ES202 Lab 2 - Overview of Minerals, Rocks, and Plate Tectonics

(Lab2_ver6_Update.doc – Jan. 2016)

Part 1 - Mineral Properties

A ES202 lab mineral set is assembled in a tray at the back of the room. The tray consists of a number of mineral specimens that are numbered on the bottom of individual boxes. Each box contains several samples of each specimen, giving multiple students access to a given specimen at a given instant. **This exercise is keyed to the 10th Edition of the AGI Geology Lab Manual.**

Familiarize yourself with the specimen numbers and look at the variety of specimens that you see. Complete the tasks below. Place answers in the space provided.

<u>1-1. Mineral Cleavage and Fracture (**p. 82-85** of lab manual)</u>

Some minerals display a characteristic cleavage pattern when they are broken into pieces. The type of cleavage is dependent upon the way in which atoms are organized in the crystal structure of the mineral, thus providing a diagnostic property that can be used to identify the mineral.

A. Specimen 12 is a dark, platy-looking mineral that has a very well-defined cleavage pattern.

______________ How many "breaking planes" or "cleavage directions" do you observe for specimen 12? (**p. 83-84**)

______________ What other specimen (answer by specimen number) is similar in appearance to 12 with respect to number of cleavage directions?

______________ What is the main physical difference that you see between specimen 1 and no. 12 above?

B. Specimen 4 is a translucent mineral (it passes light through it) that has a common usage in everyday life.

______________ How many different "breaking planes" or "cleavage directions" do you observe in specimen 4? (**p. 83-84**)

______________ What is the angle of intersection between the "breaking planes" or "cleavage planes" of this mineral (less than 90 degrees, 90 degrees, or more than 90 degrees)?

______________ Touch specimen 4 to your tongue, what is the characteristic taste of this mineral?

C. Refer to specimen 8 and answer the questions below

______________ How many different "breaking planes" or "cleavage directions" do you observe in specimen 8? **(p. 83-84**)

______________ What is the angle of intersection between the "breaking planes" or "cleavage planes" of this mineral (less than 90 degrees, 90 degrees, or more than 90 degrees)?

______________ Place a small drop of dilute hydrochloric acid (in the small dropper bottles) on specimen 8, what do you observe? Wipe the acid from the sample with a paper towel when you are finished. (**see page 86, Fig. 3.16**)

______________ What happens when you place a small drop of HCl on specimen 3? Wipe the acid from the sample with a paper towel when you are finished.

D. Refer to specimen 3 and answer the questions below.

______________ How would you best describe the "breaking characteristics" of specimen 3 (choose one): breaks into well-defined cleavage planes (list the no. of directions if you think this is correct), OR breaks or "fractures" like glass with no well-defined cleavage planes (better known as conchoidal fracture) (**p. 82 Fig. 3.11**).

______________ Can you take a guess at what the name of this common silicate mineral is?

1-2. Mineral Luster and Light Transmission (**p. 78 of lab manual**)

The luster or appearance of reflected light from a mineral is another diagnostic property that is used to identify minerals. Two luster types that are relatively easy to recognize are (1) metallic (shines like metal), and (2) non-metallic (does not shine like metal... for example glassy or dull). Other descriptive terms for luster include: (a) vitreous – shines like glass, (b) waxy – looks like candle wax, or (c) earthy or "dull".

The ability of a mineral to transmit light through it is also important. Some minerals allow light to pass through them, while others do not. Some options for light transmission characteristics include: (1) opaque (does not transmit light), (2) transparent (perfectly clear, like glass), and (3) translucent (allows some light to pass through, but not images).

Refer to the appropriate mineral samples and answer the questions below.

A. Specimen 11.

_______________ Is this mineral opaque, transparent or translucent?

_______________ Is the luster metallic or non-metallic?

B. Specimen 2.

_______________ Is this mineral opaque, transparent or translucent?

_______________ Is the luster metallic or non-metallic?

C. Specimen 3.

______________ Is this mineral opaque, transparent or translucent?

______________ Is the luster metallic or non-metallic?

D. Specimen 15.

______________ Is this mineral opaque, transparent or translucent?

______________ Is the luster metallic or non-metallic?

Question to think about and answer (and talk to the instructor about if you need to): What do you think is the primary factor that controls the physical appearance of a given mineral? That is, why are different types of minerals, well, different from one another (**hint: see p. 77 lab manual**)?

1-3. Mineral Color (**p. 77 of lab manual**)

The color of a mineral may POSSIBLY be a diagnostic criteria to aid in identifying the specimen. Color is a function of the photo-atomic reaction of light energy with the atoms composing the substance. When all components of the visible spectrum of light are combined together, we refer to this as "white light". When select wavelengths of light are absorbed by atoms, and others are reflected, then "white light" is separated into it's component spectrum (i.e. colors of the rainbow ROY G BIV... you know).

So the color of a mineral (or any substance for that matter) represents the select wavelengths of light that are reflected back to our eyes. For example a "green" color suggests that all other wavelengths are absorbed at the atomic level, but only the green part of the spectrum is reflected to our eyes. In sum, mineral color is variable, depending on the specific atoms and elements that comprise the specimen (for example, iron tends to give a red coloration, copper a bluish-green, iron-magnesium a black, etc.).

Refer to the appropriate mineral samples and answer the questions below.

Specimen 3

______________ How many different colors of specimen 3 are evident in the sample box? List them.

____

____

____

Mineral specimens can be separated into general composition categories by observing whether their color is "light" (e.g. pink, white, clear) or "dark" (black, dark gray, dark greenish-gray). Fill in the table below for the listed mineral specimens, identifying them as either "light", "dark", or "clear".

Specimen No.	Color I.D.
3	______________
5	______________
1	______________
7	______________
12	______________
4	______________
22	______________

Think about this question again (do you have it down yet?): What do you think is the primary factor that controls the color (or any physical property) of a given mineral?

1-4. Mineral Hardness (Resistance to Scratching) (p. **80-81 of lab manual, Fig. 3.7, 3.8 and 3.9**)

Hardness of a mineral is it's resistance to scratching. Some minerals are very soft (scratch easily) while others are very hard (do not scratch easily). Hard minerals are commonly used as abrasives in industry (e.g. sand paper, diamond-tipped drill bits, etc.).

The relative hardness of a mineral can be determined by conducting a hardness test. Moh's hardness scale is set up from 1-10, with 1 being the softest mineral, while 10 is the hardest. Thus, harder objects will scratch softer objects, and the relative hardness of an object can be determined. For example, a fingernail has a hardness of 2.5, so it would easily scratch gypsum or talc (H= 2 and 1, respectively), but not quartz (H = 7).

Examine Figure **3.9 on p. 81** of the lab manual, and fill in the hardness of the items below.

Item	Moh's Hardness Value
Diamond	______________
Corundum	______________
Topaz	______________
Quartz	______________
Streak Plate	______________
Orthoclase	______________
Glass	______________
Apatite	______________
Iron Nail	______________
Fluorite	______________
Copper Penny	______________
Calcite	______________
Fingernail	______________
Gypsum	______________
Talc	______________

Using the hardness testing tools available in the lab, determine the relative hardness of the following specimens (e.g. if a specimen is harder than a penny, but softer than a nail, you could say H = 3.5-4.5. or you could say H < 2.5, etc.)

Specimen No.	Relative Hardness
3	______________
8	______________
22	______________
21	______________
1	______________

1-5. Mineral Identification with Identification Charts.

Now that you know some of the basic physical properties of minerals, let's try identifying them using flow charts on pages **90-92** of the lab manual. Use the following procedure to identify the mineral specimens listed below:

Step 1 - decide if the mineral is light colored or dark colored, metallic or non-metallic luster (align your observation with the top row of the **ID charts on p. 90-92**)

Step 2 - read the specimen description and compare to the appropriate chart, determine the mineral name. From left to right, make the following observations and compare to the key (**p. 90-92**): (a) hardness, (b) cleavage, (c) luster and other physical properties, and (d) name the mineral.

Look at the specimens and fill in the table below.

Specimen No.	Key Physical Properties	Mineral Name
3	Non-metallic, light color, fractures like glass, cleavage absent, may form crystals, may be colorless, smoky gray or pink, hardness >5.5.	______________
5	Non-metallic, light color, excellent cleavage, hardness >5.5, pink or white, sometimes green	______________
1	Non-metallic, light color, excellent 1 direction of cleavage, splits into thin sheets, hardness 2-2.5	______________
12	Non-metallic, dark color, hardness <5.5, black, excellent 1 direction of cleavage, splits into thin sheets	______________
8	Non-metallic, light colored, hardness <5.5, white, fizzes with drop of acid, 3 directions of cleavage not at 90 degrees (rhombohedrons)	______________
4	Non-metallic, light colored, hardness ~2.5, tastes salty, 3 directions of cleavage - breaks into cubes.	______________
2	Metallic, hardness > 5.5, brass yellow color, sometimes shows 5-sided polygonal crystals.	______________
15	Non-metallic, light colored, soft (H< fingernail), white to light gray color, sometimes needle-like crystals	______________

Part 2 - Overview of Rocks

A ES202 lab rock set is assembled in a tray at the back of the room. The tray consists of a number of rock specimens that are numbered on the bottom of individual boxes. Each box contains several samples of each specimen, giving multiple students access to a given specimen at a given instant.

Familiarize yourself with the specimen numbers and look at the variety of specimens that you see. Complete the tasks below. Place answers in the space provided.

2-1. Igneous Rocks

A. Igneous Rock Texture

Igneous rocks form from the cooling of magma (under ground) or lava (volcanic eruptions at the surface). As the magma cools, the mineral crystals that make up the rock take on characteristic sizes and shapes (**see Fig. 4.2 p. 114 for diagram of rock cycle**). One basic observation of rock materials is that of *Texture - refers to the size, shape, and arrangement of mineral crystals in a rock (***see Fig. 4.4 p. 118***).*

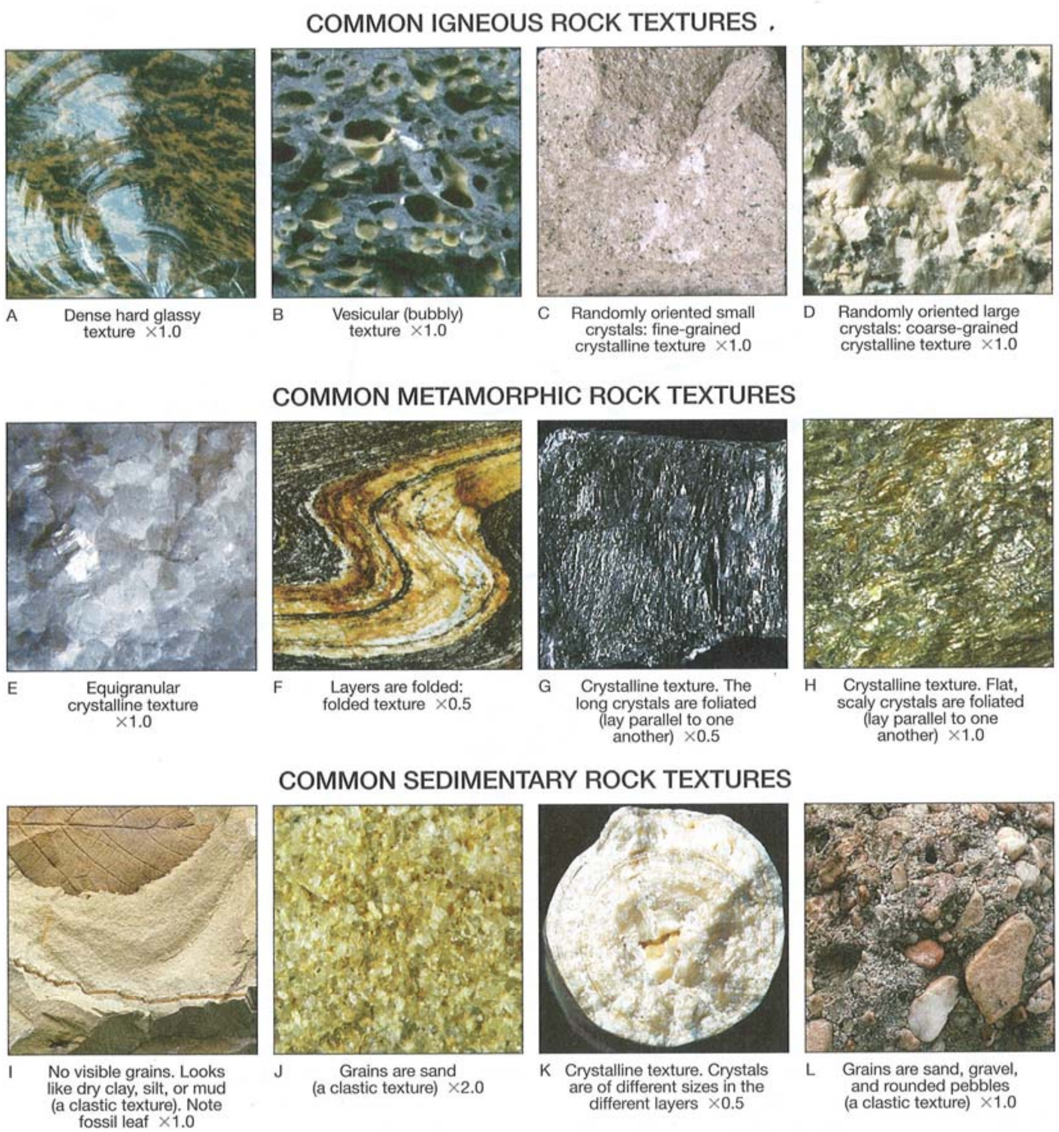


FIGURE 4.3 Some common textures of igneous, metamorphic, and sedimentary rocks. For use with Figure 4.4.

Examine the following specimens, and match their texture with the terms and descriptions below. Write the texture of the specimen in the space provided.

Textural Terms and the processes that form them (**refer to Fig. 5.4 on p. 136, read over p. 132-135**)

Phaneritic - can easily see separate mineral crystals with the "naked" eye. Phaneritic texture is associated with slow cooling magma beneath the Earth's surface.

Aphanitic - microscopic mineral crystals that can NOT be readily viewed with the naked eye. Aphanitic texture is associated with fast cooling lava ejected from a volcano.

Porphyritic - larger mineral crystals floating in a matrix of smaller mineral crystals. Porphyritic rocks represent two-phase cooling of magma, with some crystals formed before eruption (the larger ones), and then rapid cooling of the remaining lava, once ejected from a volcano.

Glassy - glassy appearance to rock. Represents very rapidly cooled lava... cools so rapidly that mineral crystals do not have time to physically form.

Vesicular - volcanic rocks with holes and air pockets throughout. Vesicular texture represents very gas-charged, frothy lava in which the gas rapidly escapes during cooling. The results is a very porous rock, with many air holes.

Fill in the Table Below **Using Fig. 5.4 on p. 136 for Comparison**

Rock Specimen Number	Texture (match from above)	Interpretation of how the rock formed (match with above)
1		
9		
5		
6		
10		
4		
7		

B. Igneous Rock Composition and Rock Color

Igneous rocks are comprised of common silicate rock-forming minerals. The overall color of the rock is directly related to the types of minerals that comprise the rock. Dark minerals will make for a dark rock, and vice versa. Since this is only an introduction to rocks and minerals, we are probably not that great at mineral identification yet, but we can use the color of the rock to make some generalizations about what it is made of.

Refer to pages **136-137** of the lab manual. The Figures show the general relationships between rock color, mineralogy, and rock classification. The three basic color - mineral composition options are:

(1) Felsic Igneous Rocks - made up of primarily light colored minerals (white, pink, light gray), with less than 15% dark minerals.

(2) Intermediate Igneous Rocks - "salt and pepper" appearance, medium gray colors, made up of admixtures of light and dark-colored minerals (15-45% dark minerals).

(3) Mafic Igneous Rocks - made up mostly of dark-colored minerals (black, dark-green, dark gray).

Match the terms felsic (light), mafic (dark), and intermediate with the following specimens, fill in the table below.

Rock Specimen Number	Rock Color / Mineral Composition
1	______________________________
9	______________________________
5	______________________________
6	______________________________
4	______________________________

C. Igneous Rock Classification and Naming

Igneous rocks are classified and named on the basis of their (1) mineral composition (i.e. rock color), and (2) texture (what the mineral crystals look like).

Examine the specimens listed below, use the summary descriptions, and look at **Figure 5.4 on p. 136** to derive the name of the rock. Fill out the table... you know what to do.

Rock Specimen No.	Summary Description	Rock Name
1	Felsic (light colored minerals), phaneritic (coarsely crystalline)	______________________
9	Mafic (dark colored minerals), phaneritic (coarsely crystalline)	______________________
5	Mafic (dark colored minerals), aphanitic (finely crystalline)	______________________
6	Intermediate (medium gray), porphyritic (larger black crystals in aphanitic matrix)	______________________
10	glassy volcanic rock	______________________
7	vesicular texture, mafic color (dark minerals) aphanitic mineral matrix (finely crystalline)	______________________

2-2. Sedimentary Rocks

We are not going to spend much time with sedimentary rocks here, since we will focus on them in the next two labs. However, here's a couple quick questions to get you thinking about them, answer in the space provided. Use your lab manual, **p. 114 Fig. 4.2 Rock Cycle, p. 157 description of sedimentary rocks, and p. 165 Fig. 6.10 block diagram of sedimentary environments,** answer the following questions.

A. How are sedimentary rocks different from igneous rocks? Which type of rock would you consider the "parent" rock (i.e. which rock type precedes the other in the life cycle of the Earth)?

B. What is the difference between detrital, chemical, and biochemical sedimentary rocks. Focus you answer on how these different types of sedimentary rocks form.

2-3 Metamorphic Rocks

Metamorphic rocks result from the physical and chemical alteration of pre-existing rocks. The primary agents of metamorphism are (1) heat, (2) pressure, and (3) chemically active fluids (**refer to p. 187-189 for introduction to metamorphic rocks and Fig. 7.1 p. 188 for diagram**). In essence, any pre-existing rock can be metamorphosed by heating it up, squeezing it (pressure), or circulating hot, chemically-charged fluids through it. With heat and pressure over long periods of time, a rock can be altered with respect to it's composition (mineralogy) and texture. The "parent" of a metamorphic rock refers to the type of original, pre-existing rock that was altered to form the new metamorphic rock product.

A. Metamorphic Textures (see **p. 192-195** of lab manual)

Like igneous and sedimentary rocks; the size, shape, and arrangement of minerals can be used to classify and organize metamorphic rocks.

There are basically two textural options for metamorphic rocks:

(1) Foliated - the rock has a layered or color-banded appearance (color banding = alternating layers of light and dark minerals)

(2) Non-Foliated - the has a massive appearance (without distinct layering or color banding).

Identify the following specimens as either foliated or non-foliated:

Rock Specimen No.	Metamorphic Texture
2	______________________
1	______________________
3	______________________
5	______________________

B. Naming and Classifying Metamorphic Rocks

Use the Metamorphic Rock Classification Chart in **Fig. 7.16 (p. 197)** of the lab manual to name the following specimens. Fill in the table below (hint: use the summary descriptions below to help you... you've done this before!)... see next page for table. Work the ID charts from left to right across the page: (1) observe the texture, foliated or non-foliated, (2) Observe color and mineral properties contained in the rock, (3) name the rock, and (4) interpret the metamorphic history and parent materials of the rock

Specimen No.	Summary Description	Metamorphic Rock Name	Parent Rock
2	Foliated, color banded with alternating light and dark colored minerals, medium- to coarse grained	______________	________________
1	Non-foliated, massive texture, medium grained, sugary / crystalline appearance, fizzes with drop of HCl	______________	________________
3	Non-foliated, massive texture, fine grained, sandy-like texture, hard	______________	________________
5	Foliated (thin layers), dull luster, breaks into thin layers	______________	________________

Part 3 - Overview of Plate Tectonics

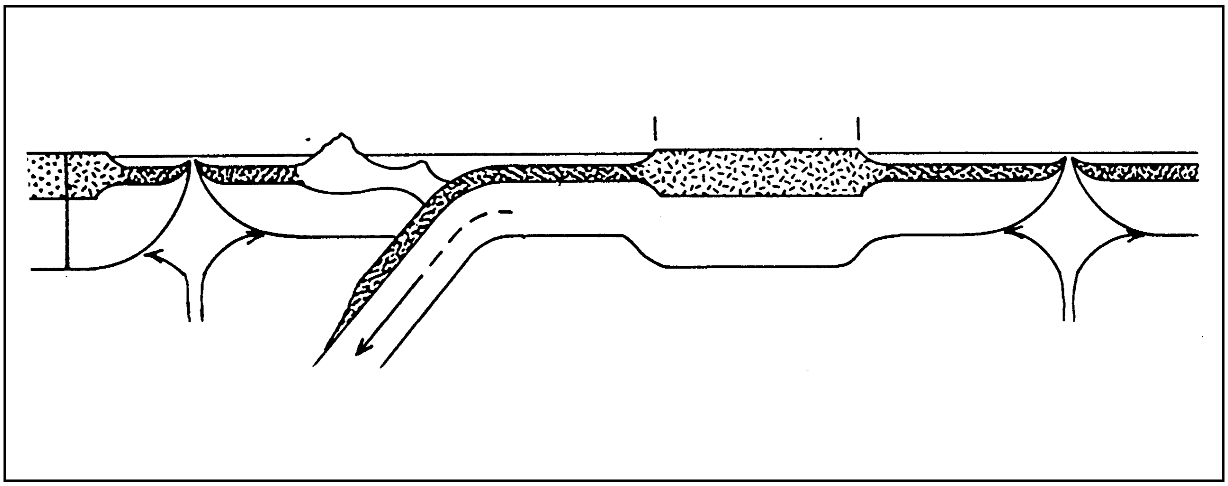
3-1. Using your lab manual (**Fig. 2.2, p. 42**) and text book, DRAW and LABEL a 3-D BLOCK diagram of two converging tectonic plates - one an oceanic plate, the other a continental plate (i.e. a subduction zone). Include in your drawing the descending oceanic slab, the relative directions of plate motion, the volcanic arc on the over-riding plate, areas of earth quakes and magma generation. LABEL ALL PARTS OF YOUR DRAWING.

3-2. Using your lab manual (**Fig. 2.2, p. 42**) and text book, DRAW and LABEL a 3-D BLOCK diagram of two diverging oceanic plates, at a mid-ocean spreading center. Include in your drawing plate thickness, fracture zones, areas of earth quakes and magma generation. LABEL ALL PARTS OF YOUR DRAWING.

3-3. Using the following list, label the tectonic cross-section below (use your lab manual **Fig. 2.2, p. 42**)

A. Continental Crust
B. Volcanic Arc
C. Subduction Zone
D. Zone of Divergence

E. Spreading Center
F. Oceanic Crust
G. Zone of Convergence
H. Mantle Convection Cell
I. Asthenosphere
J. Base of the lithosphere
K. Sea Level
L. Very Young / Recent Oceanic Crust
M. Mid-Ocean Rift
N. Accretionary Wedge



3-4. Using the attached world map worksheet, complete the following exercises as directed. For reference, use the global tectonic maps in the lab, and the tectonic maps in your lab manual (**p. 48, Fig. 2.5**) and text book.

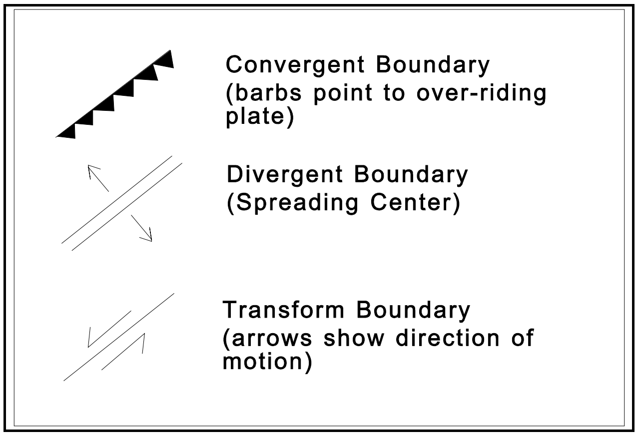
A. Identify and label the following continents and ocean basins on your working map (Use a pencil for all your work).

<u>Continents</u>
North America
South America
Greenland
Eurasia
Africa
Australia
Antarctica

<u>Oceans</u>
Atlantic Ocean
Indian Ocean
Pacific Ocean

B. Identify and label all of the major global lithospheric plates and their corresponding plate boundaries.

(i). Draw in plate boundaries identifying them as either convergent (subduction zone or continental collision zone), divergent (spreading or rift center) or Transform. Use the following symbols to represent the plate boundaries on your working map:



Generalize the boundaries, showing only major boundary type (i.e. generalize in spreading centers while ignoring minor transform faults offsetting them, show only major transform fault boundaries where defineable)

C. Label the plates with the appropriate number code as follows:

1. North American Plate	8. Anarctic Plate
2. Juan de Fuca Plate	9. Scotia Plate
3. Caribbean Plate	10. Eurasia Plate
4. Cocos Plate	11. Arabian Plate
5. South American Plate	12. African Plate
6. Nazca Plate	13. Philippine Plate
7. Pacific Plate	14. Indo-Australian Plate

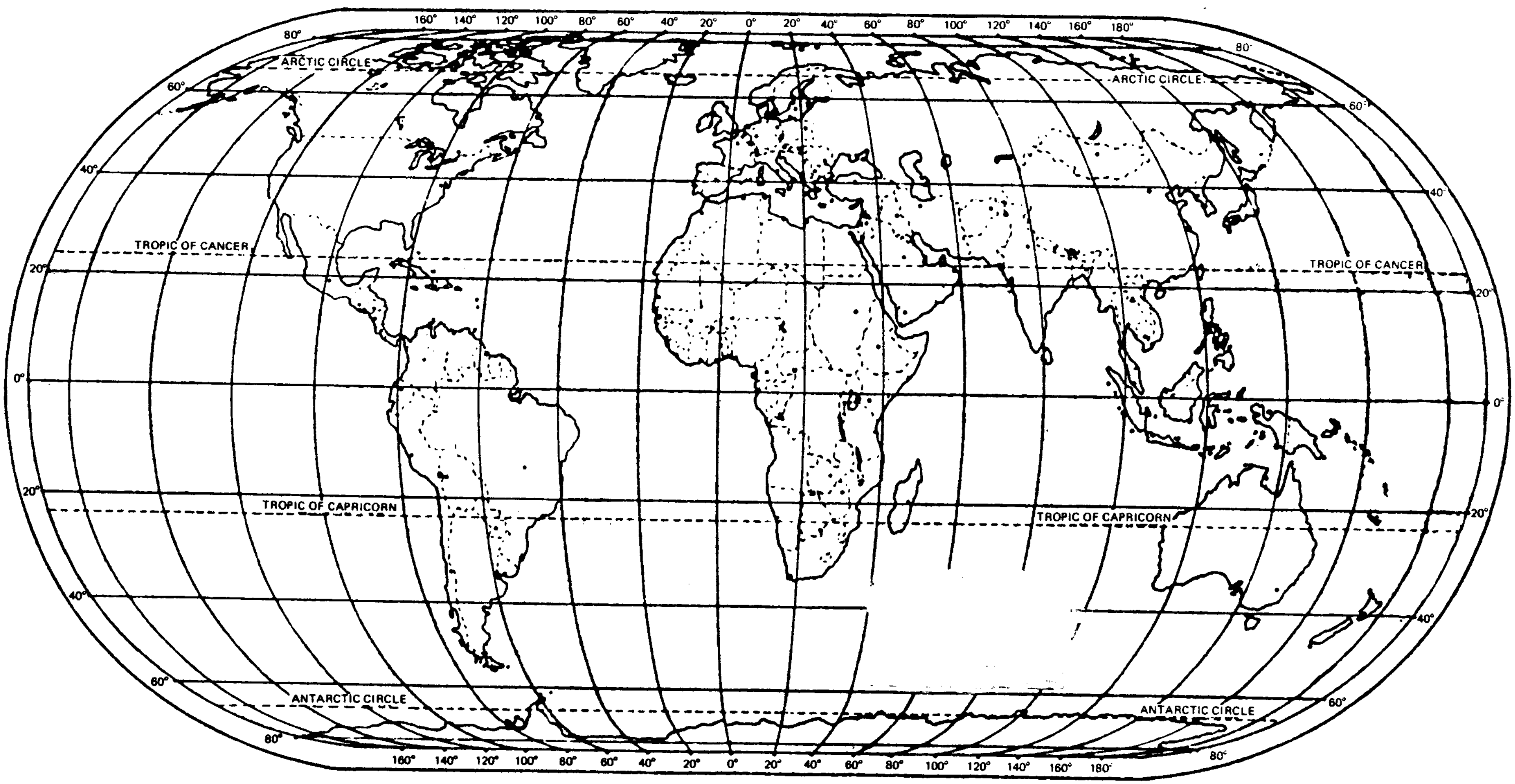
D. For purposes of discussion, assume that the North American Plate is stationary. Given this assumption, draw arrows on the other plates showing their relative direction of movement. Remember that spreading centers move away from one another, and convergent plates toward one another.

E. Using the available maps and classroom resources, locate the following prominent physical geographic features, show their approximate location with the appropriate letter code.

A. Cascade Mountains (volcanic)	G. Japan Volanic Islands
B. New Zealand (volcanic)	H. Red Sea (sub-sea volcanism)
C. Iceland (volcanic)	I. East African Rift (volcanic)
D. Hawaiian Islands (volcanic)	J. Himalayas (compressive faults)
E. Alps (compressive faults)	K. Andes Mountains (volcanic)
F. San Andreas Fault	

4. Using your plate tectonic maps in the lab and textbook, identify the type of tectonic processes these features are associated with (e.g. spreading center, subduction zone, transform fault, intraplate position)

Physical Feature	Tectonic Process	Physical Feature	Tectonic Process
Cascades	______________________	San Andreas	______________________
New Zealand	______________________	Japan	______________________
Iceland	______________________	Himalayas	______________________
Hawaii	______________________	Andes Mountains	______________________
Alps	______________________		



ARCTIC CIRCLE
TROPIC OF CANCER
TROPIC OF CAPRICORN
ANTARCTIC CIRCLE