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Locating an Epicenter

Chap 19

Background Information

Whenever an earthquake occurs, shock waves spread out in all directions. Some of these waves cause rock particles to vibrate from side to side as they pass through the rock. Other types of waves cause rock particles to vibrate forward and backward. Different types of earthquake waves travel through rocky material at different speeds. The earthquake shock waves that travel fastest are known as P, or primary, waves. P waves are also sometimes called push-pull waves. Certain slower waves are referred to as S, or secondary, waves. S waves, also known as shear waves, are the type that cause rock particles to vibrate from side to side. S waves reach locations distant from the earthquake's point of origin somewhat later than P waves. The underground point of origin is called the earthquake's focus. The point on the land surface directly above the focus is known as the epicenter.

To detect earthquake shock waves, geologists use a very sensitive instrument called a seismograph. It can detect even the weakest of shock waves. From the information recorded by a seismograph, scientists are able to determine the exact arrival times of both P and S waves. Since P waves travel faster than S waves, you have probably realized that you can determine how far away you are from the earthquake's epicenter if you know the difference in the arrival time of the two types of waves. And that is exactly how seismologists determine the distance to an earthquake's epicenter, even when it is thousands of kilometers away. When similar information from stations in different locations is compared, the precise location of the epicenter can be determined.

In this investigation, you will duplicate this procedure in a model situation.

Problem

How can an earthquake's epicenter be located?

Materials *(per student)*

Drawing compass with pencil
The accompanying graph
The accompanying map of the United States

Procedure

1. Carefully observe Figure 1, which shows a comparison of the difference in arrival time between P and S waves and distance to the epicenter of an earthquake. Note that the two quantities are directly related; that is, the greater the difference in arrival time, the greater the distance to the epicenter.

2. Before going further in this investigation, you will need to become familiar with the graph. Use the graph to answer Questions 1 through 4 in Observations.

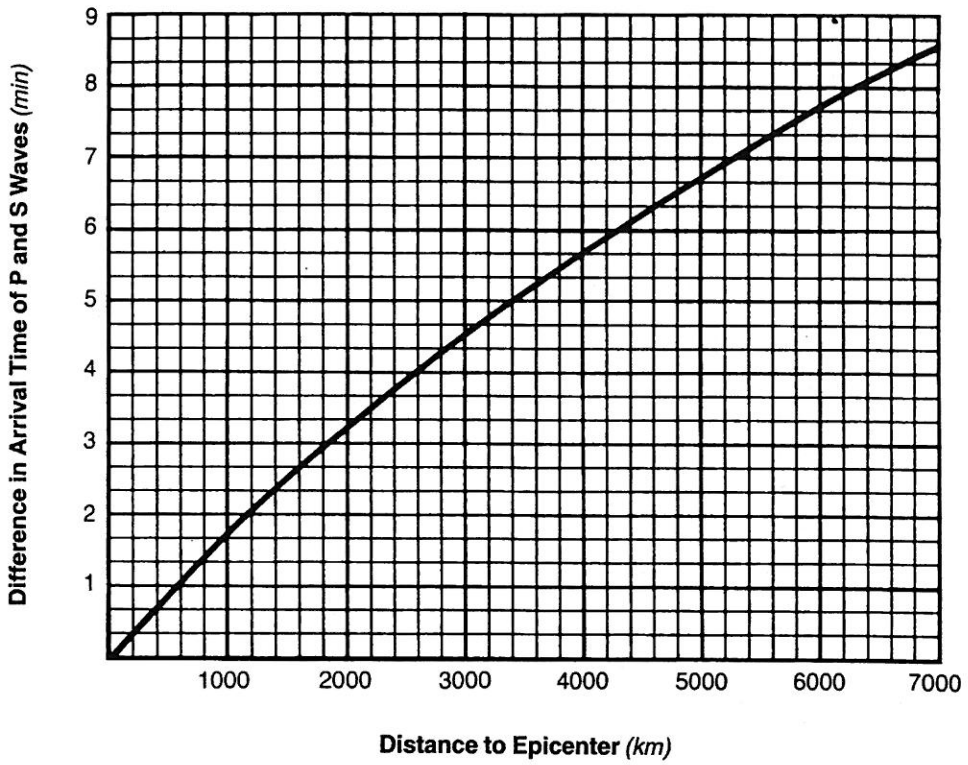

Figure 1

3. Now that you know how to read the graph, see if you can put it to use. Assume that an earthquake has occurred and that the times of arrival of the P and S waves from it have been detected and recorded by seismographs located at the three cities listed in the Data Table. Note that the difference in P and S wave arrival times has been included in the table.

4. Using Figure 1, determine each city's distance from the earthquake epicenter. Enter your figures in the Data Table.

5. Use the map scale to set your compass at a radius equal to the distance from Denver to the earthquake epicenter.

6. Draw a circle with the radius determined in step 5, using Denver as the center. Draw the circle on the map in Figure 2.

7. Repeat steps 5 and 6 for Houston and Miami.

8. If you have worked carefully, the three circles should intersect at one point. This point marks the epicenter of the earthquake.

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Observations

DATA TABLE 1

City	Difference in P & S wave arrival time	Distance *(km)*
Denver, Colorado	2 min 25 sec	
Houston, Texas	4 min 10 sec	
Miami, Florida	5 min 40 sec	

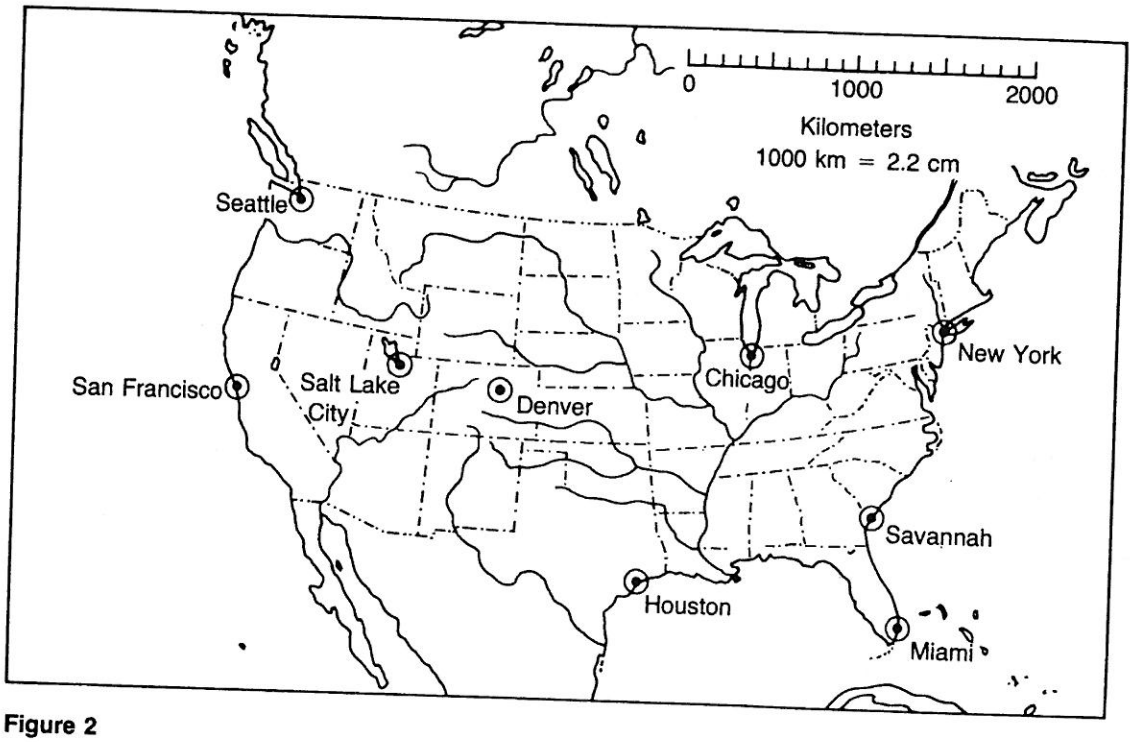

Figure 2

1. If the difference in arrival time for P and S waves at a certain location is 3 min, how far from that station is the epicenter? (1) 430 km (2) 1400 km (3) 1800 km (4) 2100 km

2. If a seismograph shows that a P wave arrives 7 min 20 sec before an S wave, how far is it to the earthquake's epicenter? _____

_____

3. If a recording station is known to be 4600 km from an earthquake epicenter, what is the difference in arrival time between the P and S waves from that earthquake?

_____

4. If a seismograph is located 2200 km from an earthquake epicenter, how great will be the difference in arrival time between the P and S waves at this station?

_____

Conclusions

1. **a.** Which city on the map is closest to the earthquake epicenter?

_____

b. How far, in km, is this city from the epicenter? _____

2. Which of the three cities listed in the Data Table would have become aware of the earthquake first? _____

Second? _____

Third? _____

3. Why was it necessary to know the distance from the epicenter for at least three recording stations to be able to locate the epicenter? _____

_____

4. If the epicenter of this earthquake were located in San Francisco, how much earlier than the S wave would the P wave arrive for an observer in New York City?

_____

5. As the distance beween an observer and an earthquake *decreases,* the difference in arrival times of P and S waves (1) decreases, (2) increases, (3) remains the same.

Critical Thinking and Application

1. What can happen to the earth's surface when the vibrations from an earthquake travel through the crust? _____

_____

_____

_____

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2. What relationship do you think exists between the amount of energy an earthquake contains and the amount of damage it will do?

3. Is it possible for seismologists to know for sure that an earthquake or volcanic eruption will *not* occur in a particular area? Explain your answer.

Going Further

Find out about the construction of buildings in earthquake zones. Buildings in areas that have earthquakes are built with certain unique construction features. What do you think some of these features might be? You may want to write to the National Center for Earthquake Research, Geologic Survey Field Center, Menlo Park, Calif. 94025, and request some information about the construction of earthquake-proof buildings.