Teacher Guide: Earthquake – Determination of Epicenter

Learning Objectives

Students will…

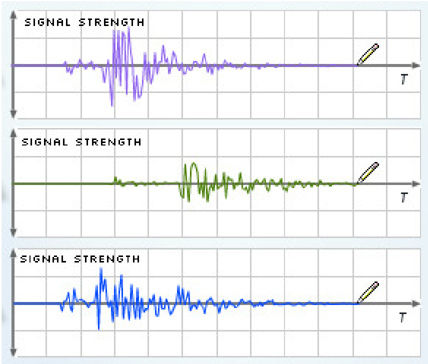
- Locate the first P and first S wave on a seismogram.
- Determine the time difference between P and S waves on a seismogram.
- Use a seismogram to determine the distance from the epicenter of an earthquake to a recording station.
- Use data from three recording stations to locate the epicenter of an earthquake.

Vocabulary

body wave, earthquake, epicenter, fault, focus, P wave, S wave, seismic wave, seismogram, seismograph

Lesson Overview

The *Earthquake – Determination of Epicenter* Gizmo™ is the second of two Gizmos that allow students to interpret seismograms. With this Gizmo, students use three seismograms to locate the epicenter of an earthquake.



The Student Exploration sheet contains one activity. In this activity, students measure the P – S wave time interval on three seismograms to find the distance of the epicenter from each recording station. This information is then used to find the exact location of the epicenter.

Note: This activity requires a data table and graph that students made while completing the Earthquake – Recording Station Student Exploration sheet. If students do not have these materials, ask them to do that activity before starting the Earthquake – Determination of Epicenter Gizmo.

Suggested Lesson Sequence

1. **Pre-Gizmo activity** (30 – 45 minutes)
   Do the activities in the *Earthquake – Recording Station* Gizmo and Student Exploration sheet. After doing these activities, each student should have a graph that relates the distance of the epicenter to the time interval (ΔT) between the P and S wave arrivals. The ratio of distance to ΔT ranges from 6 for short distances (<200 km) to 8 for long distances (>500 km).

2. **Prior to using the Gizmo** (10 – 15 minutes)
   Before students are at the computers, pass out the Student Exploration sheets and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers at this point. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations. Demonstrate how to take a screenshot and paste the image into a blank document.

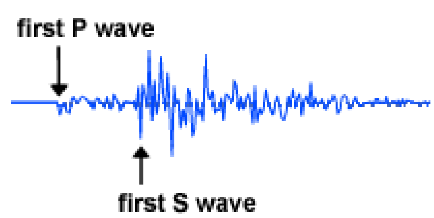
3. **Gizmo activities** (15 – 20 minutes per activity)
Assign students to computers. Students can work individually or in small groups. Ask students to work through the activities in the Student Exploration using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. **Discussion questions** (15 – 30 minutes)
As students are working or just after they are done, discuss the following questions:
   - How do you recognize the first P wave on a seismogram?
   - How do you recognize the first S wave on a seismogram?
   - What is the relationship between the P and S wave time difference (*ΔT*) and the distance to the epicenter?
   - Why does the Gizmo draw a circle around each recording station?
   - How many possible locations for the epicenter are there with data from one seismogram? Two seismograms? Three seismograms?
   - Why is it important to know the exact location of the epicenter?

5. **Follow-up activity: Build a seismograph** (variable)
A *seismograph* is a machine that seismologists use to measure seismic waves. You and your students can build a classroom version of a seismograph machine using a brick, a felt-tip pen, a roll of adding machine tape, string, and a wooden frame. Instructions for this seismograph can be found in the **Selected Web Resources** at the end of this guide. Test the seismograph by jumping up and down as the paper unspools.

   For a quick demonstration, you can make a very low-tech version of a seismograph. Lay a strip of paper on a desk. Position one student so that she is holding a felt-tip marker that rests lightly on the paper. As a second student pulls the strip of paper, two other students can shake the desk back and forth, perpendicular to the strip of paper. The result will be a wiggly line similar to a seismogram.

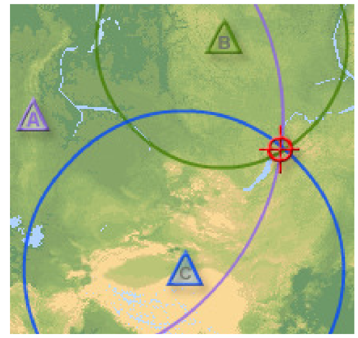
Scientific Background



A *seismogram* is an image of seismic waves created by a seismograph. When an earthquake occurs, it releases two types of waves: P waves, or primary waves, and S waves (secondary waves). P waves travel more quickly than the S waves and will reach the seismograph first. Therefore, the first "wiggle" in the seismogram is the first P wave. P waves continue to arrive, causing a series of small wiggles in the seismogram. When the first S wave arrives, it creates a larger wiggle because now the energies of P and S waves are combined.

Both P and S waves are known as *body waves* because they travel through solid rock below Earth's surface. When these waves reach the surface, their effects combine in *surface waves*, which shake the ground back and forth, up and down, and side to side. Surface waves account for the largest wiggles on the seismogram and are the most damaging in an earthquake.

The distance to an earthquake can be found by measuring the time difference (*ΔT*) between the arrival of the first P wave and the first S wave. As *ΔT* increases, the distance increases as well.



If you know the distance of the earthquake from three seismograph recording stations, you can determine the epicenter of the earthquake. To do this, plot the three recording stations on a map. Draw a circle around each station whose radius is equal to the distance of that station from the epicenter. Each circle represents all of the possible epicenter locations based on the data from that station. The three circles will intersect at one point, which is the epicenter of the earthquake.

Finding the epicenter can be important for many reasons. If you are directing rescue operations, it is helpful to know where the epicenter is so that you can place rescue workers and supplies in the hardest-hit areas. Most earthquakes occur along *faults* that can be mapped by plotting the epicenters. Knowing the locations of active faults helps seismologists to forecast future earthquakes and determine the earthquake danger of a given area. Finally, knowing the distance from a seismograph to the epicenter allows scientists to calculate the *magnitude*, or power, of the earthquake.

Current events connection: Deadly Chinese earthquakes

Many parts of China are characterized by high population densities, poor construction, and mountainous terrain in an earthquake-prone region. This lethal combination has resulted in some of the most devastating earthquakes in history. The Shaanxi earthquake of 1556 was the worst, taking over 800,000 lives. Many of those killed were rural farmers who lived in *yaodongs*—caves that were dug out of the hard-packed loess hills that characterize the region.

In 1976 an earthquake destroyed the city of Tangshan, killing between 242,000 (official figures) and 700,000 people. In downtown Tangshan, almost 80% of the buildings collapsed, trapping thousands in rubble. After this earthquake, the Chinese government upgraded building codes throughout the country.

These standards were put to the test on May 12, 2008, when a magnitude 7.9 quake struck in the Sichuan province near Chengdu. The worst damage was reported near the epicenter, where some towns were completely leveled. Landslides buried roads and villages, hindering aid and killing some rescue workers. Tragically, scores of children perished when shoddily built schools collapsed. Altogether, about 70,000 people were killed in the earthquake. Most agree this number would have been much higher were it not for the heroic efforts of rescuers.

Selected Web Resources

Build a seismograph: http://cse.ssl.berkeley.edu/lessons/indiv/davis/hs/Seismograph.html
Seismology: http://www.geo.mtu.edu/UPSeis/index.html
    Locating the epicenter: http://www.geo.mtu.edu/UPSeis/locating.html
Virtual earthquake: http://www.sciencecourseware.org/VirtualEarthquake/VQuakeExecute.html
How a seismograph works: http://www.wwnorton.com/college/geo/egeo/flash/8_3.swf
Sichuan earthquake: http://www.guardian.co.uk/world/interactive/2008/may/12/china, http://www.newyorker.com/online/2008/05/19/080519on_onlineonly_hessler?currentPage=all, http://www.cbc.ca/documentaries/doczone/2009/chinaearthquake/index.html

Related Gizmos:
Earthquake – Recording Station: http://www.explorelearning.com/gizmo/id?367
Plate Tectonics: http://www.explorelearning.com/gizmo/id?446