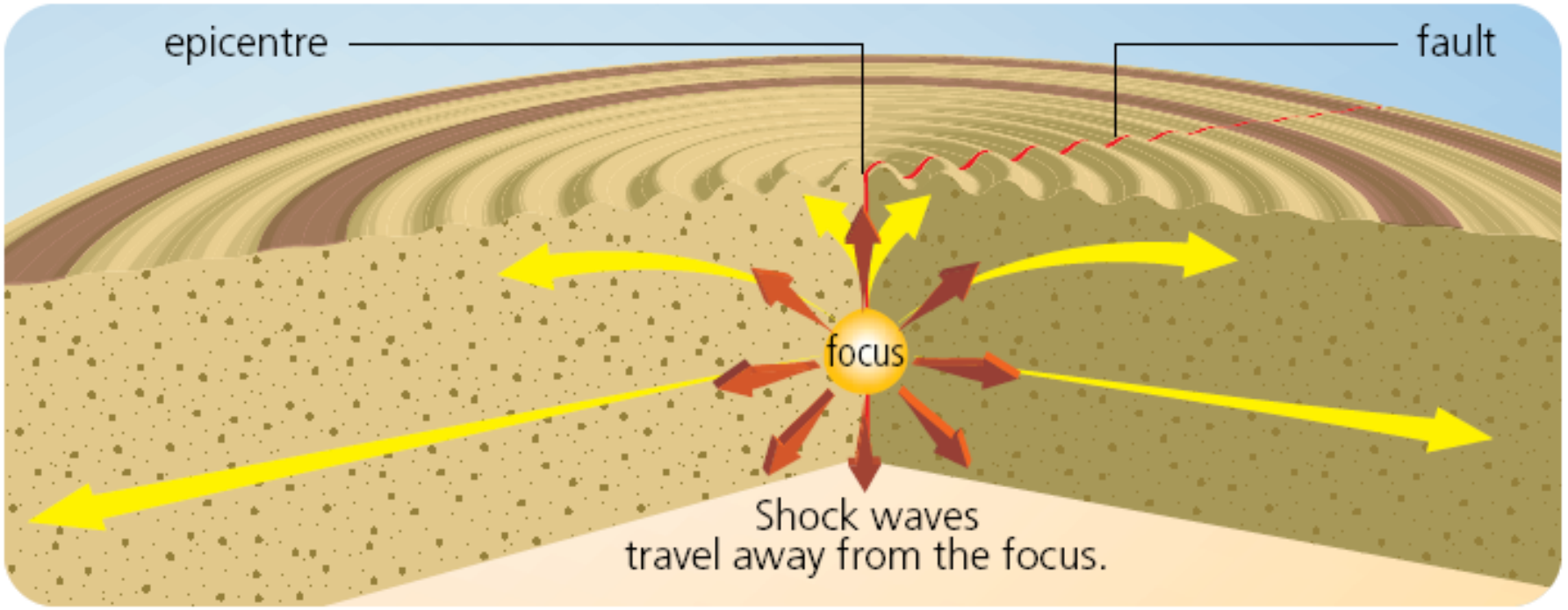
Earthquake

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

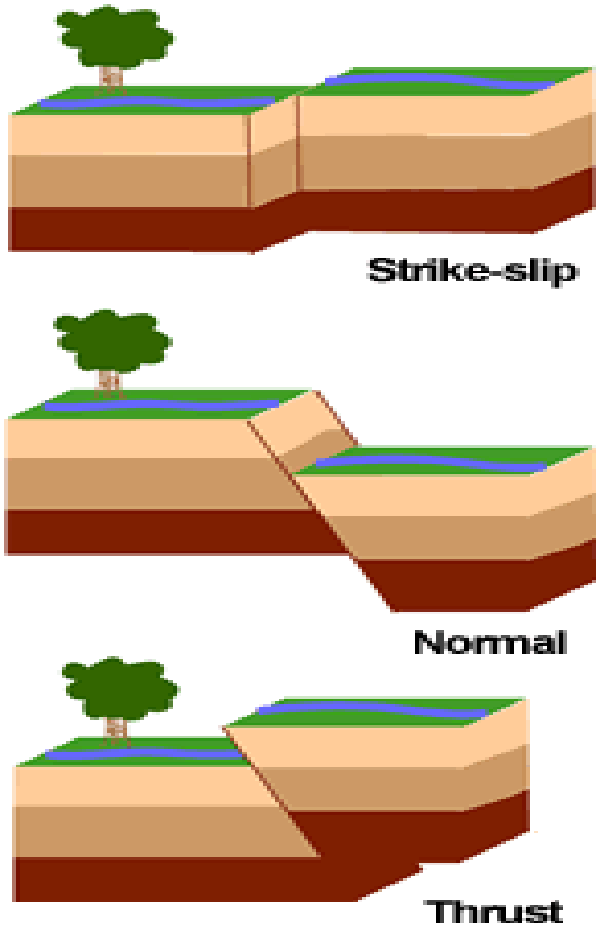


- **Focus – point <u>inside</u> the Earth <u>where an earthquake begins</u> (*point of initial rupture*). The majority of tectonic earthquakes originate in depths not exceeding tens of kilometers.**
- **Epicenter – point <u>on the surface</u> of the Earth <u>directly above the focus</u> where the shaking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

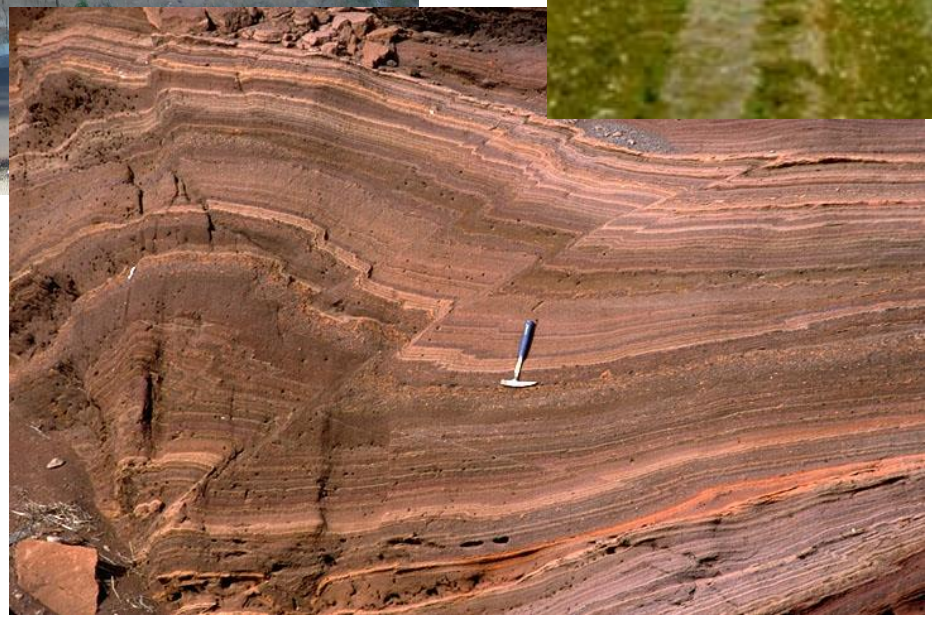
- **Strike-slip faults are vertical (or nearly vertical) fractures where the blocks have mostly moved horizontally.**
- **If the rock mass above an *inclined fault* moves down, the fault is termed normal, whereas if the rock above the fault moves up, the fault is termed thrust.**
- **Faults are found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



What type of faults are these?

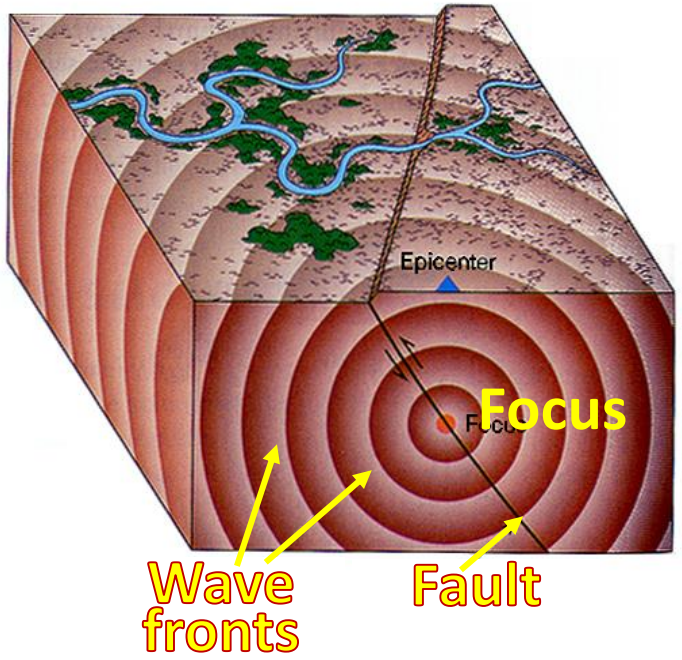
Normal

Strike-slip



Thrust

Seismic Waves



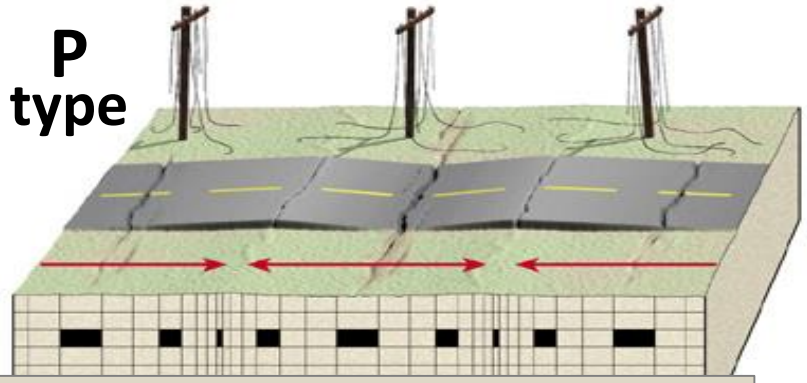
- **<u>Energy</u> released from the earthquake source (its focus) <u>radiates in all directions</u>.**
- **Energy is in the form of *waves* called seismic waves.**
- **Earthquakes create <u>distinct types of seismic waves</u> that travel through the Earth's layers with different velocities:**

1. **<u>Body waves</u> - travel through the Earth <u>interior</u> (*travel fast*).**
2. **<u>Surface waves</u> - travel on the Earth <u>surface</u> (*travel slow – more destructive!*).**

Types of Seismic Waves

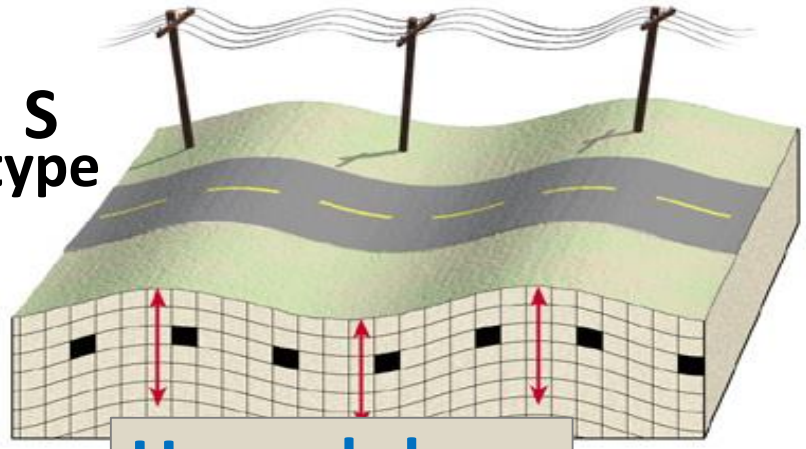
BODY WAVES

P type



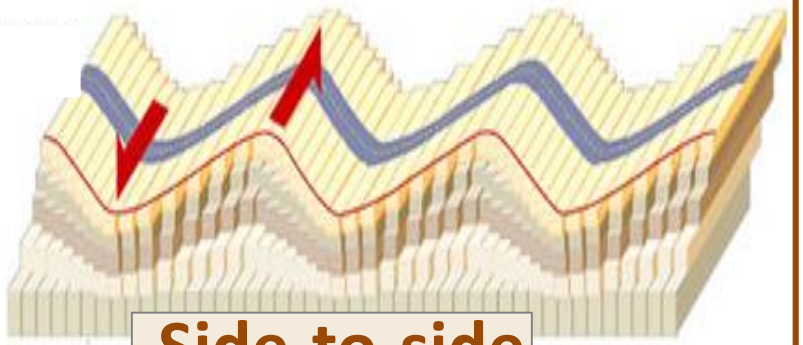
Compression-expansion

S type



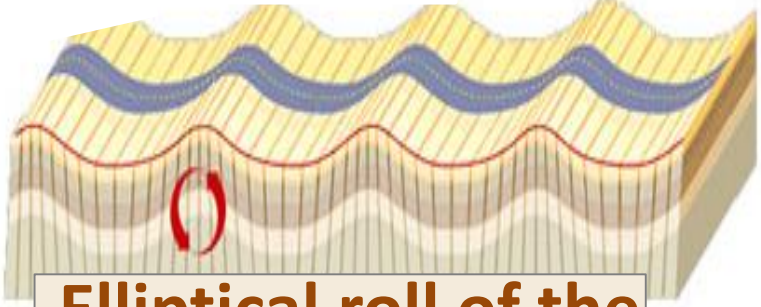
Up-and-down

SURFACE WAVES



L type

Side-to-side horizontal movement

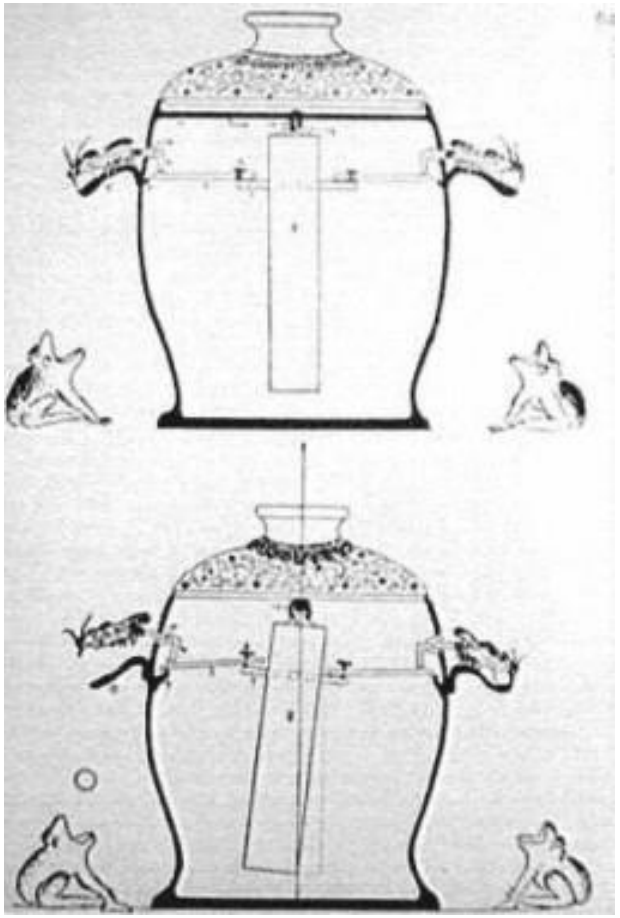


Elliptical roll of the ground oriented vertically

R type

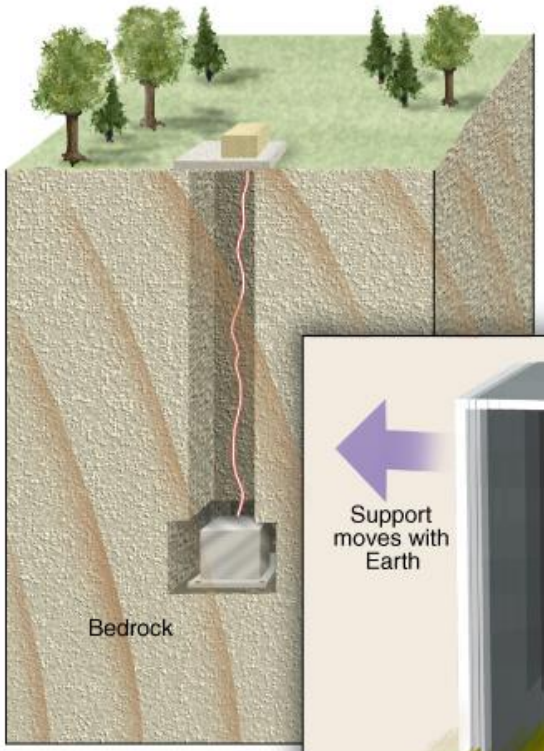
Detecting an Earthquake

Chinese created <u>the first earthquake detector</u> 2000 years ago!



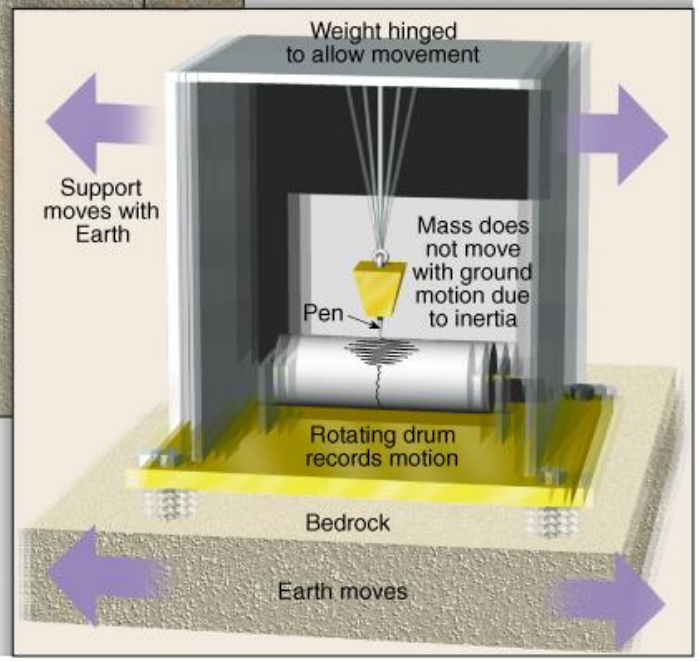
Measuring an Earthquake

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

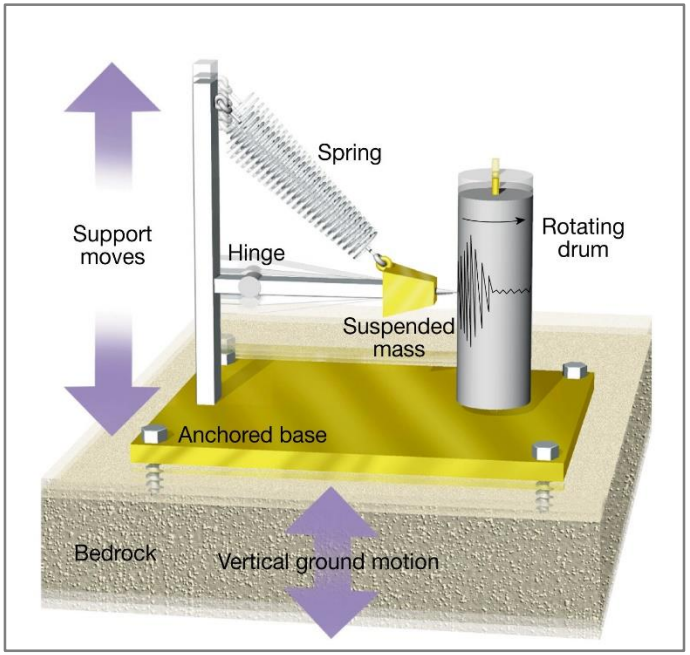


Different *seismograph types* are needed to record both <u>vertical</u> and <u>horizontal</u> ground motion:

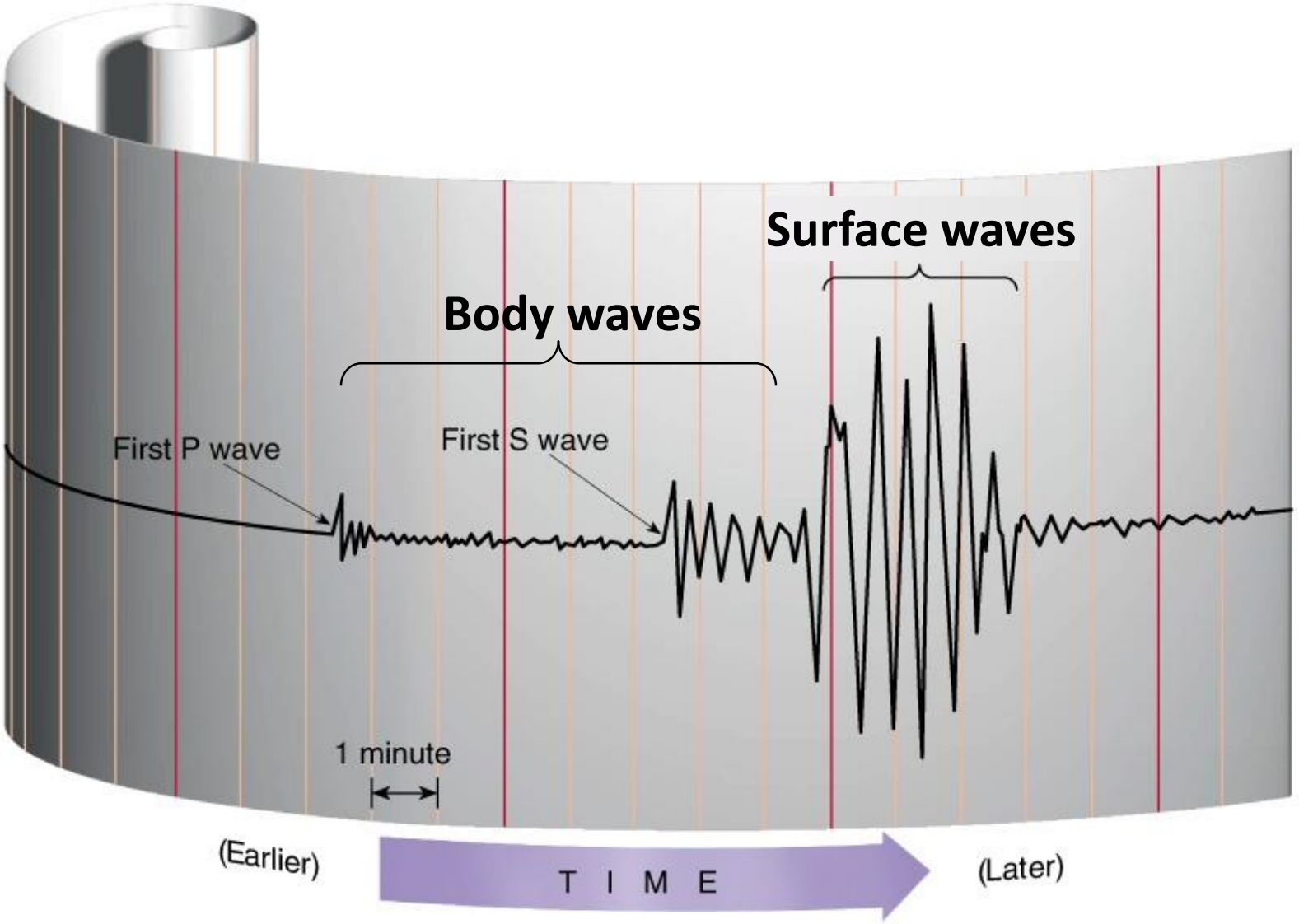
Horizontal



Vertical

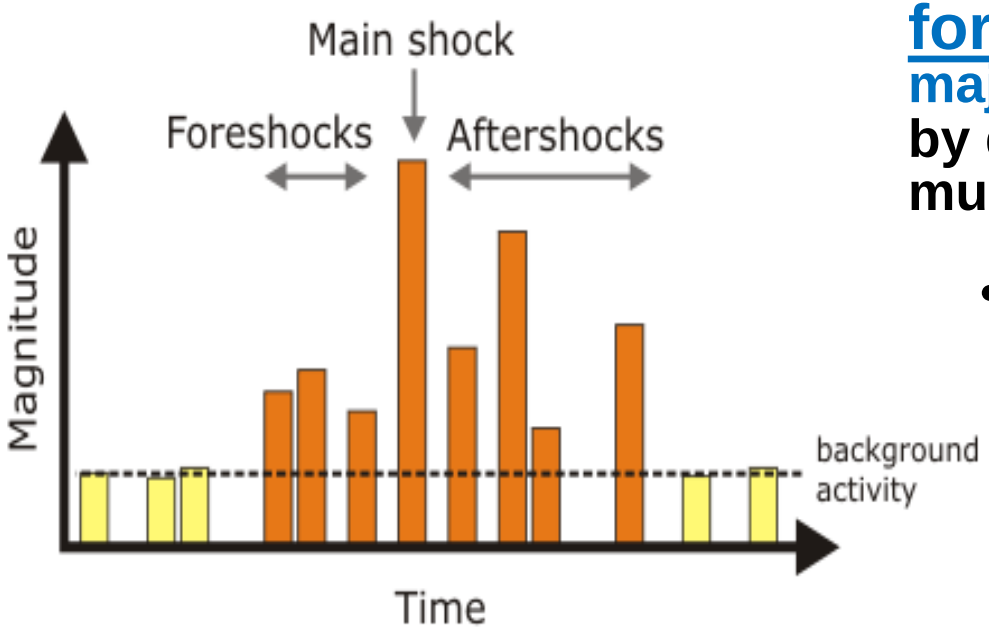


Simplified Seismogram



Foreshocks and Aftershocks

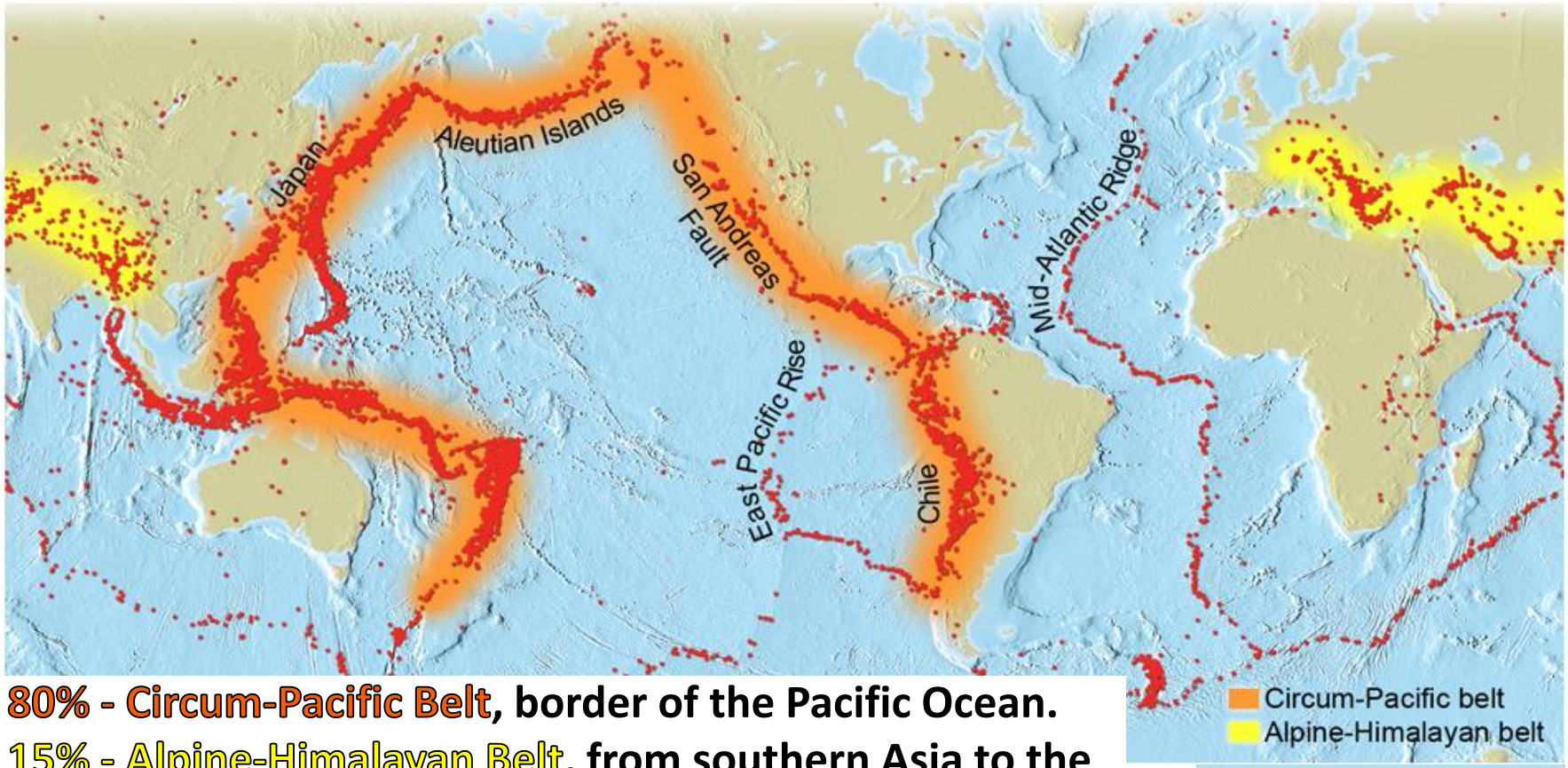
Earthquakes often occur as a sequence rather than individual events:



- **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