Earthquakes

Photo credit: USGS
Pancaked Building - 1985 Mexico City

Earthquakes don’t kill people - buildings do!
An earthquake is the motion or trembling of the ground produced by sudden displacement of rock in the Earth's crust. Earthquakes result from crustal strain, volcanism, landslides, and collapse of caverns.
Structural failure #1

Northridge, California Earthquake
January 17, 1994
Magnitude 6.7

Photo Credit: J. Dewey, U.S. Geological Survey
Structural failure #2

Loma Prieta earthquake,
October 17, 1989
Oakland, California
Magnitude: 6.9

Photo Credit: H.G. Wilshire,
U.S. Geological Survey
Structural failure #3

Santa Monica Freeway
Northridge earthquake,
January 17, 1994
Magnitude 6.7

Photo credit: M. Celebi,
U.S. Geological Survey
Structural failure #4

Armenian Earthquake December 7, 1988
Spitak, Armenia
Magnitude 6.9

Photo Credit: C.J. Langer, U.S. Geological Survey
Structural failure #5

San Francisco, CA, October 18, 1989
Loma Prieta earthquake
Magnitude 6.9

Photo Credit: D. Perkins,
U.S. Geological Survey
Structural failure #6

Izmit (Kocaeli) earthquake, August 17, 1999
Izmit, Turkey
Magnitude 7.4

Photo Credit: National Geophysical Data Center
Landshift #8

Motagua, Guatemala
February 4, 1976
Magnitude 7.5

Photo Credit: U.S. Geological Survey
Landshift #9

Government Hill School, March 27, 1964
Anchorage, Alaska
Magnitude 9.2
Landslide #10

El Salvador
January 13, 2001
Magnitude 7.6

Photo Credit: USGS
Landslide #11

Puget Sound, Washington
May 2, 1996
Magnitude 5.3

Photo Credit: USGS
Landslide #12

Seattle, Washington
April 29, 1965
Magnitude 6.5

Photo Credit: University of California, Berkeley
Landslide #13

Alaska Earthquake
March 27, 1964
Magnitude 9.2

Photo Credit: U.S. Geological Survey, Menlo Park, CA
Liquefaction #14

Niigata, Japan
June 16, 1964
Magnitude 7.4

Photo Credit: National Geophysical Data Center
Resulting fires #15

Great Alaska Earthquake
March 28, 1964
Valdez, Alaska
Magnitude 8.4

Photo Credit: EERI,
Slides on Learning from Earthquakes, Set IV
Resulting tsunami #16

Alaska Earthquake
March 28, 1964
Whittier, Alaska
Magnitude 9.2

Photo credit: U.S. Geological Survey
Resulting tsunami #17

Flores Island, Indonesia
September 1, 1992
Magnitude 7.0

Photo Credit: Harry Yeh, University of Washington
Earthquakes

- Forces inside the earth
- Causes of earthquakes
- Rocks push pull or slide beyond their elastic limit causing faults
Fault is an area where rock move against each other.
Earthquake

- is an area where pressure builds then a rock breaks causing a sudden release of energy
What are the three forces inside the earth and what is their direction of movement?*

- Normal Faults – Tension force
- Reverse Faults – compression force
- Strike slip Faults – shear forces

What are the three fault types and what force cause each?*
Plate Boundaries

- Plate boundary is where areas of the crust move different directions
  - Divergent
    - Where two plates move apart
    - Normal fault
  - Convergent
    - Where two plates move together
    - Reverse fault
  - Transform
    - Where two Plates slide by each other
    - Strike slip fault

What type of fault is at a convergent plate boundary?*
What type of fault is at a divergent plate boundaries?*
Earthquake information

- Earthquake focus: the point in earth’s interior where the energy is released along a fault.
- Epicenter: the area directly above the fault.
Quiz

1. What are the three types of faults and what force causes each?
2. What are the three types of plate boundaries and what type of faulting is at each type?
Seismic Waves

- **Primary waves** – move in the same direction wave is moving (compressional wave)

- **Secondary wave** – The particles in the Earth move at right angles to the direction the wave is going (Transverse)

- **Surface waves** – travel on the surface directly outward from the epicenter
  - Surface waves cause the most destruction during an earthquake

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Which seismic wave does the most property damage and why?*

List the seismic waves in order from the fastest to the slowest.*
Seismic Wave Types

Body Waves

Surface Waves
Which type of waves stretch and compress rocks?
Locating the Epicenter

- Scientist use the different speeds that primary, secondary and surface waves travel to calculate distance from epicenter.
- If there are 3 seismographical stations making distance recording they can find the epicenter.

Why is a seismic record from three location needed to determine the position of an epicenter?*

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*Why is a seismic record from three location needed to determine the position of an epicenter?*
Earthquake Location by Range

Epicenter

Denver 2000 km

St. Johns

Y 5300 km

Lima 9000 km

X

Z

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Locating the Epicenter

How can a seismologist tell how far a recording station is from the epicenter?*

*Map showing the locations of various seismograph stations across North America and the calculation of epicenter distance using circular arcs. The map includes labels for B = Berkeley, D = Denver, NY = New York, and the epicenter symbol.
Earthquakes & Earth’s Structure

- help scientist understand the structure of the earth
Earth’s Structure

- Inner core solid dense are composed of iron and nickel
- Outer core – liquid iron & nickel
- Mantle – molten silicon, Iron, oxygen & magnesium
- Crust – outer most layer separated from the mantle by Moho discontinuity
- Lithosphere is made up of the crust and upper mantle
Be able to label the different areas on the earth.*

Earth’s Structure
Shadow zone
• Secondary waves are stopped completely by liquid outer core primary waves are slowed
Shadow zone - is the area where no wave is detected.

Destruction of Earth Quakes
Shadow Zone

- Earthquake epicenter
- Key:
  - P-wave (black arrows)
  - S-wave (red arrows)
- S-wave shadow zone
- Seismic station records:
  - Both P and S waves (black and red waves)
  - No P or S waves (black and red waves)
  - P waves only (black waves)
Seismology

- Study of earth quakes
Seismograph

- records seismic waves
  - Use drum attached to the earth and a stationary pendulum

*Explain how a seismograph works.*
Seismograph

How can a seismologist tell how far a recording station is from the epicenter?*
Vertical Component Seismometer
Horizontal Component Seismometer

- Revolving paper-covered drum
- Heavy weight
- Wire
- Column
- Pen
- Ground movement
- Rock
What scale is used to measure the magnitude of an earthquake?*

What conditions cause greater loss of life in different earthquakes with the same magnitude?*

Richter scale

- the energy in the break is measured
- The greater the energy, the greater the earthquake
- For each increase of one, the amplitude of the largest surface wave increases by 10
- About 32 times as much energy is released with each increase of one on the Richter scale.

<table>
<thead>
<tr>
<th>Effects of Tremor</th>
<th>The Richter Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only detected by seismometers</td>
<td>2</td>
</tr>
<tr>
<td>Felt by walkers, window and doors rattle</td>
<td>4</td>
</tr>
<tr>
<td>Severe structural damage to houses</td>
<td>6</td>
</tr>
<tr>
<td>Total destruction, ground actually rises and falls</td>
<td>8</td>
</tr>
</tbody>
</table>
Tsunamis

- earth quake in the ocean that cause an abrupt change and a wave to come ashore
How Tsunamis Work: Tsunamigenesis

- UPWARD WAVE
- FAULT LINE
- crust
- mantle