EOSC105

NATURAL DISASTERS LAB
UNIVERSITY OF SAN DIEGO
LABORATORY READER
FALL 2019

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GEOLOGIC TIME SCALE: THE HISTORY OF THE EARTH

- **OBJECTIVES:**
  - To create a timeline of Earth's history
  - To gain familiarity with the metric system
  - To get a sense of the scale of human events compared to geologic events

- **INTRODUCTION:**

  The Earth has changed dramatically and repeatedly over a history that spans nearly 5 billion years. Such immense spans of time are difficult for most of us to comprehend. They fall outside our range of human experience. We normally deal with much shorter time intervals, like the time of our next class or the number of days until the next exam, or even the number of years until graduation!

  It is important for students of the Earth Sciences to expand their sense of time. Extremely slow geologic processes, considered only in terms of human experience, have little meaning. To appreciate the magnitude of geologic time and the history of our incredible planet, you will be creating a timeline of important geologic events scaled to a size more tangible and familiar.

- **INSTRUCTIONS:**

1. Construct a timeline of Earth's history on a long strip of adding machine tape. The timeline should be **done to scale**.
   - 1 meter (100 cm) = 1 billion years (1000 million years)
   - 10 cm = 100 million years
   - 1 cm = 10 million years
   - 1mm = 1 million years
   - There are <u>ten</u> 100 million years in one billion years, or 100 cm in 1 meter.
   - There are <u>ten</u> 10 million years in 100 million years.

   a) **Measure out a strip of adding machine tape 5 meters long**. A meter stick will be provided in lab.

   b) Select one end of the tape to represent today. Beginning at that end, **mark off and write each billion years** (1 billion, 2 billion, etc.) at <u>1 meter increments</u>.

   c) Draw a bold line and label (in color) to **show the <u>beginning</u> of the three eras (Paleozoic, Mesozoic, Cenozoic**) and the **<u>two Cenozoic periods,</u> Tertiary and Quaternary**.
   To help you get started: 542 Million yrs ago from today would be (50 cm+ 4cm + 2mm) from the "today" end of the paper roll, or (40cm + 5cm + 8mm) from the 5 billion mark.

   d) Refer to the **Geologic time scale** in this reader and **p. 14 in the lab manual**. Dates might vary slightly.

   e) **Mark off and write numbers** at <u>10 cm increments</u> **ONLY WHEN NECCESARY** (plotting boundaries or events)

   f) **Starting with the oldest event** (Event #1), mark off all of the important events in Earth's history shown in the list on the next page. In each case you should **<u>write the date and event</u> directly on the timeline.**

   g) Come up with your own Earth shattering event (do some research), plot the event on your time scale, and present to the class.

2. **Write a brief paragraph** on your perspective of the history of the Earth, or geologic time, that you did not realize before doing this timescale exercise.

Some Important Events in Earth's History		
Event #	**Date in years before present**	Event
1	4.56 billion	Earth forms
2	4.3 billion	Oldest rock
3	3.8 billion	First evidence of life
4	460 million	First fish
5	410 million	First land animals
6	250 million	Largest mass extinction occurs
7	247 million	First dinosaurs
8	240 million	First mammals
9	220 million	Breakup of super-continent Pangaea begins
10	65 million	Dinosaurs and other animals go extinct
11	1.8 million	First primate in genus Homo
12	40,000	First Homo *sapiens*
13	10,000	End of last Ice Age
14	?	Your birthday

(Please note that some of these ages may differ slightly from those given in your text or that you found in another source. These dates change, but the general order stays constant.)

Work Space:

R. Steinberg
DMC 1-12

0.012 Ma = 12,000 yr.

Geologic Time Scale

	Eon	Era	Period		Epoch	Boundary Dates (Ma)
	Phanerozoic	Cenozoic	Quaternary		Holocene	0.012
					Pleistocene	2.6
			Neogene	Tertiary	Pliocene	5.3
					Miocene	23.0
			Paleogene		Oligocene	33.9
					Eocene	55.8
					Paleocene	66
		Mesozoic	Cretaceous			146
			Jurassic			200
			Triassic			251
		Paleozoic	Permian			299
			Carboniferous	Pennsylvanian		318
				Mississippian		359
			Devonian			416
			Silurian			444
			Ordovician			488
			Cambrian			542
PRECAMBRIAN	Proterozoic	Neo-	Ediacaran			~635
		Meso-				
		Paleo-				2500
	Archean					4000
	Hadean		No Rock Record on Earth			
			ORIGIN OF EARTH			~4600

Note #1: Vertical timeline of boundary dates *is not* drawn with a uniform scale.
Note #2: Boundary dates from the International Commission on Stratigraphy 2010 Geologic Time Scale
Note #3: Carboniferous, Paleogene, and Neogene are more commonly used outside of the U.S.
Note #4: Epochs for the Mesozoic and Paleozoic are too numerous to be shown.
Note #5: The Hadean Eon is not formally recognized.

MINERALS

LAB OBJECTIVES:
1) Identify common minerals based on their physical properties.
2) Explain the significance of the silicate minerals.

1) PLEASE READ CAREFULLY AND FOLLOW INSTRUCTIONS:

- **Review** mineral properties on **p. 16-26** in GEOS lab manual. Pay close attention to **fig. 20 on p. 26 and figure 25 on p.33** *Striations on plagioclase feldspar verses exsolution lamellae (thicker lines of alternating color) on K-feldspar.*
- **Use** the **mineral identification keys** on **p. 30-32** in lab manual to correctly identify the minerals listed below. Make sure you have the correct sample number next to each mineral below and next to your description on the worksheets.
- **Use worksheets** on **p. 28-29 of the lab manual** to write **mineral ID** number and **properties of each mineral.**

Minerals highlighted in **bold** are part of the Mohs hardness scale. See p. 74 in lab manual

SILICATE MINERALS (Igneous rock forming minerals)

ID number FILL OUT P. 28 IN LAB MANUAL

- ______ **Quartz**
- ________ ______ **K-feldspar** [Orthoclase (white) and Microcline (pink)]
- ________ ________ Pagioclase Feldspar (2 samples)
- ______ Muscovite mica
- ______ Biotite mica
- ______ Hornblende (amphibole mineral group)
- ______ Augite (pyroxene mineral group)
- ______ Olivine

NONSILICATE MINERALS

- ______ **Calcite**
- ______ **Gypsum**

Please **make sure you have the correct mineral identification for each** sample **before you leave.** There are **samples (**same numbers) **in the library** available to check out for review.

Fill out mineral chart on **p. 28**

ROCKS

LAB OBJECTIVES:
1. Classify common igneous rocks based on their mineral composition, texture, and color index.
2. Classify common sedimentary rocks and develop a general understanding of sediment grain size and permeability.
3. Classify common metamorphic rocks. Be able to distinguish between foliated and nonfoliated metamorphic rocks.

IGNEOUS ROCKS

PLEASE READ CAREFULLY AND FOLLOW INSTRUCTIONS:
- **Review p. 42-46** in lab manual. Pay attention to igneous textures (see **p. 43-44).**
- **Use** the igneous rock identification key on. **p. 46** in lab manual to correctly identify and describe the rocks listed below. Make sure you have the correct sample number next to each rock name below and next to your rock description on the worksheet.
- **Use worksheet chart** on **p. 48** **in the lab manual** to write **rock ID** number and **description** for each rock sample.

HELPFUL STEPS IN IGNEOUS ROCK IDENTIFICATION:

Determine the color: indicates mineral composition (see p. 45 in lab manual**)**
- a) Felsic (light) → Granite and Rhyolite
- b) Intermediate → Diorite and Andesite
- c) Mafic (dark) → Gabbro and Basalt
- d) Ultramafic (dark w/ green) → Peridotite

Determine the texture: indicates cooling history = Intrusive or Extrusive (see p. 43-44 in lab manual**)**
- a) Phaneritic (coarse-grain) = large minerals → Intrusive
- b) Aphanitic (fine-grain) = small minerals, too small to identify with the naked eye→ Extrusive (volcanic)
- c) Porphyritic = matrix of small minerals with larger minerals (called phenocrysts)→ Extrusive (Most of the samples in lab are porphyritic)
- d) Vesicular = holes from trapped gas → Extrusive (volcanic)
- e) Glassy = obsidian (look for concoidal fracture)→ Extrusive (volcanic)

INTRUSIVE IGNEOUS ROCKS
ID number

- _______ _______ **Granite** (2 samples: different #s)
- _______ **Diorite**
- _______ **Gabbro**

EXTRUSIVE IGNEOUS ROCKS
ID number

- _______ **Rhyolite** (2 samples: same #)
- _______ **Andesite** (2 samples: same #)
- _______ **Basalt**
- _______ **Obsidian**
- _______ **Pumice**

Fill out igneous rock chart on **p. 48**

INTRODUCTION TO SEDIMENT:

Detrital sedimentary rocks are the most abundant rock type in the San Diego area. **Detrital Rocks are classified based on the grain size**. The following brief exercise will help with differentiating between sand, silt, and clay.

Identify the trays of sediment on the table **before proceeding with sedimentary rock identification**.

Match sediment classification (a-e) to sediment sample tray number:

Tray 1: ____________________________

Tray 2: ____________________________

Tray 3: ____________________________

Tray 4: ____________________________

Tray 5: ____________________________

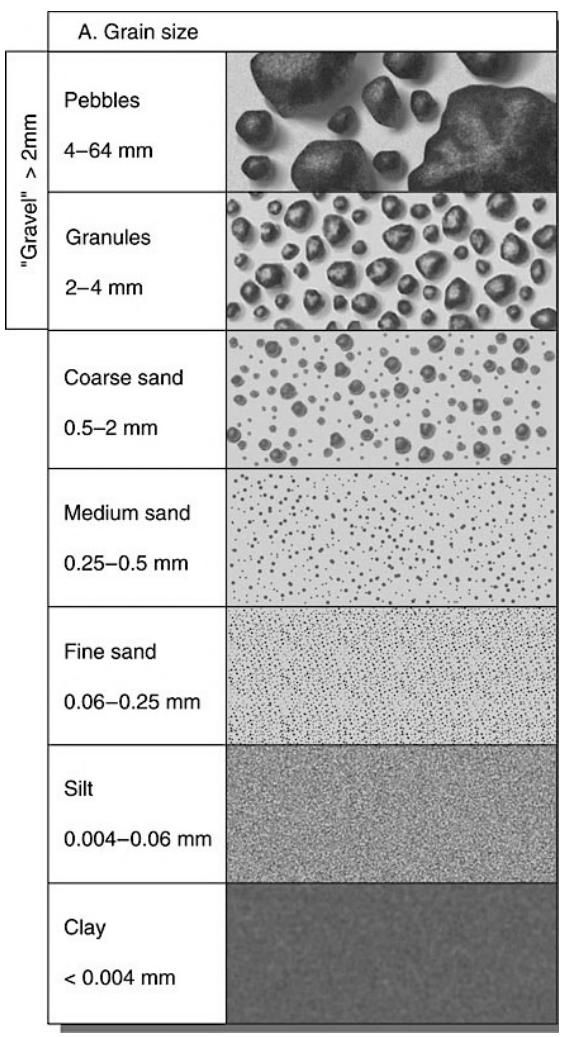
a) Coarse sand

b) Medium sand

c) Fine sand

d) Silt

e) Clay



SEDIMENTARY ROCKS

PLEASE READ CAREFULLY AND FOLLOW INSTRUCTIONS:

- **Use** classification table and identification key on. **p. 51 (fig. 14) and 50 (fig. 13)** in lab manual to correctly identify and describe the rocks listed below. Make sure you have the correct sample number next to each rock below and next to your rock description on the worksheet.
- **Use worksheet (rock chart)** on **p. 52** to write **rock ID** number and **description** for each rock (use 2 rows for each sample). Place your comments in column below Texture on the worksheet. **Also, think about** "strength" of rock during an earthquake event compared to the igneous rocks.

DETRITAL SEDIMENTARY ROCKS

- ________ **Conglomerate**
- ________ **Quartz Sandstone** (2 samples: same #)

Mudstones (silt and/or clay)

- ________ **Siltstone**
- ________ ________ **Shale** (2 samples: different #s)

CHEMICAL/BIOCHEMICAL SEDIMENTARY ROCKS

- ______ **Fossil Limestone**

METAMORPHIC ROCKS

PLEASE READ CAREFULLY AND FOLLOW INSTRUCTIONS:

- **Use** classification table and identification key on. **p. 57 (fig. 21)** in lab manual to correctly identify and describe the rocks listed below. Make sure you have the correct sample number next to each rock below and on the **worksheet (Rock Chart), p. 58**.

Foliated

- ________ **Gneiss** (possibly 2 sample #s)
- ________ **Schist** *(may not be in your box)*
- ________ **Slate**

Nonfoliated

- ________ **Marble**
- ________ **Quartzite**

Please **make sure you have the correct rock identification for each** sample **before you leave.** There are **samples** (same numbers) **in the library** available to check out for review.

Fill out charts on **pages 52 and 58**

TAKE HOME CONVERSION EXERCISE

NAME: ____________________________

Directions: Do the following calculations. To receive credit, please show your work.
See p. 1 to 4 in lab manual and **http://serc.carleton.edu/mathyouneed/units/index.html** for help.
Conversion chart is on the next page. **Points deducted if no work.**

Unit Conversion Problem	**Unit Conversion Calculation: SHOW ALL WORK HERE**
Example: 2.5 miles = 4.0 kilometers	2.5 mi x 1.6 km/mi = 4.0 km (miles cancel)

a. 10.0 miles = _______ kilometers

b. 1.0 foot = ______ meters

c. 16 kilometers = ______ meters

d. 25 meters = ______ centimeters (cm)

e. 1.3 liters (L) = ______ milliliters (ml) or cubic centimeters (cm^3)

f. 25.4 mL = ______ cm^3

g. 120 pounds = ______ kilograms (kg)

h. 2 ounces = ______ grams

i. **Velocity = distance/time**. An object travels 280 miles in 4 hours, the velocity of the object: _______ **km/hr**
show work:

Scientific Notation

We convert very large or small numbers to scientific notation in order to shorten them and to make them easier to manipulate in expressions. For example:

- 19,000,000 = 1.9×10^7
- 0.0000000756 = 7.56×10^{-8}

1) Write one billion (1,000,000,000) in scientific notation. ____________________________________

2) Write 276,000,000 in scientific notation. ______________________________________

3) Write 0.00000000602 in scientific notation. ____________________________________

4) Convert 100,000,000 cm to km, give answer in scientific notation ________________ **km**
(100cm = 1m; 1000m = 1km) **show work:**

Mathematical Conversions

To convert:	To:	Multiply by:	
kilometers (km)	meters (m)	1000 m/km	**LENGTHS AND DISTANCES**
	centimeters (cm)	100,000 cm/km	
	miles (mi)	0.6214 mi/km	
	feet (ft)	3280.83 ft/km	
meters (m)	centimeters (cm)	100 cm/m	
	millimeters (mm)	1000 mm/m	
	feet (ft)	3.2808 ft/m	
	yards (yd)	1.0936 yd/m	
	inches (in.)	39.37 in./m	
	kilometers (km)	0.001 km/m	
	miles (mi)	0.0006214 mi/m	
centimeters (cm)	meters (m)	0.01 m/cm	
	millimeters (mm)	10 mm/cm	
	feet (ft)	0.0328 ft/cm	
	inches (in.)	0.3937 in./cm	
	micrometers (μm)*	10,000 μm/cm	
millimeters (mm)	meters (m)	0.001 m/mm	
	centimeters (cm)	0.1 cm/mm	
	inches (in.)	0.03937 in./mm	
	micrometers (μm)*	1000 μm/mm	
	nanometers (nm)	1,000,000 nm/mm	
micrometers (μm)*	millimeters (mm)	0.001 mm/μm	
nanometers (nm)	millimeters (mm)	0.000001 mm/nm	
miles (mi)	kilometers (km)	1.609 km/mi	
	feet (ft)	5280 ft/mi	
	meters (m)	1609.34 m/mi	
feet (ft)	centimeters (cm)	30.48 cm/ft	
	meters (m)	0.3048 m/ft	
	inches (in.)	12 in./ft	
	miles (mi)	0.000189 mi/ft	
inches (in.)	centimeters (cm)	2.54 cm/in.	
	millimeters (mm)	25.4 mm/in.	
	micrometers (μm)*	25,400 μm/in.	
square miles (mi2)	acres (a)	640 acres/mi^2	**AREAS**
	square km (km^2)	2.589988 km^2/m	
square km (km2)	square miles (mi^2)	0.3861 mi^2/km^2	
acres	square miles (mi^2)	0.001563 mi^2/acr	
	square km (km^2)	0.00405 km^2/acr	
gallons (gal)	liters (L)	3.78 L/gal	**VOLUMES**
fluid ounces (oz)	milliliters (mL)	30 mL/fluid oz	
milliliters (mL)	liters (L)	0.001 L/mL	
	cubic centimeters (cm^3)	1.000 cm^3/mL	
liters (L)	milliliters (mL)	1000 mL/L	
	cubic centimeters (cm^3)	1000 cm^3/mL	
	gallons (gal)	0.2646 gal/L	
	quarts (qt)	1.0582 qt/L	
	pints (pt)	2.1164 pt/L	
grams (g)	kilograms (kg)	0.001 kg/g	**WEIGHTS AND MASSES**
	pounds avdp. (lb)	0.002205 lb/g	
ounces avdp (oz)	grams (g)	28.35 g/oz	
ounces troy (ozt)	grams (g)	31.10 g/ozt	
pounds avdp. (lb)	kilograms (kg)	0.4536 kg/lb	
kilograms (kg)	pounds avdp. (lb)	2.2046 lb/kg	

To convert from degrees Fahrenheit (°F) to degrees Celsius (°C), subtract 32 degrees and then divide by 1.8 To convert from degrees Celsius (°C) to degrees Fahrenheit (°F), multiply by 1.8 and then add 32 degrees.
*Formerly called microns (μ)

From Pearson: AGI & NAGT Lab Manual in Physical Geology 10th ed.

PLATE TECTONICS

NAME ______________________________

Student names in group:

____

SECTION 1: LAB MANUAL EXERCISES:

1) **Please Read through carefully and complete activities listed below. Write in manual.** *This looks like a lot, it's not once you get started!*

- Activity 1 #1 and 2, **p. 62-63**
- Activity 2 #1 through 3, **p. 64**
- Activity 6 #1 through 6, **p. 69**
- Activity 7A #1 through 4, **p. 70**
- Activity 7B #1 and 2, **p. 71**
- Activity 7C #1 through 4, **p. 71-72**
- Activity 8 #1 through 3, **p. 72-73**

SHOW ALL WORK IN THE LAB MANUAL.

TEAR OUT PAGES AND STAPLE TO THE REST OF THIS LAB EXERCISE.

Helpful Conversions
100 cm = 1 meter
1×10^5 cm = 1 km
1000 meter = 1 kilometer
1 million yr = 1×10^6 yr

POINTS DEDUCTED IF ALL WORK IS NOT SHOWN INCLUDING UNITS

2) **LAVA LAMP EXERCISE:** ***please be careful, tops are unstable***

Describe the important heat transport mechanism you are observing. Apply to solid Earth and plate tectonics:

Helpful website for velocity calculation: http://serc.carleton.edu/mathyouneed/rates/index.html

EARTHQUAKES **Name: ___________________________________**

STUDENT NAMES IN GROUP:

____

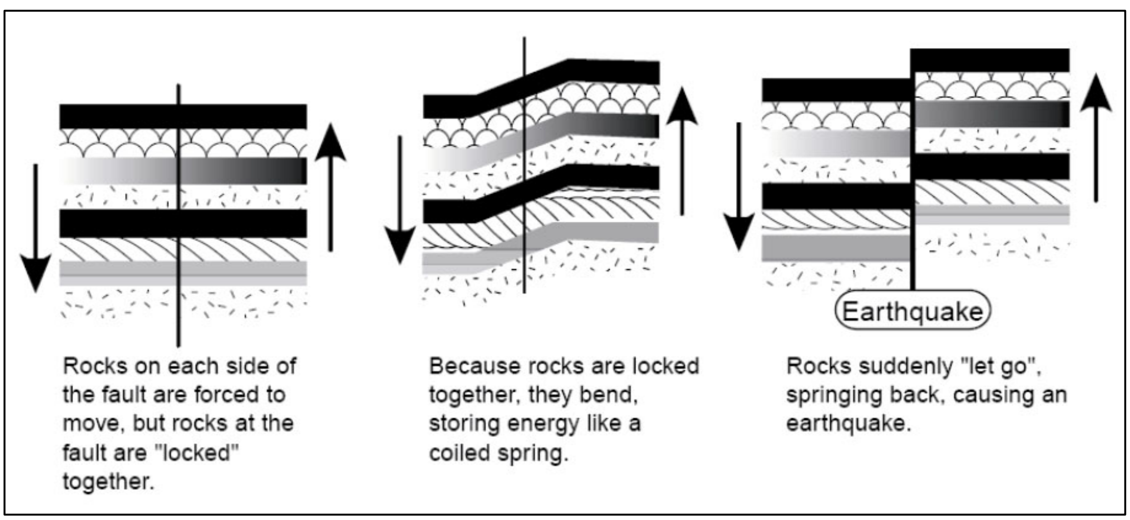
The main goal of this exercise is to model the generation of earthquakes on faults in Earth's crust. Although we know regions of Earth that are earthquake prone and where earthquakes have occurred in the past, future earthquakes cannot be predicted with any accuracy. Earthquakes follow some general patterns – but from one episode to another there may be great variations in magnitude, changes to the landscape, or damages caused.

OBJECTIVES: When you have completed this lab you should be able to:

1. Describe the role of faults and plate tectonics in generating earthquakes.
2. Plan an experiment that uses a physical model to investigate alternative hypotheses for earthquake generation.
3. Explain how scientists determine the cumulative amount of slip on faults.

INTRODUCTION: please read

- Movement on faults is related to the stress associated with plates interacting or intraplate stress.
- All rocks are slightly elastic. The accumulation of strain due to stress (compression, tension, or shear) causes the rock to deform (change shape) prior to fault movement.
- After decades or centuries, strain builds up to sufficient levels to overcome friction along the fault surface and cause an existing fault to rupture.
- Earthquake activity is cyclical; after the break, there will be a period of relative quiet along the fault while stored energy (strain) slowly builds to a level sufficient to break the fault again. The length of time necessary to build up enough stress to cause a fault to break again is known as the **recurrence interval**. The recurrence intervals for the largest earthquakes are measured in centuries but more moderate sized earthquakes may reoccur on intervals measured in decades.
- Faults may be hundreds of kilometers in length. However, faults tend to break along shorter segments that are typically no more than a few tens of kilometers in length.

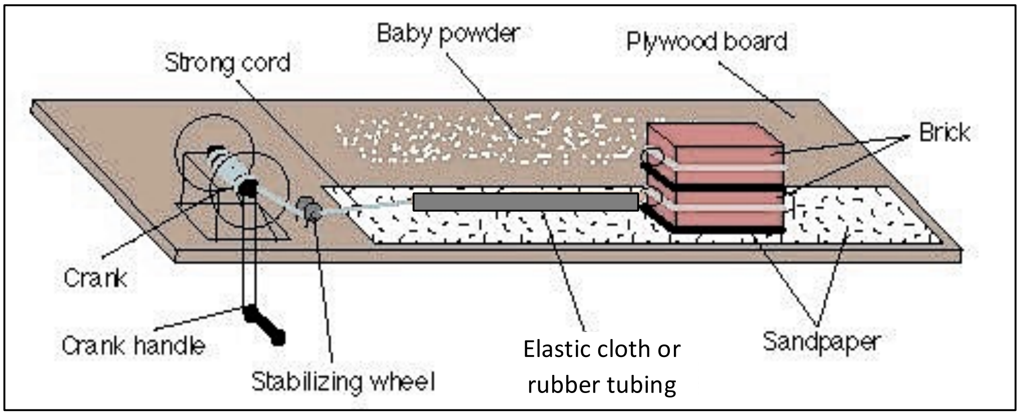


https://www.e-education.psu.edu/geosc10/book/export/html/1811

Parts of this lab were used with permission from work by Dr. Ann Bykerk-Kauffman, Department of Geological and Environmental Sciences, California State University, Chico.

Earthquake Machine:

We will use an earthquake machine to model the behavior of Earth's crust at and near an earthquake fault. While this model accurately simulates the strain energy that slowly accumulates in rock surrounding a locked fault that is released in a sudden slip event—a process known as the Elastic Rebound Theory—it is ultimately a simplification of a complex earth system



Earthquake Machine Questions

1. What is an earthquake (one statement)?

2. In nature, what are the equivalents for:
   a. The sandpaper surface:
   b. The movement of the brick:
   c. The turning of the crank handle:
   d. The stretching of the tubing:

Earthquake Machine Experiment 1:

For this experiment, the set up for your Earthquake machine will consist of: **One brick on the fine (tan) sand paper, with one short elastic tube attached to the crank.** Your goal is to calculate the total slip. You will complete three reps of the experiment, and use the table below to record your results. **STUDENTS USING THE CRANK AND ASSISTING IN RECORDING MUST WEAR EYE PROTECTION.**

Experiment 1:

	Start (cm)	End (cm)	# Cranks	Total Slip (cm) (end-start)	Slip Rate (Slip/# Cranks)
Trial 1					
Trial 2					
Trial 3					
Average					

Earthquake Machine Experiment 2:

It is important to understand how **different** variables (rock type, plate contact, force) can impact the potential for an earthquake to occur. For the second experiment, **each group will be assigned by the instructor a new machine set up**. Your goal is to again calculate total slip, and then compare the changes you observe in total slip. You will complete three reps of the experiment, and use the table below to record your results. **STUDENTS USING THE CRANK AND ASSISTING IN RECORDING MUST WEAR EYE PROTECTION.**

Variables (one per group, assigned by instructor):

1. Two Bricks, Short Tubing, Fine Sandpaper

2. One Brick, Short Tubing, Coarse Sandpaper

3. One Brick, Long Tubing, Coarse Sandpaper

4. One Bring, Long Tubing, Fine Sandpaper

Experiment 2: First brick

	Start (cm)	End (cm)	# Cranks	Total Slip (cm) (end-start)	Slip Rate (Slip/# Cranks)
Trial 1					
Trial 2					
Trial 3					
Average					

Experiment 2: Only use if you were assigned variable 1 (two bricks). Record the slip of brick 2.

	Start (cm)	End (cm)	# Cranks	Total Slip (cm) (end-start)	Slip Rate (Slip/# Cranks)
Trial 1					
Trial 2					
Trial 3					
Average					

3. Did you experience any variability between trials? If so, why?

4. Please give a short explanation of the changes you saw between experiment 1 and 2. Please indicate your variable, what changed, and why.

5. After all groups have reported on the results of their experiment, provide a short statement of the different findings. How does this compare to the "real life" equivalents?

6. What was happening to the rubber tubing while you were turning the crank but there was no motion of the brick?

7. When you were turning the crank, you were exerting energy. Energy cannot be created or destroyed.

- **a.** **<u>During</u>** earthquakes, where do you suppose that energy was going in the model? Explain how this is analogous to the real world.

- **b.** **<u>After</u>** earthquakes, where do you suppose that energy was going in the model? Explain how this is analogous to the real world.

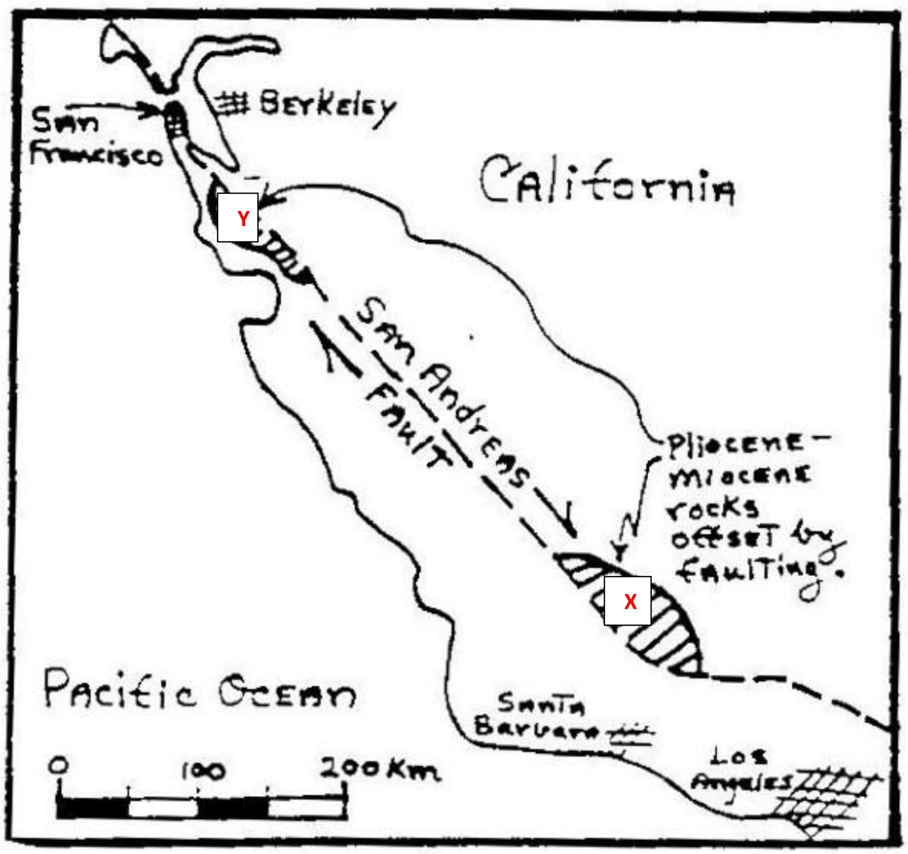
8. Analysis: Fault Slip and Recurrence Interval

The San Andreas Fault, California, is an active fault zone, marked by frequent earthquake activity. The crust southwest of this strike-slip fault (including San Diego) is sliding to the northwest relative to the other side.
It is possible to estimate the average annual rate of movement by recognizing rock of an earlier geologic age that have been offset by the lateral movement along the fault. Examine the generalized geologic map of southern California, which shows Pliocene-Miocene age rocks offset along the San Andreas Fault. These rocks have been determined to be **25 million years** old.

a) Use the map below to **calculate the average annual rate of movement in centimeters per year** along the San Andreas Fault. **Show your calculations**. Velocity = Distance (Y to X)**/**Time

SHOW WORK (including unit conversion):

__________ **cm/yr**



b) While the plate is moving, a fault can be stationary and be slowly accumulating strain that will eventually be released as movement that generates an earthquake. **If the San Andreas Fault moves 200 cm (2 meters) per big earthquake**, and plate movement (slip rate) is **xx cm/yr** (your answer above), **how many years of plate motions must accumulate to produce one big earthquake?** This is the **recurrence interval** for earthquakes of this size.

- Slip Rate = average slip per major rupture**/**recurrence interval.

SHOW WORK (including unit conversion):

__________ **years**

TOPOGRAPHIC MAPS

NAME ________________________________

STUDENT NAMES IN GROUP:

____

LAB OBJECTIVES:

- Develop basic topographic map skills: measure distances with map scales, interpret contour lines, and determine the latitude and longitude of a location on a map.
- Identify potential hazards.

Please **refer to p. 77-84** and **90-97** in lab manual for help. Pay **CLOSE ATTENTION** to the maps on **p. 82-83.**

PART 1: GLOBE

1. Using the globe provided, determine the approximate latitude and longitude of San Diego.
2. Using same globe, determine approximate latitude and longitude of Tokyo, Japan, and Lima, Peru.

a) San Diego:

b) Tokyo:

c) Lima:

PART 2: TOPOGRAPHIC MAP: SWEENY PASS QUADRANGLE

1. Determine the latitude/longitude of the 4 corners. **Remember to put ^{0}N and ^{0}W**

NW corner: ____

NE corner: ____

SW corner: ____

SE corner: ____

- What is the difference in latitude from the NW corner to the SW corner? ____________________________

2. Write the verbal scale for this map (p.80) ____

3. Write the ratio scale for this map (p.80) ____

4. What is the contour interval? __________________________

5. Name the topographic quadrangle (map) to the northeast of this map. _____________________________________

6. Name the map to the northwest. ____________________________________ (look for a *map name* at NW corner)

7. See top of map, find section 16 and section 36. Describe the topography for each section if you hiked from the west side of the section to the right side (flat; steep; etc.). *Section numbers are red numbers in the middle of township and range squares.*

   a) Section 16 (top of map):

   b) Section 36:

8. Which direction does Carrizo Creek flow? ____________What is the evidence supporting your answer?

9. How many miles is Carrizo Canyon from the bottom of section 25 (southern portion of map) to the top of the other section 25 (northern portion of map)? (***PAY ATTENTION*** *to bar scale*)

_______________________ miles

PART 3: TOPOGRAPHIC MAP: LA JOLLA QUADRANGLE: See **p. 96 in lab manual** for help with **relief and gradient**

1. What is the magnetic declination? ______________________________

2. What is the year of the map? __________________________________

3. Why is the magnetic declination different when compared to the same map 20 yrs. later?

4. What is the highest elevation of Soledad Mountain (hint: look for radio towers)? ___________________________

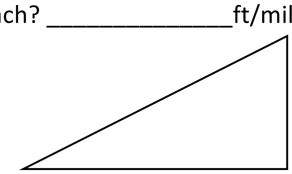
5. What is the approximate elevation of USD? (look for small △ at the west end of campus) __________________

6. What is the elevation change (relief = rise) going from USD to Mission Beach? _______________________ ft

7. "As the crow flies" (horizontal distance = run), how many miles to Mission Beach? _____________________mile

8. How many feet per one mile elevation change (**gradient**) from USD to Mission Beach? _______________ft/mile

SHOW WORK:



9. **Find % slope**: units for rise and run must be the same, then x 100 to give a % for the slope. **Show Work.**
(5280 ft = 1 mile)

HELP WITH SLOPE
Convert gradient to % slope (example):

- start with: Gradient = 60ft /mile
- change miles to feet, feet will cancel
- 60ft / 5280ft = .01 (5280ft = 1 mile)
- .01 x 100= 1% slope

HELPFUL WEBSITES:
http://serc.carleton.edu/mathyouneed/slope/index.html
http://serc.carleton.edu/mathyouneed/slope/slopes.html

RIVERS AND FLOODS

NAME________________________

SEE Stream Processes in lab manual on p. 111

ANSWER THE FOLLOWING:

1) What are the 3 types of RIVER CHANNELS? (see p. 120 for help)

a) ____ develops on relatively flat topography, lateral erosion.

b) ____ develops in response to a high sediment load.

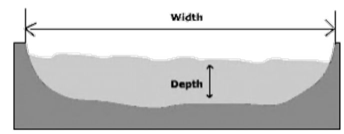
c) ____ develops on relatively steep slopes and resistant rock.

2) STREAM DISCHARGE (Q): (see p. 117 for help)

a) Calculate the **stream velocity** using the following data: A stick floats 50 ft downstream in 29 seconds. ____________**ft/sec**
show work:

b) Calculate the **stream discharge** using the velocity calculated above and the following measurements of the stream channel: Width = 30 ft and Depth = 2 ft

show work: ________________**ft^3/sec.**



c) There are 7.48 gallons in a cubic foot of water. How many gallons of water will flow past the place where you are standing along the stream in one 24-hr period?
show work:

3) COMPLETE IN LAB MANUAL:

1) Activity 2 on p. 127, **INTRODUCTION TO STREAM PROCESSES AND LANDSCAPES**:

- **Part A #1a through h (p. 127)**

2) Activity 3 on p. 131, A MOUNTAIN STREAM

- Refer to Ennis Montana map on **p. 114** when you are asked to see **Fig. 2.**
- **Part A #1a through e (p. 131-132)**
- Describe why **Alluvial Fans** form at the base of mountain slopes? What kinds of hazards would you encounter living on an alluvial fan *(many communities in the CA deserts do)*?

4) SAND BOX: Please be careful not to get sand on the floor.

Create a landscape with a drainage basin and divide. Show your instructor before leaving.

5) STREAM TABLE EXERCISE: Please be careful not to get the "synthetic sediment" on the floor.

As a team, construct a river channel or system. Utilize your construction tools (rocks & sticks) to create an anthropogenic feature (bridge, dam, house, etc.) and protect that by using your tools to create an erosion proof river system.

1. What type of channel did you choose to construct and why? (meandering, braided, straight) ____________________

2. What anthropogenic feature did you choose to construct? _____________________________________

3. What tools did you choose to use to protect your river, where and why?

4. Sketch your river!

5. In your own words, explain what happened to your river as the flow velocity increased. Why do you think this happened?

6. If you were to repeat this experiment, what would you do differently (if anything) to your river system and why?

SUNSET CLIFFS COASTAL EROSION AND SD RIVER FLOOD HAZARDS

FIGURES TO SUPPLEMENT EXERCISE WILL BE HANDED OUT DAY OF FIELD TRIP

STOP 1: SUNSET CLIFFS

PARKING LOT: WEST SIDE OF SUNSET CLIFFS BLVD BETWEEN ADAIR AVE AND OSPREY AVE

Sunset Cliffs, on the west side of the Point Loma peninsula, are made of the **Point Loma Formation** (late cretaceous)**,** which is composed of interbedded fine-grained dusky-yellow sandstone and olive-gray clay shale that occur in graded beds. On top of the Point Loma Fm. is the **Cabrillo Formation** (late cretaceous), a massive medium-grained sandstone and cross-bedded cobble conglomerate. **(see handout).**

Much younger deposits from the Pleistocene, 1 million years or less in age, lie directly on top of the gently dipping Point Loma and Cabrillo Formations. This marine terrace deposit called the **Bay Point Formation,** marine and nonmarine, poorly consolidated, fine- and medium-grained, pale brown, fossiliferous sandstone.

QUESTIONS TO ANSWER:

1) Which formation seems to be more susceptible to erosion based on your observations? ___________________________

2) Would you classify this coastline as an **erosional** (wave activity→caves, arches, etc.) or **depositional coastline** (sediment deposition→ spits, bars, deltas)?

____

3) List **coastal landforms** (see list of landforms on handout) that suggest wave erosion is occurring here:

-
-
-
-

4) Is there damage to any "man made" structures suggesting coastal erosion is occurring? Explain.

5) Coastal erosion along Sunset Cliffs has been occurring in response to a combination of geologic processes and human activity. Make a list for each (see your list of factors affecting coastlines):

a) Geologic and natural processes:

-
-
-
-

b) Human induced:

-
-
-
- Explain with a simple figure how the **mission beach jetty** to the north interfers with sand migration to the south towards Sunset Cliffs:

6) Are there any "mitigation efforts" to reduce wave erosion seen here? What are they? Will they be effective in the long term?

7) Look towards Mount Soledad (north): **1)** How many marine terraces do you see? **2)** What do these multiple terraces suggest about Mount Soledad?

8) Make a sketch with 2 marine terraces and an abrasion (wave-cut) platform and label the youngest marine terrace.

STOP 2: THE MOUTH OF THE SAN DIEGO RIVER

Topics to be discussed:

- Estuarine Environment: Salt water/fresh water interaction (some mudflats just downstream).
    - Hydrology is dominated by daily tidal flows
    - Fresh water input during and after storms (winter and El Nino years) See "PAVE LESS" note on kiosk.
- Formation of floodplain, river channel, and levees
    - Repeated flooding
    - Lateral erosion by a meandering river
    - Characteristics of the sediments on floodplains
- Rose Canyon Fault and liquefaction hazard

ANSWER QUESTIONS A THROUGH D:

a. Describe the topography and vegetation.

b. Is there a well-defined floodplain? _____________ WHY?

c. The rock at your feet was trucked from East County. Why is this rock used along the river? Why not use rocks from the coast, they are closer than the rock from east county (mountains).

d. Estimate where the Rose Canyon Fault is located relative to this area. Do you think liquefaction is a hazard here? WHY?

STOP 3: SAN DIEGO RIVER AT FASHION VALLEY MALL

Topics discussed:

- Urbanization and its impact on stream flow
- Infiltration of different land use surfaces
- USGS gauging station

ANSWER QUESTIONS A THROUGH F:

a. Is there a well-defined floodplain? Why?

b. Why is the vegetation different from the last stop?

c. What are the major land use types in this area?

d. Compare **infiltration on natural versus paved surfaces** (see Hydrograph on handout).

- Urbanization increases or decreases the peak (maximum) stream flow? **Circle answer**
- What effect does urbanization have on the lag time between peak rainfall and peak stream discharge?
- Total runoff occurs over a shorter or longer period of time in an area that has been urbanized. **Circle answer**

e. During a flooding event, which store(s) in the mall will be flooded most severely?

f. How would you measure the discharge at this location? **Discharge (ft^3)= Area (ft^2) x Velocity (ft/sec):**

SHOW WORK:

FLOODING IMPACTS ALONG SAN DIEGO RIVER

8.8 Feet - Fashion Valley Road closed. Officials barricade the road to travel.
11.3 Feet - Minor flood. Water flows into Fashion Valley parking lot.
13.5 Feet - Parking structures designed for flooding fill with water. Golf course under water.
16.5 Feet - All intersections in Mission Valley flooded and impassable, except for major bridge structures. Evacuations begin for businesses and residences. Hotels evacuated and golf course inundated. Major damage to businesses.
18.5 Feet - Widespread damage to businesses, residences, and roads throughout Mission Valley. Evacuations necessary. Large portions of business district under water.
19.6 Feet - Most of the Mission Valley under water. Major damage.

FLOOD CATEGORIES (in feet)

Major Flood Stage:	16.5
Moderate Flood Stage:	13.5
Flood Stage:	11.3
Action Stage:	7.5

HISTORICAL CRESTS

(1) 19.30 ft on 01/27/1916 Maximum discharge, 75,000 ft^3/s
(2) 16.30 ft on 02/21/1980
(3) 14.01 ft on 12/22/2010
(4) 13.47 ft on 03/06/1995
(5) 13.11 ft on 03/02/1983

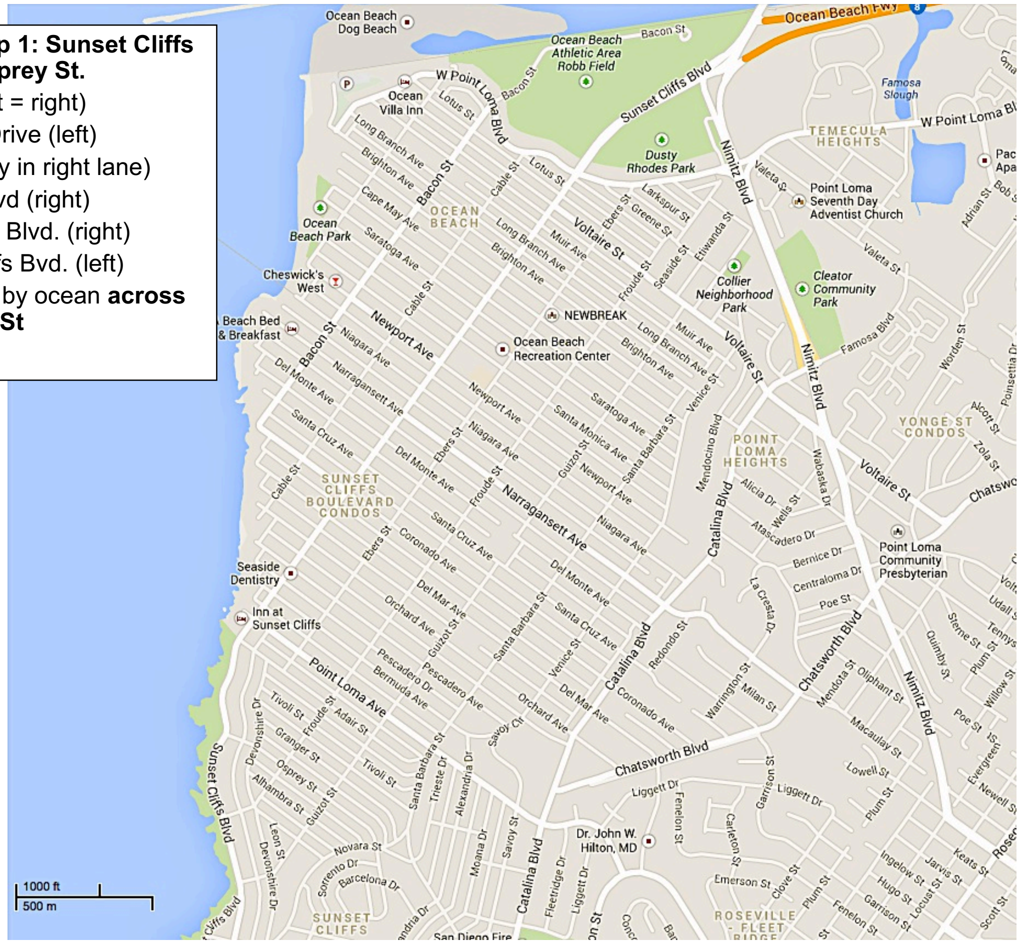
Sunset Cliffs Coastline

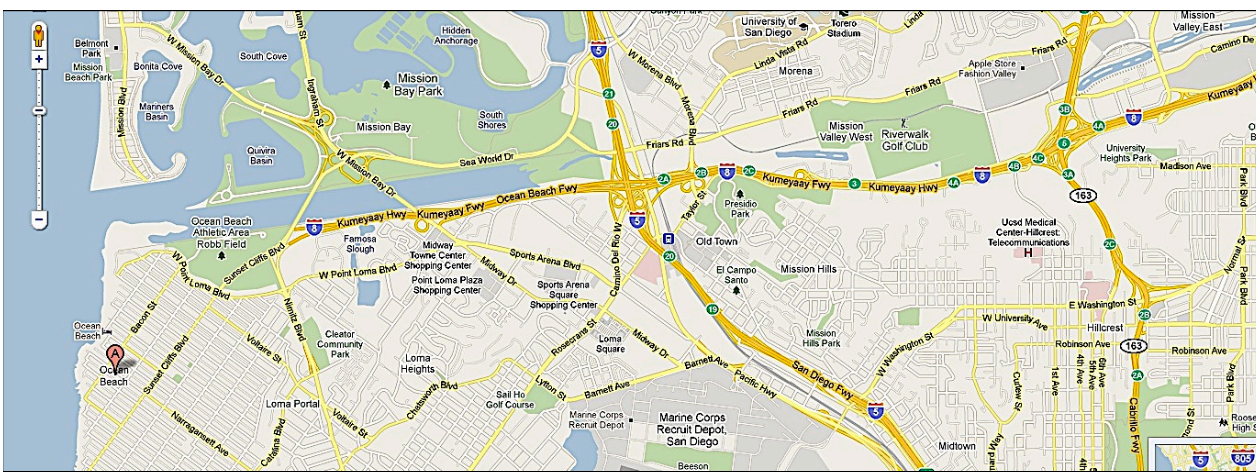
google earth

Figure 1

From USD to Stop 1: Sunset Cliffs Blvd. and Osprey St.

1) Friars (west = right)
2) Seaworld Drive (left)
3) Nimitz: (stay in right lane)
4) Catalina Blvd (right)
5) Point Loma Blvd. (right)
6) Sunset Cliffs Bvd. (left)
7) Pull into lot by ocean **across from Osprey St**





From Sunset Cliffs to Stop 2:

1) Leave Sunset Cliffs Blvd. Heading NE.
2) Stay in left lane as you cross SD River.
3) Road becomes Sea World Drive.
4) Procede on Sea World Drive and
5) Make a right turn onto S Short Park, then make an immediate right turn along frontage
6) Take frontage road to the West to the kiosk sign. (drive slowly on this shared bicycle road)

From Stop 2 to Stop 3:

1) Proceed back East on the frontage road, carefully entering right onto Friars Rd.
2) Make a **right turn** at the 4th traffic light onto Fashion Valley Road (at ARCO gas)
3) Make **left turn** under the Trolley bridge, by Fashion Valley Mall, and park along the dirt strip on right of road.

HAZARD ASSESSMENT EXERCISE: NATURAL HAZARDS ON THE BIG ISLAND OF HAWAII

STUDENT NAMES IN GROUP:

____

OVERVIEW

- Hazard zone maps are used for making land-use decisions before hazards occur.
- Hazard zones are based primarily on the location and frequency of past events.
- Hazard assessment is based on the assumption that future events will be similar to those in the past.
- Hazard zones also take into account topographic features that will affect the risk. Volcanic hazards decrease with increasing distance from the vent or source. The threat from earthquakes is widespread and influenced by local ground conditions. Danger from tsunami depends on local topography and direction of the coastline.

INSTRUCTIONS: **PLEASE READ!**

Your lab instructor will give you directions on how to proceed with the exercise.

- Each group will turn in **one** completed topographic map which can be found with the other figures in this exercise and **one** summary.
- The topo. map should show all the hazards assessed during this exercise (lava flows, local earthquakes, tsunami run-up, offshore landslides, and rainfall). Delineate each hazard zone with a different color, create a legend to explain colors.
- Each group will compose a brief hazard assessment summary on a separate piece of paper.
- Ultimately your group will decide on a "safe" location to build a structure/building, your reasoning for this location should be included in the summary. Your instructor will tell you the type of structure.
- **EACH** member of the individual groups should do their own work.

EARTHQUAKE MAP QUESTIONS:

1. Beneath which volcanoes do most earthquakes occur?

2. At what depth do the largest earthquakes occur? __________________

3. Complete the Seismic cross-section exercise (located at the end of this exercise). **Draw the approximate locations of earthquakes** along a cross section from A to B showing the depth of earthquakes beneath the Island of Hawaii.

4. What do the different earthquake magnitudes generally mean in terms of the shaking and damage?

5. What is a possible cause of earthquakes beneath Kīlauea Volcano?

LAVA FLOW MAP QUESTIONS:

1. Where do the lava flows originate (in general) and where do they end?

Start:

End:

2. How far did the longest historical flows travel? ____

3. Which volcanoes have historical lava flows (since 1790)?

4. Where are the oldest lava flows (in general) and where are the youngest lava flows?

Oldest:

Youngest:

5. How long (in general) does it take lava flows on Mauna Loa Volcano to travel from where they erupt to the coast? What factor is important in determining how fast lava flows travel?

-
-

6. **Complete the lava flow velocity exercise** (located at the end of this exercise).

7. **See the recent (2018) Kīlauea lava flow map** from the USGS. **How do these recent flows compare to some of the historical flows?**

TSUNAMI MAP QUESTIONS:

1) Where was the location of the **highest tsunami run-up** *for each of the six large historical tsunami* generated by the different earthquakes around the Pacific Ocean? See figure at the bottom of the next page.

1.

2.

3.

4.

5.

6.

2) Which earthquake caused the highest run-up? ____

3) Can you identify the location of the earthquakes on the Pacific Ocean Region map *for each of the six tsunami* events on the run-up map? What was the depth of each of the earthquakes?

1. ____ Depth: ____________________

2. ____ Depth: ____________________

3. ____ Depth: ____________________

4. ____ Depth: ____________________

5. ____ Depth: ____________________

6. ____ Depth: ____________________

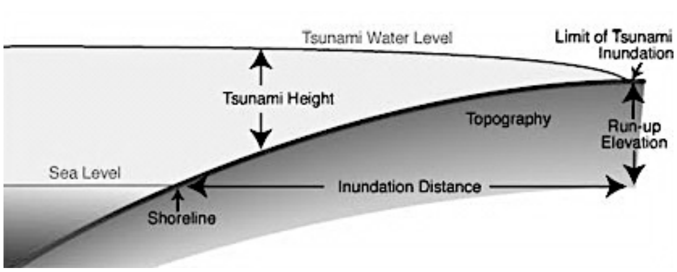
4) Why do large earthquakes occur around the rim of the Pacific Ocean?

5) What factors may influence tsunami run-up height?

6) Which coastal areas on the Island of Hawaii are most at risk for tsunami run-up based on where the largest earthquakes occur around the Pacific Ocean Region?

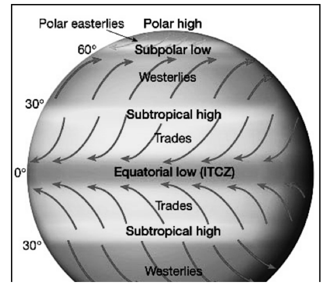
-
-
-
-

Run-up elevation is the elevation above sea level of a tsunami at the limit of inundation.



RAINFALL IN HAWAII QUESTIONS:

See figures on the lab table for the following questions:



1) Why is there an <u>orographic effect</u> on the Big Island of Hawaii (or any Hawaiian island)?

2) Which side (east or west) of Hawaii is the "wet" side? ______________________

3) What is the range (in mm) of the mean annual rainfall on the east side of the island? _________________________

4) What are the names of the winds that affect Hawaii (20^0N latitude)? ____________________________________

5) Using the information above, delineate the "most likely to flood zones" on your topo. map.

LANDSLIDES OFFSHORE HAWAII QUESTIONS

See figures on the lab table for the following questions:

The Hawaiian Islands are home to some of the largest landslides on the planet. The steep cliffs along the sides of the islands are not due to wave erosion. They are scarps from the debris flows that extend out onto the abyssal plain (deep, relatively flat region of the seafloor).

1) Where is the largest landslide located? Offshore which island and direction (N, S, SE, NE, etc.)?

-
-

2) What would happen if a landslide occurred here today? (local effect, regional effect, global effect)

-
-
-

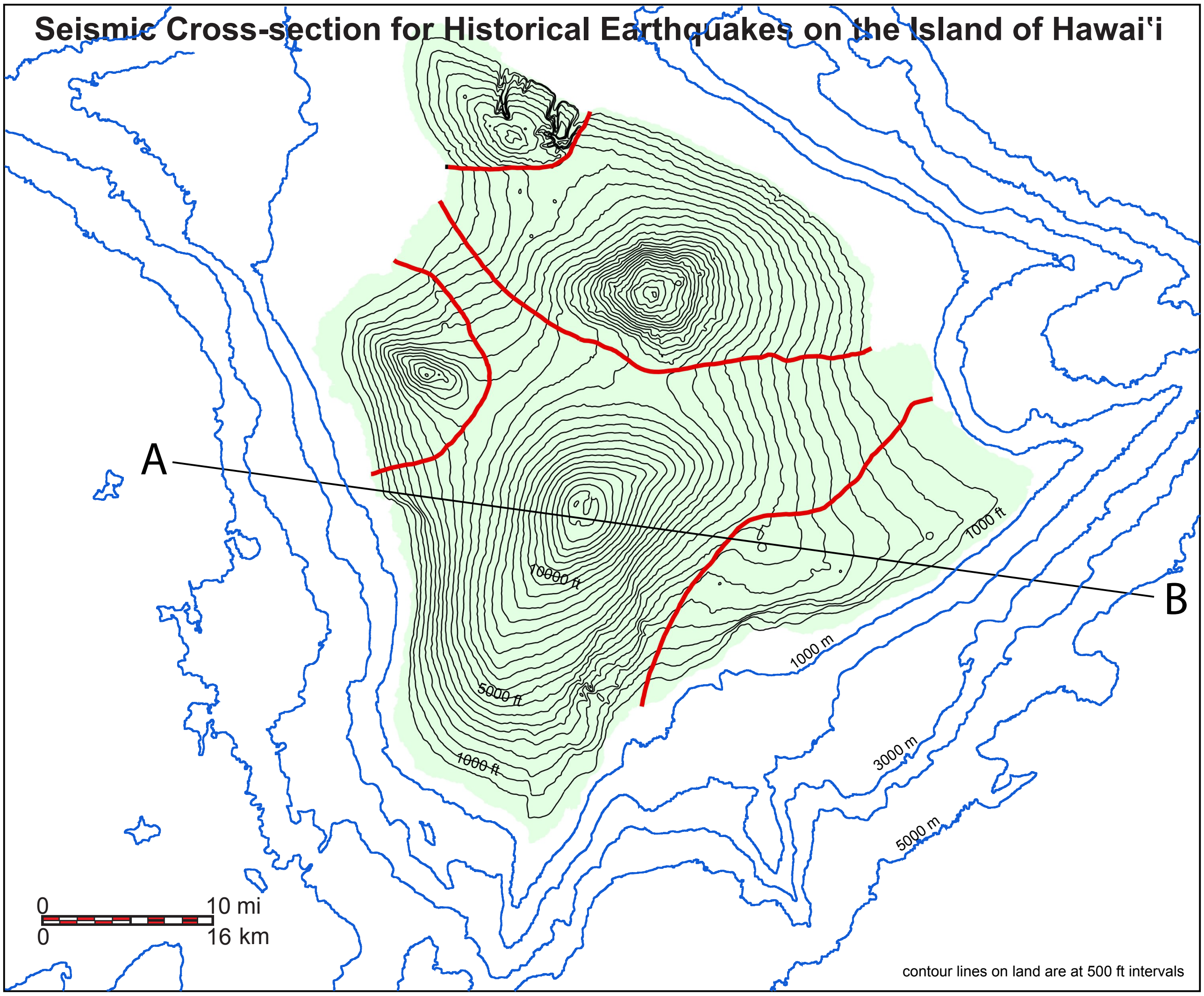
3) Provide the <u>approximate area</u> of the largest landslide in km^2. ________________________

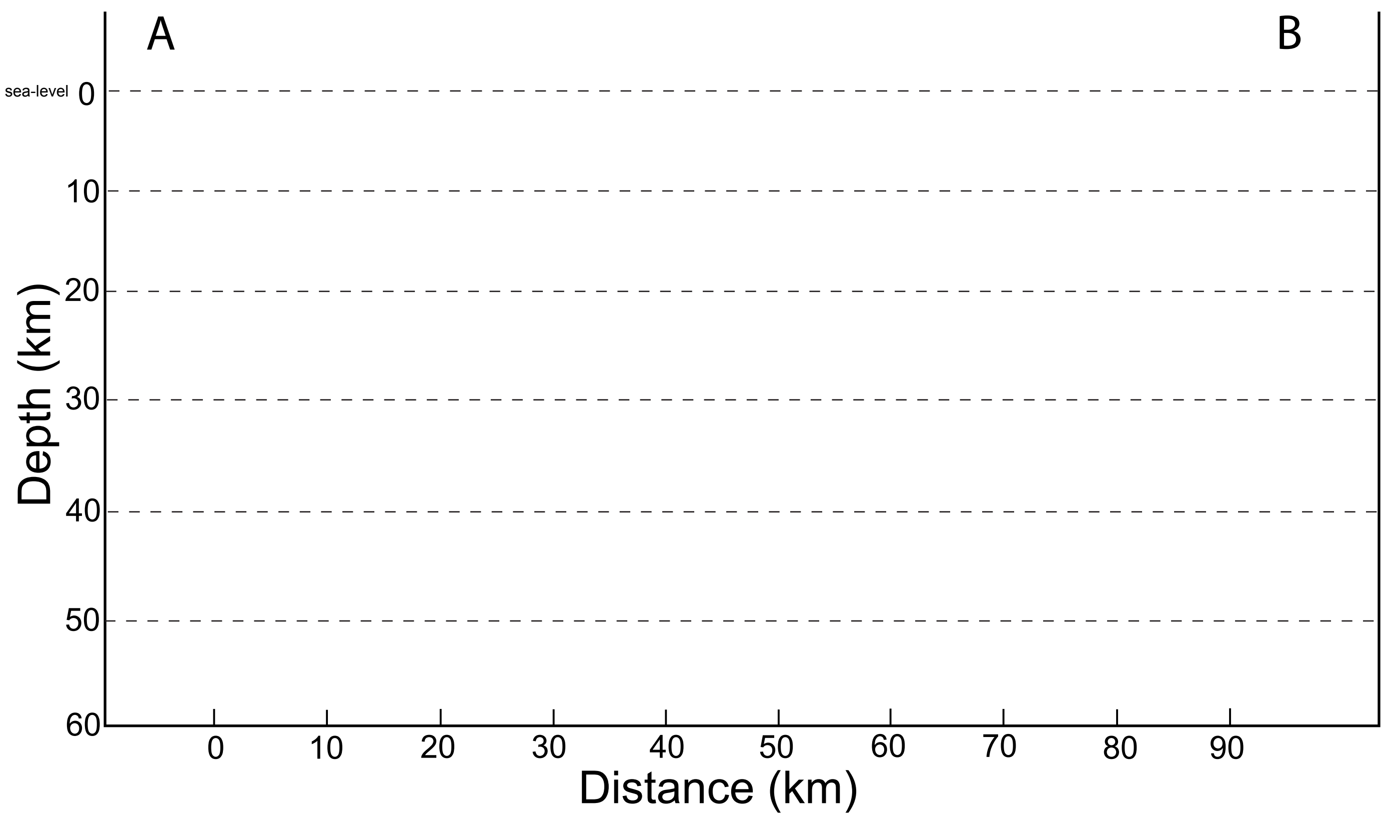
4) What is the <u>relief</u> from Mauna Kea to the abyssal plain (in ft)? How does this compare to Mt. Everest? (29,029 ft) (*<u>Relief</u> = highest elevation – lowest elevation* ***or*** *If below sea level: <u>Relief</u> = shallowest depth – deepest depth)*

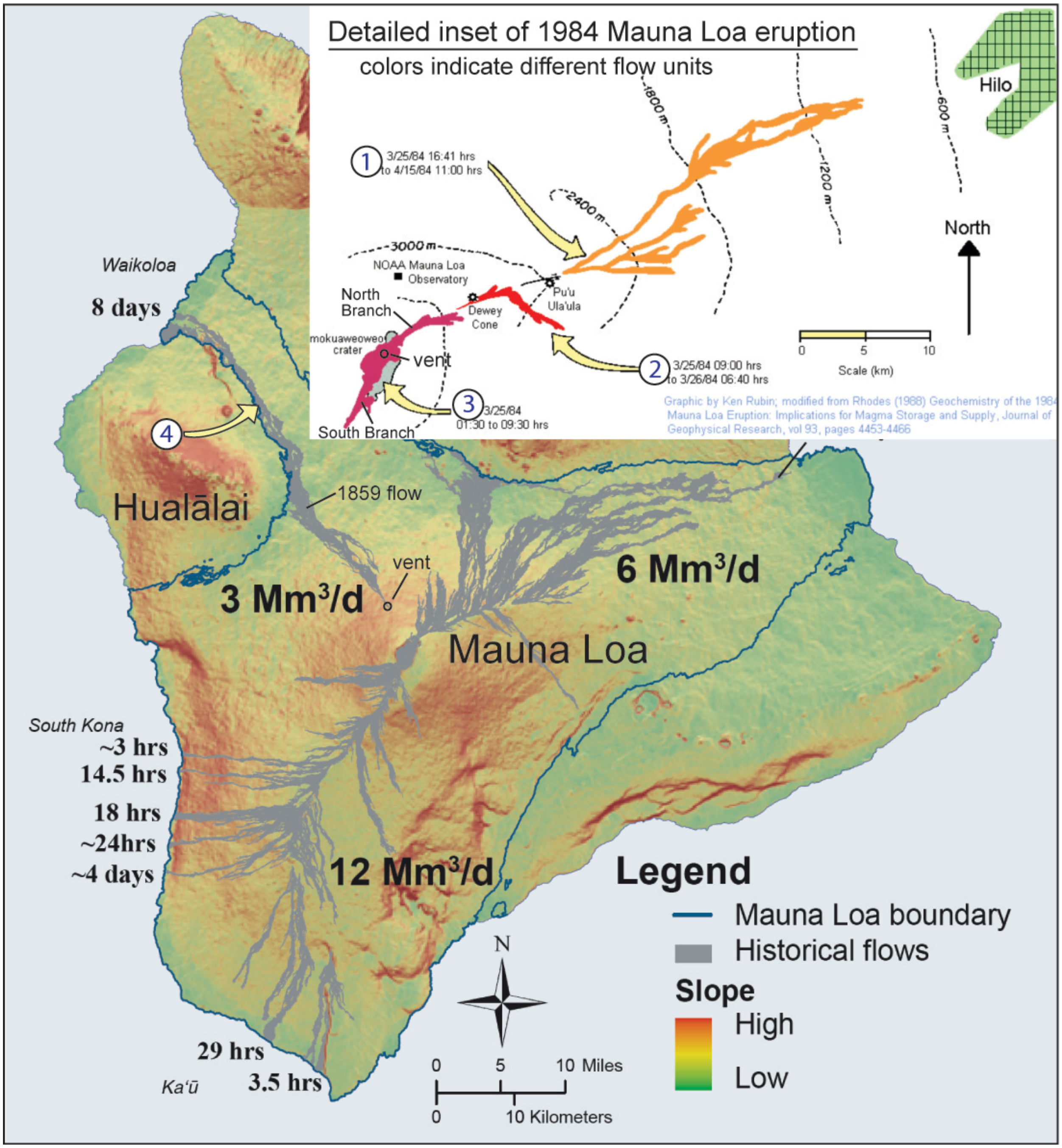
Show work and units:

Natural Hazards on the Island of Hawaii

Andrew R. Greene, Hawai'i Pacific University (agreene@hpu.edu)
Michael O. Garcia, University of Hawai'i at Manoa (mogarcia@hawaii.edu)
Nathan Becker, NOAA Pacific Tsunami Warning Center (nathan.becker@noaa.gov)
**Michael Poland, USGS-HVO, provided comments and input (mpoland@usgs.gov)*
All maps from: https://serc.carleton.edu/NAGTWorkshops/environmental/activities/74390.html


Seismic Cross-section for Historical Earthquakes on the Island of Hawai'i
A
B
10000 ft
5000 ft
1000 ft
1000 ft
1000 m
3000 m
5000 m
0
10 mi
0
16 km
contour lines on land are at 500 ft intervals


A
B
sea-level 0
10
20
30
40
50
60
Depth (km)
0
10
20
30
40
50
60
70
80
90
Distance (km)



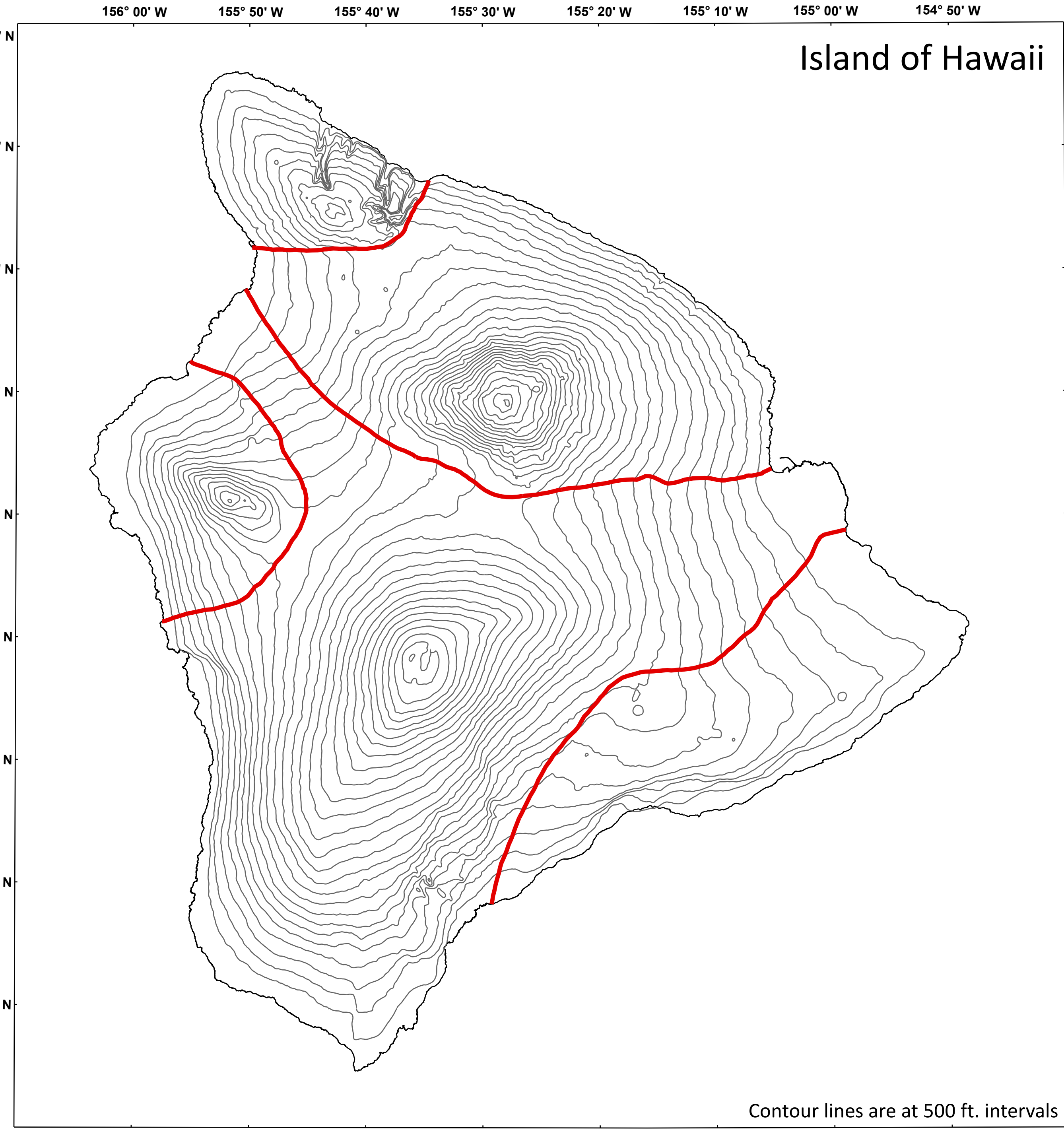
<u>Lava flow velocity exercise</u>

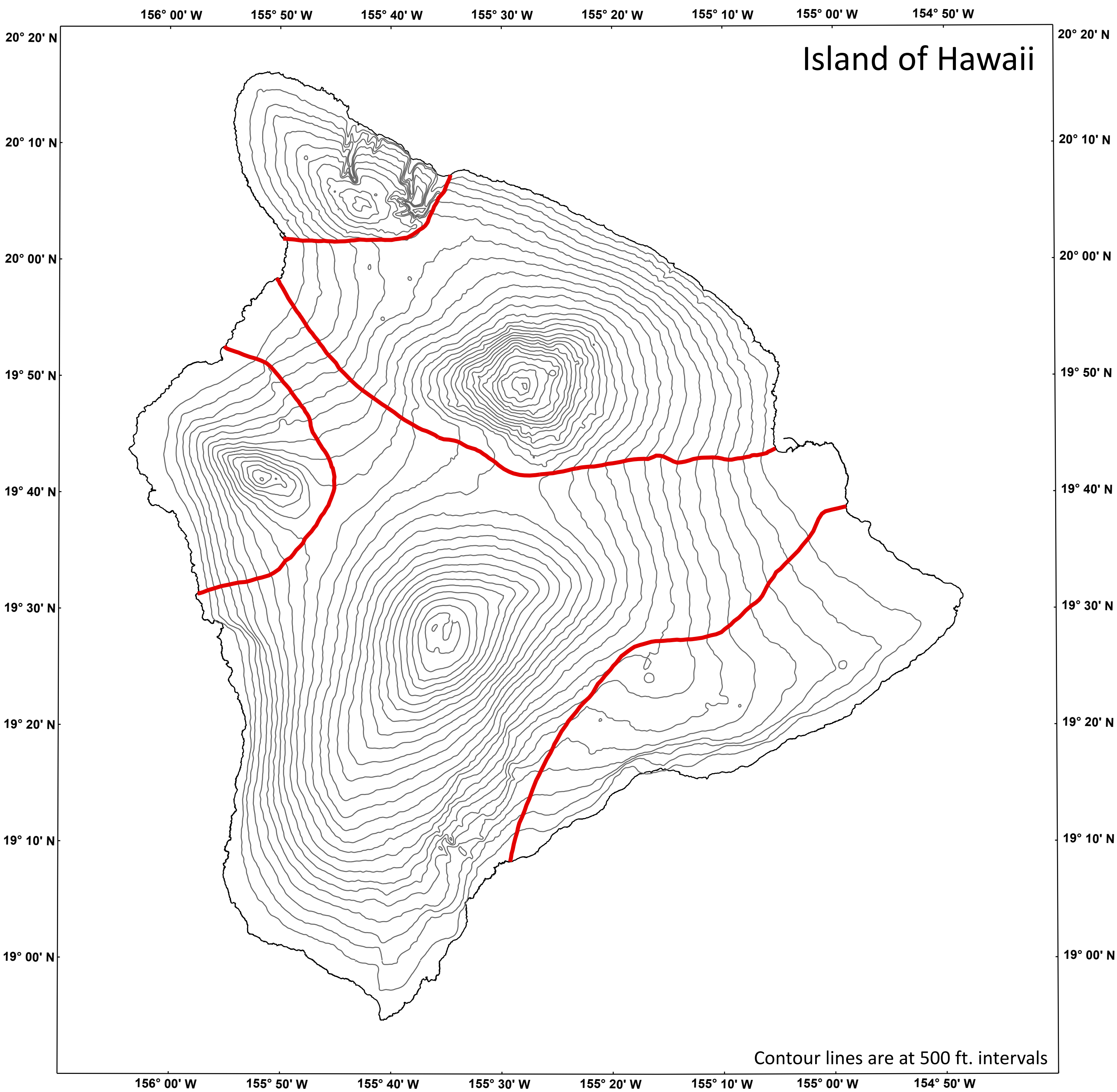
Historical lava flows from Mauna Loa are shown in gray, and the numbers along the coastline indicate the approximate time that the lava flows took to reach the sea after the vent(s) opened high on the volcano. Lava flows from the 1984 eruption of Mauna Loa are shown in the inset map. Start and end times, or duration for 1859 flow (#4), are indicated for each flow unit.

- Calculate the lava flow velocities (in km/hr) for the three lava flows indicated with arrows (#1-3) in the inset map at the top.

- Calculate the lava flow velocity (in km/hr) for the 1859 lava flow on the north side of Mauna Loa (#4) that traveled around Hualālai Volcano.

-Indicate on the maps where the vents were for the four numbered lava flows?


Island of Hawaii
156° 00' W
155° 50' W
155° 40' W
155° 30' W
155° 20' W
155° 10' W
155° 00' W
154° 50' W
20° 20' N
20° 10' N
20° 00' N
19° 50' N
19° 40' N
19° 30' N
19° 20' N
19° 10' N
19° 00' N
Contour lines are at 500 ft. intervals



Island of Hawaii
156° 00' W
155° 50' W
155° 40' W
155° 30' W
155° 20' W
155° 10' W
155° 00' W
154° 50' W
20° 20' N
20° 10' N
20° 00' N
19° 50' N
19° 40' N
19° 30' N
19° 20' N
19° 10' N
19° 00' N
Contour lines are at 500 ft. intervals

GEOLOGIC AND HAZARD MAPS

NAME ______________________________

STUDENT NAMES IN GROUP:

____

PART 1) GEOLOGIC MAPS: LA MESA QUADRANGLE

1. What is the elevation of Cowles Mountain? ________________________

2. Estimate the Latitude ________________ and Longitude __________________ of the top of Cowles Mountain.

3. What is the age and rock type of rocks making up Cowles Mtn? __________________ ________________________

4. Explain why Cowles Mtn. is a "topographic high." See map legend for rock composition.

5. What does **Qls** stand for? _____________________________ Is Qls associated with sedimentary or igneous rock types *(circle answer)*?

Why? ____

6. Why is the San Diego river valley wide by Santee Lakes, narrow through Mission Gorge, and wide again as it enters Mission Valley?

7. List at least 2 potential natural hazards for this region and briefly explain why.

Hazard:

Reason:

Hazard:

Reason:

GEOLOGIC MAP: LA JOLLA QUADRANGLE

1. Mission Valley and San Clemente Canyons are generally east-west trending stream erosion valleys that dissect the mesas (flat areas). This topography has developed in response to water flowing from the higher elevation terrain in the eastern part of San Diego County towards sea level (west).

a) Looking at San Clement Canyon, how do you know the water flows east to west?

b) Do you think flooding is a hazard in Mission Valley? Why? List some structures and property that might be at risk; evaluate the topography and how the valley formed.

Why:

Structures and property at risk:

2. Follow the trace of the Rose Canyon Fault Zone from Mission Valley to La Jolla Shores beach.

a) The general trend of the Rose Canyon Fault Zone is **1)** N-S **2)** NW-SE **3)** NE-SW **4)** E-W *circle answer*

b) What are the 3 primary faults that collectively make up the Rose Canyon Fault Zone (**northern section** which trends through **La Jolla**)?

1) ____

2) ____

3) ____

3. Landslides (see Qls) on Mount Soledad are associated with which geologic rock layer (formation)? ___________________ (keep this in mind on the field trip)

Why? ____

4. Look at the cross-section B - B' at the bottom of the page.

a) Following the geologic rock layer Kp, how many faults offset Kp? _________________________

b) How old is the geologic layer Kp? ___________________

c) How old is the geologic layer Ta? ___________________

d) Are the faults older or younger than Ta? ____________________

5. What is the dominant **rock type** (Igneous, Sedimentary, or Metamorphic) on this map? ___________________________

6. What is the magnetic declination (degrees)? ______________________________

7. What is the year of the map? ________________________

8. Do you think students were texting on their way to class the year the map was made? __________________

PART 2: SAN DIEGO HAZARD MAPS

- **See the 4 hazard maps** (Grids 16, 17, 20, and 29) on your table.
  San Diego Hazard maps can be found: http://www.sandiego.gov/developmenservices/industry/hazards/

- **What are the most common hazards** for each of the locations listed below.

  - Select from the geologic hazards below (also see legend on hazard maps):
    a) liquefaction, **b)** slide-prone formations, **c)** landslides, **d)** fault zone, **e)** coastal bluff stability

1) Point Loma western Coastline (Grid 16): *We will visit this coast next week*.

2) Shelter Island, Harbor Island, and northern Coronado Island (Grid 16):

3) Downtown San Diego coastline (Grid 17):

4) SD River mouth and Mission Bay (Grid 20):

5) La Jolla (Grid 29):

7) What are the 2 most common hazards after reviewing the 4 hazard maps? Why?

1) ____________________________________ Why?

2)____________________________________ Why?

8) What does **Qaf** stand for (see any geologic map)? _________________________. Which hazard do you correlate with this unit? _______________________________ Why?

9) What does **Ta** stand for (see La Jolla geologic map)? _________________________. Which hazard do you correlate with this unit? _______________________________ Why?

PART 3: SOUTHERN CA SHAKE MAP: **SEE the following on the lab table**: **1)** 8 ½ x 11 color shake map, **2)** Figure with Southern CA faults, **3)** Riverside/Orange County Faults

A. There are 3 major faults east of the Rose Canyon Fault zone. All have the potential to produce earthquakes large enough to cause significant ground shaking:
What are the names going west→east: 1) ___________________ 2) ______________________ 3) ___________________

B. What is the region called just east of SD highlighted in green? (hint: intrusive igneous rock)

Why does this area have a relatively "low" shaking potential? (2 reasons):
1)

2)

…

PART 4: SIMULATING EARTHQUAKES EXPERIMENT

A Common Earthquake Hazard:

LIQUEFACTION: Shaking resulting from earthquakes is exaggerated in areas where the underlying sediment is weak or saturated with water. Liquefaction occurs when water separates from sediment and moves to the surface when the water saturated materials are violently shaken. The shaken water-saturated sediment loses its strength as it is converted from a solid to a liquid. The loss of water can result in a decrease in land elevation by several meters.

1. Fill a small paper or plastic cup about two-thirds full with dry sand. Place some coins in the sand, standing on edge so that they resemble walls. Follow the instructions below and complete the experiments.

   a. **Experiment 1** – Observe what happens to the coins as you tap the cup (not shake) on the table top while turning it slowly. What did you observe?

   b. **Experiment 2** – Remove the coins and add a small amount of water to the sand. Press down and compact the sand. Place coins in cup and repeat Experiment 1. What did you observe?

   c. **Experiment 3** – Remove coins and add more water to the sand until it is saturated. Place the coins in the cup and repeat Experiment 1. What did you observe?

   d. On the basis of your observations, rank the three types of materials in order from less hazardous to more hazardous to build on in a region with a history of earthquake activity.

EOSC105 CLIMATE LAB

Name ___________________________________

Student names in group:

____

The science of global warming is clear and the situation is urgent. Human activities are loading our atmosphere with heat-trapping gases. The disruption of our planet's climate system is already having serious impacts. Heat waves, forest fires, and heavy downpours are intensifying. Sea level is rising and will continue to rise for many centuries[1]. **This lab exercise will give you the opportunity to investigate the following and gain a better understanding of 1)** how rapidly CO_2 levels are increasing in the atmosphere, **2)** how melting of continental ice sheets is affecting sea level rise, and **3)** how changes in albedo affect the climate.

Before getting started with the lab see sea level rise experiment.

CO_2 EXERCISE *(From: https://serc.carleton.edu/introgeo/interactive/examples/co2.html Randy Richardson, University of Arizona)*

Carbon Dioxide (CO_2) is a greenhouse gas that is strongly correlated with global temperatures -- the more CO_2 in the atmosphere, the warmer Earth's atmosphere and surface become. In this exercise, you will investigate the CO_2 data set from Mauna Loa, Hawaii, and estimate the rate at which atmospheric CO_2 has been increasing recently.

<u>This exercise will help you understand:</u>

1) the basis for conclusions about how quickly CO_2 concentrations are rising globally,
2) estimate how long it will take for global CO_2 concentrations to double at today's rate of increase, and
3) the effects of looking at only a portion of a data set in terms of describing its properties.

Part I: The complete monthly Mauna Loa, Hawaii, CO_2 data set for the seven years between 2005 and 2011 consists of 84 data points.

a. Plot the data points you selected from the bag on the graph paper provided.

b. Now estimate the **slope** of the data. To do this, you must first find the *best fitting straight line* through the data points and then measure the rise (change in Y-axis) over the run (change in X-axis) of this line. Draw the best fit line on your plot of the data points. The slope should have units of ppm/year. **Show your work.**

Result ________ ppm/year

c. Based on your estimate above, predict the current atmospheric CO_2 level (2019).

_____________ ppm

d. How does your estimate above compare to the current CO_2 level (see lecture)? Why might these values be different? (**be specific**)

e. Compare your estimate of the slope with slopes estimated by other groups. How does your value compare to that of others? Remembering that each group is taking random samples from the 84 monthly values, are your surprised (Yes or No)? Explain why or why not.

1: https://www.climatecommunication.org/climate/introduction/

Part II. In this section, you will estimate how long, based on the rate of increase you determined from your data set, it will take for atmospheric CO_2 concentrations to double.

a. At the rate of increase of atmospheric CO_2 concentration you determined in Part I (i.e., with the slope your group determined), how many years will it take for CO_2 concentrations to **double** from the *earliest value plotted on your graph*? For example, if the beginning value were 300 ppm and the rate of increase were 3 ppm/year, it would take 300/3 = 100 years to increase by 300 ppm (i.e., double). **Show your work.**

Result ________ years

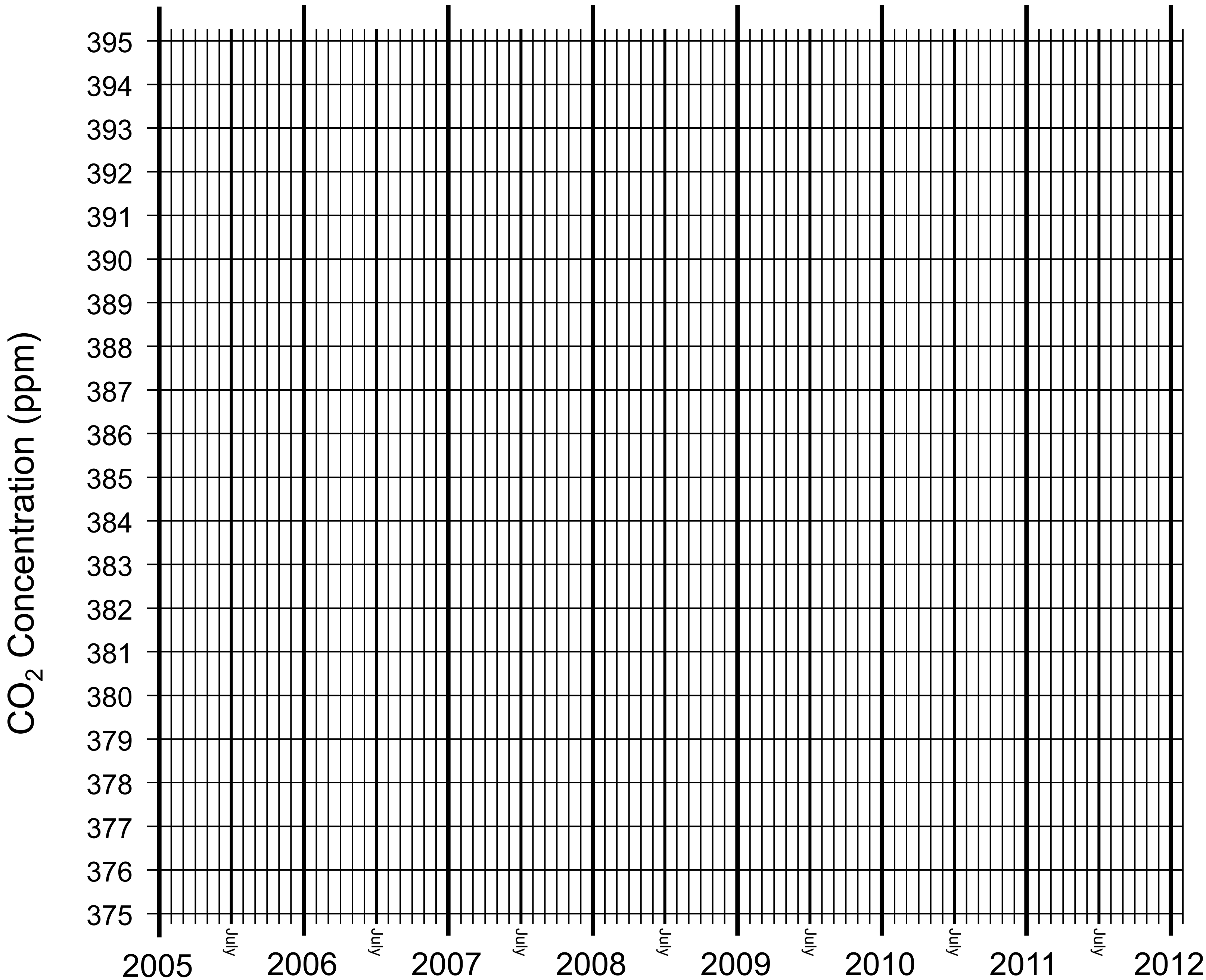
b. It is worth noting that the rate for the last ten years is higher than the rate for the 10 years before, and that the rate may continue to increase in the future. If the rate increases in the future, will the time needed to double the atmospheric CO_2 concentration increase, decrease, or stay the same? Circle the correct answer.

Part III. Please reflect on what you have learned in this exercise.

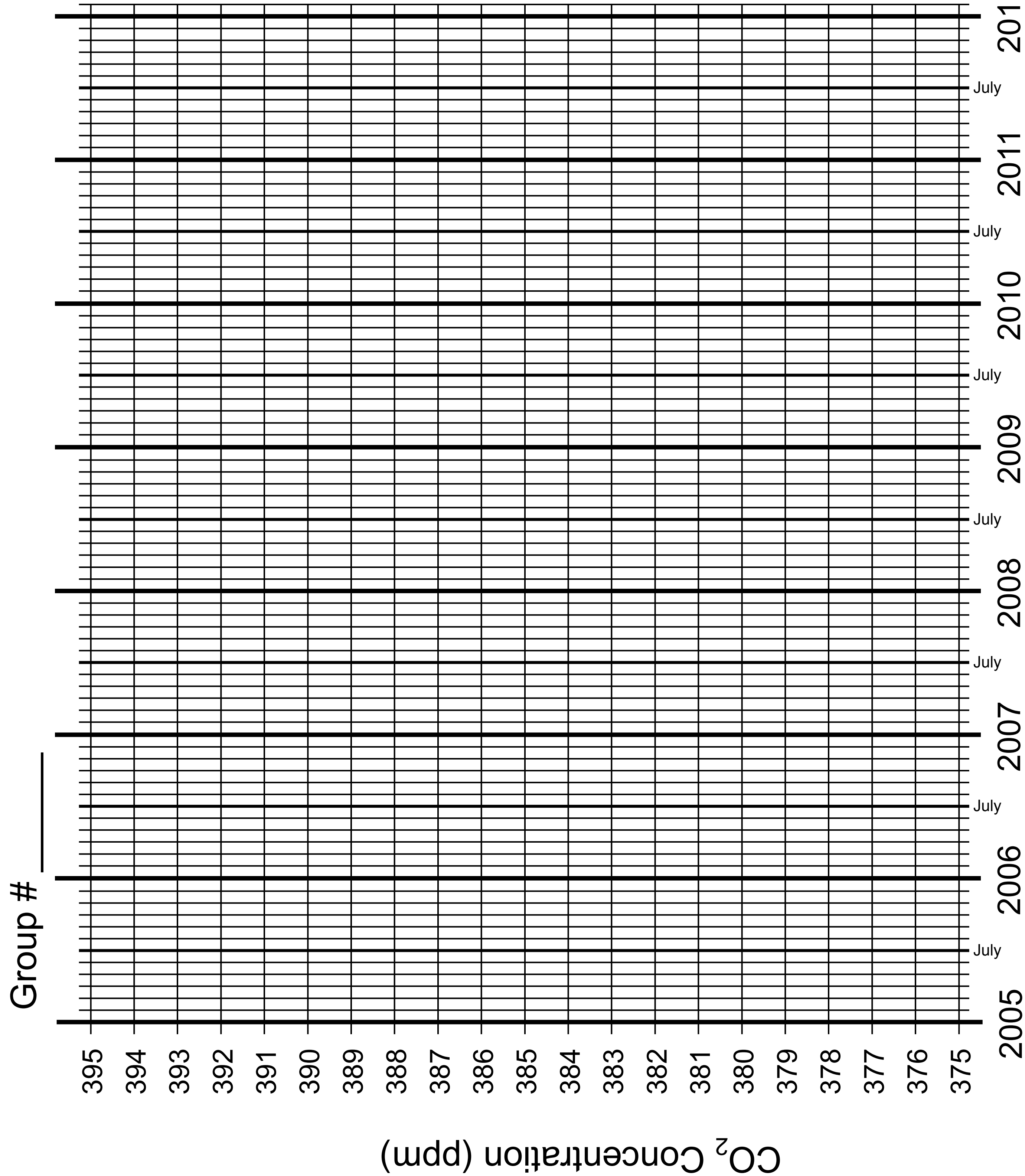
1) What have you learned about global atmospheric CO_2 trends from this exercise? Use numbers to support your answer.

2) How does global climate change affect extreme weather? (**refer to article on your table**) How do you think climate change will affect the frequency of natural disasters in San Diego?

Group # _______



CO2 Concentration (ppm)
395
394
393
392
391
390
389
388
387
386
385
384
383
382
381
380
379
378
377
376
375
2005
July
2006
July
2007
July
2008
July
2009
July
2010
July
2011
July
2012


Group # ____
CO2 Concentration (ppm)
395
394
393
392
391
390
389
388
387
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385
384
383
382
381
380
379
378
377
376
375
2005
July
2006
July
2007
July
2008
July
2009
July
2010
July
2011
July
2012

CALCULATING SEA LEVEL RISE EXERCISE

Sea-level rise exposes coastlines to greater risks of flooding and erosion and is expected to affect millions of additional people each year by late this century.[1]

Geographic information:
Earth's land surface: 510,000,000 km^2
Land-covered area: 150,000,000 km^2
Ocean-covered area: 360,000,000 km^2

Antarctica
Area: 14,000,000 km^2
Ave. height of ice cap: 2.1 km

Greenland
Area: 2,000,000 km^2
Ave. height of ice cap: 1.3 km

Other ice sheets
Area: 5,000,000 km^2
Ave. height of ice cap: 0.1 km

1) Put the size of Earth's ice sheets in context by comparing the area of Antarctica's ice sheet to the area of California (423,970 km^2; the 3rd largest state in the U.S.). ***Show relevant calculations below.***

Antarctica's ice sheet is ________ times the size of California.

2) Use the data above to calculate the **volume of water** stored in Antarctica, Greenland, and other ice sheets. (volume = area x height) **Show work:**

- **Antarctica: ________________**
- **Greenland: ________________**
- **Other: __________________**

3) Thinking about your answers above in #2 and your observations of the ice sheets on Google Earth (see computer monitor in front of room), <u>hypothesize:</u> how much sea level would rise (in meters, 3ft. = 1 meter) if all of the ice on Earth melted.

4) Now calculate the following: If all of the water stored in the ice sheets melted and flowed into the ocean, how much would **sea level rise** (in meters)? (height = volume / ocean area). **Show all work**

5) Please refer to the USGS article (see article on the table): How do your calculations compare to the data in the article?

USGS ____________________ my calculation: ____________________

Sea Level Rise Experiment: Set up before starting this Climate Exercise

Objective: Students will investigate which type of ice (land ice or sea ice) poses a greater threat to sea level rise if large-scale melting due to climate change occurs.

Hypothesis: *(A hypothesis is a tentative, testable answer to a scientific question).*

Materials:

Large graduated cylinders (two)

- water
- ice cubes
- funnel

Method:

1. Place exactly **12 ice cubes in one of the graduated cylinders** and fill about three-quarters of the way full with water. (Simulating sea ice.)
   - Water level in sea ice graduated cylinder: __________________ml
2. Fill the other graduated cylinder **to the exact same level** as the first graduated cylinder.
   - Water level in sea ice graduated cylinder: __________________ml
3. Place the funnel in the top of the second graduated cylinder and **put the same number of ice cubes (12)** in it as you did in the first cylinder. (Simulating land ice.)
4. Wait ~ 2 hrs for the ice to melt and observe how much the water level has increased in both graduated cylinders.
   - Rise in water level in sea ice graduated cylinder: __________________
   - Rise in water level in land ice graduated cylinder: __________________

Analysis:

Was your hypothesis supported by the data? Explain.

EARTH'S ENERGY BUDGET-RADIATION EXERCISE

PLEASE READ: The proportion of absorbed, emitted, and reflected incoming solar radiation steers the Earth's climate system causing fluctuations in temperature, winds, ocean currents, and precipitation. The climate system remains in equilibrium as long as the amount of absorbed solar radiation is in balance with the amount of terrestrial radiation emitted back to space. Earth's **albedo values are very important in shaping local and global climates through the radiation budget**, determined as the **difference between the amount of absorbed shortwave radiation (input) and the outgoing longwave radiation (output).** Approximately half of the incident solar energy is absorbed by the Earth's surface. This energy is then used to heat the land and oceans. *http://www.eoearth.org/view/article/149954/*

The amount of sunlight being absorbed or reflected by Earth is one of the driving forces for weather and climate. **The lower the albedo, the more energy from the Sun is absorbed.**

Changes in Earth's surfaces can therefore affect how much of the Sun's energy is absorbed – such as a decrease in snow cover or an increase in the area used for agriculture. If the amount of energy absorbed changes, this has an effect on **Earth's energy budget and ultimately affects our weather and climate.**
http://www.esa.int/Our_Activities/Observing_the_Earth/Reflecting_on_Earth_s_albedo

<u>**ALBEDO**</u> is a non-dimensional, unitless quantity that indicates how well a surface reflects solar energy. Albedo (α) varies between 0 and 1. Albedo commonly refers to the "whiteness" of a surface, with 0 meaning black and 1 meaning white. A value of 0 means the surface is a "perfect absorber" that absorbs all incoming energy. Absorbed solar energy can be used to heat the surface or when sea ice is present, will melt the surface. A value of 1 means the surface is a "perfect reflector" that reflects all incoming energy. *http://nsidc.org/cryosphere/seaice/processes/albedo.html*

INSTRUMENT USED TODAY:
Li-Cor Light Meter (pyranometer) – <u>shortwave</u> radiometer.
The Pyranometer measures the power of electromagnetic radiation in watts per square meter. It is sensitive to near infrared, visible, and UV radiation, where 90% of solar energy is concentrated.

ANSWER #1 and #2 BEFORE YOU GET STARTED WITH THE ALBEDO EXERCISE:
1) Hypothesize how albedo will influence surface temperature:

2) Hypothesize how water will affect albedo of a surface:

3) Compare the albedo of the following (*record and calculate values on the table at the end of this exercise*):

a. Vegetation (grass)
b. Concrete (dry and wet)
c. Asphalt (dry and wet)
d. Soil (dry and wet)
e. Other (add to the table any additional surfaces)

4) How do you determine the albedo of a given surface material?

- Albedo = (reflected solar radiation) / (incoming solar radiation)
  Show your work on the table

5) After completing the exercise and calculating albedo for the surfaces**, answer the following questions:**

a) How does albedo influence the temperature of the surface material?

b) What other factors influence surface temperature?

c) What is the difference in surface temperature between dry and wet conditions?

d) How does water affect the albedo of most surfaces?

6. In your own words, briefly summarize how humans have influenced climate by changing the albedo of various surfaces, both manmade and natural.

Table: - Solar reflectance (albedo) of select material surfaces

Material surface	Solar Reflectance
Black paint	0.06
White paint	0.8
Sand (wet)	0.2 to 0.3
Sand (dry)	0.35 to 0.45
Soil (dark and wet)	0.05 to 0.15
Soil (dry)	0.225 to 0.35
Forest	0.05 to 0.15
Desert	0.25
Savanna	0.17
New concrete (traditional)	0.2 to 0.5
New concrete with white Portland cement	0.3 to 0.7
Grass(green)	0.1to 0.35
Grass(dry)	0.2to 0.45
Water (small zenith angle)	0.03 to 0.1
Water (large zenith angle)	0.1 to 1
Snow (old – fresh)	0.4 to 0.85
Agricultural crops	0.15 to 0.25
Clouds (thick)	0.6 to 0.9
Clouds (thin)	0.3 to 0.5

Sources: Oke, 1992, Ahrens, 2006

CLIMATE LAB REFLECTION

In a short paragraph, **briefly explain your understanding of the connection between 1)** increase in CO_2 levels in the atmosphere, **2)** melting of continental ice sheets, **3)** sea level rise, and **4)** change in albedo due to melting ice sheets.

Date ______________________________

Site Description ____

Weather Conditions ____

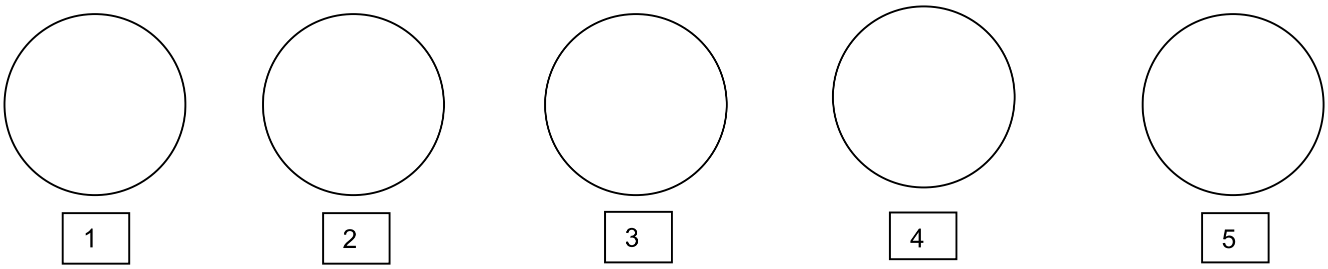
Time	Surface Type	Insolation (W/m2)	Reflected (w/m2)	albedo	Shade (Y/N)	Surface T (°C)

STUDENT NAMES IN GROUP:

____

Part A: WIND & CORIOLIS EFFECT:

Using the lazy susan apparatus, A: sketch how the ball travels (use an arrow to show direction) and B: <u>draw arrows outside circle to show direction of rotation,</u> clockwise (C) or counter-clockwise (CC).



1. Non-rotating platform

2. Platform rotates clockwise at slow speed

3. Rotates clockwise at faster speed

4. Rotates counter-clockwise at slow speed

5. Rotates counter-clockwise at faster speed

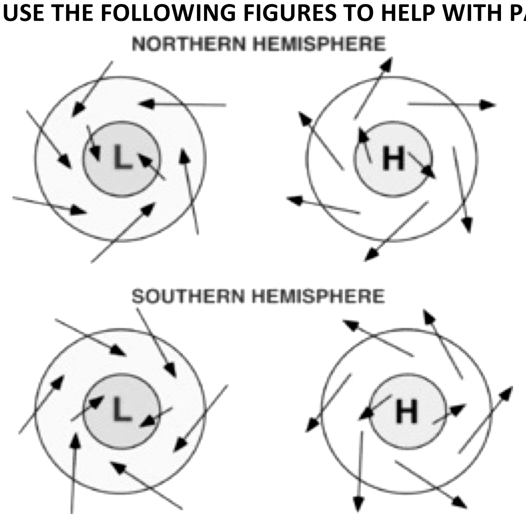
6a. How does Coriolis effect influence moving objects in Northern Hemisphere? ______________________________________

b. What is the direction of rotation looking down on the North pole? ____

7a. How does Coriolis effect influence moving objects in Southern Hemisphere? ______________________________________

b. What is the direction of rotation looking down on the South pole? ____

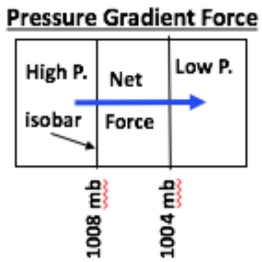
USE THE FOLLOWING FIGURES TO HELP WITH PART B on the next page



Circulation of **surface winds** around low and high pressure systems **= pressure gradient force + Coriolis force**

http://www.physicalgeography.net/fundamentals/7n.html

8. Explain pressure gradient force:



Part B: Weather Map **(see weather map at the end of this exercise)**

Read the following information below, answer questions, and complete the weather map (see handout)
The highest barometric pressure ever recorded on Earth was 1,094 mbar measured in in northern Siberia on December 31, 1968. The weather was clear and very cold at the time, with temperatures between -40° and -58° F. The lowest pressure ever measured was 870 mbar, set on 12 October 1979, during Typhoon Tip in the western Pacific Ocean. The measurement was based on an instrumental observation made from a reconnaissance aircraft.

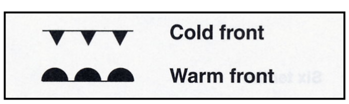
1. What causes wind?

2. What is an isobar? ____

3. Which isobar pattern represents high velocity wind?

Refer to the weather map and answer the following: **See p. 145-146 in lab manual for help.**

4 a) Highlight the fronts with a different color on the map and legend below.
1) cold front **2)** warm front



b) For the cold and warm fronts, use bold arrows to indicate the direction of front movement.

c) **Draw arrows on the map** to illustrate the rotation of wind around the _______________system over the Great Lakes

and the __________________system in the west. (Use colors that will stand out)

d) What are the weather conditions in the western U.S.? Great Lakes region?

-
-

e) What is the approximate pressure in the middle of the high? ____________ mb (Idaho) **standard isobar interval is 4 mb*

f) What is the approximate pressure in the middle of the low? _____________ mb (Wisconsin)

g) Where (general area) are the strongest winds on the map? Why?

PART C: HURRICANE KATRINA

READ CAREFULLY:

Plot data on the **map found at the end of this exercise**. ONLY use the **BOLD highlighted** latitude and longitude values from the data chart below to plot the path of hurricane Katrina. **Write at each dot TD, TS, or the correct hurricane category. Connect dots with a solid line** and **highlight with a different color** for each stage (including TD and TS).

TABLE 1: Hurricane KATRINA 23-31 AUG 2005

http://www.weather.unisys.com/hurricane/atlantic/

ADV	LAT	LON (- = west)	TIME	WIND	PR (mb)	STAT
1	**23.10**	**-75.10**	**08/23/18Z**	**30**	**1008**	**TROPICAL DEPRESSION (TD)**
2	23.40	-75.70	08/24/00Z	30	1007	TROPICAL DEPRESSION
3	23.80	-76.20	08/24/06Z	30	1007	TROPICAL DEPRESSION
4	**24.50**	**-76.50**	**08/24/12Z**	**35**	**1006**	**TROPICAL STORM (TS)**
5	25.40	-76.90	08/24/18Z	40	1003	TROPICAL STORM
6	26.00	-77.70	08/25/00Z	45	1000	TROPICAL STORM
7	26.10	-78.40	08/25/06Z	50	997	TROPICAL STORM
8	26.20	-79.00	08/25/12Z	55	994	TROPICAL STORM
9	**26.20**	**-79.60**	**08/25/18Z**	**60**	**988**	**TROPICAL STORM (TS)**
10	**25.90**	**-80.30**	**08/26/00Z**	**70**	**983**	**HURRICANE-1**
11	25.40	-81.30	08/26/06Z	65	987	HURRICANE-1
12	**25.10**	**-82.00**	**08/26/12Z**	**75**	**979**	**HURRICANE-1**
13	24.90	-82.60	08/26/18Z	85	968	HURRICANE-2
14	**24.60**	**-83.30**	**08/27/00Z**	**90**	**959**	**HURRICANE-2**
15	24.40	-84.00	08/27/06Z	95	950	HURRICANE-2
16	24.40	-84.70	08/27/12Z	100	942	HURRICANE-3
17	**24.50**	**-85.30**	**08/27/18Z**	**100**	**948**	**HURRICANE-3**
18	24.80	-85.90	08/28/00Z	100	941	HURRICANE-3
19	**25.20**	**-86.70**	**08/28/06Z**	**125**	**930**	**HURRICANE-4**
20	25.70	-87.70	08/28/12Z	145	909	HURRICANE-5
21	**26.30**	**-88.60**	**08/28/18Z**	**150**	**902**	**HURRICANE-5**
22	27.20	-89.20	08/29/00Z	140	905	HURRICANE-5
23	**28.20**	**-89.60**	**08/29/06Z**	**125**	**913**	**HURRICANE-4**
24	**29.50**	**-89.60**	**08/29/12Z**	**110**	**923**	**HURRICANE-3**
25	31.10	-89.60	08/29/18Z	80	948	HURRICANE-1
26	**32.60**	**-89.10**	**08/30/00Z**	**50**	**961**	**TROPICAL STORM**
27	34.10	-88.60	08/30/06Z	40	978	TROPICAL STORM
28	**35.60**	**-88.00**	**08/30/12Z**	**30**	**985**	**TROPICAL DEPRESSION**
29	37.00	-87.00	08/30/18Z	30	990	TROPICAL DEPRESSION
30	**38.60**	**-85.30**	**08/31/00Z**	**30**	**994**	**EXTRATROPICAL DEPRESSION**
31	**40.10**	**-82.90**	**08/31/06Z**	**25**	**996**	**EXTRATROPICAL DEPRESSION**

(NOTE: Pressures are in millibars and winds are in knots where one knot is equal to 1.15 mph)

SAFFIR-SIMPSON SCALE

Type	Category	Pressure (mb)	Winds(knots)	Winds(mph)
Tropical Storm	TS	-----	34-63	39-73
Hurricane	1	> 980	64-82	74-95
Hurricane	2	965-980	83-95	96-110
Hurricane	3	945-965	96-112	111-130
Hurricane	4	920-945	113-135	131-155
Hurricane	5	< 920	>135	>155

MAP TO PLOT HURRICANE KATRINA TRACK CAN BE FOUND AT THE END OF THIS EXERCISE.
Answer the following questions: Use the data in table 1 (see previous page) and your completed map.

1) What stage was Katrina when she made landfall in Florida? _______________________________

2a) Where is Katrina's position at category stage 5? ____________________________________

b) What are the maximum winds? (wind speed on chart is in knots, convert to mph) _____________mph
show work *(*1 knot = 1.15 mph)

3) What stage was Katrina when she made landfall in Louisiana? _______________________________

4) Looking at all of the data in table 1: What is the highest pressure? _______________________mb

Lowest pressure? ___________________mb

5) Are only the coastal states affected by Katrina? Explain:

6a) Why does the low pressure system (Katrina) start to head in a northeasterly direction after it makes landfall? (think winds) **b)** Is the low pressure system (remnants of Katrina) moving faster over land or when it was a tropical cyclone offshore? How can you tell? *(**hint:** see table on previous page and observe changes in latitude as storm migrates)*

<u>**Answers:**</u>

a)

b)

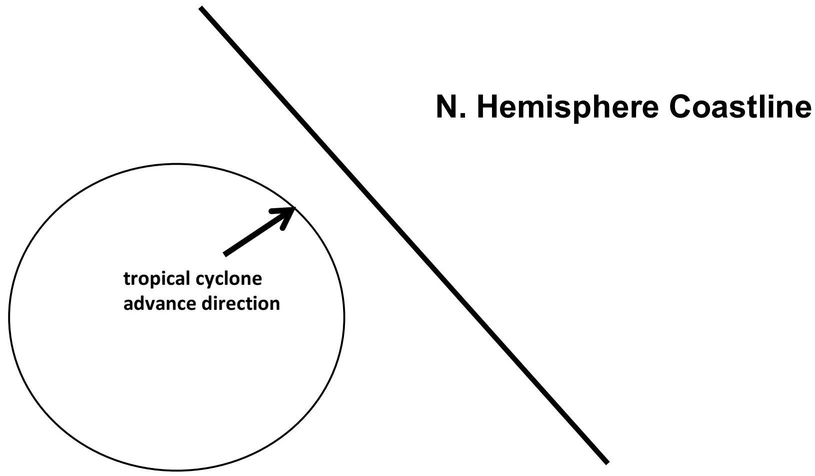
7) Clouds form because the air is ___________

(1) sinking, expanding, and cooling
(2) sinking, compressing, and warming
(3) rising, expanding, and cooling
(4) rising, compressing, and warming

8) A decrease in the atmospheric pressure indicates _____________

(1) Humidity is decreasing.
(2) Temperature is decreasing.
(3) Skies are clearing (no cloud formation).
(4) A storm is approaching.

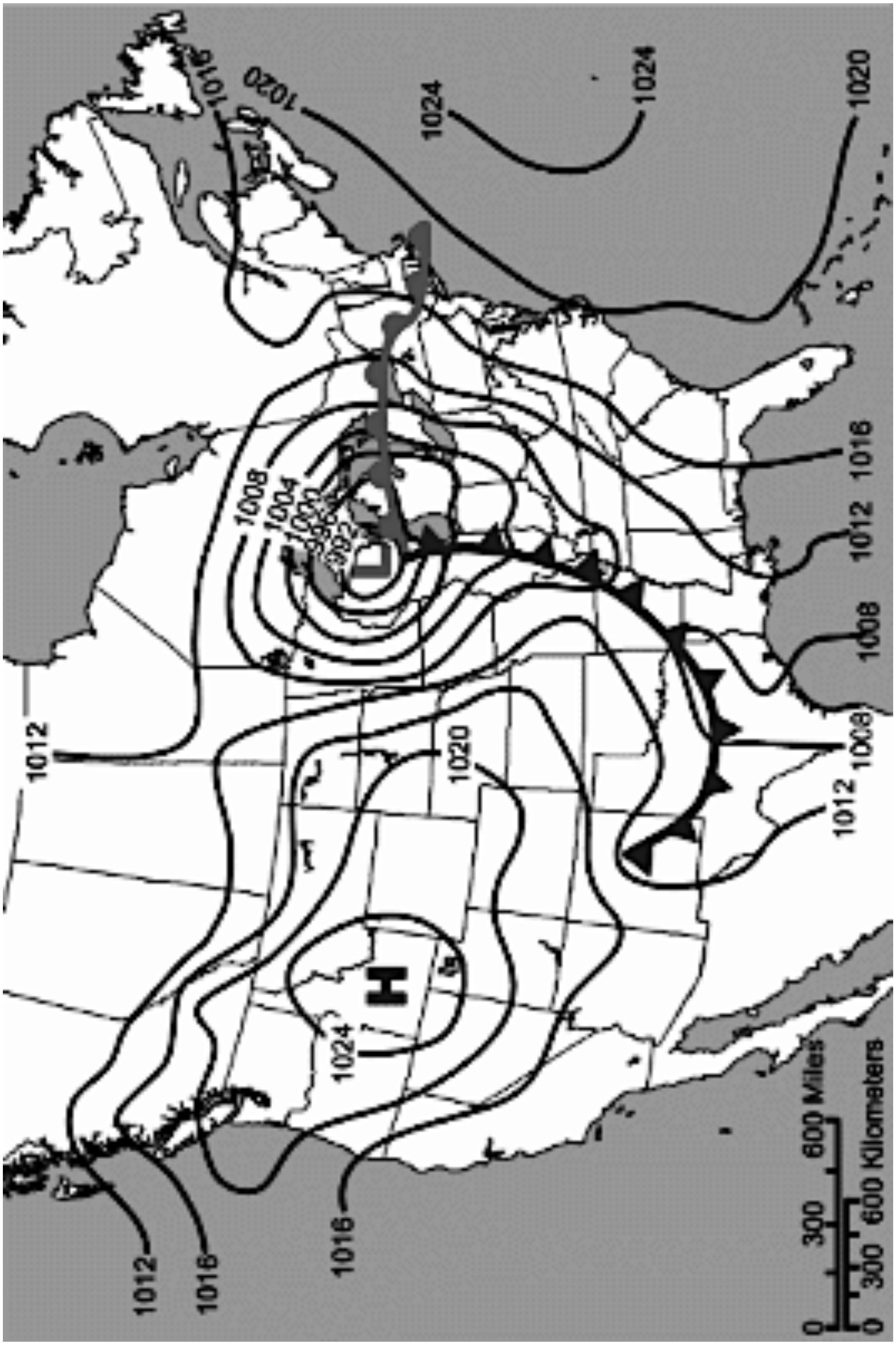
9) On the figure below, place an X where the highest storm surge will occur. Draw arrows to show circulation of winds around the tropical cyclone (the circle). Make sure your arrows show initial movement of wind towards the center of the low and coriolis effect (see figure on first page of this exercise).



Why is storm surge higher where you placed the X?

10) Draw the same figure in the southern hemisphere:

11) Complete Lab Manual Activity 3, #5 through #12 on p. 149.   Write in the lab manual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0 300 600 Miles
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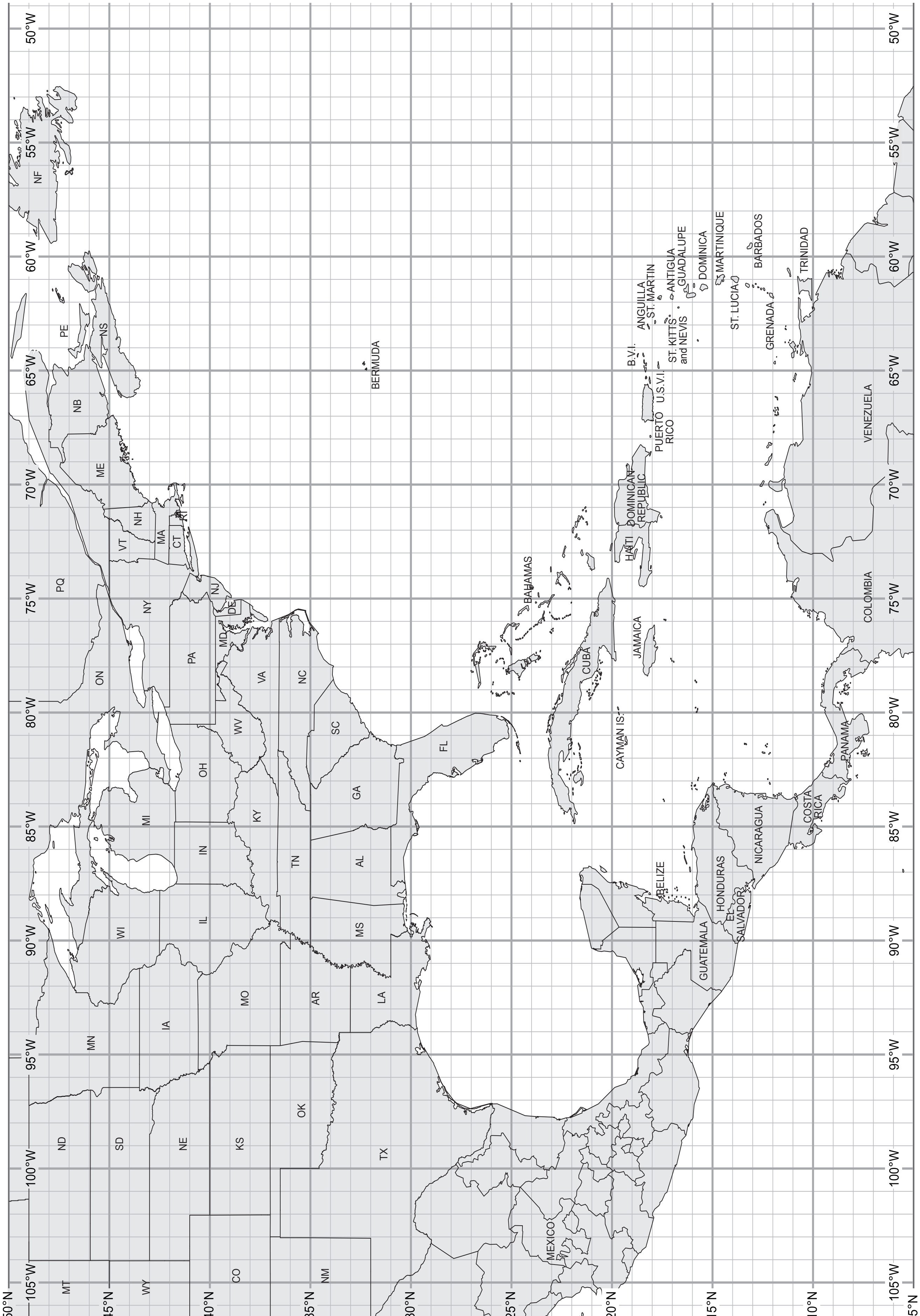
50°N
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35°N
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10°N
5°N
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65°W
70°W
75°W
80°W
85°W
90°W
95°W
100°W
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MEXICO
BERMUDA
BAHAMAS
CUBA
JAMAICA
CAYMAN IS.
HAITI
DOMINICAN REPUBLIC
PUERTO RICO
U.S.V.I.
B.V.I.
ANGUILLA
ST. MARTIN
ST. KITTS and NEVIS
ANTIGUA
GUADALUPE
DOMINICA
MARTINIQUE
ST. LUCIA
BARBADOS
GRENADA
TRINIDAD
VENEZUELA
COLOMBIA
PANAMA
COSTA RICA
NICARAGUA
HONDURAS
EL SALVADOR
GUATEMALA
BELIZE