ACTIVITY 3— HOW BIG WAS IT?

Background Information

Reports on earthquakes commonly note kinds of damage and a magnitude. Damage might include collapsed buildings or cracks in roads. Magnitude is a number, maybe 5.2 or 7.8. These descriptions reflect the two ways seismologists describe the size of earthquakes: intensity and magnitude. Intensity is determined from personal observations of the effects of an earthquake's effects on people, structures, and the Earth's surface at a given locality. Magnitude is a measure of the energy released during an earthquake and is usually based on the magnitude of ground vibration, as measured by the amplitude of waves on a seismometer, and compensated for the distance of the instrument from the earthquake epicenter.

The intensity scale was developed in 1902 by Giuseppe Mercalli and is often referred to as the Mercalli scale. It is based on the effects an earthquake has on people and structures. The scale has been modified over time and is now divided into 12 degrees of severity (see pages 143 – 145 in the Student Book). During an intensity III earthquake, vibrations are felt indoors and hanging objects swing. In an intensity IX earthquake there is general panic and houses may shift off their foundations. Intensity is measured by the observations of people and does not require an instrument for measurement. Therefore, prior to the invention of the seismometer, all earthquake sizes were reported as intensity. Because, in general, intensity decreases with increasing distance away from the source of the earthquake, and an individual earthquake has a range of intensities. The maximum intensity is reported. Intensity can also vary because of underlying geologic materials (soft materials shake more) or types of buildings (older buildings tend to be less earthquake resistant). Intensity requires observers to be present. Therefore, earthquakes in remote areas or under the ocean do not have measured intensities.

Intensity can vary with underlying geology. Solid bedrock is very stiff, so it transmits the energy of the earthquake waves at relatively high speeds and relatively small wave amplitudes. Soft materials, like gravel, sand, clay, or landfill material, on the other hand, are much less stiff and transmit wave energy more slowly but often with much greater amplitudes, thus increasing the observed intensity of the earthquake. Parts of several major cities, including San Francisco and Mexico City, are built on soft material and therefore experience higher intensities than adjacent areas where structures are built on harder rocks. Also, earthquakes sometimes cause water-rich sediments to become temporarily liquefied. This happens when vibrations of some kind cause the packing geometry of the sediment particles to shift to more compact packing, and while the particles are being rearranged, they temporarily lose contact. The material then behaves like a liquid. Structures built on such materials can founder when liquefaction occurs.

Isoseismal maps show areas that have the same earthquake intensity. The maps are constructed by assigning intensities to observations, placing the intensities on a map, and then grouping areas of equal intensity, usually by drawing lines between areas that experienced different intensities.

These maps can be used to identify the general area of the earthquake epicenter. Interpretation of isoseismal maps of historical earthquakes provide estimates of the intensity people will experience if a similar earthquake occurs in the future.

The magnitude scale is based on the amplitude of seismic waves on a seismogram. The scale was originally called the Richter scale, after Charles F. Richter, the geophysicist who developed it in 1935. The original Richter scale was applicable only to certain kinds of relatively shallow earthquakes detected by a certain type of seismometer, and only in southern California. Since then the Richter scale has been modified for more general use. Modern measurements of magnitude are still based on the amplitude of the recorded waves, but more sophisticated methods are now used that are applicable to a wider range of earthquakes anywhere in the world. The magnitude scale is logarithmic; for example, a magnitude 2 earthquake produces 10 times the ground motion of a magnitude 1 earthquake, and a magnitude 3 earthquake produces 100 (10×10) times the ground motion of a magnitude 1 earthquake. A ten-fold increase in ground motion corresponds to about a thirty-fold increase in energy released by an earthquake. For example, a magnitude 2 earthquake releases 30 times more energy than a magnitude 1 earthquake, and a magnitude 3 earthquake releases 900 (30×30) times the energy of a magnitude 1 earthquake. There is no upper limit to the magnitude scale; it is open-ended. In the 1900s only a few earthquakes have had magnitudes equal to or greater than 8.9. Small earthquakes are far more common than large earthquakes; see the table on page 147 of the Student Book. In contrast to the intensity scale, if a large earthquake occurs in a remote area, its magnitude can be calculated using distant seismometers.

The *EarthComm* web site www.agiweb.org/earthcomm contains a variety of links to web sites that will help you to 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.