Introduction to Engineering Seismology

Seismology is the branch of Geophysics concerned with the study and analysis of Earthquakes and the science of energy propagation through the Earth's crust.

Engineering Seismology is concerned with the solution of engineering problems connected with the Earthquakes. Seismology is extremely important because:

- Study of earthquakes gives us important clues about the earth’s interior
- Understanding earthquakes allows us to minimize the damage and loss of life

What is an earthquake?

- **An earthquake is the vibration of Earth produced by the rapid release of accumulated energy in elastically strained rocks**
  - **Energy released radiates in all directions from its source, the focus**
  - **Energy propagates in the form of seismic waves**
  - **Sensitive instruments around the world record the event**

What causes an earthquake?

Movement of Tectonic Plates

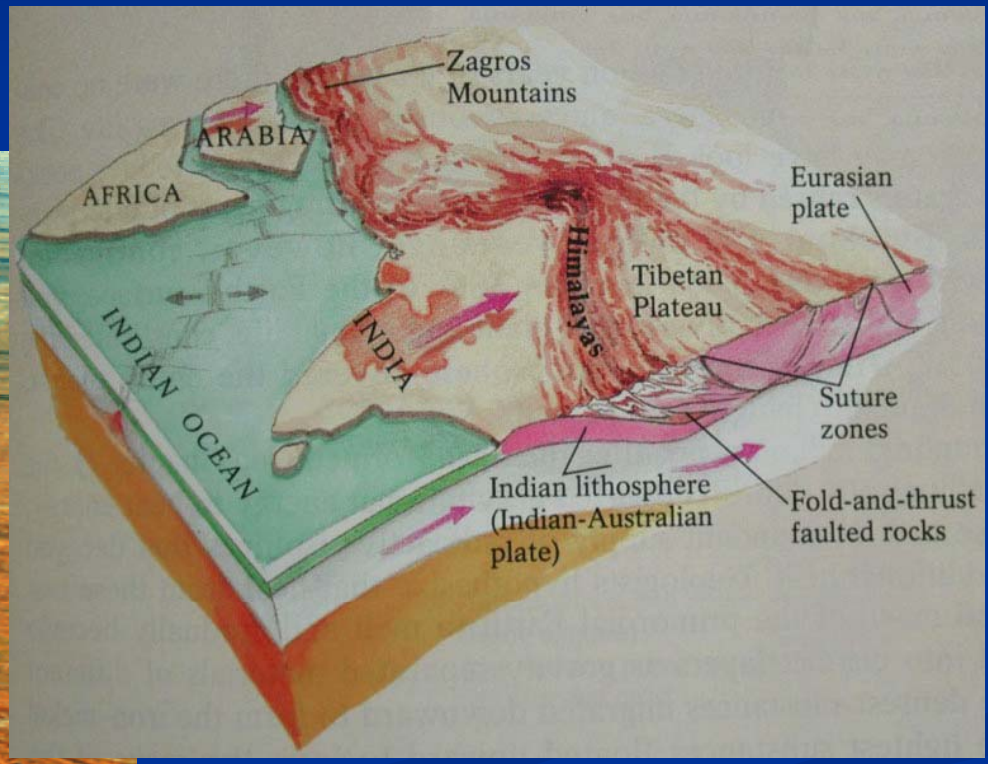
Earth is divided into sections called Tectonic plates that float on the fluid-like interior of the Earth. Earthquakes are usually caused by sudden movement of earth plates

Rupture of rocks along a fault

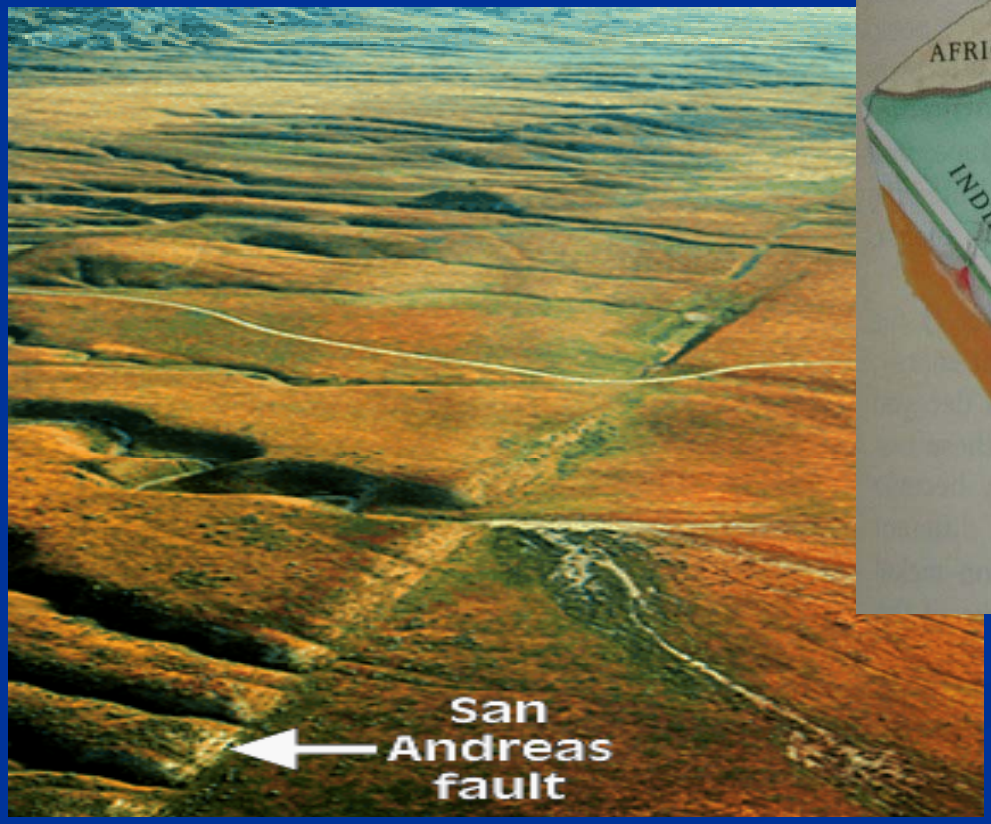
Faults are localized areas of weakness in the surface of the Earth,sometimes the plate boundary itself

Where do earthquakes occur?

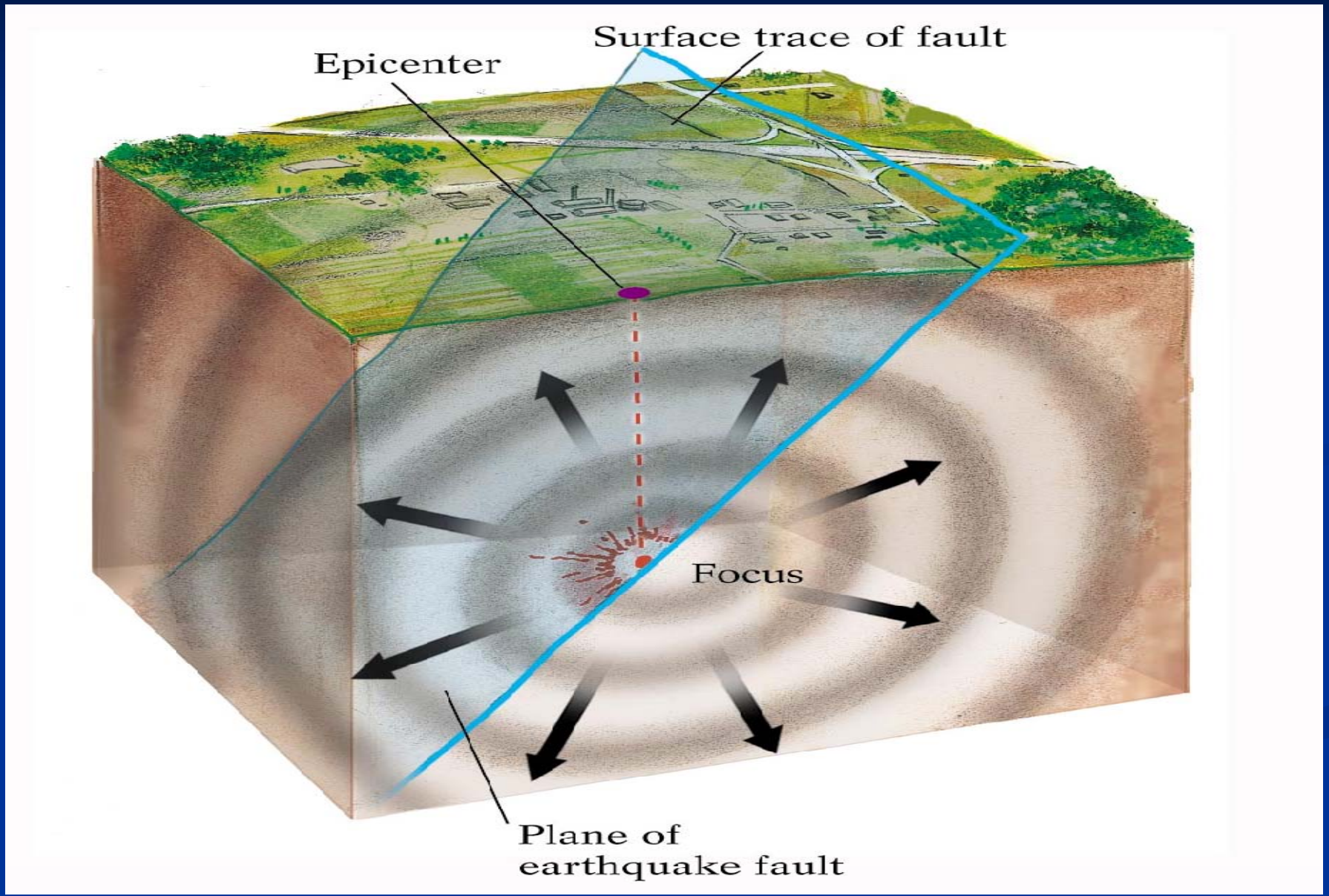
plate boundaries



faults

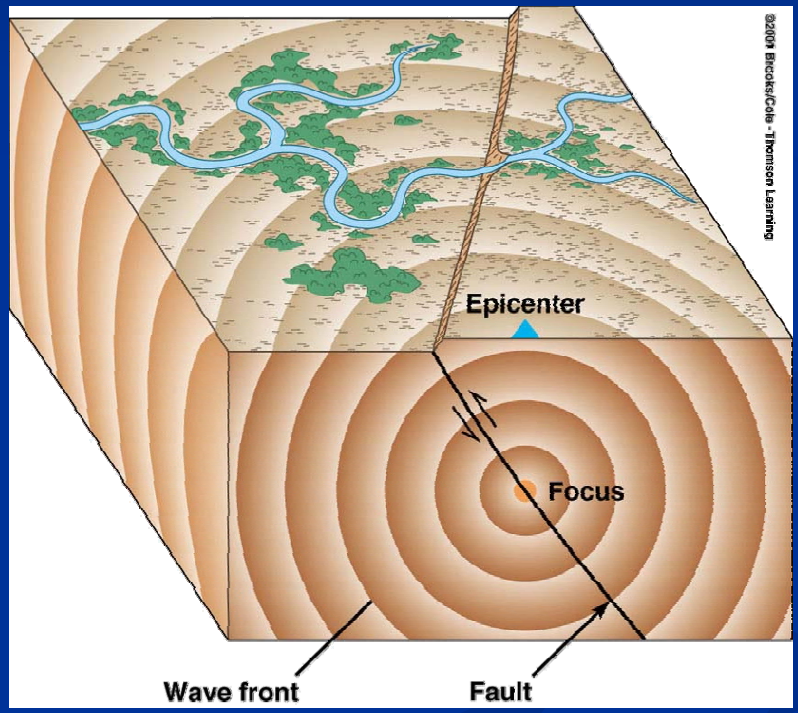


Release of Accumulated energy



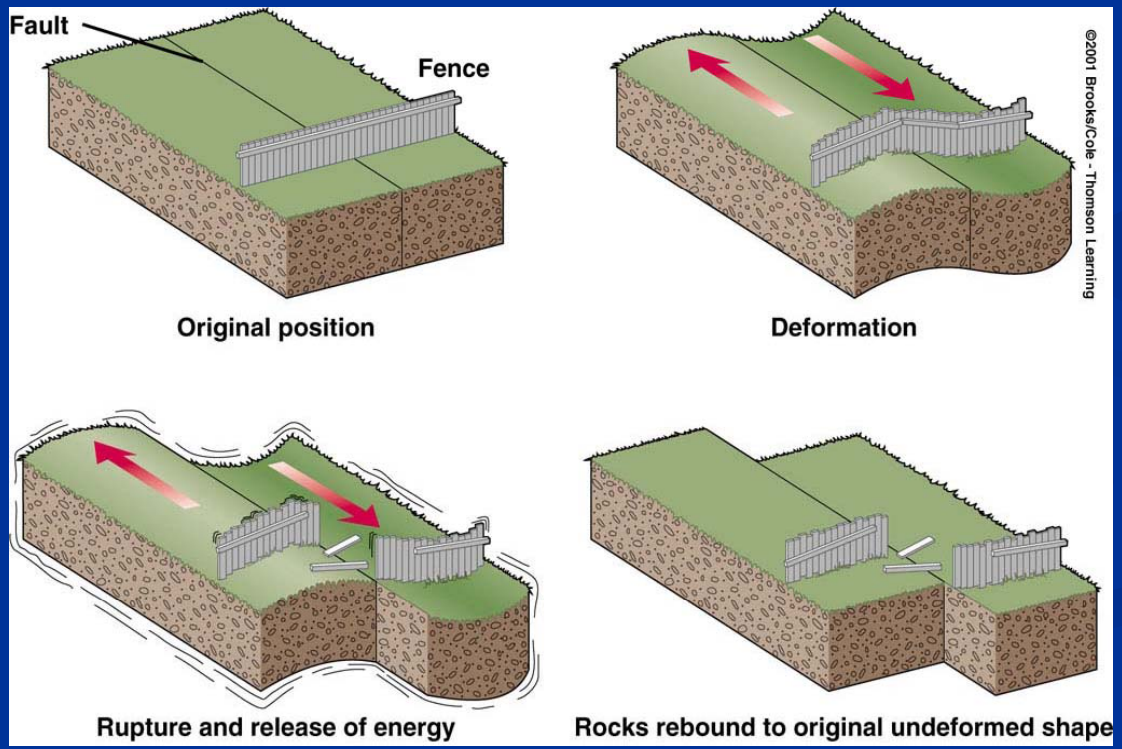
The Focus and Epicenter of an Earthquake

- The point within Earth where faulting begins is the focus, or hypocenter
- The point directly above the focus on the surface is the epicenter



Elastic Rebound Theory

Rocks bend under stress while storing elastic energy. When the strain in the rocks exceeds their strength, breaking will occur along the fault. Stored elastic energy is released as the earthquake. Rocks“snap back”, or rebound to their original condition.



Foreshocks and aftershocks

- **Adjustments that follow a major earthquake often generate smaller earthquakes called aftershocks**
- **Small earthquakes, called foreshocks, often precede a major earthquake by days or, in some cases, by as much as several years**

Study of earthquakes

- The study of earthquake waves, **Seismology**, dates back almost 2000 years to the Chinese **Seismographs**, instruments that record seismic waves. The first seismograph called Di-Dong-Di was invented by Cheng Heng (132 A.D.).

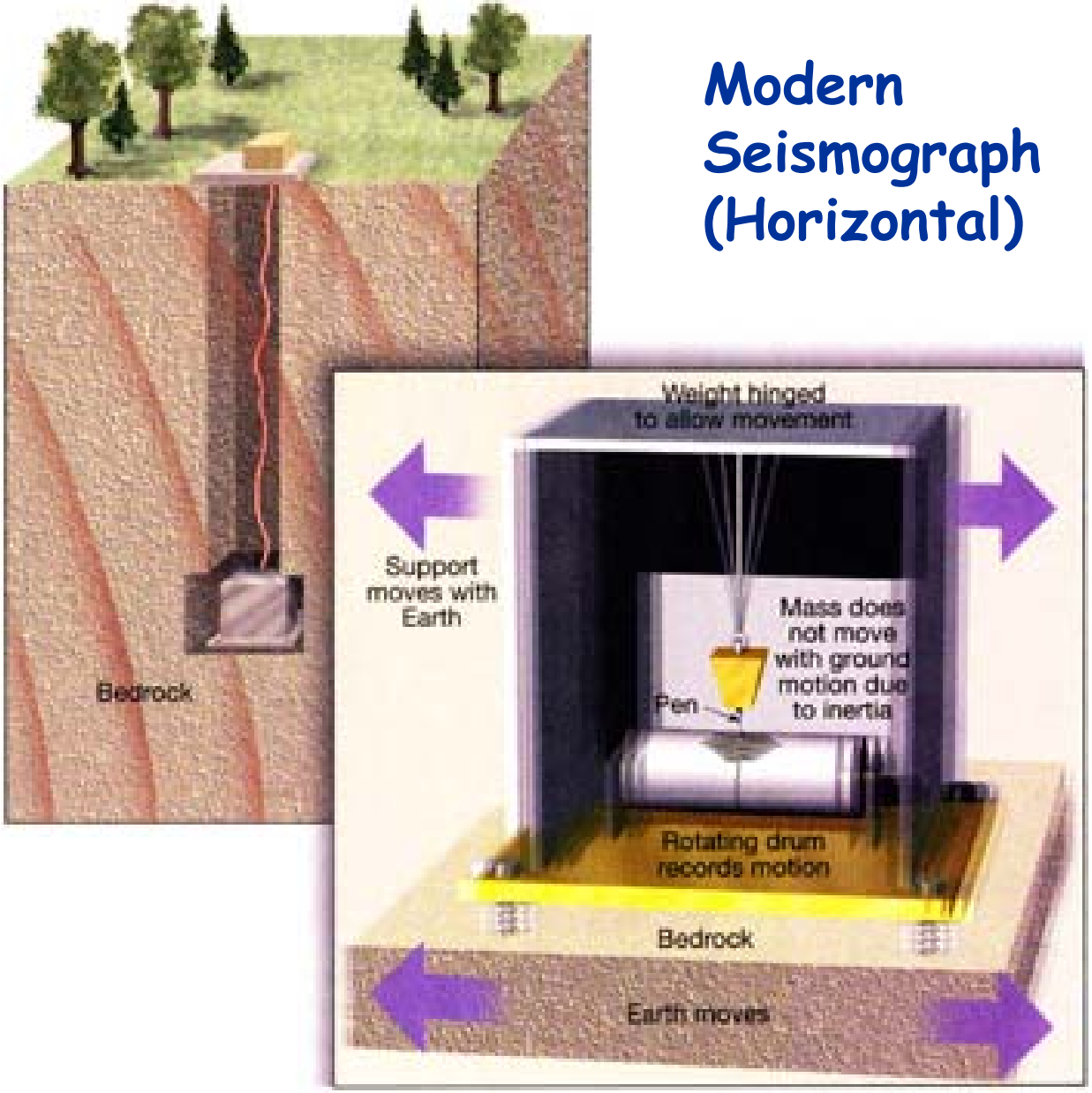

Ancient
Chinese
seismograph

The ancient Chinese seismograph consist of a special vase that had eight sculpted dragons mounted around the vase in eight primary directions. Each dragon held in its mouth a metal ball. When the ground shook, some of the balls would fall from the mouths of the dragons into the waiting mouths of the sculpted frogs to show how the ground had moved.

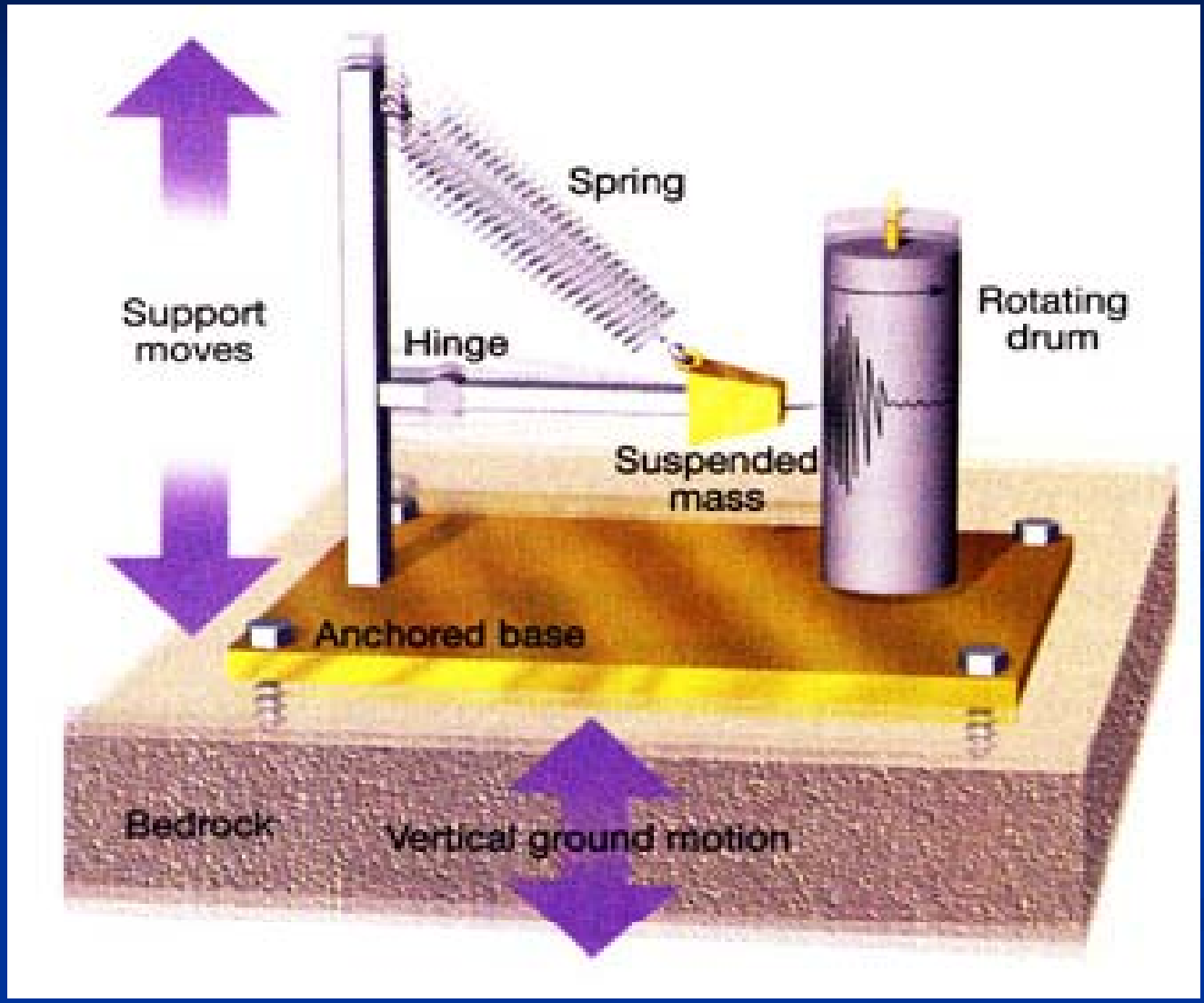
Earthquake Waves

- **The energy released during the earthquake travels as waves**
- **Modern Seismograph can measure the intensity and duration of these waves in different directions.**
- **Seismogram is visual record of arrival time and magnitude of shaking associated with seismic wave, generated by a seismograph.**

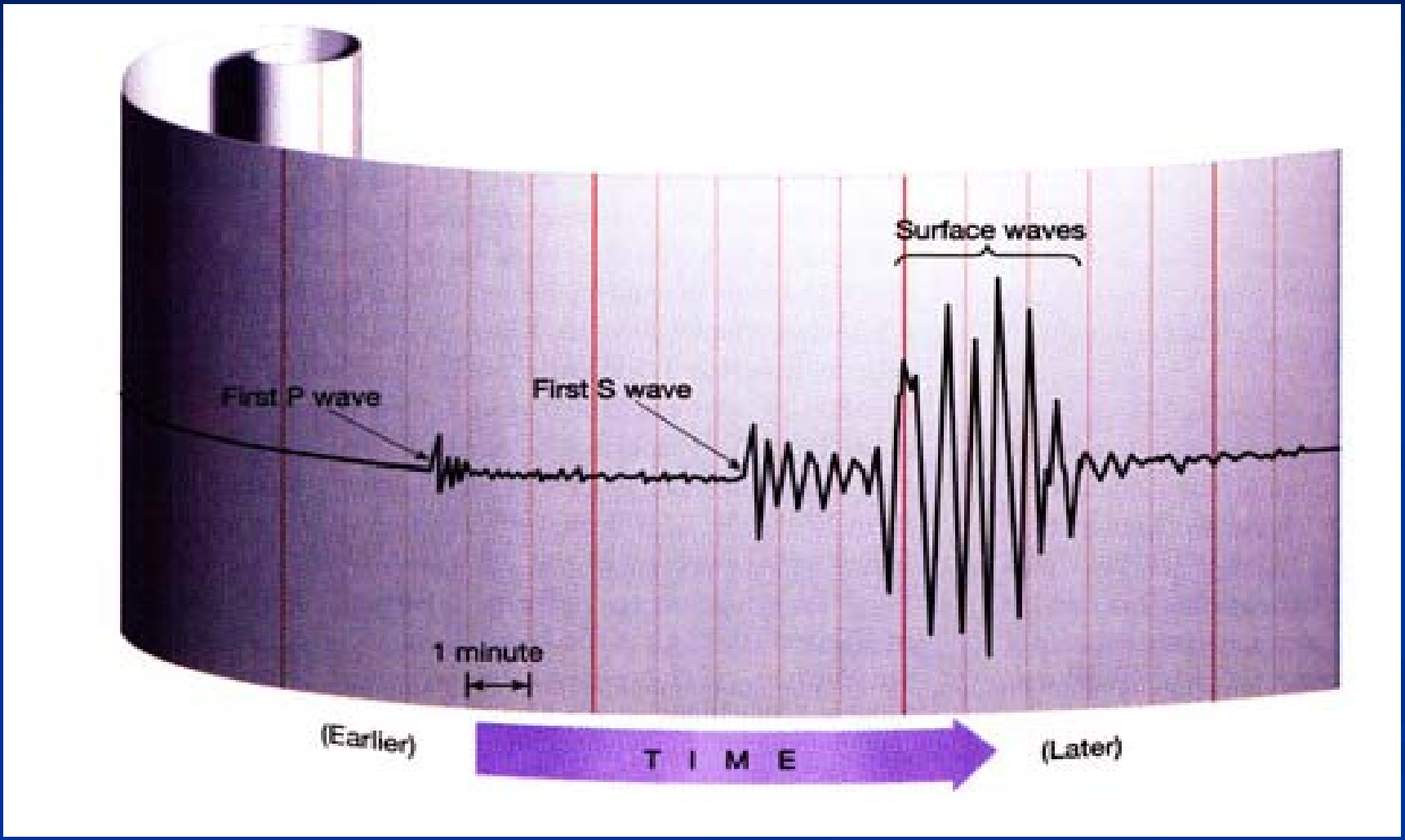
Modern Seismograph (Horizontal)



Modern Seismograph (Vertical)



Seismogram


Surface waves
First P wave
First S wave
1 minute
(Earlier)
T I M E
(Later)

Location and Intensity of Earthquake

seismographic stations around the World work together to

- record earthquake location
- determine earthquake strength

Earthquake Depth

Earthquakes usually occur at some depth below the ground

Surface. The depth can also be calculated from seismograph

records

Earthquake foci are described as:

- Shallow: less than 70 km depth
- Intermediate: 70 - 300 km depth
- Deep: 300 - 700 km depth

90% of earthquake foci are less than 100 km deep

Large earthquakes are mostly at < 60 km depth

No earthquakes occur deeper than 700 km

Predicting Earthquakes

Strange Animal Behavior

stress in the rocks causes tiny hairline fractures to form, the cracking of the rocks evidently emits high pitched sounds and minute vibrations imperceptible to humans but noticeable by many animals.

Foreshocks

unusual increase in the frequency of small earthquakes before the main shock

Changes in water level

porosity increases or decreases with changes in strain

Seismic Gaps

based of the chronological distribution of major

PROTECTING AGAINST EARTHQUAKE DAMAGE

Prepare a **Seismic Risk Map** for the globe which identifies rock types, liquefaction potential, landslide potential.

Extensive geologic surveying has to be done to identify all active faults, including hidden faults.

Earthquake Resistant Design of Structures

Enact building codes to design and build earthquake-resistant structures in high seismic risk areas. wood, steel and reinforced concrete are preferred as they tend to move with the shaking ground *(unreinforced concrete and heavy masonry tend to move independently and in opposition to the shaking, battering one another until the structure collapses)*

Critical facilities such as nuclear power plants and dams