EARTHQUAKES

Largest Earthquakes in the World Since 1900

1. Chile (1960), Magnitude = 9.5
2. Alaska (1964), Magnitude = 9.2
3. Sumatra (2004), Magnitude = 9.1
4. Japan (2011), Magnitude = 9.0
5. Russia (1952), Magnitude = 9.0
6. Chile (2010), Magnitude = 8.8
Earthquakes - More Deaths (since 1900)

1. Haiti (2010), Magnitude = 7, deaths ~366,000
2. China (2008), Magnitude = 7.5, deaths ~242,000
3. Sumatra (2012), Magnitude = 9.1, deaths ~228,000
Earthquakes:
- 9/19/2017, Mag=7.1
- 9/7/2017, Mag=8.1

Rock can deform:
- **1. Plastically**
  - Stress deform the rock, when stress is removed, the deformed rock keeps the new shape. Like molding clay.
Rock can deform:

- **2. Elastically**
  - An elastically deformed rock will spring back to its original shape and release its stored elastic energy when the force is removed.
  - However, every rock has a limit beyond which it cannot deform elastically. Under certain conditions, an elastically deformed rock may suddenly fracture.

Rock can deform:

- **2. Elastically**

  The fracture releases the elastic energy, like letting go of one end of the stretched rubber band, and the rock springs back to its original shape. When large masses of rock in Earth’s crust deform and then fracture, the resultant rapid motion creates vibrations that travel through Earth and are felt as an earthquake.
Earthquakes

(A) A road is built across an old fault.

(B) The rock stores elastic energy when it is stressed by a tectonic force.

(C) When the rock moves rapidly along the fault, it snaps back to its original shape, creating an *earthquake*.

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Earthquakes

- The initial rupture point, where abrupt movement creates an earthquake, typically lies below the surface at a point called *the focus*. The point on Earth’s surface directly above the focus is the *epicenter*. 
An earthquake produces several types of seismic waves:
- Body waves (p and s) and surface waves

1. P-waves
- A P wave is a compressional elastic wave that causes alternate compression and expansion of the rock
- P waves are called primary waves because they are so fast that they are the first seismic waves to reach an observer.
- P waves travel at speeds between 4 and 7 kilometers per second in Earth’s crust and at about 8 kilometers per second in the uppermost mantle. (speed of sound in air is only 0.34 kilometer per second)
- P-waves travel through air, liquid, and solid material.
2. **S-waves**

- It is a shear wave. S waves arrive after P waves and are the “secondary” waves to reach an observer.
- Although the wave travels parallel to the path, the individual particles in the rope move at right angles to the path.
- S waves are slower than P waves and travel at speeds between 3 and 4 kilometers per second in the crust.
- Unlike P waves, S waves move only through solids.

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3. **Surface waves**

- Surface waves travel more slowly than body waves. Two types of surface waves occur simultaneously: an up-and-down rolling motion and a side-to-side vibration.
- During an earthquake, Earth’s surface rolls like ocean waves and writhes from side to side like a snake.
A seismograph is a device that records seismic waves. A heavy weight was suspended from a spring. A pen is attached to the. A graph paper was mounted on a rotating drum that was attached firmly to bedrock.
**Seismographs**

- A seismograph is a device that records seismic waves.
- A heavy weight was suspended from a spring. A pen is attached to the. A graph paper was mounted on a rotating drum that was attached firmly to bedrock.
- During an earthquake, the graph paper jiggled up and down, but inertia kept the weight and its pen stationary. As a result, the paper moved up and down beneath the pen. The rotating drum recorded earthquake motion over time. This record of Earth vibration is called a seismographs.
- Modern seismographs use electronic motion detectors, which transmit the signal to a computer.

**Magnitude of earthquake**

3 main types:

1. **Mercalli Scale.** It is based on structural damage. An earthquake that destroyed many buildings was rated as more intense than one that destroyed only a few. Did not accurately measure the energy released by a quake, because structural damage also depends on distance from the focus, the rock or soil beneath the structure, and the quality of construction.

2. **Richter Magnitude.** It is calculated from the height of the largest earthquake body wave recorded on a specific type of seismograph. The Richter scale is more quantitative than earlier intensity scales, but it is not a precise measure of earthquake energy.

3. **Moment Magnitude.** Comes from product the amount of movement and the surface area of a fault that moved during a quake. Most seismologists now use moment magnitude rather than Richter magnitude because it more closely reflects the total amount of energy released during the earthquake.
Magnitude of earthquake

3. Moment Magnitude (Mw).

- In a seismogram, an order of magnitude higher is equivalent to:
  - 10 times larger displacement in the seismogram, and
  - 32 times more release of energy.
  - Mw=6 ~ 1 Hiroshima atomic bomb
  - Mw=7 ~ 32 Hiroshima atomic bomb
  - Mw=8 ~ (32x32) =1024 Hiroshima atomic bomb

Locating Earthquakes

- P waves travel faster than S waves, and the surface waves are the slower.

- If a seismograph is located close to an earthquake epicenter, the different waves will arrive in rapid succession.
- On the other hand, if a seismograph is located far from the epicenter, the waves arrive at correspondingly later times after the P waves arrive, and the surface waves are even farther behind.
Locating Earthquakes

- P waves travel faster than S waves, and the surface waves are the slower.

The first P wave arrives 3 minutes before the first S wave, the recording station is about 1,900 kilometers from the epicenter. But this distance does not indicate whether the earthquake originated to the north, south, east, or west. To pinpoint the location of an earthquake, geologist compare data from three or more recording stations.

Locating an earthquake. The distance from each of three seismic stations to the earthquake is determined from time-travel curves. The three arcs are drawn. They intersect at only one point, which is the epicenter of the earthquake.