

Experiment 8

Locating an Epicenter

Abstract

As you have learned in class, earthquakes are vibrations caused by large releases of energy. These energy releases can occur as a result of fault movements, asteroid impacts, volcanic eruptions, and movements of magma, as well as by explosions. As a result, vibrations can begin both in and on the Earth's crust. The energy released radiates away from the point of origin, the **focus**. Commonly, when describing the location of an earthquake, scientists and the media often talk about the earthquake's **epicenter**, the point on the Earth's surface directly above the focus.

Earthquake energy can be recorded on a **seismograph**, producing a **seismogram**. Seismographs can "pick up" several types of energy waves, which travel through the Earth, and radiate in all directions from the focus. Two of these waves are used to locate earthquake epicenters:

- **"P"-waves or longitudinal waves:** "P" stands for primary. These waves travel fastest and arrive at seismographs first. They are compressional ("push-pull") waves.
- **"S"-waves or transverse waves:** "S" stands for secondary. These waves travel more slowly and arrive at seismographs after P-waves. They are perpendicular ("side-to-side") waves.

We use travel time graphs (see page 5, Figure 3) to show how long it takes each type of seismic wave to travel a distance, measured on Earth's surface. The difference between the S wave arrival time and the P wave arrival time corresponds to the distance of the seismograph from the focus of the earthquake. However, these waves can arrive at a seismograph from any direction! Thus, one seismograph is not enough to determine the epicenter of an earthquake. A second seismogram, recorded in a different location, can narrow down the possible location to some degree, but at least three seismograms are required in order to accurately plot the epicenter.

In this lab, you will. You will use the P and S wave arrival time difference to determine distance to epicenter, then use a compass to record the distance radius measured by each station. Remember, accuracy is important. Take care to make accurate measurements!

Purpose

1. To use seismograms from three locations to determine the epicenter of an earthquake.
2. To use the P and S wave arrival time difference to determine distance to epicenter, then use a compass to record the distance radius measured by each station.

Materials

3 seismograms from the same earthquake
P and S wave travel time curve
Straight edge

Safe drawing compass
Map for plotting the earthquake epicenter

Procedure

1. Examine Figure 1, which shows seismograms of an earthquake recorded at three different locations. Note that the first set of zigzags at each city indicates the arrival of P waves, and the second set of zigzags indicates the arrival of S waves. In order to determine the time of arrival for each P and S wave, move your finger in a straight line down to the time axis beneath the wave.
2. Estimate to the nearest ten seconds, the times of the first arrival of the P waves and S waves at each station in Figure 1. Then, subtract the S minus P.
3. Now use the S minus P times and *Figure 3: Earthquake P-Wave and S-Wave Travel Time* (see Page 5) to estimate the distance from the epicenter for each location. Refer to the following procedure to accomplish this:
 - a. Lay a strip of blank paper along the time axis of *Figure 3: Earthquake P-Wave and S-Wave Travel Time* (see Page 5). Mark two dots on the edge of the paper corresponding to the S - P time difference calculated for the first location above.
 - b. Keeping the edge of the paper parallel to the vertical lines on the graph, slide the paper along the S and P curves until the two dots lie exactly on the S and P curves.
 - c. A vertical line through the S and P curves at these points should intersect the horizontal axis. This is the distance between the seismograph at this location and the earthquake's epicenter.
 - d. Record this distance in the table 1 under observations. Repeat this procedure for the next two S - P times.
4. Next, find the earthquake's epicenter, using the distances just obtained and the procedure below.
 - a. Use the scale in Figure 2 to set the appropriate radius on your compass. You can do this by opening your compass to a length equal to the Distance to Epicenter determined for San Jose, Costa Rica, as recorded in the observations section.
 - **NOTE:** You may notice that the distance is LONGER than the scale. Open the compass to the entire length of the scale (3,000 km). Then, move the compass to the LEFT until the point that WAS on 3,000 touches 0. Then, continue opening it the REMAINING length.
 - b. Place your compass point on the circle labeled San Jose on your map. Scribe a complete circle around the seismic station.
 - c. Repeat this procedure for New York and San Francisco.
 - d. The circles you should draw should intersect near one point. This point is the epicenter!

Observations

Figure 1: Seismograms Recorded at Three Different Locations for a Single Event

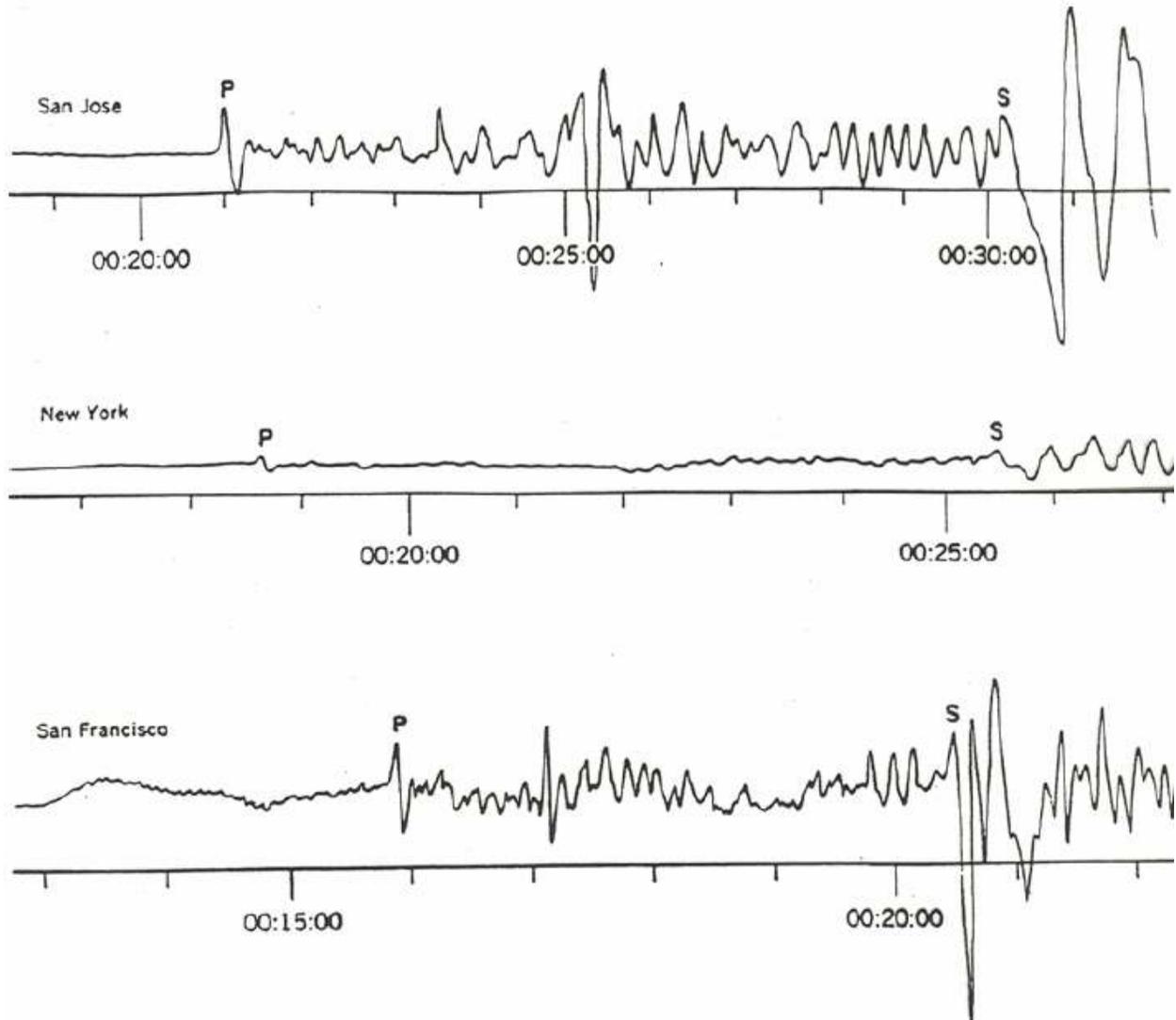


Table 1: S and P Wave Arrival Times

| | First P Arrival | First S Arrival | S – P |
|----------------------|-----------------|-----------------|-------|
| San Jose, Costa Rica | | | |
| New York, USA | | | |
| San Francisco, USA | | | |

Table 2: Seismograph Location in Relation to Epicenter

| Seismograph Location | Distance to Epicenter (km) |
|----------------------|----------------------------|
| San Jose, Costa Rica | |
| New York, USA | |
| San Francisco, USA | |

Figure 2: Map of North America for Plotting Epicenter

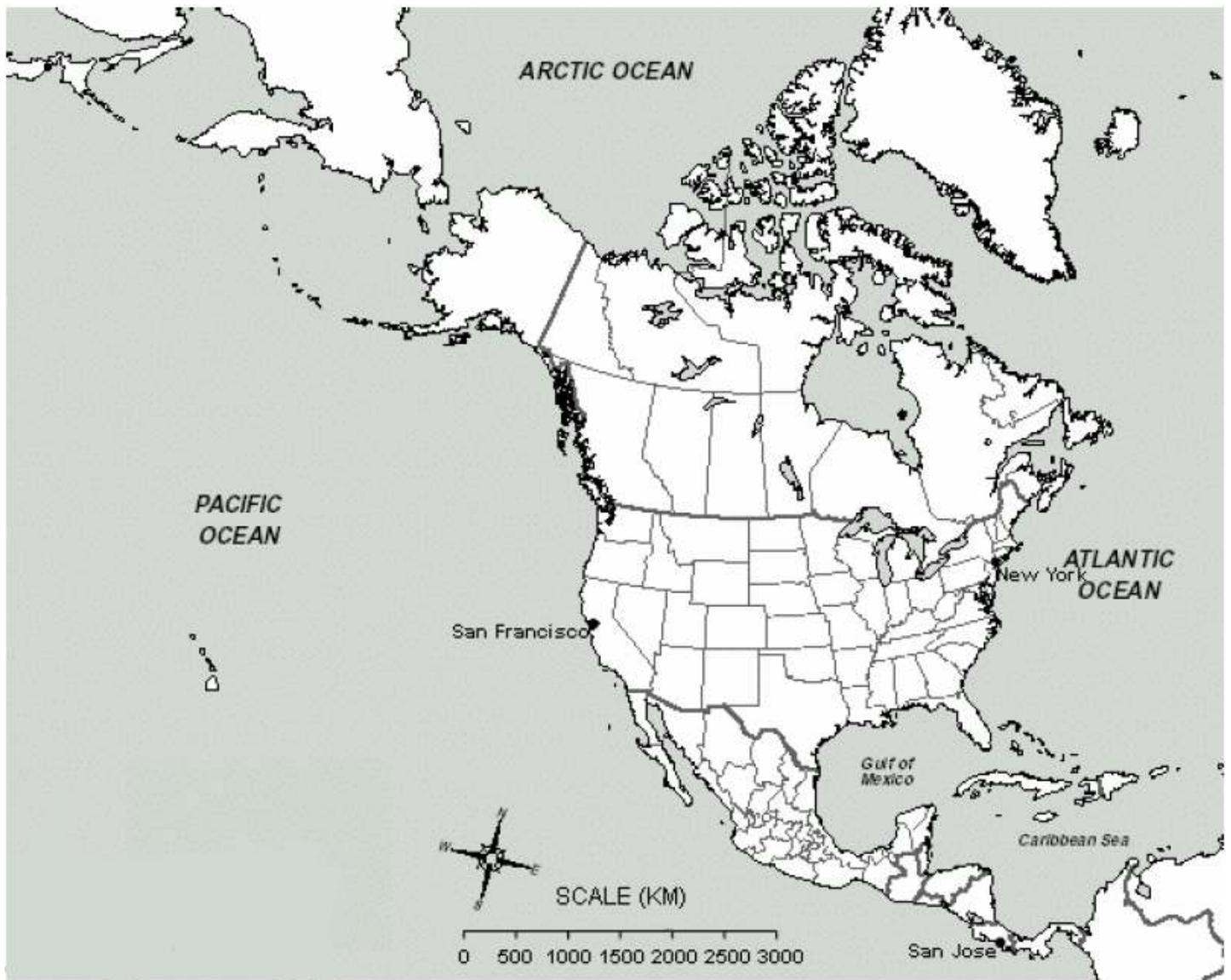
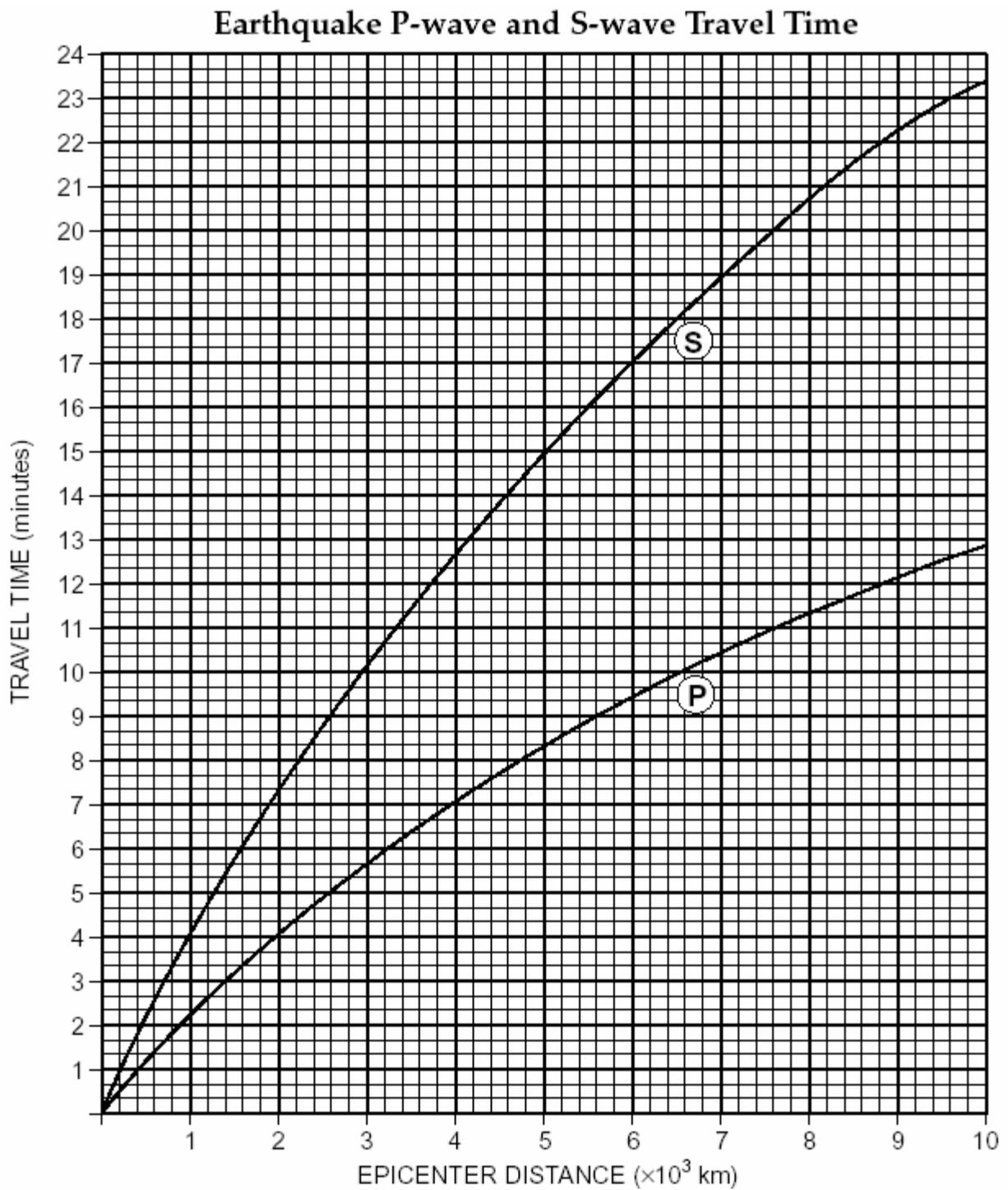


Figure 3: Earthquake P Wave and S Wave Travel Time



Questions

1. What is the origin time of the earthquake (at what time did the earthquake occur)?
2. Which seismograph recorded the earliest P-wave arrival? The latest?
3. What does the difference described in question 2 suggest about the relative locations of each seismograph?
4. Where was the epicenter (which State and/or Country?) of this earthquake located?
5. Use your **Data Booklet** to determine what type of plate boundary is located here.
6. Which plates are found along this boundary?
7. Describe what might be happening here to cause earthquakes at this location. **Be specific!**
8. Your circles may not have intersected precisely at one point. Other than error in your measurements, what are the possible reasons for this? **Be specific!**
9. You have been using the P and S wave travel time curve to determine the distance to the epicenter. You have been asked to use this curve for every earthquake you study. Explain why this curve might not be appropriate in all situations, and justify your answer.