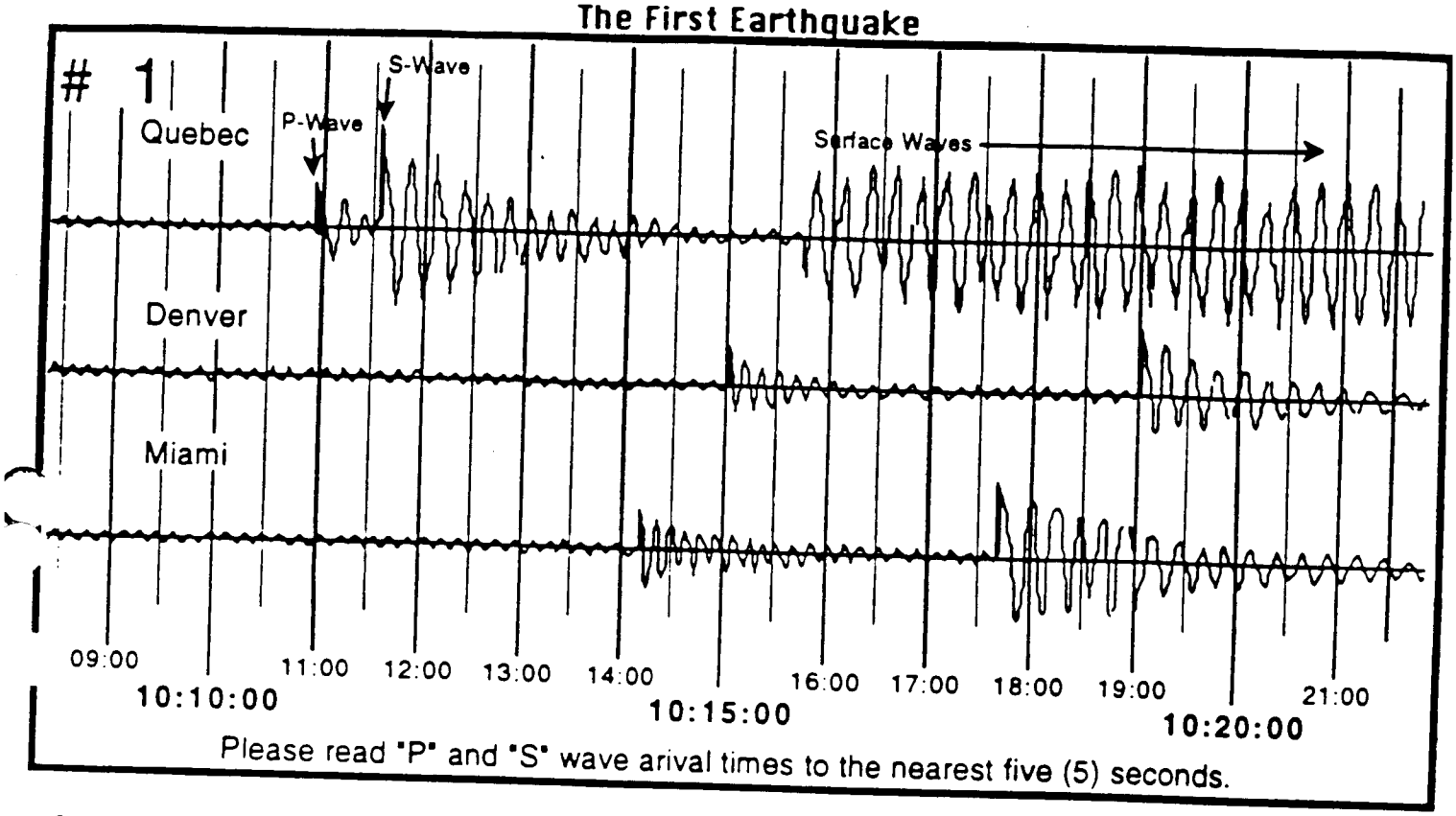
Date _____ Per. _

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. In addition, the seismic recordings can be used to determine the time at which the earthquake took place, and how powerful 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



Please read "P" and "S" wave arival times to the nearest five (5) seconds.

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
# 1	Quebec					

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.

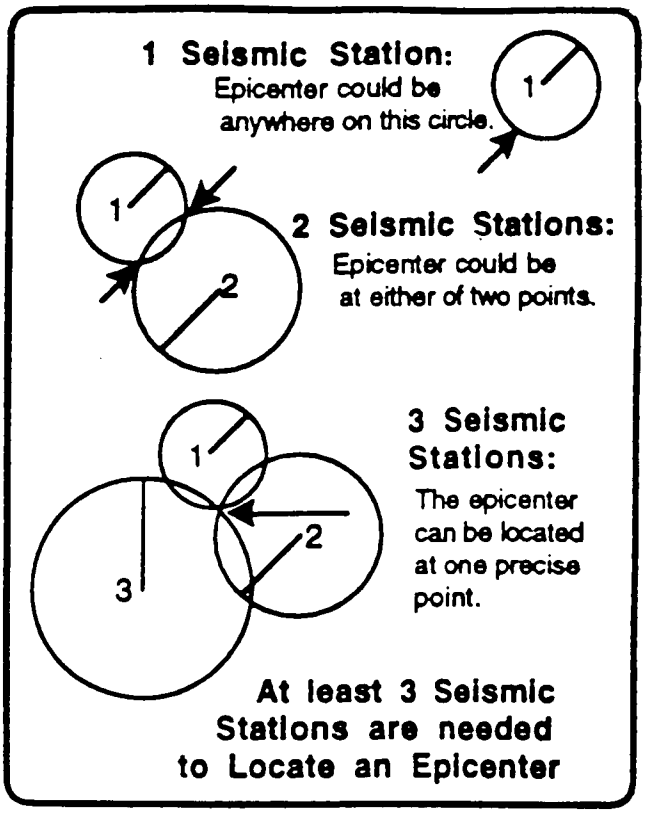
A second station allows us to make another circle and determine two possible locations.

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

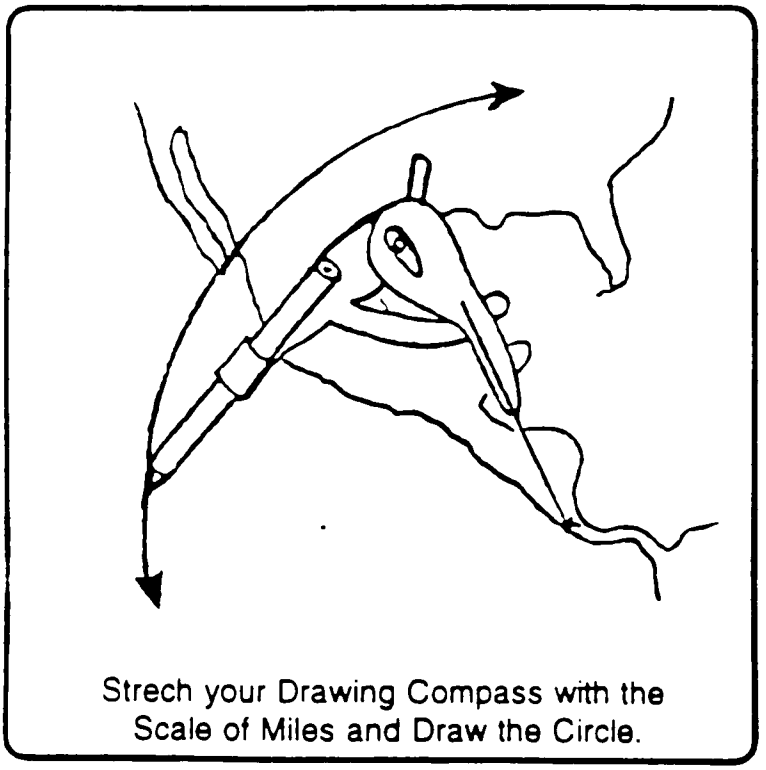
4. Why are *more* than two seismic stations needed to locate the epicenter of an earthquake?

_____

_____



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:

Arrival Time
- Travel Time
Origin Time

Read the arrival time from a seismogram. 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.

Once again, *just draw the parts of the second and third circles that you really need.*
On the map on page 5, clearly label the first epicenter #1, and label the epicenter for this earthquake #2.

2

Seismic Station	"P" Arrival Time	"S" Arrival Time	"S" Time – "P" Time	Distance to Epicenter	P-Wave Travel Time	Origin Time
Seattle	13:08:10	13:10:50				
Denver	13:07:35	13:09:50				
Anchorage	13:11:50	13:17:15				

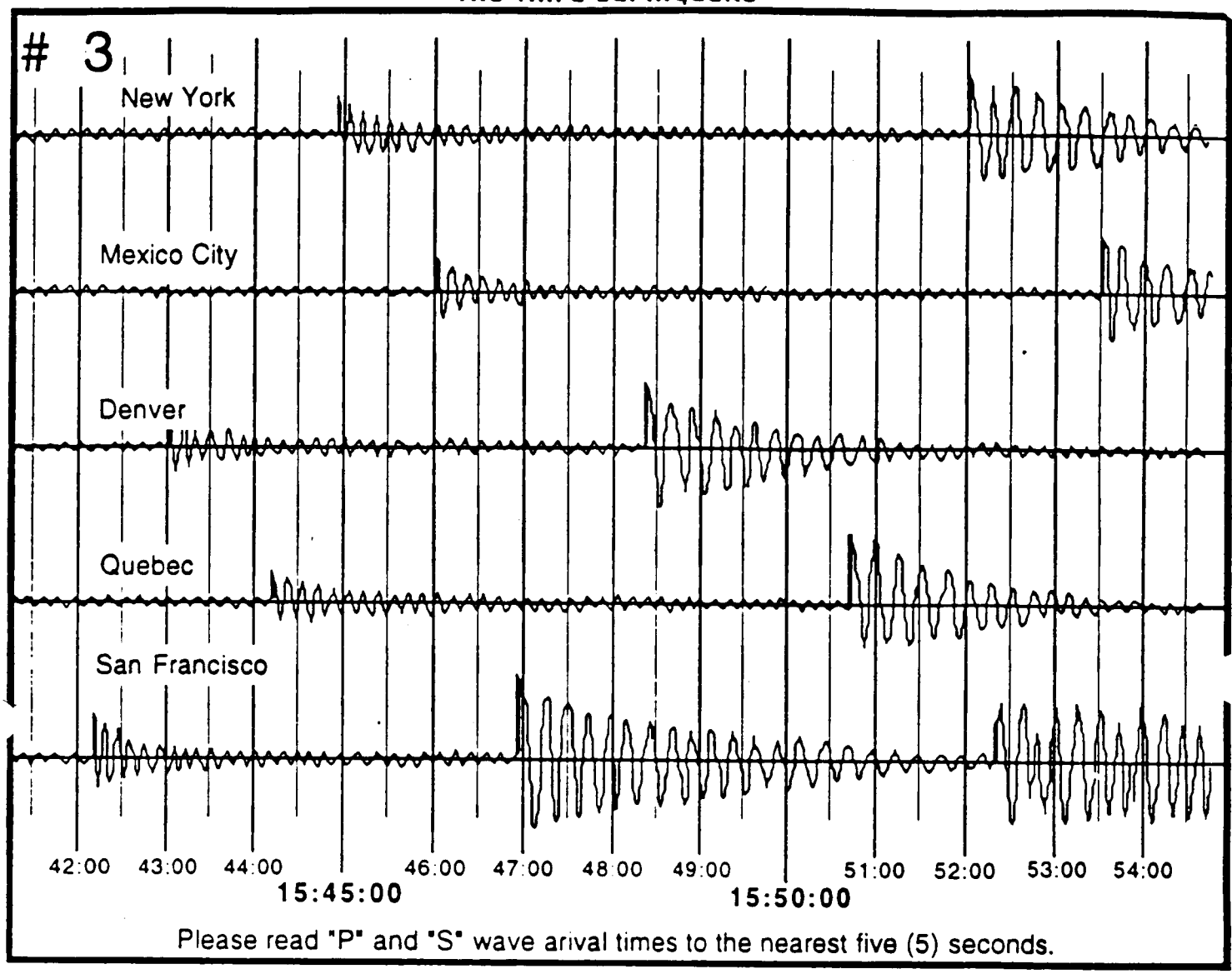
8. How can we determine the distance to an earthquake from the records of a single seismic recording location?

_____

_____

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 the useful parts of all five circles, even though three should be enough to show the location of the epicenter.

The Third Earthquake

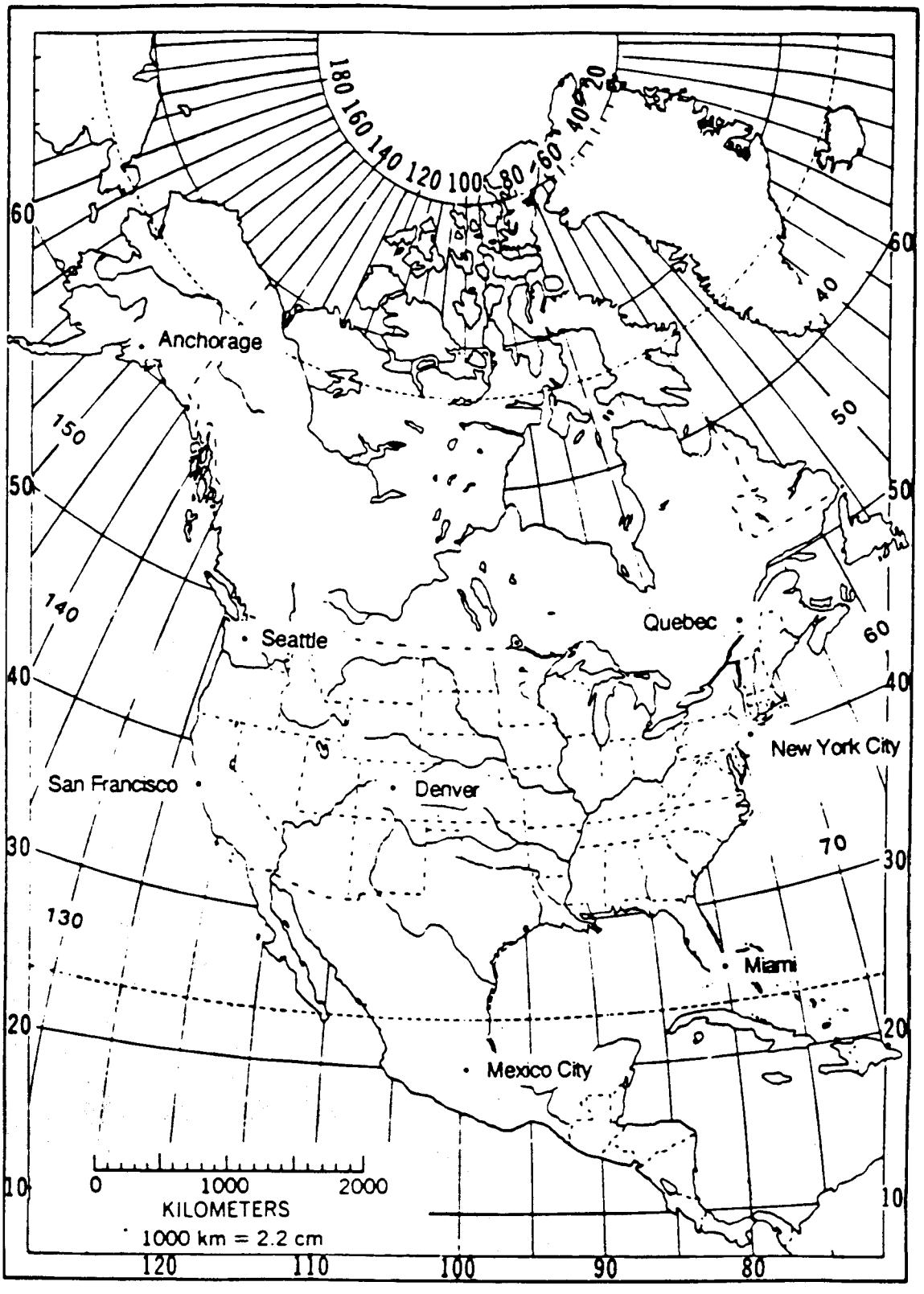


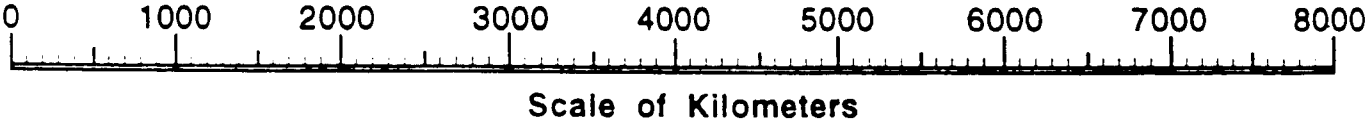
Please read "P" and "S" wave arival times to the nearest five (5) seconds.

Seismic Station	"P" Arrival Time	"S" Arrival Time	"S" Time – "P" Time	Distance to Epicenter	P-Wave Travel Time	Origin Time
# 3						

9. What is your best estimate of the origin time of the third earthquake (#3, above)? _____

(Be sure all three epicenter locations are marked on the map: #1, #2 and #3. Then continue to page 6.)


Anchorage
Seattle
San Francisco
Denver
Quebec
New York City
Miami
Mexico City
0 1000 2000
KILOMETERS
1000 km = 2.2 cm


0 1000 2000 3000 4000 5000 6000 7000 8000
Scale of Kilometers

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

11. In what three ways are P-waves different from S-waves?
    A. _____
    B. _____
    C. _____

12. To locate an epicenter, subtract the _____ arrival time from the _____ arrival time. Then, use the travel time chart in the _____, find the _____ at which that time separation applies. Do the same for at least _____ more seismic stations. Around each seismic recording station, draw a _____ at the proper distance. Where the three circles _____ is the epicenter. To find the origin time, subtract the _____ for any P or S-wave from the _____ of that wave. That's when the earthquake occurred at the epicenter.

13. Define Latitude: _____

14. Define longitude: _____

15. 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:

16. 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? (There are at least four answers to this question. You must list *two* for full credit.)
    (1) _____
    (2) _____
    (These two are optional →) (3) _____

17. What does the dairy store sell when they have an earthquake? _____