ES 106 Laboratory # 4
THE DYNAMIC OCEAN FLOOR
Sea Floor Topography and Paleomagnetism

Introduction

One of the most significant scientific revelations of the 20th Century is the fact that the ocean basins are geologically young, ephemeral features. Based upon this discovery, a revolutionary theory called plate tectonics has been developed that helps to explain and interrelate earthquakes, mountain building, and other geologic events and processes.

The theory of plate tectonics is the foundation used by Earth scientists to help explain the origin of mountains and continents, the occurrence of earthquakes, the evolution and distribution of plants and animals, as well as many other geologic processes. Using information from the ocean basins, including topography, age, and mechanisms of their evolution, Earth scientists have developed the exciting theory called plate tectonics. Plate tectonics states that Earth's surface is broken in to rigid slabs of lithosphere called plates. The plates are separating at mid-ocean ridges, where new ocean crust is forming. Along the plate margins, earthquakes are generated as plates slide past each other, collide to form mountains, or override each other causing deep-ocean trenches. This laboratory examines some of the lines of evidence that have been used to verify this comprehensive model of the way Earth scientists view our dynamic Earth.

Goals and Objectives

- Locate and describe the general features of the ocean basins with an emphasis on locating and describing the mid-ocean ridge system and deep-ocean trenches
- Determine the rate of sea-floor spreading that occurs along a mid-ocean ridge by using paleomagnetic evidence and determine age of ocean basin

Useful Websites

- http://www.pmel.noaa.gov/vents/nemo/explorer/concepts/pillows.html
- http://earthsci.org/education/teacher/basicgeol/platec/platec.html
- http://www.platetectonics.com/oceanfloors/index.asp
- http://visibleearth.nasa.gov/view_set.php?categoryID=871
- http://www.intute.ac.uk/sciences/worldguide/worldmapbig/385.html
- http://www.metric-conversions.org/

Use favoirty internet search tools (e.g. Google, Wikipedia) answer questions below.

Name_____
Lab Day/Time_____

Pre-lab Questions – Complete these questions before coming to lab.

1. Describe each of the following ocean floor features:
   A. Mid-ocean ridge

   B. Deep-ocean trench

   C. Continental shelf

   D. Continental slope

   E. Abyssal plain

   F. Seamount

2. Suppose that the ratio scale on a map is 1:50,000. This means that 1" on the map represents 50,000" on Earth's surface. If you measure the following distances on the map using a ruler, you can convert the map distances to the real world distances with the ratio scale, and change units with conversion factors. Do this for the distances indicated below. Remember to show the formulas with units that you used to convert these values. Conversion factors can be found in the appendix of your textbook. Hint: use a scale of 1:50,000 where 1 in on map = 50,000 in on ground

   A. 3 inches = _____ miles

   B. 2 cm = _____ km

   C. 10 cm = _____ miles

Refer to map scale explanation and unit conversions on on the following pages

Earth Science Laboratory

MAP SCALES & UNITS

This handout was designed to help you understand the relationships between different map scales, map units, distance, and area. You should understand the logic behind how these are used and how they should appear on real topographic maps. On your upcoming lab exam, you should also be able to convert one type of map scale into another, and calculate size differences (scale factor, area factor) between different maps.

A. Review of Common Types of Map Scales

All map scales are an expression of the numerical relationship between the MAP and the LAND that is represented. The MAP unit is always mentioned first.

1. **Verbal Scale:** The verbal scale is just a sentence stating that **"1 Map Unit = X Land Units".** For reasons of convenience, a mixture of units is commonly used, such as

1 inch = 1 mile

However, there are NO requirements that the units must be different! The expression **"1 inch = 63,360 inches"** is still a verbal scale. A mixture of map and land units makes the verbal scale difficult to compare between different maps - it must be converted first to a Representative Fraction (see below).

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2. **Representative Fraction (R.F.):** An R.F. scale is a ratio, or fraction, that expresses the mathematical relationship between MAP and LAND, such as

1 : 24,000

which means *"1 map unit is equivalent to 24,000 land units."* Because an R.F. carries no units (inches, centimeters, etc.), it means that the R.F. scales can be compared between different maps. Converting an R.F. scale to a verbal scale is very easy; simply select ONE unit and apply it to BOTH map and land numbers. The above example can be written as a verbal scale as **"1 inch = 24,000 inches"** or **"1 meter = 24,000 meters,"** etc. *(Note: YOU CANNOT MIX UNITS in an R.F.! Doing so will change the numerical relationship of the R.F.)*

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3. **Graphic Scale:** The graphic scale is a bar chart or "ruler" that is drawn at the bottom of a topographic map. This is the scale that you should use when asked to measure distances on the map. *Be Careful: Note that the zero mark is not located at the left end of the graphic scale. For your convenience, the graphic scale extends to the left of the zero mark to indicate fractions of units, such as 1/10 of a mile. You may measure distances by marking off the 2 end points on the edge of a sheet of paper and aligning the edge of the paper against the graphic scale (make sure one of your marks is on the zero).*

B. CONVERTING A VERBAL SCALE TO AN R.F.

When converting a verbal scale to an R.F., the strategy is to convert from *mixed units (verbal scale) to one unit (R.F.).* That is the basic difference between these two types of map scales.

Example:

If your verbal scale is **"1 inch = 1 mile"** how is this expressed as an R.F.?

Solution:

1. ***Decide which ONE unit to convert to:*** To become an R.F., both the map and land units (now 2 different types) must be the same. You have 2 choices to choose from: you can either *convert miles to inches* or *inches to miles. It is usually easier to convert from a larger to a smaller unit* ("how many inches are in a mile?" is easier to handle than "how many miles are in an inch?"). So, we will then convert the "1 mile of land" to "X number of inches".

2. ***Eliminate the unwanted unit by multiplication:*** One of the basic rules of algebra is that any number or unit divided by itself equals 1. If you started with miles and wanted to get rid of miles and end up with inches, how do you do this?

First, get rid of "miles" by *multiplying it by a fraction that contains "miles" in the denominator*, and an equivalent number of smaller units in the numerator. You may not know how many inches there are in a mile, but you should know that there are 5,280 feet in a mile. This will get rid of miles, but will leave you with "feet" which is still not the same unit as the Map Unit (inches). To get to inches, get rid of "feet" by multiplying by a fraction that contains "feet" in the denominator and the equivalent number of inches in the numerator:

$$\text{1 mile} \times \frac{\text{(5,280 feet)}}{\text{(1 mile)}} \times \frac{\text{(12 inches)}}{\text{(1 foot)}} = \text{63,360 inches}$$

Now that the original land unit "1 mile" has been converted to 63,630 inches, both the map and land units are now the same type, and the R.F. is written simply by deleting the units and substituting a colon for the equal sign:

1 inch = 63,360 inches

1 : 63,360

There is no "right" way or "wrong" way to multiply - you must decide how to set up the fractions so that the units you don't want get canceled, and the unit you do want ends up as your answer.

C. CONVERTING AN R.F. TO A VERBAL SCALE

Converting an R.F. to a verbal scale is usually much easier than the reverse. ***By definition, an R.F. means that both the map and land units are the same,*** so you can choose any ONE unit: **1 : 24,000** can be **"1 cm = 24,000 cm"** or **"1 inch = 24,000,"** *so long as you do not use two different units.* ***Remember, there is NO REQUIREMENT that a verbal scale must use different units!***

D. COMPARING SCALES AND AREAS BETWEEN DIFFERENT MAPS

One of the major advantages of using the R.F. (Representative Fraction) scale is that it allows you to directly compare the sizes of objects between different maps. Because the R.F. eliminates the use of specific units (such as inches, feet, miles, etc.), there are no complicated conversions needed.

Comparing R.F. Scales Between Different Maps

Simply divide the larger map scale by the smaller one to get the SCALE FACTOR:

$$\textbf{SCALE FACTOR} = \frac{\textbf{R.F. of Map A}}{\textbf{R.F. of Map B}} = \frac{\textbf{1:50,000}}{\textbf{1:10,000}} = \textbf{5}$$

Relationship Between Scale & Area

A map *scale* measures *distance*, which is a one-dimensional unit. *Area* is a 2-dimensional quantity, calculated by measuring "Length X Width." Note that *when a map scale is changed by a certain number factor, the area changes by the square of that number.* In other words, *if the scale is 2 times larger, the area becomes 4 times larger; if the scale is 5 times larger, the area becomes 25 times larger:*

Map A

Area = (500 feet horizontal) X (500 feet vertical)

100 ft.	100 ft.	100 ft.	100 ft.	100 ft.
100 ft.				
100 ft.				
100 ft.				
100 ft.				

Map A has an R.F. of **1:50,000.**
The above map shows a land area of
500 feet X 500 feet = 250,000 square feet.

Map B

Area = (100 feet horizontal) X (100 feet vertical)

Map B has an RF of **1:10,000**
This square parcel of land has a land area of
100 feet x 100 feet = 10,000 square feet.

Note that the entire area of this large square fits into just one of the 25 smaller squares in Map A, and that Map A displays **25** times the area of Map B (the **square of the scale factor**)

Note that although both maps are the same size, Map A covers 500 units of distance versus only 100 units for Map B. *But, Map A (500x500 = 250,000 sq. ft.) covers **25 TIMES** the AREA of Map B (100x100 = 10,000 sq. ft/).*

So, the relationship between the SCALE FACTOR and AREA FACTOR is:

$$\textbf{AREA FACTOR} = (\textbf{SCALE FACTOR})^2$$

APPENDIX –Unit Conversions

Multiply units in left column by number in table to obtain units at top of table column

Table 1: Length conversion to metric units

Unit	mm	cm	m	km
1 millimeter	1	0.1	0.001	10^{-6}
1 centimeter	10	1	0.01	0.0001
1 meter	1000	100	1	0.001
1 kilometer	10^{6}	10^{5}	1000	1
1 inch	25.4	2.54	0.0254	2.54×10^{-5}
1 foot	304.8	30.48	0.3048	3.05×10^{-4}
1 yard	914.4	91.44	0.9144	9.14×10^{-4}
1 mile	1.61×10^{6}	1.61×10^{5}	1.61×10^{3}	1.6093

Table 2: Length conversion to English units

Unit	in	ft	yd	mi
1 millimeter	0.0397	0.00328	0.00109	6.21×10^{-7}
1 centimeter	0.3937	0.0328	0.0109	6.21×10^{-6}
1 meter	39.37	3.281	1.094	6.21×10^{-4}
1 kilometer	39,370	3281	1093.6	0.621
1 inch	1	0.0833	0.0278	1.58×10^{-5}
1 foot	12	1	0.333	1.89×10^{-4}
1 yard	36	3	1	5.68×10^{-4}
1 mile	63,360	5280	1760	1

Table 3: Area conversion to metric area units

Unit	cm^2	m^2	km^2	ha
1 sq. centimeter	1	0.0001	10^{-10}	10^{-8}
1 sq. meter	10^{4}	1	10^{-6}	10^{-4}
1 sq. kilometer	10^{10}	10^{6}	1	100
1 hectare	10^{8}	10^{4}	0.01	1
1 sq. inch	6.452	6.45×10^{-4}	6.45×10^{-10}	6.45×10^{-8}
1 sq. foot	929	0.0929	9.29×10^{-8}	9.29×10^{-6}
1 sq. yard	8361	0.8361	8.36×10^{-7}	8.36×10^{-5}
1 sq. mile	1.59×10^{10}	2.59×10^{6}	2.59	259
1 acre	4.04×10^{7}	4047	4.047×10^{-3}	0.4047

Temperature Conversions : $F^0 = \left(\frac{9}{5}\times C^0\right)+32$ $C^0 = \frac{5}{9}\left(F^0 - 32\right)$

Table 4: Area conversion to English area units

Unit	in^2	ft^2	yd^2	mi^2	ac
1 sq. cm	0.155	1.08×10^{-3}	1.2×10^{-4}	3.86×10^{-11}	2.47×10^{-8}
1 sq. meter	1550	10.76	1.196	3.861×10^{-7}	2.47×10^{-4}
1 sq. km	1.55×10^{9}	1.076×10^{7}	1.196×10^{6}	0.3861	247.1
1 hectare	1.55×10^{7}	1.076×10^{5}	1.196×10^{4}	3.861×10^{-3}	2.471
1 sq. inch	1	6.94×10^{-3}	7.7×10^{-4}	2.49×10^{-10}	1.574×10^{-7}
1 sq. foot	144	1	0.111	3.587×10^{-8}	2.3×10^{-5}
1 sq. yard	1296	9	1	3.23×10^{-7}	2.07×10^{-4}
1 sq. mile	4.01×10^{9}	2.79×10^{7}	3.098×10^{6}	1	640
1 acre	6.27×10^{6}	43560	4840	1.562×10^{-3}	1

Table 5: Volume conversion to metric volume units

Unit	mL	liters	m^3
1 milliliter	1	0.001	10^{-6}
1 liter	10^{3}	1	0.001
1 cu. meter	10^{6}	1000	1
1 cu. inch	16.39	1.64×10^{-2}	1.64×10^{-5}
1 cu. foot	28,317	28.317	0.02832
1 U.S. gallon	3785.4	3.785	3.78×10^{-3}
1 acre-foot	1.233×10^{9}	1.233×10^{6}	1233.5
1 million gallons	3.785×10^{9}	3.785×10^{6}	3785

Table 6: Volume conversion to English volume units

Unit	in^3	ft^3	gal	ac-ft	million gal
1 milliliter	0.06102	3.53×10^{-5}	$2.64.10^{4}$	8.1×10^{-10}	2.64×10^{-10}
1 liter	61.02	0.0353	0.264	8.1×10^{-7}	2.64×10^{-7}
1 cu. meter	61,023	35.31	264.17	8.1×10^{-4}	2.64×10^{-4}
1 cu. inch	1	5.79×10^{-4}	4.33×10^{-3}	1.218×10^{-8}	4.329×10^{-9}
1 cu. foot	1728	1	7.48	2.296×10^{-5}	7.48×10^{6}
1 U.S. gallon	231	0.134	1	3.069×10^{-6}	10^{6}
1 acre-foot	75.27×10^{6}	43,560	3.26×10^{5}	1	0.3260
1 million gal.	$2.31 \times 10_{8}$	1.338×10^{5}	10^{6}	3.0684	1

Table 7: Time conversion

Unit	sec	min	hours	days	years
1 second	1	1.67×10^{-2}	2.77×10^{-4}	1.57×10^{-5}	3.17×10^{-8}
1 minute	60	1	1.67×10^{-2}	6.94×10^{-4}	1.90×10^{-6}
1 hour	3600	60	1	4.17×10^{-2}	1.14×10^{-4}
1 day	8.64×10^{4}	1440	24	1	2.74×10^{-3}
1 year	3.15×10^{7}	5.256×10^{5}	8760	365	1