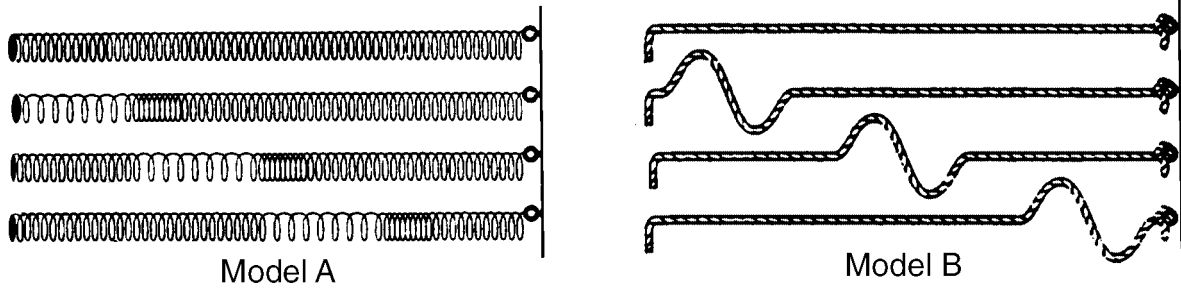


1. Base your answer to the following question on the diagram below, which shows models of two types of earthquake waves.



Model A best represents the motion of earthquake waves called

- 1) *P*-waves (compressional waves) that travel faster than *S*-waves (shear waves) shown in model B
 - 2) *P*-waves (compressional waves) that travel slower than *S*-waves (shear waves) shown in model B
 - 3) *S*-waves (shear waves) that travel faster than *P*-waves (compressional waves) shown in model B
 - 4) *S*-waves (shear waves) that travel slower than *P*-waves (compressional waves) shown in model B
-
2. A characteristic of compressional waves and shear waves is that they both
 - 1) travel at the same speed
 - 2) travel faster through more dense solid materials
 - 3) travel through liquid and solid materials
 - 4) cause rock particles to vibrate in the same direction
 3. Useful information regarding the composition of the interior of the Earth can be derived from earthquakes because earthquake waves
 - 1) release materials from within the Earth
 - 2) travel through the Earth at a constant velocity
 - 3) travel at different rates through different materials
 - 4) change radioactive decay rates of rocks
 4. What is the approximate total distance traveled by an earthquake's *P*-wave in its first 9 minutes?

1) 2,600 km	3) 7,600 km
2) 5,600 km	4) 12,100 km
 5. A seismic station recorded an earthquake with an epicenter distance of 4,000 kilometers. If the origin time of the earthquake was 11:00 a.m., what time did the *P*-wave arrive at the seismic station?

1) 10:53 a.m.	3) 11:07 a.m.
2) 11:05 a.m.	4) 11:12 a.m.
 6. What is the total distance that a *P*-wave will travel in 7 minutes and 20 seconds?

1) 2,000 kilometers	3) 5,800 kilometers
2) 4,200 kilometers	4) 7,200 kilometers
 7. In 8 minutes, an earthquake *P*-wave travels a total distance of

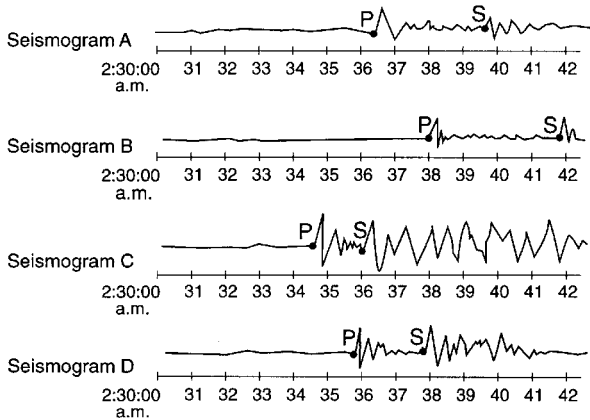
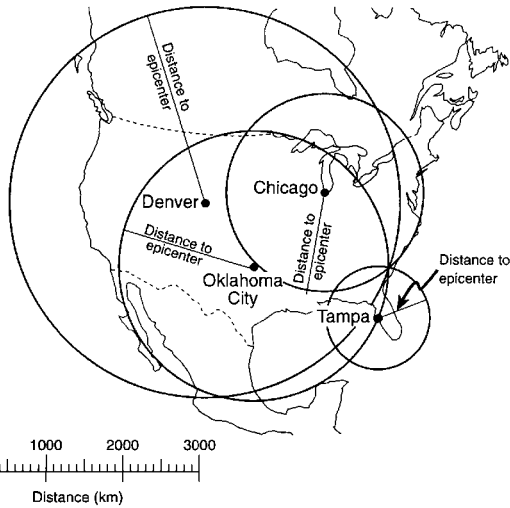
1) 2,100 km	3) 6,600 km
2) 4,700 km	4) 11,300 km
 8. Which statement best explains why the *P*-wave of an earthquake arrives at a seismic station before the *S*-wave?
 - 1) The *S*-wave originates from the earthquake focus.
 - 2) The *S*-wave decreases in velocity as it passes through a liquid.
 - 3) The *P*-wave originates from the earthquake epicenter.
 - 4) The *P*-wave has a greater velocity than the *S*-wave.
 9. Approximately how long does an earthquake *P*-wave take to travel the first 6500 kilometers after the earthquake occurs?

1) 6.5 min	3) 10.0 min
2) 8.0 min	4) 18.5 min
 10. The study of how seismic waves change as they travel through Earth has revealed that
 - 1) *P*-waves travel more slowly than *S*-waves through Earth's crust
 - 2) seismic waves travel more slowly through the mantle because it is very dense
 - 3) Earth's outer core is solid because *P*-waves are not transmitted through this layer
 - 4) Earth's outer core is liquid because *S*-waves are not transmitted through this layer
 11. How long would it take for the first *S*-wave to arrive at a seismic station 4,000 kilometers away from the epicenter of an earthquake?

1) 5 min 40 sec	3) 12 min 40 sec
2) 7 min 0 sec	4) 13 min 20 sec
 12. A seismic station 4000 kilometers from the epicenter of an earthquake records the arrival time of the first *P*-wave at 10:00:00. At what time did the first *S*-wave arrive at this station?

1) 9:55:00	3) 10:07:05
2) 10:05:40	4) 10:12:40

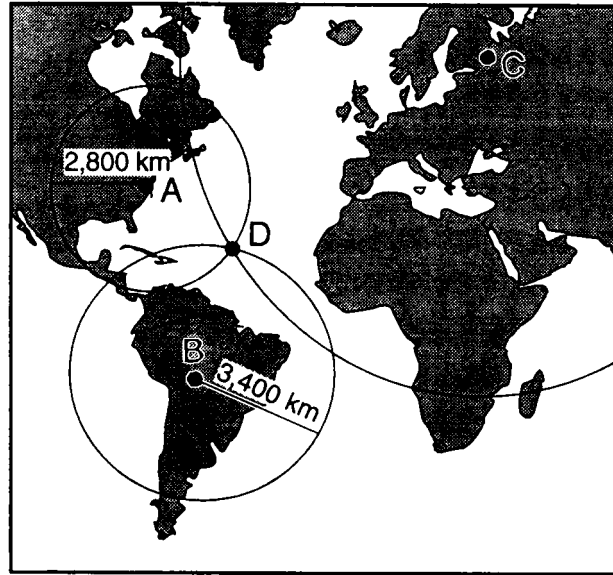
13. Base your answer to the following question on the map and seismograms below. The map shows seismic stations in Chicago, Denver, Oklahoma City, and Tampa that recorded data from an earthquake. Seismograms A, B, C, and D show, in Greenwich time, the arrival times of the earthquake waves at the four stations.



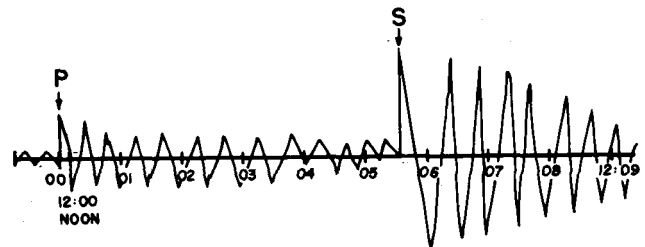
The *P*-wave generated by this earthquake took 2 minutes and 40 seconds to reach one of the seismic stations. Approximately how long did the *S*-wave take to reach this same seismic station?

- 1) 1 minute 20 seconds 3) 3 minutes 30 seconds
 2) 2 minutes 40 seconds 4) 4 minutes 50 seconds
14. A *P*-wave takes 8 minutes and 20 seconds to travel from the epicenter of an earthquake to a seismic station. Approximately how long will an *S*-wave take to travel from the epicenter of the same earthquake to this seismic station?
- 1) 6 mm 40 sec 3) 15 mm 00 sec
 2) 9 mm 40 sec 4) 19 mm 00 sec
15. A seismograph station records a difference in arrival time between the *S*- and *P*-wave of 4 minutes. About how far away is the earthquake epicenter?
- 1) 1,000 km 3) 2,600 km
 2) 1,900 km 4) 5,200 km

- Base your answers to questions 16 and 17 on the map below, which shows seismograph recording stations at locations A, B, and C. Location D is an earthquake epicenter. The distances from locations A and B to this epicenter are given in kilometers.

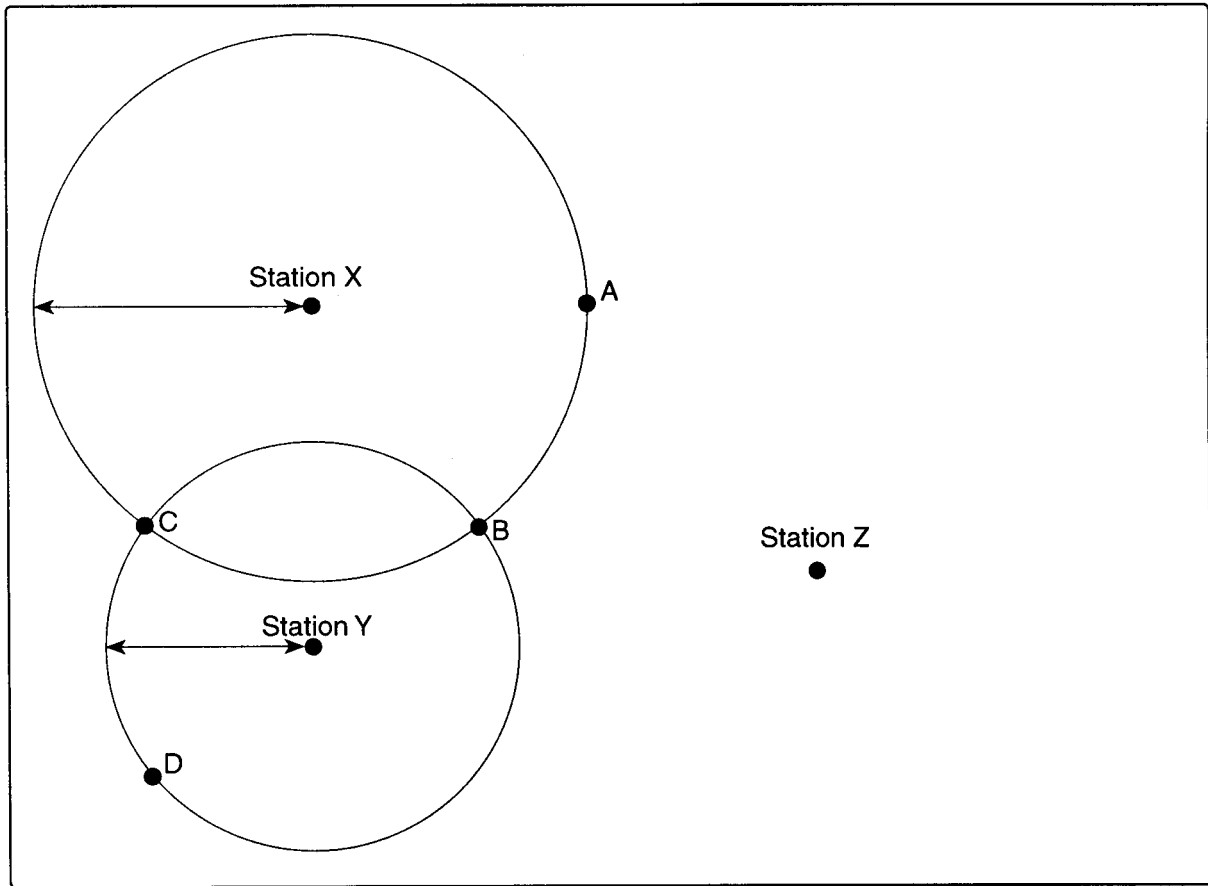


16. At which location is the arrival-time difference between the *P*-wave and the *S*-wave greatest?
- 1) A 3) C
 2) B 4) D
17. Approximately how long did the *S*-wave take to travel from the epicenter to location A?
- 1) 11 min 15 sec 3) 5 min 20 sec
 2) 9 min 35 sec 4) 4 min 20 sec
18. The seismogram below shows the arrival times of *P*- and *S*-waves from a single earthquake. How far from the earthquake epicenter was the station that recorded this seismogram?

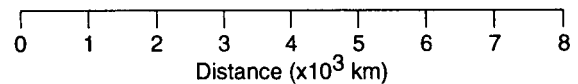


- 1) 1.5×10^3 km 3) 3.0×10^3 km
 2) 2.5×10^3 km 4) 4.0×10^3 km
19. The difference in arrival times for *P*- and *S*-waves from an earthquake is 5.0 minutes. How far away is the epicenter of the earthquake?
- 1) 1.3×10^3 km 3) 3.5×10^3 km
 2) 2.6×10^3 km 4) 8.1×10^3 km

20. Base your answer to the following question on the map below, which shows seismic stations X, Y, and Z that have recorded seismic waves from the same earthquake. The distances from seismic stations X and Y to the earthquake epicenter have been drawn on the map. Locations A, B, C, and D represent possible earthquake epicenters. The distance from seismic station Z to the earthquake epicenter has been deliberately omitted.



(Drawn to scale)

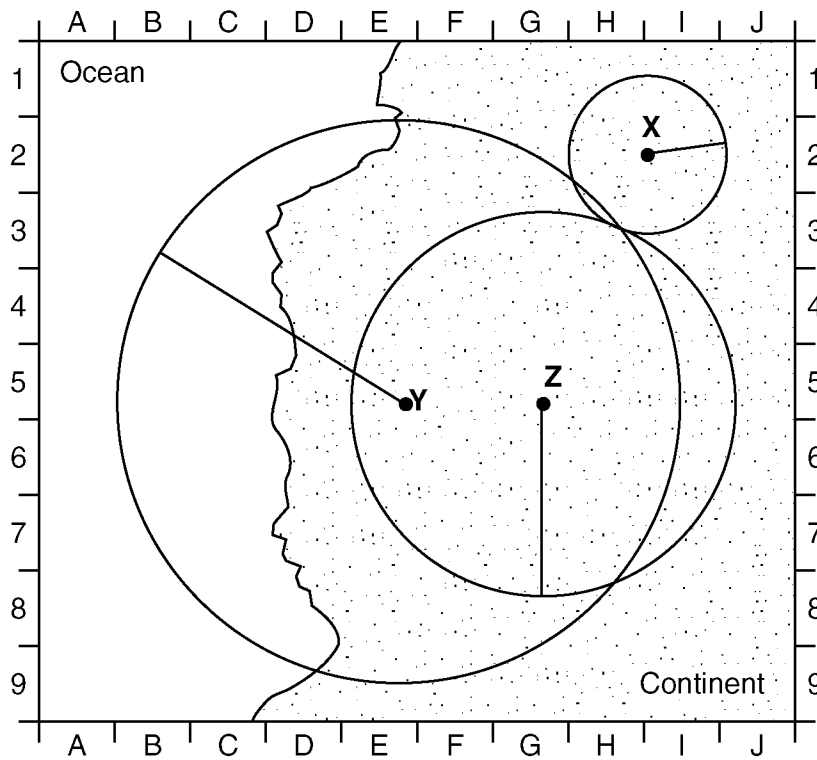
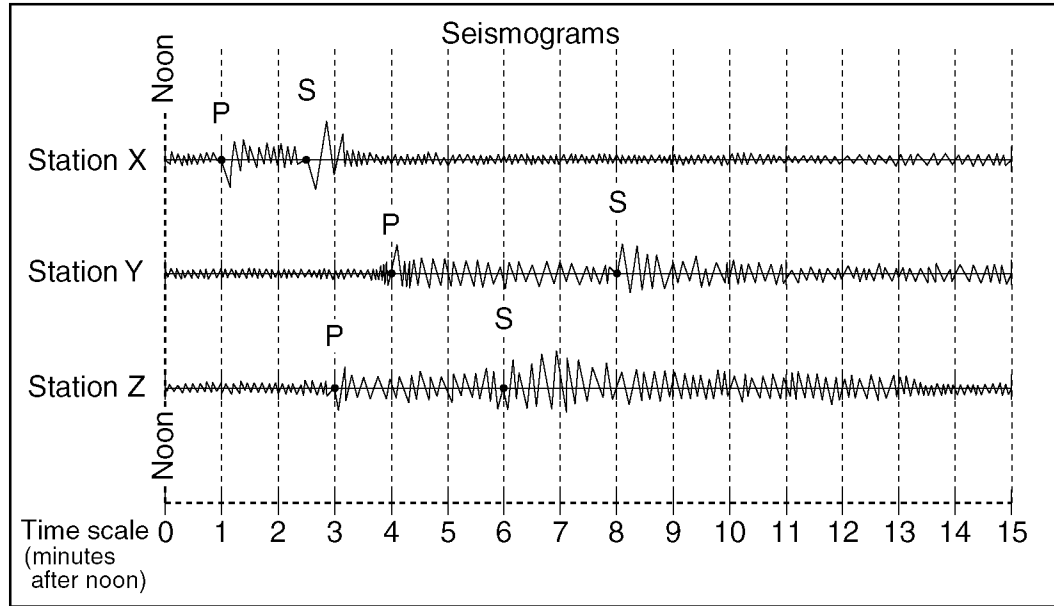


How long did the *P*-wave take to travel from the earthquake epicenter to station Y?

- 1) 2 min 10 sec 2) 3 min 40 sec 3) 4 min 0 sec 4) 5 min 40 sec

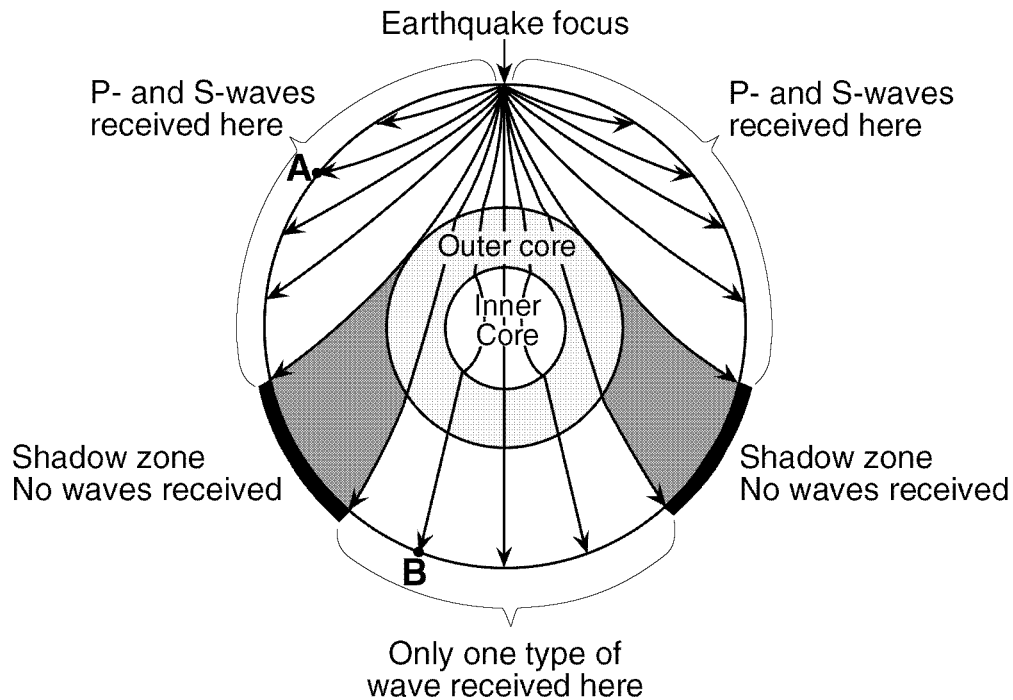
21. Following an earthquake, a seismograph station recorded the arrival of a *P*-wave at 3:09:30 a.m. and an *S*-wave at 3:14:00 a.m. What is the distance from the seismograph station to the epicenter of the earthquake?
- 1) 1,200 km 3) 6,100 km
2) 3,000 km 4) 7,500 km
22. At which epicenter distance is the difference in arrival times between *P*-waves and *S*-waves greatest?
- 1) 1,000 km 3) 5,000 km
2) 3,000 km 4) 7,000 km
23. The arrival of *P*-waves and *S*-waves at a seismic station indicated that an earthquake occurred 4,000 kilometers from the station. The *P*-wave arrived at 3:32:30 p.m. When did the earthquake occur?
- 1) 3:25:30 p.m. 3) 3:27:00 p.m.
2) 3:32:23 p.m. 4) 3:39:30 p.m.
24. If a seismograph recording station located 5,700 kilometers from an epicenter receives a *P*-wave at 4:45 p.m., at which time did the earthquake actually occur at the epicenter?
- 1) 4:24 p.m. 3) 4:36 p.m.
2) 4:29 p.m. 4) 4:56 p.m.

25. Base your answer to the following question on the diagram and map below. The diagram shows three seismograms of the same earthquake recorded at three different seismic stations, X, Y, and Z. The distances from each seismic station to the earthquake epicenter have been drawn on the map. A coordinate system has been placed on the map to describe locations. The map scale has not been included.



- Seismic station Z is 1,700 kilometers from the epicenter. Approximately how long did it take the *P*-wave to travel to station Z?
- 1) 1 min 50 sec
 - 2) 2 min 50 sec
 - 3) 3 min 30 sec
 - 4) 6 min 30 sec

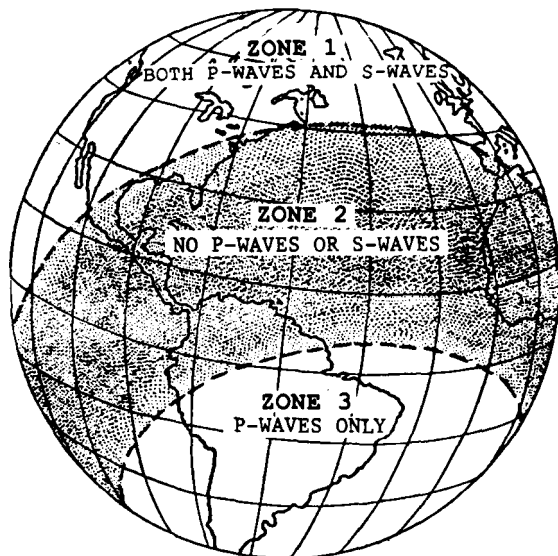
26. Base your answer to the following question on the cross-sectional view of Earth below, which shows seismic waves traveling from the focus of an earthquake. Points A and B are locations on Earth's surface.



A seismic station located at point A is 5400 kilometers away from the epicenter of the earthquake. If the arrival time for the *P*-wave at point A was 2:00 p.m., the arrival time for the *S*-wave at point A was approximately

- 1) 1:53 p.m. 2) 2:07 p.m. 3) 2:09 p.m. 4) 2:16 p.m.

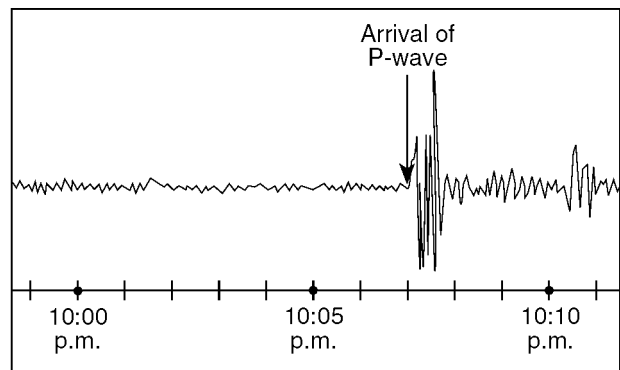
27. Base your answer to the following question on the diagram of the Earth below showing the observed pattern of waves recorded after an earthquake.



The location of the epicenter of the earthquake that produced the observed wave pattern most likely is in the

- 1) crust in zone 1 2) mantle in zone 2
3) crust in zone 3 4) core of the Earth

28. The seismogram below shows the time that an earthquake *P*-wave arrived at a seismic station in Albany, New York.



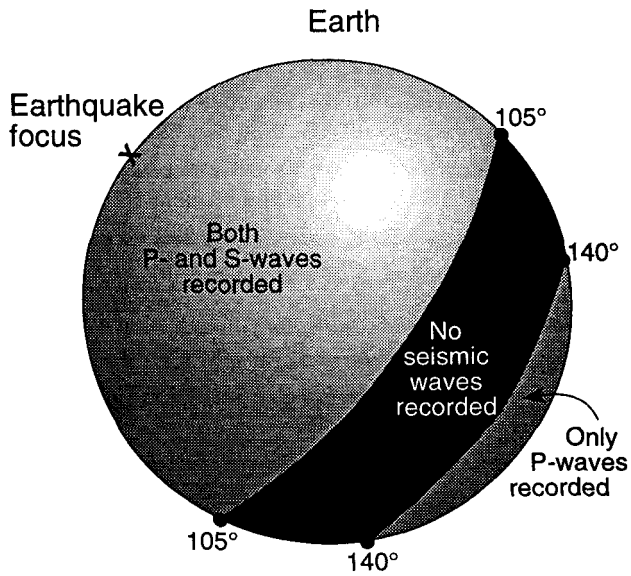
If the earthquake occurred at exactly 10:00 p.m., approximately how far from the earthquake epicenter was Albany, New York?

- 1) 1,900 km 2) 3,200 km
3) 4,000 km 4) 5,200 km

29. A seismographic station determines that its distance from the epicenter of an earthquake is 4,000 kilometers. If the *P*-wave arrived at the station at 10:15 a.m., the time of the earthquake's origin was

- 1) 10:02 a.m. 2) 10:08 a.m.
3) 10:10 a.m. 4) 10:22 a.m.

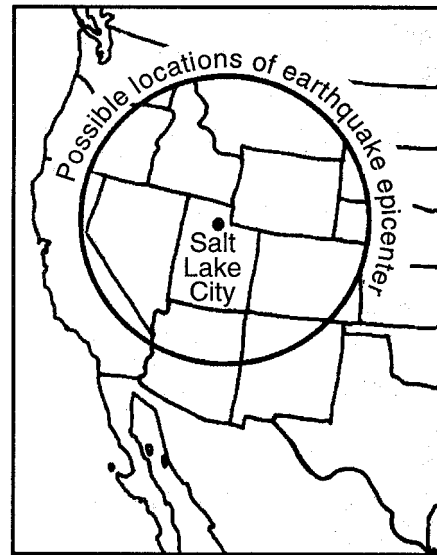
30. An earthquake recorded by seismic stations around the world created the pattern of seismic wave recordings shown in the diagram below



Which statement best explains this pattern of wave recordings?

- 1) Some seismic waves cannot travel through oceans to reach every location on Earth.
- 2) *S*-waves are too weak to travel very far from the earthquake focus.
- 3) Mountain ranges and tectonic plate boundaries absorb or bend seismic waves.
- 4) Layers with different properties inside Earth absorb or bend seismic waves.

31. The map below shows the western part of the United States.



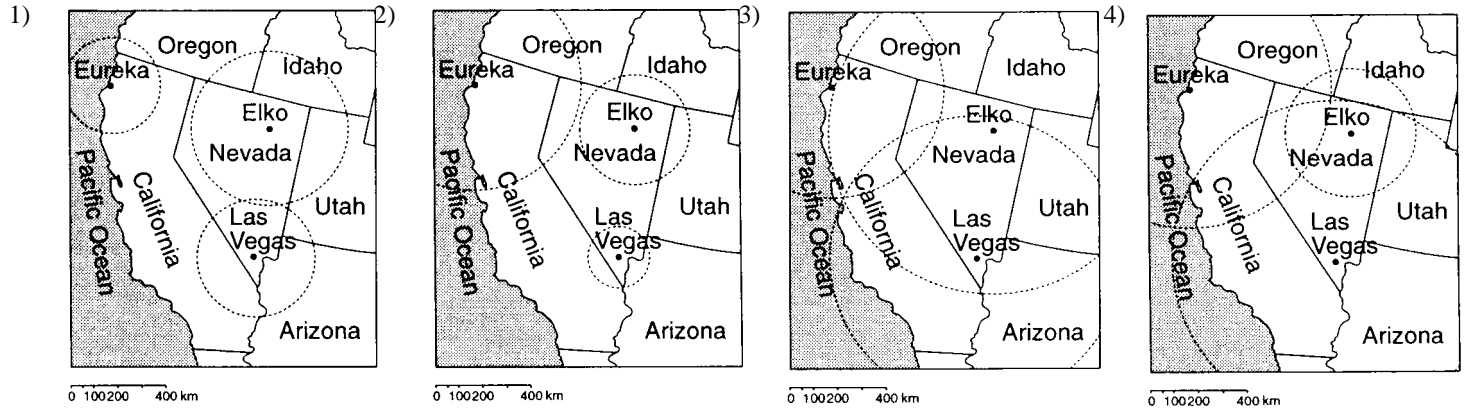
Which observation made at Salt Lake City would allow seismologists to determine that an earthquake had occurred somewhere along the circle shown on the map?

- 1) the relative strength of the *P*-waves and *S*-waves
- 2) the time interval between the arrival of the *P*-waves and *S*-waves
- 3) the difference in the direction of vibration of the *P*-waves and *S*-waves
- 4) the density of the subsurface bedrock through which the *P*-waves and *S*-waves travel

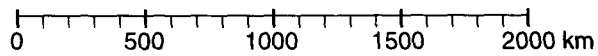
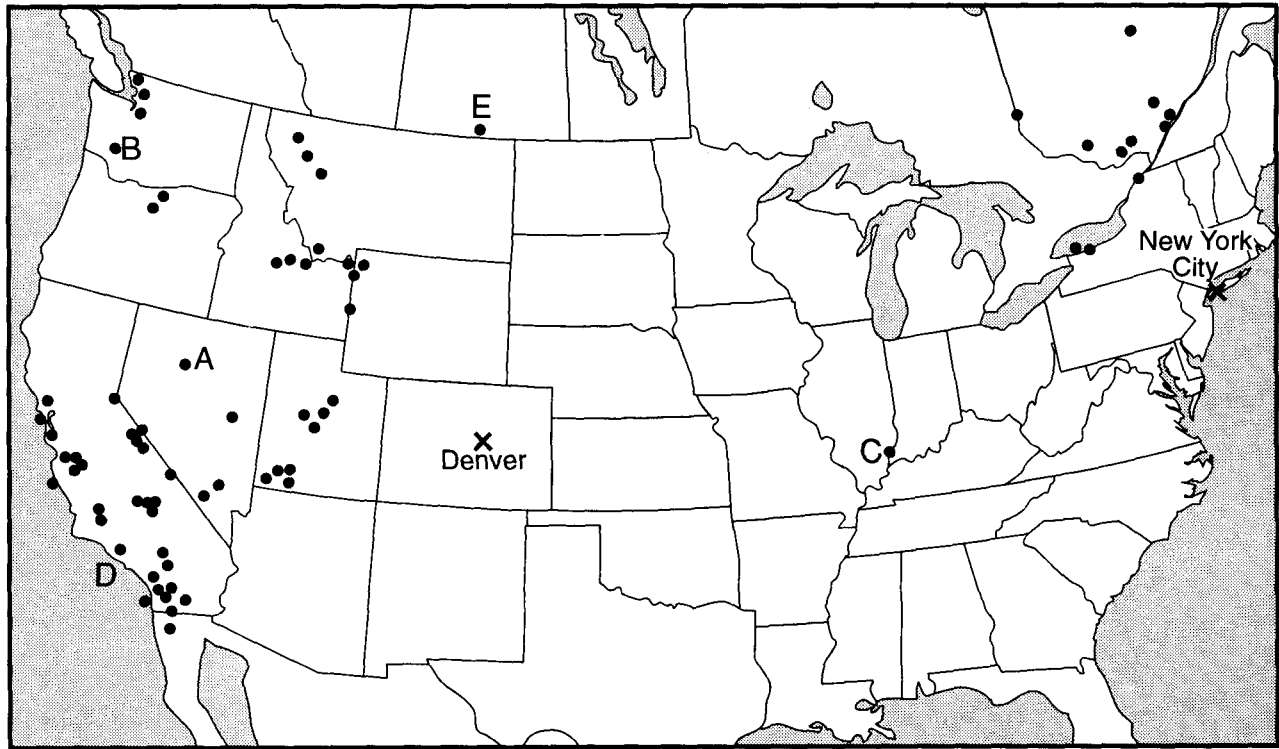
32. The same earthquake was recorded by seismic stations in Eureka, California; Elko, Nevada; and Las Vegas, Nevada. The distance to the earthquake epicenter for each station is shown below.

Seismic Station Location	Distance to Epicenter
Eureka, CA	485 km
Elko, NV	705 km
Las Vegas, NV	622 km

On which map do the circles correctly show the epicenter distance from each of the seismic stations?

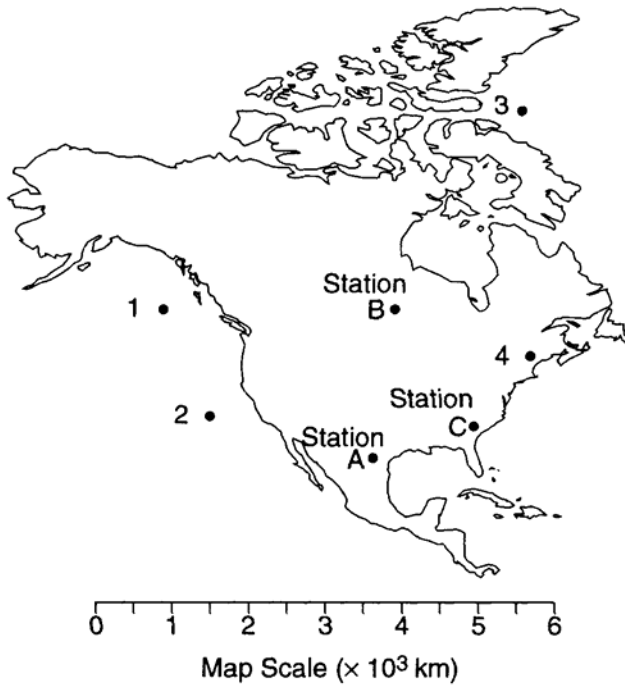


Base your answers to questions 33 and 34 on the map below which shows epicenters of some of the earthquakes that occurred in North America during a 2-week period. Five epicenters are labeled A through E. Denver and New York City are also indicated.



33. A seismograph station at Denver recorded the arrival of *P*-waves at 8:00 a.m. and the arrival of *S*-waves at 8:02 a.m. Which epicenter is located above the source of this earthquake?
- 1) A 2) B 3) C 4) D
34. The distance from epicenter *E* to New York City is 3,000 kilometers. What was the approximate travel time for the *P*-waves from this epicenter to New York City?
- 1) 1 min 20 sec 2) 5 min 40 sec 3) 7 min 30 sec 4) 10 min 00 sec

35. The map below shows the locations of seismic stations A, B, and C. The data table shows the distance from each seismic station to the epicenter of an earthquake. The numbers on the map represent possible epicenter locations.

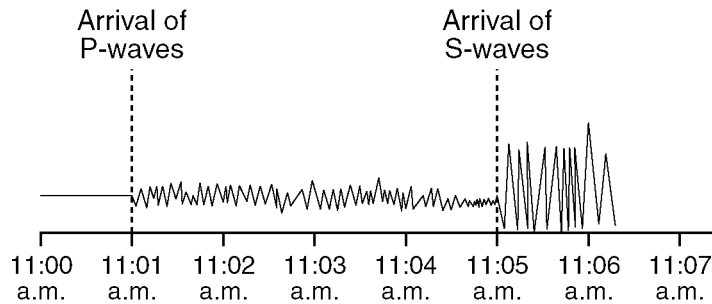


Data Table	
Station	Epicenter Distance
A	3.3×10^3 km
B	3.0×10^3 km
C	4.2×10^3 km

Which numbered location is closest to the epicenter of this earthquake?

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

Base your answers to questions 36 and 37 on the earthquake seismogram below.



36. When did the first *P*-waves arrive at this seismic station?
- 1) 3 minutes after an earthquake occurred 2,600 km away 3) 9 minutes after an earthquake occurred 3,500 km away
 2) 5 minutes after an earthquake occurred 2,600 km away 4) 11 minutes after an earthquake occurred 3,500 km away
37. How many additional seismic stations must report seismogram information in order to locate this earthquake?
- 1) one 2) two 3) three 4) four

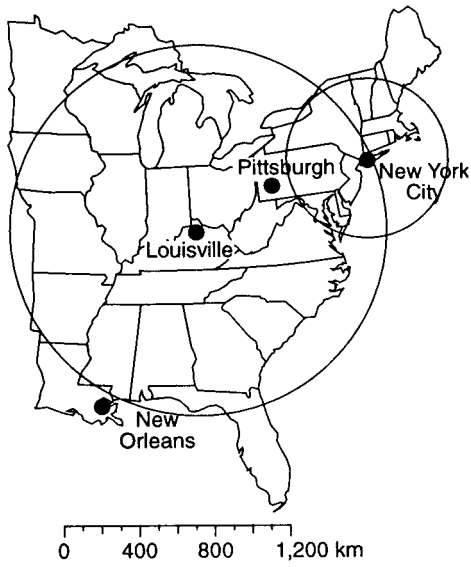
Base your answers to questions 38 and 39 on the map below. Seismic stations are located at the four cities shown on the map. Letter X represents the epicenter of an earthquake determined from seismic waves recorded at all four cities.



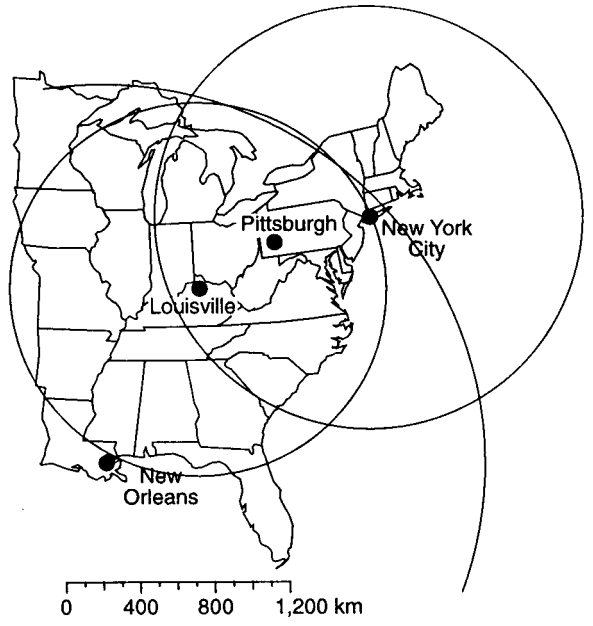
38. At which city is there a difference of approximately 3 minutes and 20 seconds between the arrival times of the *P*-waves and the *S*-waves?
- 1) New Orleans
 - 2) Louisville
 - 3) Pittsburgh
 - 4) New York City

39. Which map correctly shows how the location of the epicenter was determined?

1)



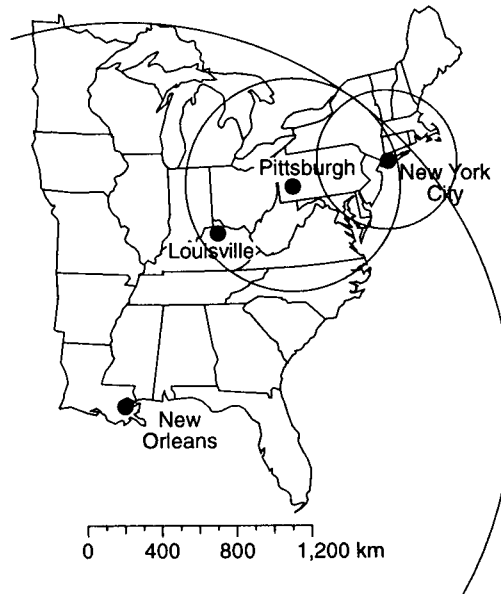
3)



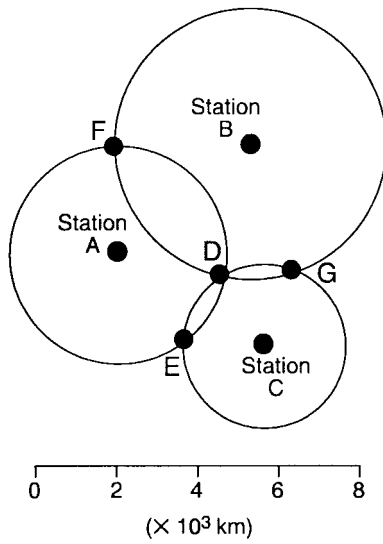
2)



4)



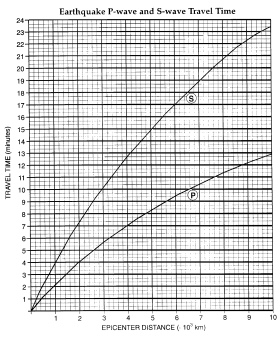
40. Base your answer to the following question on the diagram below, which represents seismic stations *A*, *B*, and *C*. The distance from each station to an earthquake's epicenter is plotted.



The *P*-wave of an earthquake originating 2,600 kilometers from seismic station *A* arrived at 5:24:45 a.m. What was the arrival time of the *S*-wave from the same earthquake?

- | | |
|-----------------|-----------------|
| 1) 1:24:45 a.m. | 3) 5:28:45 a.m. |
| 2) 5:21:05 a.m. | 4) 9:24:05 a.m. |

Reference Tables



Answer Key

1. 1
2. 2
3. 3
4. 1
5. 3
6. 3
7. 2
8. 4
9. 3
10. 4
11. 3
12. 2
13. 4
14. 3
15. 3
16. 3
17. 2
18. 4
19. 3
20. 4
21. 2
22. 4
23. 1
24. 3
25. 3
26. 2
27. 1
28. 3
29. 2
30. 4

31. 2
 32. 3
 33. 1
 34. 2
 35. 1
 36. 2
 37. 2
 38. 1
 39. 4
 40. 3
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