

Activity #3

Triangulation equals Location using Multiplication

Objective

Students will learn how the epicenter of an earthquake is located using triangulation.

Materials

Figure 1 and Table 1: Three Seismograms and Data Chart - 1 copy for each student or group

Figure 2 – 1 copy for each student

Colored pencils

Drawing Compass

Clear plastic shoebox and overhead projector

Water to fill shoebox a few inches high

Clay

5 small sticks – popsicle sticks, coffee stirrers, etc.

Background

The principal use of seismometer networks is to locate earthquakes, as it is for the QCN. Although it is possible to infer a general location for an event from the records of a single station, it is most accurate to use three or more stations. Traditionally, the location of epicenter is important, of course, in assessing the damage that the event may have caused, and in relating the earthquake to its geologic setting, but for the QCN it is also for early warning.

From a seismogram record, the time when the S wave and the P waves arrive at a station can be determined. The difference in time (in seconds) when multiplied by 8 km/sec results in the approximate distance (in kilometers) from the station to the epicenter of the earthquake. By drawing a circle on a map around the station's location, with a radius equal to the distance from the earthquake epicenter, the circle shows all possible locations for the event. With information from a second station, the circle around that station will narrow the possible locations down to two points, where the circles overlap. It is only with a third station's seismogram that you can draw a third circle that identifies which of the two previous possible points is the real one.

Currently, this activity does not use QCN seismograms because the system is still new. We will post seismograms as they become available.

Activity

1. Begin with a demonstration of radiating waves in water. Drop a pebble into the water and observe the ring of waves that move away from the source.

To set up a water demonstration, it is best to use an overhead projector and a clear plastic shoebox. If that is not available, a dish pan with water works but it is more challenging for all students to observe this as a demonstration. Place 5 sticks into the clay and place randomly in the container. They should not be evenly distributed to emphasize that most seismometer stations are not evenly distributed especially the QCN.

Each stick represents a seismometer.

2. Drop the pebble or penny into the water. Ask students what they observed. Have them follow one wave as it moves past the sticks, then have them watch one stick and watch the waves moves past it. Depending on the size of the container, it might be better to start at one end and watch the wave move across the container. Compare the sticks to the seismometer network used to detect earthquakes.
3. An alternative demonstration is to use the stereo hearing system in our heads – 2 ears on opposite sides. Go to a space where students can walk around bit – maybe in the back of the classroom or outside. Tell them to shut their eyes and listen. They should try to figure out and remember where you are as you call out numbers in order. Walk around and say 1, then walk and wait a bit and say 2. Walk back to where you were at the beginning and ask students to open their eyes. Ask them where you were for #1 and #2. Ask what differences did they hear? Lead them to think about the space between their ears. This is modeling the 3 or more seismometers used to detect the location of earthquakes.
4. Pass out the seismograms from the unknown earthquake. This is an exercise to determine the location of an earthquake based on the time that waves arrive at seismometer stations. Review that P and S waves come from one earthquake. P is the primary or first wave that moves more quickly than the S (secondary) wave. The waves are different in terms of speed and motion (shear vs. compression). Although wave speeds vary by a factor of ten or more in the Earth, the ratio between the average speed of a P wave and of its following S wave is quite constant. This fact enables seismologists to simply measure the time delay between the arrival of the P wave and the arrival of the S wave to get a quick and reasonably accurate estimate of the distance of the earthquake from the observation station.
 - a. Examine the seismograms in Figure 1. Determine the time interval between the P-wave and the S-waves and record this data in Table 1.
 - b. The distance from the epicenter of the earthquake to the first station can be determined. Subtract the time of the P wave from the S wave (in seconds). Multiply this difference by 8 to get the distance (in kilometers) from the earthquake epicenter to the station.
 - c. Repeat the process for the other two locations. Use table 1 to organize the data and calculations.
 - d. Using Figure 2, locate the three seismometers and label them. Using the map scale, take a drafting compass and set it to the appropriate length for the distance from the first location to the epicenter. Place the compass point at this location and draw an arc using the distance as the radius. Repeat for the other two locations. The intersection of the three arcs identifies the epicenter of the earthquake.

Extension or Pre-Activity: Walk - Run Activity --An S and P Wave Travel Time Simulation

This is to physically show students different speeds of waves, as they move out from the epicenter of an earthquake. S wave propagation is simulated by walking and P wave propagation is simulated by running. The Walk-Run method can be performed on a playfield or a gymnasium and requires an open space of about 30 x 30 meters. The Slow Walk – Walk method can be performed in a medium sized room such as a classroom and requires an open space of about 6 x 6 meters. For complete directions go to:
<http://web.ics.purdue.edu/~braile/edumod/walkrun/walkrun.htm>

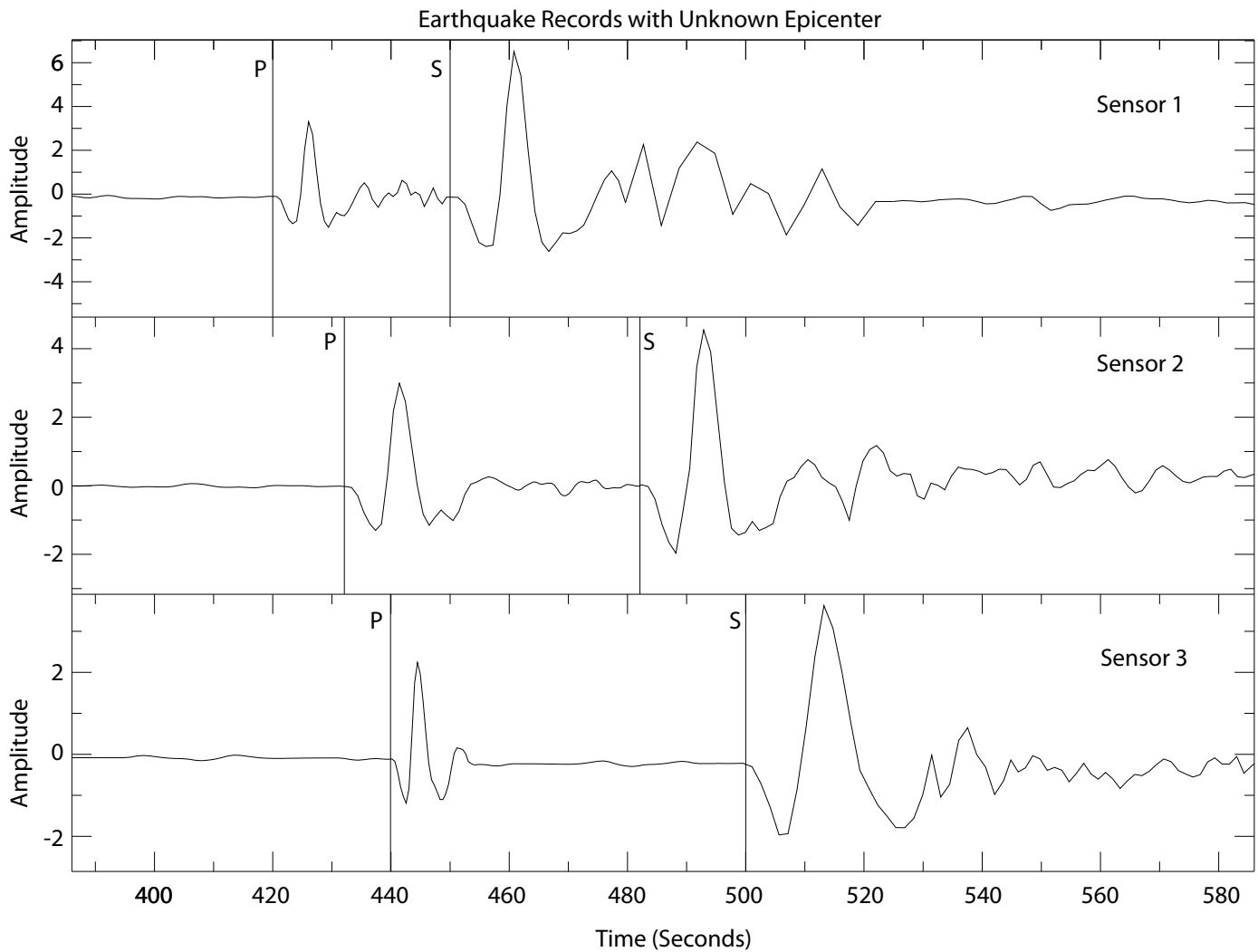


Figure 1: Siesmographs from three sensors of an earthquake at an unknown epicenter.

Table 1: Calculations to determine location of earthquake epicenter.

Sensor	Time of arrival of P wave	Time of arrival of S wave	Difference in Time between S and P wave (sec)	X 8 km/sec	Distance of Sensor from Epicenter (km)
1				8	
2				8	
3				8	

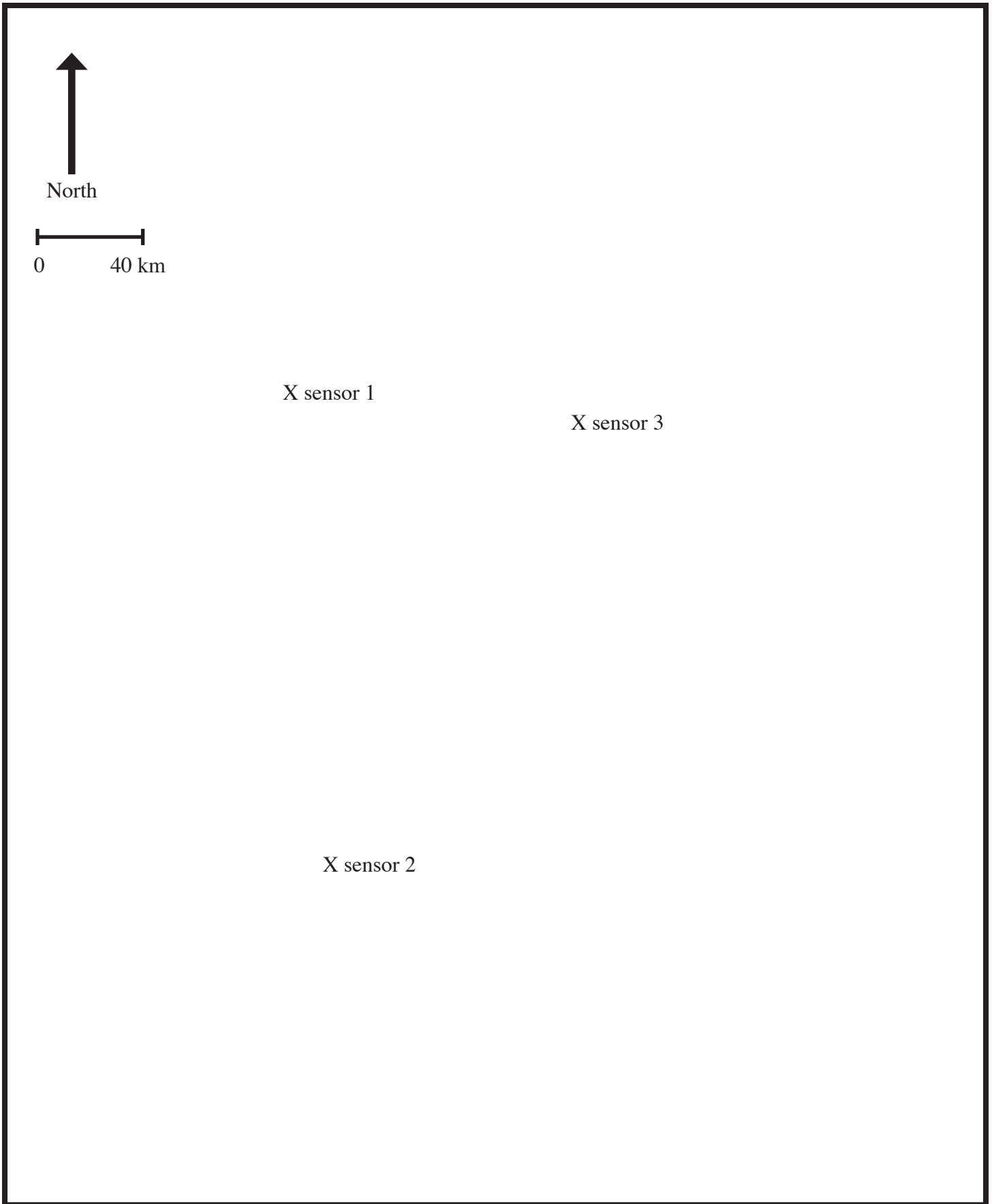


Figure 2: Map of the three seismometer sensors, located at the X. You must find the location of the earthquake epicenter using data from Figure 1 and Table 1.

ANSWER KEY



North



0 40 km

X sensor 1

X sensor 3

X sensor 2

Sensor	Time of arrival of P wave	Time of arrival of P wave	Difference in Time (sec)	X 8 km/sec	Distance of Sensor from Epicenter (km)
1	420	450	30	8	240
2	432	482	50	8	400
3	439	500	61	8	488