Department of Earth Sciences
City College of San Francisco

PHYSICAL GEOLOGY
GEOL10 HANDOUTS

INSTRUCTOR: DE VECCHIO

July 22, 2013

<u>Class Policies</u> Physical Geology Lecture (GEOL10)

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Office hours: Mon. 11-12 pm and Wed. 12:30-1:3or by appont. Earth Science website: http://www.ccsf.edu/Earth
Grading scale: A=90-100%; B=80-89%; C=70-79%; D=60-69%; F=<60%.
Grading: Your grade is equally divided between each exam and the total for all your daily quizzes. Specifically, there are 3 exams in the class, each is worth 25%, with the remaining 25% coming from weekly your quizzes.
In-class iClicker questions will be incorporated into your quiz grades and can only help your grade.

Time required (units) – For each lecture unit, expect to put in 1 hour in lecture and 2 hours in homework for an average grade of a C. For example, a 3-unit lecture class requires 3 hours in class and 6 hours homework weekly for a C average. Each student will need to put in more or less time, depending on his or her background and study techniques. Study session schedule at http://www.ccsf.edu/Earth

Class prerequisites – There are no official prerequisites. However, without the following basic skills, you will need extra help and time in this class: comprehensive reading, writing, algebra, basic geometry, and basic chemistry. If you are weak in these areas or have any questions at any time, come to office hours, see the tutor, attend study sessions, make an appointment, or e-mail me. I'm here to help!

Handouts and Lectures– All class handouts must be purchased through the bookstore and can also be found online at: http://www.surfaceprocesses.com click on Teaching then Physical Geology 2012. Lectures will also be posted each day following class at the same web location as the handouts. If you miss class, please catch up quickly on your own or with the help of your classmates so you don't fall farther behind. It is essential that you **keep all materials in one notebook for easy reference and bring it with you to class. You will need to access these handouts throughout the semester, easily, during class.**

iClicker – It is required that you have an iClicker response system for this class. We will use these during class to track attendance, assess homework completion, and track classroom participation. You must have it with you each class. If you are worried about forgetting your iClicker, you can label it with your name and store it in the classroom. We do have spare units we will loan out in emergencies (one emergency per students per semester). If there is a financial reason why you cannot purchase an iClicker, we also have a few loaners. Please contact me ASAP.

Weekly HW – #1: Read assigned new chapters. Learn vocabulary words and begin thinking about the new chapter questions. Start writing out answers to the ones that you pick up from the reading, especially the ones marked with an asterisk (*) (you won't be able to answer all of them). The more time you put in ahead, the more you'll get out of the lecture. Note: you will demonstrate your completion of this task through a daily quiz. #2: Review previous week's chapter questions and make sure you have a written answer (in your own words) to each question. Seek help from me or classmates for material that still hasn't clicked or just to help review. #3:). **WHILE DOING HOMEWORK, YOU CAN PREPARE A SINGLE PAGE OF NOTES TO USE ON QUIZZES – one page – your own writing (or typing). You will attach this page to the quiz. You must transcribe anything you use from the book or my handouts.**

Attendance – Your attendance will be tracked through your iClicker in-class responses. If you are absent for more than three classes (determined by quiz scores) or miss an exam (without immediately making contact to discuss your options), you WILL be dropped. I will not keep students enrolled just for financial aid or student visa status – if you want to stay enrolled, keep attending and contributing. **<u>You must take exams and quizzes on scheduled days.</u>** Exceptions are made only for extenuating circumstances and only when alternate arrangements have been made prior to the exam/quiz or as soon as possible after.

Cheating – The highest level of integrity is required for all quizzes and exams. Anyone found cheating will receive a zero on the exam or quiz and face disciplinary action at the college.

Loaner books – See me if, at any time, you need a temporary loaner book (NOT class text, but similar).

Seeking Help – If you have questions, come to office hours, see the tutor, attend study sessions, make an appointment, or e-mail me. It's your responsibility to seek needed help. We're here if you're ready!

Cancelled classes – If class is cancelled, for any reason, keep up with homework assigned on syllabus.

Cell phones/pagers – Please turn all electronic devices off before coming to class.

Sleeping in class – I assume your bed is more comfortable than the classroom. Please stay at home if you're too tired to stay awake in class; otherwise you drain my energy, and your fellow students suffer.

Leaving class – When arriving late to class or leaving class while it is in session, please be as nondisruptive as possible. There is no need to ask permission or give excuses. You're all adults, so I assume you're making the best choices for yourself.

Eating and drinking – No gum chewing in the room at all. No food or spillable drink containers on the tables or desks during class. Feel free to bring food, but eat it only outside the classroom. Sealed water and coffee mugs will be aloud at your desk.

Chapter Questions Handout – Are all included in the manual or will be posted at http://surfaceprocesses for you to download and print. For each chapter, you will receive a list of questions, from which most future exam questions on that chapter will come. BEFORE attending class each week, carefully and thoroughly read the assigned chapters and review the chapter questions. The more you read and study the material before class, the more you will get out of class, and the better you will do on exams. All classroom activities assume that you have taught yourself all you can on your own first and that you have a basic understanding of the material. If you do not prepare well enough, you may have difficulty following and participating in classroom discussion. If at the end of the week you still have questions or doubts on any of the topics, seek help ASAP. Start early. **These questions will appear on weekly quizzes and the exams.**

Quizzes – Starting on page 5 of the class manual you will find a vocabulary list for each chapter that that is keyed to the syllabus and the weekly Quizzes. Prior to each week's class, as you read the new chapter, learn the vocabulary and review the questions we will be covering – try to learn as much as you can on your own. Also every week, review the material we covered the week before (answers to the previous week's chapter question sheet). The first class period that begins with a new chapter will start with a quiz (see syllabus) that takes the first 10 minutes of class. **NOTE: If you show up late, no guarantees you can still take the quiz – the quiz ends when everyone finishes or 10 minutes after class starts, whichever occurs first!** ½ of the quiz content covers vocabulary for new material (matching); the other ½ covers chapter questions from the previous week (old material, short-answer). (Note: there will be a few extra-credit questions on the quiz from the new chapter – any starred question from the chapter question sheet – asked in short answer format.) You may start quizzes up to **10 minutes early**. If you cannot attend class for legitimate reasons, you may make up the quiz ahead of time. (You cannot take quizzes after the fact, only on time or before!). If you are late to class, you miss the quiz. To accommodate emergencies, I drop your two lowest quiz grades. If you have difficulties making quizzes or are not doing well on quizzes, please see me ASAP to discuss. ***Quizzes occur daily on the first day the class meets.*** **WHILE DOING HOMEWORK, YOU CAN PREPARE A SINGLE PAGE OF NOTES TO USE ON QUIZZES – one page – your own writing (or typing). You must transcribe anything you use from the book or my handouts.**

Pass Sheets and Exams – Included on the manual are Pass Sheets for each of the three exams – with ~70% of the questions that will be on the exam. As long as you can answer these questions correctly on the exam, you will get the lowest C. All additional exam questions that you answer correctly will help you to raise your grade from a C to a B (80-89) or A (90+). **YOU MUST BRING YOUR COMPLETED PASS SHEET WITH YOU TO TAKE THE EXAM – NO SHEET – NO EXAM.** If the sheet is missing any answers – any blanks – you will not be able to take the exam. (The pass sheet is your ticket, but you cannot use it ON the exam.)

Exams are closed notes, closed book. You will have the entire period to complete the exam, which will consist of questions from the Pass Sheet, multiple choice, and short answer questions that cover topics that have appeared on chapter question handouts. **NO DICTIONARIES OR ELECTRONIC DEVICES ALLOWED DURING EXAMS OR QUIZZES *(CALCULATORS OK IF NECESSARY, BUT UNPROGRAMMABLE ONES ONLY).*** Please ask me during the exam if you don't understand a question. You will need to bring your own **pencil** and eraser. Although the first 2 exams are not comprehensive and exams will focus on the chapters covered since the last exam, you will need to remember some are the basic information from previous exams in order to answer some questions. **Final note: we do NOT go over pass sheets in class – these are for you to complete on your own, with your classmates, or in office hours with me.**

Getting the best grade – Follow this plan to get the highest grade possible:

1. Teach yourself BEFORE we go over the material in class. Read each chapter thoroughly. Learn the key words and compose and write answers to as many of the questions on the chapter handout as you can on your own. If you do this before each new chapter you will get an A on all of the Quizzes which will lock-in 25% of your course grade.
2. Use class to deepen your understanding. Ask questions, take notes on the correct answers to the questions, and participate in in-class discussions and activities. Note: You will not have time during class to write verbatim what you hear in lecture. If you need such detail, bring a tape recorder.
3. Review material after class. Review and study question handout (and correct answers) at the end of each week. If you are missing any answers or don't feel confident about some of your answers, compare with other students in the class and/or check the answers with me. **Be sure you have all of your answers on the PassSheets are correct before you take the exam.**

Please keep all class materials in one notebook for easy reference.

GEOL 10: Physical Geology
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unconformity (generic term)

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stromatolite (Fig. 8.33)
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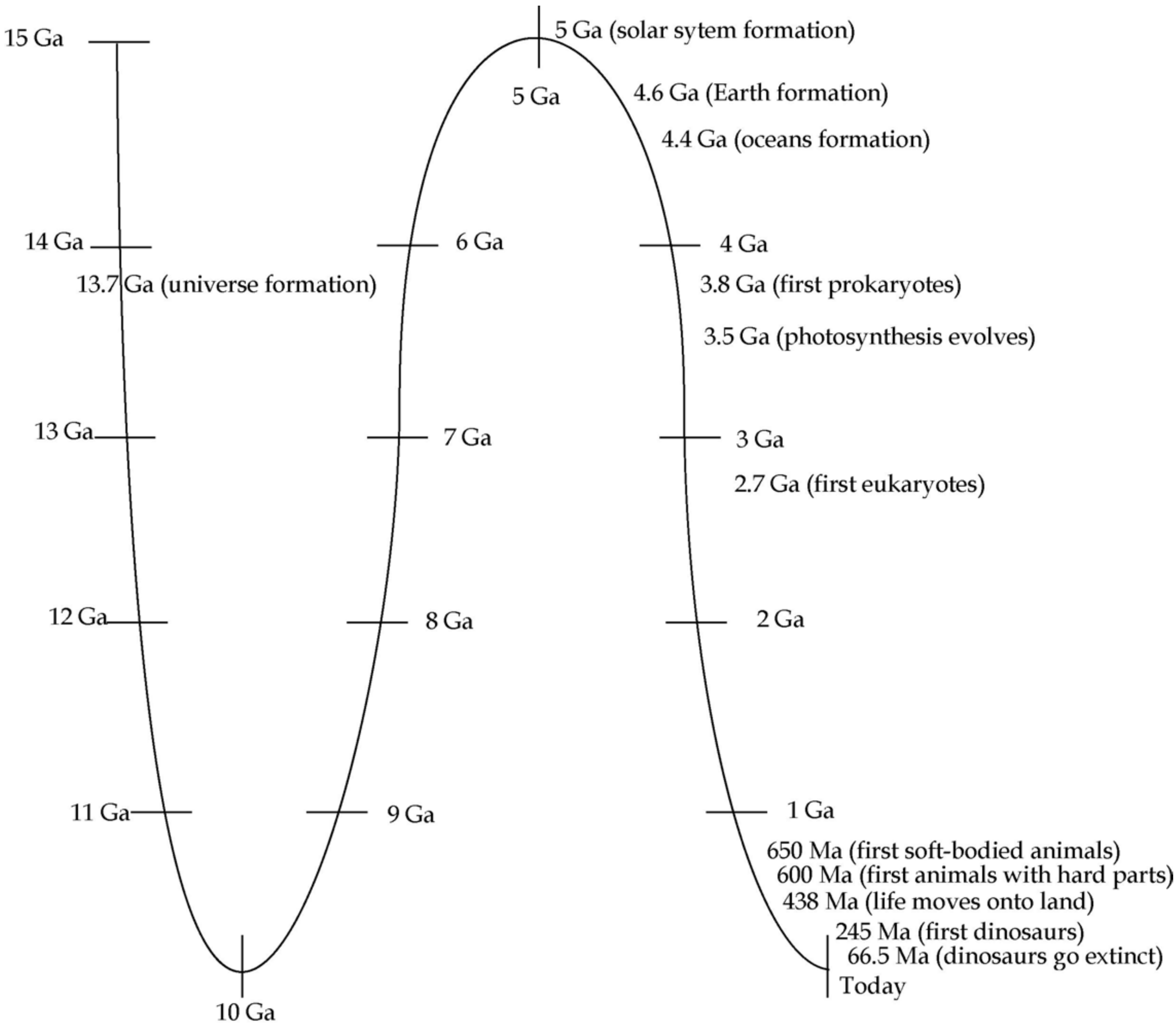
<u>Chapter 1a (p. 2-20) Questions</u> — Earth First Look Chapter Questions

1. What is the age of the Universe?
2. **When did Earth and our solar system form?
3. **What is the solar nebula hypothesis and what are the 5 stages of that lead to the modern solar system (Homogenous to Heterogeneous)?
4. How do we know Earth's age?
5. **Explain how the composition of Earth evolved after forming (Homogenous to Heterogeneous).
6. Understand the concept of differentiation (Homogeneous to Heterogeneous).
7. Compare and contrast igneous, sedimentary, and metamorphic rocks.
8. Know the rock cycle.
9. Know how Earth's moon formed and the evidence for why scientists believe it formed this way.
10. What is the difference between felsic rocks and mafic rocks
11. (Basic Physics) Understand density and why any substance floats, sinks or rises.
12. **How is isostatic equilibrium of Earth's crust similar to the floating equilibrium of a cargo ship?



* Ma = millions of years old; Ga = billions of years old.

Brief History of Earth

10-25 Ka	Wisconsin ice age (most recent one; land bridges form and humans migrate from Asia into North America)
100-300 Ka	Homo Sapiens first appear.
400 Ka	San Francisco Bay forms.
1.6 Ma	Period of frequent ice ages begins and continues to today.
2-4 Ma	Ancient Hominids first appear.
50-25 Ma	San Andreas Fault forms as North American margin stops subducting.
63 Ma	Primates evolve.
65 Ma	Dinosaurs and other organisms go extinct making the way for the Age of Mammals.
145 Ma	First mammals, including platypus, shrews, and opossums.
152 Ma	First birds evolve from small, fast-running dinosaurs.
225 Ma	**Pangaea**, the most recent supercontinent completes its formation, and then begins its breakup (to create the Atlantic Ocean). Two halves: **Gondwanaland** (Australia, India, Africa, S. American, Antarctica) and **Laurasia** (N. America, Greenland, Europe, and Asia).
230 Ma	First dinosaurs, reptiles that distinguished themselves from others by standing upright on two legs.
240 Ma	First vertebrates to fly – the Pterosaurs, dinosaur cousins.
245 Ma	The largest mass extinction in Earth's history. Over 75% of all marine groups eliminated, making way for the Age of Dinosaurs
350-290 Ma	Giant Swamp Forests thrived in lowlands at the edges of rivers and seas (like today's Louisiana bayous). Tropical climates encouraged dense growth of ferns, tree ferns, and club-mosses. The buried material from these forests eventually became much of the world's current coal resources.
400 Ma	First lungs.
430 Ma	First jawed fish.
438 Ma	First plants move onto land, followed within 10 million years by animals (aquatic scorpions and other arthropods).
480 Ma	Large continent known as **Gondwanaland** forms from the collision of Australia, India, Africa, South America, and Antarctica. Pacific Plate subducts under North America's western margin. The western margin grows through accretion of oceanic rocks and islands (**terranes**).
520 Ma	First vertebrates (cartilaginous fish with tails and fins).
570 Ma	First organisms with hard body parts (shells,, exoskeletons). Beginning of the Age of Trilobites. Also existing early on were brachiopods and ammonites.
670 Ma	First multicelled animals evolve: Ediacaran fauna, soft-bodied marine animals that get their food primarily from small algae.
700 Ma	**Rodinia** breaks up into pieces.
1 Ga	Sexual reproduction begins leading to an increase in the rate of evolution. Red Beds stop forming in large amounts and free oxygen begins to accumulate in the atmosphere. The atmosphere begins to evolve to one closer to today's: 80% Nitrogen, 20% Oxygen. Eventually enough oxygen accumulates in the atmosphere that UV radiation interacted with it in the upper atmosphere, split the molecules, and produced **ozone**, a gas that then acted as a UV shield, protecting life on Earth's surface.
1.2 Ga	**Rodinia**, the oldest known supercontinent, forms through collision of Earth's plates. Plate Tectonics has likely been active for billions of years.
2 Ga	**Red Beds** form on land. These beds are land-based rust piles that take the place of the oceanic BIFs as free oxygen now leaves the oceans and enters the atmosphere. The Red Beds absorb most of the available oxygen.
2.7 Ga	**Eukaryotes** evolve: organisms with a nucleus.
3.8-2 Ga	**Banded Iron Formations (BIFs)** form in a long-lived oceanic rust storm. Earth's oceans would have had a lot of dissolved iron, due to the accumulation of hundreds of millions of years of rock weathering and underwater volcanic eruptions. Newly formed oxygen, released from photosynthesis, readily and quickly combined with the iron to form layers of rust.
3.5 Ga	First prokaryotes to perform **photosynthesis**: energy derived from sunlight is used to make their food. These organisms, cyanobacteria that create mounds called **Stromatolites**, lived in mucous layers to avoid UV-radiation damage by the sun. Ocean and atmospheric chemistry begins to change as O_2 is added and CO_2 removed. (Photosynthesis: $6H_2O + 6CO_2$ + sunlight = $C_6H_{12}O_6$ (sugar) $+6O_2$.)

3.8 Ga	The earliest known life forms develop, in the oceans where they are hidden from the sun's ultraviolet rays (no ozone layer yet, because no oxygen in the atmosphere). These early bacteria were known as **prokaryotes**: single celled organisms with no nucleus, otherwise known as bacteria. These early life forms were likely **chemosynthetic**, making food from energy derived from gases emitted at hydrothermal vents on the bottom of the seafloor.
4.4 Ga	Earth's surface cools enough for a solid crust to form. Earth's atmosphere (accumulated gases from **volcanic outgassing** and comets) contains (in decreasing order) carbon dioxide, nitrogen, water vapor, methane, ammonia, carbon monoxide, sulfur dioxide, hydrogen sulfide, and hydrogen cyanide. Because of the solid cooler surface conditions, much of the atmospheric water now rains down and fills in basins to form the first oceans.
4.5 Ga	A Mars-sized object crashes into Earth creating debris that ends up in orbit around the Earth, eventually coalescing through accretion to form the **Moon**.
4.6 Ga	As the solar disk cools down, orbiting material collides and clumps to form larger objects (**accretion**). Continued accretion led to larger bodies with higher gravity that swept up more material within their orbits and ultimately became **planets**. Not all the material got swept up in this process. A large belt of leftover rocky debris – **asteroids** – exists between Mars and Jupiter. A belt of leftover icy debris – **comets** – orbits in the outer solar system. At this point, the interior of the Earth is mostly molten from the heat of accretion. **Density stratification** occurs: dense material, like iron, sinks to form the **core** while less dense material rises to form the **crust**; the remainder becomes the **mantle** layer. All planets are hot from the accretion process. Volcanic activity and continual meteorite collisions dominate the surface. Gases from volcanoes and comets form an early, hot, toxic, atmosphere.
5 Ga	Debris from past supernovas is perturbed, likely by nearby star activity, and starts to clump together to form a new star – a single hot, spinning mass of gas – our proto Sun. The gas giants (Jupiter, Saturn, Neptune, Uranus) began forming soon after the Sun started coalescing, through similar processes. Large clumps of H and He separately coalesced and contracted, increasing in density and attracting material to become gas giant protoplanets. They are not stars because they never grew big enough and hot enough for fusion to occur in their cores. Eventually the material in the proto Sun completely condenses, fusion starts, and our **Sun** forms. As the Sun spins, the surrounding matter flattens into a rotating disk and begins to condense into solids, liquids, and gases – all very hot! It was too hot near the Sun for ices and many gases (like water, ammonia, and methane) to be stable, so condensates near the Sun consisted of iron oxides, aluminum oxides, and silicates – high-density minerals stable at high temperatures. In the cooler outer solar system, all materials were stable and condensed alongside each other. Hence, the inner rocky planets formed from the accretion of rocky material, whereas the moons, comets, and gas giants of the outer solar system formed (or completed their formation) from the accretion of all materials.
12.7-5 Ga	Throughout most of the life of a star, deep in their cores, H nuclei are fused to produce He and energy. Stars "shine" because they are radiating the energy produced from this nuclear fusion. High-mass stars burn the hydrogen fuel in their core rapidly and are short lived—the largest lasting only 10 million years. Low-mass stars burn their fuel slowly—the smallest lasting hundreds of billions of years. (Note: our **Sun** is medium sized and will last 10 billion years.) Once the H is nearly used up, He atoms begin to fuse, and the core temperature of the star rises dramatically. As temperatures rise higher, elements of successively higher mass—like carbon, nitrogen, and oxygen—are produced through fusion. Stars that are ten times more massive than the Sun can create elements as heavy as iron. Eventually the energy produced can't be shed fast enough; a high-mass star explodes in a **supernova** event, ejecting much, if not all of its matter, and producing a **supernova remnant**. Elements up to uranium can form in the supernova's blast waves. New stars eventually form from supernova remnants. Through repeated generations of star birth and death by supernova, these remnants can be enriched enough in heavy elements to form planets. *(Based on the abundance of heavy elements in our solar system, our Sun is likely a third- or fourth-generation star.)*
12.7 Ga	The universe is no longer smooth and uniform. High-density regions of H and He gas generate gravitational fields – the more mass, the more gravity. The more gravity, the more mass from surrounding areas is pulled in. Eventually localized regions condense under their own weight. Gravitational energy is converted into heat – temperature rises. Once the size of this dense spinning sphere of gas is great enough, and its core temperature rises above 10^6 K, nuclear fusion begins – primarily the fusion of H to produce He and energy. As this newly created energy radiates outward, a shining **star** is born. When billions of stars orbit a shared center of gravity, we call them a **galaxy**. There are hundreds of billions of galaxies in the observable Universe.
13.7 Ga	**Big Bang**: the universe is born in an instant in time and expands outwards from one infinitesimally small point. Original material = very high energy (hot) subatomic particles. Universe inflates and cools until protons, neutrons, and electrons form, and matter is governed by the laws of physics as we know them. 380 m.y. later, the universe is 75% Hydrogen (H) and 25% Helium (He) gas.

*Age is when division begins: Ka = thousands of years old; Ma = millions of years old; Ga = billions of years old.
For more information, see http://www.ccsf.edu/TimeLife.

Geologic Time Scale (not to scale)

Eon		Era	Period	Epoch	Age	Events
Phanerozoic		**Cenozoic**	Quarternary	Holocene	10 Ka	
				Pleistocene	1.6 Ma	Wisconsin ice age (10-25 Ka) Fort Funston marine terrace formed (100 Ka) (CALIF) Illinoisian ice age (130-270 Ka) Homo Sapiens first appear (100-300 Ka) Eruption of Mt. Lassen spews ash across state (400 Ka) (CALIF) Kansan ice age (350-600 Ka) San Francisco Bay forms (400 Ka) (CALIF) Nebraskan ice age (1-2 Ma) Merced formation begins accumulating (1 Ma) (CALIF)
			Tertiary	Pliocene	5.3 Ma	Ancient hominids first appear (3.4-3.8 Ma) Purisima Formation deposited (Moss Beach) (3-5 Ma) (CALIF) Uplift of Coast Ranges and Mt. Diablo begins (5 Ma) (CALIF)
				Miocene	23.7 Ma	
				Oligocene	36.6 Ma	San Andreas fault formed (25 Ma) (CALIF)
				Eocene	57.8 Ma	
				Paleocene	66.4 Ma	
		Mesozoic	Cretaceous	Upper	97.5 Ma	Last dinosaur (66.4 Ma) Montara Mountain granite forms in Sierras (88 Ma) (CALIF) First modern mammal (90 Ma)
				Lower	144 Ma	Marin Headlands Terrane accretes in Franciscan Subduction Zone (100 Ma) (CALIF)
			Jurassic		208 Ma	Pangaea break up (Atlantic Ocean) (175 Ma) Franciscan subduction zone (65-175 Ma) (CALIF) Marin Headlands Chert and Shale accumulate on seafloor (100-200 Ma) (CALIF) Marin Headlands Pillow Basalt forms at spreading center (200 Ma) (CALIF)
			Triassic		245 Ma	Pangaea formation is complete (225 Ma) Smartville subduction zone (175-225 Ma) (CALIF) First dinosaur (228 Ma)
		Paleozoic	Permian		286 Ma	Mass extinction event (245 Ma)
			Carboniferous	Pennsylvanian	320 Ma	First reptiles
				Mississippian	360 Ma	First bony fish (360 Ma)
			Devonian		408 Ma	First amphibians Sonomia subduction zone (225- 375 Ma) (CALIF) First forests and insects (400 Ma)
			Silurian		438 Ma	First land plants
			Ordovician		505 Ma	First primitive fishes
			Cambrian		570 Ma	First trilobite (540 Ma) First organisms with shells (570 Ma)
Precambrian	Proterozoic	Late			900 Ma	First multicelled organisms (670 Ma) North American western margin is passive (900-400 Ma) (CALIF)
		Middle			1.6 Ga	
		Early			2.5 Ga	First one-celled organisms with nucleus (2.2 Ga)
	Archean	Late			3.0 Ga	
		Middle			3.4 Ga	
		Early			3.8 Ga	First evidence of photosynthesis (stromatolites) (3.5 Ga) First evidence of life (bacteria – single celled with no nucleus) (3.8 Ga)
	Hadean				4.6 Ga	Formation of oceans and oldest known rocks (4.4 Ga) Formation of Earth and its immediate differentiation into layers (4.6 Ga)

*Age is when division begins: Ka = thousands of years old; Ma = millions of years old; Ga = billions of years old.

<u>Chapter 11 Questions</u> — Earth's Interior

1. **Review these properties of Earth's interior compositional and physical layers. While you do not need to memorize thicknesses or densities, you should how these values compare relatively to one another. **Know why Earth is also subdivided into different rheological states. Understand the different composition and state (rheology) of the different layers, and be able to draw a picture, to scale, of all of Earth's layers. *Be able to compare and contrast oceanic crust and the continental crust.*

Earth's Compositional Layers

Layers	Thickness	Composition	Density
Oceanic crust	3-10 km	Si, O, Fe, Mg, Al = Basalt	2.9 g/cc SOLID
Continental crust	30-50 km	Si, O, Al = Granite	2.7 g/cc SOLID
Mantle	2900 km	Mg, Fe, Si, O	4.5 g/cc SOLID
Core	3500 km	Fe, Ni (S, Si)	11-16 g/cc LIQUID

Earth's Rheologic Layers:

Layers	Thickness	Composition	Rheology
Lithosphere	100-200 km	100% Crust + a portion of the Upper Mantle	RIGID, SOLID, BRITTLE: breaks into pieces, called plates
Asthenosphere	100-350 km	Portion of the Upper Mantle	PLASTIC (flows), but SOLID
Mesosphere	2500 km	100% Lower Mantle	RIGID - SOLID
Outer core	2200 km	Portion of the Core	LIQUID
Inner core	1300 km	Portion of the Core	SOLID

2. The Moho is the boundary between the crust and mantle. What's the difference between the asthenosphere, lithosphere, crust, and mantle? In which rheological layer is the Moho located?
3. **Understand the geothermal gradient and understand what the effect of temperature and composition are on the different rheological layers of Earth.
4. **What is magnetic polarity? Understand how it has changed with time
5. Earth's magnetic field is generated in the Earth's outer core. Be sure know the three key requirements that enable the outer core to generate the magnetic field.
6. What kind of materials align themselves to the Earth's magnetic field? When?
7. **What is <u>paleomagnetism</u>?

Earth’s Interior

-Take 5 minutes to label the major divisions of the Earth. On the Left side, label according to the Composition, on the right side label according to the rheologic/state divisions. Rheology refers to ability of the geologic layer to “flow”. Specifically is it a rigid solid, plastic and deformably, or is it a liquid.

-Take 10 minutes to discuss the Rheologic and compositional structure of Earth with your group and answer the structure of Earth and the Questions below.

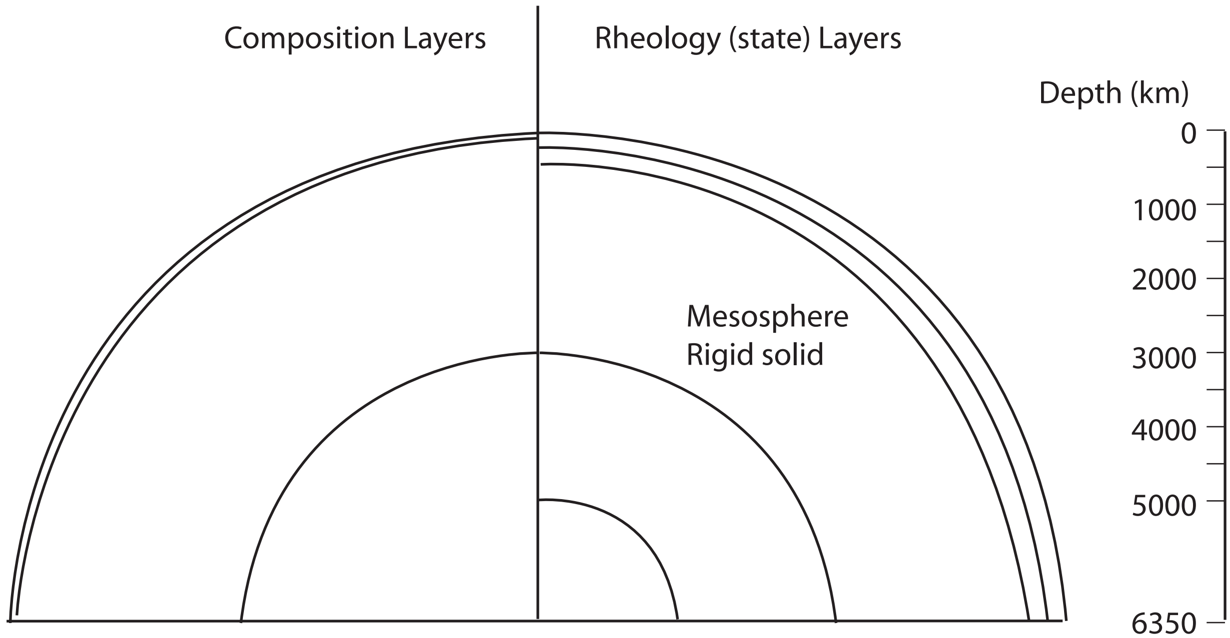


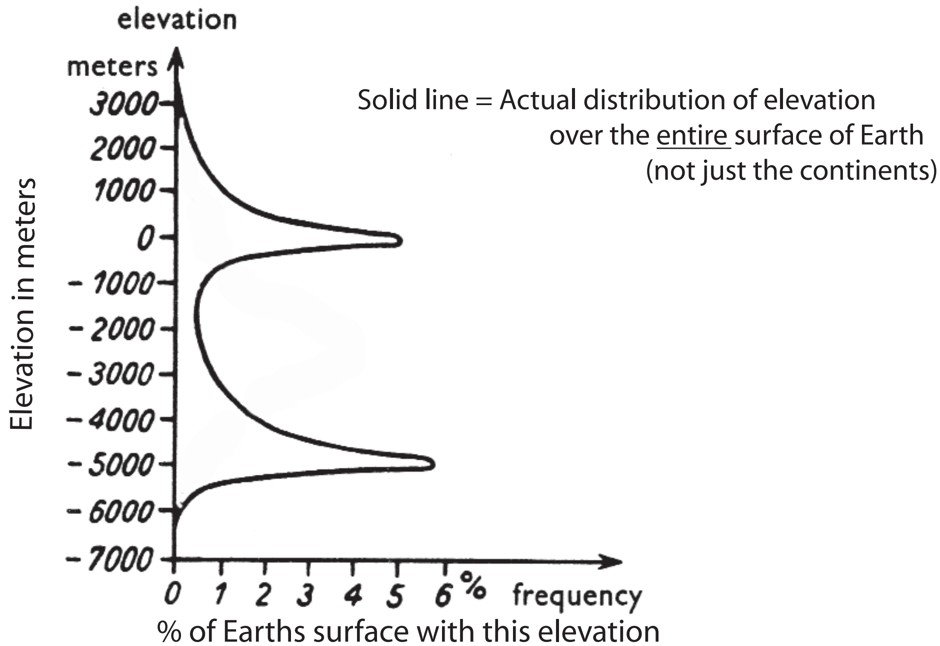
Figure 1

2. What compositional layers compose the Lithosphere?

3. The Moho is found within the Lithosphere. Discuss and describe what the Moho represents? Label it on the diagram above.

4. Looking at the diagram above is there a relationship between any of the Compostion layers and Rheology layers?

Distribution of Earths Elevation (Wegener, 1915)



1) Describe the distribution of actual elevations on the Earth.

2) What is the mean elevation of the two dominate distributions of elevation on the Earth? What do you think they represent?

3) After looking at this graph, what do you think about the significance of mountain ranges on the Earth (> 2500 m)? Specifically, are mountains common features on the surface of the Earth, as the researchers of Alfred Wegeners time (early 1900') thought? Explain.

4) Why do you think the Earths elevations not normally distributed, as you might have expected?

What Controls the Rheologic Structure of Earth

Using the data below plot Earth's Geothermal gradient and the Solidii of silicate rocks and iron alloy on the graph on the next page. While plotting the data keep in mind what you are plotting; The geothermal gradient represents the temperature of rock at different depths within the Earth and Solidii lines represent the melting temperature of different Earth materials at different depths.

Geothermal Gradient		Solidus Silicate Rocks		Solidus of Iron alloy	
Depth (km)	Temp. (C)	Depth (km)	Temp. (C)	Depth (km)	Temp. (C)
0	0	0	1500		
20	500	20			
40	750	40	1500		
60	1100	60	1550		
80	1300	80	1600		
100	1500	100	1725		
120	1650	120	1750		
140	1780	140			
160	1850	160			
180	2000	180		**No Iron Alloy at these depths**	
200		200			
220	2200	220	2250		
240		240			
260	2300	260			
280		280	2500		
300	2400	300			
Scale Change		Scale Change			
1500	2650	1500	3000		
2000		2000			
2500	3050	2500	4250		
3000		3000	4500	3000	2800
3500	3500			3500	
4000				4000	3500
4500	3900			4500	
5000		**No Silicate Rocks at these depths**		5000	4250
5500	4250			5500	
6000				6000	
6250	4400			6250	5100

1. Describe and discuss what the shape of the the geothermal gradient, specifically how does the upper 60 km of the geothermal gradient compare to the lower 6000 km.

2. Describe and discuss the shape of the solidii.

3. The location of rheologic boundaries with Earth are Variable around the planet depending on the Geothermal gradient which is not constant globally. Disucss and draw at what depths the Lithoshpere-Asthenoshere boundary, the Asthenosphere-Mesosphere boundary, and inner core-outer core boundaries occur.

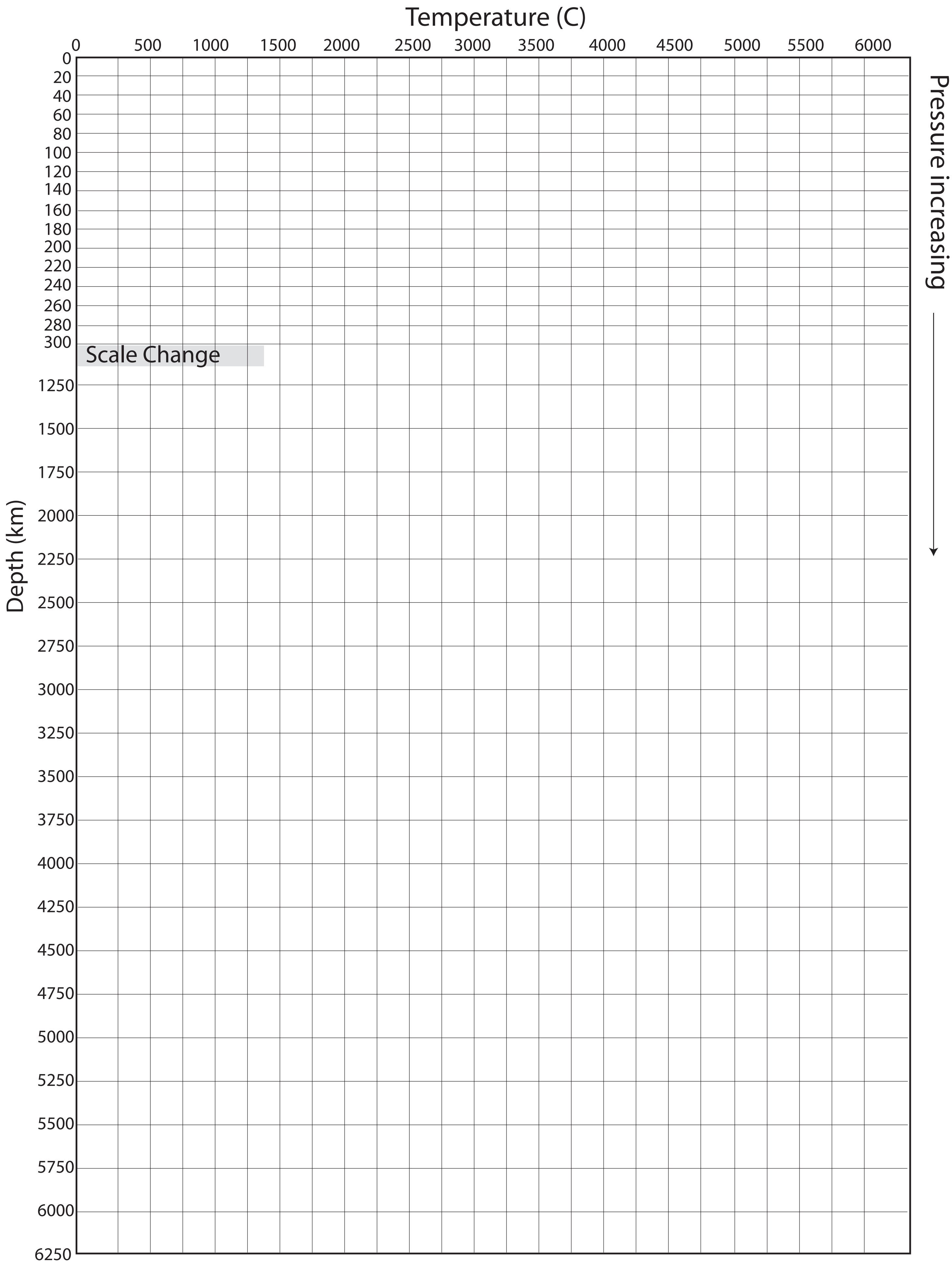

Temperature (C)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
Depth (km)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
Scale Change
1250
1500
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
4250
4500
4750
5000
5250
5500
5750
6000
6250
Pressure increasing

Figure 2

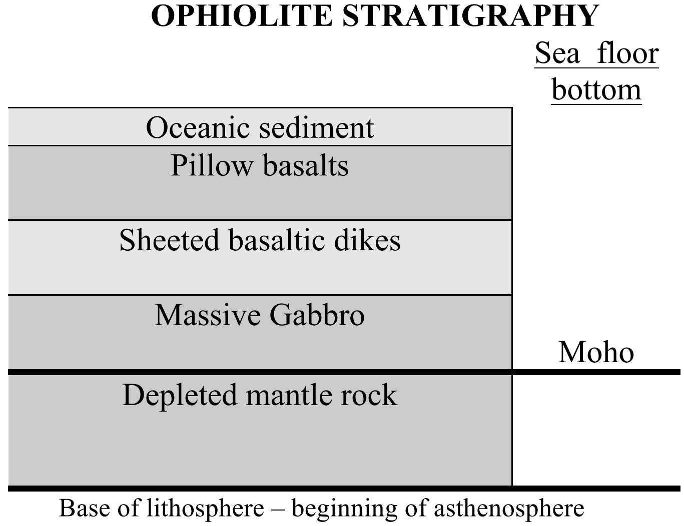
Chapter 1b (p. 21-37) and Chapter 12 – Chapter Questions Plate Tectonics and the Formation of the Oceans and Continents

1. **What were Alfred Wegener's lines of evidence to support Continental Drift Hypothesis?
2. **What were Harry Hess's lines of evidence for Sea floor spreading? (lecture only)
3. **What is the Vine Mathews Hypothesis and how did it contribute to Plate Tectonic Theory
4. Where in the world's oceans are the youngest rocks? Oldest rocks? How old are they?
5. What was Pangaea?
6. Describe the process of rifting of a continent. Where in the world is such activity happening today?
7. Describe how a guyot forms.
8. **Compare and contrast active and passive continental margins. What are the primary features of each?
9. **What happens when two oceanic plates converge? What happens when two continents converge? What happens when Continental plate and an oceanic plate converge?
10. Describe the locations and causes of these features globally.

Feature	Location and cause	Feature	Location and cause
Earthquakes		Volcanism	
Trenches		Fracture zones	
Mid-ocean ridges		Accretionary wedges	
Rift valleys		Mountain belts	

11. Define *ophiolite*. Be sure you can remember the exact stratigraphy of one. How do they form?
12. **What is a hydrothermal vent? Where are they found?
13. What processes occur at a hydrothermal vent?
14. What is Serpentinite? How is it formed, and why is it important in California?
15. **What kind of plate boundary exists in Northern California and the Pacific Northwest?
16. **What kind of plate boundary exists in Central and Southern California?

OPHIOLITE STRATIGRAPHY



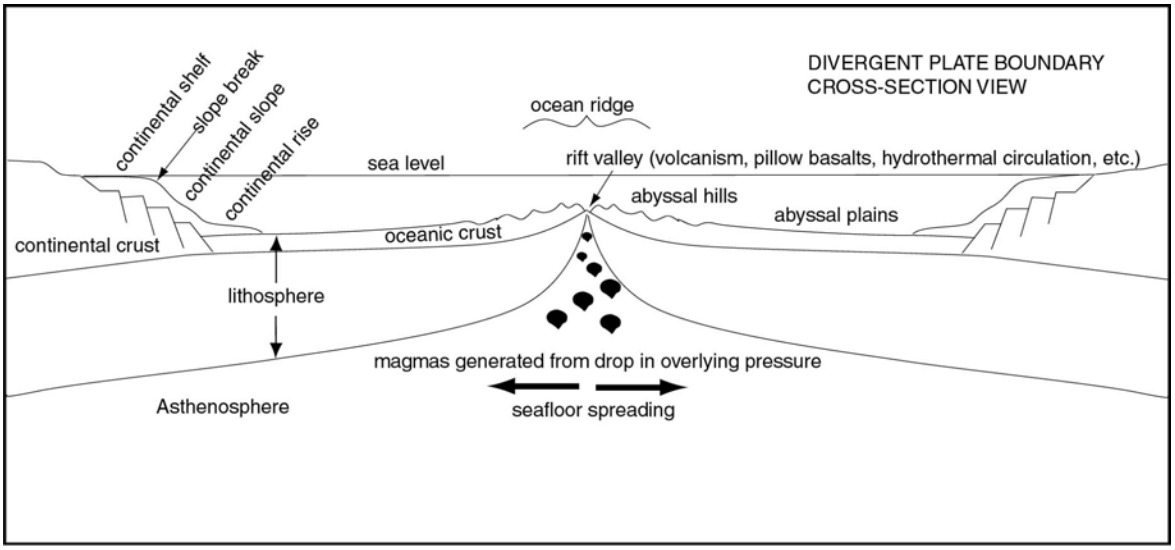
<u>Chapters 12 and 13 Questions</u> — Plate Tectonics and the Formation of the Oceans and Continents

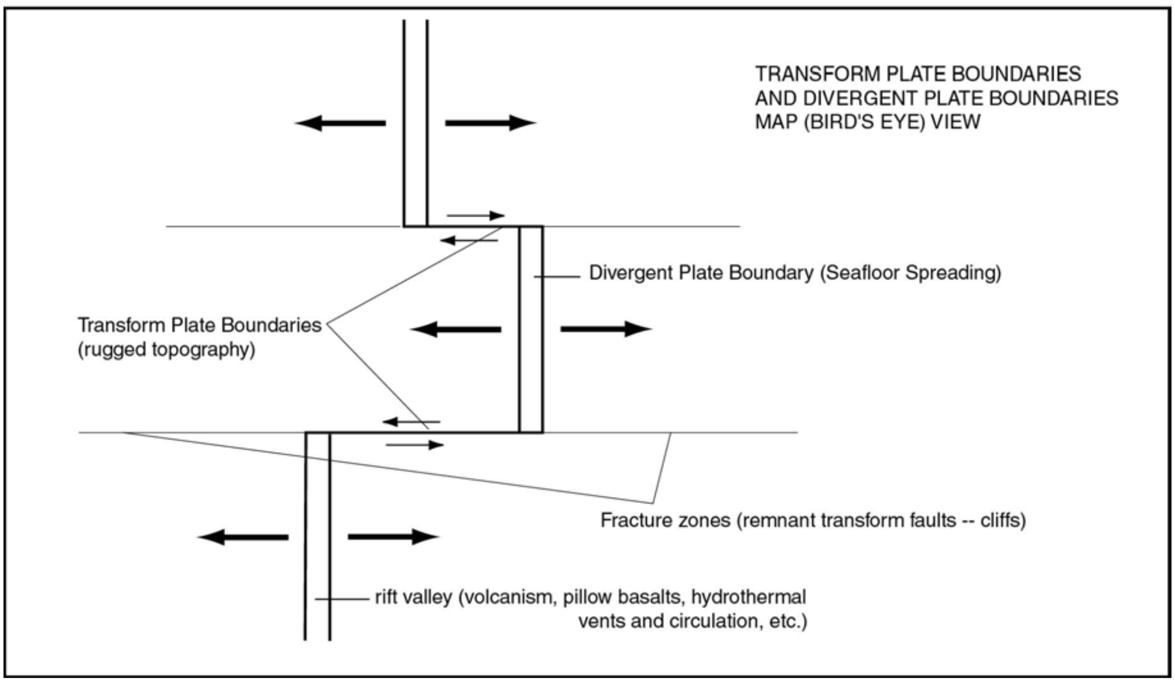
<u>MAFIC</u> – igneous rocks whose composition is low in Si and high in Fe, Mg, and Ca – usually found in oceanic volcanic settings like seafloor spreading centers and ocean hotspots. Example: Basalt.
<u>FELSIC</u> – igneous rocks whose composition is high in Si and low in Fe, Mg, and Ca – usually found in continental volcanic settings like subduction zone volcanic arcs, continental hotpots, or continental rifting. Example: Granite.

An **accretionary wedge** is a mass of sediment that derives from two sources: 1) sediment that is scraped off a subducting oceanic plate (might include pieces of ocean lithosphere as well), and 2) sediment that erodes off the volcanic arc behind the subduction zone (land). This thick sequence of sediment is folded and compressed between the trench and the volcanic arc, often creating compressional mountain ranges. A **terrane** is anything that has been accreted to the continent and is now a hardened attachment. Terranes include ophiolites (sections of complete ocean lithosphere), accretionary wedges, continental fragments.

1. **What is the difference between an accretionary wedge and a terrane? How do they form?
2. Describe the origins and evolution of continental crust. Through what two methods do continents grow?
3. Explain why continents are about 20 times older than the oldest ocean basins. Where are the oldest continental rocks?
4. What is the driving force of plate tectonics?
5. How can you use a hotspot track to determine plate speed and direction?
6. **Describe the process of rifting of a continent. Where in the world is such activity happening today?
7. **Compare and contrast active and passive continental margins. What are the primary features of each?
8. Can a passive margin turn into an active margin? If so, how? Vice versa?
9. Know and be able to draw the anatomy of a Continent.

Plate Tectonics Summary





DIVERGENT

MOTION: Apart

FEATURES:

Oceanic ridges. Seafloor spreading. Melted mantle rock due to reduced overlying pressure. Rift valleys with volcanism, pillow basalts, hydrothermal vents, and hydrothermal circulation. Serpentinites form at depth in mantle rocks that are undergoing hydrothermal alteration. Transform faults (associated with transform plate boundaries) break up divergent boundaries into small sections offset from one another.

WORLD EXAMPLES: Mid-Atlantic Ridge, Iceland.

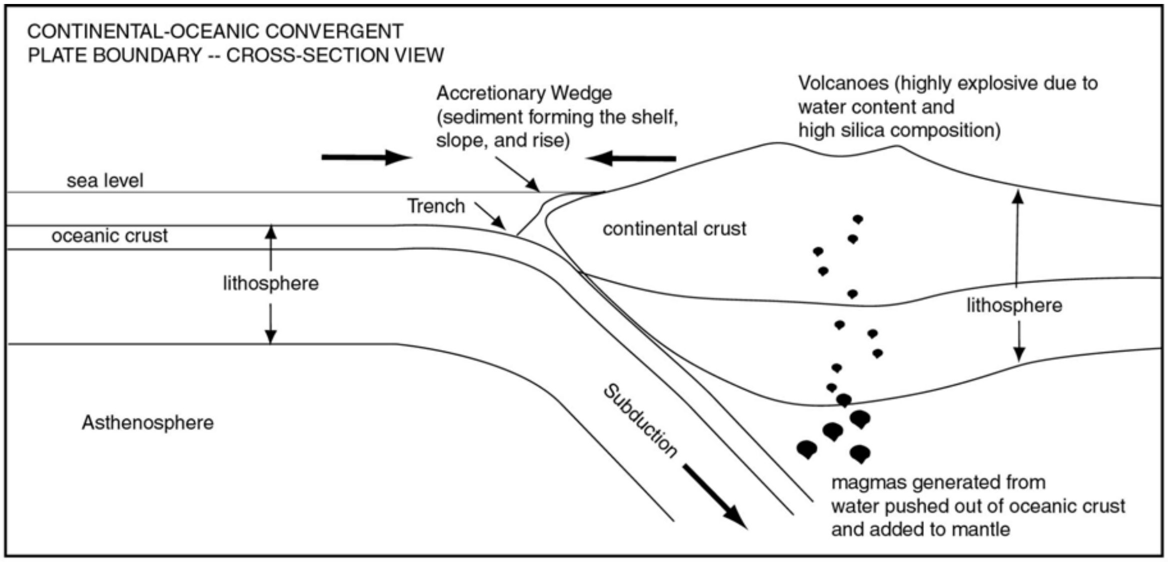
TRANSFORM

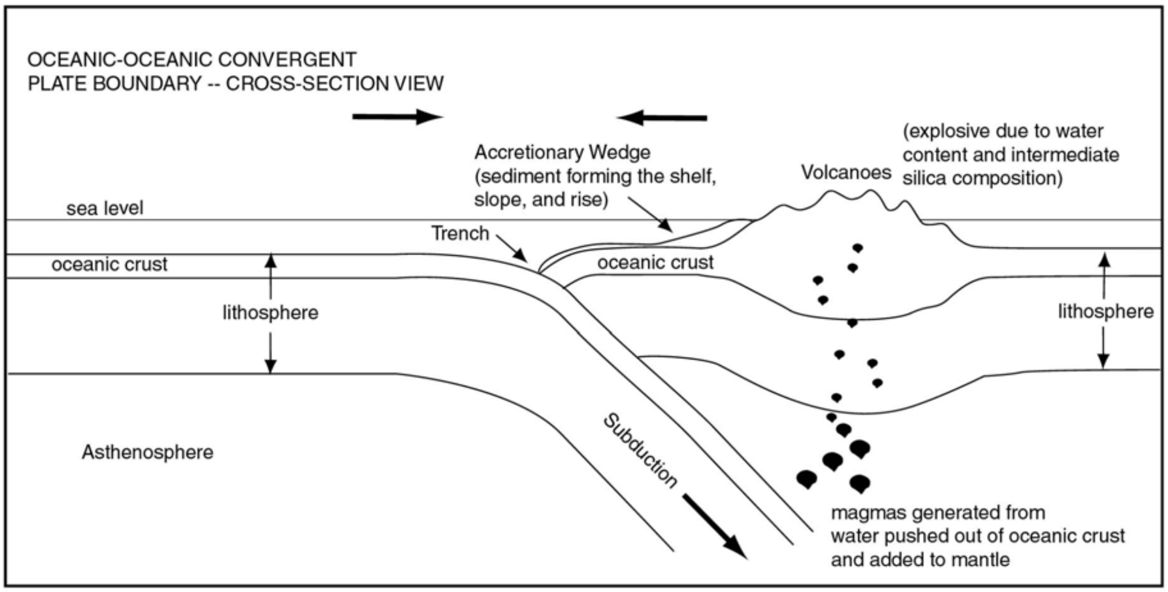
MOTION: side by side

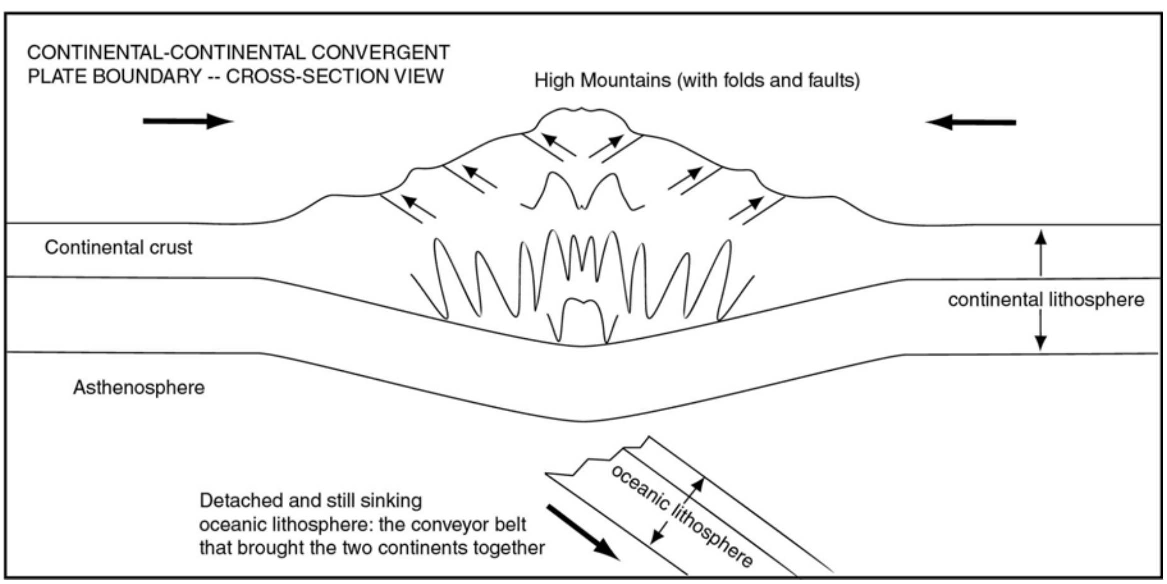
FEATURES:

Fracture zones (old transform faults, no longer active, because lithosphere on both sides are part of the same plate). Rough topography (cliffs where ridges offset. Oceanic ridges and spreading centers on both sides.

WORLD EXAMPLES: California, Iceland







<u>**CONVERGENT**</u>

MOTION:
Towards each other

FEATURES:

Continent-Ocean
Subduction zones (ocean crust sinks back into mantle). Melted mantle rock due to addition of water, which drops the melting point of the underlying mantle. Volcanoes above subduction zone where magmas move upward. Trenches on ocean floor where ocean crust begins subducting. Volcanism is granitic mostly, because it moves through thicker continental crust.
WORLD EXAMPLES:
W. coast S. America
Pacific Northwest

Ocean-Ocean
Subduction zones (ocean crust sinks back into mantle). Melted mantle rock due to addition of water, which drops the melting point of the underlying mantle. Volcanoes above subduction zone where magmas move upward. Trenches on ocean floor where ocean crust begins subducting. Volcanism is basaltic mostly, because it moves through thinner oceanic crust.
WORLD EXAMPLES:
Japan, Philippines,
Aleutian Islands

Continent-Continent
Fold and thrust mountains, thickened lithosphere.
WORLD EXAMPLES:
Himalayas (India)
Alps (Europe)

<u>Chapter 9 Questions</u> — Earth's Structures: Folds, Faults, and Fabrics

1. **Compare and contrast pressure, stress, shear, and strain.
2. **What are the three types of stress? (Use arrows to indicate the motion that causes each.)
3. A stressed rock can experience three kinds of deformation: elastic, brittle, or ductile (plastic). What conditions favor each? What are the results of each? (Answers in table below – be sure you understand!)

Deformation type	**Causes**	**Results**
Elastic – temporary deformation	Stress not greater than elastic limit of rock	Strain released and shape returns to normal
Brittle – permanent break	Stress greater than yield point or elastic limit of rock (usually <u>colder temperatures</u> – nearer surface – <u>rapid</u> stress application)	Strain released with break in rock (faulting)
Plastic – permanent ductile deformation	Stress greater than yield point or elastic limit of rock (usually <u>higher temperatures</u> – deeper underground – stress applied slowly over <u>long time</u>)	Strain is permanent (folding)

4. What is yield point or elastic limit? What does it mean?
5. **Compare and contrast anticlines and synclines.
6. Imagine the above structures were eroded to a flat top. If you were walking across these tops, where would you find the oldest rocks? Draw pictures of each and indicate oldest and youngest beds.
7. Describe a plunging fold. What does it look like when its top surface is eroded flat?
8. How can you tell the difference on the surface between a plunging syncline or anticline?
9. **Compare and contrast dip-slip and strike-slip faults.
10. Explain right-lateral and left-lateral strike-slip faults.
11. **Compare the movement of normal and reverse faults. What type of force produces each?
12. **Explain hanging wall and footwall.
13. Be able to label diagrams of faults with relative fault motion arrows, stress direction, fault name, and hanging wall and foot wall. (For right-and left-lateral strike-slip faults AND reverse and normal faults.)
14. **What kind of the fault is the San Andreas Fault?
15. Review this table. Be able to complete it, if blank, and ensure your understand why each box is true:

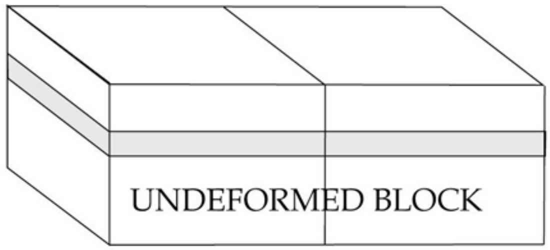
Mountain type	**Formed by**	**World examples**	**California examples**
Fold and Thrust	*Compressive stress (usually at convergent plate boundaries)*	*Himalayas*	*Transverse Mountain Range (Santa Barbara and eastward)*
Fault-Block	*Tensile stress (usually at divergent plate boundaries)*	*East African Rift Zone Basin and Range*	*Sierra Nevadas*
Domes	*Single point of pressure pushing up from inside Earth (salt dome rising or magma rising, but not erupting)*	*Adirondacks, Sheep Mountain*	*Mt. Diablo*
Erosional Remnant	*Resistant rock that sticks out from surroundings, because they eroded more quickly and easily*	*Devil's Tower, Wyoming*	*Twin Peaks*
Volcanic	*Volcanic activity associated with hotspot, divergent plate boundary, or subduction zone*	*Cascade Mountains, Andes Mountains*	*Mt. Shasta, Glass Mountain, Mammoth Mountain*

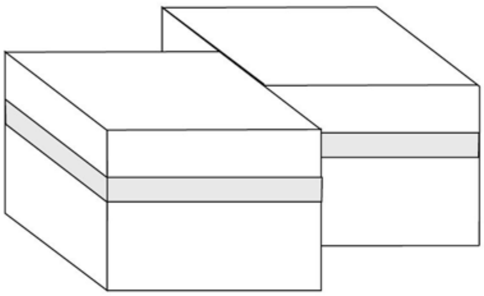
16. Review this table. Be able to complete it, if blank, and ensure your understand why each box is true:

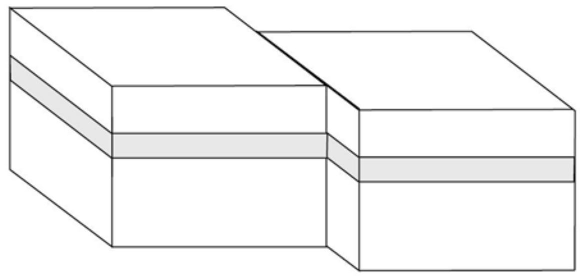
Stress types	**Plate boundaries**	**Fault types**	**Crustal thickening or thinning or both/none?**	**Mountain types (if any)**
Compression	*Convergent*	*Reverse (+ thrust)*	*Thickening*	*Fold and Thrust*
Tension	*Divergent*	*Normal*	*Thinning*	*Fault-Block*
Shear	*Transform*	*Strike-slip*	*None*	*None*

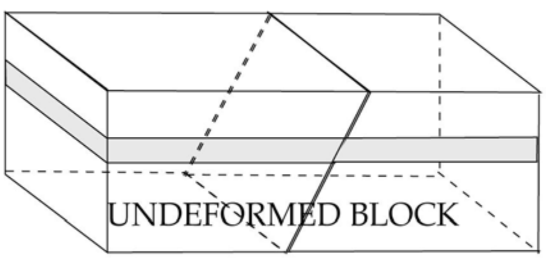
For each deformed block below:

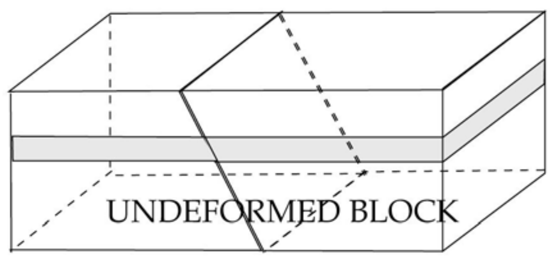
1. Draw arrows parallel and on both sides of fault plane to indicate relative motion of the two sides.
2. If a dip-slip fault, label hanging wall and footwall; If a strike-slip fault, indicate if right or left lateral.
3. Indicate fault type (name). Indicate stress type and draw arrows on outside of block to indicate direction.

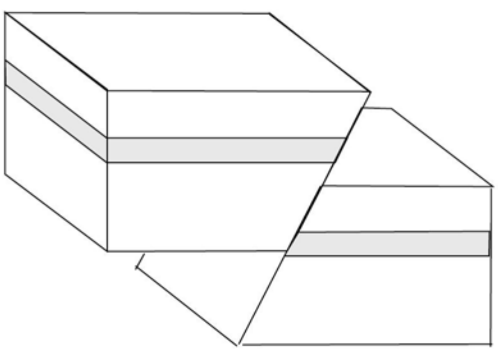


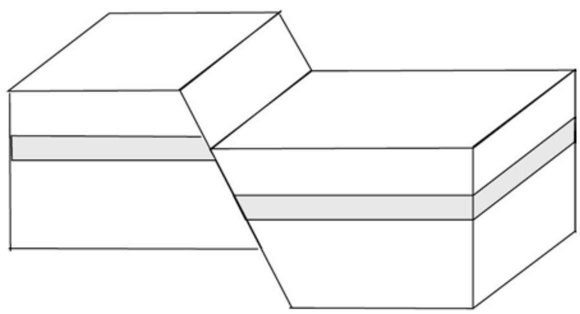


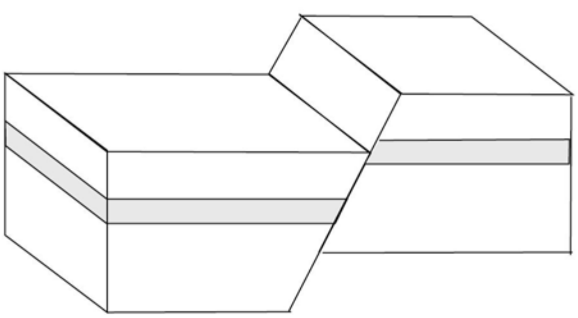


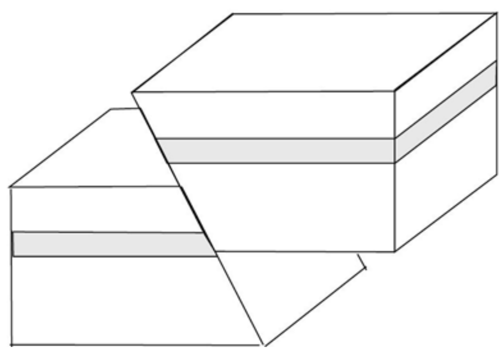


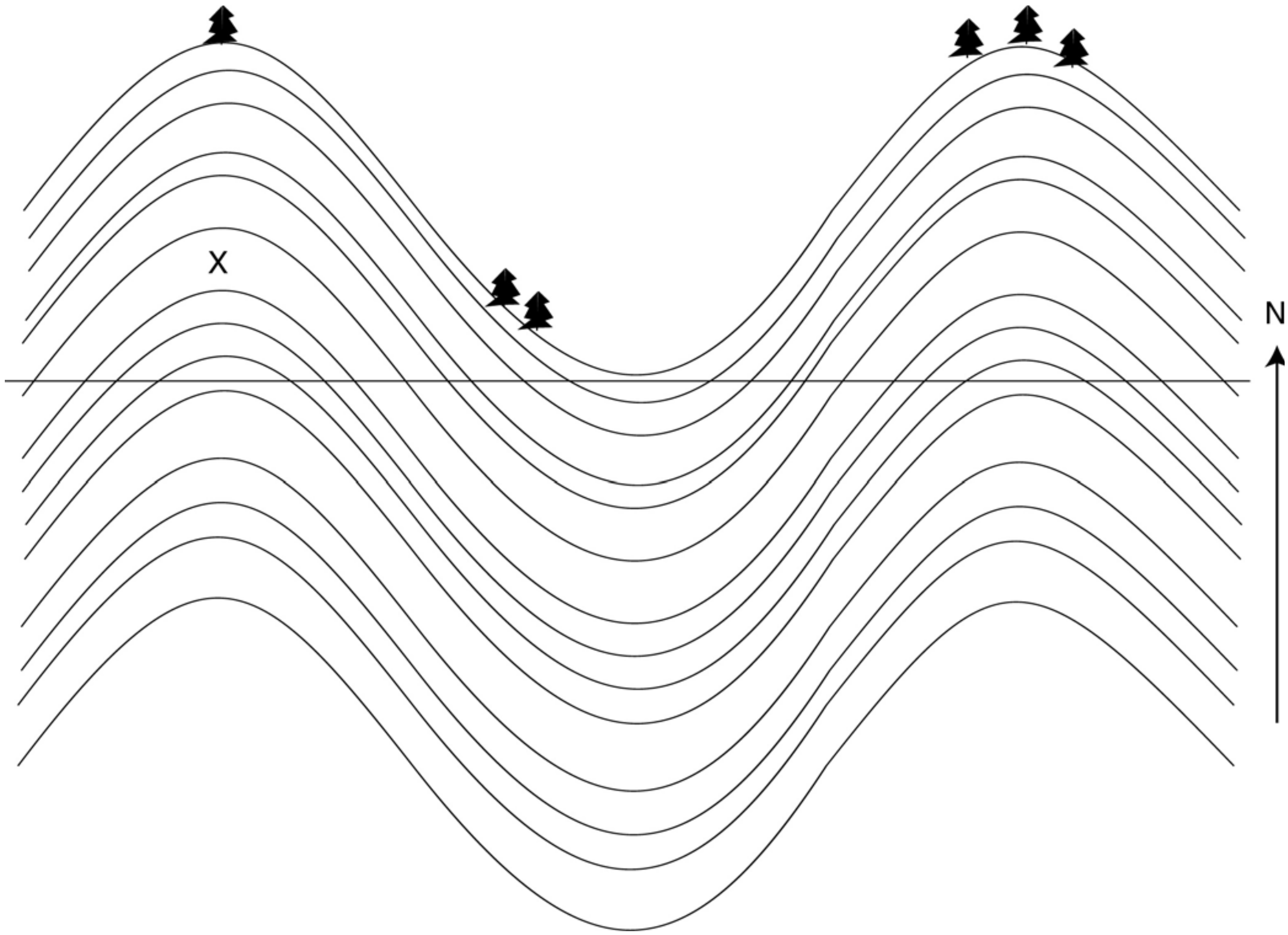












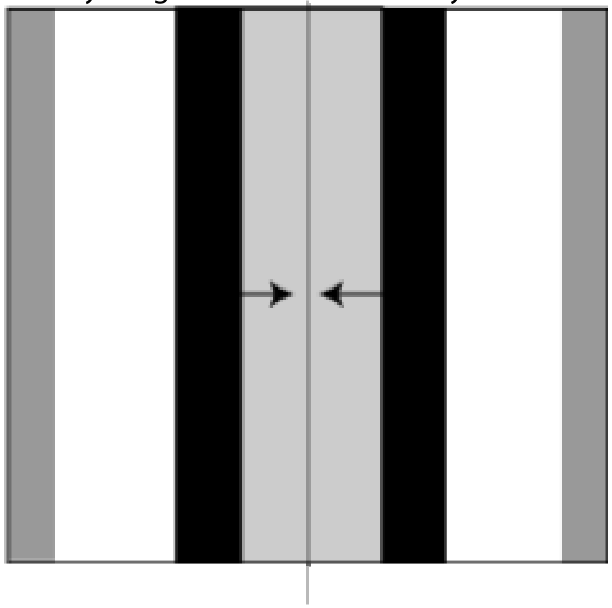
In the picture above, you are seeing the cross-section view of perfectly vertical and symmetrical anticlines and synclines.

1. Label which structures are anticlines and which are synclines.
2. Label each layer from youngest (1) to oldest (13).
3. Indicate with a drill well where you would drill if you were an oil company looking for trapped oil. Assume that layer X is a sandstone, rich in pore space (acts as a reservoir rock); the layer directly above X is impermeable (acts as a cap rock); and the layer directly below X is an organic-rich shale (material degrades under pressure to produce oil and gas). Remember, fluids and gases migrate towards the surface, unless prevented somehow!

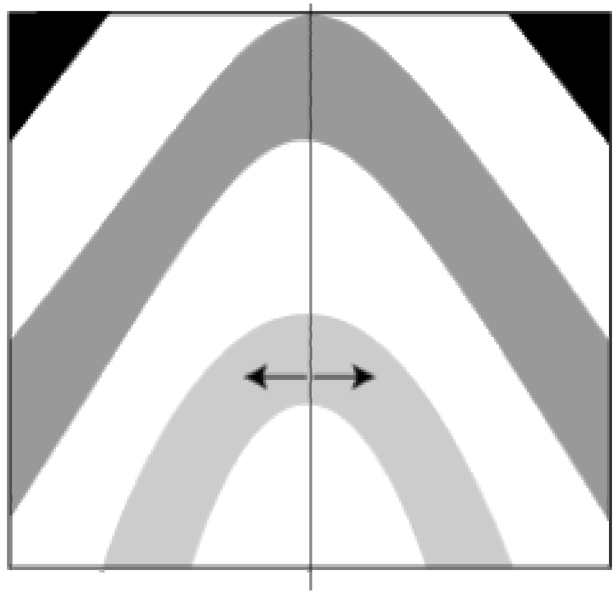
The accompanying box diagram, when complete, will show you what the surface would look like if it eroded down to the indicated erosion line above. First, get scissors and cut out the box diagram. Be sure you can make it into a 3-D image, but don't staple or tape it yet. Complete the blank sides of the diagram: draw the way that the beds would look on all uncompleted sides. Be precise!

1. Color both diagrams, so you can see the matching beds.
2. Indicate with a star where would you buy property (on the surface) if layer X contained gold, and you were a miner.
3. Indicate with an X', where you would buy property if all surface exposures were already purchased.
4. If there was a visible fault line that ran from the northwest corner to the southeast corner straight through the middle of this area, and the fault dipped underground at a 45° angle (goes under to the NE), on which side of the fault would you build your house?

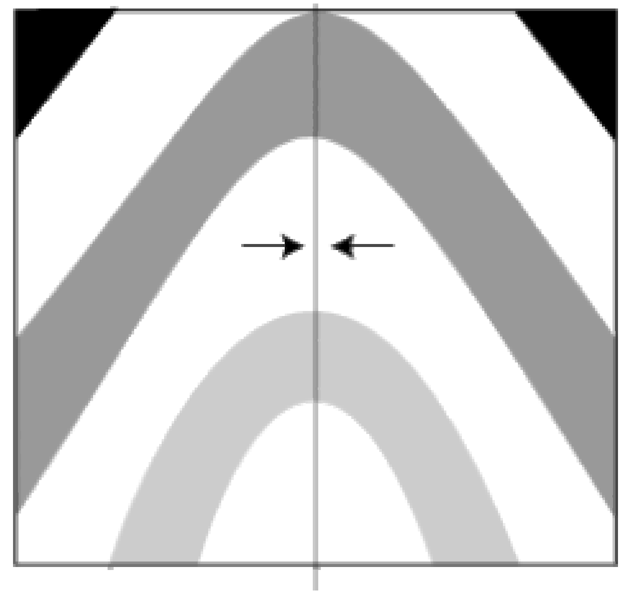
Syncline
Label youngest and oldest rock layers

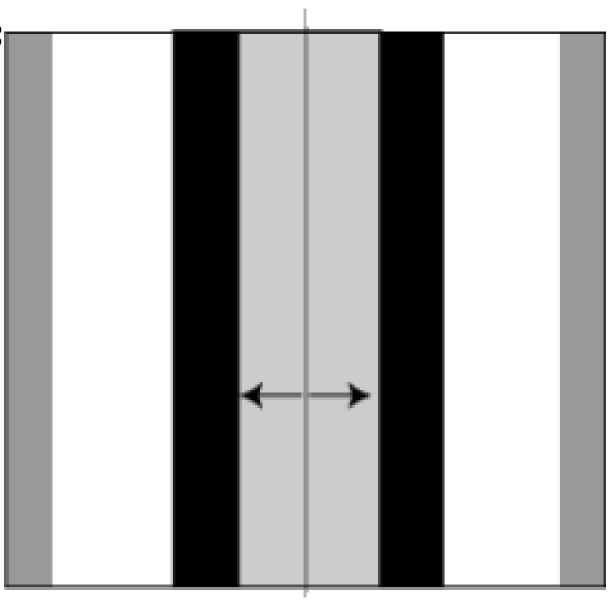


Plunging antiline
Label youngest and oldest rock layers



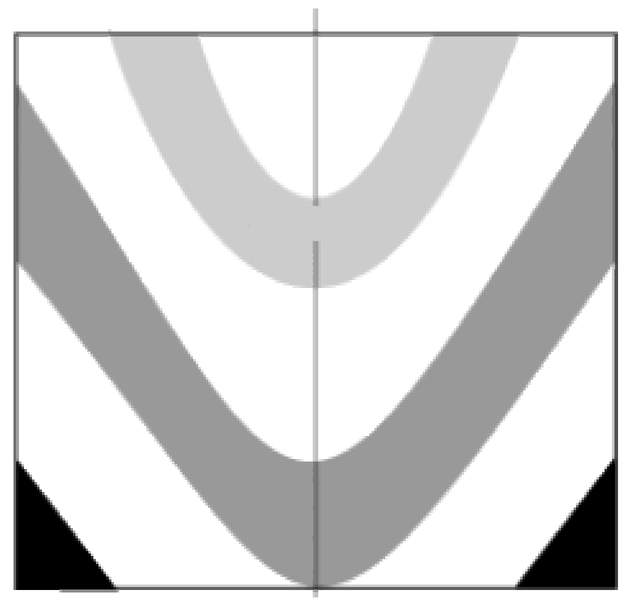
Plunging syncline
Label youngest and oldest rock layers





Anticline
Label youngest and oldest rock layers

North Plunging fold
Determine what type of fold this is, Label the fold axis and the youngest and oldes strata



South Plunging fold
Determine what type of fold this is, Label the fold axis and the youngest and oldes strata

Chapter 10 Questions — Earthquakes

1. Memorize and understand this seven-part explanation of what causes an earthquake. Explain what is meant by elastic rebound.

    1. Stress (pressure) is continually applied to rocks or pre-existing faults.
       This stress most likely comes from plate tectonics and is at a plate boundary.
    2. Stress builds where strong rocks or locked faults withstand it.
       (Friction is the internal force that locks a fault, making its two sides stick together.)
    3. Rocks and faults deform elastically (strain) in response to the building stress. Elastic strain energy accumulates.
    4. Stress finally builds higher than rock strength and rocks breaks or fault slips.
    5. The rocks or faults elastically rebound and strain energy is released in the form of seismic waves that move outward in all directions.
    6. After the rocks or faults have settled back into place, the stress begins building again.

2. Faults that are experiencing no active creep may be considered "safe." Rebut or defend this statement.
3. **How are faults, foci, and epicenters related?
4. **Distinguish between surface waves and body waves.
5. **Understand the major differences between P and S waves (demonstrate them with slinky or rope).

	P wave	**S wave**
Speed	7 km/s	3.5 km/s
Arrival time	First!	Second
Motion type	Compressional (push-pull)	Transverse (side to side)
Materials wave can travel through?	All	Solids only

6. Which type of seismic wave causes the greatest destruction to buildings? Why?
7. **Distinguish between the Mercalli Intensity, Richter, and Moment-Magnitude scale. What does each measure?
8. Describe the principle of a seismograph.
9. An earthquake measuring 7 on the Richter scale has an amplitude how many times taller than a size 6 earthquake? How many times more energy released? An 8 compared to a 6? What's the difference between energy and amplitude?
10. Approximately how many earthquakes occur for the following magnitudes each year?

magnitude <4.0	**magnitude 4-6**	**magnitude > 6.0**

11. On a seismogram, identify the arrival of the P and S waves. Measure the time interval between their arrival.
12. Determine the approximate distance between an earthquake and a seismic station if the first S wave arrives 3 minutes after the first P wave.
13. What more information do you need to determine exact location of the earthquake?
14. **List factors that increase the amount of destruction caused by earthquakes.
15. **What is a tsunami? How is one generated?
16. Where are earthquakes concentrated globally?
17. What kind of property and home design would you look to buy in earthquake country to minimize damage?

See next page for additional Earthquake information

Activity on Earthquakes

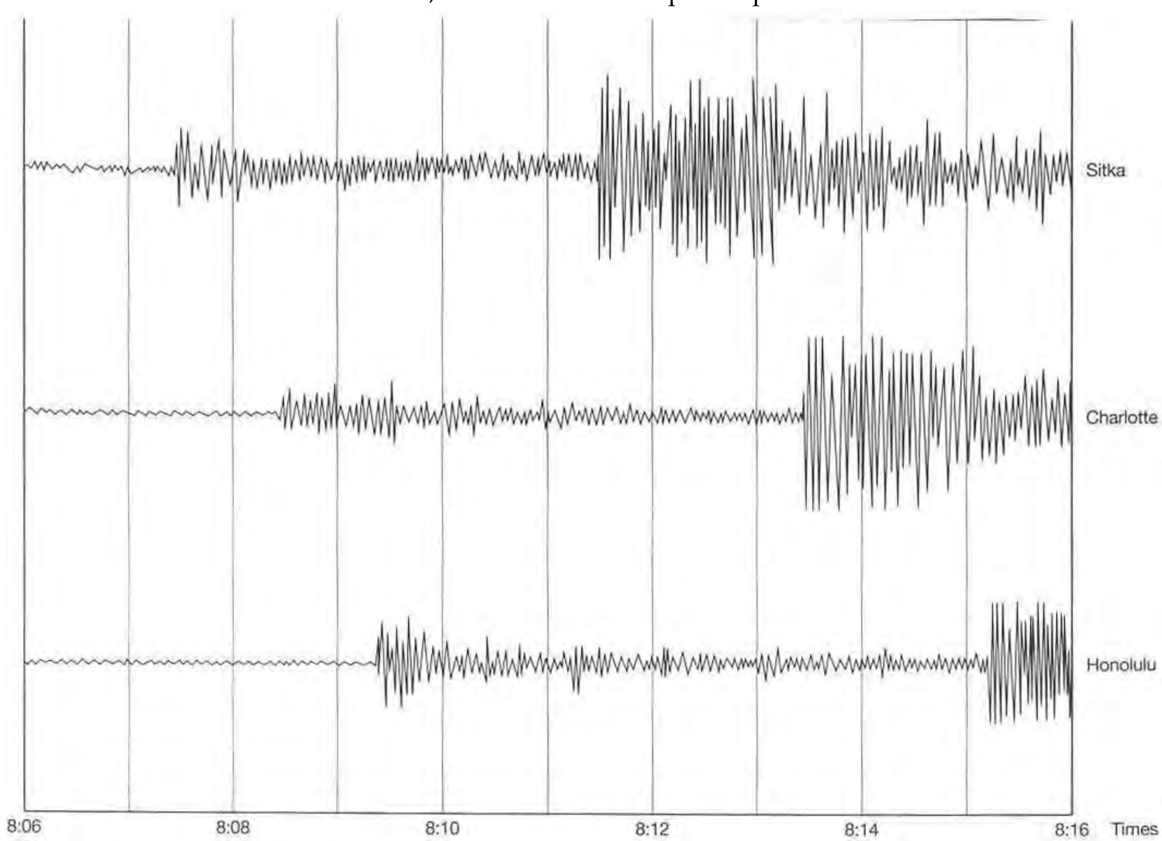
1. Determine the location of the earthquake recorded in the following seismograms.
2. Determine when the earthquake occurred.

Using travel-time curves and seismograms to determine earthquake distance
Travel-time curves indicate how long it takes a specific type of seismic wave to travel a distance measured on the Earth's surface. The difference between the S-wave arrival time and the P-wave arrival time determines how far away the earthquake occurred. You can determine exact distance by using the seismogram and the travel time curve. Follow these steps:

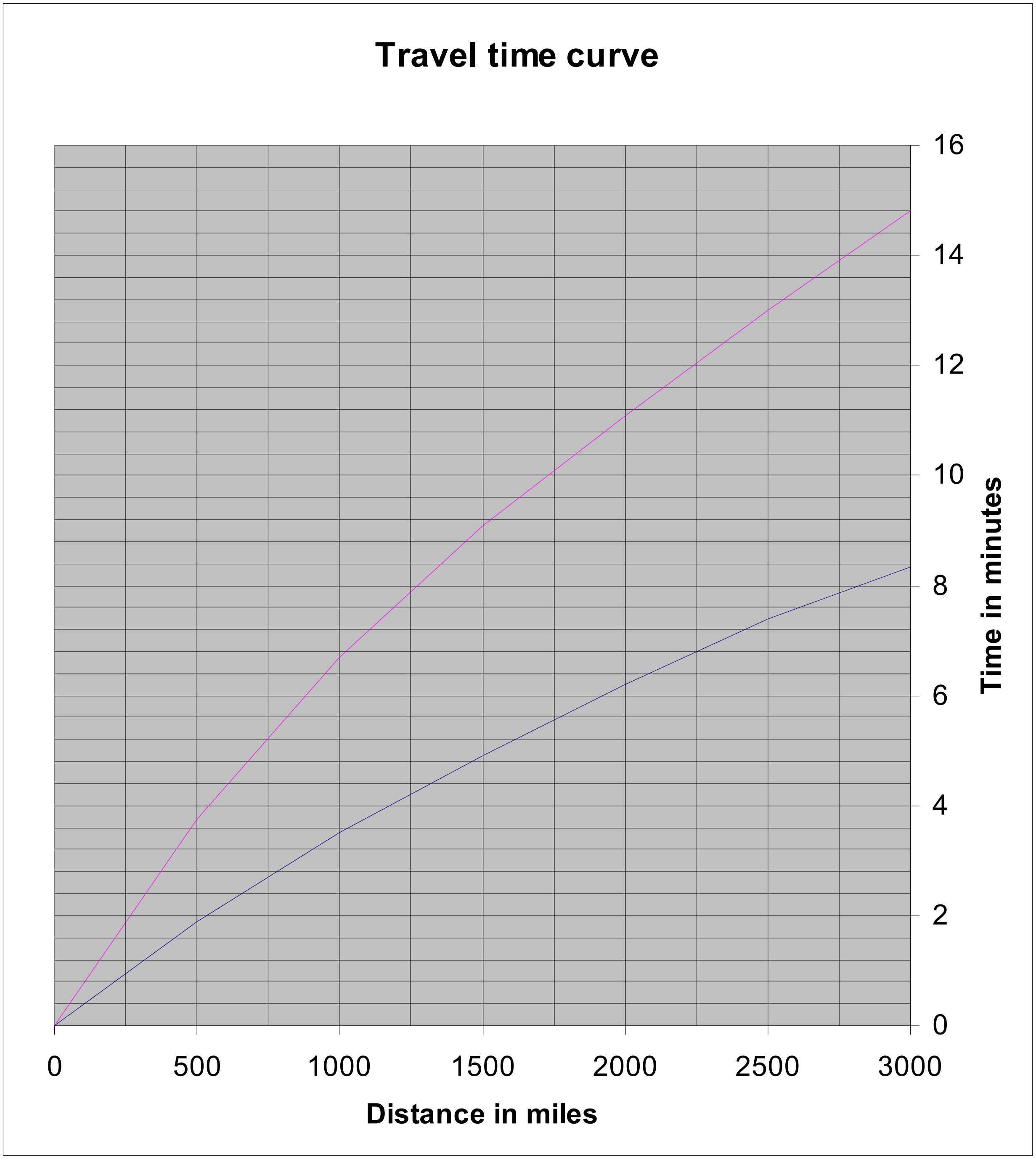
1. Lay a strip of paper along the time axis of the seismogram. Mark a dot where the P wave first appears and then one where the S wave first appears. Move the first dot to a specific, known time on the time axis, and approximate the total time difference between the two dots.
2. Lay a strip of paper along the time axis of the travel-time curve. Mark a dot at t=0; Mark a second dot when t = the time that you determined in step 1.
3. Keeping the strip of paper vertical, place the bottom dot on the P curve. Move the strip across the travel-time curve, keeping the bottom dot always on the P curve, and keeping the strip vertical. When the top dot intersects the top S curve (the bottom dot still on the P curve), stop. Drop a vertical line down to the x-axis and determine the distance. This is the distance of the earthquake!

Determining earthquake location

1. For three different earthquake recording stations (seismographs), determine distance to the same earthquake.
2. On a world map, for each station, draw a circle around the station, where radius is the measured distance.
3. Where the three circles intersect, there lies the earthquake epicenter!

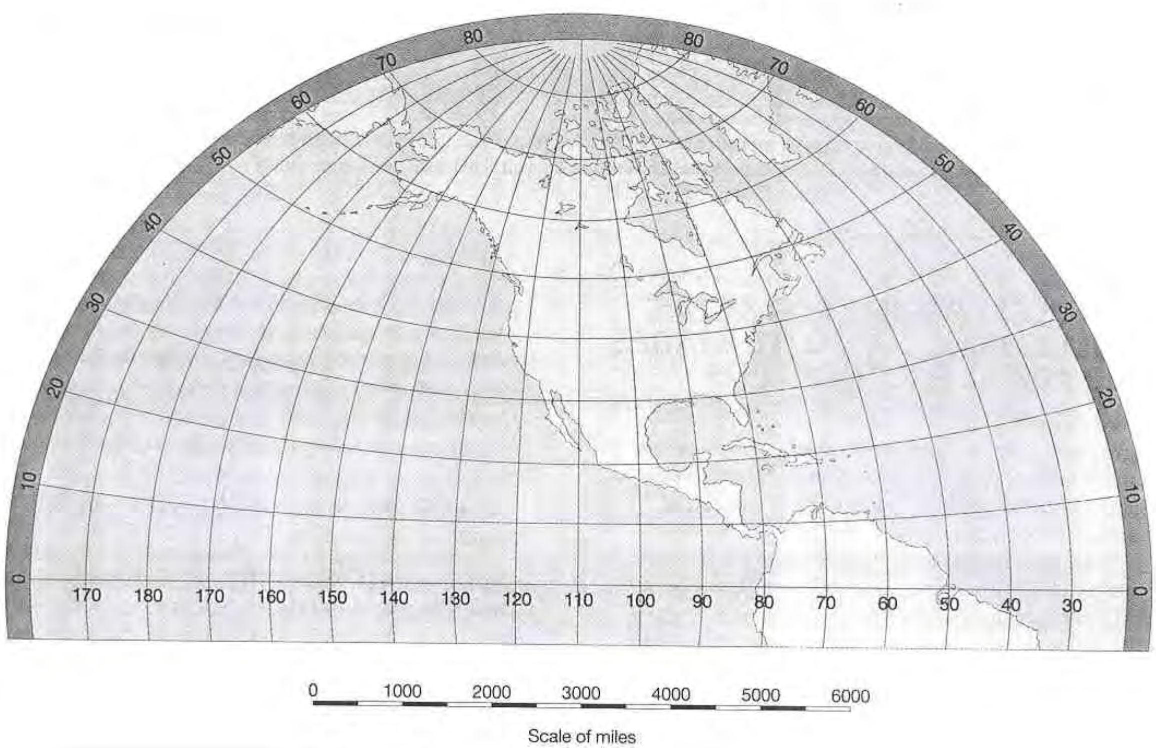


Determining when earthquake occurred:



P-Wave curve on bottom; S-Wave curve on top.

4. Pick one wave (P or S) at one station. Use the clock on the seismogram to determine when that wave arrived at that station.
5. Based on how far away that station is from the earthquake, use the time-travel curve to determine how long it takes that wave you picked to travel that distance.
6. Subtract the travel time from the arrival time to get the departure time.



Sitka: 57N, 135W
Charlotte: 35N, 81W
Honolulu: 21N, 158W

Geology 10 – Exam 1 Pass Sheet

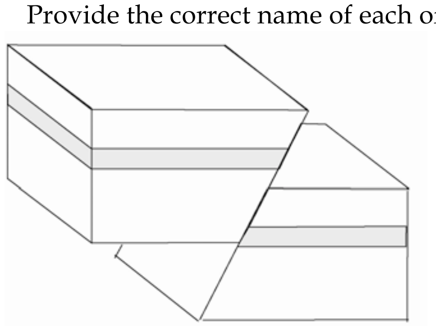
If you can answer all these questions correctly on the exam, you will get a 70% pass. (Questions will appear on the exam in a different order and with different numbers.) There will be additional question on the exam (~25 to 30%). These can help you to raise your grade from 70 (C) to a B (80-89) or A (90+). Note: YOU MUST BRING THIS COMPLETED SHEET WITH YOU TO TAKE THE EXAM – NO SHEET – NO EXAM. Exam will be closed notes, closed book, – you cannot use this sheet on the exam. Good luck!

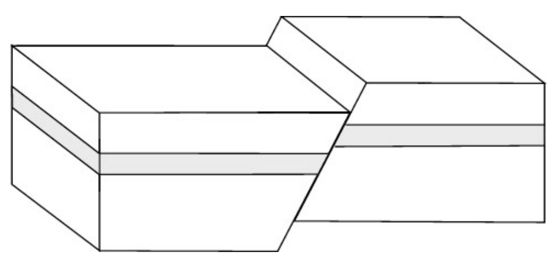
1. How old is the universe?	
2. How old is Earth (be specific to one decimal place)?	
3. List five of Alfred Wegeners main lines of evidence to support Continental Drift (be specific).	1. 2. 3. 4. 5.
4. What were Harry Hess' three lines of evidence to support Sea Floor Spreading (be specific)?	1. 2. 3.
5. Explain what is meant by <u>planetary</u> differentiation.	
6. Explain what is meant by <u>solar system</u> differentiation.	
7. Where in the oceans is the youngest (newest) ocean crust found?	
8. What kind of continental margin is the East Coast of the United States?	
9. What kind of continental margin do we live on here in San Francisco?	
10. How do we know the age of Earth?	
11. Volcanic activity can be found in three different geologic settings. What are these and what is the cause of melting at each setting?	1. 2. 3.
12. In which layer does Earth's magnetic field originate?	
13. What three characteristics and behavior of this layer produce the magnetic field? (Be specific!)	
14. Which seismic wave can travel through all materials (solids, liquids, gases) and how do the particles in the wave move with respect to wave propagation drection?	
15. Explain the processes by which the ocean floor has magnetic stripes on it (seafloor magnetic anomalies)	

DATE: ______________________________ **NAME:** ____

16. Based on the principles of isostatic equilibrium or adjustment, what happens to mountains when the top is eroded away?	
17. After an earthquake, which seismic wave arrives second?	
18. Which earth layer is responsible for plate tectonics? (Without this layer there could be no tectonic movements!)	
19. How does the process of convection contribute to plate tectonics? <u>In other words, relate convection to plate tectonics</u>.	
20. Give three ways that **<u>continental</u>** crust differs from oceanic crust (be SPECIFIC!).	1. 2. 3.
21. What do the rocks of the Bay Area tell us about the geologic setting of north America during the Mesozoic (245-65 Ma).	
22. Be able to determing the temperature and pressurs for a specific depth from graph of a geothermal gradient. (practice this with in class activity page 17 Class Hnadouts).	

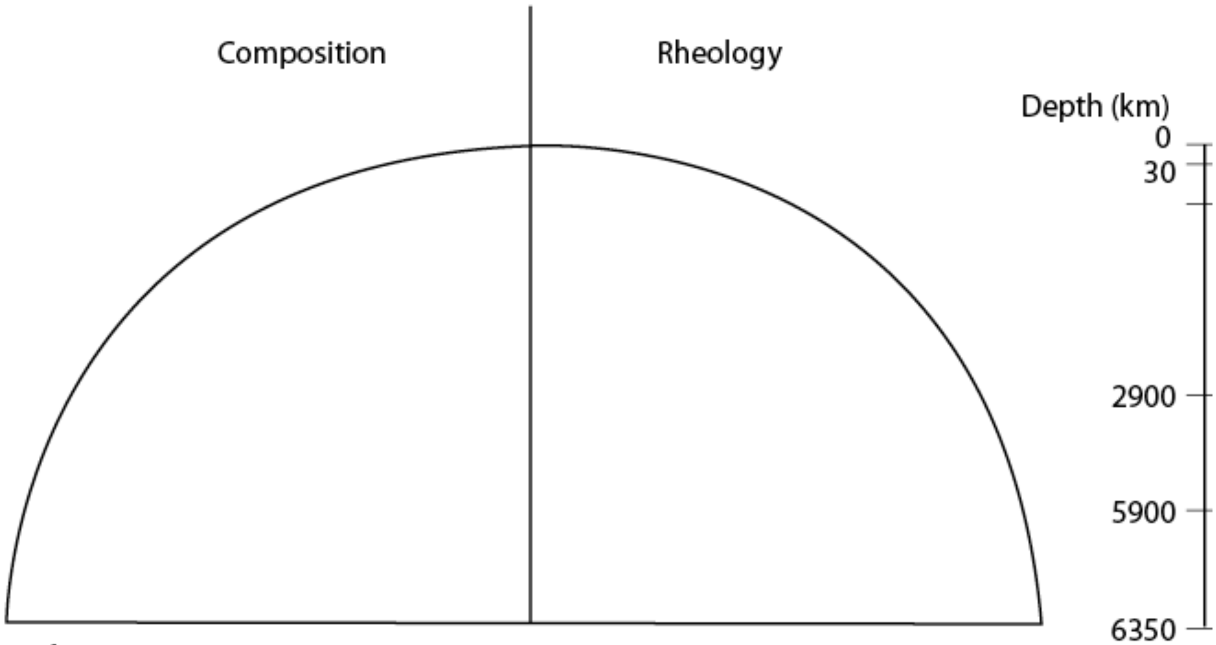
23. Draw arrows on the right and left of the drawings to indicate the <u>directions of stress</u>.
24. Draw arrows along the fault planes to indicate <u>relative motion</u>.
25. Label hanging wall and footwall for each set of blocks
26. Provide the correct name of each of the two faults shown?





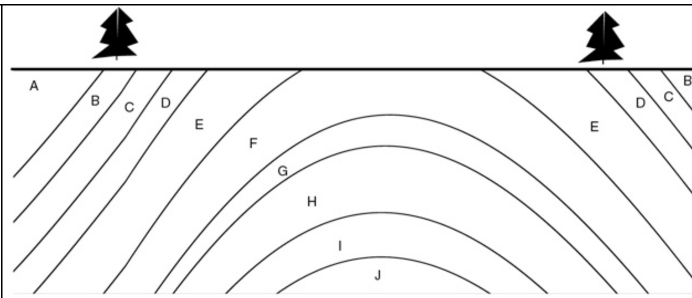
27. What are the three thrings that determine whether a rock behaves brittlely of plastically?	1. 2. 3.

28. Name the four layers of ocean crust known as the ophiolite sequence:	1.Name of uppermost rock type- 2. 3. 4. 5.Bottommost unit is–sheared peridotite
29. Draw a picture (to scale) of Earth's MAIN compositional **Label (crust, moho, mantle, core.** Draw an arrow pointing to the Moho.	30. Draw a picture (to scale) of Earth's rheologic layers. **Label (inner core, outer core, mesosphere, lithosphere, asthenosphere)**



31. Draw a picture (to scale) of a subduction zone. Label and include everything! See textbook and class handouts for example of a subduction zpne

32. What are the 6-step leading an earthquake (elastic rebound theory)	1. 2. 3. 4. 5. 6.

33. Place an X on the picture where you think the oldest rocks are located	

34. Draw a cross-section through the Atlantic Ocean. Show both continental margins of Africa and South America and draw as deep as the Asthenosphere. Label all features of plate boundaries and margins (one side only). Be thorough and precise. See Handouts for different parts of the shelf.

Plate boundary type	Transform	Divergent	Convergent
35. Stress type			
36. Type of faulting			
37. Type of Mountains (if any)			
38. Give example			

39. How are fracture zones and transform faults related?	
40. What is the difference between accretionary wedge and an exotic terrane.	
41. How can you use a hotspot track to determine plate speed and direction. You may be asked to calculate this on an exam.	
42. What is the difference between elastic strain and plastic strain?	
43. Compare and contrast strike-slip and dip-slip faults.	
44. Distinquish between the Mercalli, Richter, and Moment magnitude scales.	
45. *Approximately* how many times more **energy** is released in a magnitude 7 earthquake than in a 6?	
46. What is the difference in ground shaking between a magnitude 7 and a magnitude 6 on the Richter Scale?	
47. How is a tsunami generated (be Specific)?	
48. What is needed to determine the location of an earthquake?	
49. Explain how we know the outer core is a liquid.	
50. Explain what the **solidus** line represent on a temperature-depth graph of Earth?	

51. For each of the following objects, place in order from smallest (top) to tallest (bottom) and give depths/thicknesses/etc. in kilometers. (8 pts)

Average thickness of ocean crust
Continental shelf break depth
Deep sea floor (abyssal plain) depth
Deepest hole ever drilled on the planet
Depth sea level would fall during an ice age
Depth sea level would rise if all the ice melted
Highest mountain elevation
Radius of planet Earth

Arrange the list to the left based on height or thickness (smallest at top)	**Depth in meters (unless >1000 m then use km)**

52. For each of the following events, place in order from youngest (top) to oldest (bottom). To do so, you'll have to research the age of each, **but you need only memorize the ages of the items with ***.

Age of Earth*
Dinosaurs first evolve
Dinosaurs go extinct*
First life forms (bacteria)*
Fishes
Organisms develop hard parts*
Largest mass extinction on planet Earth*
Life moves onto land*
Mammals first evolved
Pangaea breaks apart
Pangaea forms
Photosynthesis*
Start of the Cenozoic Period*
Start of the Mesozoic Period*
Start of the Paleozoic Period*
Start of the Pleistocene Epoch*
Start of the Precambrian Period*
Trilobites

Event	**Age**

<u>Chapter 2 Questions</u> — Minerals

1. **What are the 5 MAIN requirements of a substance to be called a mineral? *(Naturally occurring, solid, has a crystal structure, can be defined by a chemical formula, and is inorganic. To be inorganic, the chemical formula cannot contain O, C, AND H (all three together)).*
2. How do minerals differ from rocks? Which of these are minerals: gold, glass, sugar, salt, ice?
3. **What's the difference between fracture and cleavage?
4. Gold has a density (or specific gravity) of 20. If a pail of water weighs 2 kg, what does the same size pail of gold weigh?
5. How can you use the hardness scale to determine the hardness of a mineral?

Moh's scale:	**Other items:**
1. Talc	
2. Gypsum	2.5 fingernail
3. Calcite	3.5 copper wire
4. Fluorite	4.5 iron wire or nail
5. Apatite	5.5 glass or masonry nail or knife blade
6. Orthoclase	6.5 streak plate
7. Quartz	
8. Topaz	
9. Corundum	
10. Diamond	

6. **What is the basic structure of an atom? What are the main particles? How do they differ?
7. If the number of electrons in an atom is 20; its atomic mass is 41; how many protons? Neutrons? The atomic number? The number of electrons in its outer shell (**<u>valence electrons</u>**)?
8. What is an isotope?
9. **What is the octet rule and why is it important?
10. **What are polymorphs? Give an example of a set.
11. **Compare and contrast the three main bond types: how is each formed? Why?

	Covalent bonds	**Ionic bonds**	**Hydrogen bonds**
Description	Shared electrons to complete outer shell.	Atoms exchange electrons to complete outer shell. Now atoms are ions that are oppositely charged and attracted to each other.	Water molecules (because of shape) have a slightly positive end and slightly negative end. These molecules are attracted to each other and to other ions.
Relative strength	Strongest	Medium	Weakest
Example	Diamond Quartz Water (between H and O atoms)	Halite (salt)	Water (between water molecules – how they stick to each other)

Mineral Identification Chart – LECTURE

NONMETALLIC MINERALS (listed in decreasing hardness) Review mineral formula to connect to family! H=Hardness; SG = specific gravity

Mineral	H	SG	Streak	Color (and/or luster)	Form	Cleavage/Fracture	Distinctive properties
Garnet $X_3Y_2(SiO_4)_3$ *where X and Y are combinations of Ca, Mg, Fe, Al*	7	3.5-4.3	White	Red, black, or brown; can be yellow, green, pink. Glassy. Translucent.	Dodecahedrons (12-sided polygons)	No cleavage. Brittle. Conchoidal fracture.	Dodecahedron form, red, glassy, conchoidal fracture, H=7.
Olivine $(Mg,Fe)_2SiO_4$	7	3.3-3.4	White	Pale or dark olive green to yellow or brown. Glassy. Transparent.	Short prisms (usually too small to see).	Conchoidal fracture. Brittle.	Green, conchoidal fracture, glassy, H=7. Usually granular.
Quartz SiO_2	7	2.7	White	Colorless, white, or gray; can occur in all colors. Glassy and/or greasy.	Massive; or hexagonal prisms that end in a point.	Conchoidal fracture.	Glassy, conchoidal fracture, H=7. Hex. prism with point end.
Plagioclase Feldspar family: Anorthite and Labradorite $CaAl_2Si_2O_8$ to Oligoclase and Albite $NaAlSi_3O_8$	6	2.6-2.8	White	Colorless, white, gray, or black; can have iridescent play of color from within. Translucent to opaque.	Tabular crystals or thin needles	2 good cleavage planes at nearly right angles.	Twinning. 2 cleavages at 90°.
Potassium Feldspar family: Orthoclase and Microcline $KAlSi_3O_8$	6	2.5-2.6	White	Pink. Or white, orange, brown, gray, green. Translucent to opaque.	Tabular crystals	2 good cleavage planes at nearly right angles.	Subparallel exsolution lamellae. 2 cleavages at 90°. Pink color.
Pyroxene family: Augite $Ca(Mg,Fe,Al)(Al,Si)O_6$	5.5-6	3.2-3.5	White, pale grey	Green to black; opaque.	Short, 8-sided prisms (if visible).	2 good cleavage planes at nearly right angles.	H=5.5. Dark green or black. 2 cleavages at 90°. (Looks like HB.)
Amphibole family: **Hornblende** $Ca(Mg,Fe)_4Al(Si_7Al)O_{22}(OH)_2$	5.5	3-3.3	Grey-green, white	Dark green to black. Opaque.	Long, perfect prisms.	2 cleavages planes. Angles: 60° and 120°. Brittle. Splintery fracture.	H=5.5. Dark green or black. 2 cleavages at 60° & 120°. Splintery fracture. Long prisms.
Serpentine $Mg_6Si_4O_{10}(OH)_8$	2-5	2.2-2.6	White	Pale or dark green, yellow, grey. Opaque. Dull or silky.	Smooth, rounded masses.	No cleavage.	Mottled green color. Smooth, curved surfaces.
Fluorite CaF_2	4	3-3.3	White	Colorless, purple, blue, grey, green, or yellow. Glassy. Opaque to transparent. Rainbow luster in places.	Usually cubes or octahedrons.	4 excellent cleavage directions. Gives crystal shape triangular faces. Brittle.	Cubic or octahedral form. 4 directions of cleavage. Triangular faces. Rainbow luster in places.

Mineral	H	SG	Streak	Color (and/or luster)	Form	Cleavage/Fracture	Distinctive properties
Calcite $CaCO_3$	3	2.7	White	Usually colorless, white, or yellow, can be green, brown, or pink. Glassy. Opaque to transparent.	Rhombohedrons.	3 excellent cleavage planes. Angles: < 90° and > 90°.	Bubbles in HCL. Double refraction (2 images visible through clear sample). Rhombs, 3 cleavage planes (not 90°), H=3.
Mica family: **Biotite** $K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$	2.5-3	2.7-3.1	Grey-brown	Black, green-black, brown-black. Transparent to opaque.	Short tablets. Like a tablet of paper.	1 excellent cleavage – splits easily into thin, flexible sheets.	1 flexible cleavage plane (sheet), dark colored; brown streak.
Mica family: **Muscovite** $KAl_3Si_3O_{10}(OH)_2$	2-2.5	2.7-3	White	Colorless, yellow, brown, or red-brown. Transparent to opaque.	Short tablets. Like a tablet of paper.	1 excellent cleavage – splits easily into thin, flexible sheets.	1 flexible cleavage plane (sheet), light colored; white streak.
Halite NaCl	2.5	2.1-2.6	White	Colorless, white, yellow, blue, brown, or red. Glassy.	Cubes.	Brittle. 3 excellent cleavage planes: cubes.	Salty taste. H=2.5. Cubic form and cleavage.
Gypsum $CaSO_4*2(H_20)$	2	2.3	White	Colorless, white, or grey. Translucent to transparent.	Tabular, prisms, blades, or needles.	1 good cleavage plane.	H=2. 1 cleavage plane. Translucent.
Talc $Mg_3Si_4O_{10}(OH)_2$	1	2.7-2.8	White	White, grey, pale green, or brown. Opaque. Greasy or silky luster.	Shapeless masses (if no cleavage visible) or tabular.	1 poor cleavage plane (may not be visible).	Feels greasy or soapy. H=1. Opaque.

METALLIC MINERALS (listed in decreasing hardness) Review mineral formula to connect to family! H=Hardness; SG = specific gravity

Mineral	H	SG	Streak	Color	Form	Cleavage/Fracture	Distinctive properties
Pyrite FeS_2	6-6.5	5	Dark grey	Brass yellow; tarnishes brown.	Cubes or octahedrons	Brittle. No cleavage.	Cubic form, brassy color, and SG=5.
Magnetite Fe_3O_4	6	5.2	Dark grey	Silvery grey to black. Tarnishes grey. Opaque.	Octahedrons	No cleavage.	Attracted to a magnet. SG=5.2. No cleavage.
Hematite Fe_2O_3	1.5-6	2.1-2.6	Red to red-brown	Silvery grey, black, or brick red. Luster can also be nonmetallic.	Thin tabular crystals or shapeless masses.	No cleavage.	Red streak. Metallic + nonmetallic. Earthy red.
Galena PbS	2.5	7.6	Grey to dark grey	Silvery grey. Tarnishes dull grey.	Cubes and octahedrons	Brittle. 3 good cleavage planes (cubes).	SG=8. Dense! Silver cubes (form and cleavage).
Graphite C	1	2.1-2.3	Dark grey	Silvery grey to black.	Flakes, short hexagonal prisms, and masses.	1 excellent cleavage plane.	Dark grey. H=1. Greasy. Dark grey streak.

Mica family: **Biotite** $K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$	**Garnet** $(Ca_3,Mg_3,Fe_3Al_2)n(SiO_4)_3$
Mica family: **Muscovite** $KAl_3Si_3O_{10}(OH)_2$	**Olivine** $(Mg,Fe)_2SiO_4$
Halite NaCl	**Quartz** SiO_2
Gypsum $CaSO_4$*2(H_20)	**Plagiociase Feldspar** family: Anorthite and Labradorite $CaAl_2Si_2O_8$ to Oligoclase and Albite $NaAlSi_3O_8$
Talc $Mg_3Si_4O_{10}(OH)_2$	**Potassium Feldspar** family: Orthoclase and Microcline $KAlSi_3O_8$
Pyrite FeS_2	**Pyroxene** family: Augite $Ca(Mg,Fe,Al)(Al,Si)O_6$
Magnetite Fe_3O_4	Amphibole family: **Hornblende** $(Ca,Na)_{2-3}(Fe,Mg,Al)_5$ $Si_6(Si,Al)_2O_{22}(OH)_2$
Hematite Fe_2O_3	**Serpentine** $Mg_6Si_4O_{10}(OH)_8$
Galena PbS	**Calcite** $CaCO_3$
Graphite C	**Fluorite** CaF_2

Not metallic. Dodecahedron form, red, glassy, conchoidal fracture, H=7.	Not metallic. 1 flexible cleavage plane (sheet), dark colored; brown streak.
Not metallic. Green, conchoidal fracture, glassy, H=7. Usually granular.	Not metallic. 1 flexible cleavage plane (sheet), light colored; white streak.
Not metallic. Glassy, conchoidal fracture, H=7. Hex. prism with point end.	Not metallic. Salty taste. H=2.5. Cubic form and cleavage.
Not metallic. Twinning. 2 cleavages at 90°.	Not metallic. H=2. 1 cleavage plane. Translucent.
Not metallic. Subparallel exsolution lamellae. 2 cleavages at 90°. Pink color.	Not metallic. Feels greasy or soapy. H=1. Opaque.
Not metallic. H=5.5. Dark green or black. 2 cleavages at 90°. (Looks like HB.)	Metallic. Cubic form, brassy color, and SG=5.
Not metallic. H=5.5. Dark green or black. 2 cleavages at 60° & 120°. Splintery fracture. Long prisms.	Metallic. Attracted to a magnet. SG=5.2. No cleavage.
Not metallic. Mottled green color. Smooth, curved surfaces.	Red streak. Metallic + nonmetallic. Earthy red.
Not metallic. Bubbles in HCL. Double refraction (2 images visible through clear sample). Rhombs, 3 cleavage planes (not 90°), H=3.	Metallic. SG=8. Dense! Silver cubes (form and cleavage).
Not metallic. Cubic or octahedral form. 4 directions of cleavage. Often has triangle-shaped edges due to cleavage. Surface luster contains rainbow refraction in place.	Metallic. Dark grey. H=1. Greasy. Dark grey streak.

Atomic Particles, Atoms, Isotopes, and Bonding Worksheet

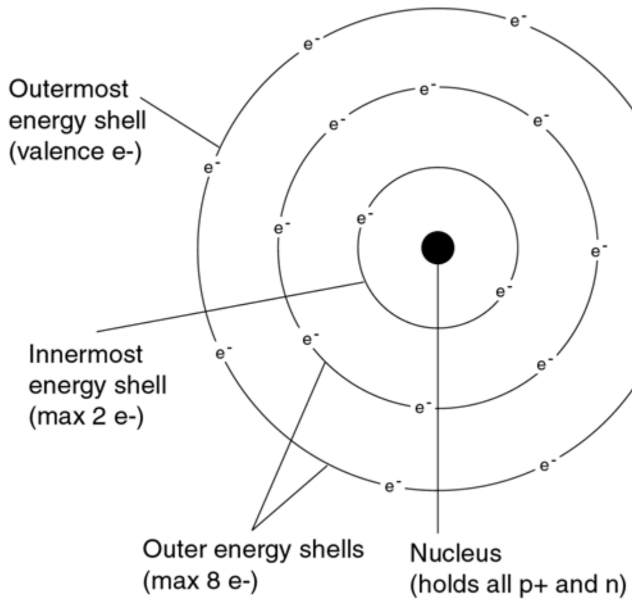
Atomic Particles (amu = atomic mass unit)

Name	Symbol	Charge	Mass	Location
Electron	e-	-1	0	Energy shells surrounding nucleus
Proton	p+	+1	1 amu	Nucleus
Neutron	n	0	1 amu	Nucleus

Atomic mass = total mass of atom = # of protons + # of neutrons
Atomic number = # of protons = designation for element
Energy shells: electrons reside in energy shells surrounding the nucleus of an atom.
- Shell 1 maximum = 2 electrons (no more allowed)
- Shell 2, 3, 4, 5… maximum = 8 electrons (no more allowed)
- Therefore, the first two electrons go into shell 1, the next eight into shell 2, and so on.

Octet rule: All atoms want to completely fill their outermost energy shell: 2 electrons maximum in the first shell and 8 maximum in all other shells.
Valence electrons = the number of electrons residing in the outermost unfilled energy shell
Bonding = Atoms attempts to fill their outermost energy shell by removing, adding, or sharing electrons.
- **Ionic bonding** = Atom A gives up electrons to Atom B, so that both can achieve the octet rule. The result: two ions with equal and opposite charges that now attract each other.
- **Covalent bonding** = Atoms A and B both share one of their electrons with each other, thereby effectively gaining one. In such cases, the electrons orbit both nuclei, gluing them together most strongly.
- **Hydrogen bonding** = Hydrogen atoms bonded to oxygen (like in water) act as weak positive ions that can then weakly attract negative ions. This is how water dissolves ions so easily, by surrounding and attacking ionic bonds, pulling the positive and negative ions apart. Hydrogen bonds are weak bonds, and so it take a number of water molecules to pull apart one salt molecule, for example.

Isotopes = atoms with same atomic number (same # protons), but different # of neutrons. Therefore, they are the same element, but with different masses.
Atomic weight = the average atomic mass of a given sample of an element (averaging in all its naturally occurring isotopes).



p+ = #e- = 18

n = 22

atomic # = 18

element = Argon

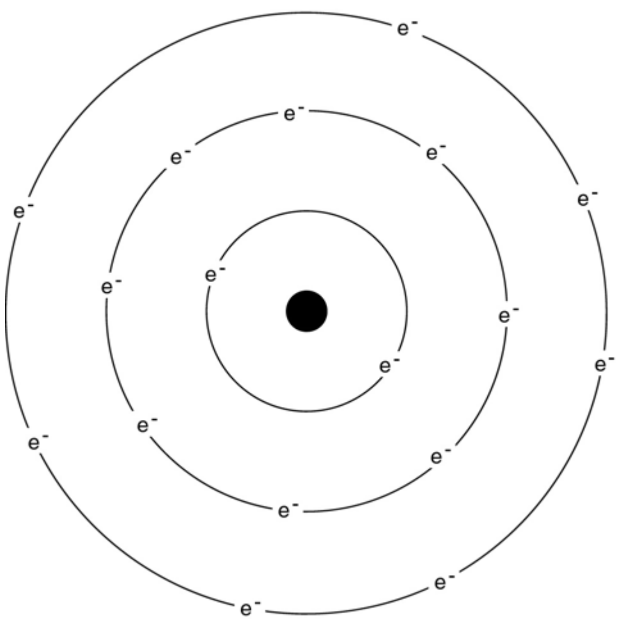
atomic mass = 40

Argon	18 Ar 40

valence e- = 0

Change in e- desired? None

Complete these diagrams with all the missing information



p+ =

n =

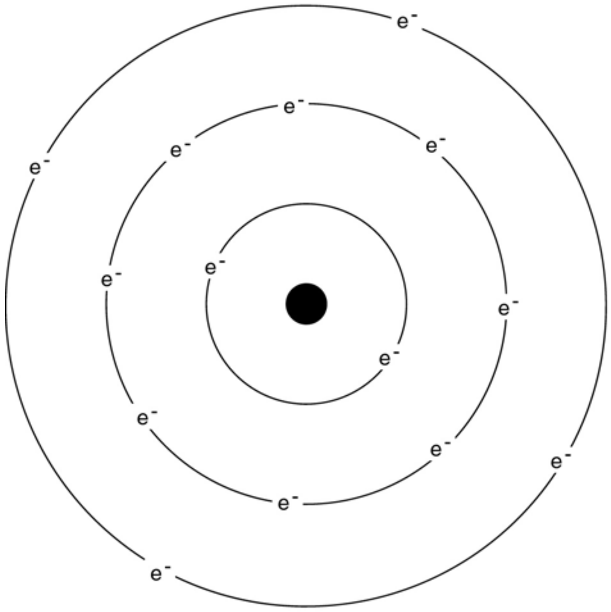
atomic # =

element =

atomic mass = 36

valence e- =

Change in e- desired?



p+ =

n =

atomic # =

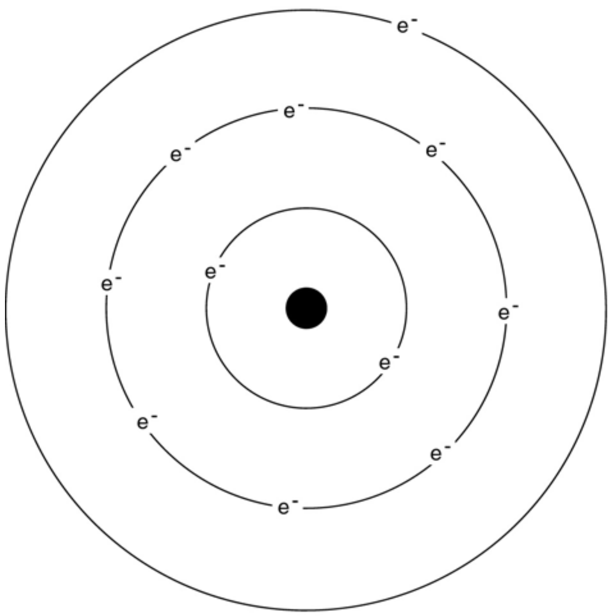
element =

atomic mass = 28

☐

valence e- =

Change in e- desired?



p+ =

n =

atomic # =

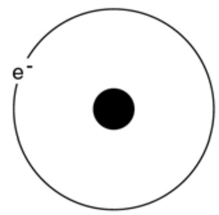
element =

atomic mass = 23

☐

valence e- =

Change in e- desired?



p+ =

n =

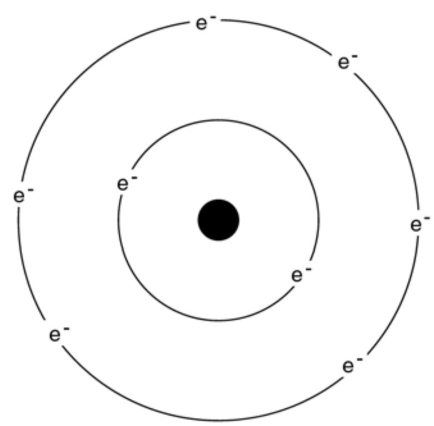
atomic # =

element =

atomic mass = 1

valence e- =

Change in e- desired?



p+ =

n =

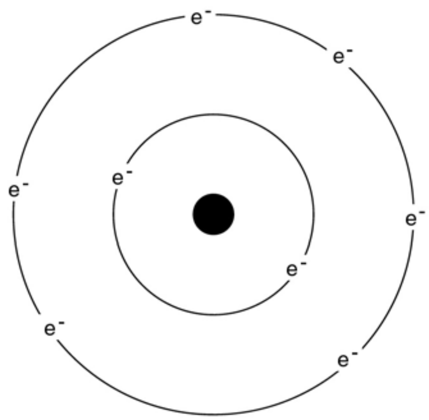
atomic # =

element =

atomic mass = 16

valence e- =

Change in e- desired?



p+ =

n =

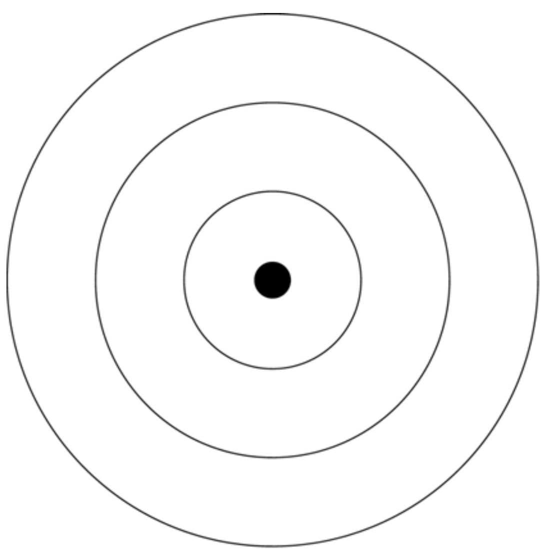
atomic # =

element =

atomic mass = 18

valence e- =

Change in e- desired?



p+ =

n =

atomic # =

element =

atomic mass =

13
Aluminum Al
27

valence e- =

Change in e- desired?

p+ = 11

n = 12

atomic # = 11

element = Sodium

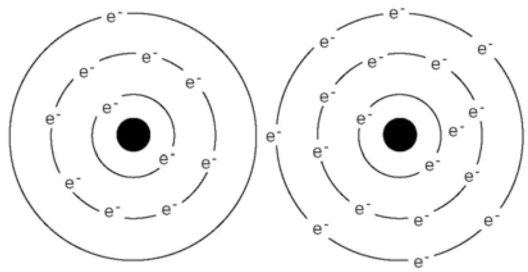
atomic mass = 23

valence e-

before bond:

after bond:

Net charge:



Ionic Bonding
NaCl

p+ = 17

n = 18

atomic # = 17

element = Chlorine

atomic mass = 35

valence e-

before bond:

after bond:

Net charge:

p+ = 7 # n = 7

atomic # = 7

element = Nitrogen

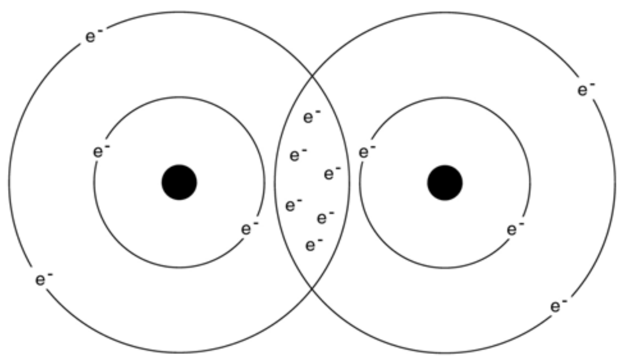
atomic mass = 14

valence e-
before bond:

e- shared
with other?

e- gained
from other?

valence e-
after bond:



Covalent Bonding

$N2$ (gas)

p+ = 7 # n = 7

atomic # = 7

element = Nitrogen

atomic mass = 14

valence e-
before bond:

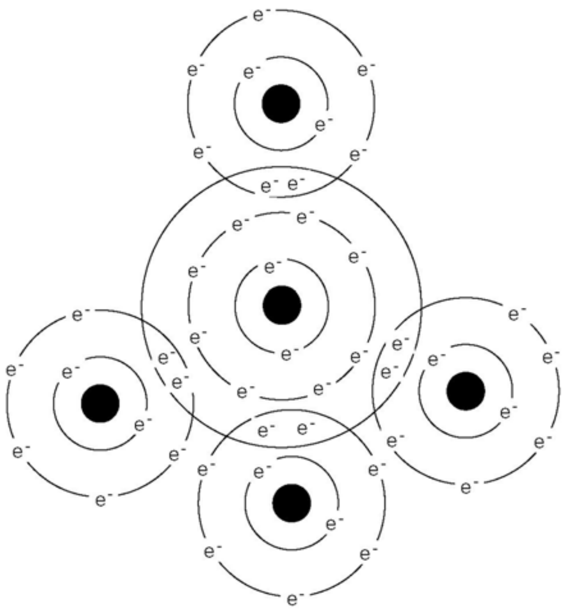
e- shared
with other?

e- gained
from other?

valence e-
after bond:

Covalent Bonding -- SiO_4

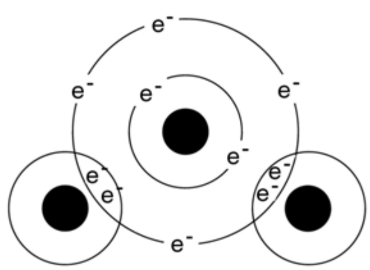
4 ATOMS Each:
p+ = 8 # n = 8
atomic # = 8
element = Oxygen
atomic mass = 16
valence e- before bond:
e- shared with other?
e- gained from other?
valence e- after bond:



CENTER ATOM:
p+ = 14 # n = 14
atomic # = 14
element = Silicon
atomic mass = 28
valence e- before bond:
e- shared with other?
e- gained from other?
valence e- after bond:

Covalent Bonding -- H_2O

2 ATOMS Each:
p+ = 1 # n = 0
atomic # = 1
element = Hydrogen
atomic mass = 1
valence e- before bond:
e- shared with other?
e- gained from other?
valence e- after bond:



CENTER ATOM:
p+ = 8 # n = 8
atomic # = 8
element = Oxygen
atomic mass = 16
valence e- before bond:
e- shared with other?
e- gained from other?
valence e- after bond:

<u>Chapter 3 Questions</u> — Igneous Processes and Igneous Rocks –

1. **How does magma differ from lava?
2. **What two criteria do we use to classify igneous rocks?
3. Igneous rocks are divided into four main compositions. Be sure you know these four compositions, their primary chemical differences, mineral compositions, and rock names.

Composition	**Name**	**Mineral composition**	**Intrusive rock names**	**Extrusive rock names**
< 45% Si	Ultramafic	Major: Olivine Minor: Pyroxene, Plagioclase	Peridotite	NONE EXIST ON PLANET EARTH
45 – 55% Si	Mafic	Major: Pyroxene, Ca-rich Plagioclase Minor: Olivine, Hornblende	Gabbro	Basalt, Scoria
55 – 65% Si	Intermediate	Major: Hornblende, Biotite, Na-rich Plagioclase Minor: Pyroxene	Diorite	Andesite, Pumice, Tuff
> 65% Si	Felsic	Major: Quartz, K-Feldspar, Muscovite Minor: Biotite, Hornblende, Na-rich Plagioclase.	Granite	Rhyolite, Pumice, Tuff, Obsidian

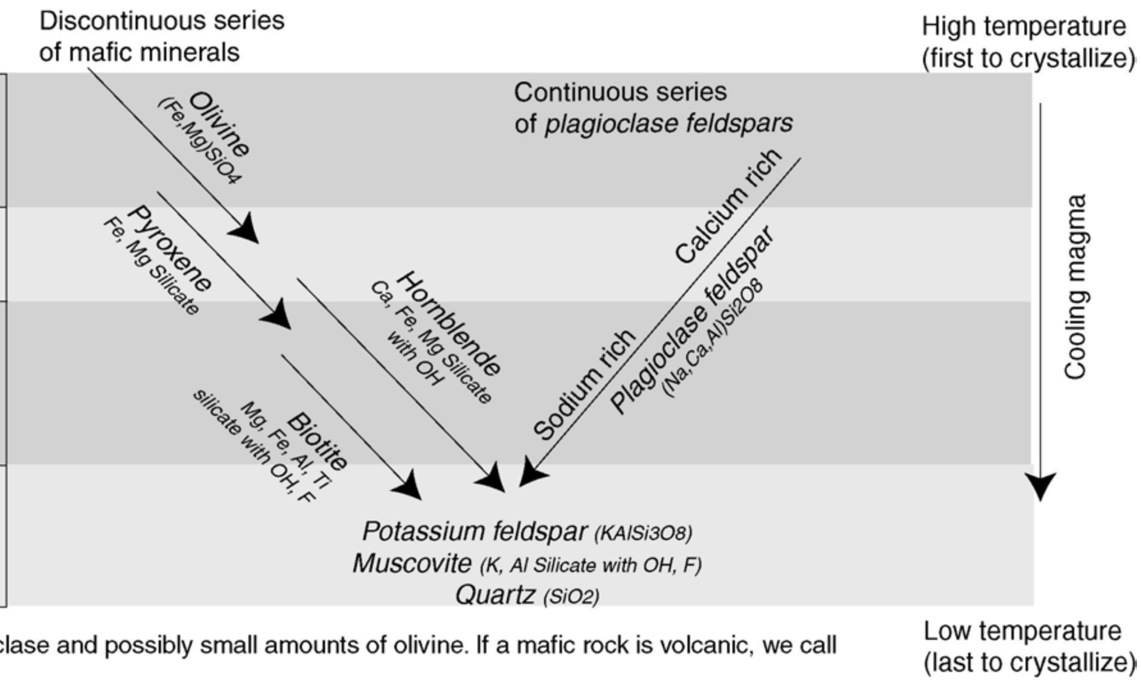
4. Igneous rocks are divided into five main textures. Describe those five textures.
5. **What is viscosity?
6. What characteristics of a magma can increase viscosity?
7. What three major factors increase the crystal size of minerals in igneous rocks?
8. **Under what circumstances will no crystals form when a melt solidifies? What do we call such a product?
9. **What is **<u>porphyritic</u>** texture? What does it indicate about the formation of an igneous rock?
10. How do magmas of identical compositions produce rocks of different compositions? (What processes change a magma's composition after it forms?)
11. Explain how magmas' physical and chemical characteristics change as they rise to the surface and progress through Bowens Reaction Series (fill out table below):

Temperature		Si, K, Na content		Fe, Mg, Ca content		Viscosity	
Water content		Quartz content		Olivine content		Plagioclase content	

12. According to Bowen's reaction series, what minerals crystallize first as magmas cool? Last? What minerals will you never find together? Always find together?
13. **Compare and contrast extrusive and intrusive rocks. Be sure you understand what features and textures are found in each

Bowen's Reaction Series

COMPOSITION NAME	EXTRUSIVE OR VOLCANIC ROCK NAME	INTRUSIVE OR PLUTONIC ROCK NAME
Ultramafic		*Peridotite*
Mafic	*Basalt*	*Gabbro*
Intermediate	*Andesite*	*Diorite*
Felsic	*Rhyolite*	*Granite*



Example: A mafic rock contains pyroxene and plagioclase and possibly small amounts of olivine. If a mafic rock is volcanic, we call it basalt. If it is plutonic, we call it gabbro.

Volcanic Tuff	**Obsidian**
Pumice	**Scoria**
Andesite	**Basalt**
Gabbro	**Rhyolite**
Granite	**Diorite**

Glassy texture.	Pyroclastic texture.
Frothy texture. Mafic composition (dark colored).	Frothy texture. Felsic/Intermediate composition (light colored).
Aphanitic texture. Mafic composition (dark colored or with olivine, plagioclase, or pyroxene phenocrysts).	Aphanitic texture. Intermediate composition (grey colored or with hornblende or biotite phenocrysts).
Aphanitic texture. Felsic composition (light colored or with quartz, K-feldspar, or muscovite phenocrysts).	Phaneritic texture. Mafic composition (mostly olivine, plagioclase, and pyroxene).
Phaneritic texture. Intermediate composition (mostly hornblende, biotite, and plagioclase).	Phaneritic texture. Felsic composition (mostly quartz, K-feldspar, and muscovite).

<u>Chapter 4 Questions</u> — Volcanoes and Volcanism

1. **Describe flood basalt formation.
2. What is its effect on global climate and Earth history?
3. Understand the three primary methods for melting mantle rock and learn which three locations on the Earth's surface you find magmas formed through each of those methods (discussed last week).

Geologic setting for volcanism	**Magmas produced by:**	**World example:**
Hotpots	Increased heat	Hawaii, Yellowstone, Iceland
Subduction zones	Addition of water causes melting point of mantle to drop.	Cascade Mtns, Andes Mtns, Indonesia, Aleutian Islands, Japan, Philippines
Divergent plate boundaries	Drop in pressure causes melting point of mantle to drop	Iceland, Oceanic ridges everywhere, East African Rift Zone, Long Valley

4. Oceanic volcanism is mostly what igneous composition? Continental volcanism? Why?
5. **List the main gases released in a volcanic eruption. (<u>*Book Error*</u> p. 106. *Correction*: Major gases: CO_2, H_2O, SO_2. Minor gases: Cl_2, N_2.)
6. What are the two primary ways to make a volcanic eruption more hazardous? Why?
7. **What does *pyroclastic* mean? Describe all types of pyroclastic material.
8. What do we call a rock composed of compacted pyroclastic material? Why is such a rock usually felsic?
9. **What is a pluton? Compare and contrast these three kinds of common plutons.

	Sill	**Dike**	**Batholith**
Parallel to surrounding bedding (concordant) or cross-cutting (discordant)	Parallel	Cross-cutting	Cross-cutting
Shape: tabular or massive	Tabular	Tabular	Massive
Size	5-30 m thick	0.5-30 m thick	100s of km wide

10. For each of these igneous rock types, describe its texture and composition: **Andesite, Basalt, Diorite, Gabbro, Granite, Obsidian, Rhyolite, Scoria, Tuff**
11. Compare and contrast the various hazards and materials that volcanoes produce:

See next page for additional Volcano information

12.

Hazard	Definition	Speed	Distance travelled	Dangers
Dust, ash, and pyroclastic bombs	Material thrown from the vent of a volcano	Ash: as fast as wind (20-80 km/h)	Ash: All over world, potentially	Ash: Roof collapse, asphyxiation, clogged machinery, lost crops, breathing problems increased for asthmatics, Bombs: bodily injury/death
Lahar	Mudflow: ash + water (rain or melted glacier)	Up to 40-50 km/h	100s of km from vent (along river valleys)	Drowning, destruction of all bridges and buildings near water's edge
Pyroclastic flows	Ash, gas, lava, rocks	Up to 200 km/h	10s of km from vent	Death and destruction to any and all in its path.
Lava flows	Flowing molten rock	2-4 km/h	10s of km from vent (if basalt), 1 km if rhyolite	Destruction to property and vegetation. Little hazard to human life.
Gas clouds	High density rolling CO_2 gas.	??	10s of km from vent	Asphyxiation of all life.
Acid rain	SO_2 gas + H_2O creates sulfuric acid.	Same as wind	10s of km from vent	Temporary lull in growth of vegetation and contamination of water.

13. Compare and contrast these main types of volcanic landforms:

	Shield volcano	**Stratovolcano or composite cone**	**Cinder or pyroclastic cone**	**Continental Caldera**	**Volcanic dome**
Size	200 km wide 9 km tall	18 km wide 3 km tall	1500 m wide 300 m tall	200 km wide 1-2 km tall	50 m wide 25 m tall
Shape	Shield	Perfect cone (or composite of many cones)	Perfect cone shape	Broad dome in continental crust	Dome
Major materials produced	Lavas primarily	Equal: pyroclastics & lavas	Scoria or pumice only (pyroclastics)	Tuffs and lava flows	Lava only
Magma compositions	Mafic	Intermediate and Felsic	All	Rhyolite	Felsic
Eruptive style (relative hazard)	Low	High	Low	Very High	Low to Intermediate
Typical locations	Over hotspots	Subduction zone arcs and continental rifts	Flanks of all volcanoes	Hot spots beneath continents	Craters of stratovolcanoes

Volcanic Hazards Summary

Ashfall

Ash mantles topography. It moves as fast as the wind that carries it. Therefore, it is distributed in the direction the wind is blowing during the eruption, at the same speed as the wind is blowing. For example, with winds of 66 km/hr, if a farm is in the down wind direction during an eruption, and is 66 km away, it will take 1 hour for the ash to arrive, and the farmers have 1 hour to evacuate. Towns and agriculture in the up wind direction are likely to be unaffected by ash during the eruption.

The thickness of ash deposited during eruptions is related to how far away from the summit you are.
For example, in a small eruption, if you are 80 km downwind from the eruption, you get 2 cm of ash falling. In an extreme eruption, you could get as much as 90 cm. Note: if you lived 80 km away in the opposite direction of the wind, you would probably receive nothing. As you get closer to the wind direction, the ash thickness would increase until it reaches the maximums described above.

Much of the volume of ash produced in an eruption will be deposited outside the 1 cm boundary, but such small amounts generally constitute only a mild hazard, significant only under special circumstances, for example for people with severe respiratory disease and for jet engines if ash enters intakes.

- **Zone 1 – Moderate Hazard – Thickness between 1 and 10 cm .** Less than 10 cm thick, ash can cause plenty of damage by clogging machinery, overwhelming sewage treatment plants when it gets into storm drains, causing auto crashes due to sliding and decreased visibility, covering grass that animals normally graze, etc. But less than 10 cm of ash is unlikely to cause much loss of life.
- **Zone 2 – Severe Hazard – Thickness between 10 cm to 100 cm (1 meter).** 10 cm of ash is enough to collapse roofs (crushing the inhabitants), especially if the ash gets wet, which increases load on roofs.
- **Zone 3 – Extreme Hazard – Thickness exceeds 1 m.** One meter of ash is enough to collapse nearly all roofs, and it would bury vegetation so deeply, recovery would be impossible. The size of the pumice lumps and rocks torn from the vent increases toward the vent (big particles fall out of the column closer to the vent than smaller particles), just as the thickness of the deposit does. Where the deposit is thick, there is also a severe hazard of being clobbered by falling pumice lumps and rocks.

Lava Flows

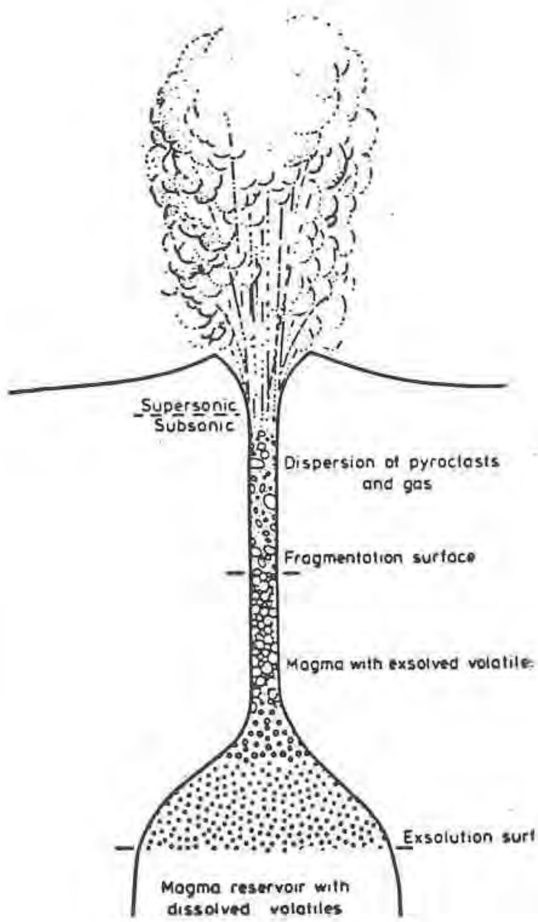
Lava flows are composed of 100% molten lava, originating from a vent or fissure. They tend to move slowly: the higher the viscosity (higher the silica content) of the lava, the slower the flow. Andesitic lava flows move about 4 km/hr on steep slopes and only about 0.5 km/hr on flat areas. Gravity pulls lava flows downhill, while increased magma supply from above gives them added push. The slower the lava flow, the closer it stays to the vent. Low viscosity pahoehoe lavas can flow thousands of kilometers (if volume is high enough, like in flood basalts). High viscosity rhyolitic lavas never flow more than a kilometer or two. Where magma supply is high (like in hotspots), flow rate increases.

Volcanic Mudflows

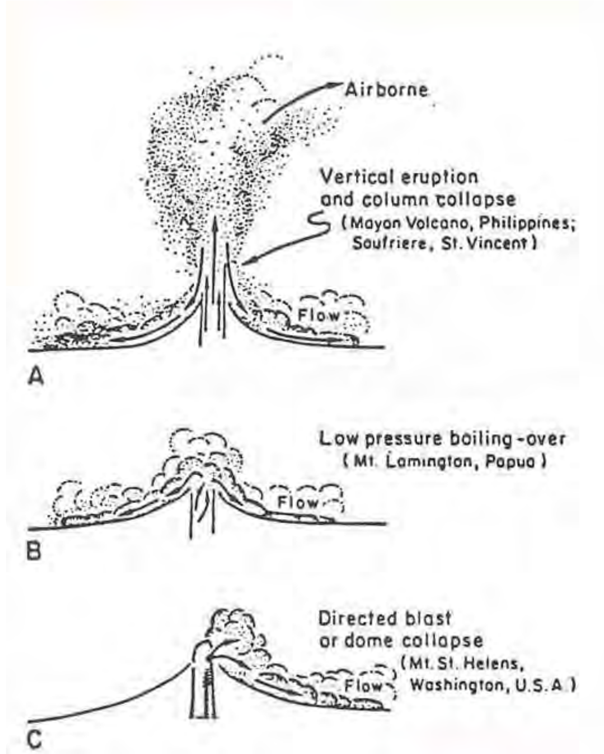
Mudflows are composed of ash and usually meteoric water (nonmagmatic) such as melted ice, lake water, sea water, and groundwater. They move rapidly (30 km/hr), pulled downhill by gravity. They stick to river valleys, basins, and lakes. They usually involve such large amounts of water that they cause lakes and rivers to overflow their banks. Mudflows (often referred to as Lahars when they occur on volcanoes) can take out bridges, houses, and cars, and can travel hundreds of kilometers from the vent. Because they flow down existing river valleys, they do most of their damage in the flood plains of rivers. Note: lahars can occur during and after eruptions. Lahars that occur during eruptions usually are the result of hot ash raining down on and melting glaciers, or the combination of hot ash and water breaking through dams. Lahars that occur after eruptions usually result from rains that mobilize recently deposited ash and carry it to streams.

Pyroclastic Flows

Pyroclastic flows form in a variety of ways. Hot ones form by initial collapse of the outside of an ash column. They can also form as colder rock and glass from the front of lava flows falls off, exposing magma underneath that is still full of gases. Another cause is catastrophic depressurization of a hydrothermal system (as in the Mt. St Helens eruption, when the bulge on the side of the mountain slid away, after an earthquake).



Pyroclastic flows are composed of original magmatic material. They are fast because they are light and contain gases, which help reduce friction (75 km/hr). Pyroclastic flows are intensely heated with minute fragments of magma, crystals, gas, ash and any other rocks or sediments they can entrain as they flow from the vent or fissure, much like an avalanche.



Surges

A surge is the fastest and most dangerous type of pyroclastic flow (200 km/hr). They are sometimes referred to as nuee ardentes. They differ from a more typical pyroclastic flow because of increased volume of gas and the small size of particles they carry. Pyroclastic flows can carry large sizes; surges transport mostly fine-grained material.

Warm to cold surges usually come from nonmagmatic water, such as melted ice, lake water, sea water, and groundwater. This water comes in close contact with magma or hot rock and flashes to steam. Most surges don't go very far, because either they entrain cooler air and rise upwards, or they literally run out of steam. The biggest surges will extend a few kilometers beyond the base of the volcano. Surges mantle topography, but tend to be thick in valleys and thin on ridges. They are powered partly by the initial gas expansion (blast), which gives them a lateral component. (Close the vent, surges cover everything!) But surges also are flowing in response to gravity, so they tend to prefer to go downhill. They can climb topography near the vent if they are going fast enough, just as large snow avalanches can go uphill.

Chapter 5 (p. 144-156) and Chapter 6 Questions — Weathering: The Breakdown of Rocks (not including soils) & Sedimentation and Sedimentary Rocks

Know **T**he **C**anyon's **H**istory, **S**tudy **R**ocks **M**ade **B**y **T**ime — From Top to bottom the layers of the Grand Canyon include: Kaibab Limestone, Toroweap Shale, Coconino Sandstone, Hermit Shale, Supai Group, Redwall Limestone, Muav Limestone and Shale, Bright Angel Shale, Tapeats Sandstone.

1. **Compare and contrast weathering and erosion.
2. Describe the physical weathering process that cause frost wedging, exfoliation, and spheroidal weathering.
3. What is the most common naturally formed acid? How does it form?
4. **Understand the process and results of these types of chemical weathering:

Types	Description of process and results
Dissolution	Water molecules gang up on ions on outside of mineral lattice (surface) and break the mineral bonds, releasing the ions into solution. Water carries ions away.
Hydrolysis	Water molecules enter mineral formula, replacing other components and changing mineral to a new one: a clay mineral. Example: $2KAlSi_3O_8 + 2H^+ + 9H_2O = Al_2Si_2O_5(OH)_4 + 4H_4SiO_4 + 2K^+$ K-feldspar + water = Kaolinite clay + silicic acid and potassium ions
Oxidation	Oxygen bonds with Fe ions on outside of mineral lattice (surface) removing Fe from mineral and producing Hematite (rust).

5. What two minerals are most common in detrital sedimentary rocks? Why are these minerals so abundant?
6. How can you use grain composition (minerals), sorting, and grain size and shape to tell sediment maturity (distance the mineral has traveled from its source and/or time mineral has been exposed at surface)?

Characteristic	Description where grain forms:	Description of grain after major transit by water:
Grain composition	All compositions possible	Only most resistant minerals left: clay and quartz
Grain size	All possible (gravel, sand, mud)	Only fine sand and mud
Grain sorting	Very poor	Very good
Grain shape	Angular	Rounded

7. **How is detrital or organic (both together = clastic) sediment turned into sedimentary rock (lithified)? (Two main processes, not including precipitation.) For what kind of sediment does each occur?
8. Describe the three most common cements for sedimentary rocks. Why do you think these are the 3 most common?
9. The term clay can be used in two different ways. Describe the two meanings of this term.
10. **What are evaporites? How do they form?
11. Distinguish between clastic and chemical textures. How does this differ from detrital vs clastic?
12. Discus the role of stream power and its affect on deposition or erosion.
13. Where are most sedimentary rocks deposited? Why?
14. What evidence is there in the Grand Canyon to support multiple phases of uplift and subsidence (lowering) of the continental platform.
15. Describe the basic distinguishing characteristics of these major sedimentary rocks (bolded names are the only ones required):

conglomerate, breccia, sandstone (including arkose, quartz arenite, graywacke), **mudstone** (including **shale**) **limestone** (including **chalk** and coquina), **chert** (including **diatomite**), **evaporite**.

Sedimentary Rock Characterization and Identification – LECTURE

Chemical sedimentary rock (precipitated minerals or recrystallized shells – interlocking microscopic crystalline texture)

Composition	Texture and physical properties	Name	Depositional environment
Calcium carbonate $CaCO_3$	Interlocking texture, crystals too fine to see. Light brown, grey, or white.	**Limestone***	Precipitation in the deep sea or recrystallization of shells accumulated on the deep sea floor (clastic texture gone).
	Layers of crystals – formed from evaporation of water.	**Limestone** (Evaporitic or crystalline)	Precipitation in salt lakes and inland seas.
Quartz SiO_2	Interlocking texture, crystals too fine to see. White, red, brown, black, or green.	**Chert**	Precipitation in the deep sea or hydrothermal zones or recrystallization of shells accumulated on the deep sea floor (clastic texture gone).
	Occurs as black nodules, usually surrounded by powdery white rind.	**Chert** (Flint)	Precipitation in hydrothermal zones.
Halite NaCl	Crystalline; salty taste	**Rock salt**	Precipitation in salt lakes and inland seas.
Gypsum $CaSO_4\ 2H_2O$	Very soft, crystalline	**Rock Gypsum**	Precipitation in salt lakes and inland seas.

***Remember: use mineral ID skills to help distinguish among these!**

Clastic sedimentary rock (cemented or compacted fragments)

Grain sizes: Gravel (>2mm); Sand (>1/16 mm; < 2 mm); Mud (<1/16) mm

Organic (biochemical) sedimentary rock (mostly shell fragments)

Composition and Texture	Grain size	Name	Depositional environment
Calcium carbonate $CaCO_3$ WHITE (usually); Macro/microscopic shell fragments; Loosely cemented; porous.	Gravel	Coquina (**Limestone**)	Beach with fringing reef
	Sand	Calcarenite (**Limestone**)	At outside edges of fringing reefs
	Mud	**Chalk** (Limestone)	Deep seafloor where zoo/phytoplankton with microscopic $CaCO_3$ shells rain down.
Silica SiO_2 WHITE (usually); Macro/microscopic shell fragments. Loosely cemented; porous.	Mud	**Diatomite** (Chert)	Deep seafloor where zoo/phytoplankton with microscopic SiO_2 shells rain down.

Detrital sedimentary rock (mostly rock and/or mineral fragments)

Grain size	Texture and composition	Name	Depositional environment
Gravel > 2 mm	Rounded fragments; poorly sorted	**Conglomerate**	Beach headlands, river banks, canyon fans.
	Angular fragments; poorly sorted	**Breccia**	Base of landslides, faults, and debris flows.
Sand < 2 mm > 1/16 mm	Mostly quartz grains; well sorted; well rounded	**Sandstone** (quartz sandstone)	Beach, sand dunes (desert or beach); river banks.
	>25% potassium feldspar grains, with quartz	**Sandstone** (arkose)	Beach sands; river deposits.
	Mixed mineral grains/rock fragments.	**Sandstone** (greywacke)	Beach sands; river deposits.
Mud < 1/16 mm	Microscopic quartz/clay grains; can be bedded. **Shale variety is compact; splits into thin layers.**	**Mudstone** or **Shale**	Shallow, quiet lagoon; tide flats; outer continental shelf; deep sea.

*Dolostone is similar to chemical limestone (same depositional environment, look, and texture), but has Mg in it.

Weathering of Silicate Minerals Worksheet

Types	Description of process and results
Dissolution	Water molecules gang up on ions on outside of mineral lattice (surface) and break the mineral bonds, releasing the ions into solution. Water carries ions away.
Hydrolysis	Water molecules enter mineral formula, replacing other components and changing mineral to a new one: a clay mineral. Example: $2KAlSi_3O_8 + 2H^+ + 9H_2O = Al_2Si_2O_5(OH)_4{}^+ 4H_4SiO_4 + 2K^+$ K-feldspar + water = Kaolinite clay + silicic acid and potassium ions
Oxidation	Oxygen bonds with Fe ions on outside of mineral lattice (surface) removing Fe from mineral and producing Hematite (rust).

Complete the following table to indicate what happens to primary igneous and metamorphic minerals when they undergo chemical weathering on the Earth's surface. During chemical weathering of a rock, the usual element distribution is:

- Fe – Oxidizes: combines with O to form insoluble iron oxides, giving red to yellow soil cover.
- Al, Si, O – Hydrolizes: combines with water to form clays (only if all three (Al, Si, O) are in mineral).
- Quartz – Stays in place; doesn't break down chemically.
- Na, Ca, K, Mg, other cations, AND excess silica (silica not in quartz or not combined with Al and O to form clays) – Dissolves and is removed by water.

Mineral undergoing chemical weathering:	What happens to its components?
Amphibole family: **Hornblende** [Silicate with Ca, Mg, Fe, Al, OH]	
Feldspar family: • **Plagiociase Feldspars**: Anorthite and Labradorite[$CaAl_2Si_2O_8$] to Oligoclase and Albite [$NaAlSi_3O_8$] • **Potassium Feldspars**: Orthoclase and Microcline [$KAlSi_3O_8$]	
Garnet Fe,Mg,Ca, Al Silicate	
Mica family: • Biotite [Silicate with K, Mg, Fe, Al, Ti, OH, F] • Muscovite [Silicate with K, Al, OH, F]	
Olivine $(Mg,Fe)_2SiO_4$	

Mineral undergoing chemical weathering:	What happens to its components?
Pyroxene family: Augite [Silicate with Fe, Mg]	
Quartz SiO_2	
Serpentine $Mg_6Si_4O_{10}(OH)_8$	
Talc $Mg_3Si_4O_{10}(OH)_2$	

Limestone (Crytalline or Evaporitic Limestone)	**Limestone**
Chert (Flint)	**Chert**
Limestone (Calcarenite)	**Limestone** (Coquina)
Diatomite (Chert)	**Chalk** (Limestone)
Mudstone	**Mudstone** (Shale)
Sandstone (Arkose)	
Sandstone (Greywacke)	**Sandstone** (Quartz Sandstone)
Conglomerate	**Breccia**

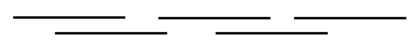
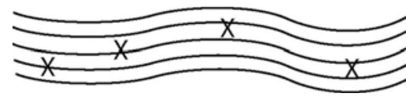
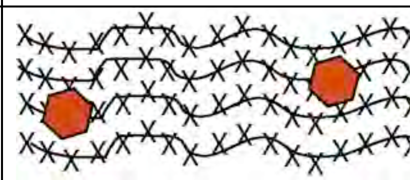
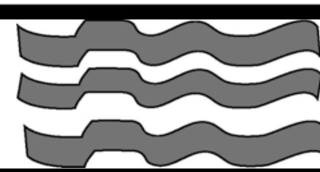
Chemical. $CaCO_3$. Interlocking texture, crystals too fine to see. Light brown, grey, or white.	Chemical. $CaCO_3$. Layers of crystals – formed from evaporation of water.
Chemical. SiO_2. Interlocking texture, crystals too fine to see. White, red, brown, black, or green.	Chemical. SiO_2. Occurs as black nodules, usually surrounded by powdery white rind.
Clastic. Organic. $CaCO_3$. WHITE (usually); Macroscopic gravel-sized shell fragments; Loosely cemented; porous.	Clastic. Organic. $CaCO_3$. WHITE (usually); Macroscopic sand-sized shell fragments; Loosely cemented; porous.
Clastic. Organic. $CaCO_3$. WHITE (usually); Microscopic mud-sized shell fragments; Loosely cemented; porous.	Clastic. Organic. SiO_2. WHITE (usually); Macro/microscopic shell fragments. Loosely cemented; porous.
Clastic. Detrital. Mud-sized grains. Compact (does break along layers).	Clastic. Detrital. Mud-sized grains. Massive (doesn't break along layers).
	Clastic. Detrital. Sand-sized grains. K-feldspar is abundant, giving the rock a red appearance.
Clastic. Detrital. Sand-sized grains. Quartz is the dominant grain. No K-feldspar.	Clastic. Detrital. Sand-sized grains. Grains consist dominantly of rock fragments.
Clastic. Detrital. Gravels, sands, and muds. Poorly sorted. Grains are angular.	Clastic. Detrital. Gravels, sands, and muds. Poorly sorted. Grains are rounded.

<u>Chapter 7 Questions</u> — Metamorphism and Metamorphic Rocks

1. **What are the agents of metamorphism?
2. **When metamorphic rocks form, what main factors dictate the rock that will form?
3. **Where does water in hydrothermal (chemically active) fluids come from?
4. Compare and contrast metamorphism, weathering/sediment lithification, and igneous rock formation.
5. **Be sure you understand the main textural changes that occur as metamorphic grade increases.

How does texture change as grade increases?	**Why?**
Density increases (volume shrinks)	Grains/crystals pack closer together under confining pressure
Foliation increases	Minerals align when under directed pressure
Crystal size increases	Grain boundaries migrate, enlarging crystal size as pressure (any kind) placed on crystal boundaries.

6. Distinguish among these types of foliation (ensure you know the definition of foliation and can recognize these textures).

Grade	**Foliation type**	**Description**	**Picture**
Low	Rock or slaty cleavage	Microscopic, aligned mica minerals. Planar cleavage. No visible minerals. Dense.	
Low to med	Phyllitic texture	Mostly microscopic, aligned mica minerals. Only a few visible, isolated minerals peeking out of satiny background. Foliation is undulating.	
Med to high	Schistosity	Mostly visible biotite minerals – all aligned, giving rock a scaly look, like a fish. Foliation is undulating and fine. Some large porphyroblasts may peek out.	
High	Gneissic texture	All visible, interlocking crystals, separated into alternating dark- and light-colored layers.	
Very high	Migmatitic texture	Gneissic texture where ½ melted, and the high temperatures caused folding of the layers.	

7. How and why do mineral compositions change as metamorphic grade increases?
8. **What is an index mineral?
9. Which of the minerals below are good index minerals? Poor?

See next page for additional Metamorphic Rock information

General mineral grade stability
Low Medium High
-------Kaolinite(clay)----------
-----------------------------------Plagioclase Feldspar__________________
---Quartz---
---K-Feldspar---
---Calcite---
------------------------------Muscovite---------------------------
---------------------------Biotite-----------------------------
-------------------------Garnet---
--------------Hornblende----------------
--------------Pyroxene----------------

10. Be sure you can describe each of the major metamorphic settings found on Earth and the P, T, and fluid conditions of each.

Common metamorphic settings for metamorphism and their characteristics and symbol

Metamorphic setting	P	T	Chemically active fluids
Contact metamorphism (C)	Low	High: increasing toward magma	High – from magma and from heated surface waters
Regional metamorphism: Deep burial (B)	High: steadily increasing with depth	High: steadily increasing with depth	Low – liberated from hydrous minerals
Regional metamorphism: Converging continents (R)	High: increasing with depth	Low to medium: increasing with depth	Low – liberated from hydrous minerals
Subduction zone metamorphism (S)	High	Low: slowly increasing with depth	High – from hydrous minerals in hydrothermally altered ocean crust.
Fault zones (F)	Shear is high. Overall pressure is low.	Low.	None
Hydrothermal (H) circulation at spreading centers	Low	High because occurs at the Moho.	High – from magmas and from circulating seawater

11. **How are **slate, phyllite, schist, gneiss,** and **migmatite** formed? (Parent rock, setting, and grade) What are there similarities? Differences?
12. How are **marble, quartzite, hornfels,** and **skarn** formed? (Parent rock, setting, and grade) What are there similarities? Differences?
13. How are **greenstone** and **eclogite** formed? (Parent rock, setting, and grade) What are there similarities? Differences?
14. **How is **serpentinite** formed? (Parent rock, setting, and grade)
15. The chart below summarizes the parent rock, setting, and grade of common metamorphic rocks. Be sure you understand all of the rock's origins.

Metamorphic rock names based on parent rock, geologic setting, and metamorphic grade.

Metamorphic settings	**B, R, S**	**B, R, S**	**S**	**B, R, S**	**B, R, S**
Parent rock	Shale	Granite	Basalt	Chert (SiO_2)	Limestone ($CaCO_3$)
GRADE: Low Low - Med Med - High High Very High	 *Slate* *Phyllite* *Schist* *Gneiss* *Migmatite*	 *Gneiss* *Migmatite*	 *Greenstone* *Blueschist* *Eclogite*	*Quartzite* *(crystals grow* *larger)*	*Marble* *(crystals* *grow larger)*

Metamorphic settings	**C**	**C**	**C**	**C**	**C**	**H**
Parent rock	Chert (SiO_2)	Limestone ($CaCO_3$)	Mixture of minerals	Shale	Basalt	Mantle rock (Peridotite)
GRADE: Low Low - Med Med - High High Very High	*Quartzite* *(crystals* *grow* *larger)*	*Marble* *(crystals* *grow* *larger)*	*Skarn* *(crystals* *grow larger;* *form new* *minerals)*	*Hornfels*	 *Hornfels*	 *Serpentinite*

Metamorphic Rock Characterization and Identification – LECTURE

Texture	Name	Parent rock	Geologic settings	Grade	Description
Foliated	**Slate**	Shale	B, R, S	Low	Dull; similar to shale, but more dense and breaks into hard flat sheets.
	Phyllite	Shale	B, R, S	Low-med	Similar to slate, but sheets are undulating (wrinkled). Luster is more silky or satiny than slate. Some isolated crystals might be visible.
	Schist	Basalt/gabbro, shale	B, R, S	Med-high	Crystals easily visible throughout rock – usually all micas, giving it a scaly look. Foliation greater than phyllite. Minerals can be garnet + biotite + chlorite + muscovite + quartz + plagioclase + epidote + kyanite. Chlorite disappears and kyanite appears as grade increases.
	Gneiss	Granite/rhyolite, shale	B, R, S	High	Grains medium to coarse; light and dark minerals segregated into bands. Gneissic texture.
	Migmatite	Gneiss	B, R, S	Very high	Contorted layers: gneissic texture that has been folded: some of the layers/bands have melted and crystallized as granite.
Weakly foliated	**Greenstone**	Basalt/gabbro	B, R, S	Low	Very fine grained (too small to see crystals); light to yellow green (from chlorite, epidote, and/or actinolite).
	Eclogite	Basalt/gabbro	S	High	Red garnets scattered uniformly throughout a finer-grained green groundmass (bright-green pyroxene: omphacite). May have quartz, biotite, or kyanite.
	Serpentinite	Peridotite	H	Med-high	Mostly serpentine. Green, mottled, massive. Smooth, rounded slippery surfaces. Can be black or reddish. Usually displays slickensides
Non foliated	**Hornfels**	Basalt/gabbro, mudstone	C	All	Smooth (glassy) or sugary microcrystalline, usually dark-colored.
	Marble ($CaCO_3$)	Pure limestone (only $CaCO_3$)	B, R, S, C	All	Sugary, sandy, or crystalline; calcite or dolomite (form of calcite with Mg) crystals fused together. White to pink. Might have dark streaks.
	Quartzite (SiO_2)	Chert (only SiO_2) Quartz Sandstone	B, R, S, C	All	Sugary, sandy, or crystalline; can sometimes see quartz sand grains fused together; grains won't rub off like sandstone.
	Skarn	Impure limestone or chert, arkose, greywacke…	C	All	Crystalline; usually with large crystals, including calcite, quartz, garnet, epidote, pyroxene and other rare minerals.

***Remember: use mineral ID skills to help distinguish among some of these!**

Schist	**Phyllite**
Migmatite	**Gneiss**
Greenstone	**Slate**
Serpentinite	**Eclogite**
Quartzite	**Marble**
Skarn	**Hornfels**

Foliated. Parent = Shale. Settings = B, R, S. Grade = Low-med. Dull; Sheets are undulating (wrinkled). Luster is silky or satiny. Some isolated crystals might be visible.	Foliated. Parent = Basalt, shale, graywacke. Settings = B, R, S. Grade = Med-high. Crystals easily visible throughout rock – usually all micas, giving it a scaly look.
Foliated. Parent = Granite, shale, graywacke. Settings = B, R, S. Grade = High. Grains medium to coarse; light and dark minerals segregated into bands.	Foliated. Parent = Gneiss. Settings = B, R, S. Grade = Very high. Gneissic texture that has been folded: some layers/bands have melted and crystallized as granite.
Foliated. Parent = Shale. Settings = B, R, S. Grade = Low. Dull; similar to shale, but more dense and breaks into hard flat sheets.	Weakly Foliated. Parent = Basalt. Settings = B, R, S. Grade = Low. Very fine grained (too small to see crystals); light to yellow green.
Weakly Foliated. Parent = Basalt. Settings = S. Grade = High. Red garnets scattered uniformly throughout a finer-grained green groundmass. May have quartz, biotite, or kyanite.	Weakly Foliated. Parent = Peridotite. Settings = H. Grade = Med-high. Green, mottled, massive. Smooth, rounded slippery surfaces. Can be black or reddish. Usually displays slickensides
Not Foliated. Parent = Pure limestone (only $CaCO_3$). Settings = All. Grade = All. Sugary, sandy, or crystalline.	Not Foliated. Parent = Chert (only SiO_2). Settings = All. Grade = All. Sugary, sandy, or crystalline.
Not Foliated. Parent = Basalt, mudstone. Settings = C. Grade = All. Smooth (glassy) or sugary microcrystalline, usually dark-colored.	Not Foliated. Parent = Impure limestone or chert, arkose, greywacke… Settings = C. Grade = All. Crystalline; usually with large crystals, including calcite, quartz, garnet, pyroxene and other rare minerals.

Geology 10 – Exam 2 (Final)Pass Sheet

If you can answer all these questions correctly on the exam, you will get a 70% pass. (Questions will appear on the exam in a different order and with different numbers.) There will be additional question on the exam (~25 to 30% of the exam will be better-than-pass questions – see weekly question sheets for content). These can help you to raise your grade from 70 (C) to a B (80-89) or A (90+). Note: YOU MUST BRING THIS COMPLETED SHEET WITH YOU TO TAKE THE EXAM – NO SHEET – NO EXAM. Exam will be closed notes, closed book, – you cannot use this sheet on the exam. Good luck!

Name the basic atomic particles and describe their charges and masses.

Particle	**Charge**	**Mass (in AMU)**
1.		
2.		
3.		

An atom has an atomic number of 19 and an atomic mass of 39. Based on this information, answer the following questions (The exam will use a different atom, so be sure you understand all of the answers given below).

4. How many protons does it have?		5. How many valence electrons does it have?	
6. How many neutrons does it have?		7. What is its symbol/name?	
8. What is it's ionic charge?		9. What is the typcial type of atomic bonding for this atom?	

Indicate for each of these substances whether or not it is a mineral. If not, indicate why not!

10. Copper		Salt	
11. Glass		Ice	
12. Sugar		Plastic	

13. $Fe2+$ substitutes for some Si in quartz. What property of quartz changes because of this substitution?	
14. Describe the primary difference between covalent and ionic bonds (be specific!).	
15. Describe what controls whether two elements bond ionically or whether they bond covalently.	
16. Describe what contols whether a mineral has 1, 2, 3, or 4 directions of cleavage, or has no cleavage (fractures).	
17. What's the textural name for igneous rocks that contain no minerals (no crystals visible to the naked eye) and how and why does this texture develop?	
18. What's the textural name for igneous rocks where two crystal sizes occur (one size that is easily visible and are surrounded by a <u>matrix</u> of minerals too small to be seen) and how and why does this texture develop?	

DATE: ______________________________ **NAME:**____

19. What's the textural name for igneous rocks where the entire rock is crystalline (all visible crystals)and how and how does this texture develop?	
20. What **two** MAJOR factors lead to increased explosivity (hazard) of a volcano? (Be specific.)	1. 2.
21. What is the liquidus and how does it differ from the solidus? Be able to use these in a graph.	
22. What **two** factors lead to <u>increased</u> magma viscosity?	1. 2.
23. List the three MAIN gases that are released during volcanic eruptions.	
24. What's the most common natural acid found in waters and how does it form in nature?	

What are the two lithofication processes by which sediment is truned into rock? For which sediment types does the lithofication process apply?

Lithification process	Sediment types to which this process applies
25.	
26.	

What are the two most common <u>detrital</u> minerals in sedimentary rocks? Why?

Most common detrital minerals	Reason why each is so common
27.	
28.	

Complete this table: For the better than pass section of the exam you should know what this looks like in pressure Temerature data plot (i.e., geothermal gradient, liquidius, solidus)

What are the three processes that magma is generated? (solid rock is melted)	In what geologic environment does this processes occur?
29.	
30.	
31.	

32. List 3 locations where fluids come from in a meta-morphic environment.	
33. Explain the difference between fracture and cleavage. (Be specific!)	
34. What is the chemical formula for Quartz?	
35. What is the chemical formula for Calcite?	

36. List three characteristic that changes that occur to metamorphic rocks as <u>grade</u> increases.	1. 2. 3.
37. Which volcanic hazard travels the farthest from the vent?	
38. Which volcanic hazard travels the fastest and is the least possible to avoid if you happen to be in its path?	
39. Which volcanic hazard travels second farthest from the vent and is the most dangerous to cities and towns?	
40. What is the difference between weathering and erosion?	
41. What is the difference between physical weathering and chemical weathering?	
42. Explain how physical weathering can enhances the rate of chemical weathering.	

<table>
<tr><td colspan="4">Characterize these five main igneous textures: (note: > means “greater than”; < means “less than”)</td></tr>
<tr><th>Textures:</th><th>(Circle correct answer)</th><th>(Circle correct answer)</th><th>(Circle correct answer)</th></tr>
<tr><td>43. Phaneritic</td><td>Crystals:
visible | microscopic | none</td><td>Vesicles:
> 50% | < 50% | Not possible</td><td>Intrusive / Extrusive</td></tr>
<tr><td>44. Aphanitic</td><td>Crystals:
visible | microscopic | none</td><td>Vesicles:
> 50% | < 50% | Not possible</td><td>Intrusive / Extrusive</td></tr>
<tr><td>45. Frothy</td><td>Crystals:
visible | microscopic | none</td><td>Vesicles:
> 50% | < 50% | Not possible</td><td>Intrusive / Extrusive</td></tr>
<tr><td>46. Glassy</td><td>Crystals:
visible | microscopic | none</td><td>Vesicles:
> 50% | < 50% | Not possible</td><td>Intrusive / Extrusive</td></tr>
<tr><td>47. Pyroclastic</td><td>Crystals:
visible | microscopic | none</td><td>Vesicles:
> 50% | < 50% | Not possible</td><td>Intrusive / Extrusive</td></tr>
</table>

<table>
<tr><td colspan="3">Characterize these igneous compositions by their silica content and main mineral components:</td></tr>
<tr><th>Compositions:</th><th>(Circle correct answer)</th><th>Main mineral components</th></tr>
<tr><td>48. Ultramafic</td><td>Silica content:
< 45% | 45 – 55% | 55 – 65% | > 65%</td><td></td></tr>
<tr><td>49. Mafic</td><td>Silica content:
< 45% | 45 – 55% | 55 – 65% | > 65%</td><td></td></tr>
<tr><td>50. Intermediate</td><td>Silica content:
< 45% | 45 – 55% | 55 – 65% | > 65%</td><td></td></tr>
<tr><td>51. Felsic</td><td>Silica content:
< 45% | 45 – 55% | 55 – 65% | > 65%</td><td></td></tr>
</table>

What are the three different types of chemical weathering and what are the end products of these three types?	
Chemical Weathering Processes	**End products**
52.	
53.	

Circle the correct P/T/Fluid conditions of these metamorphic environments.

Environment	Pressure	Temperature	Chemically active fluids
54. Contact Metamorphism	High/Low	High/Low	High/Low
55. Subduction Metamorphism	High/Low	High/Low	High/Low
56. Burial metamorphism	High/Low	High/Low	High/Low

57. List three characteristics of a rock or its environment that would ***increase*** the rate of rock weathering (be specific!).	

58. Describe the: 1) grain size, 2) shape, 3) sorting, and 4) composition of sediment that has traveled (via running water), far from its source AND not at all.	**FAR**	**NEAR**

Circle the best answer that correctly describe these volcanic landforms.

59. Which is the most catastrophic explosive eruptions?	Stratovolcano / Shield / Scoria cone /Continental Caldera /Flood basalt/ Dome
60. Which is built of pyroclastic and lava layers	Stratovolcano / Shield / Scoria cone /Continental Caldera /Flood basalt/ Dome
61. Which has the most catastrophic effusive eruptions?	Stratovolcano / Shield / Scoria cone /Continental Caldera /Flood basalt/ Dome
62. Which is built of mostly mafic lavas and does not represent significant hazard?	Stratovolcano / Shield / Scoria cone /Continental Caldera /Flood basalt/ Dome
63. Which has very low volatile content and is compossed of felsic lava?	Stratovolcano / Shield / Scoria cone /Continental Caldera /Flood basalt/ Dome
64. Which has intermediate volatile content and is built mostly of mafic pyroclastic rocks?	Stratovolcano / Shield / Scoria cone /Continental Caldera /Flood basalt/ Dome
65. Which is typically intermediate in compositon (andesite)?	Stratovolcano / Shield / Scoria cone /Continental Caldera /Flood basalt/ Dome
66. Which is commonly found on the flanks of other volcanoes?	Stratovolcano / Shield / Scoria cone /Continental Caldera /Flood basalt/ Dome

67. How is a dike different from a sill?	
68. How is a batholith different from a pluton?	
69. How does a batholith form?	

70. What is the specific cause for large eruption of a volcanoes? In other words, what needs to happen for the magma to erupt explosively?	
71. What is the relationship between the composition and viscosity of magma and/or lava?	

72. What is the octet rule?	
73. How does the tetrahedral structure of minerals change with increasing silica content? Give at least three specific mineral examples and there tetrahedral strucutre.	

74. What are the three main factors controlling the type of metamorphic rock forms?	1. 2. 3.

Complete this table	**Fraction of total that is still Parent**	**Fraction of total that is now daughter**	**Ratio of Parent to Daugther (P:D)**
1 Half Life			
2 Half Lives			
3 Half Lives			
4 Half Lives			

75. If the P:D ratio in a closed system is measured to be 1:15, and the half-life of the P:D system is 40 m.y., how old is the rock? (Show work!)	

What are the two most common detrital minerals in sedimentary rocks? Why?

Most common detrital minerals	**Reason why each is so common**
76.	
77.	

MINERAL AND ROCK MATCHING

Fill in the appropriate letter NEXT to the number. WRITE LEGIBLY. If I can't read an answer, it will be marked wrong.
REMEMBER: These matching questions below will be in a different order on the exam!

Correct Mineral Name		**Description to match to correct mineral**	**Mineral Choices**
	78.	3-D framework silicate. H=7; often clear or white; conchoidal fracture. (all colors.)	Calcite
	79.	Red dodecahedron-shaped silicate (H=7) usually in high-grade metamorphics.	Feldspars
	80.	Fe- + Mg-rich, dark chain silicates with 2 cleavage directions; prismatic form.	Olivine
	81.	Fe- + Mg-rich, green silicate; single silicon-oxygen tetrahedron; conchoidal fracture.	Quartz Garnet
	82.	Light-colored salty mineral found in sedimentary evaporates.	Pyroxene/
	83.	Light-colored carbonate that effervesces in hydrochloric acid.	hornnblende
	84.	Three-dimensional framework silicate. Twinning or exsolution lamellae. Some pink.	Halite

Correct Rock Name		**Description to match to correct rock**	**Igneous rock Choices**
	85.	Phaneritic rock of intermediate composition.	Andesite
	86.	Rock made out of ash, crystals, rock fragments, pumice, etc.	Basalt
	87.	Phaneritic rock of mafic composition.	Diorite
	88.	Aphanitic rock of felsic composition.	Gabbro
	89.	Phaneritic rock of felsic composition.	Granite
	90.	Aphanitic rock of intermediate composition.	Tuff
	91.	Aphanitic rock of mafic composition.	Rhyolite

Correct Rock Name		**Description to match to correct rock**	**Sedimentary rock Choices**
	92.	Contains poorly sorted, angular detrital fragments: gravel-sized grains.	Breccia
	93.	Contains poorly sorted, rounded detrital fragments: gravel-sized grains.	Chalk/Diatom ite
	94.	Consists primarily of well-sorted, sand-sized grains.	Conglomerate
	95.	Consists of compacted clay grains of smallest size; can split in layers.	Chert
	96.	Chemical calcium carbonate; natural precipitation or recrystallization of shells.	Limestone
	97.	Chemical silica; forms from precipitation or when shells recrystallize.	Mudstone or shale
	98.	~100% microscopic silica or calcareous shells. (Clastic, organic, from deep-sea.)	Sandstone

Correct Rock Name		**Description to match to correct rock**	**Metamorphic rock Choices**
	99.	Green, smooth rock: hydrothermal metamorphism of mantle rock in spreading centers.	Eclogite Gneiss
	100.	Nonfoliated rock consisting of grains of calcite.	Slate
	101.	Nonfoliated rock consisting of quartz.	Hornfels
	102.	Nonfoliated, dark rock: contact metamorphism of basalts or mudstones.	Marble
	103.	Garnets in green groundmass: high grade subduction zone metamorphism of basalt.	Phyllite Quartzite
	104.	Dull fine-grained; foliated; breaks in hard sheets: lo-grade regional meta. of mudstone.	Schist Serpentinite
	105.	Satiny; foliated; undulating surfaces: lo- to med-grade regional meta. of mudstone.	
	106.	Coarse-grained; foliated; mostly micas: med-grade regional meta. of mudstone/basalt.	
	107.	Coarse; foliated; dark & light bands: hi grade regional meta. mudstone/granite.	

<u>Chapter 8 Questions</u> — Telling Time Geologically

1. **Distinguish between numeric (absolute) and relative dating.
2. Why do we use both?
3. When you observe an outcrop of steeply inclined sedimentary layers, what can you say about its history?
4. A mass of granite lies below and in contact with a layer of sandstone. Using the principle of inclusions, explain how to tell whether the sandstone was deposited on top of the granite, or whether the granite intruded from below after the sandstone was deposited.
5. Explain what an unconformity is, and what it indicates about the geologic history of a region.
6. **Distinguish among angular unconformity, disconformity, and nonconformity. What history does each tell?

Disconformity sketch	Angular unconformity sketch	Nonconformity sketch

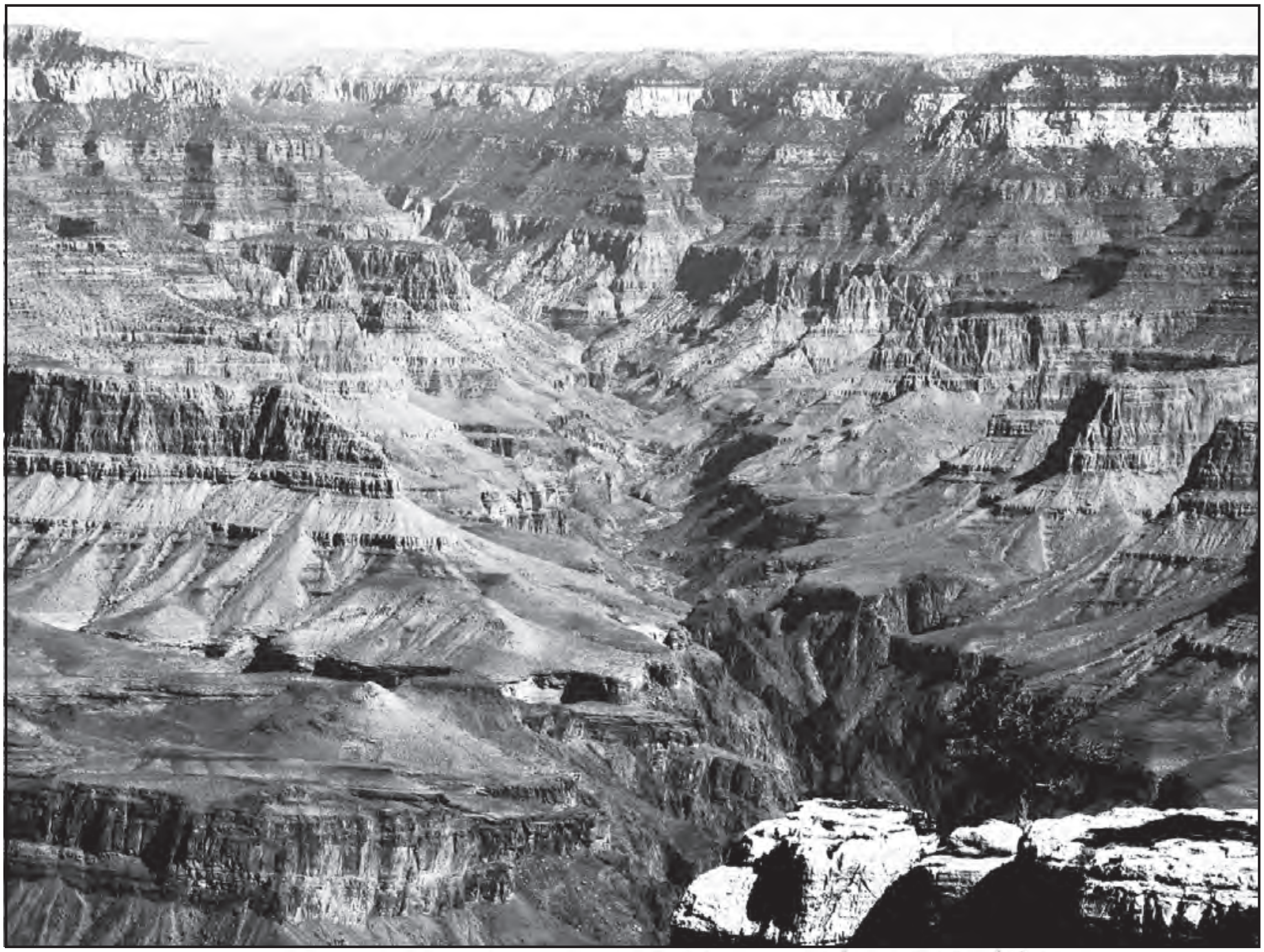
7. **What is meant by the term correlation? (see *Correlation* figure for *Grand Canyon, Zion, and Bryce Canyon*)?
8. What organisms have the best chance of being preserved as fossils?
9. **What is an index fossil? What are the two requirements to be an index fossil?
10. How else are fossils helpful in geologic investigations?
11. **What are the four major divisions of the Geologic Time Scale and what age ranges do they represent?
12. Explain why Precambrian history is more difficult to decipher than more recent geologic history.
13. Order these events in Earth's history from oldest (1) to youngest!

Action/Environment	Order	Action/Environment	Order
Dinosaurs first appear		Earliest evidence of photosynthesis	
Trilobites first appear		Earth formed	
Earliest evidence of life with hard parts		Opening of Atlantic ocean (Pangea breaks up)	
Earliest evidence of multicellular life		Dinosaurs go extinct	
Earliest evidence of life moving onto land		Earliest evidence of life (prokaryotes)	
Pangea came into existence.		Earliest evidence of rocks (hard crust)	
Oceans first appear (water)		Eukaryotes first appear (nucleus in cells)	
Mammals first appear		Fishes first appear	

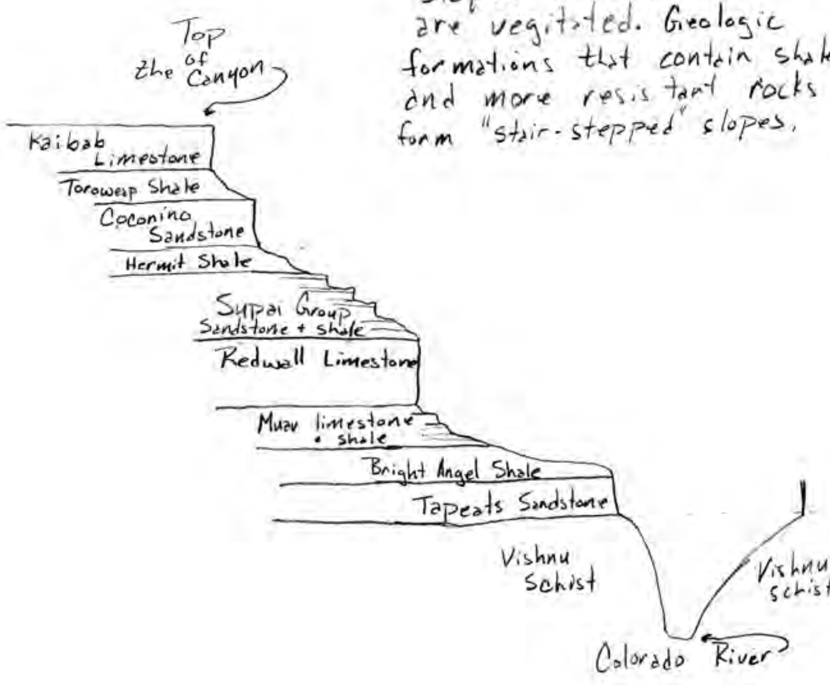
14. If a radioactive isotope of thorium (atomic number 90, mass number 232) emits 6 alpha particles and 4 beta particles during radioactive decay, what is the atomic and mass number of the stable daughter product?
15. A hypothetical radioactive isotope has a half-life of 10,000 years. If the ratio of radioactive parent to stable daughter product is 1:3, how old is the rock containing the radioactive material?
16. **To provide a reliable radiometric date, a mineral must remain a closed system from the time of its formation until the present. Why? What is a closed system?
17. The following table shows decay rates for various isotope pairs.

Parent (P)	Daughter (D)	Half-lives ($T_{1/2}$)	Materials dated
U-238	Pb-206	4.5×10^9 yr	Zircon (igneous rocks – source; and sedimentary rocks as grains)
U-235	Pb-207	0.7×10^9 yr	Zircon (igneous rocks – source; and sedimentary rocks as grains)
K-40	Ar-40	1.4×10^9 yr	Micas, volcanic rock (igneous rocks)
C-14	N-14	5700 yr	Shells, limestone, organic materials

The Grand Canyon Stratigraphy



* Note Limestones & Sandstones form prominent Clifts that can be easily Identified Whereas Shales form Slopes or benches that are vegitated. Geologic formations that contain shales and more resistant rocks form "stair-stepped" slopes.



Radioactive Decay Worksheet

Alpha decay: nucleus spontaneously emits an alpha particle (symbol: α particle), which is 2 p+ and 2 n (or also the same as a Helium (He) atom).

Result: atomic number decreases by 2 (lost 2 p+)

Result: atomic mass decreases by 4 (lost 2 p+ and 2n = 4 amu)

Beta decay: neutron in nucleus spontaneously emits a beta particle (symbol: β particle), which is essentially an electron trapped in a neutron. The neutron, therefore, turns itself into a proton.

Result: atomic number increases by 1 (gained 1 p+)

Result: atomic mass stays same (no mass lost or gained: β particle or electrons have no mass)

Beta or electron capture: proton in nucleus captures a beta particle (symbol: β particle), which is essentially an electron that can become part of a neutron. The proton, therefore, turns itself into a neutron.

Result: atomic number decreases by 1 (lost 1 p+)

Result: atomic mass stays same (no mass lost or gained: β particle or electrons have no mass)

Example

Original	alpha decay	beta decay	alpha decay	beta capture	beta decay	alpha decay
85	83	84	82	81	82	80
At	Bi	Po	Pb	Tl	Pb	Hg
Astatine	Bismuth	Polonium	Lead	Thallium	Lead	Mercury
210	206	206	202	202	202	198

Complete this table

Original	beta decay	alpha decay	beta capture	alpha decay	alpha decay	beta decay
90						
Th						
Thorium						
232						

Complete this table

Original	beta capture	alpha decay	alpha decay	beta capture	alpha decay	beta decay
92						
U						
Uranium						
238						

Radiometric Dating Worksheet

When radioactive isotopes (parent – P) decay, they produce daughter products (D) at a constant rate, called the half-life (**T**). Example: if we start with 100 atoms of the parent, after one half-life, there will be 50 parent atoms remaining and 50 daughter atoms newly made. After another half-life (two half-lives), there will be 25 parent atoms remaining and now 75 daughter atoms. Each parent-daughter isotope pair has its own half-life. To achieve the above example with U-238 takes 9 billion years (two half-lives). To achieve the above example with C-14 takes 11400 years (two half-lives). In the geologic environment, we use a mass spectrometer to count the number of Parent and Daughter atoms in a closed-system (like minerals crystallizing from magmas), and use the relative proportions to find out how old the closed-system is.

1. Assuming we start with only parent isotopes (no daughter), after one half-life has passed, there should be ½ parent remaining and ½ daughter newly formed. The ratio of P:D is ½ : ½ or 1:1. Complete the rest of this table, as in the first example:

# Halflives	Fraction of original Parent remaining	Fraction of original parent turned into daughter	Parent:Daughter ratio
1	½	½	1:1
2			
3			
4			
5			
6			

Not all rocks can be dated radiometrically. Some because they cannot maintain closed systems (like metamorphic rocks); others because they do not contain radioactive isotopes (like quartz sandstones); and finally some because the radioactive isotopes that they do contain have half-lives that are either too long or too short to be measured for a rock of a certain age (like trying to date a 1 m.y.-old rock by using C-14 decay – which would have been completely decayed after about 150,000 years).

Parent (P)	Daughter (D)	Half-lives ($T_{1/2}$)	Materials dated
U-238	Pb-206	4.5×10^9 yr	Zircon (igneous rocks – source; and sedimentary rocks as grains)
U-235	Pb-207	0.7×10^9 yr	Zircon (igneous rocks – source; and sedimentary rocks as grains)
K-40	Ar-40	1.4×10^9 yr	Micas, volcanic rock (igneous rocks)
C-14	N-14	5700 yr	Shells, limestone, organic materials

2. To date the age of a shell found in an old Indian fishing village, which isotope pair would you measure? Why?

3. If you want to date a meteorite, which isotope pair would you measure? Why?

4. If you want to date lava flows on an old lava flow on Kauai (probably about 8 m.y.), which isotope pair would you measure? Why?

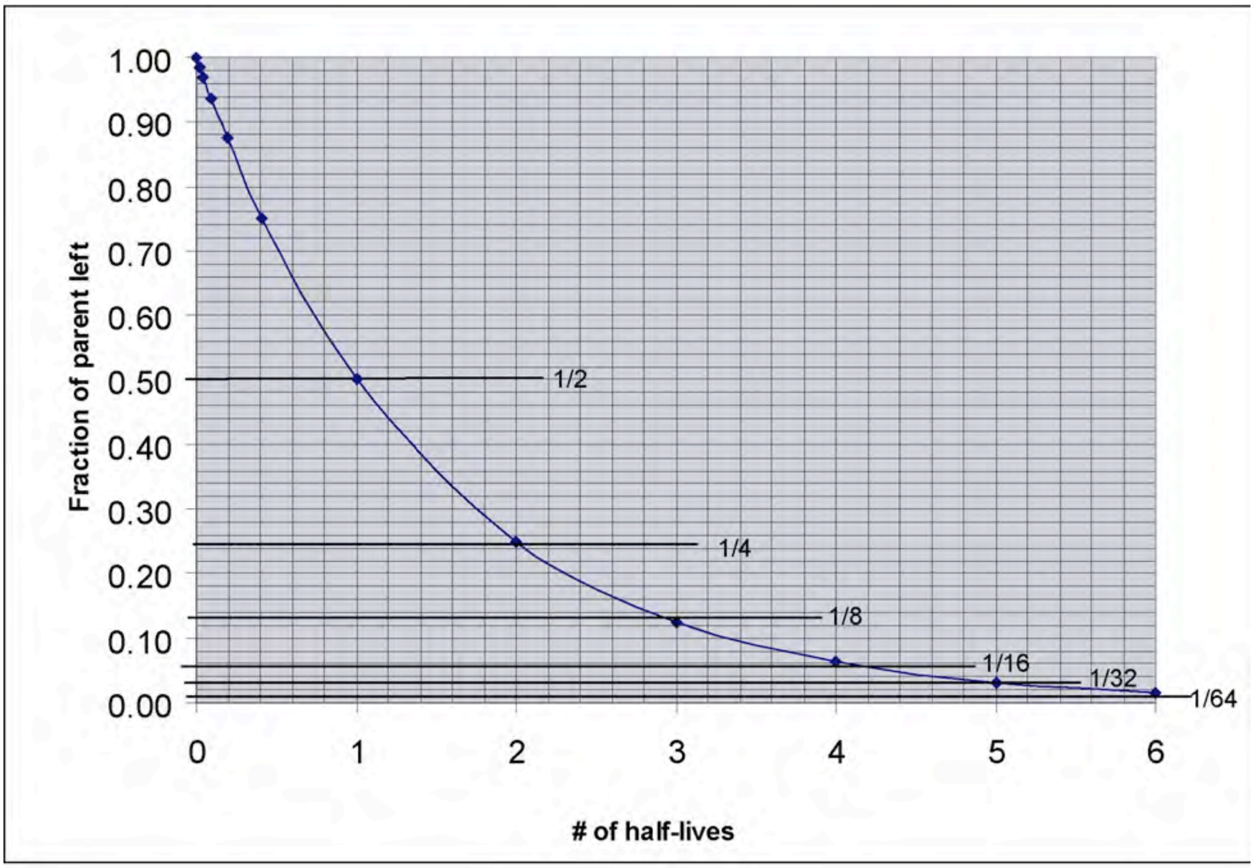
5. If you want to date zircon crystals in ancient sandstones in Australia, which isotope pair would you measure? Why?

6. If the C-14:N-14 ratio in a shell in a sandstone was found to be 1:3, how old is the shell?

7. If the U-235:Pb-207 ratio in a zircon in a sandstone was found to be 1:3, how old is the zircon?

8. If the K-40:Ar-40 ratio in a zircon in a granite was found to be 1:1, how old is the sample?

9. If the U-238:Pb-206 ratio in a zircon in a lava flow was found to be 3:1, how old is the flow?



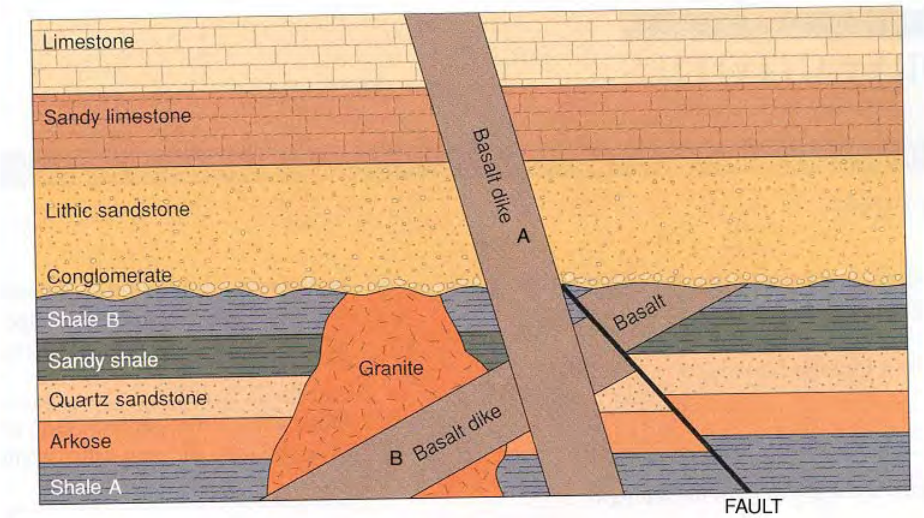
T (# of) Halflives	Fraction Parent	Daughter	Ratio
0	1	0	infinity :1
0.0227	63/64	1/64	63 :1
0.0458	31/32	1/32	31 :1
0.0931	15/16	1/16	15 :1
0.1927	7/8	1/8	7 :1
0.4151	3/4	1/4	3 :1
1.0000	1/2	1/2	1: 1
2.0000	1/4	3/4	1: 3
3.0000	1/8	7/8	1: 7
4.0000	1/16	15/16	1: 15
5.0000	1/32	31/32	1: 31
6.0000	1/64	63/64	1: 63

CURVE EQUATION: $T = -1.443\ln(f)$ f = fraction of parent left; T = # of half lives that have passed

Geologic Time Activity

Create a stratigraphy for each cross-section (list each feature in order from youngest on top to oldest on bottom). Include all beds, faults, and unconformities (appear as irregular, wavy lines). IDENTIFY unconformities (as a disconformity, nonconformity, or angular unconformity). Don't forget the surface of the entire section is usually an unconformity!

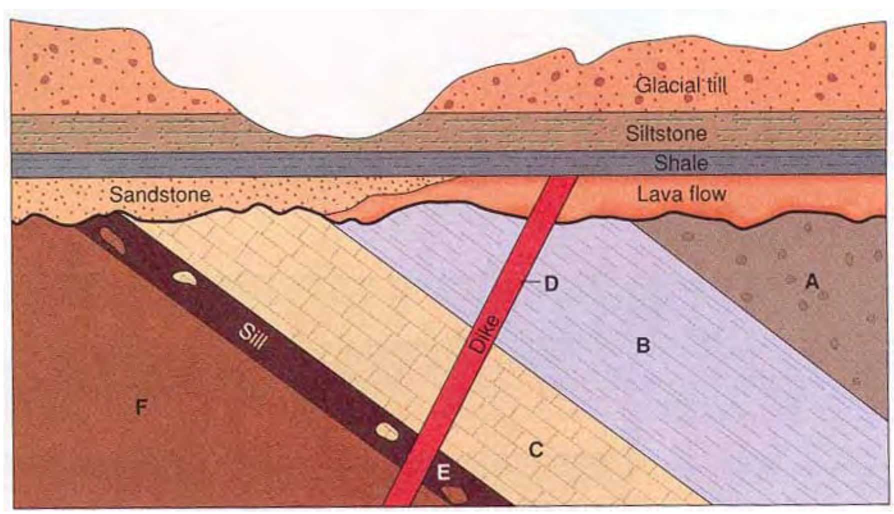
YOUNGEST



OLDEST

Sill contains inclusions of bed F and C. A, B, C, and F are all sedimentary rocks. D is a basalt dike.

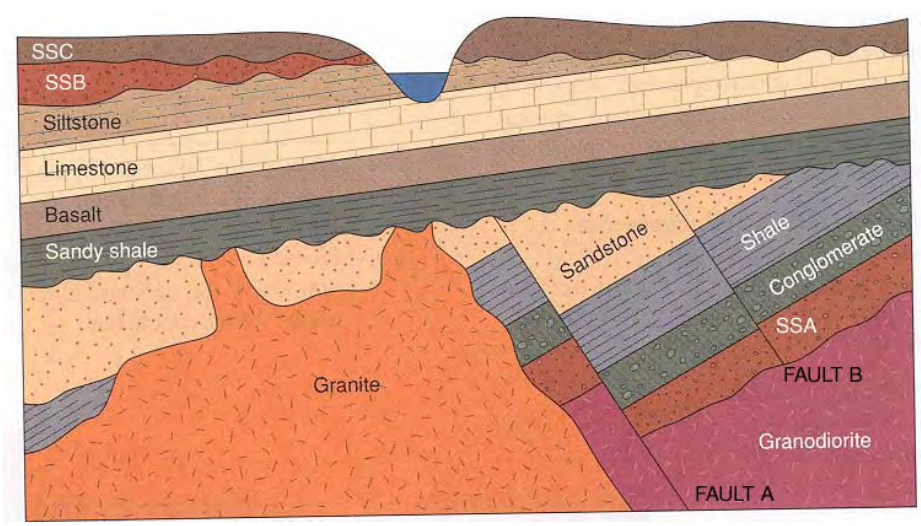
YOUNGEST



OLDEST

SSA, SSB, and SSC are all sandstone beds.

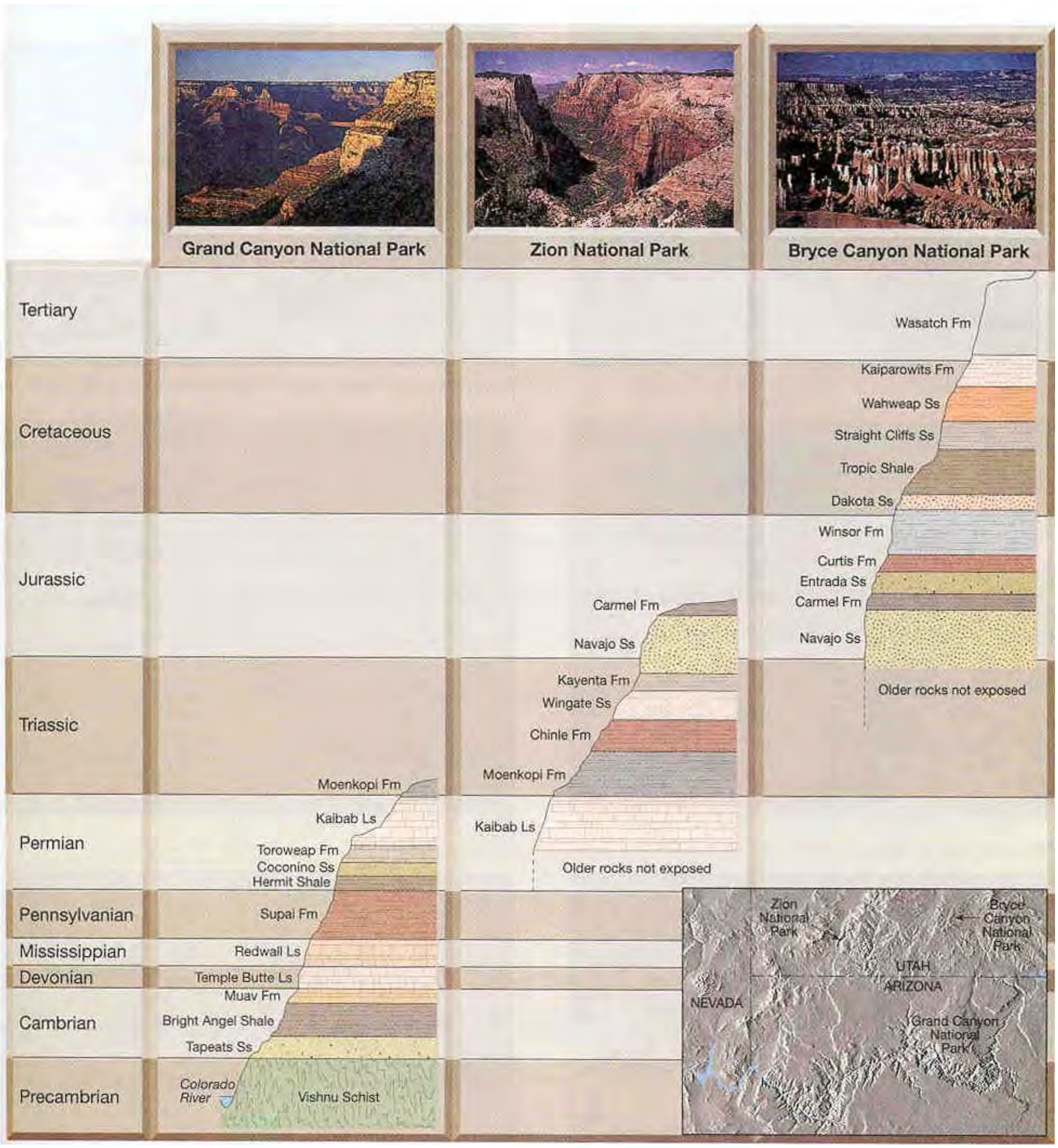
YOUNGEST



OLDEST

Page 1/1

Correlation
Correlation is the process of looking carefully at rock composition and age and matching up similar rocks from one area to another (like below). Correlations give geologists more accurate and complete histories of the region. Sometimes unconformities (uplift and erosion) or pinch outs (lack of deposition – original bed pinched out before reaching this area) can prevent certain rocks/layers from appearing everywhere). In the picture below, you can see that Grand Canyon National Park, Zion National Park, and Bryce Canyon National Park all show different rock layers, but the lower sections of one correlates to the upper sections of another.



<u>Chapter 14 and 15 Questions</u> — Mass Movements and Streams and Floods

1. **What principle force causes downslope movement? Provides resistance against downslope movement?
2. In what two ways does water increase the likelihood of mass movement on a slope?
3. Describe a slope that would be most prone to downslope movement. Least prone? Be thorough.
4. **What are some triggers for mass movement events?
5. **Compare and contrast fall, slide, flow, slump, and creep.
6. How do the driving and resisting forces between mass movements of Bedrock differ from those of unconsolidated materials?
7. **What is the angle of repose? Describe why it is not everywhere the same (Be Thorough)?

---

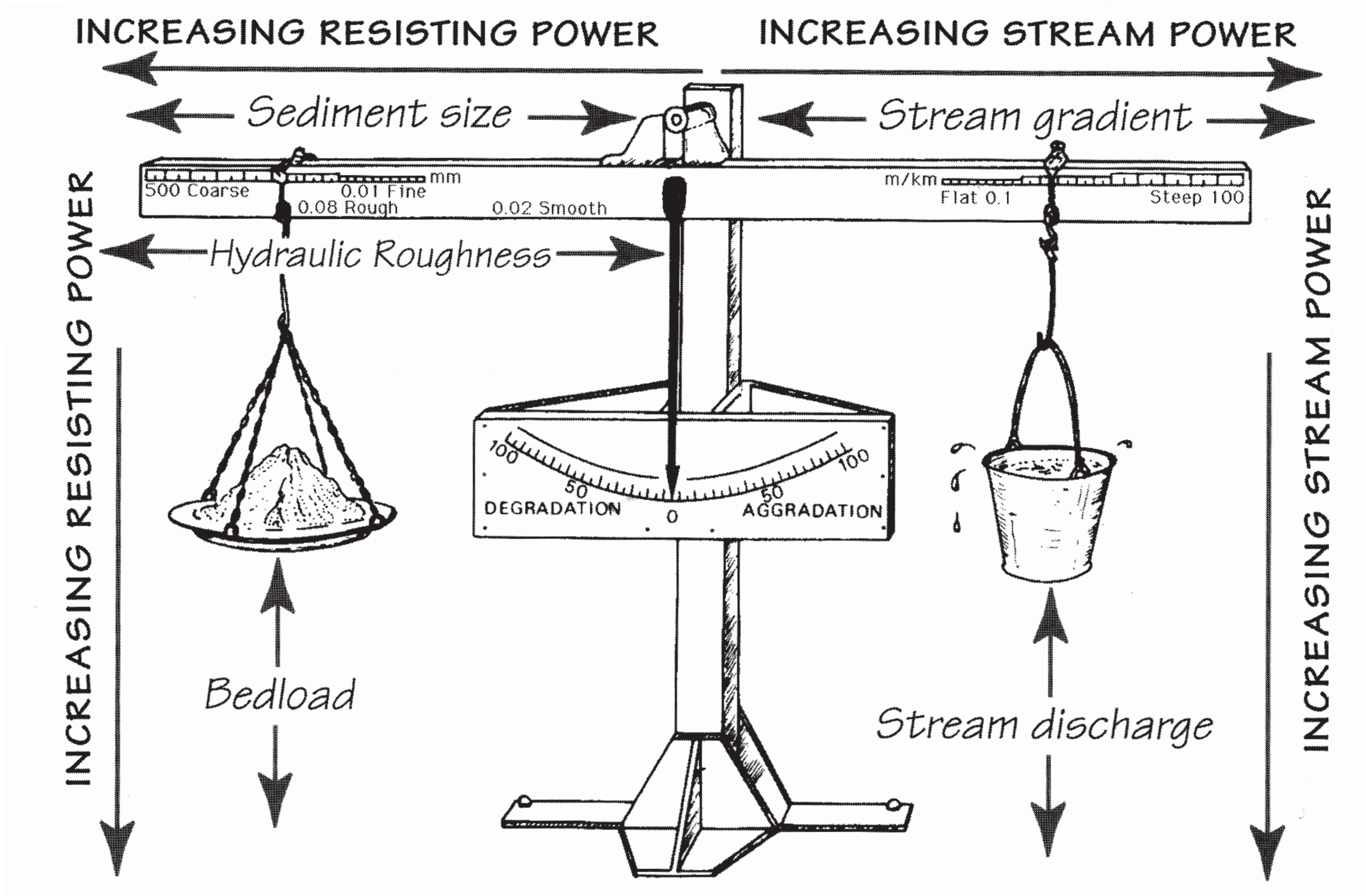
8. Describe the distribution of Earth's water. What percentage is fresh? Of that, what percentage is in each of glaciers, groundwater, and lakes + streams?
9. Describe the movement of water through the hydrologic cycle. What is the source of energy that powers the cycle? Once precipitation has fallen on land, what paths are available to it?
10. **Compare and contrast these channel patterns:

	Description or picture	**Conditions in which found**
Meandering	Stream that take circuitous, bending, looping path to base level.	Mature streams, which have eroded the backcountry mostly flat. Slope very gentle.
Braided	Stream that separates into multiple strands, all crossing an area of high sediment.	At the base of a steep slope, where there is an alluvial fan (much sediment dumped by stream, then stream makes its way across pile).
Straight	No bends. V-shaped in cross-section.	Steep slopes, usually up in the mountains.

11. A stream starts 2000 m above sea level and travels 250 km to the ocean. What is its average gradient in m/km? This stream develops extensive meanders lengthening its course to 500 km. Calculate its new gradient. Which steepness represents the more youthful stream? Why? (Be sure in your explanation that you understand the meaning of the headwaters and the mouth of a stream.)
12. Through what methods do streams physically weather rock?
13. Under what conditions do streams erode? Where along a river does this most occur?
14. **In what three ways does a stream transport its load? If you collect a jar of stream water, what part of its load settles to the bottom? What remains in the water? What part is missing?
15. Under what conditions do streams deposit sediment? Where along a river does this most occur?
16. **What is unique about alluvium (river-deposited sediment)? Why? Compare an alluvial fan and a delta.
17. **What is base level? Give some examples of local versus ultimate base level.
18. How do base level changes affect erosion and deposition equilibrium of a stream?
19. Use this table to describe various characteristics of a stream, what factors affect those characteristics, and how they change from the headwaters to the mouth of a stream. Know how these answers were determined!
20. **Explain what happens during flood stage of a river. Include a description of levees and floodplains.

See next page for additional Streams information

	Definition	Factors that increase it	Headwaters	Mouth
Gradient	elevation difference / horizontal length	Base level drops Headwaters uplift	High	Low
Discharge	water volume passing a point every second = channel width X channel depth X velocity = m^3/s	High precipitation (rain) Large drainage basin High river velocity	Low	High
Drag or friction	slowing down of the river as a result of its shape and materials	• Channel shape is narrow and deep or shallow and wide. Channel bed is rough, like boulders, gravel, and sand.	High	Low: shape is deep and wide, and bed is mud.
Speed	distance traveled / time for travel	High gradient Low drag or friction High discharge Narrow channel	Low	High
Amount of erosion	Material picked up by the running water of the river and removed.	Velocity increases Discharge increases Load of river decreases	High	Low
Amount of deposition	Material dropped by the river and left in a pile (deposit).	Velocity decreases Discharge decreases Load of river increases	Low	High
Capacity	Total load that a portion of a river can transport at any given time.	Discharge increases.	Low	High
Competence	Largest grain size that a portion of a river can transport.	Velocity increases		



Bull, W. B., 1979, Threshold of critical power in streams: Geological Society of America Bulletin, v. 90, no. 5, p. 453-464.

<u>Chapter 19 Questions</u> — Shores and Coastal Process

1. **Diagram and explain wave components (wave height, crest, trough, wavelength, and wave base). For wave base, be sure to give equation and depth from which it is measured.
2. Explain the behavior of a floating object when an ocean (oscillatory) wave moves through it. What happens to the wave? What's the motion of the object? Why?
3. What is wave period? How would you measure it?
4. When do waves feel bottom? What happens to their speed, height, length, period, and motion when they do? *(*NOTE: Book errors in saying that period decreases as waves approach the shore. Period stays the same!)*
5. **The main effect of waves hitting shore at an angle is the movement of sand and water along a beach. What is the name given to the sand movement? Water movement? How does it happen?
6. What general (most probable) direction does beach sand move on North American beaches? Why?
7. **What are the causes and effects of rip currents?
8. How does sand movement vary seasonally and why?
9. All beach sand **ultimately** comes from two sources: rivers (90%) and local beach erosion (minor amounts come from local reef erosion, if a reef exists). All beach sand **ultimately** ends up in two sinks: sucked down submarine canyons (sometimes by turbidity currents, sometimes through rip currents and just gradual raining down the canyon walls) where it lies in a pile at the base of the canyon or blown on land as a sand dune where it is later buried and turned to sandstone. In between source and sink, the longshore current distributes sand along the beaches. Be sure you understand these ultimate sources and sinks.
10. Relate the damming of rivers to the shrinking of beaches at locations along the West Coast of the U.S.
11. **Describe and list erosional features of a shoreline. What causes each?
12. **Describe and list depositional features of a shoreline. What causes each?
13. Compare and contrast the East and West coasts of the U.S. and relate those differences to plate tectonics.
14. Through what methods do humans attempt to interfere with natural coastal processes?

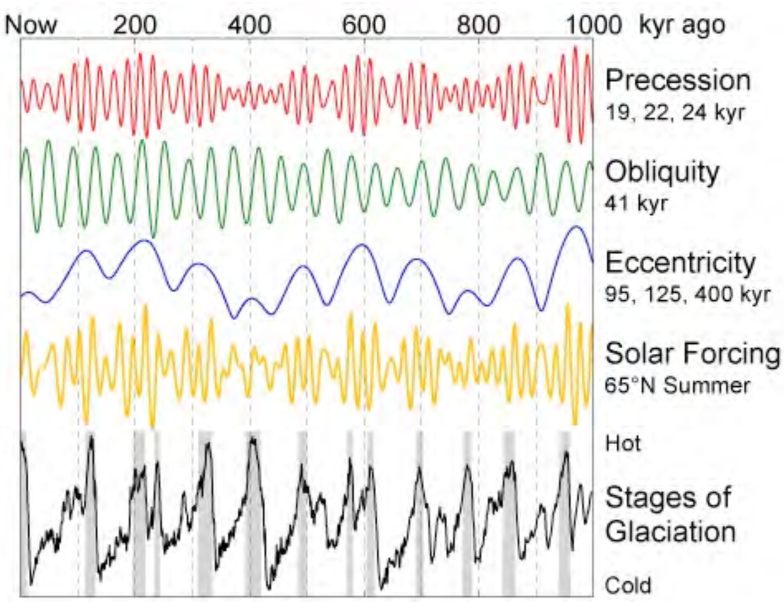
Structure	**Groin**	**Jetty**	**Seawall**	**Breakwater**
Picture or description	Wall running perpendicular to beach, extending off beach	Two parallel walls running alongside harbor mouth, perpendicular to beach	Wall running parallel to beach, on the beach	Wall running parallel to beach, but offshore
Why used?	Create a beach	Prevent mouth closing	Prevent homes, roads, etc. from erosion	Create a gentle water region for boats to anchor
Results?	Another beach is eroded to compensate; wall must be maintained.	Sand builds up in harbor mouth eventually and must be dredged. Beach forms in one location at expense of another. Jetty must be maintained.	Sand on local beach diminishes; erosion increases elsewhere; rip rap must be added.	Sand on local beach grows, eventually requiring dredging; erosion increases downcurrent; wall must be maintained.

<u>The cause of the ocean tides:</u> (Be sure you understand and can explain this cause:)
Ocean tides are caused by the differences in the gravitational pull between the moon and the Earth. Gravitational force is stronger on the side of the Earth nearer to the moon and is weaker on the side farthest from the moon. Why? Because Gravitational Force weakens as distance increases.

15. Using the above definition, explain what is a high and low tide? What are flood and ebb currents (or tides)?
16. What's the period of a tidal wave?

Chapter 17 Questions — Glaciers and Ice Ages

1. Describe all the ways in which sea level can rise and fall globally (be sure you understand how).
2. What is a glacier?
3. **What are the different types of glaciers? Where do you find each? How are they different than an ice sheet?
4. Compare and contrast the two different ways that glaciers move.
5. Describe the budget of a glacier. Under what circumstances will the front of a glacier advance? Retreat?
6. At what rates do glaciers move? What is a surge?
7. **List and describe erosional features that you'd see in an area where glaciers exist or have recently existed. Explain how they form.
8. Compare and contrast the two types of glacial drift (deposits): till and outwash. What types of sediment does each contain? What is a glacial erratic?
9. **List and describe depositional features that you'd see in an area where glaciers exist or have recently existed.
10. What are ice ages? **What percentage of Earth's land area do glaciers cover today? 20,000 years ago?
11. 75% of the world's freshwater supply is held, currently in glaciers. (This value is still only 2.15% of the world's total water supply.) What would happen if all the planet's ice melted?
12. **How does a glaciated mountain valley differ from a mountain valley that was not glaciated?
13. How do Oxygen isotopes used to determine past climate?
14. How was California affected during the last ice age?
    - Describe the effects of glaciers on sea level.
    - Describe the effects of glaciers on flora and fauna.
    - Describe other indirect effects of glaciers on the landscape (to land not covered by glaciers).



Jeffrey Lee (Lead Author);Stephen J. Reid (Topic Editor) "Milankovitch cycles". In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopedia of Earth July 7, 2010; Last revised Date January 7, 2011; Retrieved February 4, 2011 <http://www.eoearth.org/article/Milankovitch_cycles>

Geology 10 – Exam 3 (Final)Pass Sheet

If you can answer all these questions correctly on the exam, you will get a 70% pass. (Questions will appear on the exam in a different order and with different numbers.) There will be additional question on the exam (~25 to 30% of the exam will be better-than-pass questions – see weekly question sheets for content). These can help you to raise your grade from 70 (C) to a B (80-89) or A (90+). Note: YOU MUST BRING THIS COMPLETED SHEET WITH YOU TO TAKE THE EXAM – NO SHEET – NO EXAM. Exam will be closed notes, closed book, – you cannot use this sheet on the exam. Good luck!

1. From oldest to youngest know the Grand Canyon sedimentary stratigraphy (not including the Zoraster Granite)	1. youngest Grand Canyon sedimentary rock name 2. 3. 4. 5. 6. 7. 8. 9. Oldest Grand Canyon sedimentary rock name Vishnu Schist (oldest metamorphic rock under sedimentary strata)
2. What percentage of the Earth was covered at some time by ice during the Pleistocene?	
3. What is the principal force that makes things move downhill?	

4. Under what conditions does the snout of an alpine glacier advance?	
5. Under what conditions does the snout of an alpine glacier retreat?	
6. List three depositional features of a glaciated valley.	
7. List three erosional features of a glaciated valley and explain how they form	*1.* *2.* *3.*
8. What is till and how is it differentiated from glacial outwash?	
9. Over the past 1 m.y. have glacial advances and retreats exhibited any cyclicity? If so, how long is this period?	
10. List the two major causes of global sea level rise. (NOT just locally).	

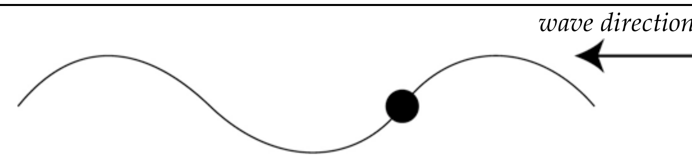
11. Describe how the shapes of river eroded valley differs from a glacially eroded mountain valleys (be specific!).	
12. Which organisms have the best chance of being preserved as fossils?	

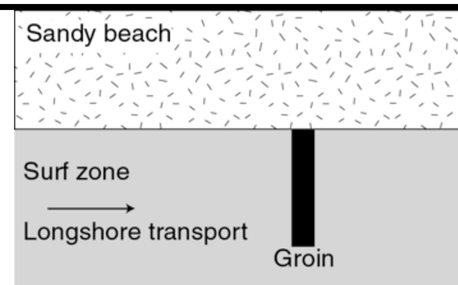
DATE: ______________________________ **NAME:**____

12-15. Complete this table	**Fraction of total that is still Parent**	**Fraction of total that is now daughter**	**Ratio of Parent to Daugther (P:D)**
1 Half Life			
2 Half Lives			
5 Half Lives			
7 Half Lives			
16. If the P:D ratio in a closed system is measured to be 1:15, and the half-life of the P:D system is 40 m.y., how old is the rock? (Show work!)			

17. Name two depositional landfroms composed of glacial till and explain how they develop.	1. 2.

18. Explain what an <u>elevated</u> ratio of $^{18}O/^{16}O$ (more ^{18}O than ^{16}O) tells us about the paleoclimate and why?	
19. What are the three main requirements needed for an ice ages?	*1.* *2.* *3.*
13. Why can't plate tectonics be the sole driving force of advances and retreats of glaciers?	
14. Describe the relationship between paleo CO_2 records and paleo global temerpature.	

15. Label crest and trough. Be precise! 16. Label wavelength and wave height. Be precise! 17. Draw a line at the depth below which water is unaffected by this wave's energy motion. Make it clear from where depth is measured. (Give equation for wave base.)	
18. In this drawing of a floating ball on the water, indicate with arrows the motion of the ball when a wave passes through from the right side.	

19. In this drawing of a typical beach, note that someone just installed a groin – indicate on the graphic what happens to the beach as a result (the arrow represents direction of longshore drift).	
20. Where does all beach sand **ultimately** go? (Give the two **primary** sinks.)	
21. From where does all beach sand originally come? (Give the two **primary** sources.)	
22. List three depositional features of a shoreline.	
23. List three erosional features of a shoreline.	

24. Which coastal process **dominates** the East Coast of North America? (circle) **Why**?	deposition erosion	
25. Which coastal process **dominates** the West Coast of North America? (circle) **Why**?	deposition erosion	

26. What direction does a rip current move?	
27. What causes a rip current?	

	Period	**Speed**	**Height**	**Wavelength**
28. When waves approach the coast, what happens to these traits? (Circle correct answer.)	Increases Decreases No change	Increases Decreases No change	Increases Decreases No change	Increases Decreases No change

29. What is the general direction of longshore transport on North American beaches?	
30. What is the principal force that makes things stay on a hillside and NOT move downhill?	
31. How often do rivers flood (overtop their banks)?	
32. What is the principal force that makes things move downhill?	
33. When rivers flood, where do the largest grain sizes end up?	

34. Under what conditions does the ice in an alpine glacier move downhill?	
35. Under what conditions does a glacier retreat?	
36. List three depositional features of a glaciated valley.	
37. List three erosional features of a glaciated valley.	

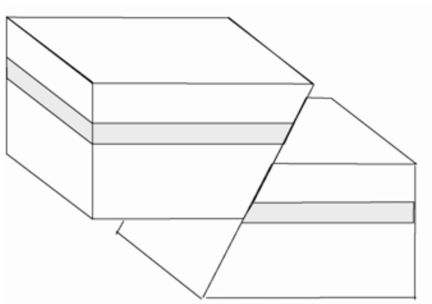
38. What is glacial till, and what are its sedimentary characteristics. Specifically how would you differentiate it from glacial outwash	
39. List three different ways for sea level to rise globally (NOT just locally).	
40. Describe at least three different characteristics of a hillside that would make it more prone to downslope movement.	
41. List at least three triggers that could make the above-described hillside finally fail (***not volcanoes***!).	
42. What/where is **ultimate base level** and how is different from ***local* base level**?	
43. What three changes could happen to the river environment that could cause it to start erododing its channel.	
44. What three changes could havpeen to the river environment that would cause depositon to occure?	
45. List and describe the **three** kinds of load that a river transports.	
46. Describe how the shapes of river-eroded and glacially eroded mountain valleys differ (be specific!).	
47. When does most of the erosion happen for a river (and when rivers are most likely to change their paths?)	

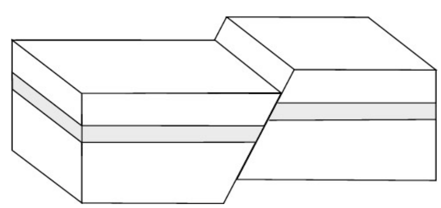
48. Where is **EROSION RATE** highest? (circle) Headwaters Mouth	49. Where is **FRICTION / DRAG** highest? (circle) Headwaters Mouth	50. Where is **GRADIENT** highest? (circle) Headwaters Mouth	51. Where is **DISCHARGE** highest? (circle) Headwaters Mouth

PassSheet 1

52. How old is the universe?	
53. Explain what is meant by <u>planetary</u> differentiation.	
54. How old is Earth (be specific to one decimal place)?	
55. List five of Alfred Wegeners main lines of evidence to support Continental Drift (be specific).	1. 2. 3. 4. 5.
56. In which layer does Earth's magnetic field originate?	
57. What characteristics and behavior of this layer produce the magnetic field? (Be specific!)	
58. Where in the oceans is the youngest (newest) ocean crust found?	
59. What kind of continental margin is the East Coast of the United States?	
60. In which layer does Earth's magnetic field originate?	
61. How does the process of convection contribute to plate tectonics? In other words relate convection to plate tectonics.	
62. Give three ways that continental crust differs from oceanic crust (be SPECIFIC!).	

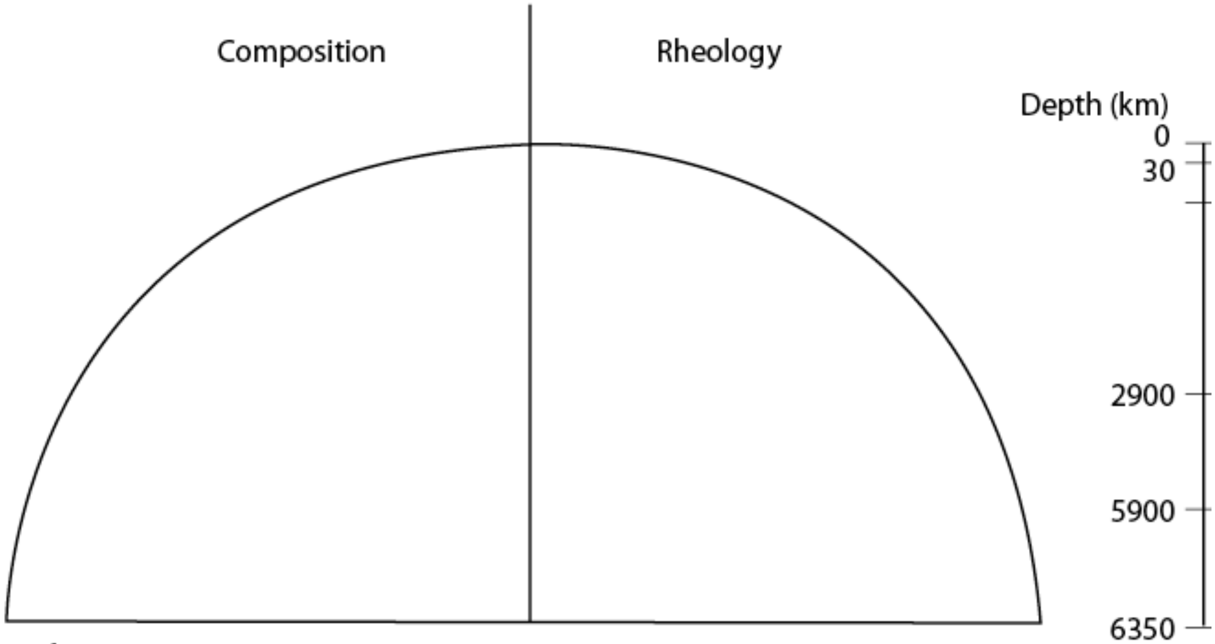
63. Draw arrows on the right and left of the drawings to indicate the directions of stress.
64. Draw arrows along the fault planes to indicate relative motion.
65. Label hanging wall and footwall. What is the name of each fault?





66. Know what rock types are present in the Bay Area and what that tells us about plate tectonics in the past.	

67. Draw a picture (to scale) of Earth's MAIN compositional **Label the crust, mantle, core, and Moho.**	68. Draw a picture (to scale) of Earth's rheologic layers. **Label (inner core, outer core, mesosphere, lithosphere, asthenosphere)**



69. Draw a cross-section through the Atlantic Ocean. Show both continental margins and draw as deep as the Asthenosphere. Label all features of plate boundaries and margins (one side only). Be thorough and precise.

70. Know how to interpret a graph that contains a geothermal gradient, dry solidus, wet solidus, and a liquidus.	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
71. How do we know the outer core is a liquid.	
72. What are the time 4 major time periods of Earth's History and when did they begin and end.	

Complete this table: For the better than pass section of the exam you should know what this looks like in pressure Temerature data plot (i.e., geothermal gradient, liquidius, solidus)	
What are the three ways that magma is generated?	**Geologic environment where this melt method occurs:**
73.	
74.	
75.	

PassSheet 2

Name the basic atomic particles and describe their charges and masses.		
Particle	**Charge**	**Mass (in AMU)**
76.		
77.		
78.		

An atom has an atomic number of 14 and an atomic mass of 28. Based on this information, answer the following questions (The exam will use a different atom, so be sure you understand all of the answers given below).			
79. How many protons does it have?		80. How many valence electrons does it have?	
81. How many neutrons does it have?		82. What is its symbol/name?	
83. What is it's ionic charge?		84. What is the typcial type of atomic bonding for this atom?	

85. Describe the primary difference between covalent and ionic bonds (be specific!).	

86. What's the textural name for an igneous rocks that contain no minerals (no crystals visible to the naked eye) and how and why does this texture develop?	
87. What's the textural name for igneous rocks where two crystal sizes occur (one size that is easily visible and are surrounded by a matrix of too small to be seen crystals) and how and why does this texture develop?	
88. What's the textural name for igneous rocks where the entire rock is crystalline and how and why does this texture develop?	

What are the two most common detrital minerals in sedimentary rocks? Why?	
Most common detrital minerals	**Reason why each is so common**
89.	
90.	

91. List three characteristic that changes that occur to metamorphic rocks as grade increases.	
92. What is the difference between physical weathering and chemical weathering?	

Characterize these igneous compositions by their silica content and main mineral components:		
Compositions:	**(Circle correct answer)**	**Main mineral components**
93. Ultramafic	Silica content: < 45% | 45 – 55% | 55 – 65% | > 65%	
94. Mafic	Silica content: < 45% | 45 – 55% | 55 – 65% | > 65%	
95. Intermediate	Silica content: < 45% | 45 – 55% | 55 – 65% | > 65%	
96. Felsic	Silica content: < 45% | 45 – 55% | 55 – 65% | > 65%	

What are the three different kinds of chemical weathering and their end products?	
Chemical Weathering Processes	**End products**
97.	
99.	

100. Describe the grain size, shape, sorting, and composition of sediment that has traveled (via running water), far from its source AND not at all.	**FAR**	**NEAR**

101. What is the relationship between magma/lava composition and viscosity?	