Critical Thinking – Earthquake Analysis

An earthquake has just occurred in the western United States and Asha Damayanti, a geophysicist with the United States Geological Survey, must calculate the epicenter and magnitude of the quake. She has to get this information out quickly because the media are calling and they want to describe the quake accurately on the evening news. Help Asha with her calculations.

In order to locate the epicenter of an earthquake, you need to estimate the time interval between the arrival of the P and S waves (the S-P interval) on the seismograms from at least three different measuring stations. You have to measure the interval to the closest second and then use a graph to convert the S-P interval to the distance to the epicenter. The seismogram in *Figure 1* is an example that shows the first P wave and S wave arrivals. The S-P interval is 36 seconds as counted on the vertical lines each of which is equal to 2 seconds. The figure also shows a graph that relates S-P interval to epicenter distance. Notice that 36 seconds is roughly equal to 350 km.

Three seismograms (*Figure 2*) have been sent to Asha so that she can make the necessary calculations. These are from Eureka, CA, Elko, NV, and Las Vegas, NV shown in *Figure 2*.

1. Please complete Table 1.

TABLE 1

Station	S-P Time Inteveral	Distance from Epicenter
Eureka, CA	_____ seconds	_____ Km
Elko, NV	_____ seconds	_____ Km
Las Vegas NV	_____ seconds	_____ Km

TABLE 2

Station	Distance from Epicenter	S-wave Amplitude
Eureka, CA	_____ Km	_____ millimeters
Elko, NV	_____ Km	_____ millimeters
Las Vegas NV	_____ Km	_____ millimeters

2. Use the map in *Figure 2* to draw three circles around each seismogram station. The radius of each circle should be equal to the distance from the epicenter. Use the map scale to measure the circle radius.

3. The epicenter of the earthquake is located at _____.

Now that you know where the quake occurred, it is time to calculate the magnitude of the event. Two measurements are needed to calculate the magnitude of an earthquake: the S-P interval and the maximum amplitude of the seismic waves. The seismogram shown in *Figure 3* illustrates the measurement of seismic wave amplitude. The blue horizontal gridlines are spaced at 10 millimeter intervals. In this example the maximum amplitude is about 185 mm.

Although the relationship between Richter magnitude and the measured amplitude and S-P interval is complex, a graphical device called a *nomogram* can be used to simply estimate earthquake magnitude. An example of how to use the nomogram is shown in *Figure 3*.

The horizontal dotted line (A) depicts an earthquake 100 km away that produces 1 mm of amplitude on the seismogram. It is assigned a magnitude of 3. Line B depicts an earthquake 100 km away with 10 mm of amplitude. It has a magnitude of 4. An earthquake at the same epicenter with 100 mm amplitude would produce a 5.0 magnitude quake (Line C). Hence, it is clear that a change of one unit in earthquake magnitude (say from 4 to 5) increases the maximum wave amplitude by a factor of 10. The last line drawn, line D, shows that an earthquake with an amplitude of 150 mm at a distance of 600 km would have a magnitude of about 7.3 on the Richter scale.

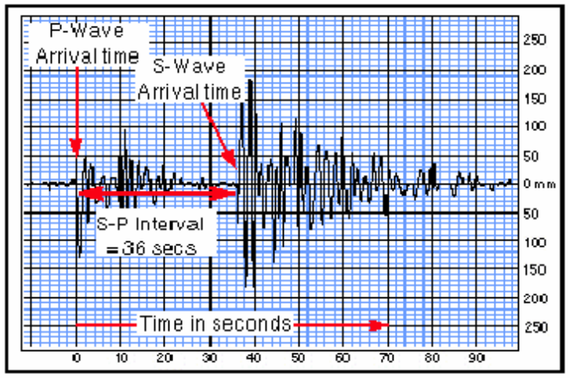
Although only one amplitude measurement is necessary to estimate the magnitude of an earthquake, it is better to use measurements from several seismograph stations. This enables you to determine the magnitude value as an average of several values, thus increasing the likelihood that you are accurate in your estimate.

4. Draw lines on the nomogram for the three seismic stations and complete the following table.

5. The magnitude at Eureka is _____, at Elko is _____, and at Las Vegas is _____.

6. The average magnitude of the earthquake is _____.

7. Write a small one paragraph press release describing your methodology and conclusions for the media.



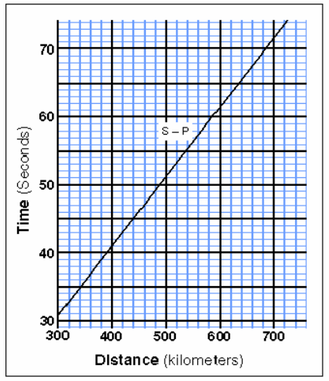
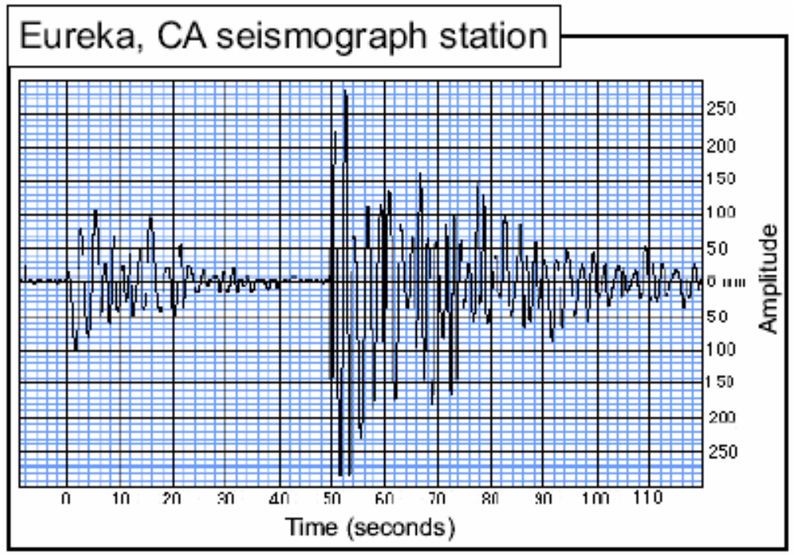
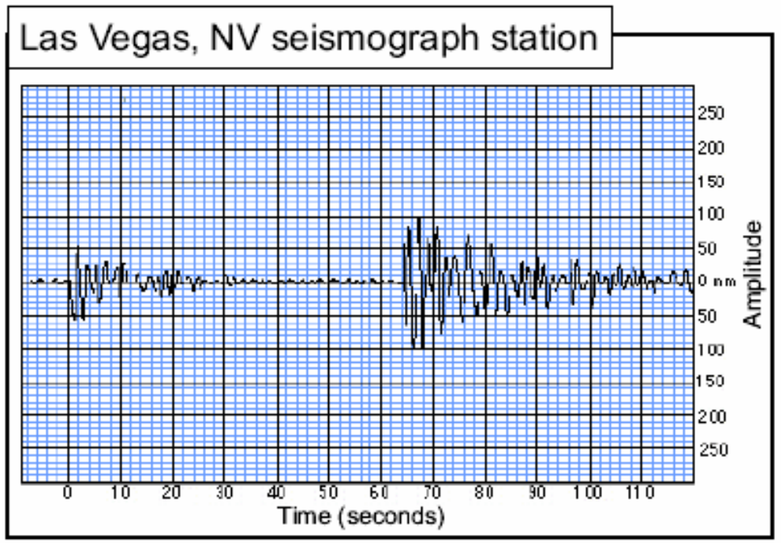
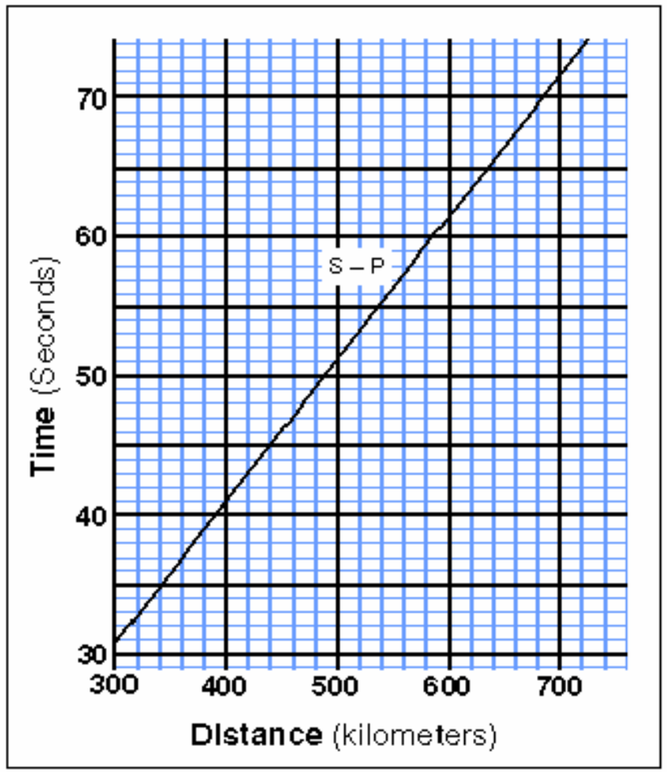
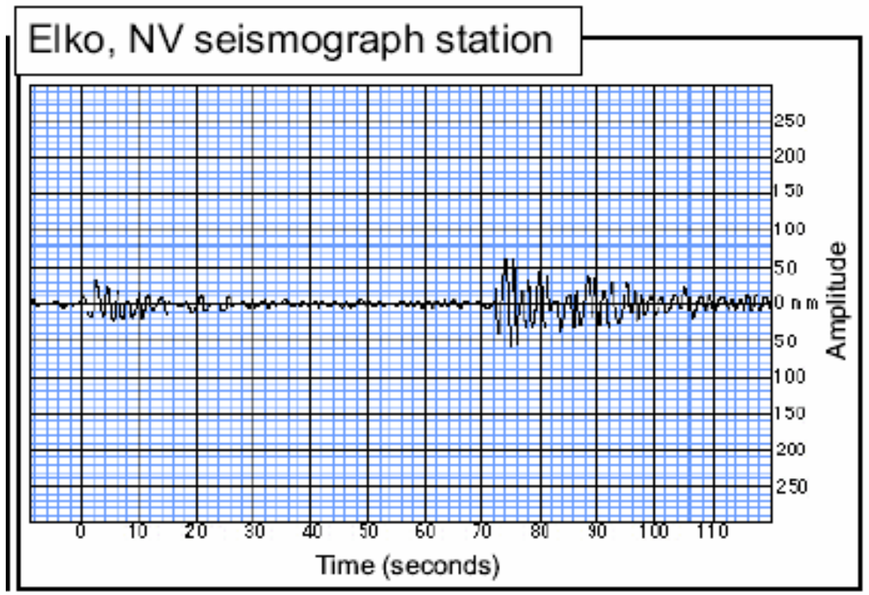


Figure 1 Seismogram and S-P relationship to distance.









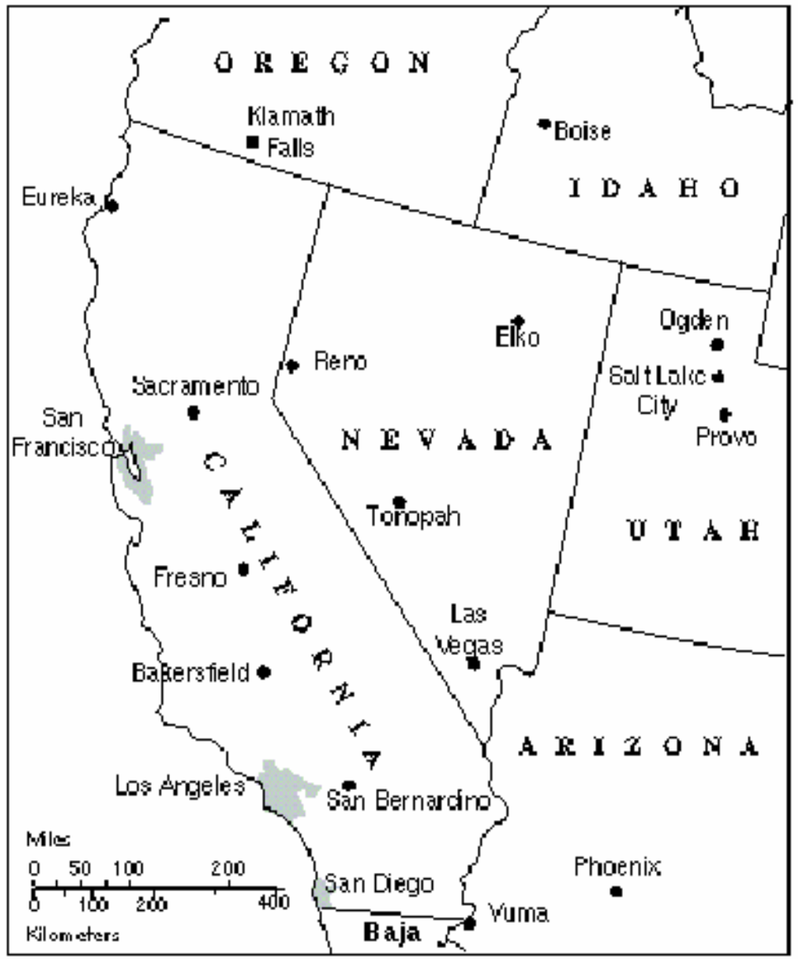


Figure 2 Seismograms and map of the quake.

Figure 3 Calculating seismic magnitude.