

**Earthquake**

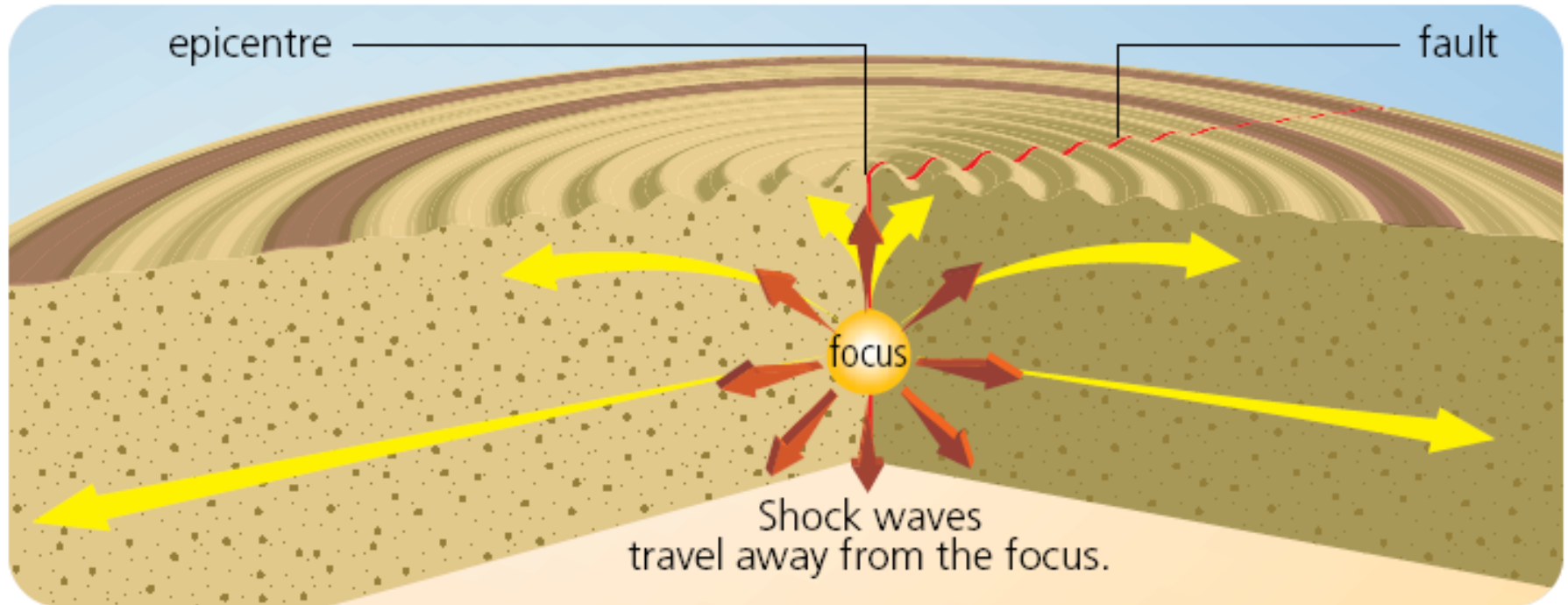
# What is an earthquake?

Earthquake is the **vibration (shaking) and/or displacement of the ground** produced by the **sudden release of energy**.

- Rocks under *stress* accumulate *strain energy* over time.
- Stress results from tectonic plate movement, magmatic or volcanic activity.
- When stress exceeds strength of rocks, rock breaks and slips.
- Rock slippage/rupture occurs at the weakest point (*fault*).
- Strain energy is released as **seismic waves**.



# Focus and Epicenter

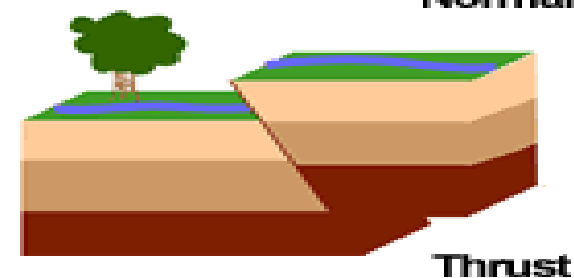
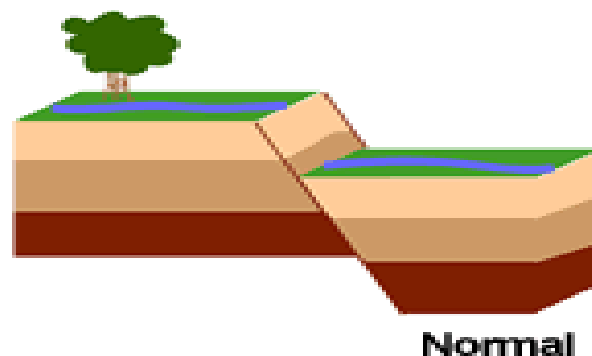
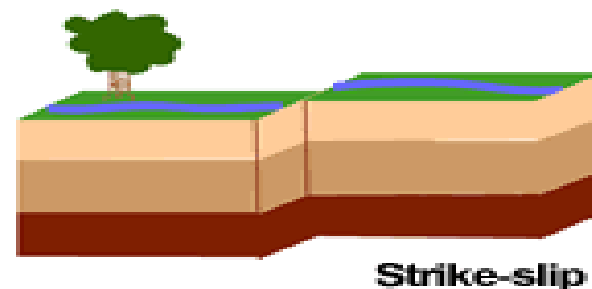


- **Focus** – point inside the Earth where an earthquake begins (*point of initial rupture*). The majority of tectonic earthquakes originate in depths not exceeding tens of kilometers.
- **Epicenter** – point on the surface of the Earth directly above the focus where the shaking is usually felt most strongly.

# Geological Faults

Earthquakes most often occur along existing faults: **planar fractures in a volume of rock**, across which there has been significant displacement as a result of prior movement.

- **Strike-slip faults** are vertical (or nearly vertical) fractures where the blocks have mostly moved horizontally.
- If the rock mass above an ***inclined fault*** moves down, the fault is termed **normal**, whereas if the rock above the fault moves up, the fault is termed **thrust**.
- Faults are found alone or in clusters, creating a **fault zone**.



# What type of faults are these?



↑  
**Normal**



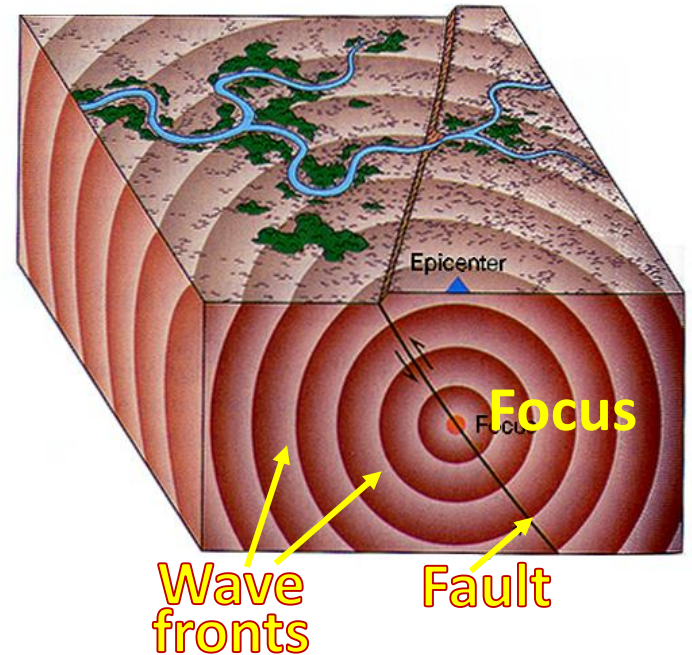
↑  
**Strike-slip**



←  
**Thrust**

# Seismic Waves

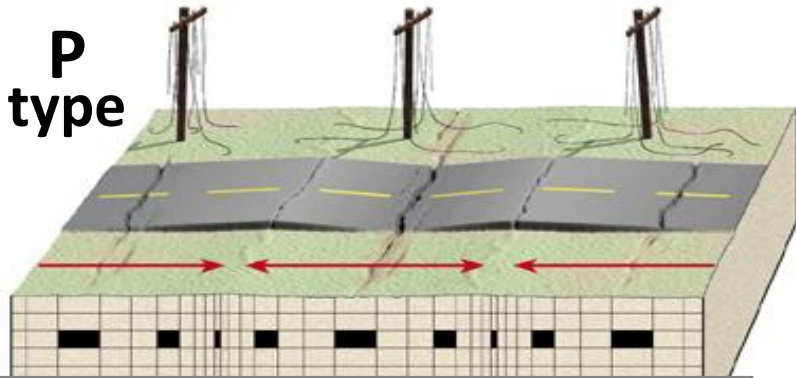
- Energy released from the earthquake source (its focus) radiates in all directions.
- Energy is in the form of waves called **seismic waves**.
- Earthquakes create distinct types of seismic waves that travel through the Earth's layers with different velocities:
  1. Body waves - travel through the Earth interior (*travel fast*).
  2. Surface waves - travel on the Earth surface (*travel slow – more destructive!*).



# Types of Seismic Waves

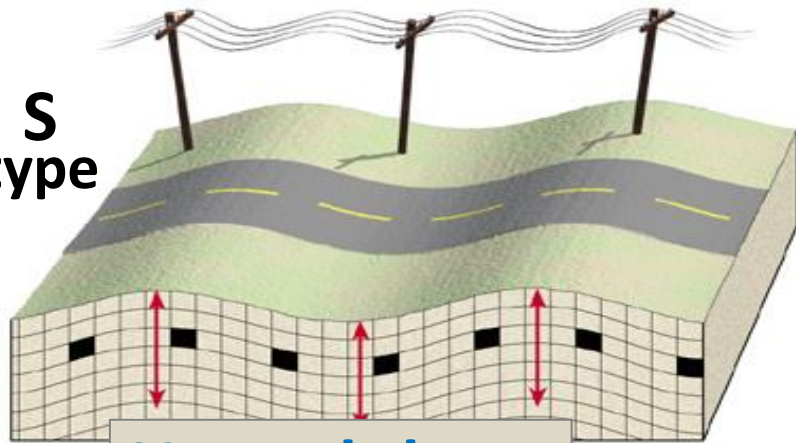
## BODY WAVES

**P**  
type



**Compression-expansion**

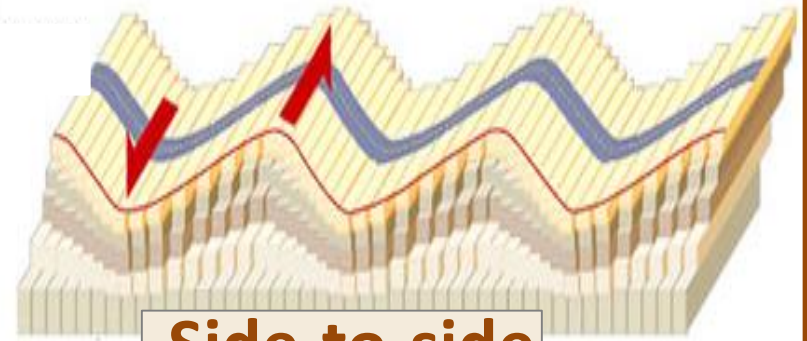
**S**  
type



**Up-and-down**

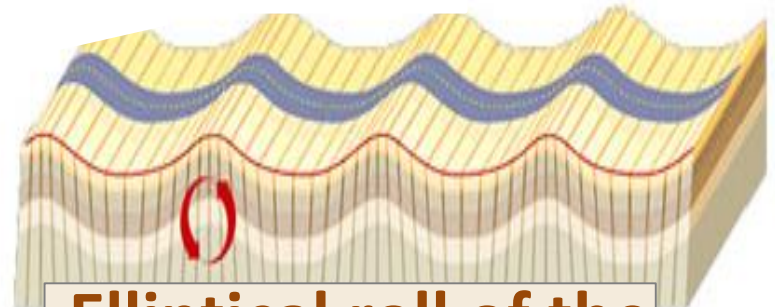
## SURFACE WAVES

**L**  
type



**Side-to-side  
horizontal  
movement**

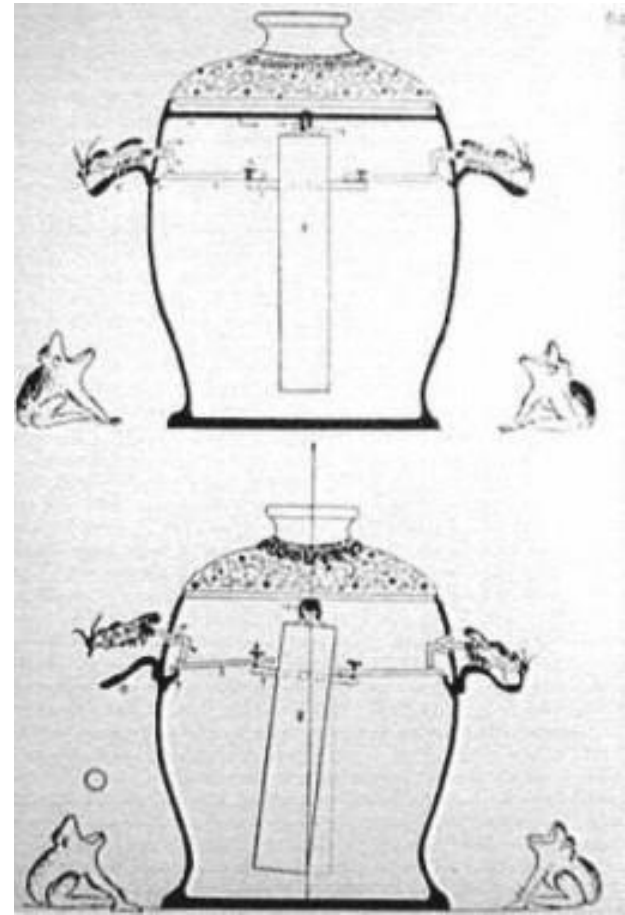
**R**  
type



**Elliptical roll of the  
ground oriented  
vertically**

# Detecting an Earthquake

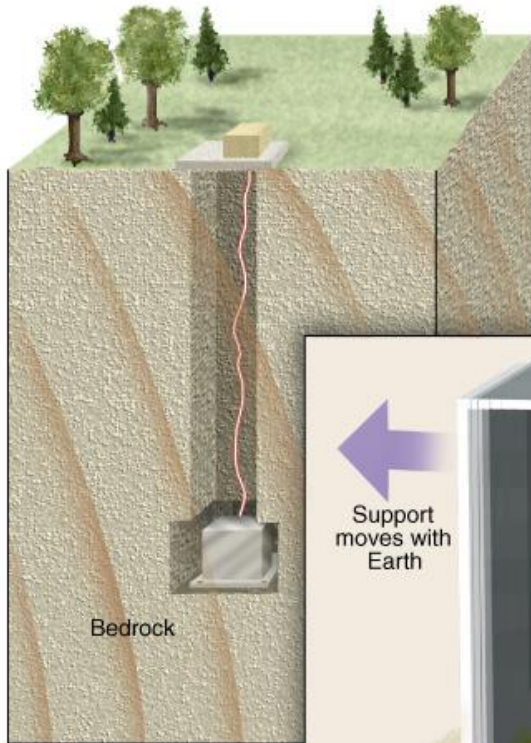
Chinese created the first earthquake detector  
2000 years ago!





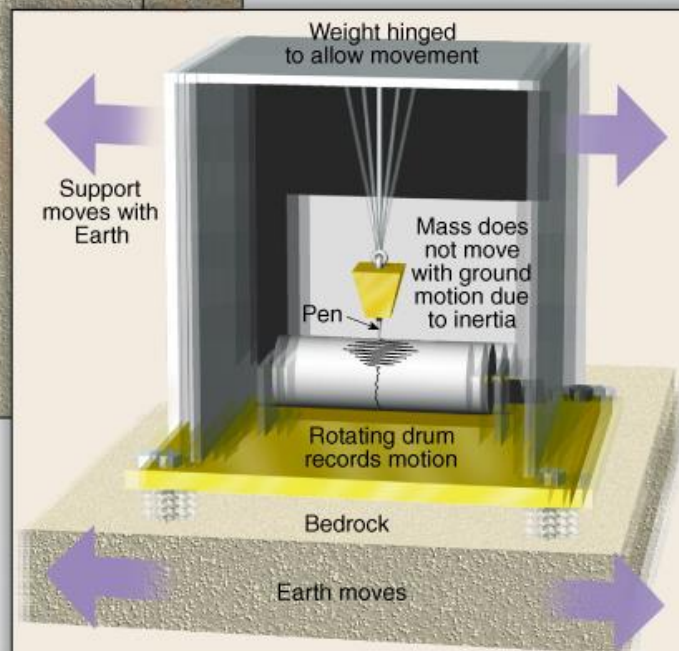
# Measuring an Earthquake

Earthquakes are measured using observations from **seismographs**, instruments that record seismic waves.

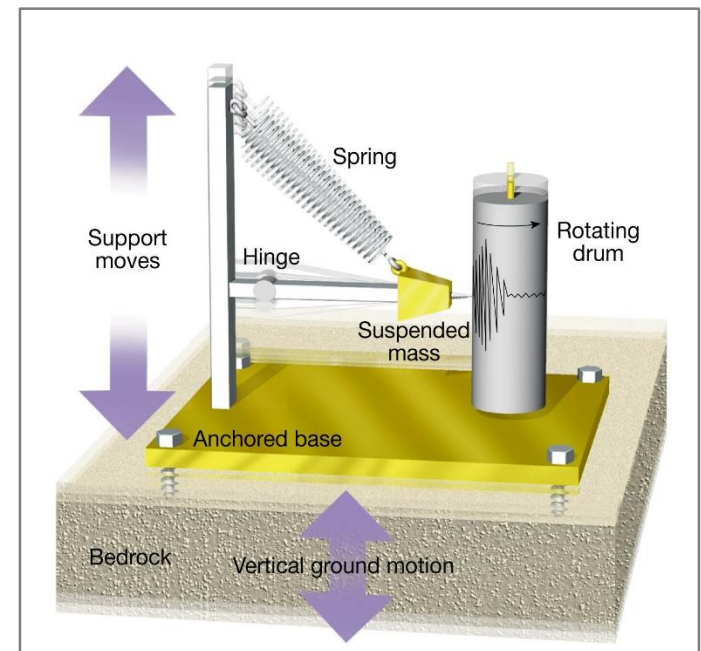


Different *seismograph* types are needed to record both vertical and horizontal ground motion:

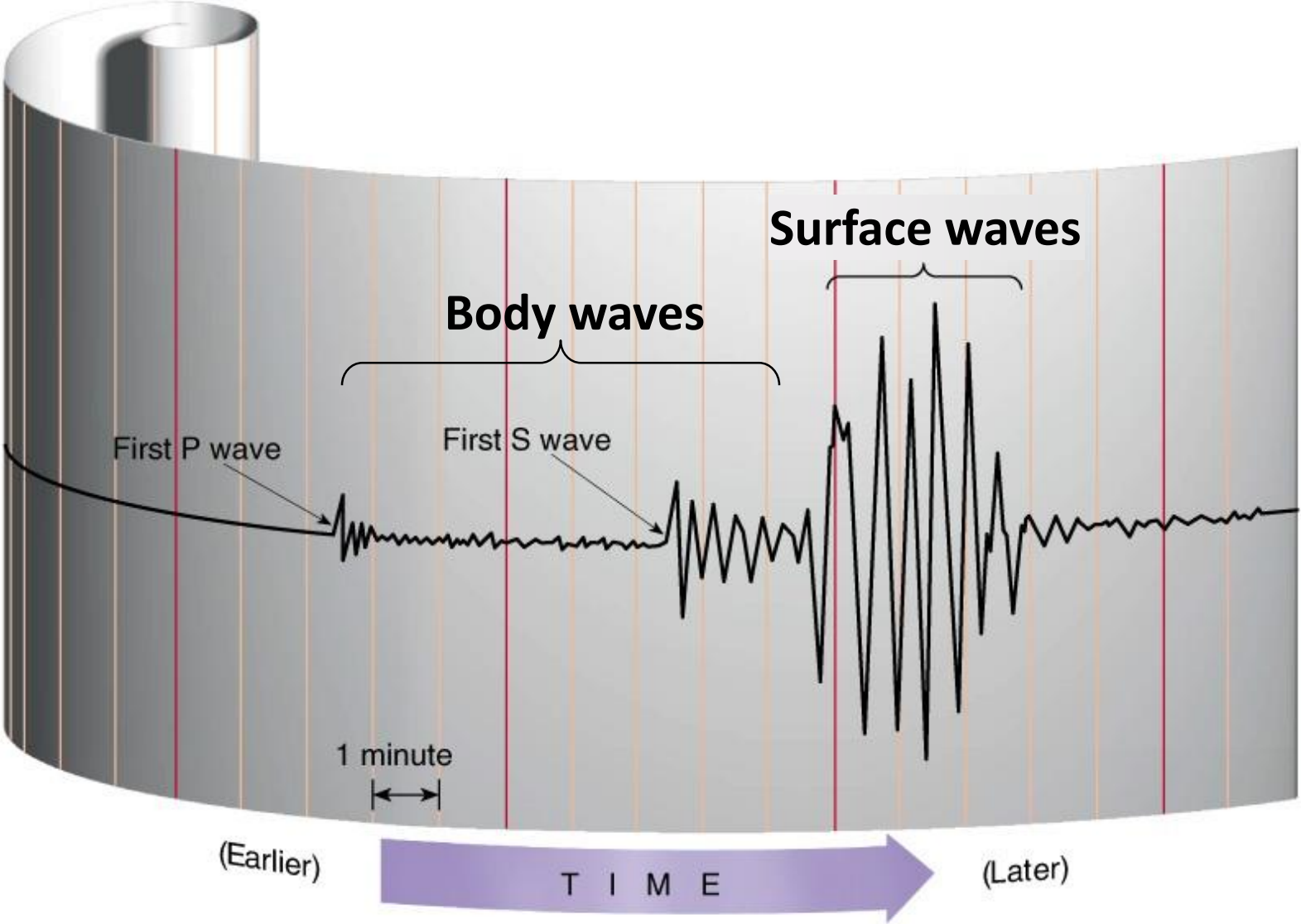
## Horizontal



## Vertical

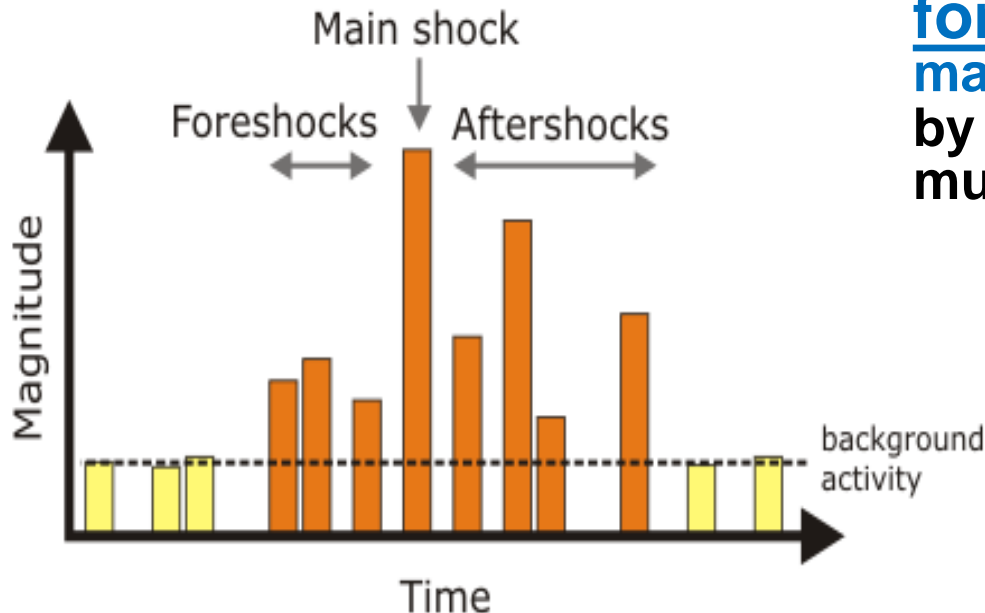


# Simplified Seismogram



# Foreshocks and Aftershocks

Earthquakes often occur as a sequence rather than individual events:

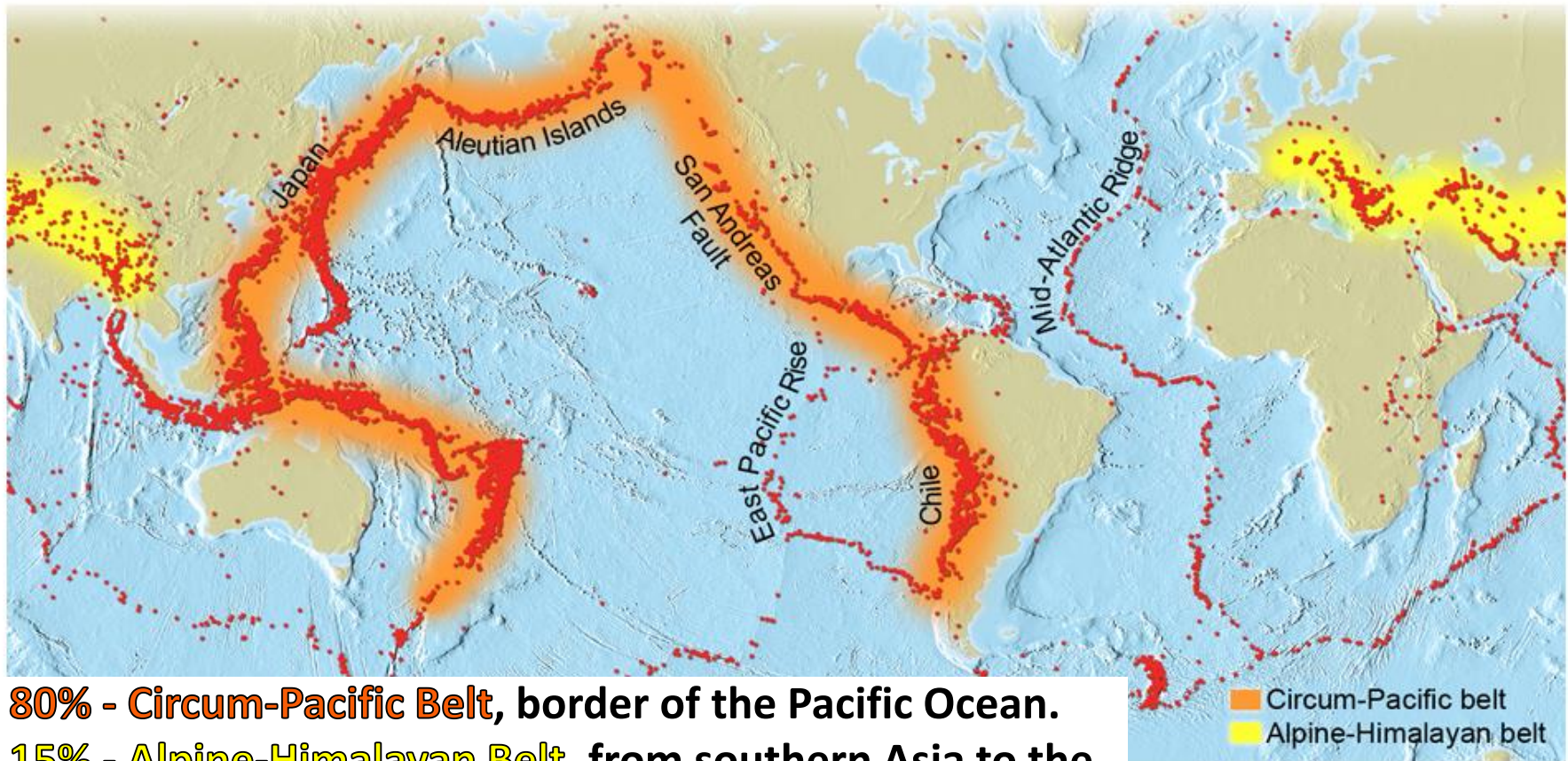


- Small earthquakes, called **foreshocks**, often precede a **major earthquake (main shock)** by days or, in some cases, by as much as several years.
- **Adjustments of crust** (redistribution of stress on the fault) that **follow a major earthquake** often generate smaller quakes in the same area called **aftershocks**.

- **Bigger earthquakes** often have *more and larger* aftershocks and the sequences can last for years.
- **Earthquake swarms** are **sequences of earthquakes** striking in a specific area within a short period of time in which **no single earthquake has notably higher magnitudes** than the other.

# Earthquakes Around the World

mostly happen around tectonic plate boundaries.



**80% - Circum-Pacific Belt**, border of the Pacific Ocean.

**15% - Alpine-Himalayan Belt**, from southern Asia to the Mediterranean region.

**5% - parts of the Arctic, Atlantic, and Indian Oceans.**

**Antarctica and Australia experience the least amount of earthquake activity** then any other areas of the world.

Graph shows 15,000 larger magnitude (>5) earthquakes over 10-year period.

# How common are earthquakes?

- It is estimated that **around 500,000 earthquakes occur each year**, detectable with current instrumentation.
- About **100,000** of these **can be felt** (ground shaking during a moderate to large earthquake typically lasts about 10 to 30 seconds).
- **Minor earthquakes occur nearly constantly** around the world; **larger earthquakes occur less frequently**.
- While most earthquakes are caused by movement of the Earth's tectonic plates, the following human activities can also produce earthquakes:
  - storing large amounts of water behind a dam
  - drilling and injecting liquid into wells
  - coal mining and oil drilling

# **Additional Information**

**<http://earthquake.usgs.gov/learn/animations/>**

**<http://earthquake.usgs.gov/learn/facts.php>**