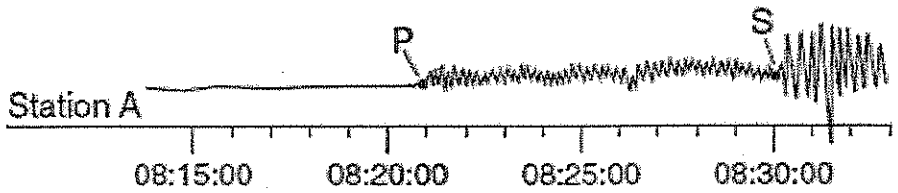
Name:_____

# Finding Epicenters

Earthquakes are vibrations caused by large releases of energy. The energy released radiates from the point of origin, the focus. The term epicenter is used to describe the location on the earth's surface directly above the focus. Earthquakes generate several types of energy waves that radiate in all directions that can be recorded on seismograms. Two of these waves are used to locate epicenters:



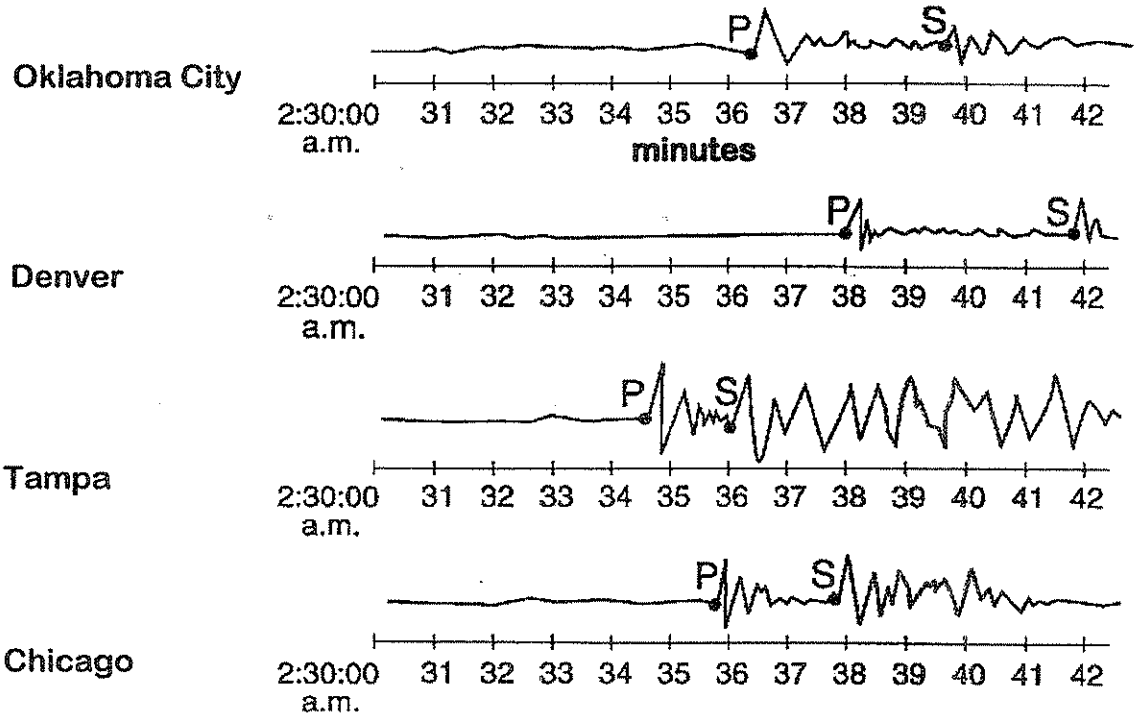

**P** (primary) waves: Vibrate back and forth and because they travel faster arrive at seismograph station first.

**S** (secondary) waves: Perpendicular (side to side) waves travel slower than P waves but they do more damage.

**The P waves and S waves start out together from the epicenter.** For a nearby earthquake, the P and S waves arrive with little separation. The greater the distance, the time delay or lag will be longer. Because P waves travel faster than S waves, as the distance from the epicenter increases, so does the time separation between the arrival of the P wave and the arrival of the S wave. The delay in the S wave arrival can be used to determine the distance from the recording station to the epicenter.

In order to calculate the time delay between P and S waves, you must be familiar with the technique of borrowing from the minutes or hours columns. (Keep in mind there are 60 seconds in each minute and 60 minutes in each hour) Times are written HOURS: MINUTES: SECONDS.

Step 1:
The following 4 seismograms are from the same earthquake detected at 4 different seismic stations. Use the seismograms to calculate the time difference between the P and S wave arrival times. Please record all arrival times to the nearest 10 seconds.

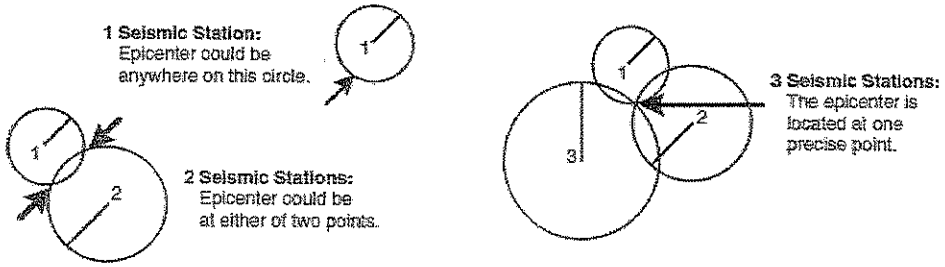



| Seismic Station | P wave arrival time | S wave arrival time | S wave Time - P wave Time | Distance to Epicenter kms. |
|---|---|---|---|---|
| Oklahoma City. OK | | | | |
| Denver, CO | | | | |
| Tampa, FL | | | | |
| Chicago, IL | | | | |

**Step 2:**
**Once the time difference between the P and S wave travel time is known, the distance from the epicenter to any seismic station can be found using pg. 11 of your ESRT.**

**Your teacher will demonstrate how to determine the distance on the graph with a scrap sheet of paper. Record your distance to the epicenter in the table above.**

**Step 3:**
**The data you entered in the table can be used to locate the epicenter. The following diagram shows you why you need at least 3 circles to determine the exact epicenter. Drawing 4 circles is even more accurate.**



Use the map scale below to stretch out the drawing compass the proper distance from each recording station. Draw 4 circles and they should intersect at one location, the epicenter. Mark the location with an X.

# EPICENTER LOCATION MAP

Step 4:
The actual time at which the earthquake took place at the epicenter is called the **origin time**. Once the distance from the epicenter to any one recording station is known, it is possible to use a single seismogram to find the origin time of the earthquake. You can double check the origin time by using the P waves from other stations.

P wave Arrival Time
- P wave Travel Time
Origin Time

a. Using the time travel graph, how long does it take a P wave to travel 4,000 kms? _____

b. If the P wave from an earthquake 4,000 kms. away arrived at our station at exactly 12:00:00, when did it start its journey? This is our origin time.

_____

c. Use this technique to determine the origin time of the earthquake recorded in your data table. You can check yourself by doing the calculations on at least 3 of your stations.

| Seismic Station | P-wave arrival time | Distance to Epicenter | P wave travel time | P wave arrival time – P wave travel time = Origin Time |
|---|---|---|---|---|
| Oklahoma City | | | | |
| Denver | | | | |
| Tampa | | | | |
| Chicago | | | | |

The table below shows data from another earthquake. Complete this table for practice. You do not have to draw the circles to find the epicenter.

| Seismic Station | P wave arrival time | S wave arrival time | S time - P time | Distance to Epicenter | P wave travel time | P wave arrival time – P wave travel time = Origin Time |
|---|---|---|---|---|---|---|
| Seattle, WA | 12:08:10 | 12:10:50 | | | | |
| Denver, CO | 12:07:35 | 12:09:50 | | | | |
| San Francisco | 12:11:50 | 12:17:15 | | | | |