ACTIVITY 2— DETECTING EARTHQUAKE WAVES

Background Information

Detailed information about the origin of earthquakes and the interior of the Earth could not be obtained until sensitive recording devices could be made. As early as AD 132 a Chinese scientist, Chang Heng, built an instrument that supposedly could determine the direction from which the earthquake waves came (but not the location of the focus). Instruments with designs similar to modern seismometers have been in operation since the 1800s. These instruments use a compact mass as a reference. The mass is suspended by some very flexible suspending material in a frame that is attached to the ground. As earthquake waves cause the ground to vibrate, the frame moves up-and-down and/or side-to-side. The mass remains almost motionless, because of its inertia, and provides a fixed reference from which to measure the motion of the frame and therefore ground. Seismometers record the motions using ink on paper or electronically.

At first glance, the record of the passing earthquake wave, called a seismogram (see Student Book, page 135), looks like a confusing mess. Careful examination by experienced seismologists, however, can reveal which wiggles correspond to which kinds of waves. A few key observations are helpful. Remember that P waves are faster that S waves and S waves are faster than surface waves; therefore, P waves always arrive first, followed by S waves and then, finally, by surface waves. Look for changes in height of the waves (the wave amplitude) and the spacing between when individual waves arrive (the wave period, corresponding to the wave frequency). All seismograms include a time reference that is based on an extremely accurate clock. (Seismologists have to be meticulous about keeping their clocks synchronized.) This allows the exact time that certain waves arrive to be determined. Prior to the arrival of the first wave, the trace of the pen shows tiny vibrations (see the interval 8:06 to 8:08.2 in *Figure 2* of the Student Book, page 137). These slight motions are caused by very small movements of the Earth or distant man-made energy sources and are recorded because the instrument is very sensitive. The first deflection of the pen records the arrival of a wave with noticeably larger magnitude. Because this is the first wave to arrive, it must be the P wave (8:08.2 in the Student Book, page 137). As time passes, the amplitude of the P wave decreases. The next significant change is another large increase in amplitude, marking the arrival of the S wave (8:11.4 in the Student Book, page 137). As the amplitude of the S waves begins to decrease, the surface waves arrive and make up much of the latter part of the seismogram. The gradual decline in the amplitude of the waves is similar to the decreasing size of ripples on a pond as they travel away from their source.

The distance from a seismometer to the earthquake focus can be determined using the seismogram. The key measurement is the time between the arrival of the P wave and the arrival of the S wave. Because the two waves travel at different speeds, as time passes and the waves travel greater distances the time interval between the arrival times of the two waves increases. Therefore, for earthquakes close to the seismometer, the separation is relatively small (a short time interval), but for earthquakes that originate as far away as on the other side of the Earth, the separation is relatively large (a long time interval). The time interval separating the P and S waves is read directly from the seismogram (3.2 minutes for *Figure 2* in the Student Book). Seismologists have constructed a travel-time curve for earthquake waves (see Student Book, page 138). Note that, with increasing distance from the epicenter (horizontal axis) the time separation of the wave increases (vertical axis). To find the distance, mark the time interval for the separation of the waves on a piece of paper (measured off the vertical axis) and slide the paper along the P and S curves until the interval on your paper matches the curves (see Student Book, page 138). Then read the distance from the horizontal axis (for the figure on page 138 in Student Book, the distance is about 1000 km). This tells a seismologist that the earthquake is a certain distance away, but it still does not tell the direction back to the source. The location of the focus of an earthquake can be determined using the distances from three seismometers, by triangulation.

If you feel the need to familiarize yourself with the basics of the process of triangulation, or to help students understand the process, here is a simple exercise you can do. On a blank sheet of paper, mark three points that form a large triangle. Put a dot anywhere in the triangle. Measure the distances from each corner of the triangle to the dot. Now transfer the triangle to a fresh sheet of paper, and stick pushpins into each corner of the triangle. Cut thin paper strips with lengths corresponding to the distances from each of the corners to the original dot. Pin one end of each of the paper strips to the corresponding corner of the triangle. Now rotate the strips around until the free ends of all three strips fall at the same point. That is the position of the dot you originally made inside the triangle. The principle is the same for finding the location of an earthquake, but instead of just three points there are many, and the points are located on a sphere rather than on a flat piece of paper.

The *EarthComm* web site www.agiweb.org/earthcomm contains a variety of links to web sites that will help you deepen your understanding of content and prepare you to teach this activity. Many of the sites also contain images which can be downloaded and made into overheads for incorporation into class discussions.