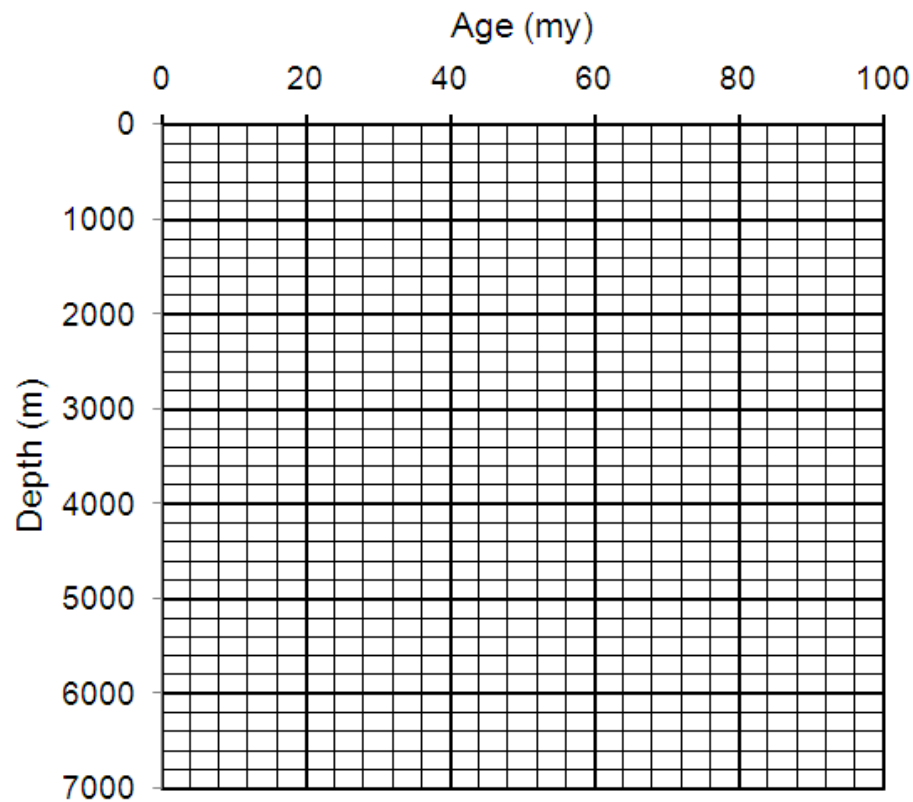
Dist. from MOR (km)	Depth (m)	Age (my)	SQRT Age (my) ^{1/2}
0	2500	0	0.00
100	3100	5	2.24
200	3850		
300	4200		
400	4550		
500	4800		
600	5200		
700	5450		
800	5500		
900	5550		
1000	6000		
1100	5850		
1200	5800		

MOR = Mid-ocean ridge

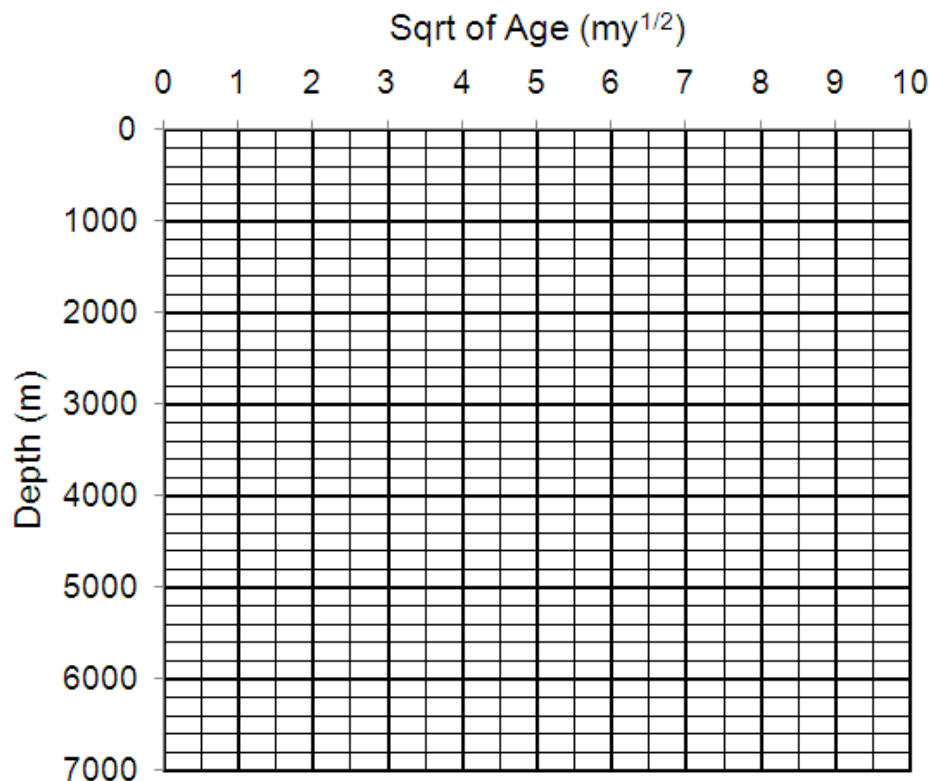
m = meters, km = kilometers

my = millions of years

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



On the graph below, plot the square root of age and depth data. Use a dot (•) for each SQRT (age) - depth data point. How does the depth change with increasing SQRT (age)? _____



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):

Depth = _____ • SQRT (age) + _____ (Depth is in m, age is in m.y.)

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 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>.