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# Locating an Earthquake's Epicenter

## Grade Level:

- 7
- 8
- 9
- 10
- 11
- 12

## Lesson Time:

45 minutes

**Objective:**

- Students will be able to understand how S and P waves are used to find the epicenter of an earthquake by applying their seismic knowledge and mathematical skills to seismographs in order to triangulate an earthquake epicenter.

**Preparation**

Before going to the classroom, you will need to:

1. Contact the teacher to find out the length of the class period, as well as how many copies of handouts and sets of materials you need to bring.
2. Collect all the materials in the list.
3. Make photocopies of the handouts.
4. Make an overhead copy of each of the handouts.  Notify the classroom teacher of technology needs (overhead projector).
5. Collect any giveaways for the students, such as earthquake posters or plate tectonic fliers.
6. Run through the investigation yourself and record the data, just to see how long it takes. Adjust the timing to the class period, remembering that you will need time to introduce the investigation, clean up afterwards, and re-set up for the next class (if you are working with more than one class).

**Materials:**

Provide each student, with the following:

- Map of southwestern United States
- Seismograms from seismic stations in Fresno, CA, Phoenix, AZ, and Las Vegas, NV
- A modified travel time curve for S-P wave
- A Data Table for the Seismic Stations
- A drawing compass
- Pencil

For instructional purposes

- Overhead transparency of each of the handouts
- Overhead projector (contact classroom teacher about this) and screen
- Optional: overhead transparency or PowerPoint of *Photos of Earthquakes*
- Overhead transparency markers

## Purpose

Earthquakes occur every day all over the United States and all over the world. Most of these earthquakes are small tremors that can't be felt by people, but occasionally an earthquake occurs on a large magnitude that causes millions of dollars in property damage and kills hundreds to thousands of people. Earthquakes can also cause tsunamis, which are very large waves that can damage coastlines and put coastal residents in danger.

Some places are more prone to earthquakes than others. For example, the western United States has earthquakes more frequently and on a larger scale than the eastern part of the country. Earthquakes occur along faults, which are cracks in the Earth's crust that build tension. When the tension becomes too great, the fault slips, causing an earthquake. The western U.S. has more faults than the eastern U.S., and therefore the western U.S. has more earthquakes. The nation's most famous fault is the San Andreas Fault, which runs along a north-south trend in southern California, and happens to run directly through Los Angeles.

In this investigation, participants will understand that S and P waves are used to find the epicenter of an earthquake by using seismograph data to triangulate an epicenter.

## Safety

This investigation is considered generally safe to do with students. However, please review it for the specific setting, materials, students, and conventional safety precautions.

## Investigation Question

How do we determine the epicenter of an earthquake?

## What to do

1. **(5 minutes)** Prompt a discussion about earthquakes. Optional: show photos or videos of earthquakes and related damage. (See *Photos of Earthquakes* ) Be sure to accept as many explanations as you can. Some questions you might use for the discussion are:
    - What do you know about the causes and impacts of Earthquakes? (*Student responses will vary.*)
    - What do you know about seismic waves? (*Student responses will vary.*)

- Have any of you ever experienced an earthquake or know anyone who has? What did it feel like? Was there an initial quake followed by smaller quakes? (*Student responses will vary*.)

2. **(5 minutes)** Show the three seismographs and point out the first arrivals of the P- and S-waves. *Ask students to explain what they see.* Talk about how the S-P interval increases with distance between the epicenter and seismograph station. *Ask how this might be used to determine the distance from the earthquake to the station.*
3. **(30 minutes)** Hand out the work sheet (A Modified Travel Time Curve and Table 1). Describe how independent seismograph stations can determine distances that plot as circles on a map. Explainthat at least three stations are necessary to find the epicenter of an earthquake. Also explain that although three stations is the minimum, often seismologists use more than three, and the more they use the more accurate the location of the epicenter becomes. Have students work through the exercise, following these steps:
    - Use *Seismograms from seismic stations in Fresno, CA, Phoenix, AZ, and Las Vegas, NV*. For each seismogram, students will find the first arrival times of the P- and S-waves. The first "jump" is the arrival of the P-wave. In each seismogram, the P-wave arrives at time=0 seconds. Also in each seismogram, the second big "jump" is the arrival of the S-wave. For Fresno the S-wave time is 36 seconds. For Phoenix the S-wave time is 61 seconds. For Las Vegas the S-wave time is 39 seconds. It is okay if students are off by one or two seconds, but the closer they are to the correct number of seconds, the more accurate their epicenter location will be.
    - Find the S-P interval for each seismogram and record answers in the S-P column of Table 1. Because the P-wave time for each seismogram is set as 0 seconds, the S-P interval will be the time of the S-wave arrival. For example, the S-P interval for Fresno is 36 seconds (i.e.: 36 seconds-0 seconds= 36 seconds). Likewise, S-P for Phoenix is 61 seconds and S-P for Las Vegas is 39 seconds. Have students record their S-P intervals for each seismograph station in Table 1.
    - Find the distance to the epicenter (in kilometers) from each recording station and record answers in Table 1. To do this, have the students use *A Modified Travel Time Curve for S-P Wave*, which is the Modified Travel Time Curve. The y-axis shows time in seconds. The x-axis shows distance to the epicenter from the recording station in kilometers. The line is a linear plot of S-P that has been done for students previously and is specific to this example. Explain that S-P is always a linear relationship but don't worry about trying to explain why. You may confuse them if you do. To find the distance to the epicenter, use the S-P interval you found for each station in step 2. For example, S-P for Fresno is 36 seconds. On the y-axis of the travel time curve count up to 36 seconds. Then with a pencil, draw a line to the S-P line and put a dot. Finally, draw a line with a pencil down to the y-axis and make another point. That point is the distance (in kilometers) from the Fresno seismograph station to the epicenter of the earthquake. The distance is 355 kilometers. For Phoenix the distance to the epicenter is 600 kilometers, and from Las Vegas the distance to the epicenter is 380 kilometers. Have the students record their answers for each station in the Distance from the Epicenter column of Table 1. It may help to do the first one together.

- Find the epicenter of the earthquake on the map (*Map of Southwestern United States*). The students will need the drawing compass to draw circles around each seismograph station. For each station, use the scale on the map to set the drawing compass to the distances found in step 3. For Fresno the distance found was 355 km. Set the compass for 355 km using the scale on the map. Then put the point of the compass on Fresno and draw a complete circle. Do the same for Phoenix using a distance of 600 km (students will have to extend the scale to make it 600 km long). (*It may be helpful to do this before starting the lesson*). Finally, draw a circle for Las Vegas. Where the three circles meet is the epicenter of the earthquake. If the circles to not meet exactly, then the epicenter is the center of the triangle formed where the circles should meet. In this activity, the epicenter of the earthquake is in the center of Los Angeles, CA. Ask students what fault they think caused this earthquake. The answer is the San Andreas Fault.

4. **(5 minutes)** Discuss how gathering information on epicenters can be applied. If the curriculum has already covered plate tectonics, you can lead the discussion towards plate boundaries. Ask students what kind of boundary the San Andreas Fault is (a transform boundary).
5. **(2 minutes)**. Thank students for their time and attention. You can leave giveaways behind for the classroom teacher to distribute.

## References


- Activity is modified from: Amy Elleman and Chris Donovan
- Geology Labs Online
- Animation using p and s waves, for understanding epicenter location


MapofSouthwesternUnitedStates.pdf