I. Objectives

1. Apply P, S, and surface wave concepts to a seismogram to locate an earthquake.

II. Introduction

Figure 1 illustrates a typical earthquake seismogram. Each vertical line marks a one-minute interval. The three basic types of seismic waves generated by an earthquake at its focus are recorded on seismograms: P waves, S waves and surface waves. P waves have the greatest velocity while surface waves are the last to arrive at a seismograph station.

III. Materials

Ruler, compass

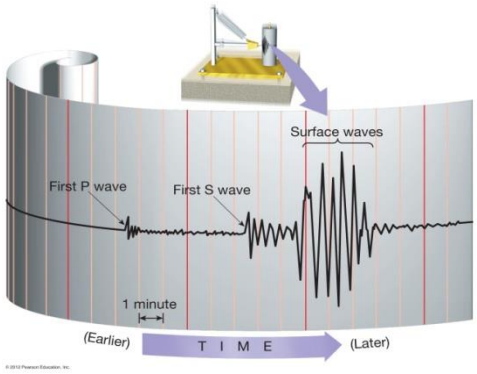

Figure 1: Typical Earthquake Seismogram

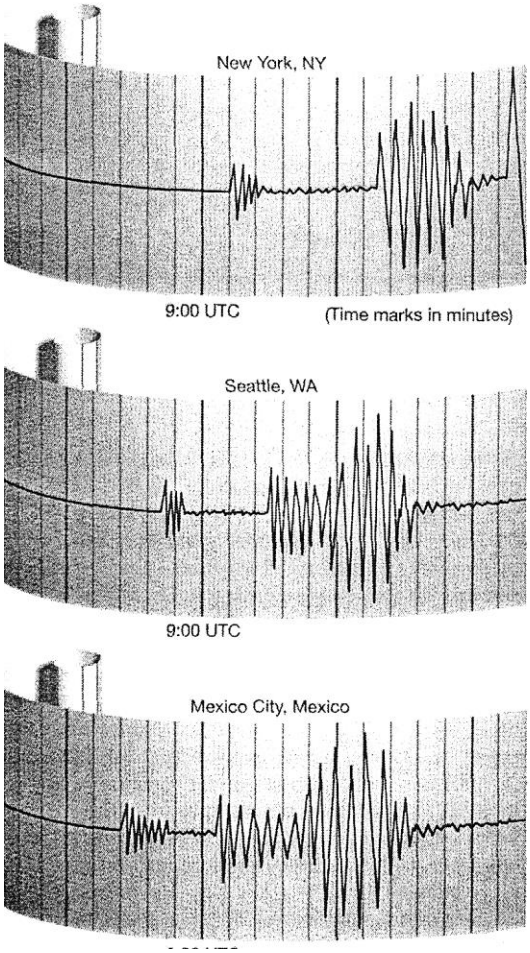

Figure 2: Seismograms for Lab

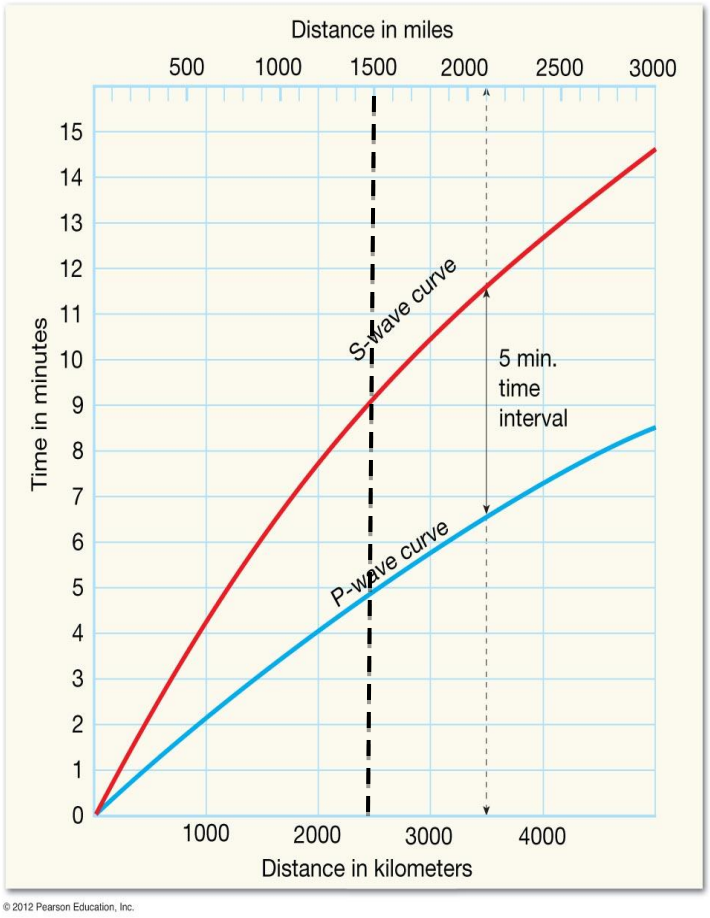

Figure 3: P-S Travel-time Curve for Lab

Figure 2 shows three seismograms of the same earthquake recorded at three different locations: New York, NY, Seattle, WA and Mexico City, Mexico.

Figure 3 shows a travel time curve, the time it takes P and S waves to travel from the epicenter of an earthquake to stations at different distances. For example, it takes a P wave approximately 5 minutes to travel 1500 miles, while the S wave takes 9 minutes to travel the same distance.

To locate an earthquake, we use the time difference between the arrival of the P and the S wave. The light dashed line on the right of Figure 3 is a time difference of 4.8 minutes (11-6.2 minutes). This corresponds to a distance (on the x-axis) of ~3,200 kilometers centered on the station. To get an earthquake location, we need information from three recording stations so we can find the intersection of three circles, which triangulates our location. This intersection is the epicenter.

IV. Prelab Definitions

1. seismic

2. P wave

3. S wave

4. surface wave

5. epicenter

6. triangulation

V. Procedure

1. Locate and label the beginning of the P wave, S wave and surface wave on each of the seismograms in Figure 2. Determine the difference in arrival times (to the half minute) of the first P wave, and the first S wave for each of the three seismograms (i.e. how many minutes elapsed between the first arrival of the P wave and first arrival of the S wave) and enter in Table 1.

2. To determine the distance between a recording station and an earthquake epicenter, find the places on the travel time graph (above) where the vertical time difference between the P and S curves is equal to the time difference between the arrival of the first P and first S waves for each recording station (use another piece of paper held up against the y-axis to mark the time and then slide this up the travel-time curve). The x-axis of the travel time graph gives the distance from each station to the epicenter. Enter these values for both kilometers and miles in Table 1.

Table 1: Seismic Data from Figures 2 & 3			
	New York	Seattle	Mexico City
P-S time interval in min			
Distance from epicenter in kilometers			
Distance from epicenter in miles			

3. On the map in Figure 4 below, use a drawing compass to draw a circle around each of the three stations with a radius, in miles, equal to the distance from the epicenter. Be sure to use the distance scale provided on the map to set the distance on the drawing compass for each station.

VI. Lab Discussion

1. What are the approximate latitude and longitude of the epicenter of the earthquake that was recorded by the three stations?

2. Does the location of this epicenter make sense tectonically? Why or why not?

3. How closely did your three circles intersect?

4. To the degree that they do not come together at a point, this is a measure of the uncertainty in your determination. What sources of error may have affected your location of the epicenter?

5. What are one or two ways you can improve upon your epicenter location without redoing any of the work you have done already?

6. How do we know when a distant earthquake occurred if no one was present to record the time of initial shaking?

Lab courtesy of Dr. Jim Washburne

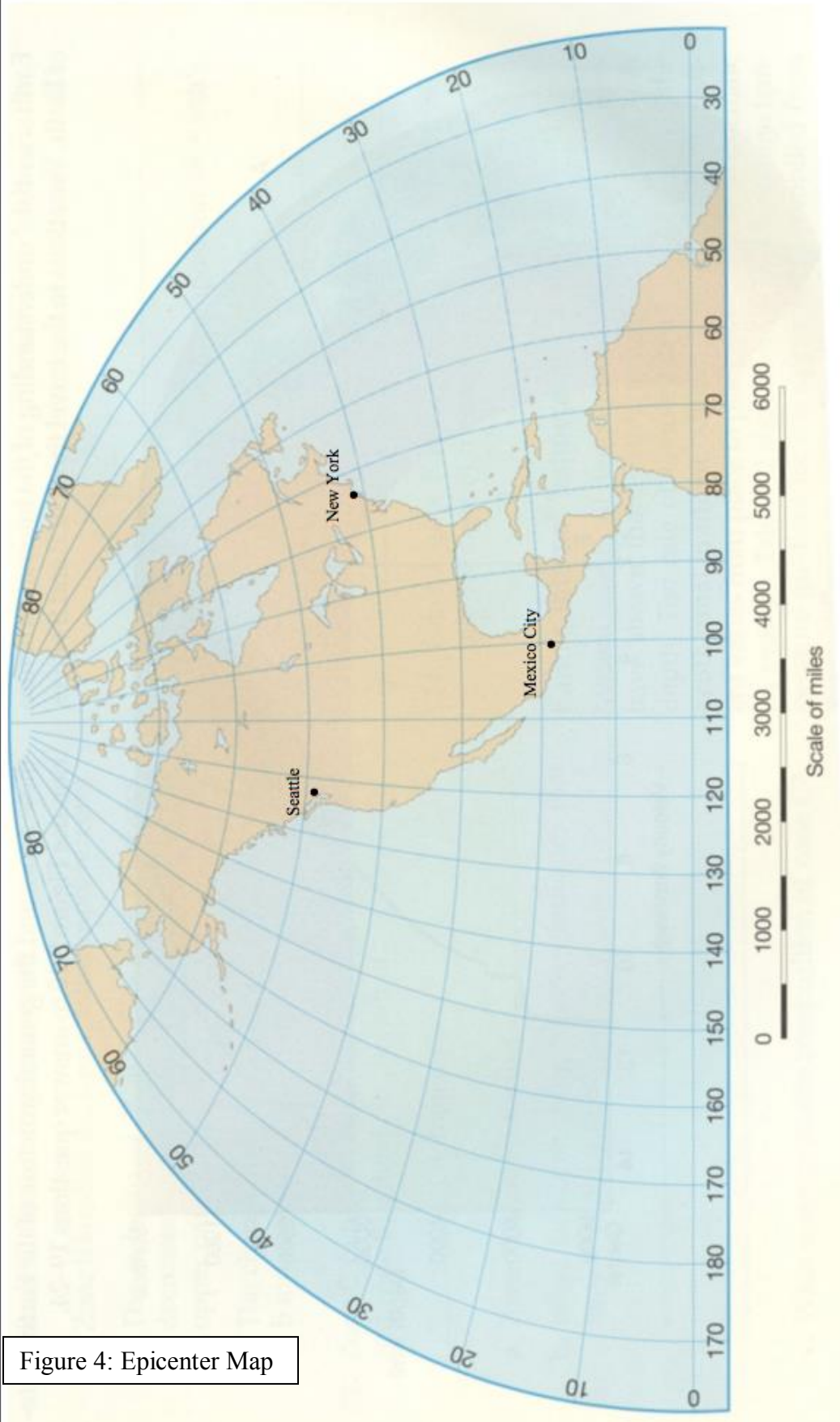

Figure 4: Epicenter Map