

## Earthquakes

Have you ever watched raindrops fall onto a lake? Each droplet forms ripples after it hits the water. The ripples move out from the center in all directions. Earthquake waves move in the same way.

An earthquake is a release of earth's energy. It is caused by changes in pressure in the crust due to movements of the Earth's tectonic plates. Rock movements cause the ground to vibrate. This energy moves out from the earthquake in waves, like the ripples on the lake.

An earthquake takes place at a point called the focus. This is a spot below the earth's surface where the rocks move. The epicenter is a point on the surface directly above the focus. This is where the most violent shaking happens. The earthquake waves reach the epicenter first.

Earthquake waves are called seismic waves. There are three types of seismic waves. Each has certain characteristics. They travel in different ways and at different speeds.

The fastest seismic waves are called P-waves. P stands for primary waves. They travel through solids, liquids, and gases. As they move deeper into the earth, they speed up. P-waves cause rock particles to move in the same direction as the waves. They push the rocks forward. The rocks compress. The particles then bounce back in the reverse direction. They run into the particles that are being pushed forward. The rocks move back and forth. If you've ever played with a slinky, you have seen the kind of movement P-waves cause.

Secondary waves, or S-waves, do not move as fast as P-waves. S-waves can only travel through solids. Like P-waves, they move faster through denser material. They are not always recorded at all locations during an earthquake. This is because part of the earth's interior is hot, liquid rock. S-waves do not move through liquids and gases. S-waves cause the rock particles to move in right angles from the wave. If you move one end of a taut rope up and down, you will simulate the movement of S-waves.

The slowest seismic waves are called surface waves. These waves move along the earth's surface in two directions. They produce an up and down movement, like an ocean wave. They also cause rocks to move from side to side. They bend and twist the crust, causing damage especially along fault lines.

Movement along faults is not always smooth. Jagged surfaces cause friction. Pressure builds up in the earth's crust. And last, the energy is released in seismic waves. These waves cause the rocks to move in different directions. The result is an earthquake.

## Earthquakes (cont'd)

If you are close to an earthquake's epicenter, you will feel violent shaking. But it may not last long. As you go farther from the epicenter, you will feel more of a rolling motion. It may be longer in duration. This is because the higher-frequency waves are absorbed into the earth's crust. Usually, the closer you are to the epicenter, the more damage there will be.

Earthquakes are usually measured using the Richter scale. This was developed by Charles Richter in the 1930's. An earthquake measuring a "1" on the Richter scale is not felt by people, but can be measured with seismographs. There may be as many as 8,000 earthquakes measuring a 1-2 each day around the world. Each number on the scale shows an increase of ten more than the previous number. An earthquake measuring a "5" will do ten times more damage than an earthquake measuring a "4."

A "minor" earthquake measures from 3.0 to 3.9. These can be felt by people. As many as 49,000 of these occurred last year. A "light" earthquake measures from 4.0-4.9. With an earthquake of this size, there is noticeable shaking of indoor items. They can cause some damage to homes and property. A "moderate" earthquake measures from 5.0-5.9. These can cause major damage to poorly constructed buildings over a small area. As many as 800 of these occur each year. A "strong" earthquake measures 6.0-6.9. These can cause damage in a 100 mile swath. Around 120 of these occur each year. A "major" earthquake measures 7.0-7.9. They cause serious damage over larger areas. Only about 18 of these occur each year. A "great" earthquake happens only about once each year. They cause serious damage in an area several hundred miles across. An earthquake measuring a 9.0 or greater only happens about once every twenty years. They can cause severe damage several thousand miles across.

Small earthquakes often follow a large earthquake. These "follow up" tremors are called aftershocks. There are usually several of these following a major earthquake. Sometimes the aftershocks can be almost as strong and can cause as much damage as the original quake.

To locate an earthquake, scientists use a seismogram. They measure the time between the P and S waves. This difference tells them how far away from the seismograph the earthquake is located. That still does not tell them exactly where the earthquake is. It could be located anywhere on a circle whose radius is equal to the distance indicated by the measurements. To locate the exact position of the earthquake's epicenter, scientists use seismograph networks.

It takes at least three seismographs to locate the position of an earthquake. Seismologists note the times at which the P-waves and S-waves arrive at the station. They subtract the P-wave time from the S-wave time. They convert this

## Earthquakes (cont'd)

to a distance using a graph. This gives the distance of the station from the epicenter. Scientists set a compass with a scaled radius of this distance. They draw a circle around the location of the station on a map. This shows all possible locations for the earthquake's epicenter.

Seismologists then do the same with the measurements at another station. This narrows the location of the quake to two points where the circles intersect. They do the same thing with the data from a third station. The point where all three circles intersect is the epicenter of the earthquake. This is called triangulation.

Why is knowing the location of an earthquake so important? It tells us where the heaviest damage most likely occurred. It also helps scientists to learn more about the interior of the earth. This information tells us more about the location of faults. It also helps seismologists predict earthquake occurrences.

An earthquake can strike at any time in any place. Scientists have recorded earthquakes around the world over time. This history shows that most occur along the edges of oceanic and continental plates. These plates float around the mantle. Sometimes they collide. This causes an earthquake.

Two of the most frequent locations for earthquakes are California and Japan. This is because they are located on the "Ring of Fire." This is a belt that loops around the Pacific Basin. Huge tectonic plates are on the move in these areas. Many earthquakes occur along this ring.

Alaska has more earthquakes per year than the rest of the United States combined. Almost 4,000 quakes are recorded there every year. Alaska is on a plate boundary where one plate is sliding under another.

Earthquakes can also occur along faults. These are cracks in the earth where blocks of rock are moving in different directions. California is the site of the famous San Andreas Fault. Over 150,000 earthquakes have been recorded in that area.

What factors control the amount of damage that occurs during an earthquake? The amplitude or the size of the surface waves is one factor. Surface waves cause the most damage. Of course, the stronger the wave, the more damage it will cause. Surface waves decrease in size the farther they move from the epicenter of the earthquake. Areas farther from the epicenter will receive less damage.

Another factor that determines the amount of damage from an earthquake is the strength of the buildings involved. Buildings made of stone or concrete are

## Earthquakes (cont'd)

easily damaged. Wood or steel buildings are more resistant. High-rise buildings are more easily damaged than shorter structures.

Earthquakes also cause damage to gas lines. Dangerous fires can be started. The fires that erupted after the San Francisco earthquake of 1906 took many lives and destroyed a large part of the city. It is believed that more people died from the fires after the quake than died from the earthquake itself.

Water lines also can be broken during a quake. Buildings and surrounding areas are often flooded. Earthquakes can also cause damage to the earth itself. In sloping areas, earthquakes can trigger landslides. Whole towns can be suddenly buried. Sandy areas can be saturated with water and turned to quicksand. Trees and houses can sink into the ground. Along fault zones, the damage can be great. The land can suddenly sink or rise. This creates a fault scarp, which is a kind of cliff. Large cracks can form in the surface. These cracks can be several yards wide in places.

If an earthquake occurs under the ocean, a tsunami can occur. This is a large ocean wave. It is formed by the up and down motion of the seafloor. When it begins, the wave is only about one meter high. As it travels to shallower water, it can grow to heights over thirty meters.

Tsunamis can reach the shore at speeds of over 500 kilometers per hour. They are dangerous threats to coastal areas surrounding the epicenter. Tsunamis travel long distances. Some areas are not affected for several days after the earthquake occurs.

A huge earthquake occurred on the ocean floor near Sumatra on December 26, 2004. This was the worst tsunami in the history of the world, and one of the ten worst earthquakes. An estimated 280,000 people lost their lives.

Of course, the worst damage from earthquakes occurs in places that are most populated. Unfortunately, many people live in areas that are prone to earthquakes. There are things that can be done to help control the amount of damage that is done. Buildings can be built lower to the ground. They can also be specially reinforced to resist damage from earthquake vibration. Even so, people who live in these areas need to be prepared for "the big one" at any time.

If you are ever in an earthquake, you should know what to do. Crawl to a safe place under a doorway or strong table. Stay away from windows and the outside walls of the house. Also, stay away from any large objects that might fall on you. Stay indoors until the shaking stops and you're sure it's safe to exit. If you are outdoors, drop to the ground. Try to crawl to a clear spot away from power lines, buildings, and trees.

Name \_\_\_\_\_

Date \_\_\_\_\_

## Earthquakes Questions

1. The point below the surface where the earthquake takes place is called the:
  - a. focus
  - b. epicenter
  - c. P-wave
  
2. What is the epicenter of an earthquake?
  - a. a point below earth's surface where rocks move
  - b. a point on the surface directly above the focus
  - c. a point of triangulation
  
3. The fastest waves are called:
  - a. S-waves
  - b. P-waves
  - c. surface waves
  
4. P-waves cause the rocks to move:
  - a. in the same direction as the waves
  - b. in the opposite direction as the waves
  - c. at right angles to the waves
  
5. Why are S-waves not always recorded at all locations during an earthquake?
  - a. S-waves don't move through the liquid part of earth's interior.
  - b. S-waves don't move through the solid part of earth's interior.
  - c. S-waves only move in one direction.
  
6. Which waves cause the most movement of the rocks during an earthquake?
  - a. S-waves
  - b. P-waves
  - c. surface waves
  
7. Usually, more damage occurs:
  - a. farther away from the epicenter of an earthquake
  - b. closest to the epicenter of an earthquake
  - c. closest to the focus of an earthquake

### Earthquakes Questions (cont'd)

8. What does the difference between the S and P waves tell a seismologist?
  - a. the depth at which the earthquake occurred
  - b. how far from the epicenter the seismograph is located
  - c. the exact position of the earthquake
  
9. How many seismograms does it take to locate the epicenter of an earthquake?
  - a. one
  - b. two
  - c. three
  
10. What do seismologists learn from locating the epicenter of an earthquake?
  - a. where the most damage is occurring
  - b. where faults are located
  - c. how to predict earthquakes
  - d. all of the above
  
11. In what state do the most earthquakes occur every year?
  - a. California
  - b. Japan
  - c. Alaska
  
12. After an earthquake damages a city, other damage is often caused by:
  - a. people rioting
  - b. broken gas and water lines
  - c. broken electrical lines
  
13. What is a tsunami?
  - a. a large ocean wave caused by movement of the ocean floor
  - b. an underwater fault
  - c. a large volcano under the ocean
  
14. What things can people do to lessen damage in earthquake-prone areas?
  - a. build shorter buildings
  - b. reinforce buildings to withstand the stress
  - c. both a and b are correct
  - d. neither a nor b
  
15. Who developed the scale to measure the magnitude of an earthquake?
  - a. Charles Darwin
  - b. Charles Mercalli
  - c. Charles Richter

Name \_\_\_\_\_

Date \_\_\_\_\_

## Earthquakes Answers

### Multiple Choice

1. a
2. b
3. b
4. a
5. a
6. c
7. b
8. b
9. c
10. d
11. c
12. b
13. a
14. c
15. c