

Name: _____ Date: _____

UNIT FOUR

Dynamic Earth

*Dedicated to: _____

ABSTRACT AND RATIONALE

To design structures that can withstand earthquakes, engineers must understand the stresses caused by shaking. To this end, scientists and engineers place instruments in structures and nearby on the ground to measure how the structures respond during an earthquake to the motion of the ground beneath. Every time a strong earthquake occurs, the new information gathered enables engineers to refine and improve structural designs and building codes. Today there are instruments installed in hospitals, bridges, dams, aqueducts, and other structures throughout the earthquake-prone areas of the United States including other seismically active regions of the nation.

TASK STATEMENT/PROBLEM BASED LEARNING/REAL WORLD PROBLEM:

After this unit, you and your group members will explore earthquake hazards and damage to buildings by constructing model buildings and subjecting the buildings to ground vibration (shaking similar to earthquake vibrations) on a small shake table. The buildings will be constructed by two- or three-person teams of students. After construction, the buildings are tested by subjecting them to earthquake shaking to see which designs and constructions are successful.

Rules:

1. Materials are limited (realistic)
2. Complete construction in limited time (realistic)

Material:

1. Posterboard (lightweight posterboard; note: there is a difference in quality and therefore strength of lightweight posterboard; the best posterboard has one smooth, almost glossy side and one dull side; lightweight posterboard can be purchased at most bookstores, convenience stores, Wal-Mart and K-Mart.)
2. Scotch Tape (2 cm or 3/4" wide) 100 cm length (Plan accordingly!)
3. Scissors
4. Ruler
5. 4 – 8 x 8 cm squares
6. 12 – 1½ x 10 cm strips
7. 12 – 1½ x 15 cm strips
8. 1 – 30 x 8 cm

Topics that we'll cover in detail to help on your task statement:

- Cause of earthquakes
- Movement of earthquakes
- Earthquake intensity
- Calculating earthquake's arrival time, origin time and distance from the origin.
- Effects of earthquake

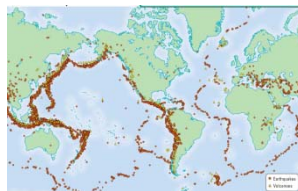
Read page#172-194 in your Earth Science textbook. Answer the questions below (specifically for each section of the reading). Remember, try to be honest and not make up any answers. This is a way for me to understand where you are having difficulty.

Page #172



1. Explain Wegner's hypothesis AND list three observations that supported his idea.

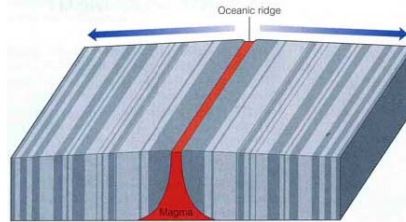
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2. What does earthquake and volcanoes relate to the theory of plate tectonics?

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3. To your best ability, explain how studying the magnetic property of igneous rock on the ocean floor supports the theory of plate tectonics

4. Write down two questions you have on that section

5. Write down three vocabularies you stumbled on while reading the text.

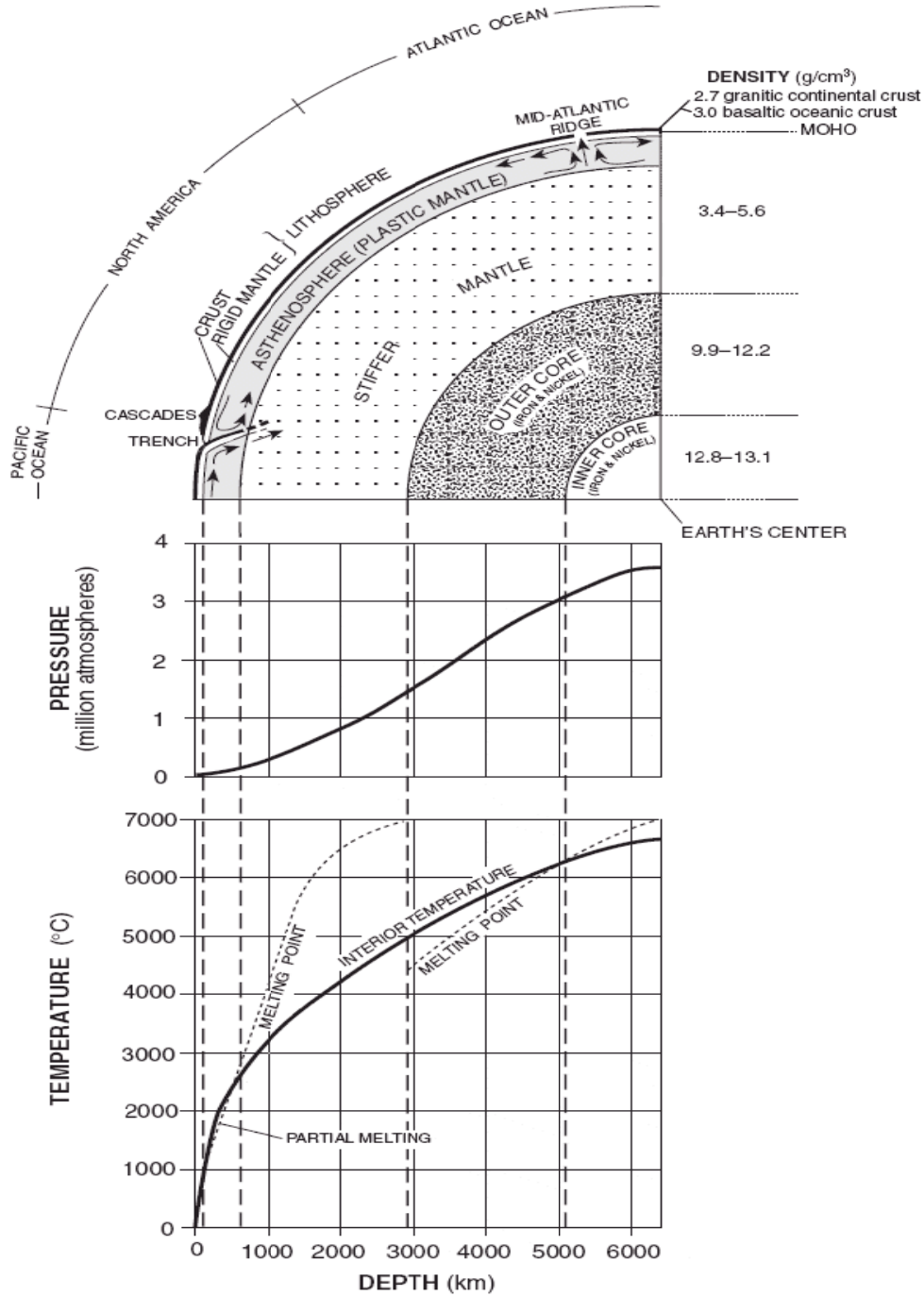
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6. How does the age of the rock at the center of the mid ocean ridge compare to the side?

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7. Summarize where and how volcanoes form

INTERIOR OF THE EARTH

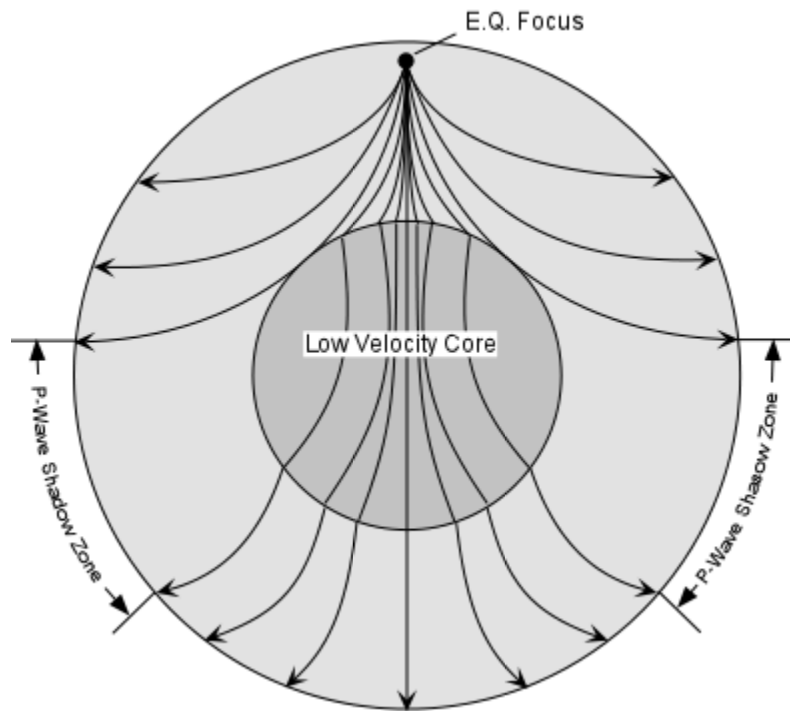


Lithosphere: _____

Asthenosphere: _____

How do we know about earth's interior?

ANS: _____



Refraction: _____

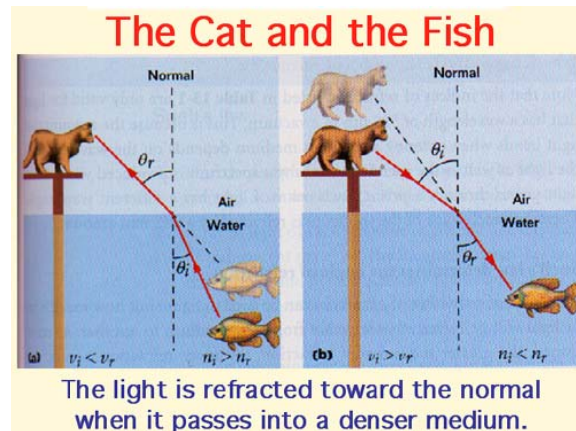
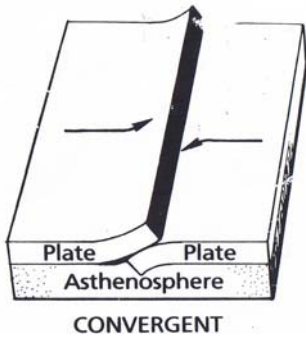


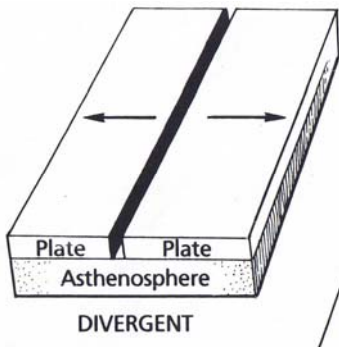
Plate Tectonic Notes

Name: _____ Date: _____

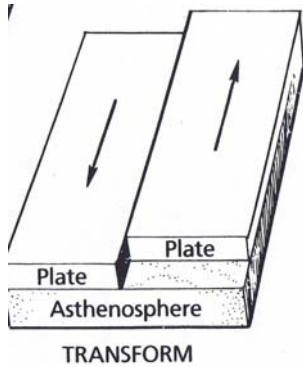


Types of plates and features of interactions

Blank space for notes on convergent plate boundaries.



Blank space for notes on divergent plate boundaries.



Blank space for notes on transform plate boundaries.

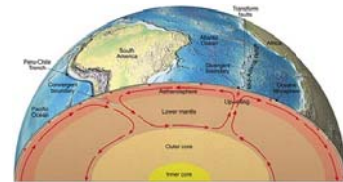
Plate Tectonics Class Exercise (ESRT pg. 5)

1. List three pieces of evidence of continental drift:

- a.
- b.
- c.

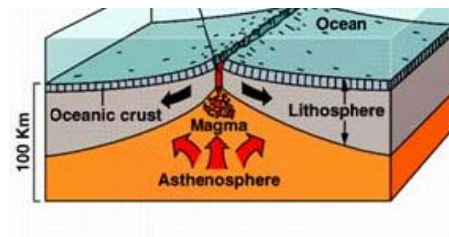
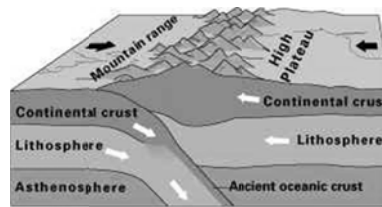
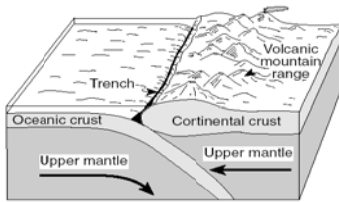


2. What is believed to cause the plates to move?



3. Describe the difference between a continental plate and an ocean plate:

4. Write the name of each type of plate boundary and the main features that form.



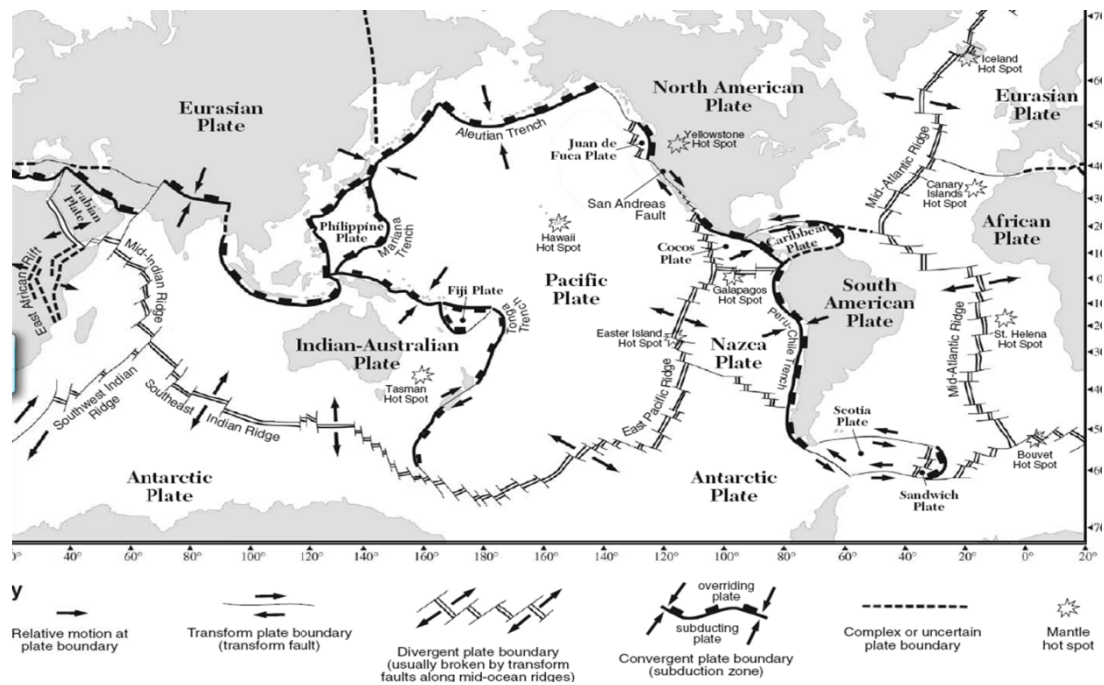
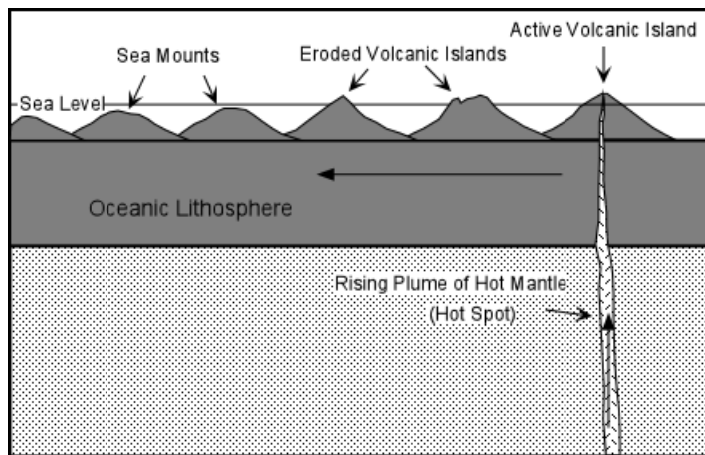
Name: _____ Date: _____

5. a. What type of boundary exists between the North American Plate and the Eurasian Plate?

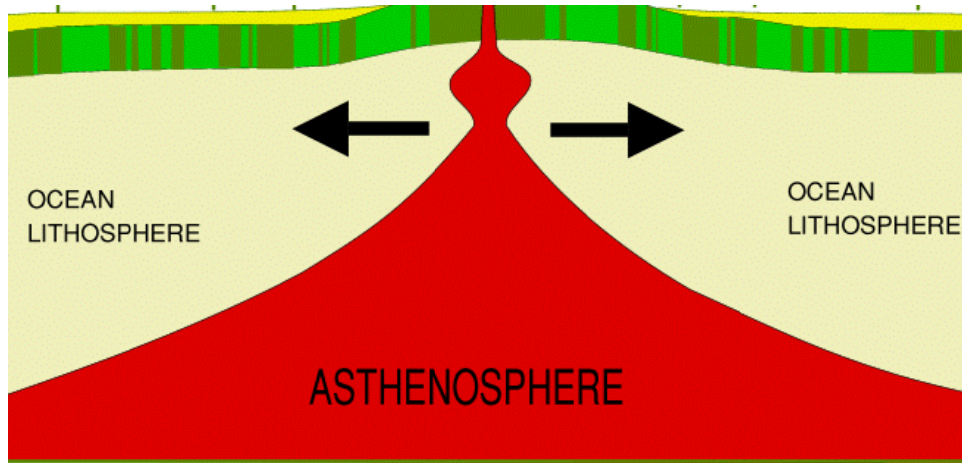
- b. What feature is forming at that boundary? _____
6. a. What type of boundary exists between the Philippine Plate and the Pacific Plate?

- b. What feature is forming at that boundary? _____
7. a. What type of boundary exists between the Nazca and South American Plates? _____
- b. What feature is forming at that boundary? _____
8. a. What type of plate boundary exists on the west coast of the USA in California? _____
- b. What feature is occurring at that boundary? _____
9. a. Name four hot spots: _____
10. a. When an ocean plate collides with a continental plate, which plate will go underneath the other? _____
- b. Why? _____
11. a. What do we know about the age of the rocks at mid-ocean ridges?
- b. What happens to the age as you get farther from the ridges?
12. Look at the Nazca and South American plate. Which plate is going underneath the other?

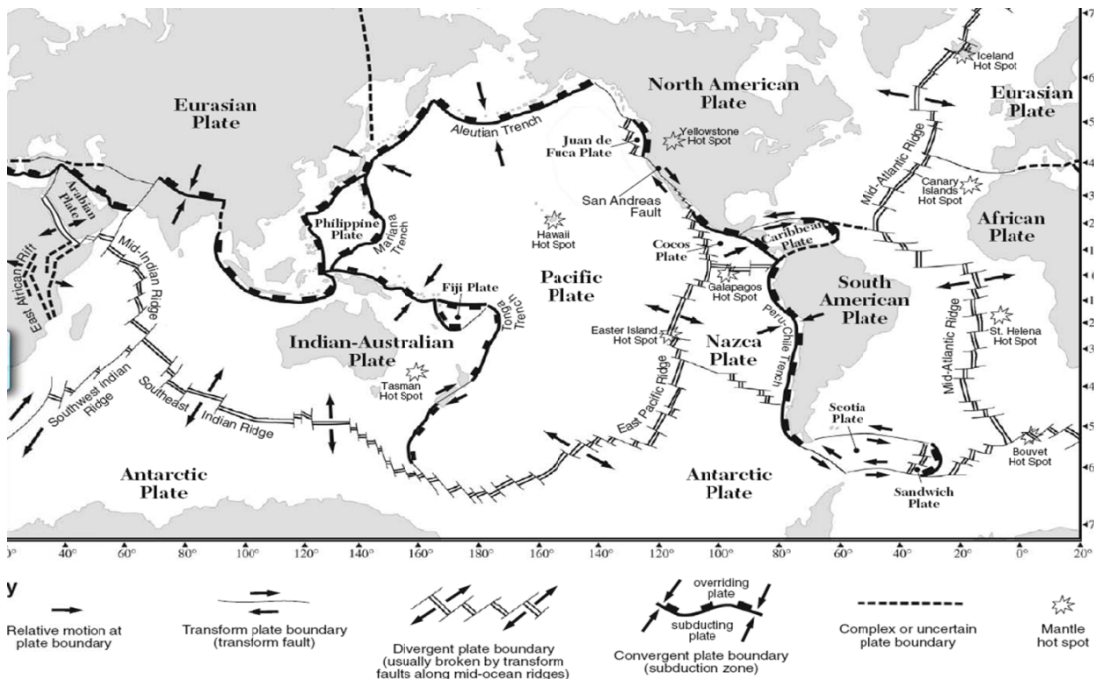
Define Hot Spots



Mid-ocean Ridge:



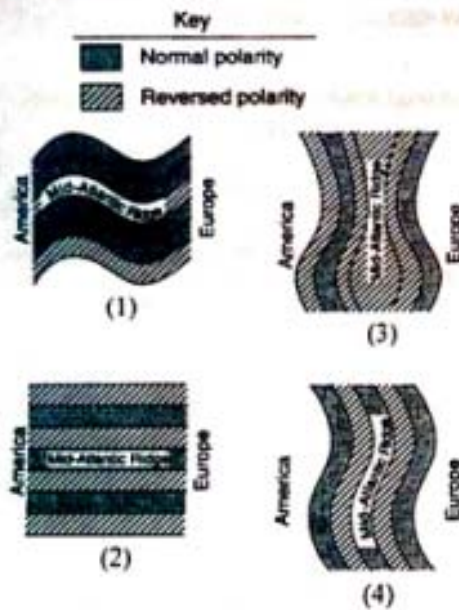
How do the rocks at MOR indicate about the Earth's magnetic field?



Which evidence supports the theory of ocean floor spreading?

- (1) The rocks of the ocean floor and the continents have similar origins.
- (2) In the ocean floor, rocks near the mid-ocean ridge are cooler than rocks near the continents.
- (3) The pattern of magnetic orientation of rocks is similar on both sides of the mid-ocean ridge.
- (4) The density of oceanic crust is greater than the density of continental crust.

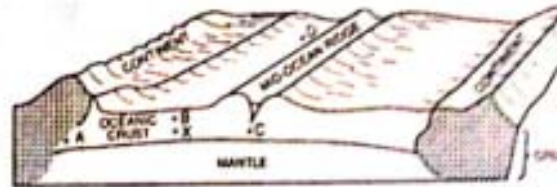
2. Which map best represents the general pattern of magnetism in the oceanic bedrock near the mid-Atlantic Ridge?



3. Where are earthquakes most likely to take place?

- (1) along the core-mantle interface
- (2) where the composition of the Earth tends to be uniform
- (3) near the Earth's Equator
- (4) near a fault zone

4. The diagram below represents a cross section of a portion of the Earth's crust and mantle. Letters A, B, C, D and X identify locations within the crust.



The age of oceanic crust increases along a line between location X and location

- | | |
|-------|-------|
| (1) A | (3) C |
| (2) B | (4) D |

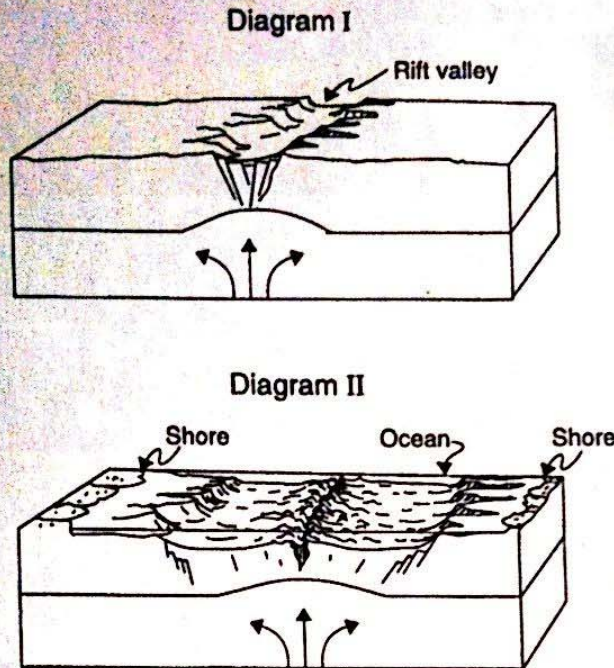
5. Which statement best supports the theory that all the continents were once a single landmass?

- (1) Rocks of the ocean ridges are older than those of the adjacent sea floor.
- (2) Rock and fossil correlation can be made where the continents appear to fit together.
- (3) Marine fossils can be found at high elevations above sea level on all continents.
- (4) Great thicknesses of shallow-water sediments are found at interior locations on some continents.

6. How does the oceanic crust compare to the continental crust?

- (1) The oceanic crust is thinner and contains less basalt.
- (2) The oceanic crust is thinner and contains more basalt.
- (3) The oceanic crust is thicker and contains less basalt.
- (4) The oceanic crust is thicker and contains more basalt.

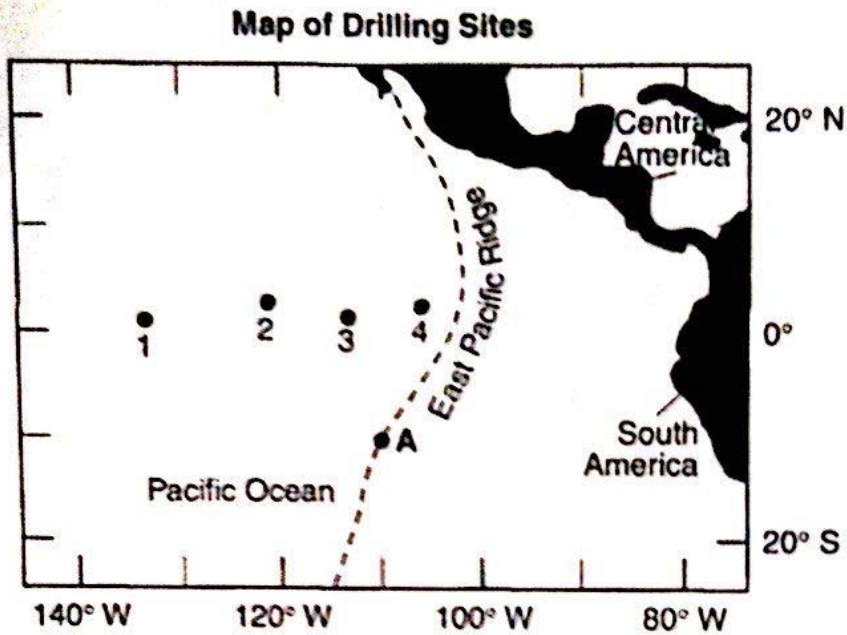
7. Diagrams I and II show the same region of the Earth's surface at two different times in the geologic past.



Which statement best explains the basic cause of the changes that occurred in this region?

- (1) Meteor impact on the crust caused widening of the valley.
 - (2) Mantle convection currents caused crustal movement.
 - (3) Climate changes caused flooding.
 - (4) Temperature changes caused melting of polar ice caps.
8. The border between the South American plate and the African plate is best described as
- (1) converging and located at an oceanic ridge
 - (2) converging and located at an oceanic trench
 - (3) diverging and located at an oceanic ridge
 - (4) diverging and located at an oceanic trench

Base your answer to the following question on the map below which shows the locations of deep-sea core drilling sites numbered 1 through 4. The approximate location of the East Pacific Ridge is shown by a dashed line. Point A is located on the East Pacific Ridge.



At which drilling site would the oldest igneous bedrock most likely be found?

- (1) 1 (2) 2 (3) 3 (4) 4

Name: _____ Date: _____

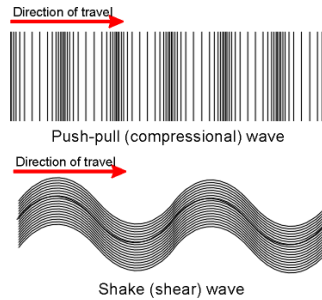
Read page#214-220 in your Earth Science textbook. Answer the questions below (specifically for each section of the reading). Remember, try to be honest and not make up any answers. This is a way for me to understand where you are having difficulty.

Page #214



1. Write a summary that explains the cause of earthquakes

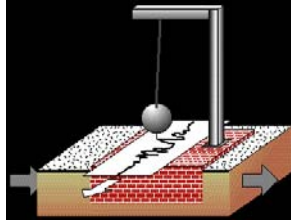
Page#215



2. Write down three things you learned about P and S waves

3. Write down two questions for each section of the reading

Question about reading on page 216:



4. To your best ability, explain how seismograph works

5. How many seismographs are needed to find the epicenter of an earthquake? _____

6. Write down two questions you have on that section

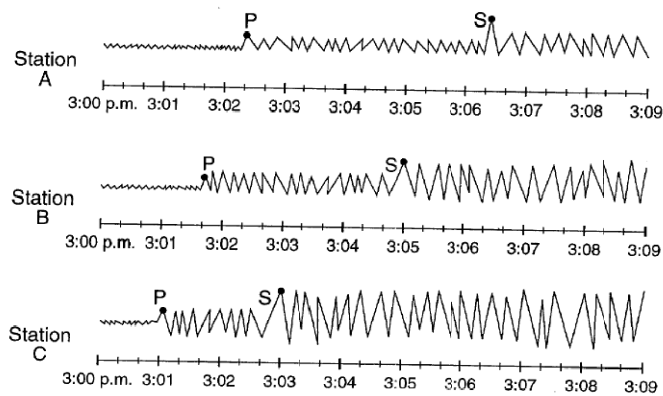
6. Write down three vocabularies you stumbled on while reading the text.

Name: _____ Date: _____

1. Where do most of the earthquakes and volcanoes happen?

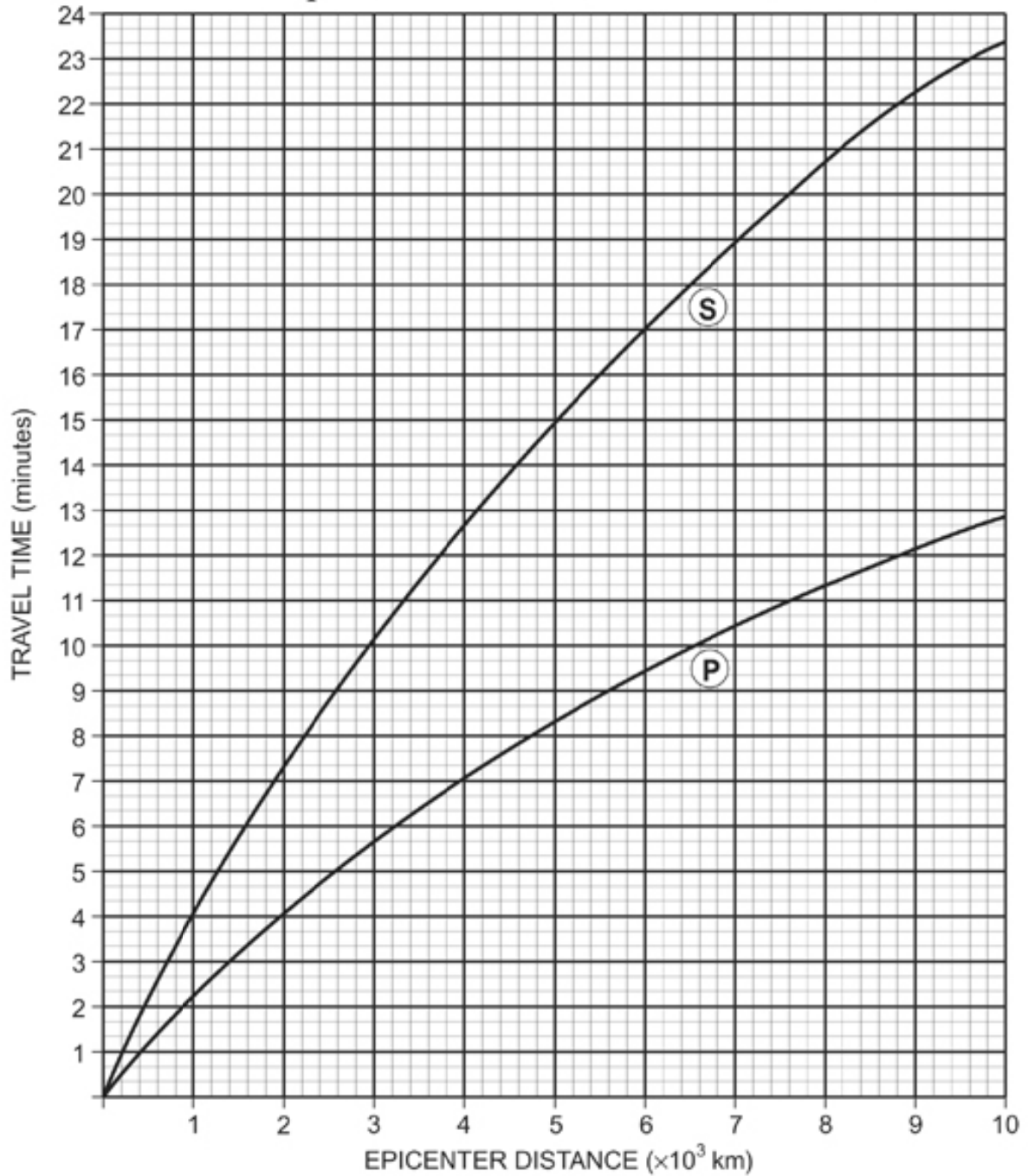
2. Define an epicenter? _____

3. Define a focus:



P wave	S wave
1)	1)
2)	2)
3)	3)

Earthquake P-wave and S-wave Travel Time



EXAMPLE#1

- How long does it take for S-Wave to travel 5,000km? _____

EXAMPLE #2

- The recording station tells us it took 6 minutes and 20 seconds for the P-Wave to reach them. How far away from the epicenter of the earthquake must they be?

ANS: _____

EXAMPLE#3

- How long does it take for P-wave to travel 6000km? _____

EXAMPLE#4

- The recording station tells us it took 3 minutes and 40 seconds for the S wave to reach them, how far away from the epicenter of the earthquake must they be?

ANS: _____

WHAT IF BOTH P AND S WAVE ARE KNOWN?

Station A: San Francisco, California

P-Wave arrival **3:02:20**

S-Wave arrival **3:06:30**

What is the time difference between P and S wave arrivals?

ANS: _____

Distance to the Epicenter? _____

Name: _____ Date: _____

Station B: Denver, Colorado

P-Wave arrival **3:01:40**

S-Wave arrival **3:04:10**

What is the time difference between P and S wave arrivals?

ANS: _____

Distance to the Epicenter? _____

Station C: Missoula, Montana

P-Wave arrival **3:01:20**

S-Wave arrival **3:03:00**

What is the time difference between P and S wave arrivals?

ANS: _____

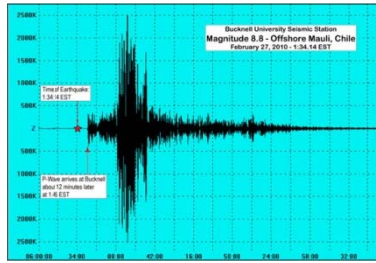
Distance to the Epicenter? _____

Individual Practice

Find the epicenter of each seismic station

P arrival time	S arrival time	Lag Time	Epicenter Distance
4:10:25	4:13:05		
4:05:00	4:10:00		
4:03:30	4:09:00		

Name: _____ Date: _____



(Seismograph from a seismic station)

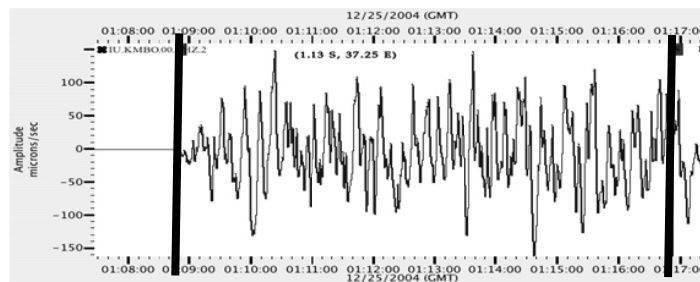
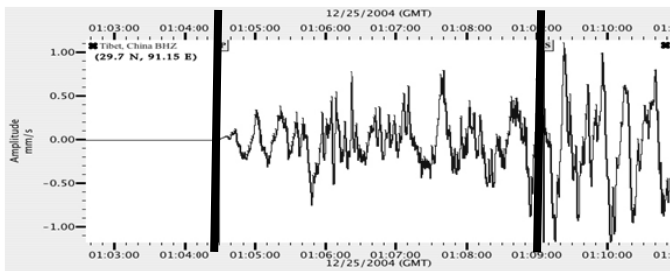
- In addition to the seismic station above, how many additional ones scientist need to predict an earthquake?

- Which plate motions are involved in the earthquake in Sumatra and Japan?

- How can the distance from an epicenter determine the level of danger?

- In United States, where could be a potential danger for Tsunami and how should you prepare?

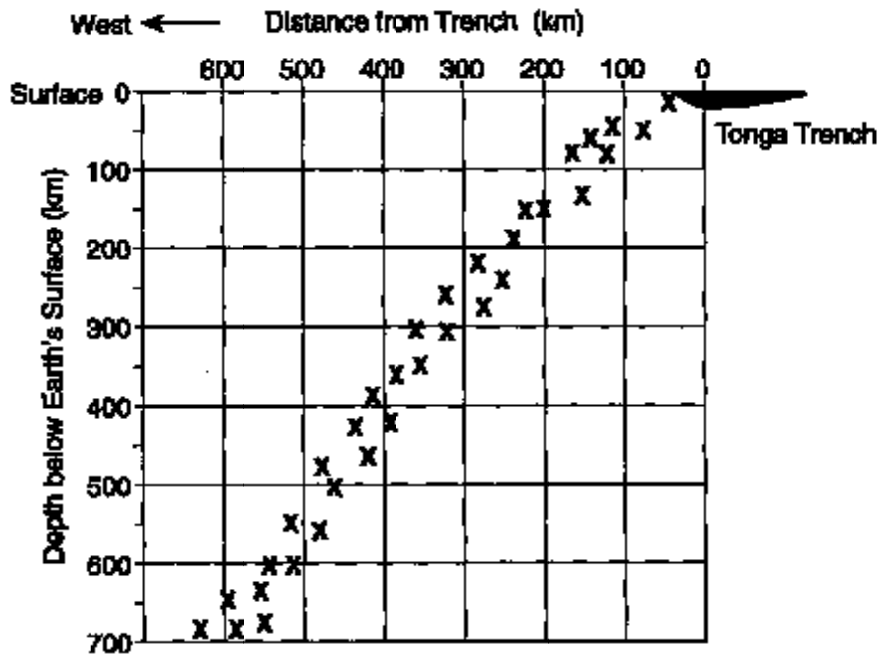
- How does the speed of seismic waves change?



- Which graphs above shows the station is located farthest from the epicenter distance?

Name: _____ Date: _____

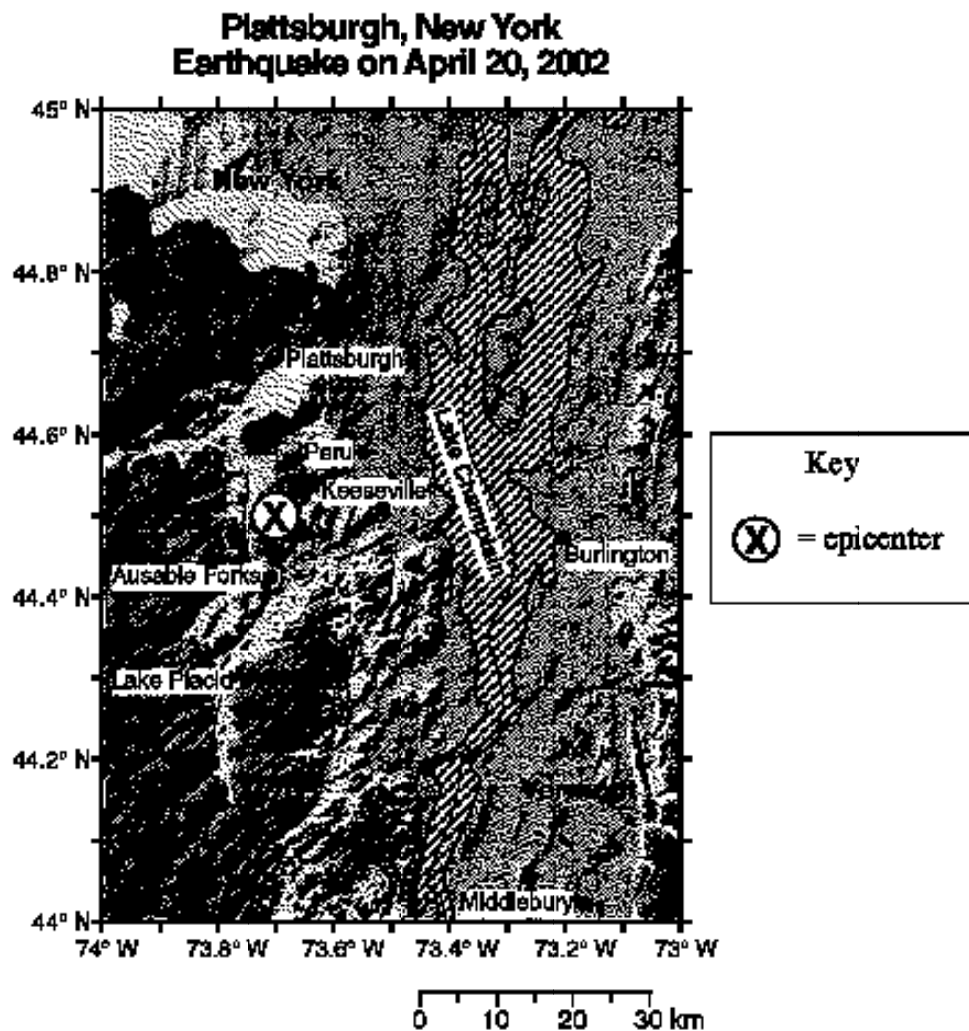
1. Base your answer to the following question on the cross section of a portion of Earth's interior below. The cross section shows the focal depth of some earthquakes that occurred west of the Tonga Trench. Data were collected along the 22 parallel.



- State the relationship between the depth of an earthquake's focus and the earthquake's distance from the Tonga Trench.
- The Tonga Trench is the crustal surface boundary between two tectonic plates. State the names of the two plates.
- Describe the relative motion of the plates along this boundary

2. Base your answer to the following question on the map below which shows the location of the epicenter of an earthquake that occurred on April 20, 2002, about 29 kilometers southwest of Plattsburgh, New York

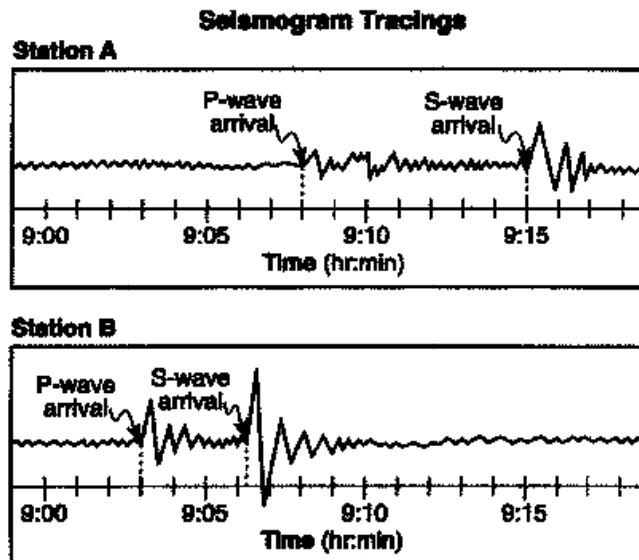
a. The map shows the epicenter of an earthquake happening near Plattsburgh, New York on April 20, 2002.



b. State the latitude and longitude of this earthquake epicenter. Express your answers to the nearest tenth of a degree and include the compass directions.

- c. What is the minimum number of seismographic stations needed to locate the epicenter of an earthquake?
- d. Explain why this earthquake was most likely felt with greater intensity by people in Peru, New York, than by people in Lake Placid, New York.

3. A seismic station located 1,800 kilometers from the epicenter recorded the P-wave and S-wave arrival times of this earthquake. Notice the difference between P and S wave arrival time at station A and station B.



- a. Explain how the seismograph recorded at station A is farther from the earthquake epicenter than station B.
- b. Seismic station A is located 5,400 kilometers from the epicenter of the earthquake. How much time would it take for the first S-wave produced by this earthquake to reach seismic station A?

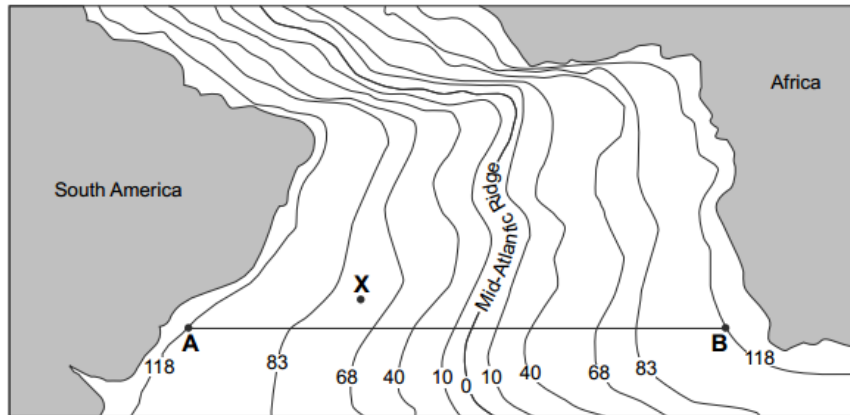
Name: _____ Date: _____

Station	P-wave arrival	S-wave arrival	S-P	Distance	P wave travel time	Origin Time
San Jose	13:17:50	13:21:00				
New York	13:19:10	13:23:20				
San Francisco	13:19:35	13:23:35				

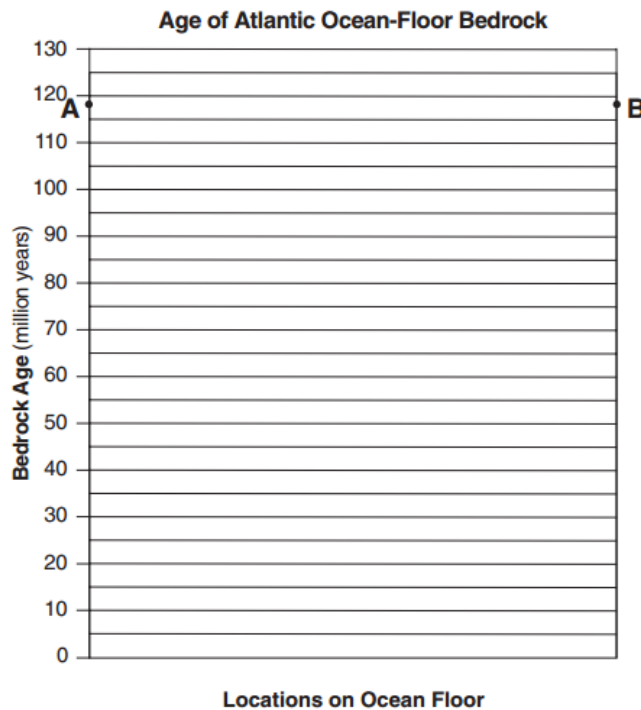
Station	P-wave arrival	S-wave arrival	S-P	Distance	P wave travel time	Origin Time
San Jose	01:17:00	01:22:30				
New York	01:24:00	01:29:40				
San Francisco	01:20:50	01:24:10				

Station	P-wave arrival	S-wave arrival	S-P	Distance	P wave travel time	Origin Time
San Jose	03:13:40	03:17:00				
New York	03:14:10	03:16:50				
San Francisco	03:14:00	03:20:00				

Base your answers to questions 1 through 4 on the generalized map below, which shows a portion of the Atlantic Ocean floor located between South America and Africa. Isolines show the approximate age, in million years, of the ocean-floor bedrock on each side of the Mid-Atlantic Ridge. Points A, B, and X represent locations on the ocean floor.

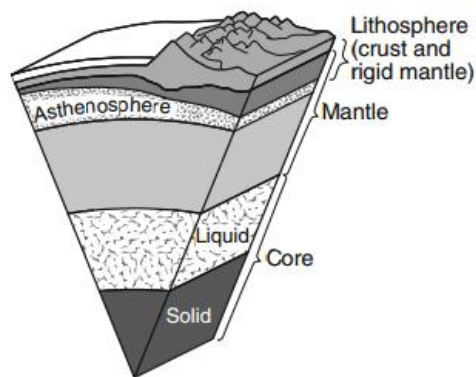


- On the grid in your answer booklet, construct a line graph of bedrock age by plotting the age of the bedrock shown by each isoline that crosses line AB. Points A and B are plotted on the grid. Connect the plots from A to B with a line.



- Estimate the age of the ocean-floor bedrock at point X.
-

4. Explain why the age of the ocean-floor bedrock increases as the distance from the Mid-Atlantic Ridge increases.
5. The Mid-Atlantic Ridge separates pairs of crustal plates, such as the South American Plate and the African Plate. Identify one other pair of crustal plates separated by the Mid-Atlantic Ridge
6. What is the approximate time difference between the first P-wave and the first S-wave recorded at a seismic station located 8000 kilometers from an earthquake's epicenter?
 - (1) 8 minutes 40 seconds
 - (2) 9 minutes 20 seconds
 - (3) 11 minutes 20 seconds
 - (4) 20 minutes 40 seconds
7. Which surface feature was produced by crustal movements at a transform plate boundary?
 - (1) East African Rift
 - (2) Aleutian Trench
 - (3) Tasman Hot Spot
 - (4) San Andreas Fault
8. A model of Earth's internal structure is shown below. Analysis of which type of data led to the development of this model?



(Not drawn to scale)

- (1) seismic waves
- (2) depth of Earth's oceans
- (3) electromagnetic radiation
- (4) isobar gradients

- 1) Which statement *best* describes the relationship between the travel rates and travel times of earthquake *P*-waves and *S*-waves from the focus of an earthquake to a seismograph station? [Refer to the *Earth Science Reference Tables*.]
 - 1) *S*-waves travel at a faster rate and take less time.
 - 2) *S*-waves travel at a slower rate and take less time.
 - 3) *P*-waves travel at a faster rate and take less time.
 - 4) *P*-waves travel at a slower rate and take less time.

- 2) The *P*-waves (compressional waves) from an earthquake travel through the Earth's
 - 1) crust and mantle, only
 - 2) crust, mantle, outer core, and inner core
 - 3) crust, mantle, and inner core, only
 - 4) crust, only

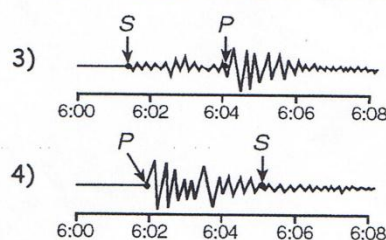
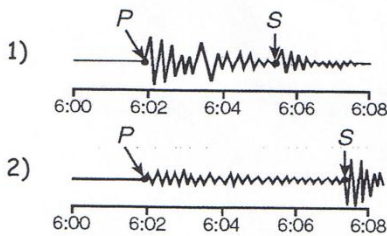
- 3) The epicenter of an earthquake is 6,000 kilometers from an observation point. What is the difference in travel time for the *P*-waves and *S*-waves?
 - 1) 13 mm 10 sec
 - 2) 7 mm 35 sec
 - 3) 9 mm 20 sec
 - 4) 17 mm 00 sec

Questions 4 through 6 refer to the following:

The table below shows some of the data collected at two seismic stations, *A* and *B*. Some data have been omitted.

Station	Arrival Time of <i>P</i> -Wave	Arrival Time of <i>S</i> -Wave	Difference in Arrival Times of <i>P</i> and <i>S</i> -Waves	Distance to Epicenter
<i>A</i>	6:02:00 p.m.	6:07:30 p.m.	5 min 30 sec	—km
<i>B</i>	—p.m.	6:11:20 p.m.	7 min 20 sec	5,700 km

- 4) Which seismogram most accurately represents the arrival of *P* and *S*-waves at station *A*?

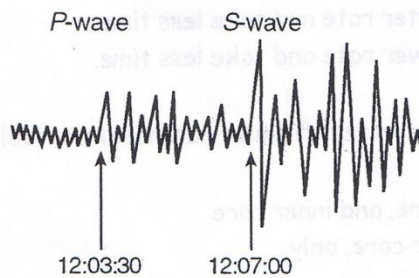


- 5) What is the approximate distance from the epicenter to station *A*?
- 1) 4,000 km
 - 2) 3,000 km
 - 3) 1,400 km
 - 4) 1,900 km

6) What is the minimum number of additional stations from which scientists must collect data in order to locate the epicenter of this earthquake?

- 1) 1 2) 2 3) 0 4) 3

7) The seismogram below shows the arrival times of *P*- and *S*-waves at a seismic station in hours, minutes, and seconds.



Approximately how far from the earthquake epicenter is this seismic station?

- 1) 1,650 km 2) 4,100 km 3) 1,900 km 4) 2,200 km

8) According to the *Earth Science Reference Tables*, what is the approximate total distance traveled by an earthquake's *P*-wave in its first 9 minutes?

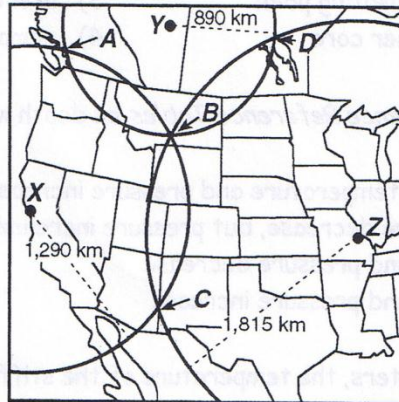
- 1) 7,600 km 2) 2,600 km 3) 12,100 km 4) 5,600 km

9) Which seismic information is needed to find the distance from an observer to an earthquake epicenter?

- 1) *P*-wave and *S*-wave arrival times 3) origin time of the earthquake
2) depth of the earthquake focus 4) *P*-wave and *S*-wave refractions

Station	Time of P-Wave Arrival	Time of S-Wave Arrival
A	8:02:00 p.m.	8:07:30 p.m.
B	8:11:50 p.m.	8:17:50 p.m.

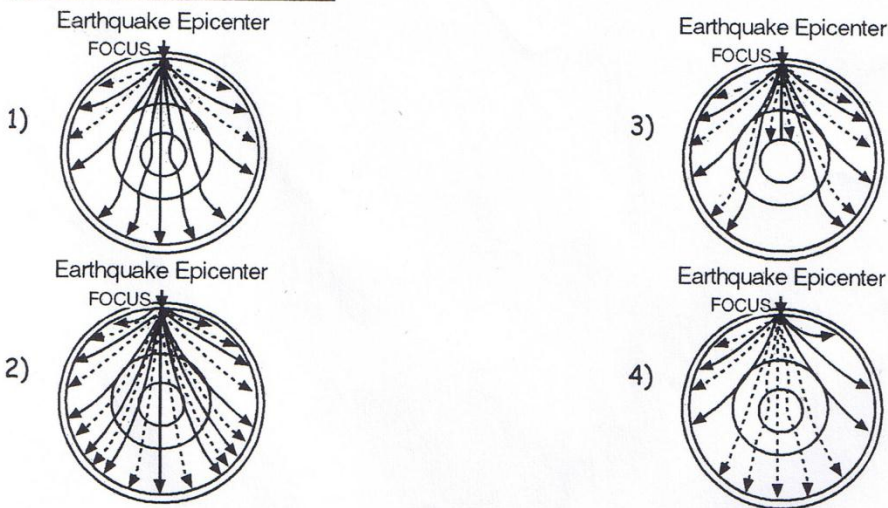
- 10) The circles on the map below show the distances from three seismic stations, X, Y, and Z, to the epicenter of an earthquake.



Which location is *closest* to the earthquake epicenter?

- 1) A 2) B 3) C 4) D
- 11) Which diagram *best* represents how P-waves and S-waves travel through the Earth?

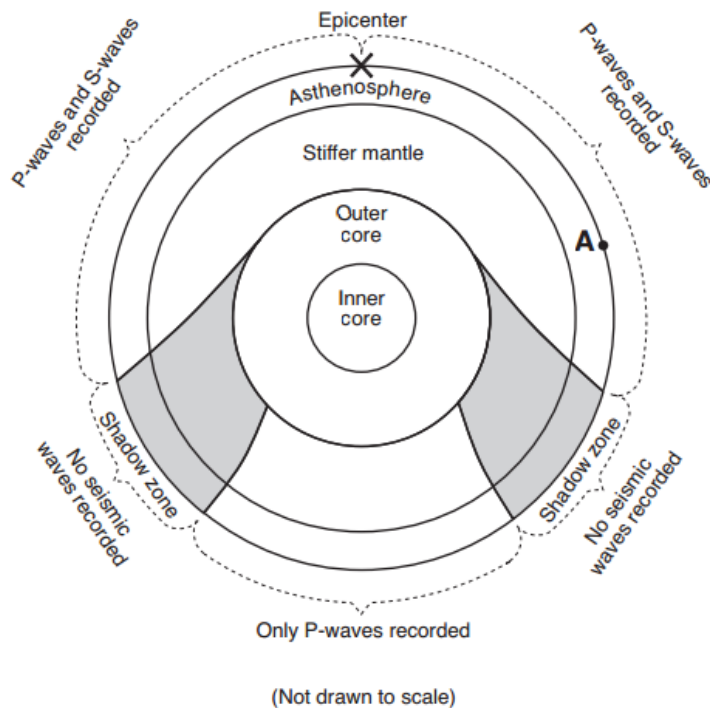
KEY:
P-waves ———> S-waves - - - ->



- 12) The structure of the Earth's interior is *best* inferred by
- 1) observing rock samples from surface bedrock
 - 2) analyzing worldwide seismic data
 - 3) determining crustal density differences
 - 4) measuring crustal temperature ranges

- 13) The fact that *S*-waves are unable to travel through the Earth's outer core supports the inference that the outer core is
- 1) hotter than the rock's melting point
 - 2) more dense than the inner core
 - 3) in the solid state of matter
 - 4) composed of iron and nickel
- 14) According to the *Earth Science Reference Tables*, as depth within the Earth's interior increases, the
- 1) density decreases, but temperature and pressure increase
 - 2) density and temperature decrease, but pressure increases
 - 3) density, temperature, and pressure decrease
 - 4) density, temperature, and pressure increase
- 15) At a depth of 2,000 kilometers, the temperature of the stiffer mantle is inferred to be
- 1) 1,500°C
 - 2) 3,500°C
 - 3) 6,500°C
 - 4) 4,200°C

Base your answers to questions 1 and 2 on the cross section below, which shows the type of seismic waves recorded at various locations after an earthquake has occurred. Point A is a location on Earth's surface and X is the epicenter of the earthquake.



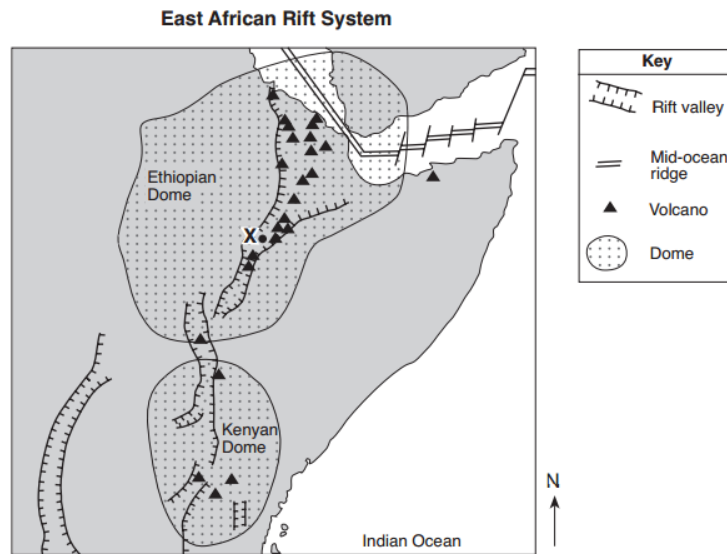
- Point A is located 7600 kilometers from the epicenter of this earthquake. How many minutes did it take the first S-wave to reach point A?

(1) 9 min	(3) 16 min
(2) 11 min	(4) 20 min
- How many kilometers did the seismic waves travel from the earthquake directly to the outside of the outer core?

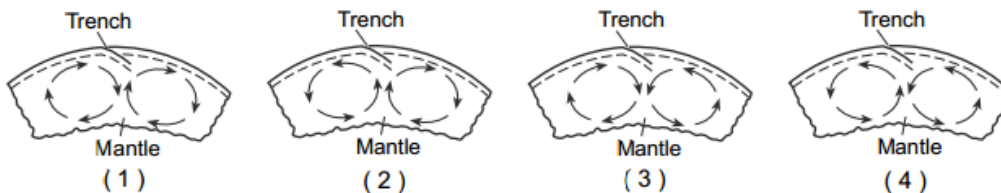
(1) 800 km	(3) 2900 km
(2) 1400 km	(4) 6400 km

The Great Rift Valley

Rifting of Earth's crust in eastern Africa began during the Neogene Period as the Ethiopian and Kenyan Domes formed. These two huge domes were created as Earth's mantle pushed up the overlying crust. As the crust was forced upward, the resulting tension cracked the crust, resulting in the eruption of volcanoes and the formation of large rifts. The crust continued to pull apart, forming rift valleys. These valleys have become deeper and are currently becoming filled with sediments, igneous rock, and water.



1. How many million years ago did the Ethiopian and Kenyan Domes form? ____mya
2. On the diagram, draw two curved arrows, one on each side of the dashed line, to show the direction of movement of the convection currents within the asthenosphere that caused the formation of the dome and the rift valley near location X.
3. Which two lithospheric plates are separated by a mid-ocean ridge in the northeastern portion of the Ethiopian Dome? _____
4. Which cross section best represents the convection currents in the mantle beneath the Peru-Chile Trench?



Rubric for plate tectonic and earthquake unit/Learning objectives

INDICATORS	JUST STARTING Novice	GETTING THERE Apprentice	YOU'VE MADE IT Practitioner	ABOVE AND BEYOND Expert
Cause of earthquakes	Explain why earthquakes happen and where they happen	Explain how earthquakes happen, where they happen and how they travel through the earth. Understand the basic vocabularies of an earthquake: Epicenter, origin, focus,	<input type="checkbox"/> Identify the different plate boundaries <input type="checkbox"/> Explain the motions of the plates and how they create different intensity of earthquakes <input type="checkbox"/> Identify and explain the different features along the plate boundaries <input type="checkbox"/> Identify the different interactions of earthquakes	<i>Practitioner Plus</i> Students built successful posterboard buildings models to with stand low to medium frequency shake test .
P and S wave (earthquake energy)	Describe the motion of p and s wave Able to know which wave arrives to the seismic station first.	Not only describe the motion and understand the definitions. Students are able to explain how p and s waves behave as they travels through the interior of the earth Understand why p and s waves are important for discovering the composition of the earth's interior.	<input type="checkbox"/> Able to use the reference table to describe the motion and definition of p and s wave <input type="checkbox"/> Calculate the p and s wave travel time <input type="checkbox"/> Calculate and find the distance to the epicenter using the p and s wave arrival time or travel time <input type="checkbox"/> Find the p and s wave travel time using the distance to the epicenter data <input type="checkbox"/> Calculate, find and draw the epicenter location(s)	<i>Practitioner Plus</i> Calculate the origin of the earthquake using epicenter distance data or from p and s wave travel time and arrival time data Understand Love and Raleigh waves.
Result of an Earthquake	Explain 1-2 cause and effect of an earthquake	Understand that tsunami is formed from underwater earthquakes	<input type="checkbox"/> Describe other possible nature disasters from the result of an earthquake. <input type="checkbox"/> Use P and S waves to detect the arrival of a tsunami and the effects of a tsunami <input type="checkbox"/> Understand in detail how the Japan tsunami and Sumatra tsunami are formed and the impact on the people	<i>Practitioner Plus</i> Describe in detail what a tsunami is and how it forms underwater