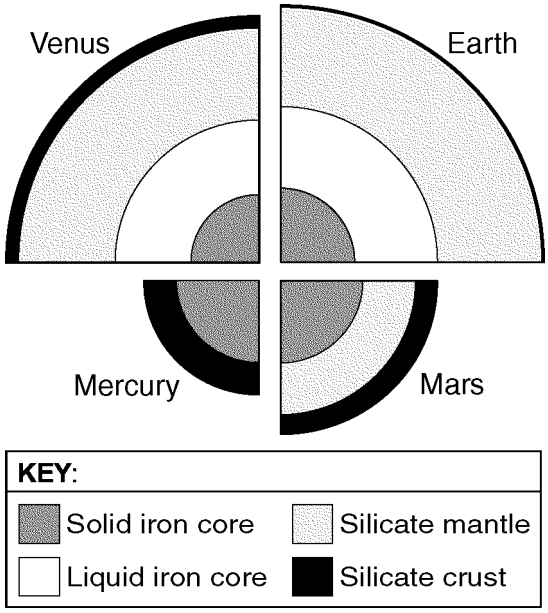
Name: _____

1) What data do scientists use to determine the magnitude of earthquakes without visiting the actual sites?

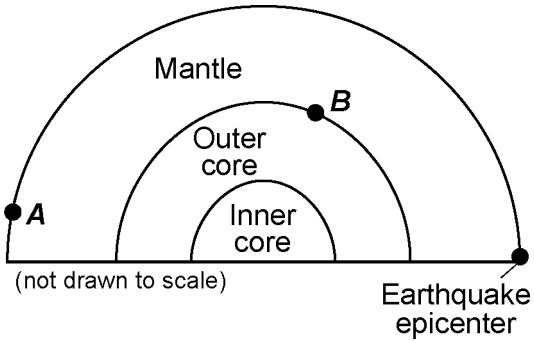
2) The diagram below shows the inferred internal structure of the four terrestrial planets, drawn to scale.



Identify the *two* planets shown that would allow an *S*-wave from a crustal quake to be transmitted through the core to the opposite side of the planet.

Questions 3 and 4 refer to the following:

The cross section below shows a portion of Earth's interior layers and the location of an earthquake epicenter. Letter *A* represents a seismic station on Earth's surface. Letter *B* represents a location in Earth's interior.

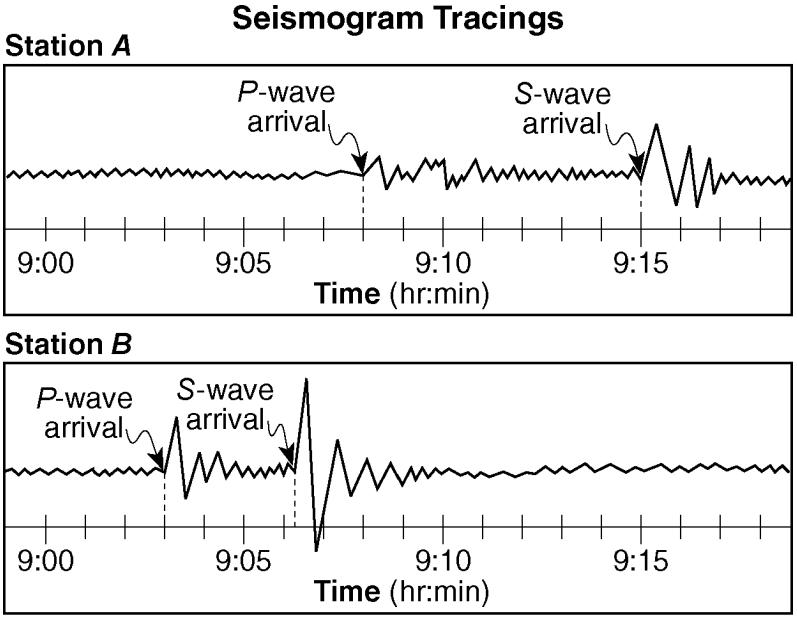


3) Explain why seismic station *A* in the given cross section receives *P*-waves but *not* *S*-waves from this earthquake.

4) What is the approximate depth at location *B* in the cross section shown?

Questions 5 and 6 refer to the following:

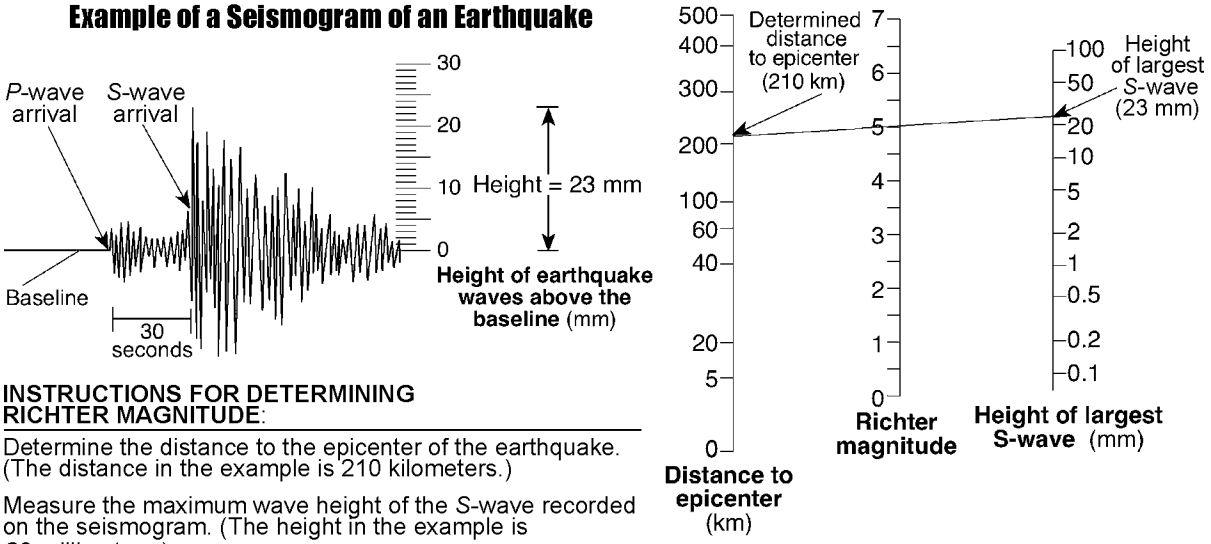
The diagram below shows two seismogram tracings, at stations *A* and *B*, for the same earthquake. The arrival times of the *P*-waves and *S*-waves are indicated on each tracing.



5) Explain how the seismic tracings recorded at station *A* and station *B* in the diagram indicate that station *A* is farther from the earthquake epicenter than station *B*.

6) Seismic station *A* in the diagram 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*?

7) An example of a seismogram and a set of instructions for determining the Richter magnitude of an earthquake are shown below. The example shows the Richter magnitude of an earthquake 210 kilometers from a seismic station.



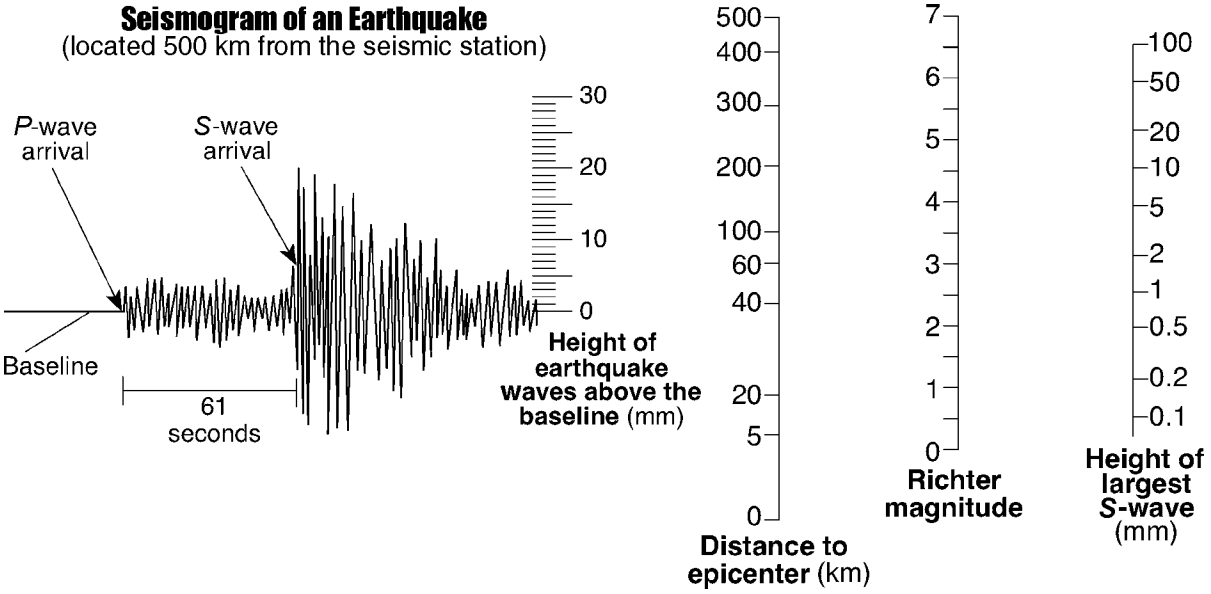
INSTRUCTIONS FOR DETERMINING RICHTER MAGNITUDE:

Determine the distance to the epicenter of the earthquake. (The distance in the example is 210 kilometers.)

Measure the maximum wave height of the *S*-wave recorded on the seismogram. (The height in the example is 23 millimeters.)

Place a straightedge between the distance to the epicenter (210 kilometers) and the height of the largest *S*-wave (23 millimeters) on the appropriate scales. Draw a line connecting these two points. The magnitude of the earthquake is determined by where the line intersects the Richter magnitude scale. (The magnitude of this example is 5.0.)

(a) Using the seismogram and scales provided below, determine the Richter magnitude of an earthquake that was located 500 kilometers from the seismic station.

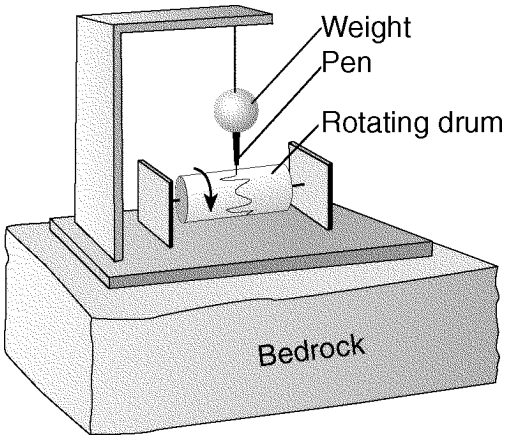


(b) Identify the information that was used to determine that the distance to the epicenter was 500 kilometers.

(c) How long did it take the first *S*-wave to travel 500 kilometers to reach the seismic station?

Questions 8 through 10 refer to the following:

The diagram below shows a seismograph that recorded seismic waves from an earthquake located 4,000 kilometers from this seismic station.



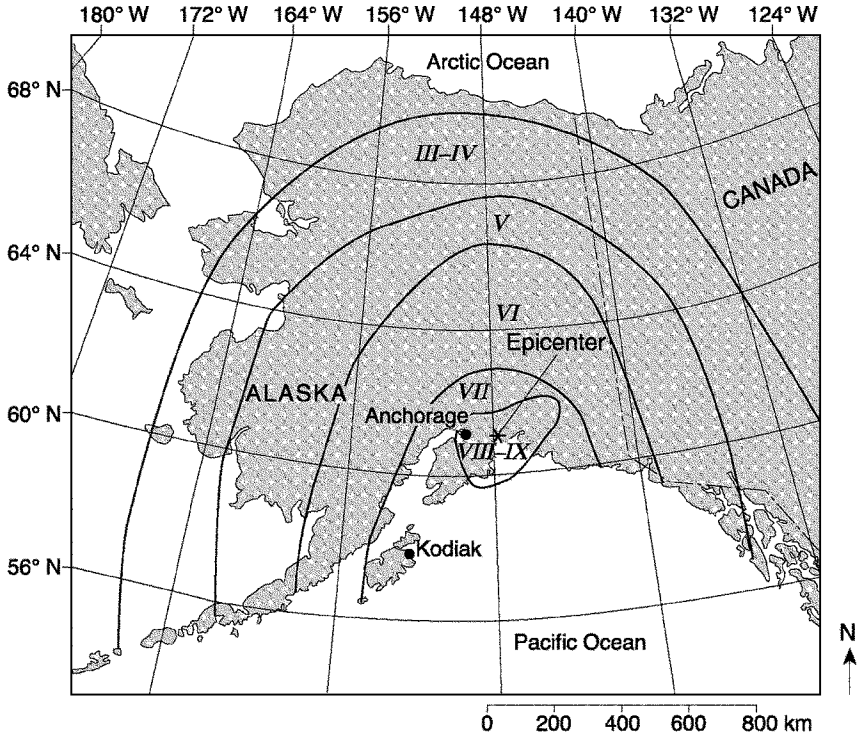
8) Which type of seismic wave was recorded first on the rotating drum shown?

9) How long does the first *S*-wave take to travel from the earthquake epicenter to the seismograph shown?

10) State *one* possible cause of the earthquake that resulted in the movement of the bedrock detected by the seismograph shown.

Questions 11 through 15 refer to the following:

The map below shows modified Mercalli intensity scale damage zones resulting from a large earthquake that occurred in 1964. The earthquake's epicenter was near Anchorage, Alaska. The cities Kodiak and Anchorage are shown on the map. The Mercalli scale describes earthquake damage at Earth's surface.



Modified Mercalli Intensity Scale

I	Instrumental: detected only by instruments	*VII*	Very strong: noticed by people in autos Damage to poor construction
II	Very feeble: noticed only by people at rest	*VIII*	Destructive: chimneys fall, much damage in substantial buildings, heavy furniture overturned
III	Slight: felt by people at rest Like passing of a truck	*IX*	Ruinous: great damage to substantial structures Ground cracked, pipes broken
IV	Moderate: generally perceptible by people in motion Loose objects disturbed	*X*	Disastrous: many buildings destroyed
V	Rather strong: dishes broken, bells rung, pendulum clocks stopped People awakened	*XI*	Very disastrous: few structures left standing
VI	Strong: felt by all, some people frightened Damage slight, some plaster cracked	*XII*	Catastrophic: total destruction

11) Determine the latitude and longitude of the epicenter shown on the given map. [*Include the units and compass directions in your answer.*]

12) Using the given information, describe *one* type of damage that occurred in Anchorage but *not* in Kodiak.

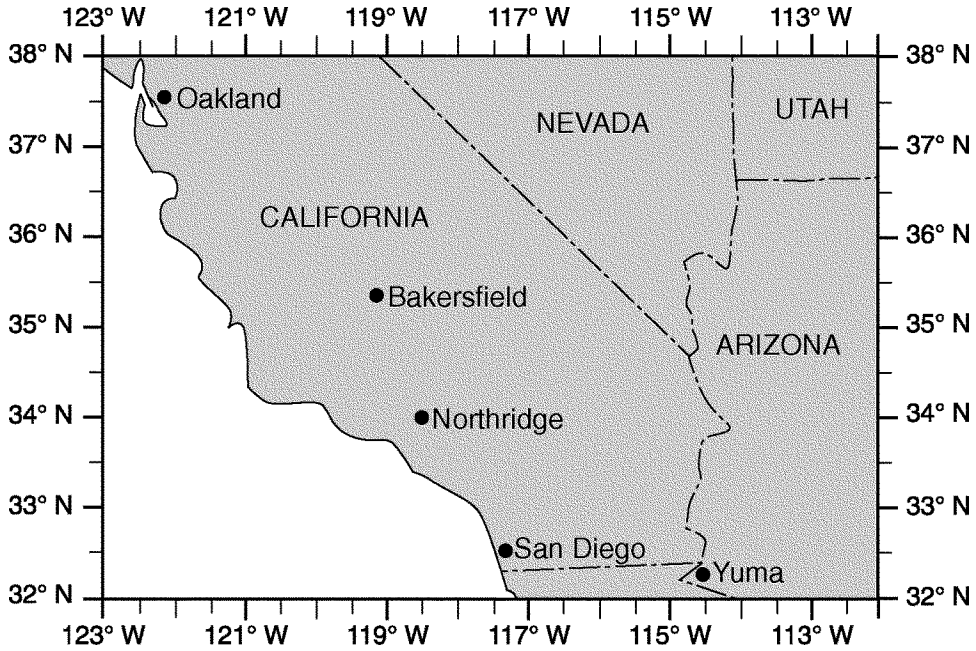
13) Explain why *S*-waves from the earthquake shown on the given map were *not* directly received on the opposite side of Earth.

14) The earthquake shown on the given map produced a large ocean-floor displacement. Identify *one* dangerous geologic event affecting Pacific Ocean shorelines as a result of this ocean-floor displacement.

15) Write the names of the *two* converging tectonic plates that caused the earthquake shown on the given map.

Questions 16 and 17 refer to the following:

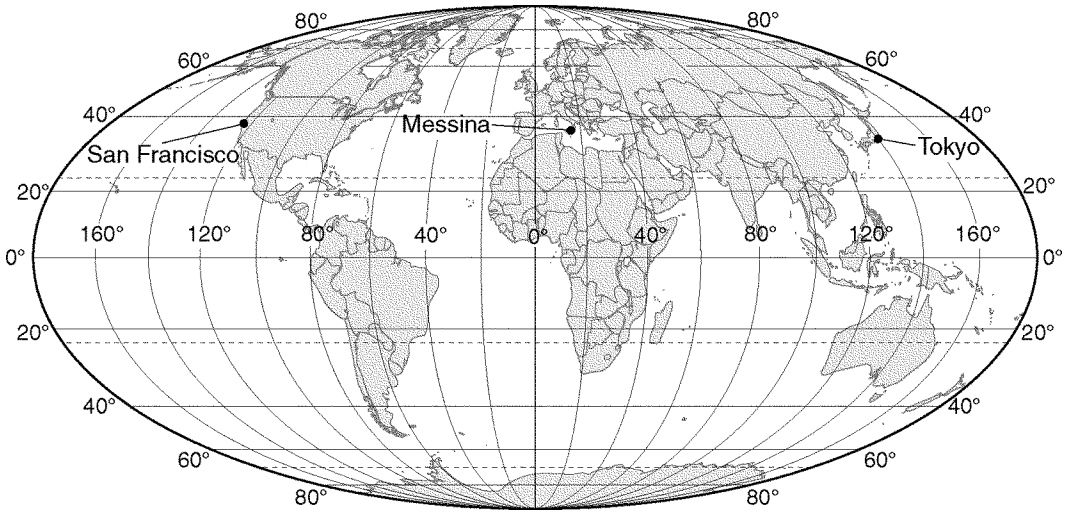
The map below shows a portion of southwestern United States. On January 17, 1994, an earthquake occurred with an epicenter at Northridge, California.



16) Of the cities shown on the map, explain why Oakland was the last city to receive *P*-waves from this earthquake.

17) Explain why earthquakes are common in the region of California shown.

18) The locations of three earthquakes are shown on the map below.



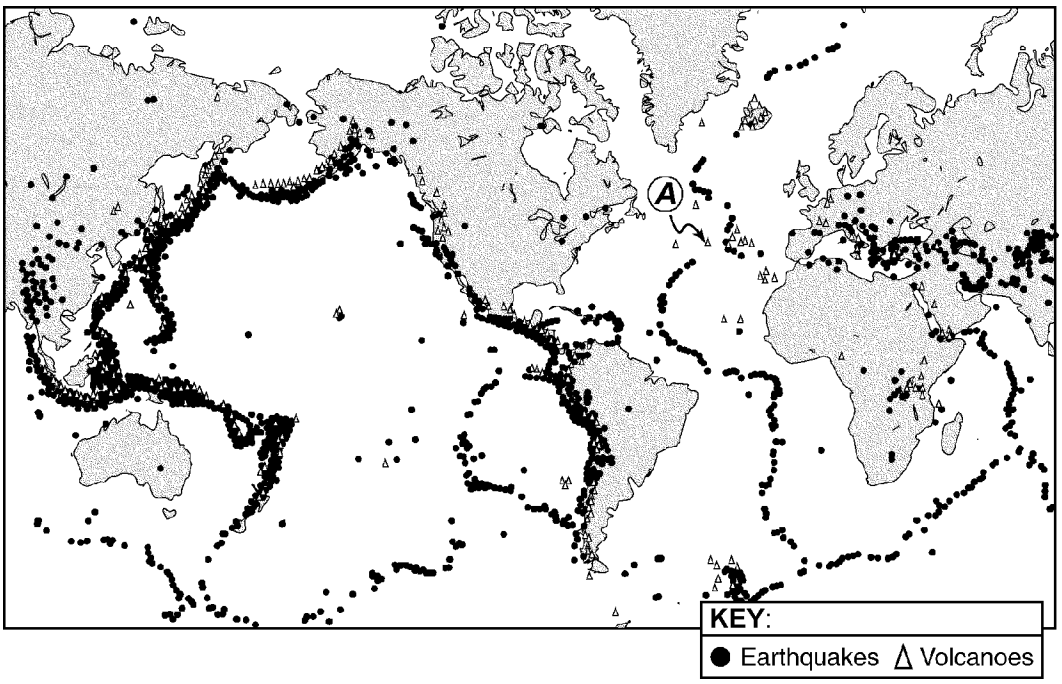
Explain how the locations of these earthquakes are related to tectonic plates.

19) List *two* actions that a homeowner could take to prepare their home or family for an earthquake.

20) Identify the source of the magma for the volcanic activity in Hawaii.

Questions 21 through 23 refer to the following:

The map below shows major earthquakes and volcanic activity occurring from 1996 through 2000. Letter *A* represents a volcano on a crustal plate boundary.



21) Place an **X** on the given map to show the location of the Nazca Plate.

22) Explain why most major earthquakes are found in specific zones instead of being randomly scattered across Earth's surface.

23) Identify the type of plate movement responsible for the presence of the volcano at location *A* in the given diagram.

Questions 24 through 26 refer to the following:

The passage describes the New Madrid fault system. The numbers on the map show the predicted relative damage at various locations if a large earthquake occurs along the New Madrid fault system. The higher the number, the greater the relative damage.

THE NEW MADRID FAULT SYSTEM:

The greatest earthquake risk area east of the Rocky Mountains is along the New Madrid fault system. The New Madrid fault system consists of a series of faults along a weak zone in the continental crust in the midwestern United States. Earthquakes occur in the Midwest less often than in California, but when they do happen, the damage is spread over a wider area due to the underlying bedrock.

In 1811 and 1812, the New Madrid fault system experienced three major earthquakes. Large land areas sank, new lakes formed, the course of the Mississippi River changed, and 150,000 acres of forests were destroyed.

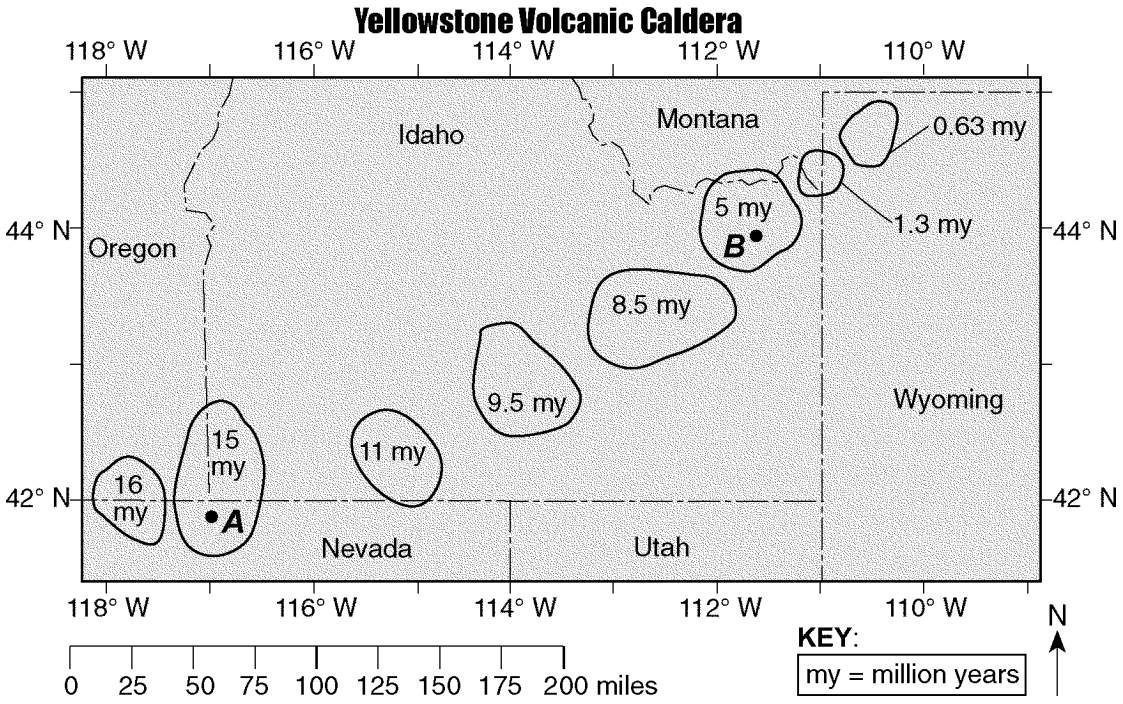
24) The distance between the New Madrid fault system described in the reading passage and Albany, New York, is 1,800 kilometers. What was the time difference between the arrival of the first *P*-wave and the arrival of the first *S*-wave at Albany when the 1812 earthquake occurred?

25) State *one* reason why earthquakes occur more frequently on the western coast of the United States than in the New Madrid region mentioned in the reading passage.

26) An emergency management specialist near the New Madrid region described in the reading passage is developing a plan that would help save lives and prevent property damage in the event of an earthquake. Describe *two* actions that should be included in the plan.

Questions 27 and 28 refer to the following:

The map below shows the outlines and ages of several calderas created as a result of volcanic activity over the last 16 million years as the North American Plate moved over the Yellowstone Hot Spot. *A* and *B* represent locations within the calderas.



THE YELLOWSTONE HOT SPOT:

The Yellowstone Hot Spot has interacted with the North American Plate, causing widespread outpourings of basalt that buried about 200,000 square miles under layers of lava flows that are a half mile or more thick. Some of the basaltic magma produced by the hot spot accumulates near the base of the plate, where it melts the crust above. The melted crust, in turn, rises closer to the surface to form large reservoirs of potentially explosive rhyolite magma. Catastrophic eruptions have partly emptied some of these reservoirs, causing their roofs to collapse. The resulting craters, some of which are more than 30 miles across, are known as volcanic calderas.

27) Based on the age pattern of the calderas shown on the given map, in which compass direction has the North American Plate moved during the last 16 million years?

28) Calculate, in miles per million years, the rate at which the North American Plate has moved over the Yellowstone Hot Spot between point *A* and point *B* in the given map.

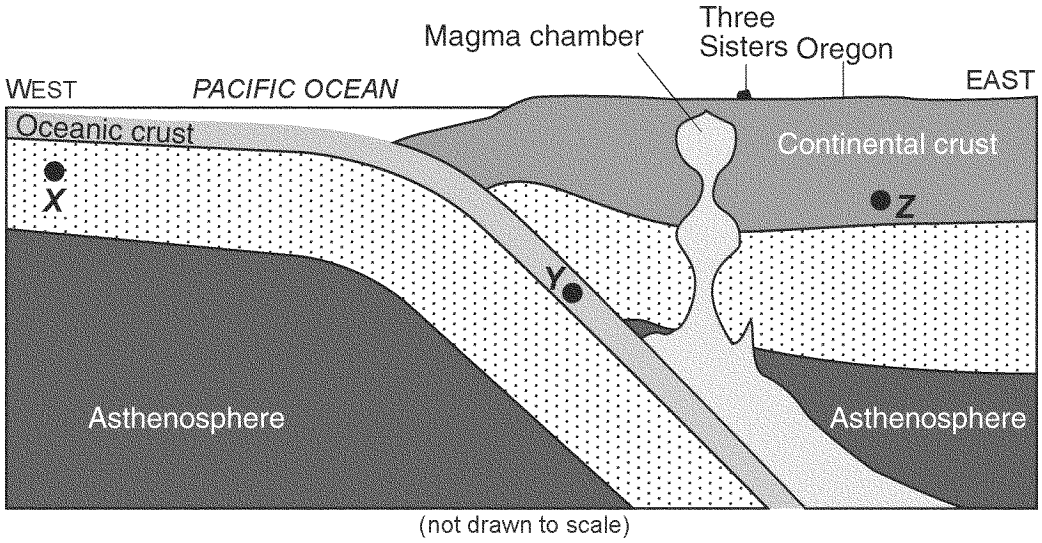
29) **A NEW OREGON VOLCANO?**

The Three Sisters are 10,000-foot volcanic mountain peaks in Oregon. Volcanic eruptions began building the Three Sisters from andesitic lava and cinders 700,000 years ago. The last major eruption occurred 2,000 years ago.

West of the Three Sisters peaks, geologists have recently discovered that Earth's surface is bulging upward in a bull's-eye pattern 10 miles wide. There is a 4-inch rise at its center, which geologists believe could be the beginning of another volcano. The uplift was found by comparing satellite images. This uplift in Oregon may allow the tracking of a volcanic eruption from its beginning, long before the smoke and explosions begin.

This uplift is most likely caused by an upflow of molten rock from more than four miles below the surface. Rock melts within Earth's interior and then moves upward in cracks in Earth's crust, where it forms large underground pools called magma chambers. Magma upwelling often produces signs that help scientists predict eruptions and protect humans. When the pressure of rising magma becomes forceful enough to crack bedrock, swarms of small earthquakes occur. Rising magma releases carbon dioxide and other gases that can be detected at the surface.

The cross section below represents Earth's interior beneath the Three Sisters mentioned in the reading passage.



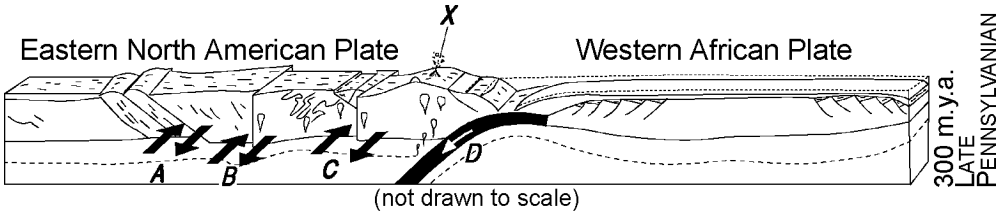
(not drawn to scale)

(a) Place a triangle, ▲, on the cross section to indicate the location where the new volcano will most likely form.

(b) On the same cross section, place arrows through each point, *X*, *Y*, and *Z*, to indicate the relative motion of each of these sections of the lithosphere.

Questions 30 and 31 refer to the following:

The block diagram below shows the tectonic plate boundary between Africa and North America 300 million years ago, as these two continents united into a single landmass. The arrows at letters *A*, *B*, *C*, and *D* represent relative crustal movements. Letter *X* shows the eruption of a volcano at that time.

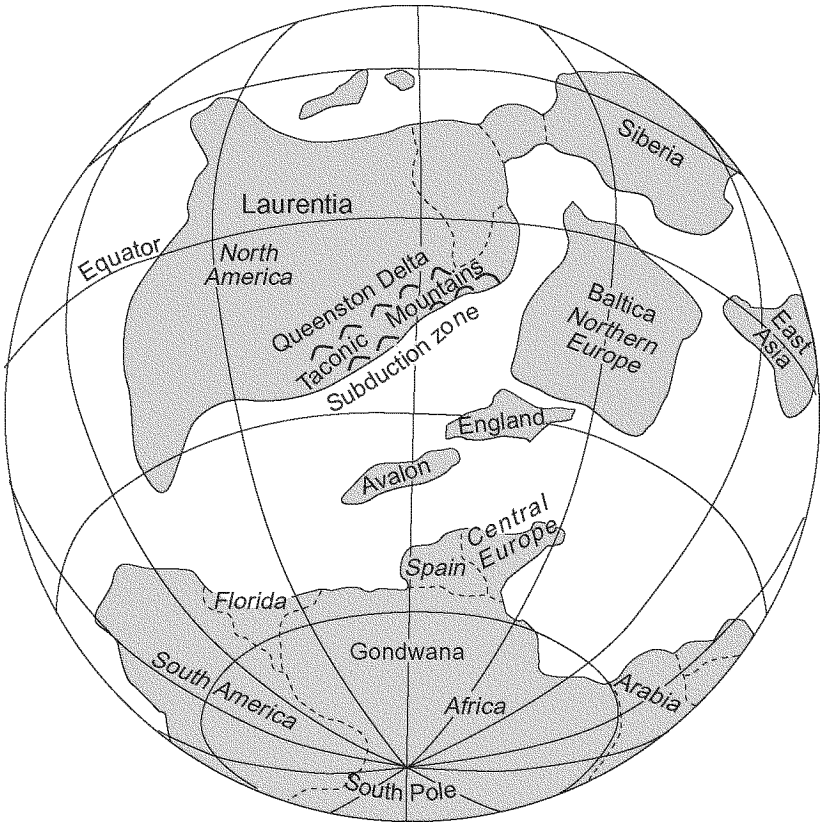


30) Identify the type of tectonic plate motion represented by the arrow shown at *D* in the given diagram.

31) Identify the type of tectonic motion represented by the arrows shown at *A*, *B*, and *C* in the given diagram.

Questions 32 and 33 refer to the following:

The map below shows the inferred position of Earth's landmasses at a particular time in Earth's history. The Taconic Mountains are shown near a subduction zone where they formed after the coast of Laurentia collided with a volcanic island arc, closing the western part of the Iapetus Ocean.



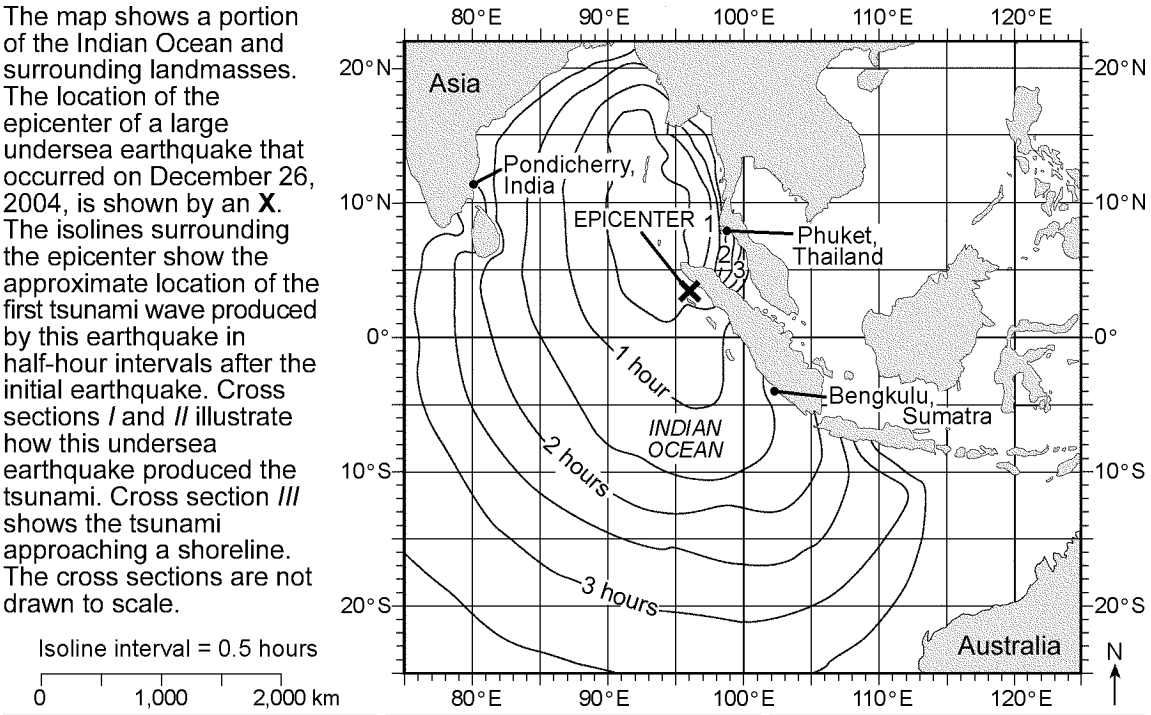
32) (a) On the map provided, place an *X* to show the approximate location of the remaining part of the Iapetus Ocean.

(b) On the map provided, draw an arrow on the Laurentia landmass to show its direction of movement relative to the subduction zone.

33) Identify the geologic time period represented by the given map.

Questions 34 and 35 refer to the following:

The map shows a portion of the Indian Ocean and surrounding landmasses. The location of the epicenter of a large undersea earthquake that occurred on December 26, 2004, is shown by an **X**. The isolines surrounding the epicenter show the approximate location of the first tsunami wave produced by this earthquake in half-hour intervals after the initial earthquake. Cross sections *I* and *II* illustrate how this undersea earthquake produced the tsunami. Cross section *III* shows the tsunami approaching a shoreline. The cross sections are not drawn to scale.



Cross section *I*
Tectonic setting before earthquake

Cross section *II*
Chain reaction caused by tectonic plate motion; results in movement of seafloor

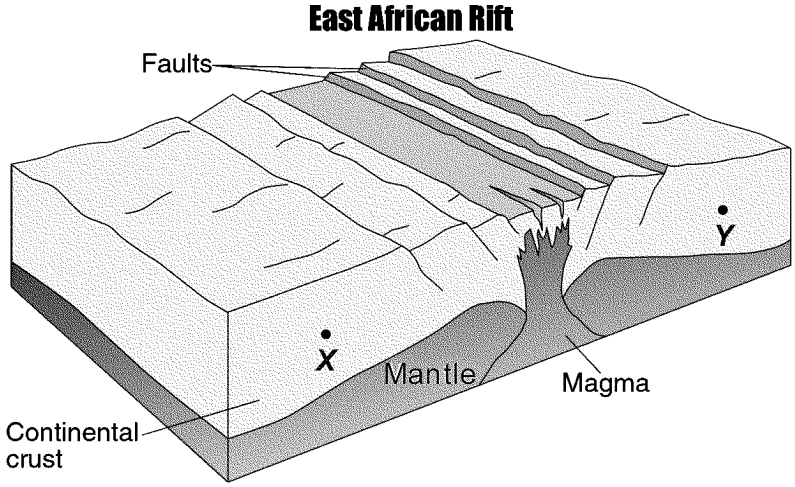
Cross section *III*
Tsunami moves into shallow waters, approaching land; trough reaches land before first wave hits land

34) Identify the overriding tectonic plate at the convergent plate boundary where the earthquake described occurred.

35) Based on cross section *III* in the given diagram, describe the ocean water-level change at the shoreline that people observed just before the first tsunami wave approached the shore.

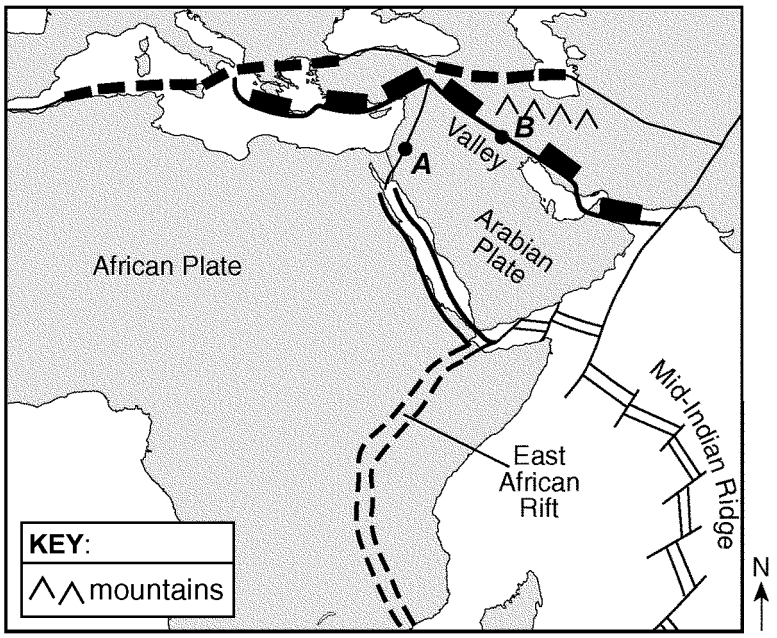
36) Identify the process in Earth's asthenosphere that is inferred to be the cause of tectonic plate motion.

37) The block diagram below represents Earth's surface and interior along the East African Rift. Draw two arrows, one through point *X* and one through point *Y*, to indicate the relative motion of each of these sections of the continental crust.



Questions 38 and 39 refer to the following:

The map below is an enlargement of a portion of the Tectonic Plates map from the *Earth Science Reference Tables*. Points *A* and *B* are locations on different boundaries of the Arabian Plate.

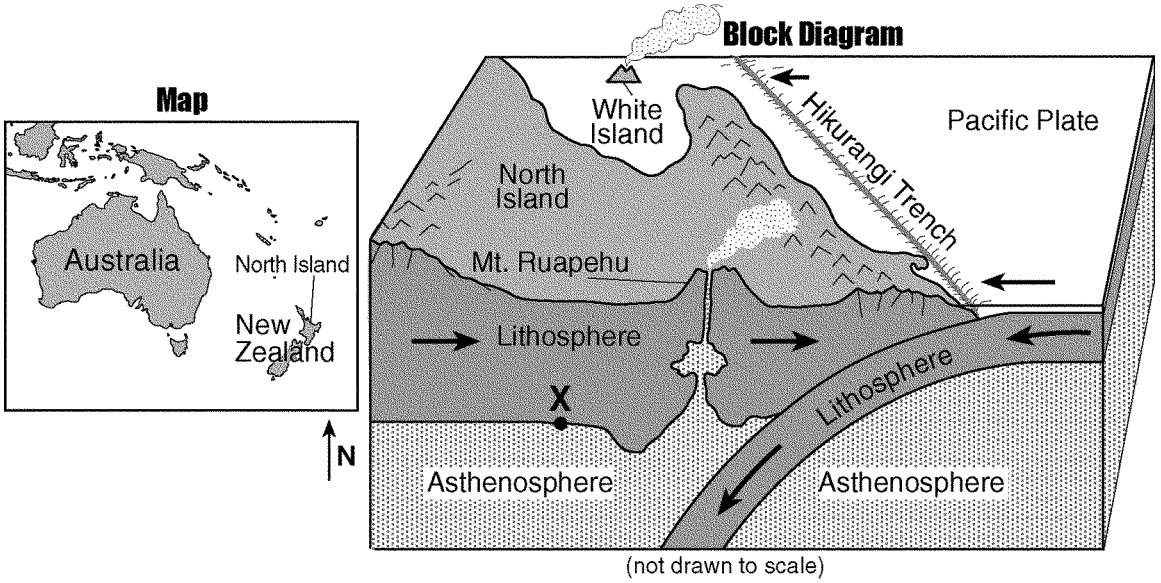


38) Identify the type of tectonic plate boundary located at point *A* in the given map.

39) On the map shown, a valley is located south of point *B* and a mountain range north of point *B*. State the tectonic process that is creating these two land features.

Questions 40 through 43 refer to the following:

The map below shows the location of North Island in New Zealand. The block diagram shows a portion of North Island. The Hikurangi Trench is shown forming at the edge of the Pacific Plate. Point *X* is at the boundary between the lithosphere and the asthenosphere.



40) State the approximate temperature at point *X* on the map shown.

41) On what tectonic plate are *both* North Island and White Island located on the block diagram shown?

42) Describe the type of tectonic plate motion that formed the Hikurangi Trench shown in the given block diagram.

43) Based on the information shown, describe *one* action that people on North Island should take if a tsunami warning is issued.

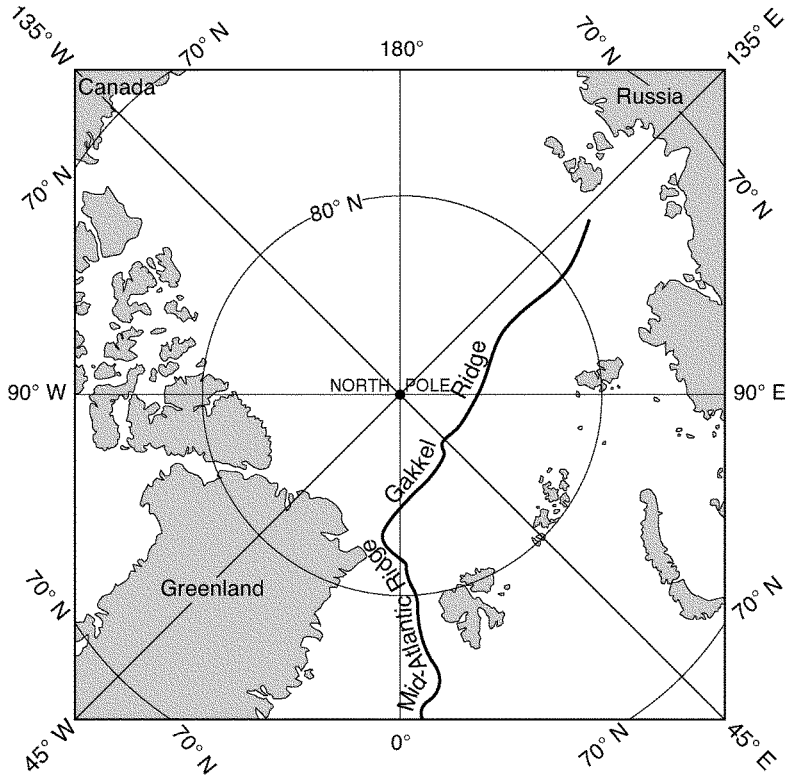
Questions 44 through 47 refer to the following:

The passage below describes the Gakkel Ridge found at the bottom of the Arctic Ocean. The map below shows the location of the Gakkel Ridge.

THE GAKKEL RIDGE:

In the summer of 2001, scientists aboard the U.S. Coast Guard icebreaker *Healy* visited one of the least explored places on Earth. The scientists studied the 1,800-kilometer-long Gakkel Ridge at the bottom of the Arctic Ocean near the North Pole. The Gakkel Ridge is a section of the Arctic Mid-Ocean Ridge and extends from the northern end of Greenland across the Arctic Ocean floor toward Russia. At a depth of about 5 kilometers below the ocean surface, the Gakkel Ridge is one of the deepest mid-ocean ridges in the world. The ridge is believed to extend down to Earth's mantle, and the new seafloor being formed at the ridge is most likely composed of huge slabs of mantle rock. Bedrock samples taken from the seafloor at the ridge were determined to be the igneous rock peridotite.

The Gakkel Ridge is also the slowest moving mid-ocean ridge. Some ridge systems, like the East Pacific Ridge, are rifting at a rate of about 20 centimeters per year. The Gakkel Ridge is rifting at an average rate of less than 1 centimeter per year. This slow rate of movement means that there is less volcanic activity along the Gakkel Ridge than along other ridge systems. However, heat from the underground magma slowly seeps up through cracks in the rocks of the ridge at structures scientists call hydrothermal (hot water) vents. During the 2001 cruise, a major hydrothermal vent was discovered at 87° N latitude 45° E longitude.



44) On the map shown, place an **X** on the location of the major hydrothermal vent described in the reading passage.

45) Describe the relative motion of the two tectonic plates on either side of the Gakkel Ridge shown on the map.

46) According to the given information, the Gakkel Ridge is a boundary between which two tectonic plates?

47) Identify *one* feature, other than hydrothermal vents, often found at mid-ocean ridges, like the Gakkel Ridge shown on the map, that indicates heat from Earth's interior is escaping.

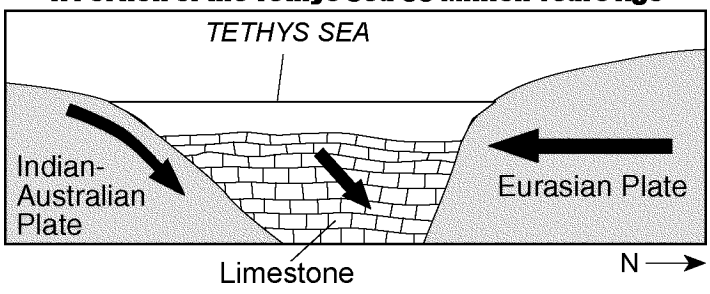
48) The passage and cross section below explain how some precious gemstones form. The cross section shows a portion of the ancient Tethys Sea, once located between the Indian-Australian Plate and the Eurasian Plate.

PRECIOUS GEMSTONES:

Some precious gemstones are a form of the mineral corundum, which has a hardness of 9. Corundum is a rare mineral made up of closely packed aluminum and oxygen atoms, and its formula is Al_2O_3. If small amounts of chromium replace some of the aluminum atoms in corundum, a bright-red gemstone called a ruby is produced. If traces of titanium and iron replace some aluminum atoms, deep-blue sapphires can be produced.

Most of the world's ruby deposits are found in metamorphic rock that is located along the southern slope of the Himalayas, where plate tectonics played a part in ruby formation. Around 50 million years ago, the Tethys Sea was located between what is now India and Eurasia. Much of the Tethys Sea bottom was composed of limestone that contained the elements needed to make these precious gemstones. The Tethys Sea closed up as the Indian-Australian Plate pushed under the Eurasian Plate, creating the Himalayan Mountains. The limestone rock lining the seafloor underwent metamorphism as it was pushed deep into Earth by the Indian-Australian Plate. For the next 40 to 45 million years, as the Himalayas rose, rubies, sapphires, and other gemstones continued to form.

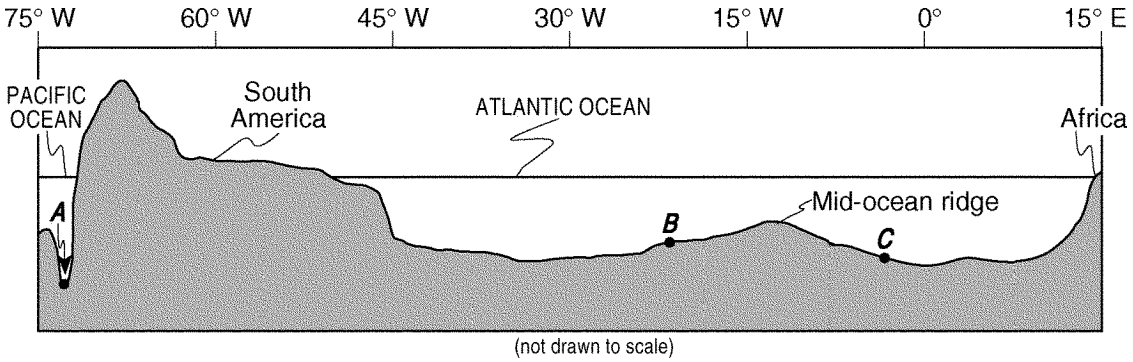
A Portion of the Tethys Sea 50 Million Years Ago



What type of tectonic plate boundary is shown in the given cross section?

Questions 49 through 51 refer to the following:

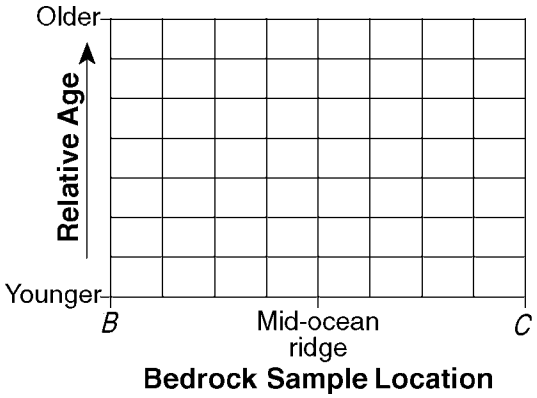
The cross section below shows the major surface features of Earth along 25° S latitude between 75° W and 15° E longitude. Points *A*, *B*, and *C* represent locations on Earth's crust.



49) Identify the crustal feature located at point *A* on the cross section shown.

50) Identify the tectonic plate motion that is causing an increase in the distance between South America and Africa.

51) Bedrock samples were taken at the mid-ocean ridge and points *B* and *C* on the cross section shown. On the grid provided below, draw a line to show the relative age of the bedrock samples between these locations.



1) SAMPLE ANSWERS: seismic wave recordings OR *P*-waves and *S*-waves OR seismograms OR damage reports

2) Mercury, Mars

3) SAMPLE ANSWERS: *P*-waves can travel through the liquid outer core, but *S*-waves cannot. OR *P*-waves travel through all parts of Earths interior. OR *S*-waves do not pass through the outer core.

4) 2,800 to 3,000 km

5) SAMPLE ANSWERS: The arrival time of the *P*-wave at station *A* is later than the arrival time of the *P*-wave at station *B*. OR The arrival time difference between the *P*-wave and *S*-wave is greater at station *A*. OR The amplitudes of the *P*-wave and *S*-wave tracings are greater on the seismogram at station *B*.

6) 15 minutes 50 seconds (±10 seconds)

7) (a) 6.0 to 6.2;
(b) SAMPLE ANSWERS: the lag time between the *P*-wave arrival and the *S*-wave arrival OR the difference in arrival time for the *P*-wave and *S*-wave OR the *P*-wave and *S*-wave arrival times;
(c) any answer from 2 minutes 0 seconds to 2 minutes 20 seconds

8) SAMPLE ANSWERS: *P*-wave OR primary wave OR compressional wave

9) 12 min 30 sec to 12 min 50 sec

10) SAMPLE ANSWERS: tectonic plate movement OR movement along a fault OR volcanic eruption

11) Latitude: any value from 61° N to 62° N
Longitude: any value from 147° W to 148° W

12) SAMPLE ANSWERS: Chimneys fell. OR Heavy furniture overturned. OR Anchorage suffered much damage to substantial structures.

13) SAMPLE ANSWERS: *S*-waves were absorbed through the liquid outer core. OR *S*-waves cannot travel through the liquid outer core.

14) SAMPLE ANSWERS: tsunami OR coastal flooding

15) North American Plate AND Pacific Plate

16) SAMPLE ANSWER: Oakland is farthest from the epicenter.

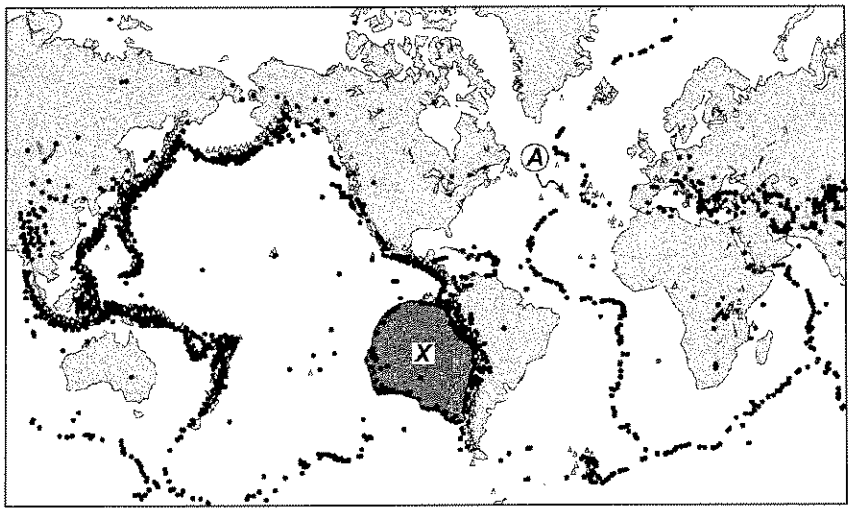
17) SAMPLE ANSWERS: It is near a plate boundary. OR The San Andreas Fault is nearby. OR The bedrock contains many faults.

18) SAMPLE ANSWERS: They are all located at or near tectonic plate boundaries. OR They are located where crustal plates meet.

19) SAMPLE ANSWERS: secure heavy objects OR prepare an emergency medical kit OR plan an evacuation route OR locate the nearest shelter OR reinforce house structure

20) SAMPLE ANSWERS: a hot spot OR a magma plume OR the mantle

21) SAMPLE ANSWER:



22) SAMPLE ANSWERS: Most major earthquakes occur at tectonic plate boundaries. OR Most earthquakes occur at the location of major fault zones. OR Crustal movement at plate boundaries causes frequent earthquake activity.

23) SAMPLE ANSWERS: divergent OR diverging lithospheric plates OR seafloor spreading OR rifting

24) 3 min 0 sec (±10 seconds)

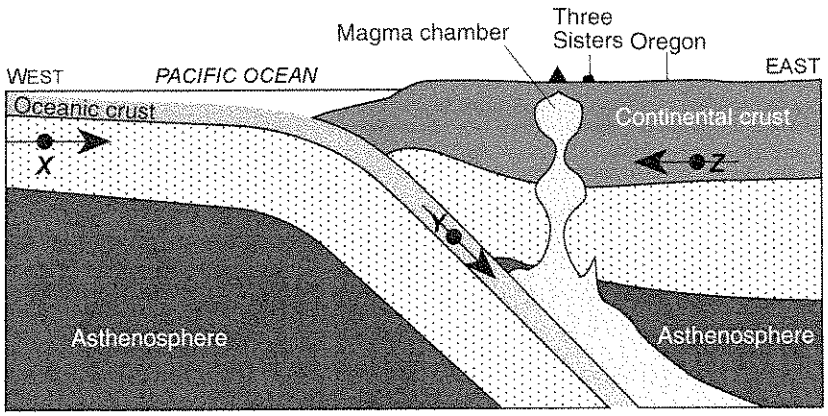
25) SAMPLE ANSWERS: The western coast of the United States is near plate boundaries. OR More major faults are located on the western coast of the United States. OR Fewer active faults are located in the central portion of the United States compared to the western coast of the United States. OR The central portion of the United States is in the middle of a tectonic plate.

26) SAMPLE ANSWERS: identify earthquake hazard zones or areas that are subject to damage during an earthquake OR plan emergency communication procedures OR develop emergency information brochures OR store food, supplies, and fresh water OR build earthquake-resistant structures OR identify shelter locations

27) SAMPLE ANSWERS: WSW OR SW OR southwest

28) 23.5 to 26.5 miles per million years

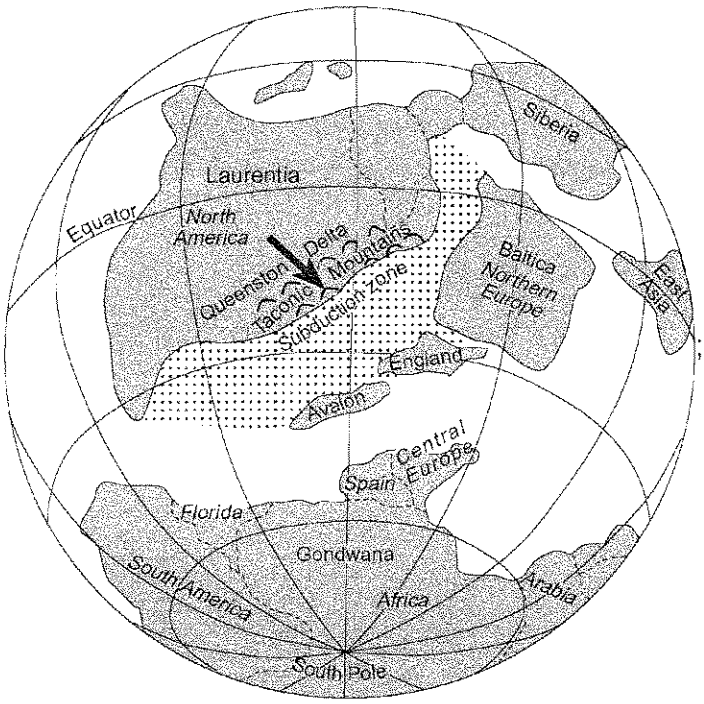
29) SAMPLE ANSWER:



30) SAMPLE ANSWERS: subduction OR convergence

31) SAMPLE ANSWERS: transform movement OR faulting OR The plates slide past each other.

32) (a-b)



(*X* is located anywhere in the dotted area.)

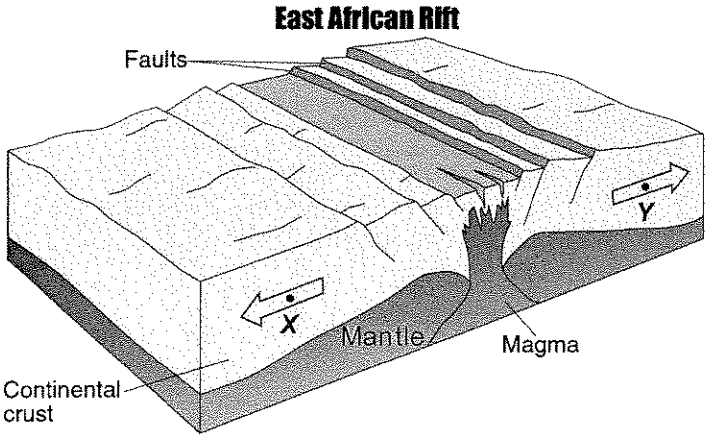
33) Ordovician Period

34) Eurasian Plate

35) SAMPLE ANSWERS: The ocean water receded. OR The water level dropped.

36) SAMPLE ANSWERS: convection currents OR convection OR density currents

37)



38) SAMPLE ANSWERS: transform boundary OR transform fault

39) SAMPLE ANSWERS: subduction of Arabian Plate OR convergence

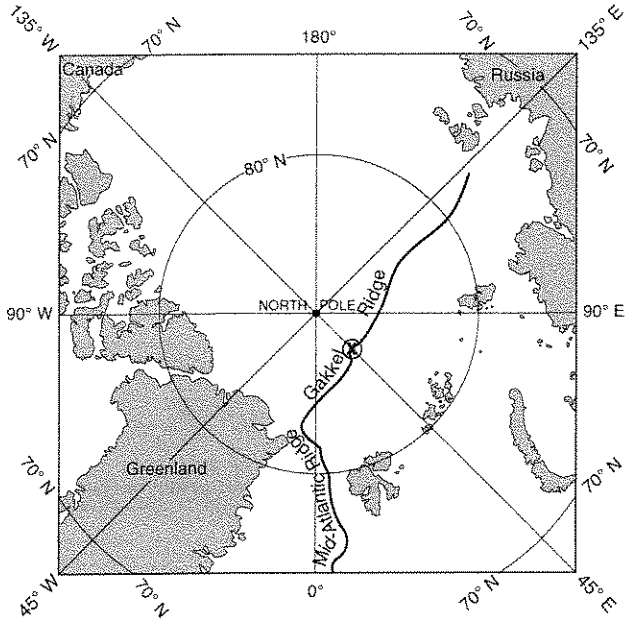
40) Any value from 500°C to 1,200°C

41) Indian-Australian Plate

42) SAMPLE ANSWERS: subduction OR convergence OR plate collision

43) SAMPLE ANSWERS: move to higher ground OR evacuate OR move inland

44)



45) SAMPLE ANSWERS: The plates are moving apart or spreading. OR The tectonic plates are moving away from each other. OR The ridge is a diverging plate boundary. OR rifting

46) North American Plate AND Eurasian Plate

47) SAMPLE ANSWERS: magma/lava OR volcanoes OR smoker vents

48) SAMPLE ANSWERS: convergent plate boundary OR subduction zone OR collision boundary

49) SAMPLE ANSWERS: trench OR Peru-Chile trench OR a subduction zone OR a convergent boundary OR a fault

50) SAMPLE ANSWERS: divergence OR seafloor spreading

51)