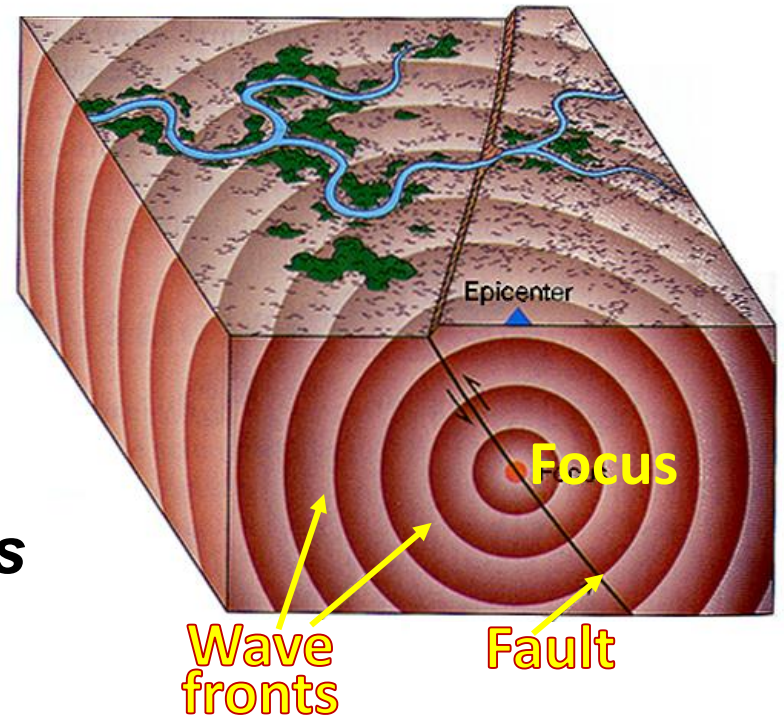


Review: What is an earthquake?

- Earthquake is the **vibration (shaking) and/or displacement of the ground** produced by the sudden **release of energy**.
- The point inside the Earth where an earthquake begins (point of initial rupture) is called **focus**.
- The area on the surface of the Earth directly above the focus where the shaking is usually felt most strongly is called **epicenter**.
- Earthquake strength is usually described by its **intensity** (a measure of the degree of shaking based on the amount of damage) and **magnitude** (an estimate of the amount of energy released at the source of the earthquake; *logarithmic scale*).
- **Energy** released from the earthquake source (its focus) propagates in the form of waves called **seismic waves**.

Seismic Waves

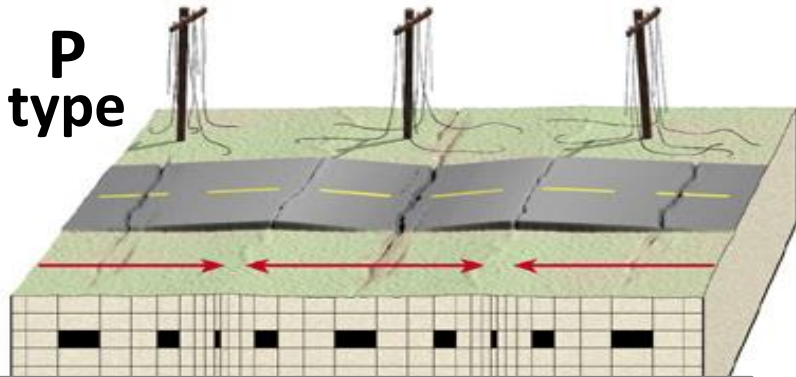
- Energy released from the earthquake source (its focus) radiates in all directions.
- Energy is in the form of waves called **seismic waves**:
 1. Body waves (*Primary waves and Secondary waves*) - travel fast through the Earth interior.
 2. Surface waves (*Love waves and Rayleigh waves*) - travel on the Earth surface; have lower frequency and travel more slowly than body waves - **more destructive**.



Types of Seismic Waves

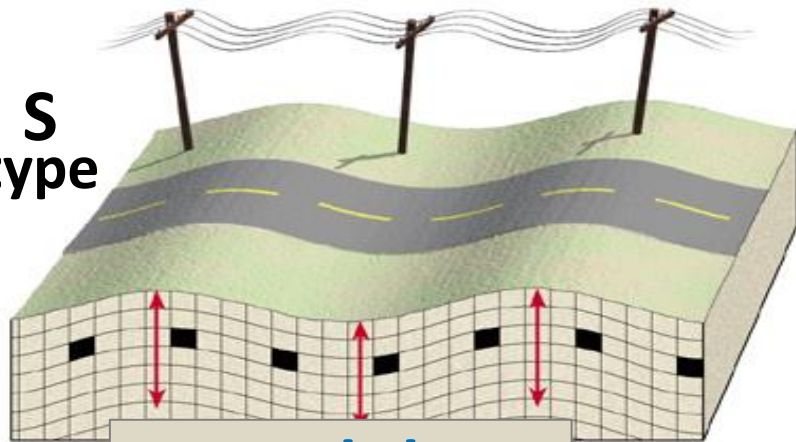
BODY WAVES

P
type



Compression-expansion

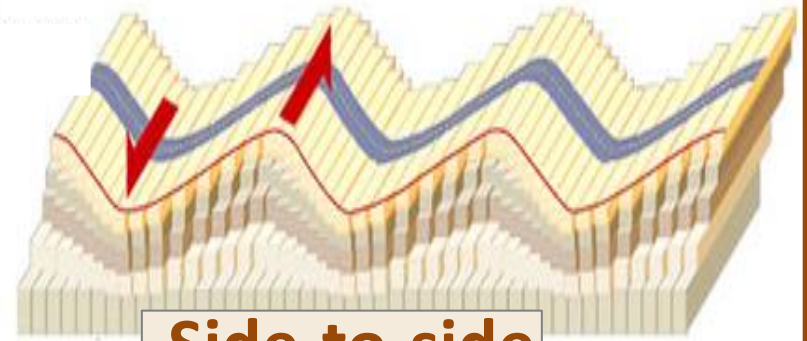
S
type



Up-and-down

SURFACE WAVES

L
type



**Side-to-side
horizontal
movement**



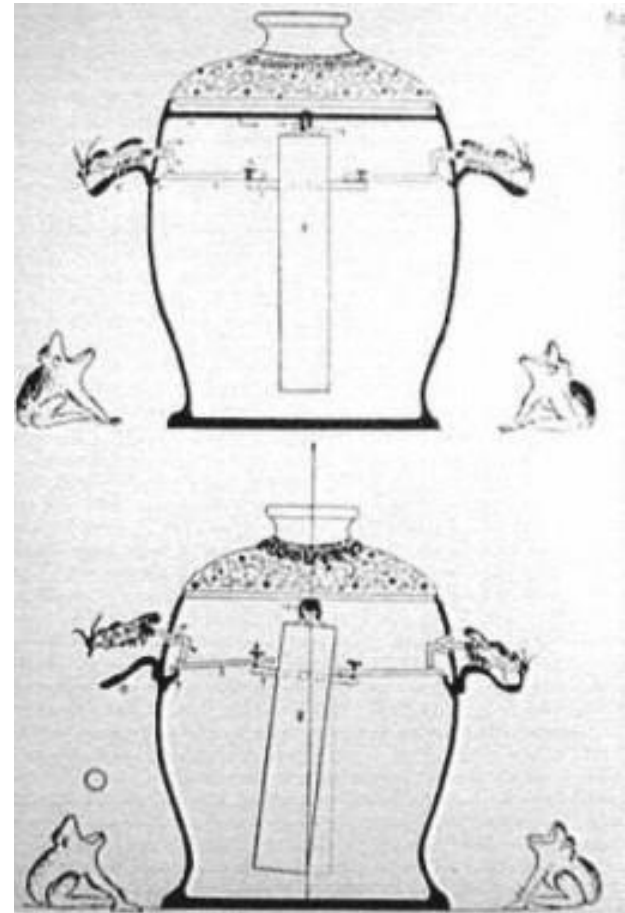
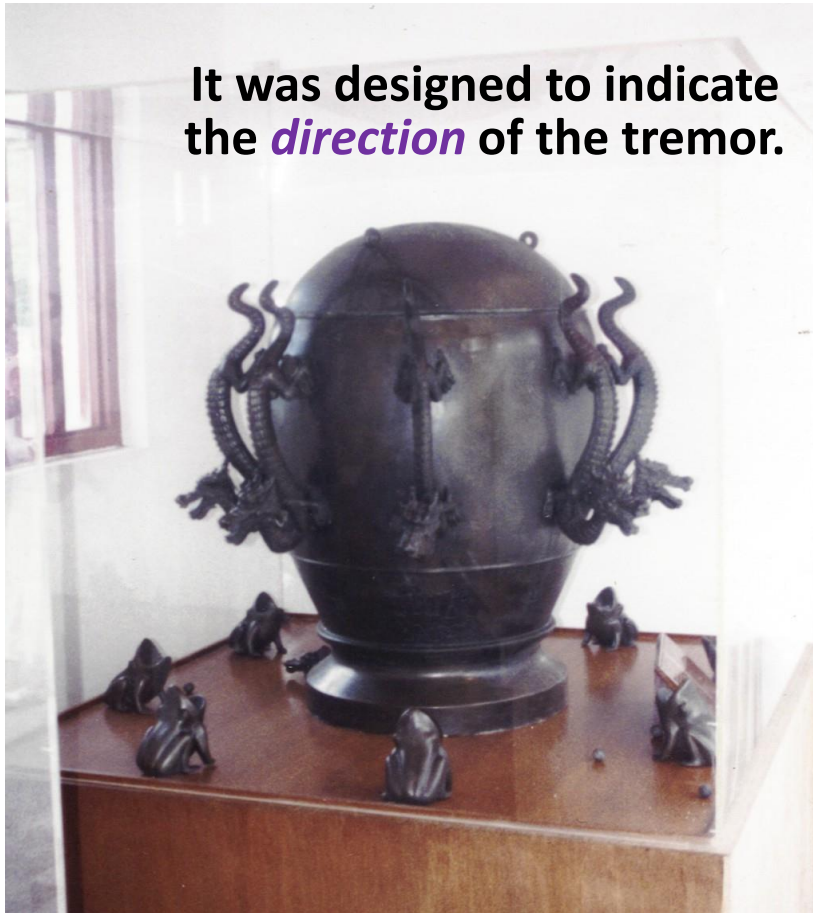
**Elliptical roll of the
ground oriented
vertically**

R
type

Detecting an Earthquake

Chinese created the first earthquake detector
over 2000 years ago!

It was designed to indicate
the *direction* of the tremor.



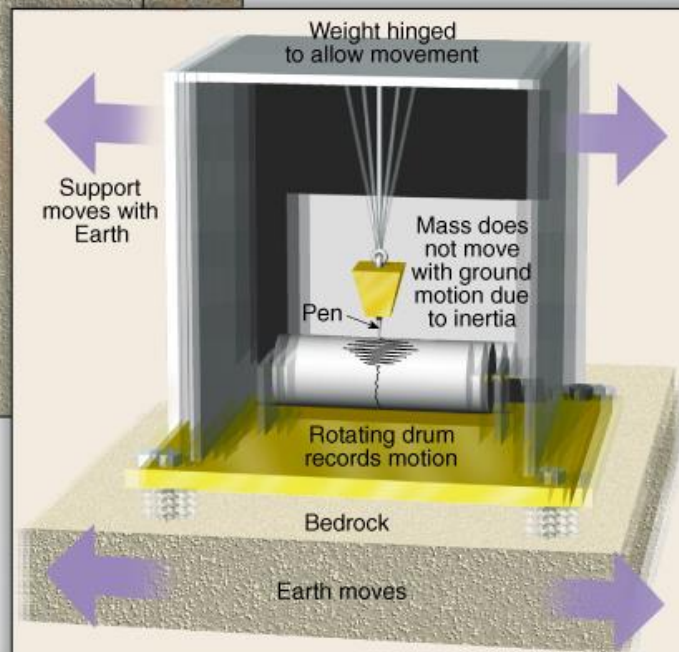
Measuring an Earthquake

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

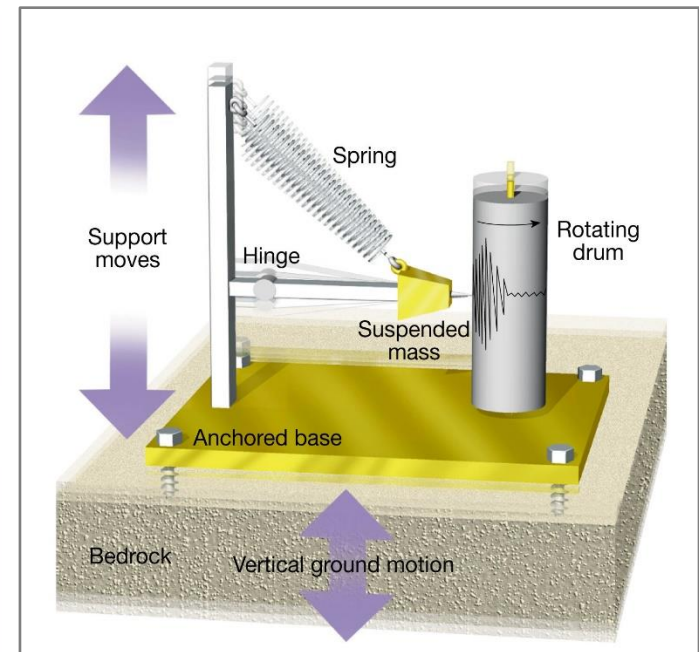


Different *seismograph* types are needed to record both vertical and horizontal ground motion:

Horizontal

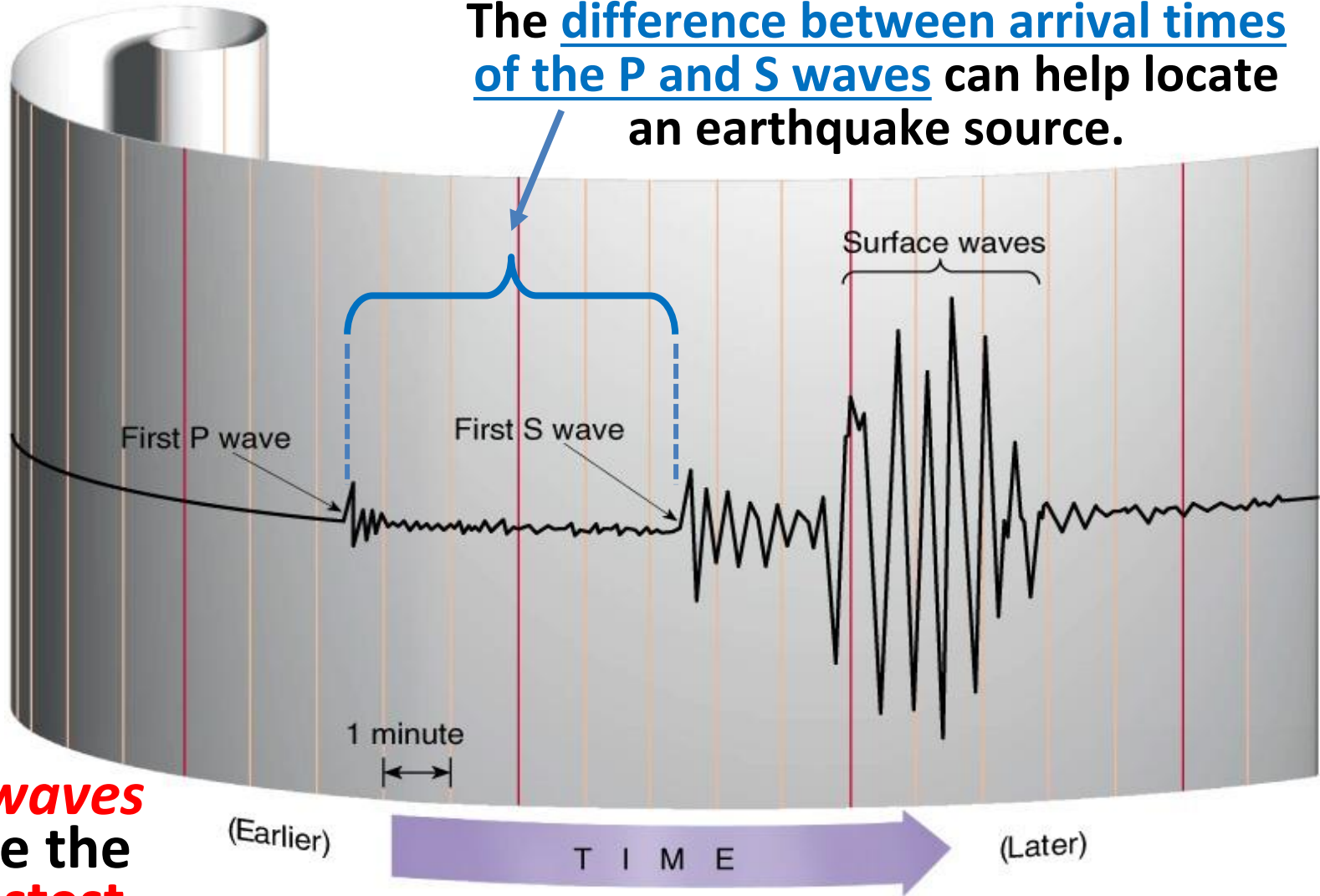


Vertical



Simplified Seismogram

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

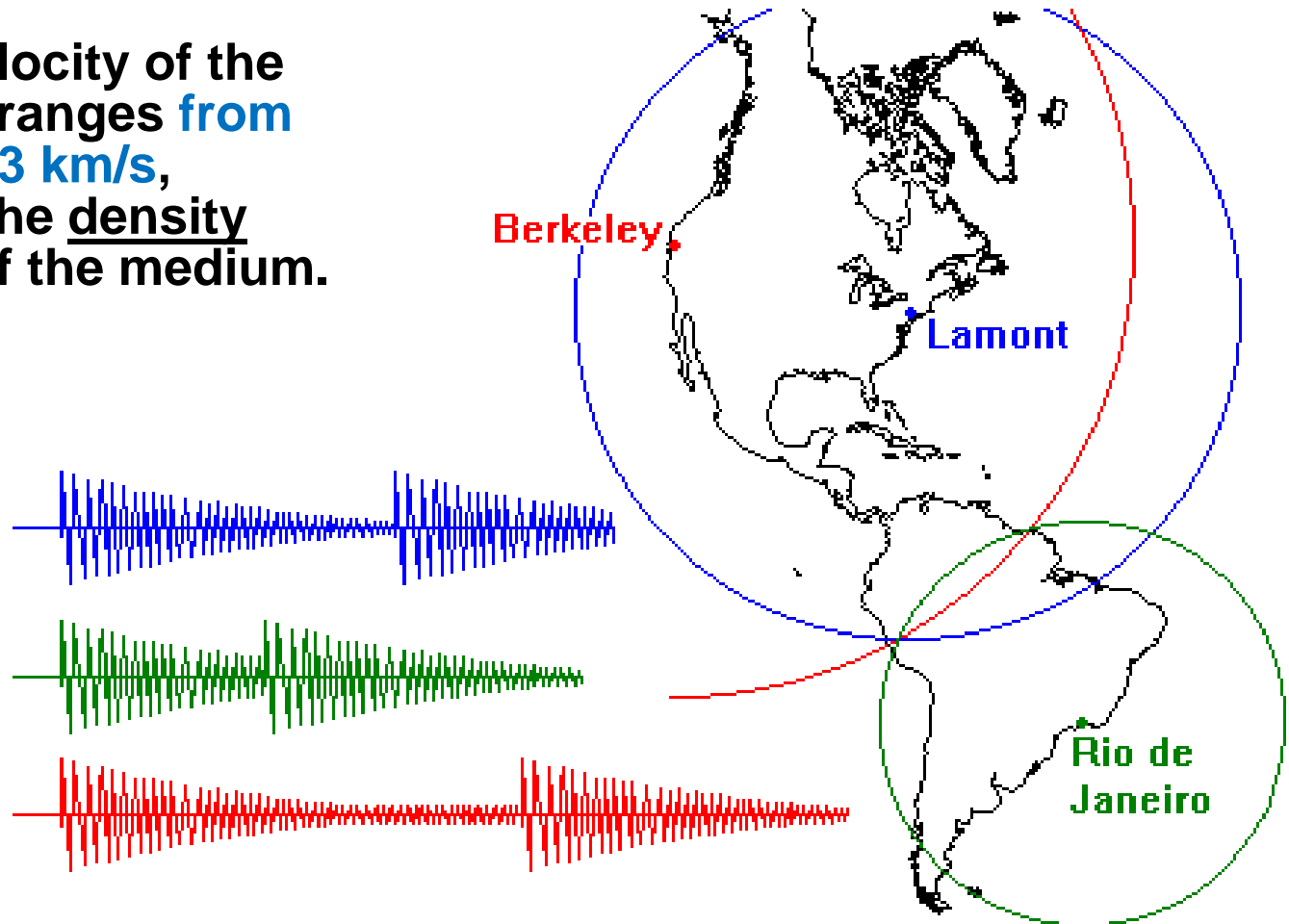


***P* waves
are the
fastest**

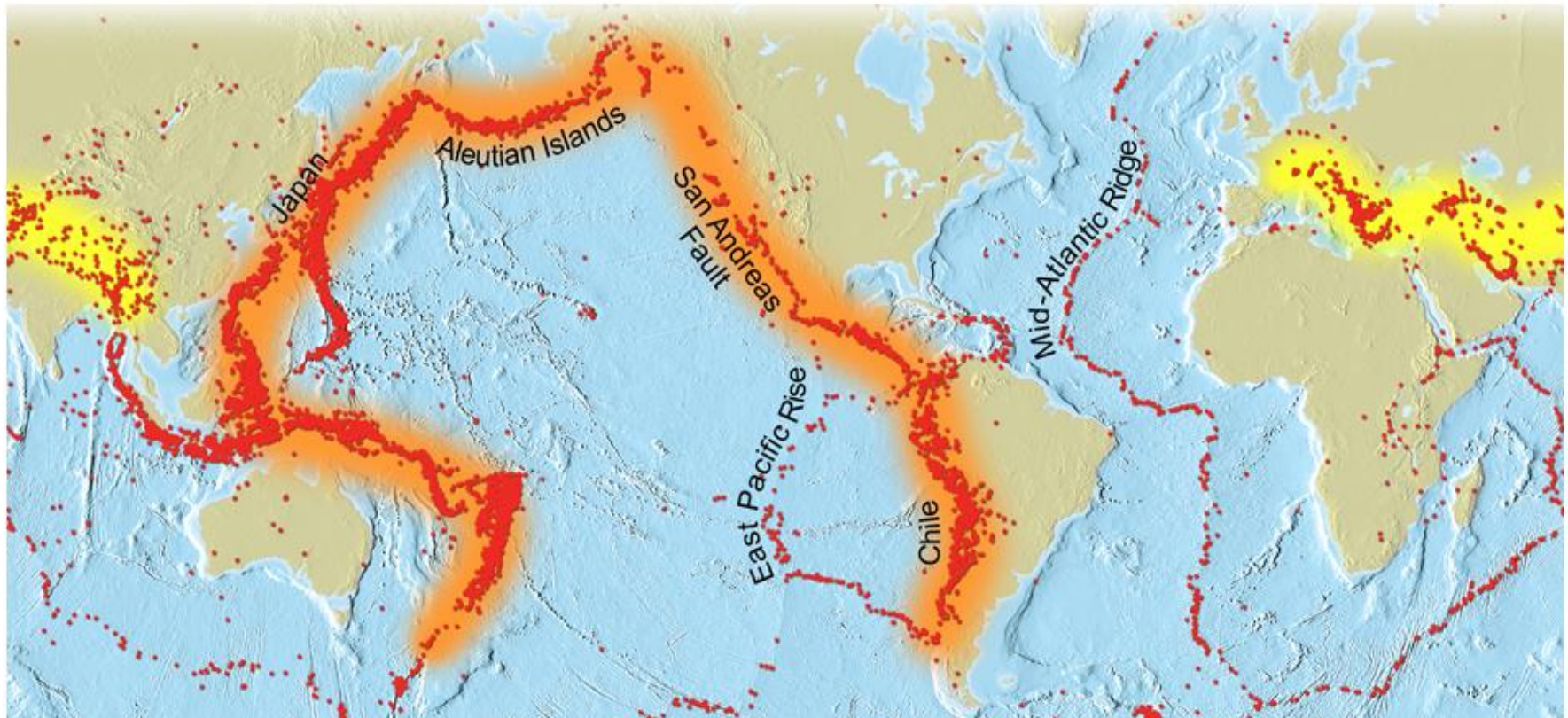
Locating Earthquakes

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.

Legend:
Circum-Pacific belt (orange)
Alpine-Himalayan belt (yellow)

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