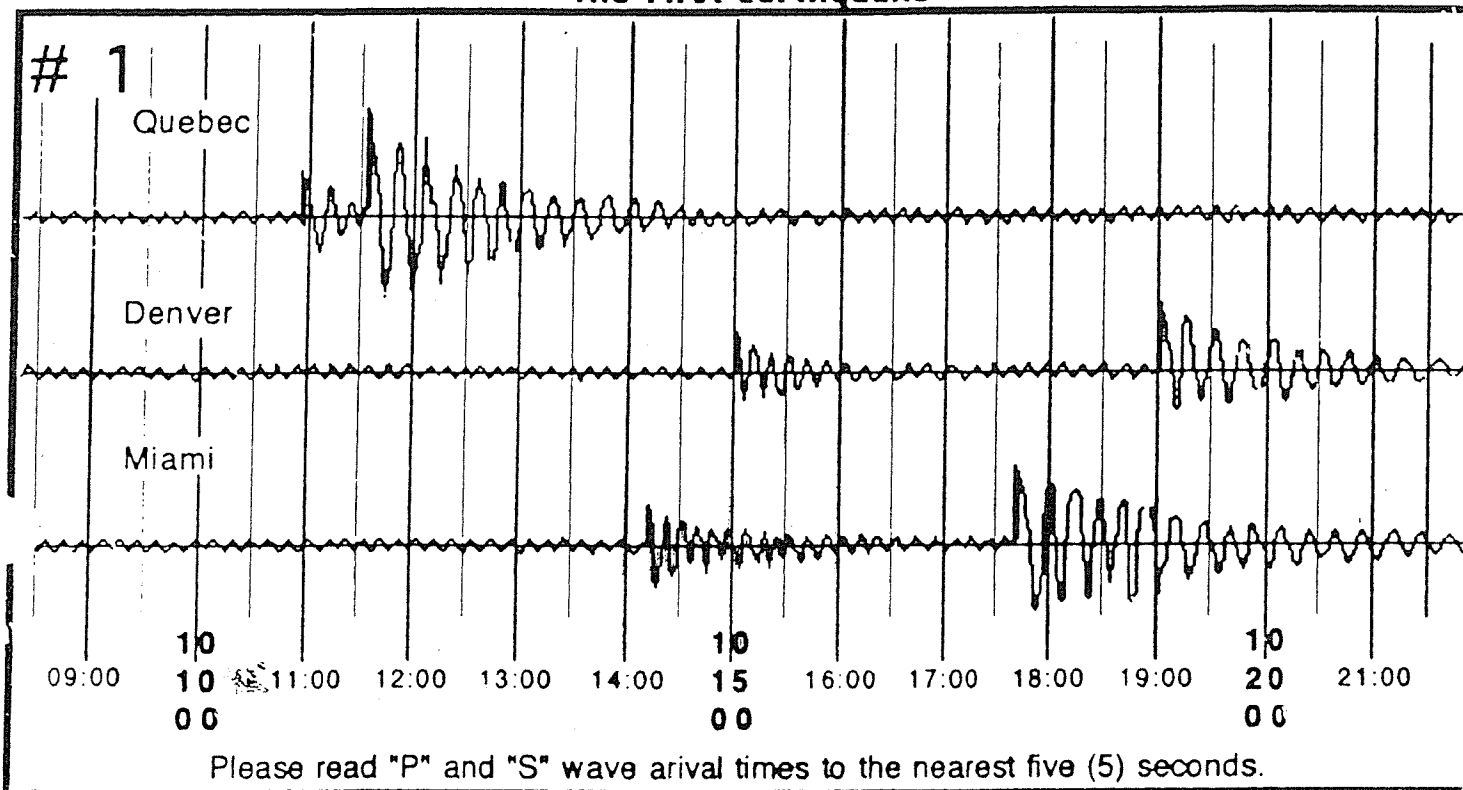


The epicenter of an earthquake is usually determined by examining seismograms from at least three recording stations. From these records, the distance from the epicenter of the earthquake, to each of the recording stations, can be determined. Circles drawn on a map from each of the seismic stations are then used to locate the epicenter. The seismic recordings can also be used to determine the time at which the earthquake took place and how severe the earthquake was at its source.

1. In the box below, what is the time separation between the vertical lines?

(Please note that the times on this chart are shown; HOURS : MINUTES : SECONDS) \_\_\_\_\_

### The First Earthquake



2. Which type of earthquake wave is the first to arrive? \_\_\_\_\_

3. The second, and usually more intense wave, is the... \_\_\_\_\_ wave.

Use the seismograms above and an earthquake travel time graph to complete the table below.

Record all arrival times to the *nearest 5 seconds*.

Seismic Station	"P" Arrival Time	"S" Arrival Time	"S" Time - "P" Time	Distance to Epicenter	P-Wave Travel Time
Quebec					

# 1

The data that you entered on the last page can be used to locate the epicenter and to find the exact time at which this earthquake occurred. Here's how.

The diagram to the right shows that with only a single station, we can tell how far away the epicenter is, but we are not able to find the direction to the epicenter.

A second station allows us to make another circle and determine two possible locations.

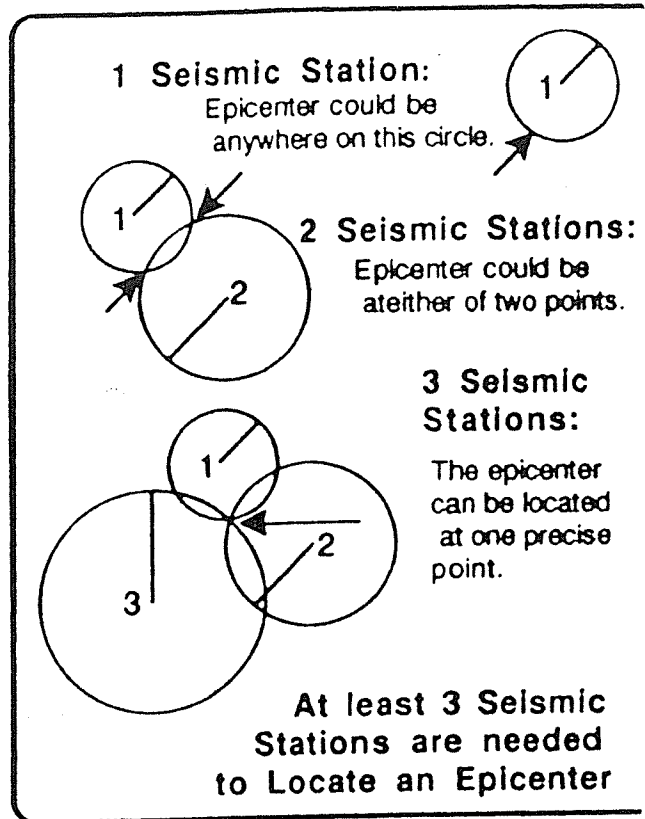
The third circle should locate the exact position of the epicenter. Three circles should intersect at a single point: the epicenter.

4. Why are *more* than two seismic stations needed to locate the epicenter of an earthquake?

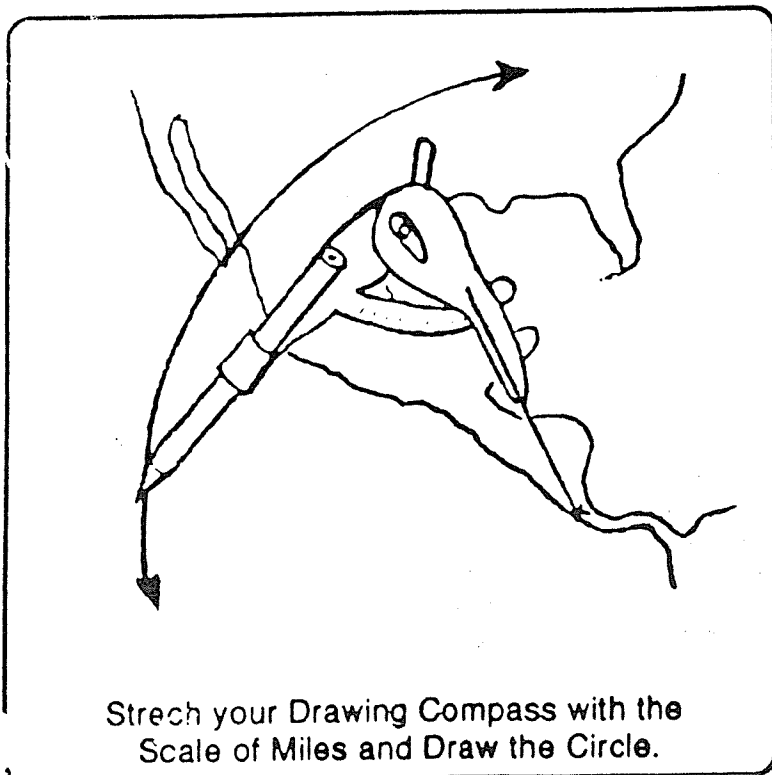
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To locate the epicenter of the earthquake shown on page 1, you will need a drawing compass, a pencil, and a copy of the earthquake travel time graph. Obtain these materials before you continue in this lab.



Use the map scale on page 5 to stretch out the drawing compass to the proper distance from each recording station. (As read from the table you completed on page 1.) *Do it now.*

Around the first station, draw a circle (in pencil) at the proper distance. ( ← See the diagram.)

When you draw the second circle, draw only the portion of the circle that intersects the first circle (with a few extra centimeters on either side). Your map will be easier to draw and to read if you only draw the needed parts of the second and third circles.

When you have drawn the first circle and the needed portions of the second and third circles, the three circles should intersect at one point, or they should make a very small triangle. That's the location of the epicenter.

For any Earthquake:

$$\frac{\text{Arrival Time} - \text{Travel Time}}{\text{Origin Time}}$$

Read the arrival time from the seismograms.

Use the P and S Wave travel time graph and the epicenter distance to find the travel time.

The actual time at which the earthquake took place at the focus (and at the epicenter) is called the origin time. Once the distance from the epicenter to any recording station is known, it is possible to find the origin time of the earthquake.

5. How long does it take a P wave to travel 4000 km? \_\_\_\_\_

(Hint: Look at the Earthquake Travel Time Graph)

6. If the P waves from that earthquake 4000 km away arrived at our station at exactly 12:00:00 (noon), when did they start their journey? (That is, when was the earthquake origin time?) \_\_\_\_\_

Use this technique to determine the origin time of earthquake #1 recorded on the front page. (You can check yourself by doing the same subtraction with the S wave or with a different station.)

7. Time that the P wave arrived at Quebec: \_\_\_\_\_

Epicenter distance from Quebec: \_\_\_\_\_ Travel time for P wave: \_\_\_\_\_

Origin time (Arrival Time minus Travel Time) \_\_\_\_\_

The table below shows you data from another earthquake. Complete this table, then use the data to *draw circles* in order to locate the epicenter of this event on the same map that you used for the first earthquake. On the map on page 5, clearly label the first epicenter #1, and label the epicenter for this earthquake #2.

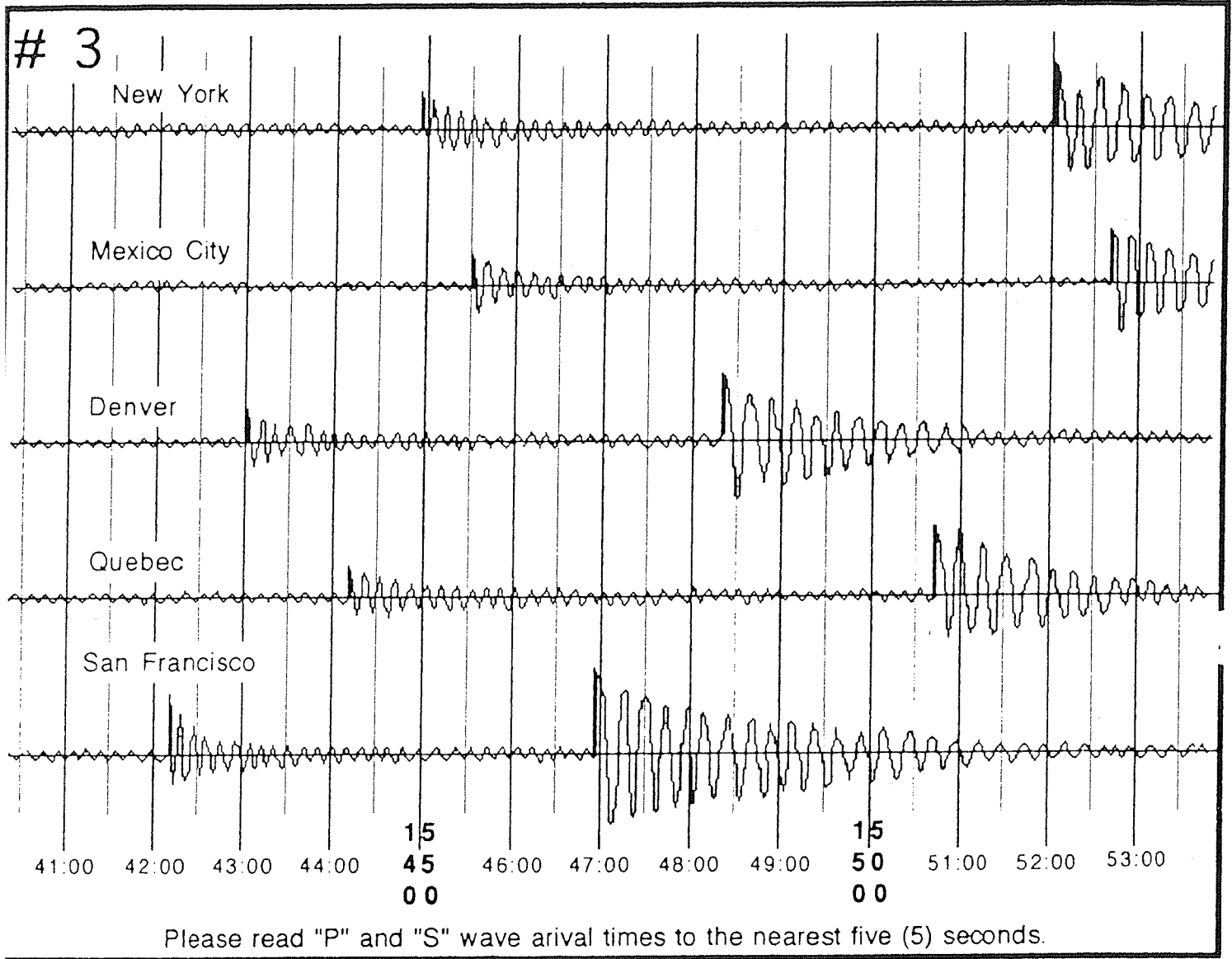
Seismic Station	"P" Arrival Time	"S" Arrival Time	"S" Time - Distance to "P" Time	Epicenter	P-Wave Travel Time	Origin Time
Seattle	13:08:10	13:10:40				
Denver	13:08:20	13:11:15				
Anchorage	13:11:50	13:17:20				

8. Use the space to the right to find the time when this earthquake originated.

(Please show your calculations clearly.)

The diagram below shows an earthquake as recorded at five recording stations. Use this information to both locate the epicenter on the map on page 5, and to determine the origin time of this event. Label it #3. Please draw all five circles, although three should be enough to show the location of the epicenter.

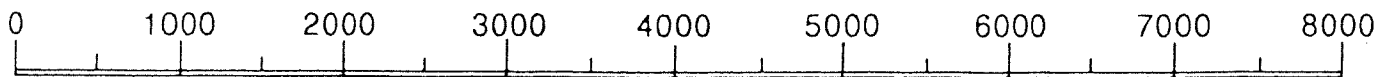
### The Third Earthquake



# 3

Seismic Station	"P" Arrival Time	"S" Arrival Time	"S" Time - "P" Time	Distance to Epicenter	P-Wave Travel Time

9. What was the origin time of the third earthquake (#3, above)? \_\_\_\_\_



Scale of Kilometers

10. How many recording stations are required to locate an epicenter? \_\_\_\_\_

11. Which type of earthquake waves is usually stronger (more intense)? \_\_\_\_\_

12. What is the difference in *vibration direction* between S and P waves?  
\_\_\_\_\_

13. From the map on page 5, list the terrestrial coordinates the three epicenters that you located in this lab. (Be sure to label each with *both* the angle and the *direction*: like 45°N, or 127°E.)

#1 Latitude: \_\_\_\_\_ #2 Latitude: \_\_\_\_\_ #3 Latitude: \_\_\_\_\_

Longitude: \_\_\_\_\_ Longitude: \_\_\_\_\_ Longitude: \_\_\_\_\_

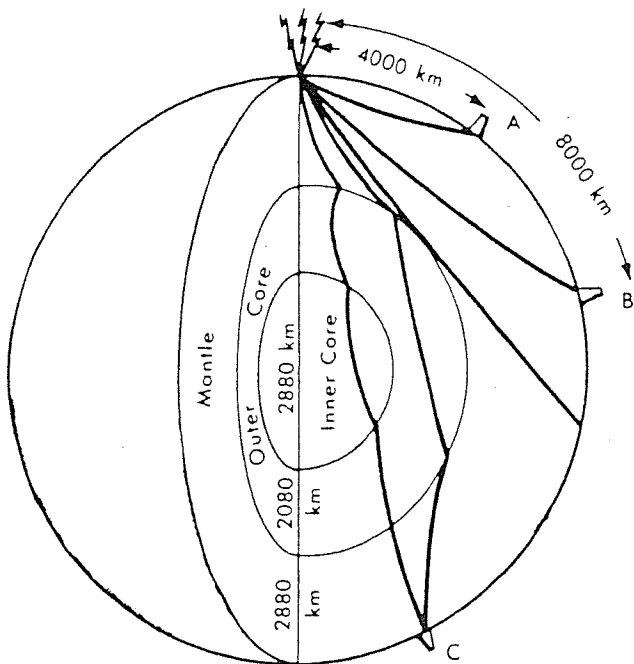
14. We are not able to locate the epicenter of an earthquake with seismic records from just one recording station. What *can* we figure out about the earthquake at its source from a single seismic station? (1) \_\_\_\_\_

(There are at least four answers to this question.

You must list *two* for full credit.) (2) \_\_\_\_\_

(The third is optional.) (3) \_\_\_\_\_

15. What is the *minimum* amount of information needed to determine both the distance and origin time of an earthquake?  
\_\_\_\_\_



Seismic Waves are Refracted and Reflected inside the Earth.

16. The diagram to the left shows a partial solid (on the left) and a partial cross section (on the right) of the Earth. It also shows an earthquake occurring at the top of the diagram, along with the paths of selected seismic waves from that event. On this diagram, show the shadow zone both in cross section on the right as well as the surficial area on the left, by shading the shadow zone lightly with pencil or pen.

17. What kind of seismic waves will be observed at both A and B, but *not* at C? \_\_\_\_\_

18. What is the distance along the surface of the Earth from the earthquake epicenter to Station C?

- a. about 5000 km
- b. about 10,000 km
- c. about 20,000 km
- d. about 40,000 km

19. What does the soda fountain sell when they have an earthquake? \_\_\_\_\_