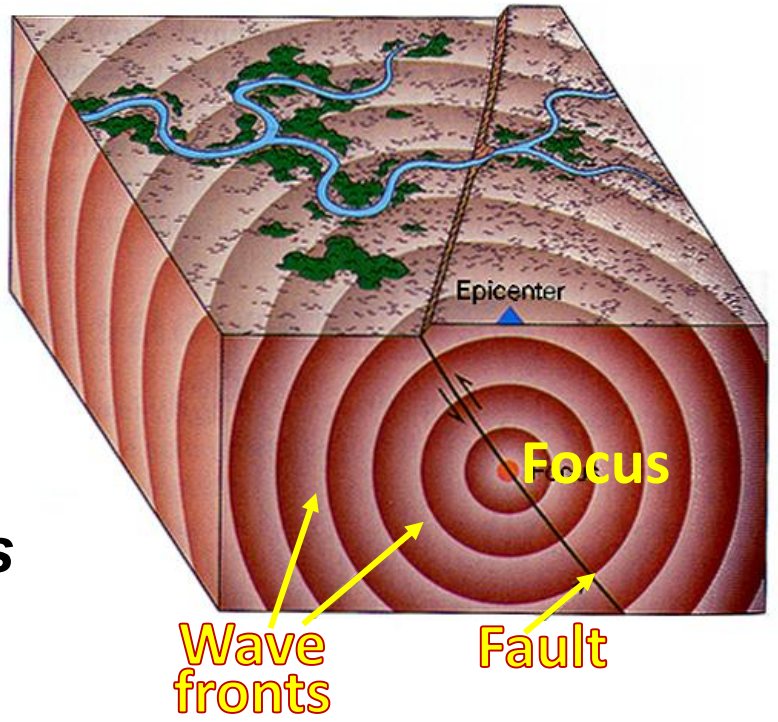
Seismic Waves



- **Energy released from the earthquake source (its focus) radiates in all directions.**

- **Energy is in the form of *waves* called seismic waves:**

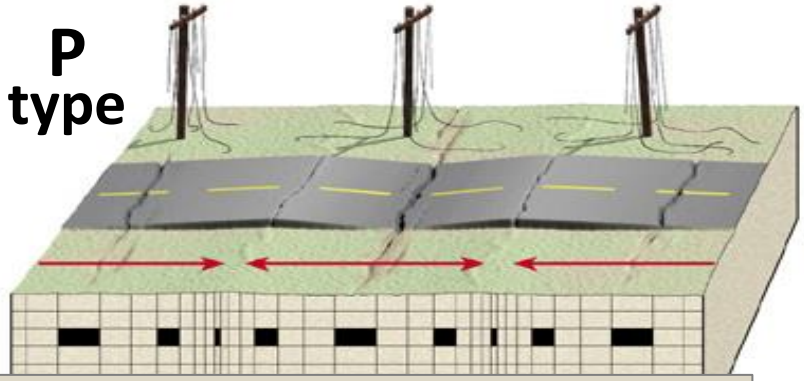
1. **Body waves (*Primary* waves and *Secondary* waves) - travel fast through the Earth interior.**

2. **Surface waves (*Love* waves and *Rayleigh* waves) - travel on the Earth surface; have lower frequency and travel more slowly than body waves - more destructive.**

Types of Seismic Waves

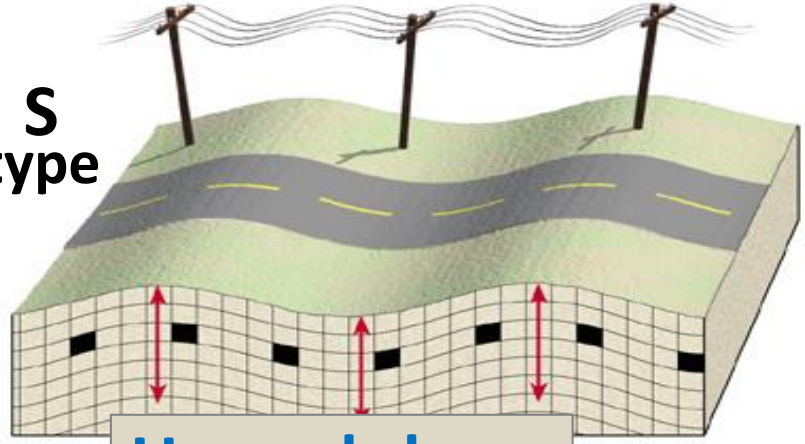
BODY WAVES

P type



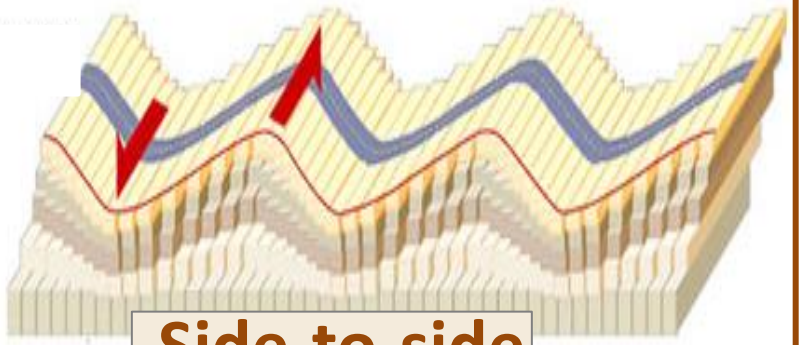
Compression-expansion

S type



Up-and-down

SURFACE WAVES



L type

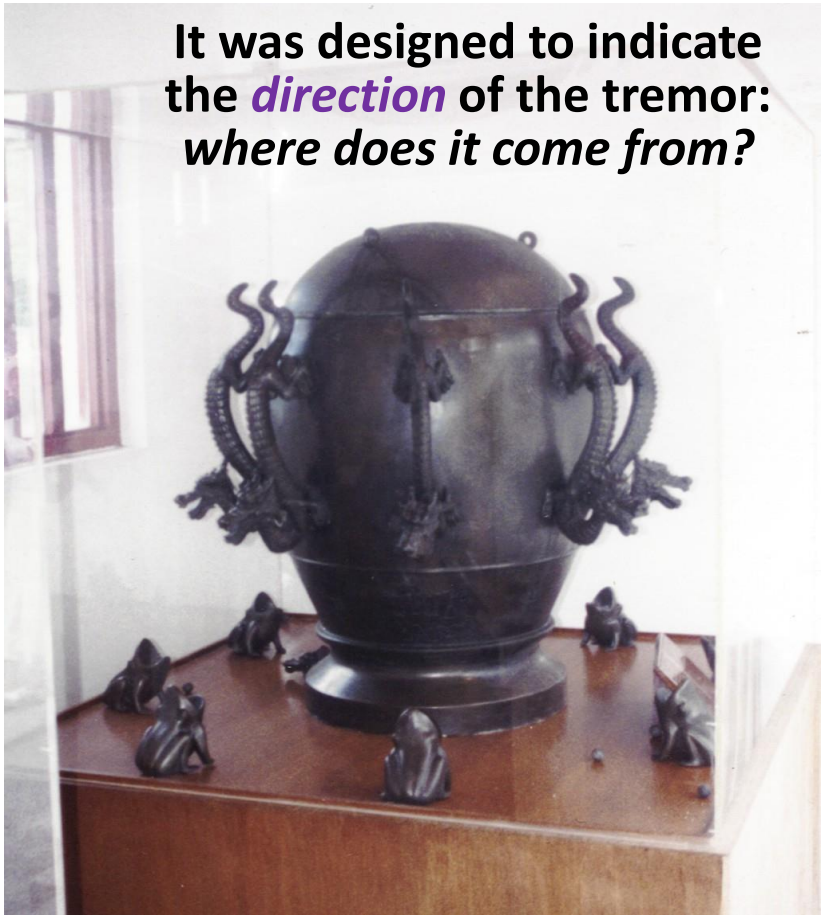
Side-to-side horizontal movement

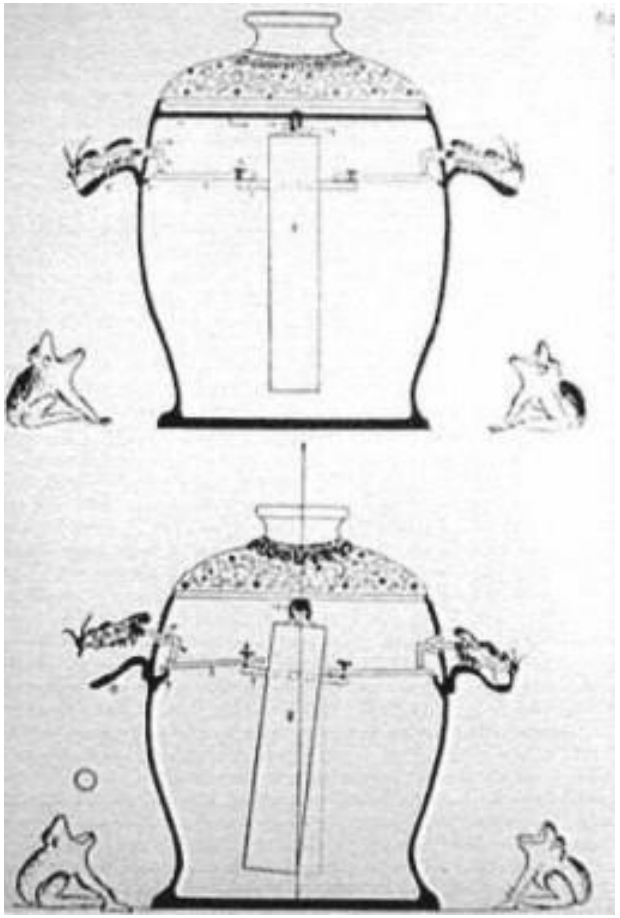
Elliptical roll of the ground oriented vertically

R type

Detecting an Earthquake

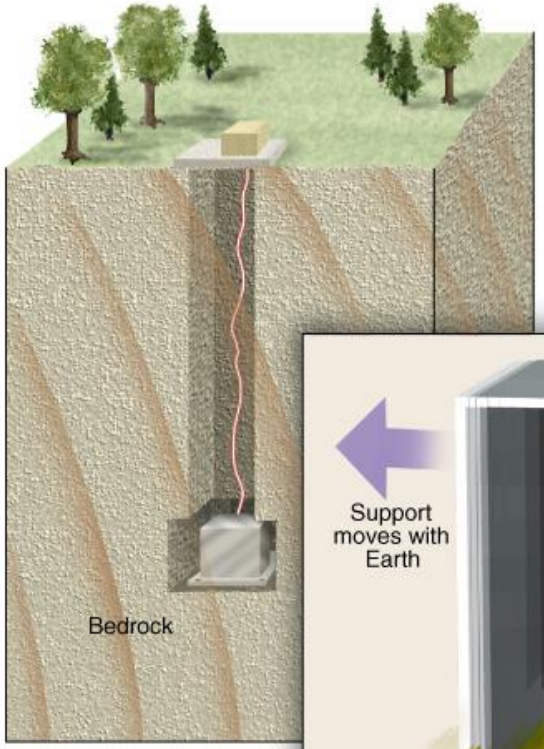
Chinese created <u>the first earthquake detector</u> over 2000 years ago!





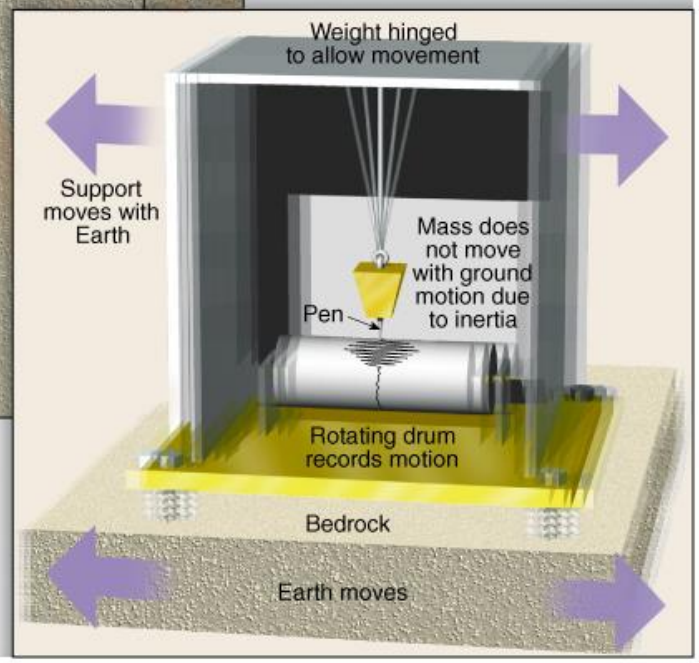
Measuring an Earthquake

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

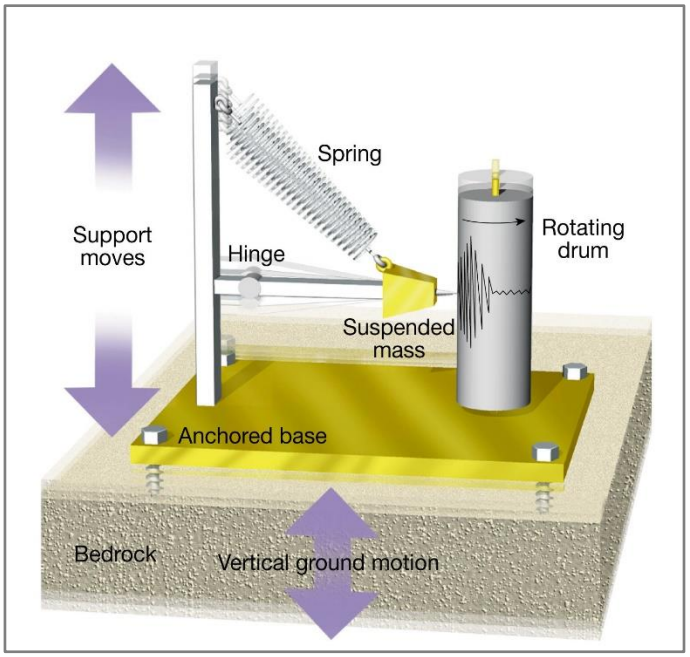


Different *seismograph types* are needed to record both <u>vertical</u> and <u>horizontal</u> ground motion:

Horizontal

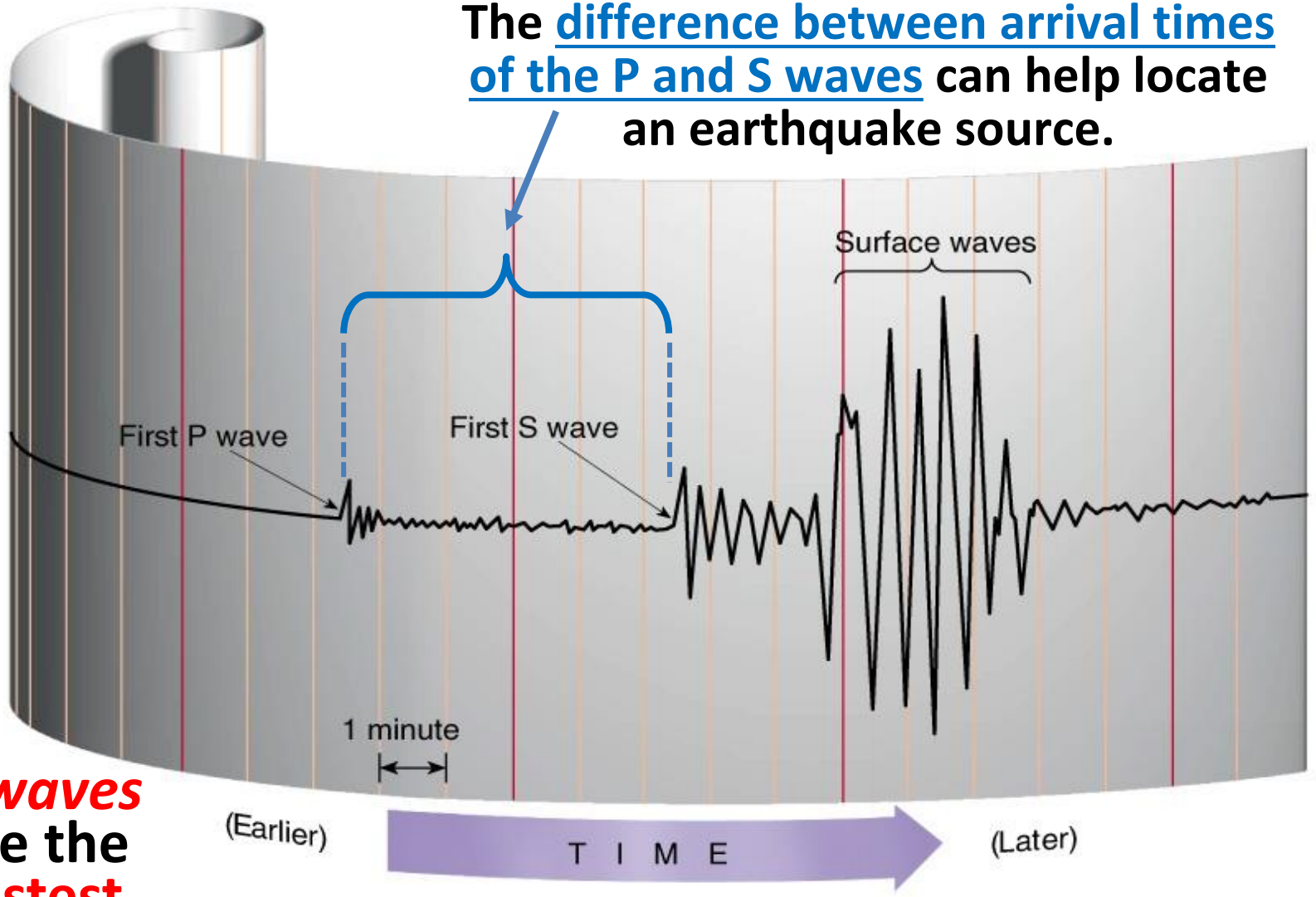


Vertical



Simplified Seismogram

The difference between arrival times of the P and S waves can help locate an earthquake source.

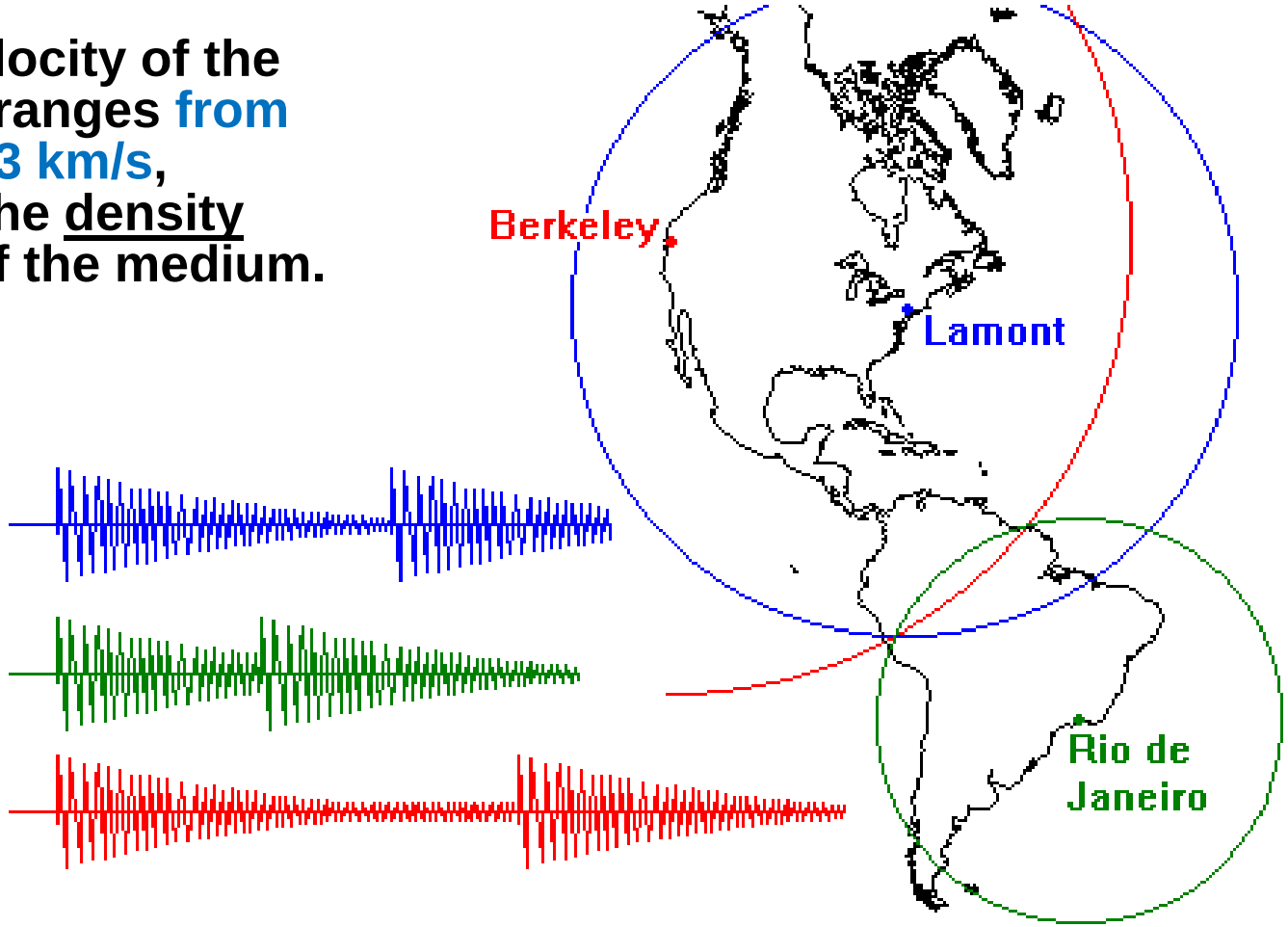


P waves **are the** **fastest**

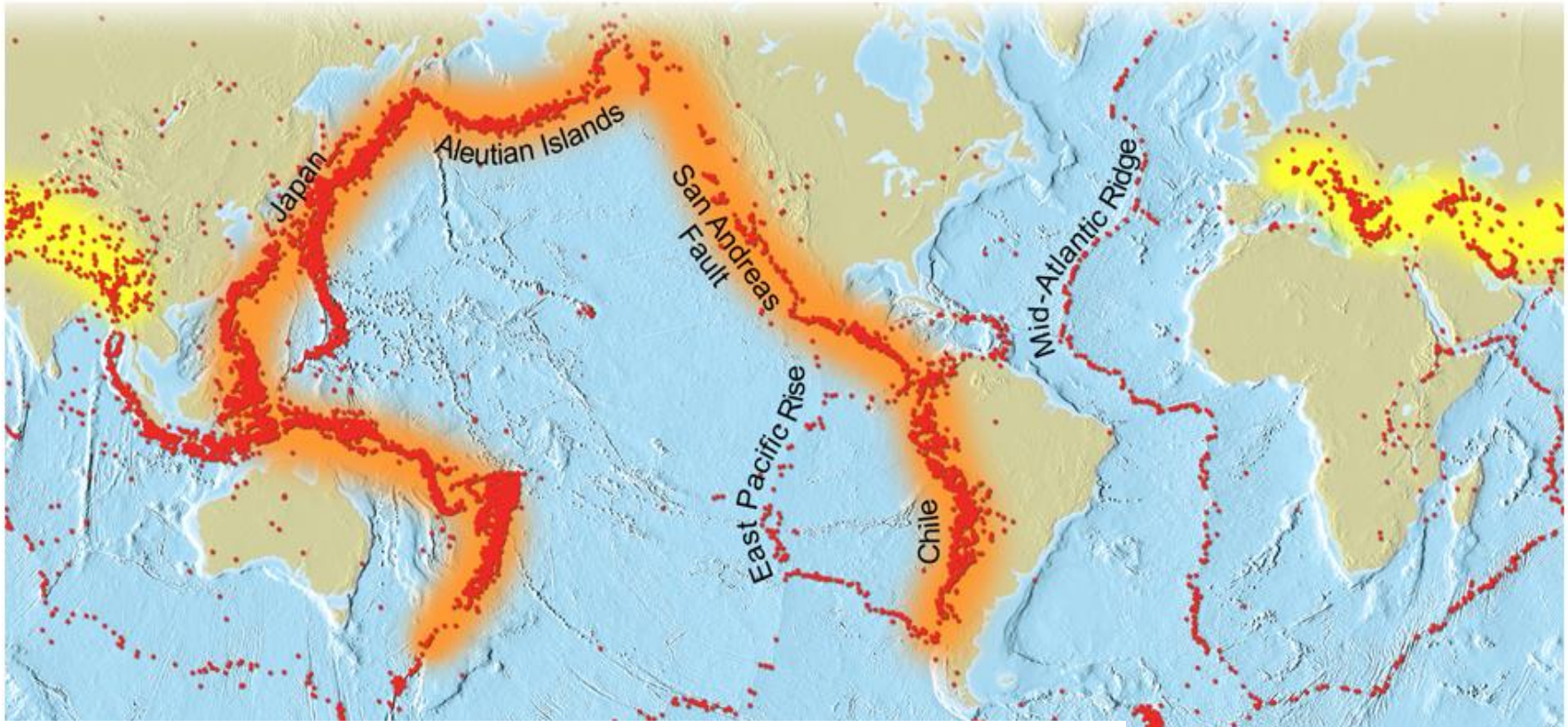
Locating Earthquakes

The further away an earthquake is from the point of detection, the greater the time between the arrival of the P waves and the S waves.

- **Propagation velocity of the seismic waves ranges from ~3 km/s up to 13 km/s, depending on the density and elasticity of the medium.**
- **Data from several different (*at least three*) seismic stations is combined to determine the earthquake epicenter location.**



Earthquakes around the world mostly happen near 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/fracking**

Greatest Earthquakes Ever Recorded

1. (M 9.5) 22 May 1960 – Great Chilean Earthquake, Valdivia, Chile:

   most powerful earthquake ever recorded; lasted ~10 min; triggered tsunami which reached Hawaii and Japan; 3000-5000 dead.

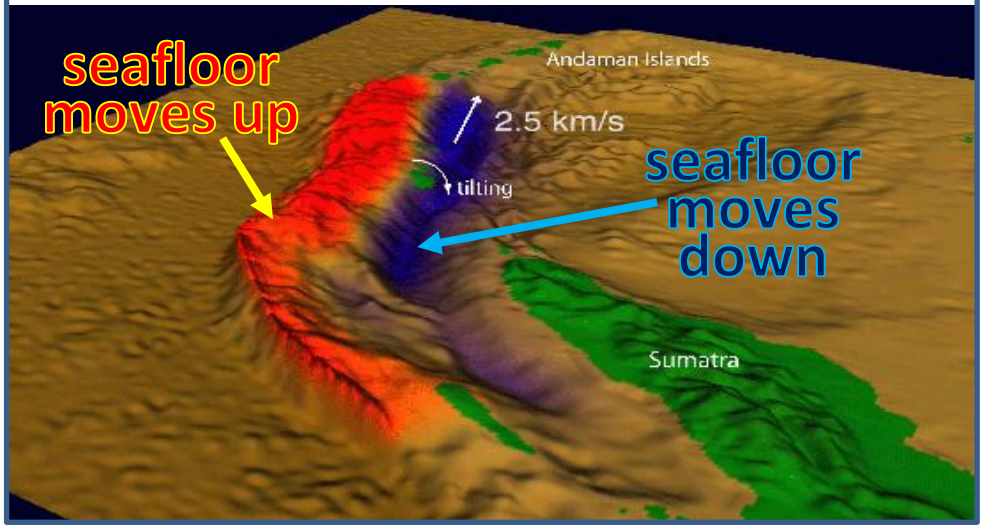
2. (M 9.2) 27 March 1964 – Great Alaskan Earthquake (aka Good Friday earthquake), Prince William Sound, AK:

   lasted ~4.5 min; tsunami, soil liquefaction; 128 dead.

Greatest Earthquakes Ever Recorded

3. (M 9.1-9.3) 26 December 2004 – Indian Ocean Earthquake (aka Sumatra-Andaman earthquake), off the west coast of Sumatra:

shaking lasted ~8 min; surface wave oscillations exceeded 1 cm everywhere on Earth; the longest ever fault rupture of 1600 km triggered tsunami waves (up to 30 m high reaching as far as 2 km inland in Indonesia); killed 230,000 people in 14 countries.



4. (M 9.0) 11 March 2011 – Great East Japan Earthquake (aka Tohoku earthquake), off the west coast of Japan:

lasted ~6 min; tsunami waves (up to 40 m high, travelled as far as 10 km inland); the disaster caused partial meltdown at Fukushima Daiichi Nuclear Power Plant; 15,800 dead.