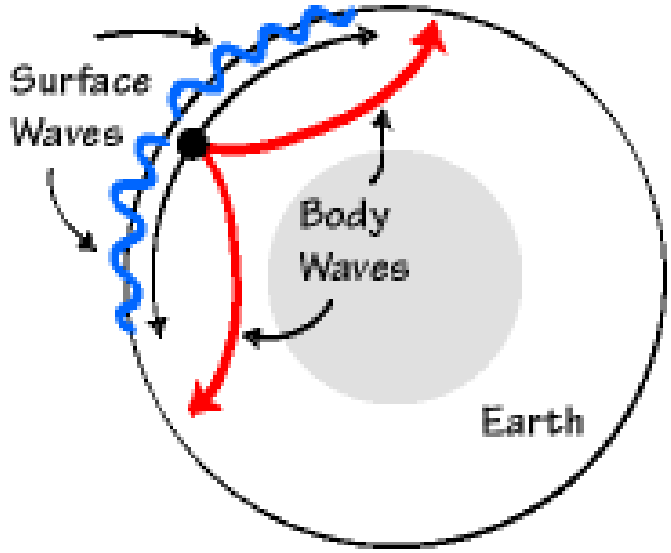
SEISMIC WAVES AND EARTHQUAKE

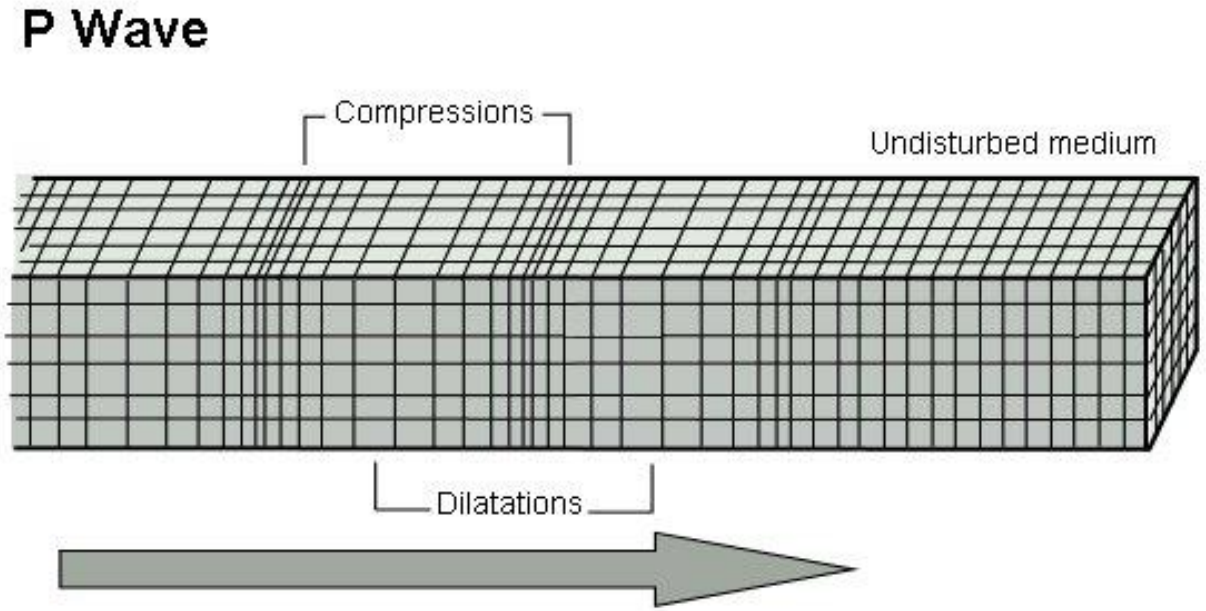
Seismic Waves

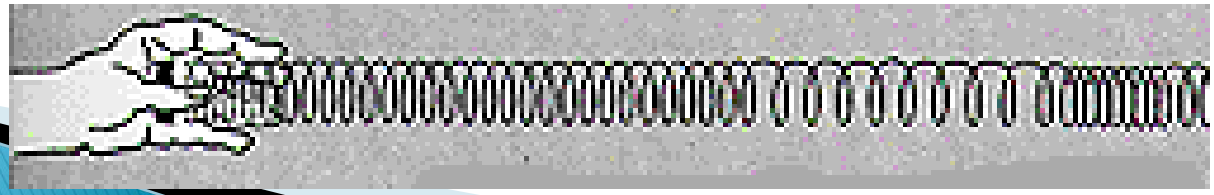
- **Seismic waves** are the waves of energy caused by the sudden breaking of rock within the earth or an explosion. They are the energy that travels through the earth and is recorded on seismographs.
- There are several different kinds of seismic waves, and they all move in different ways. The two main types of waves are **body waves** and **surface waves**.
  - **Body Waves (Travel Through the earth)**
    - Primary or p-wave
      - Compression wave
    - Secondary/shear or s-wave
      - Transverse wave
  - **Surface (Travel Primariliy on surface)**
    - Love wave
    - Rayleigh wave



Body Waves

- **P Waves (compression wave)**
- The first kind of body wave is the **P wave** or **primary wave.** This is the fastest kind of seismic wave. The P wave can move through solid rock and fluids, like water or the liquid layers of the earth. It pushes and pulls the rock it moves through just like sound waves push and pull the air.

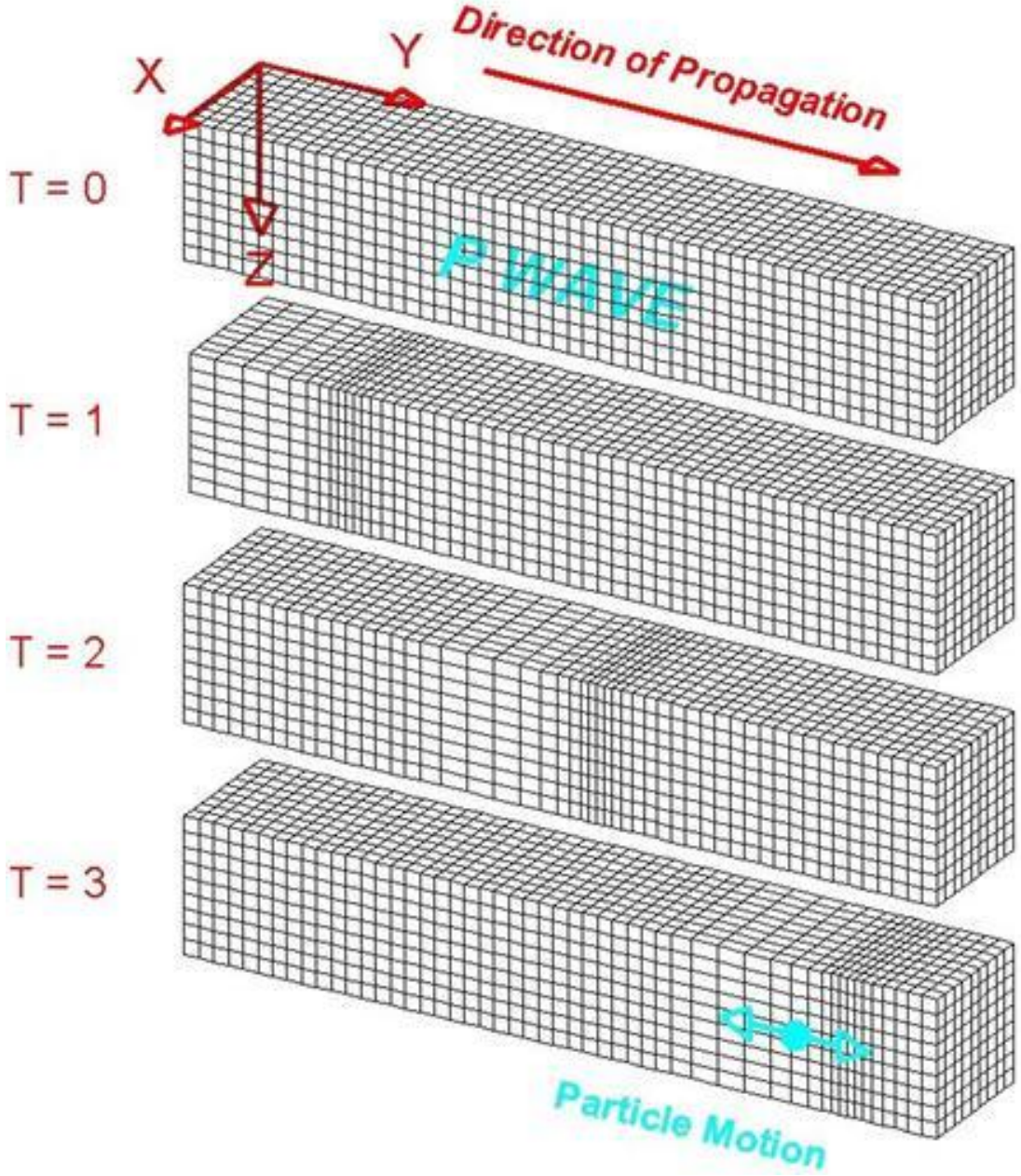




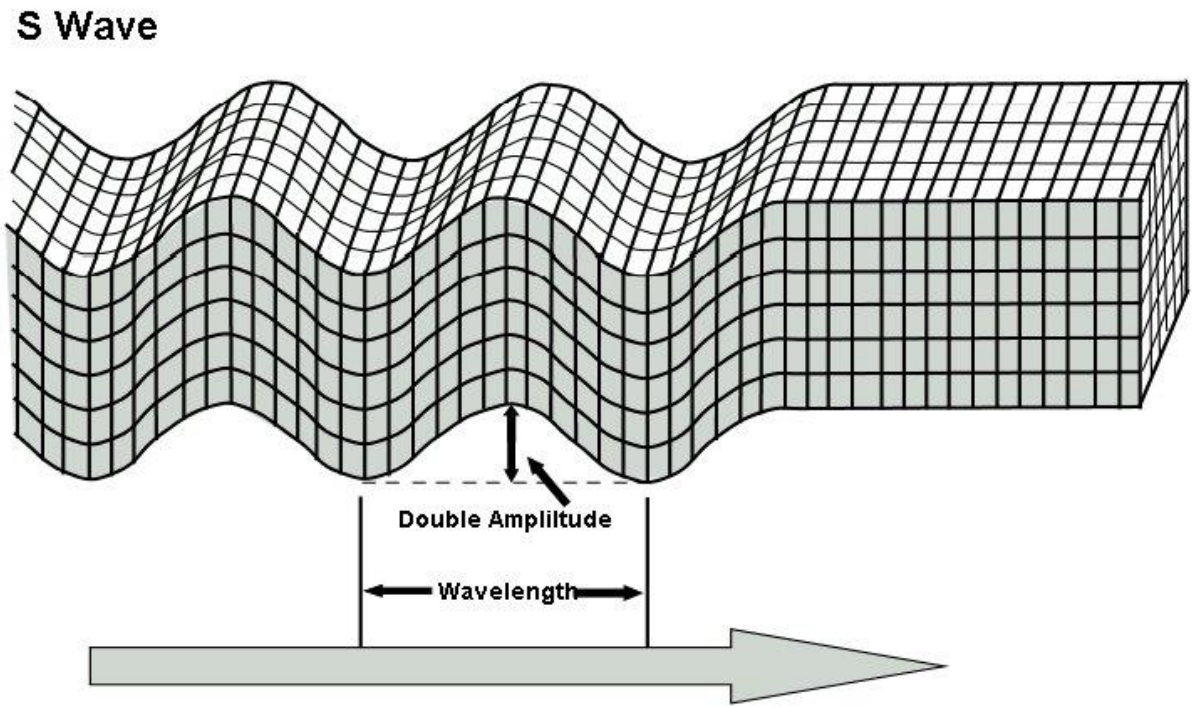
P Wave

$$P_V = \sqrt{[\{\kappa+(4/3)\mu\}/\rho]}$$

P_V – P wave velocity
κ – bulk modulus
μ – shear modulus
ρ – density



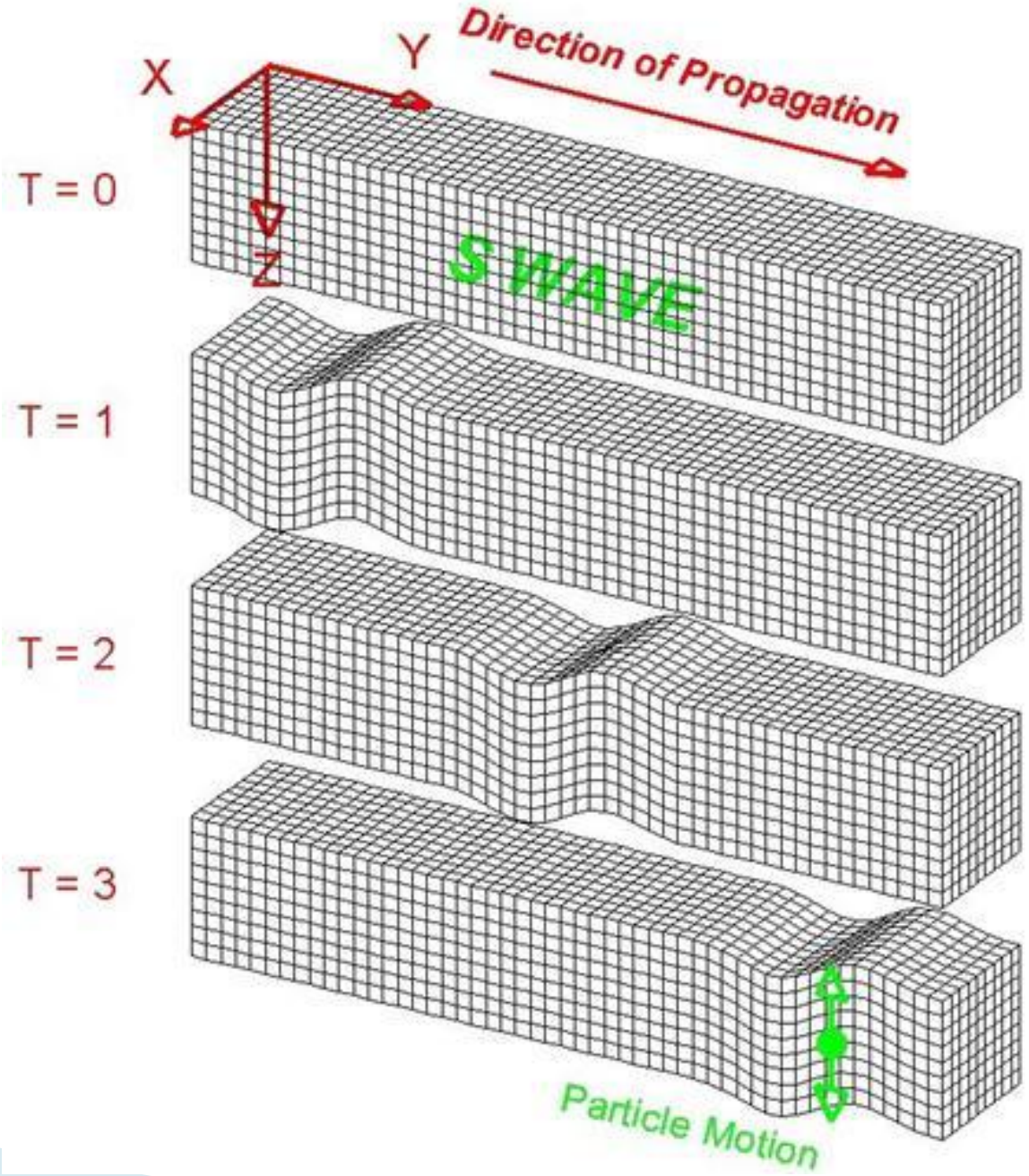
- **S wave (transverse wave)**
- The second type of body wave is the **S wave** or **secondary wave**, which is the second wave you feel in an earthquake. An S wave is slower than a P wave and can only move through solid rock. This wave moves rock up and down, or side-to-side.



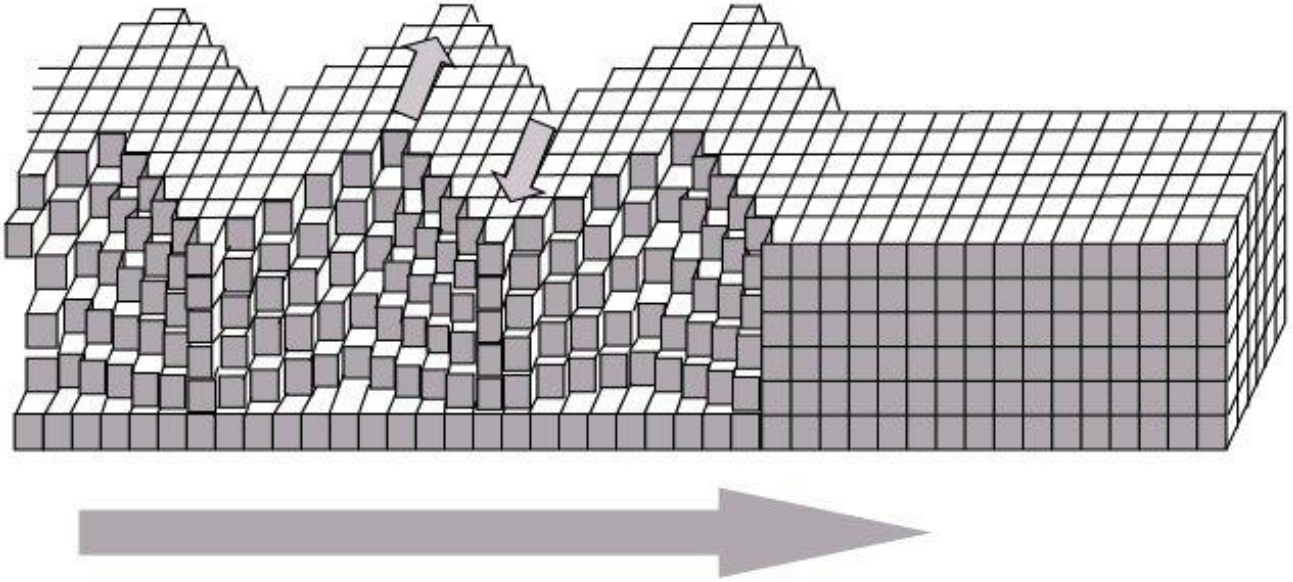
S Wave

$S_V = \sqrt{(\mu / \rho)}$

S_V – S wave velocity
μ – shear modulus
ρ – density

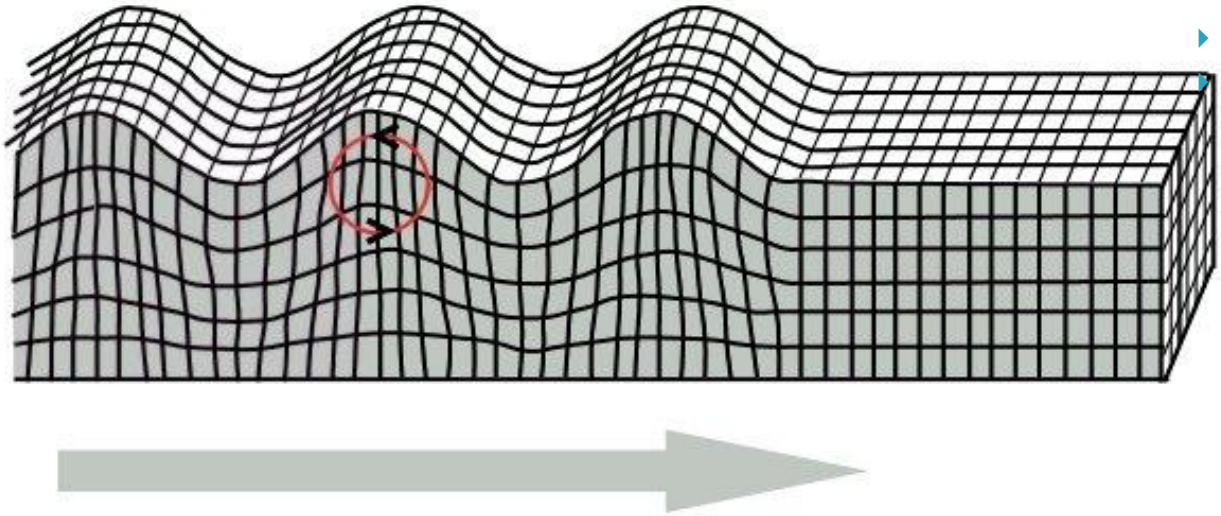


Love Wave



- **Love Waves**
- It's the fastest surface wave and moves the ground from side-to-side.

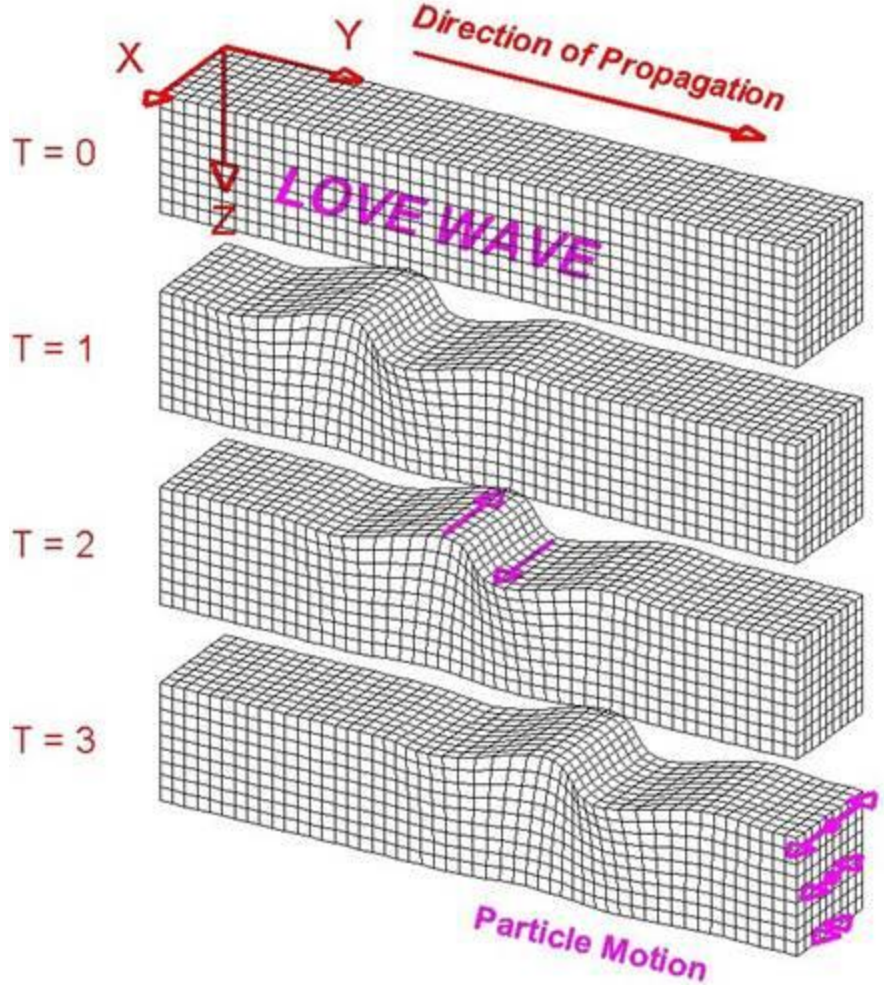
Rayleigh Wave

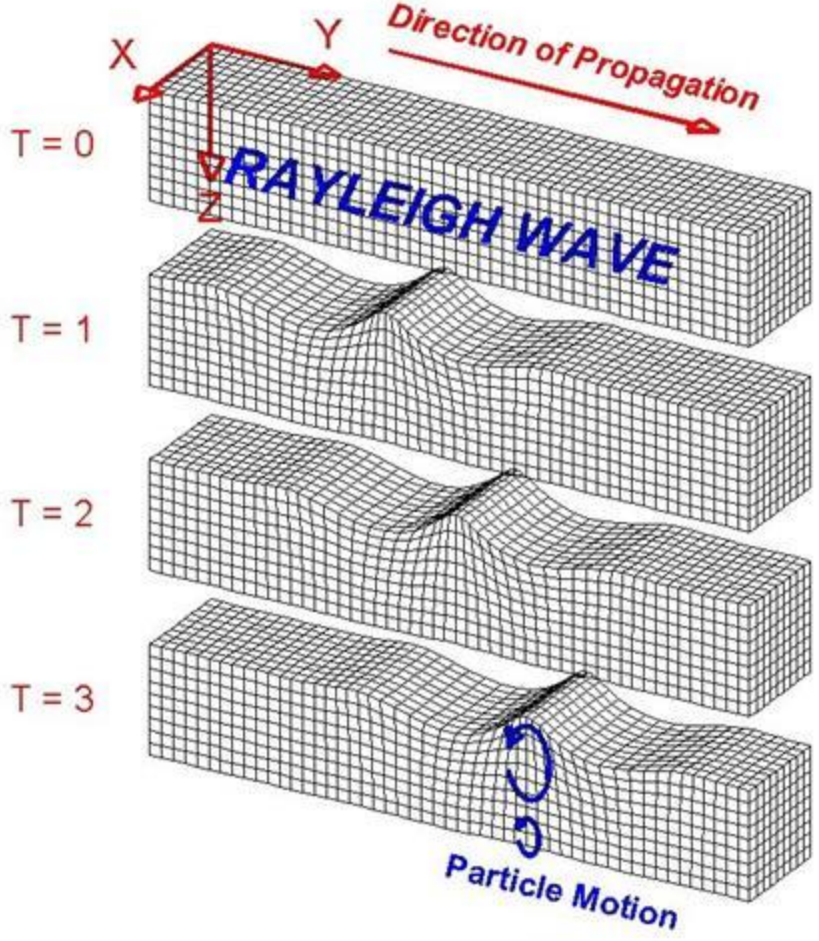


- **Rayleigh Waves**

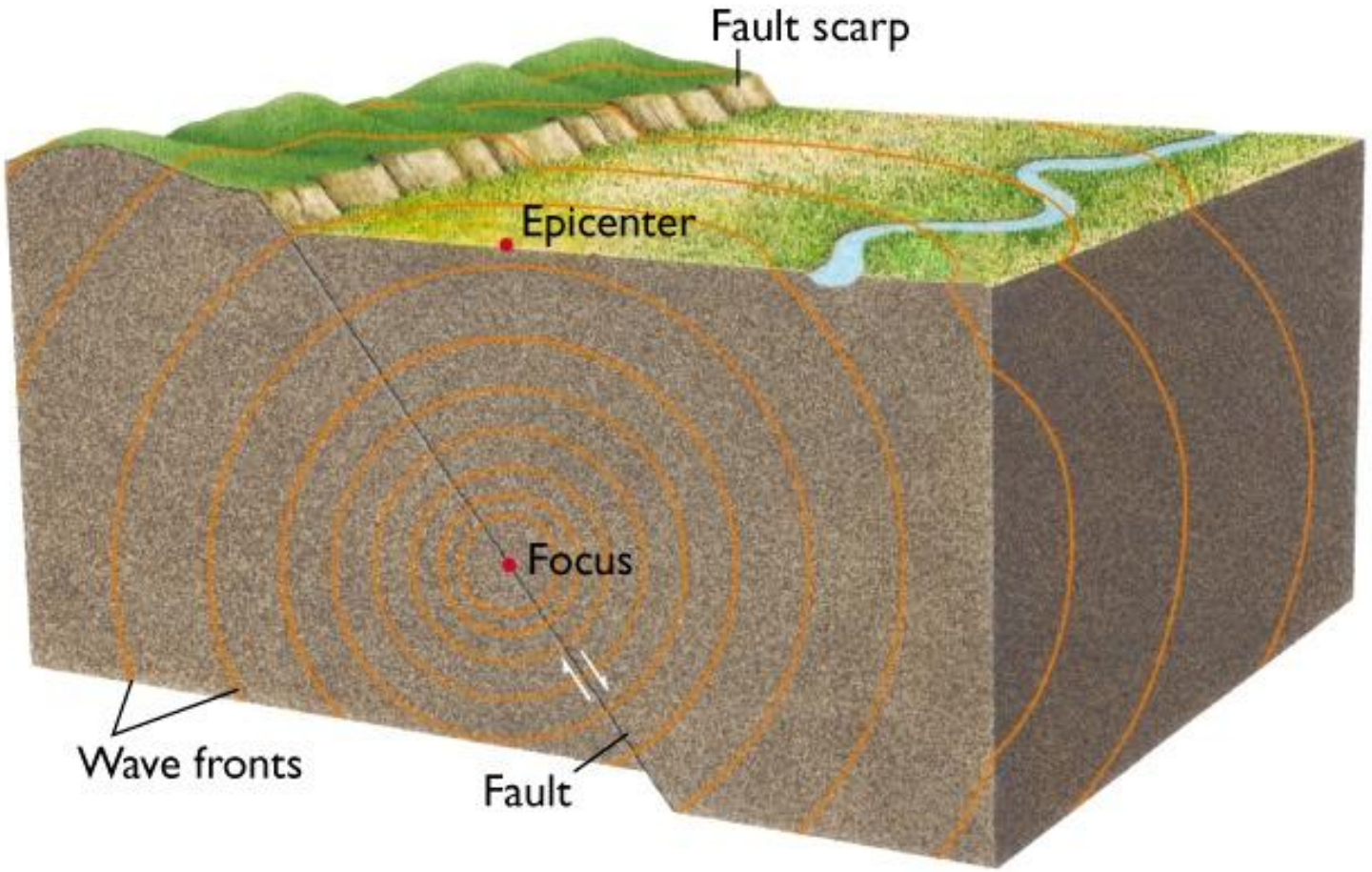
A Rayleigh wave rolls along the ground just like a wave rolls across a lake or an ocean. Because it rolls, it moves the ground up and down, and side-to-side in the same direction that the wave is moving. Most of the shaking felt from an earthquake is due to the Rayleigh wave, which can be much larger than the other waves.

Surface Waves

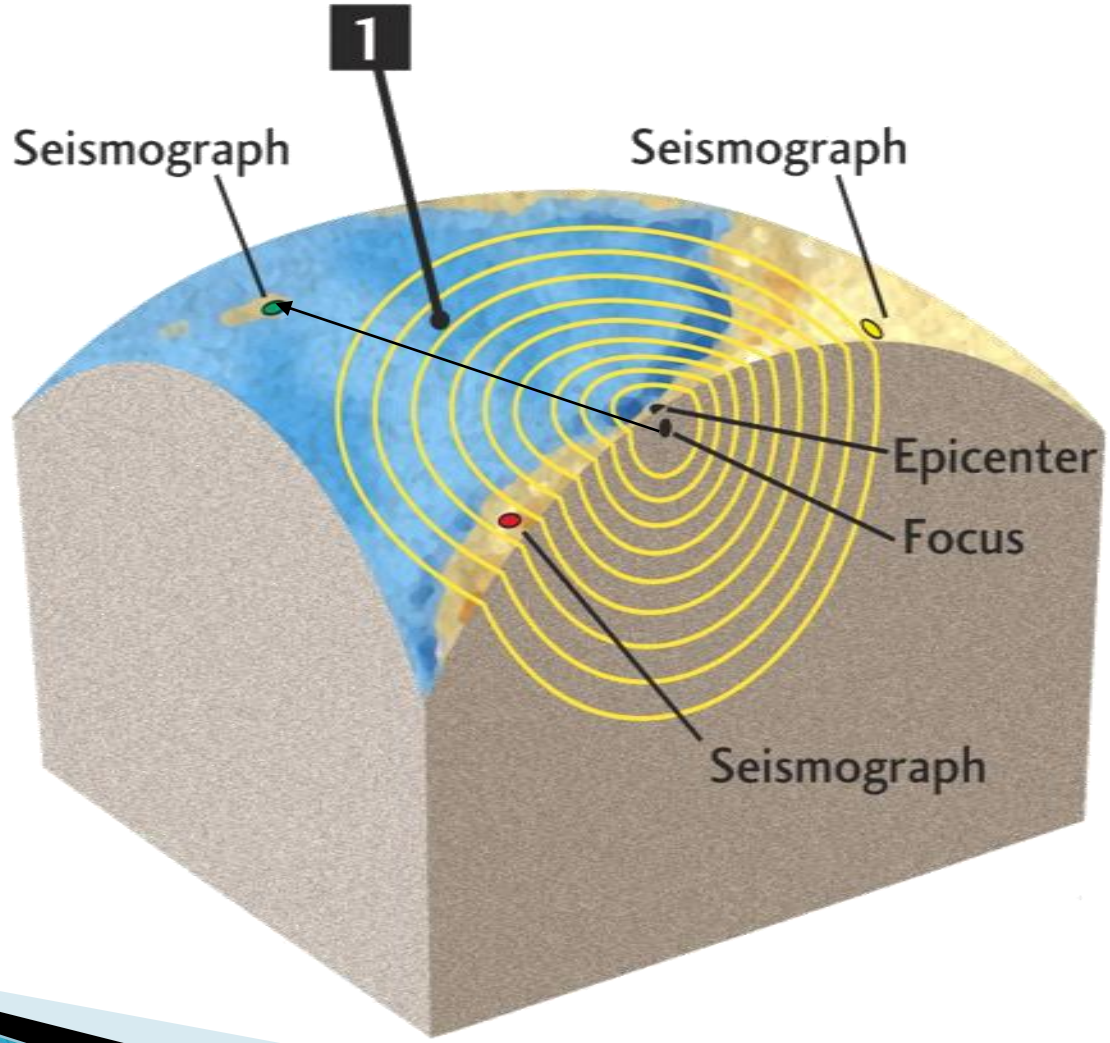




EARTHQUAKE – TREMOR or a TREMBLER



READINGS AT DIFFERENT SEISMOGRAPHIC STATIONS REVEAL THE LOCATION OF THE EARTHQUAKE EPICENTER



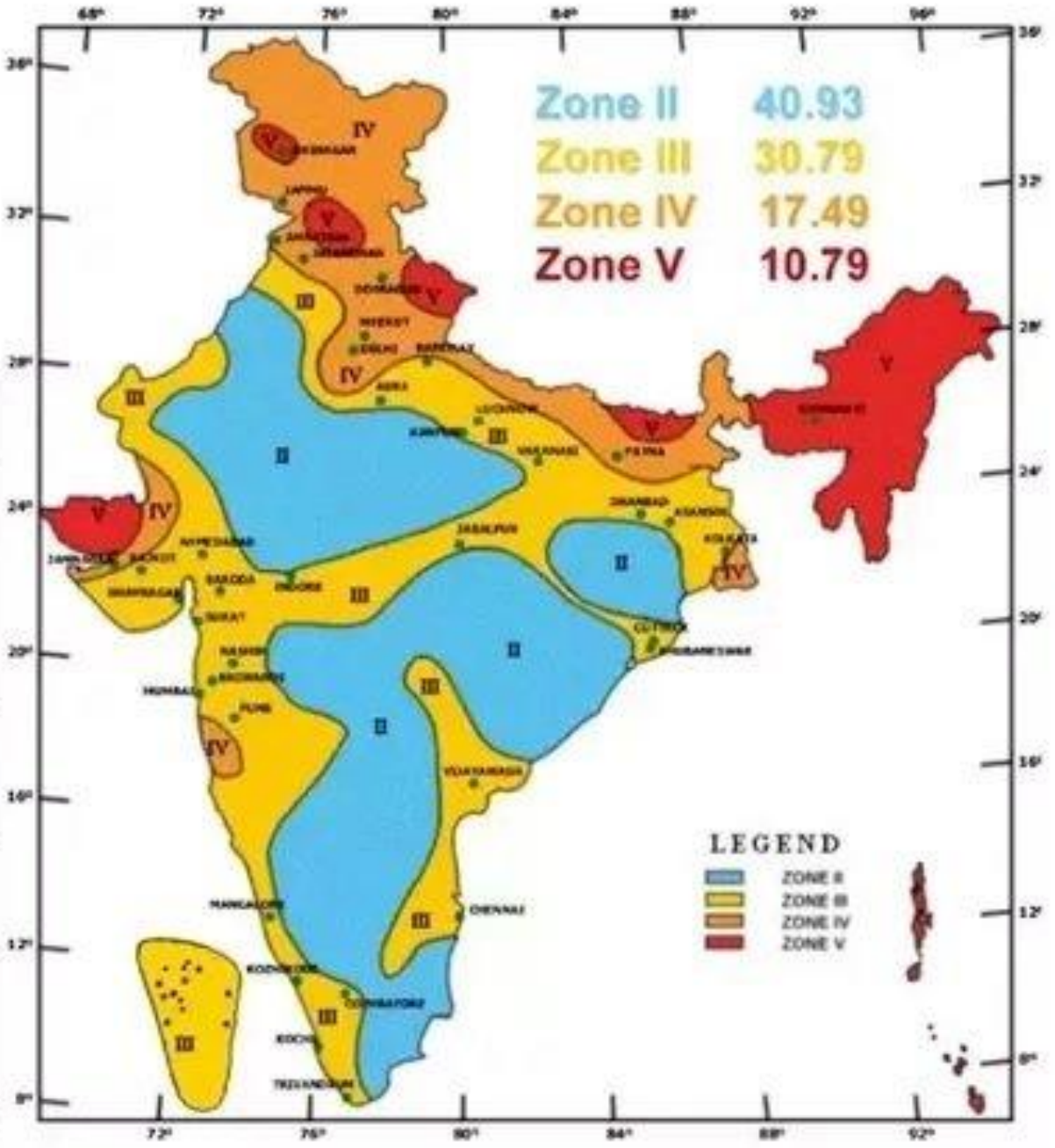
Types of Earthquakes

- A) Shallow focus earthquakes-Seismic shocks originate at a depth of 30 miles or less, below the earth surface
- B) Intermediate earthquakes-Shock originates ata depth between 30 to 150 miles
- C) Deep focus earthquakes-Origin of the shock is at a depth between 150 to 450 miles.

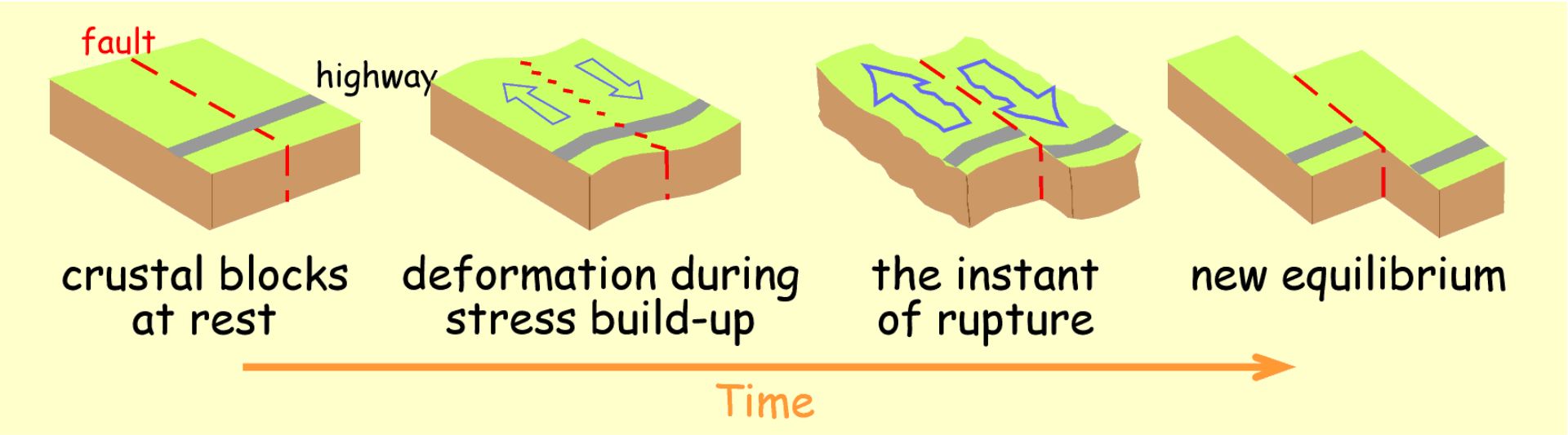
Seismic Zone Map of India: -2002

About 59 percent of the land area of India is liable to seismic hazard damage

Zone	Intensity
Zone V	Very High Risk Zone Area liable to shaking Intensity IX (and above)
Zone IV	High Risk Zone Intensity VIII
Zone III	Moderate Risk Zone Intensity VII
Zone II	Low Risk Zone VI (and lower)

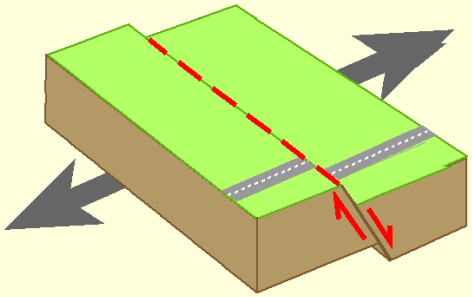
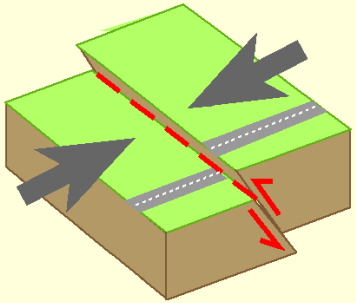
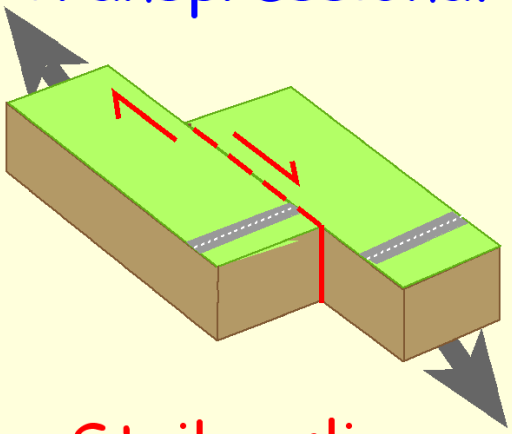


Causes: accumulated strain leads to fault rupture - the elastic rebound model



Styles of faulting

Tectonic regime

Tensional	Compressional	Transpressional
		
Normal	Reverse (Thrust)	Strike-slip

Fault type

The Richter scale

Steps:

1. Measure the interval (in seconds) between the arrival of the first P and S waves.
2. Measure the amplitude of the largest S waves.
3. Use nomogram to estimate distance from earthquake (S-P interval) and magnitude (join points on S-P interval scale and S amplitude scale).
4. Use seismograms from at least three geographic locations to locate epicentre by triangulation.

Let

d – *distance from earthquake*

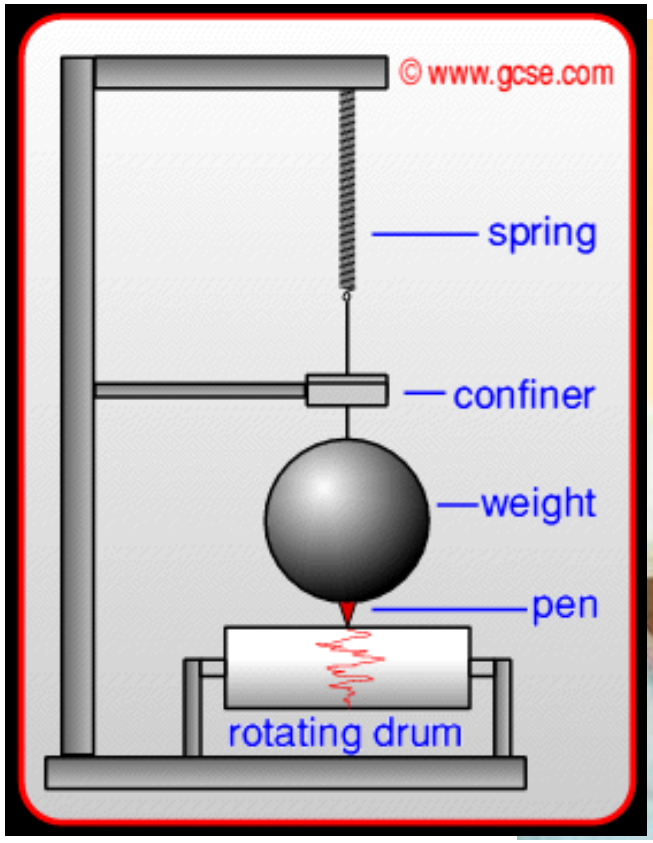
P_v – *P-wave speed*

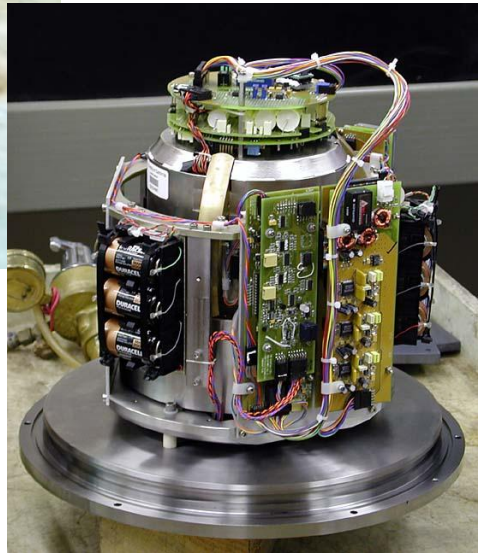
S_v – *S-wave speed*

- The travel time of the P wave is d/P_v
- The travel time of the S wave is d/S_V
- The difference in the arrival times of the waves is

$$d/S_V - d/P_v$$
$$= d(1/S_V - 1/P_V)$$

SEISMOGRAPH
SEISMOMETER

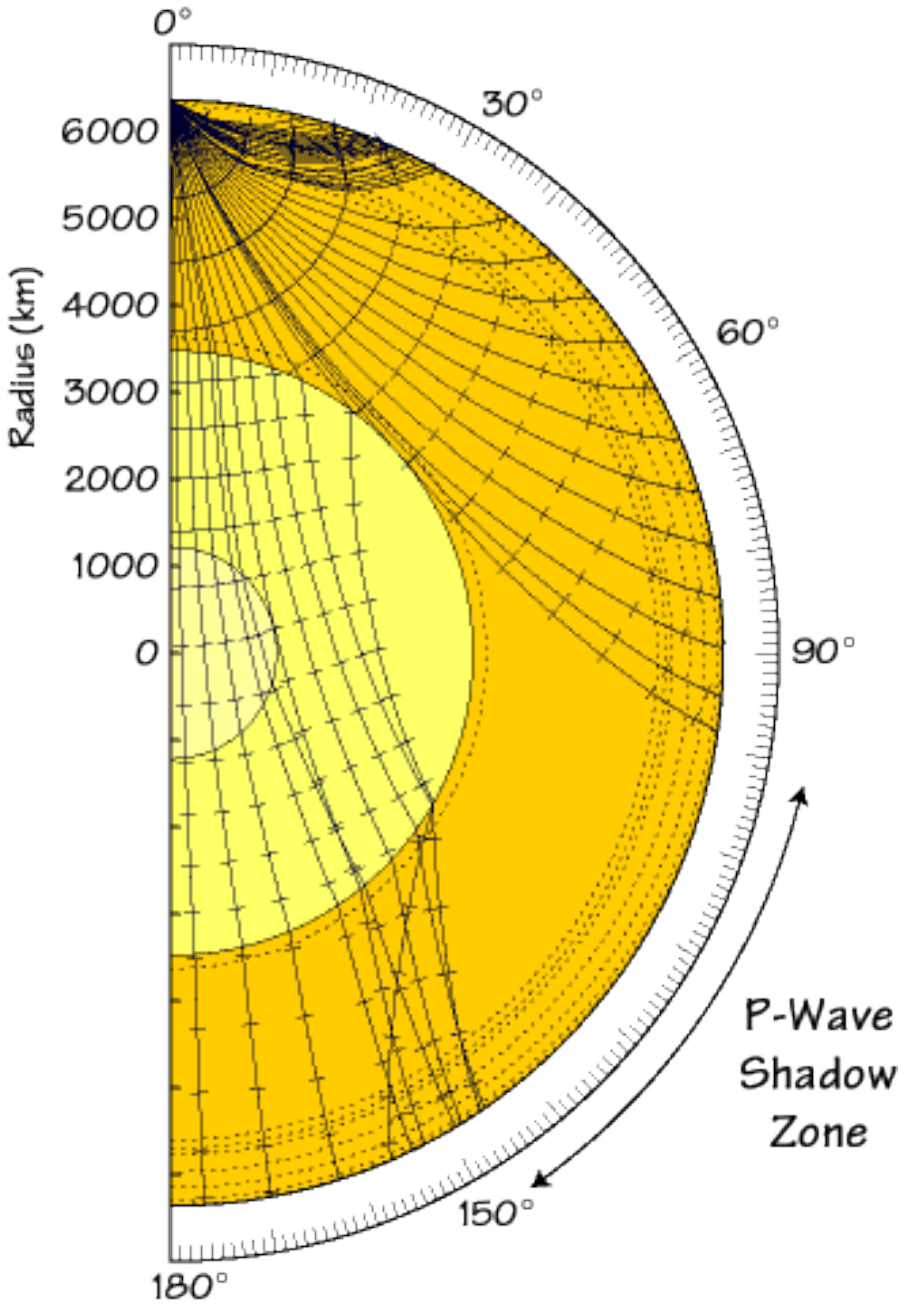


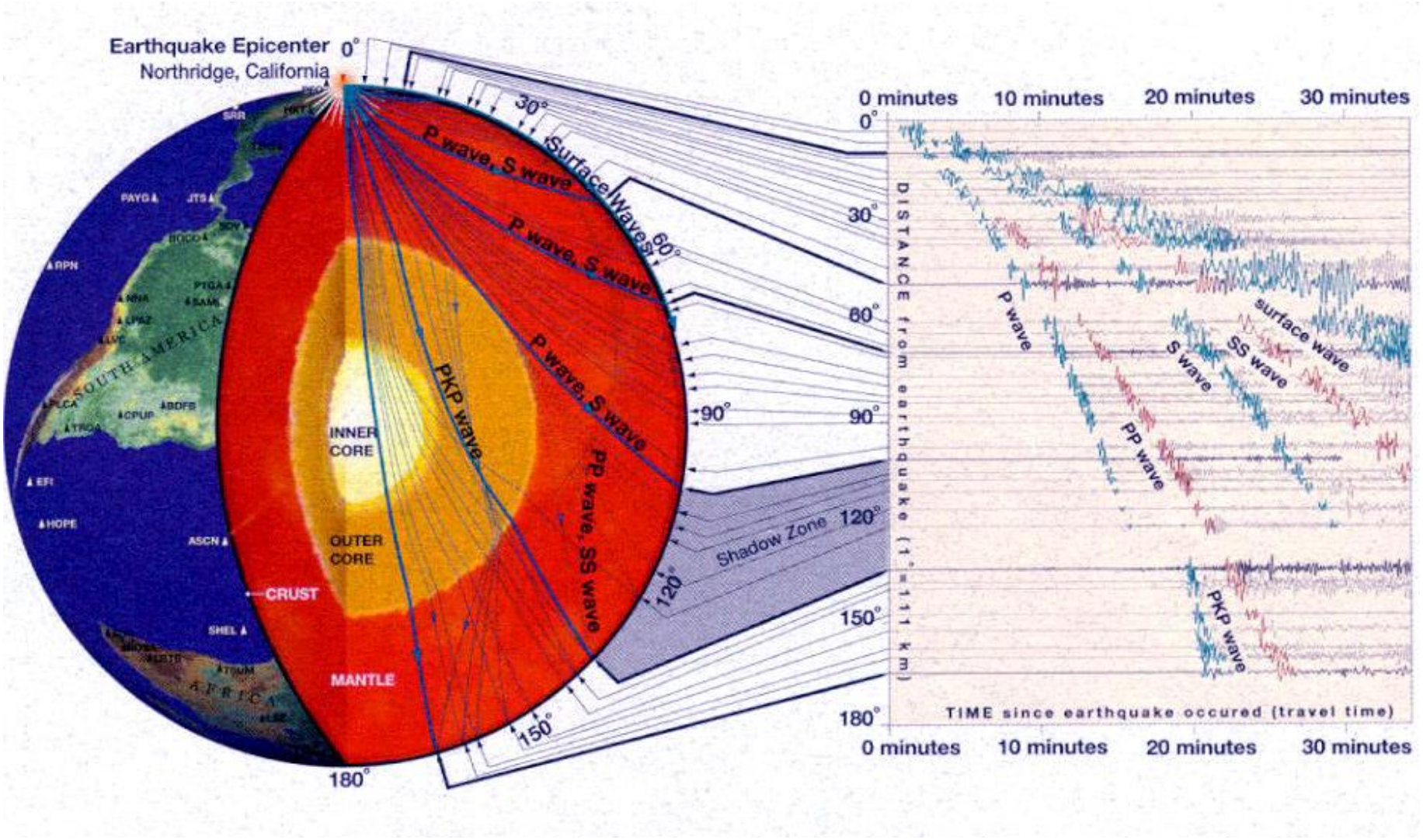


The paths of P-wave energy for a shallow earthquake located at the top of the diagram.

The main chemical shells of Earth are shown by different colors and regions with relatively abrupt velocity changes are shown by dashed lines.

The curves show the paths of waves, and the lines crossing the rays show mark the wavefront at one minute intervals.




Earthquake Epicenter
Northridge, California
0°
30°
60°
90°
120°
150°
180°
P wave, S wave
Surface Waves
P wave, S wave
P wave, S wave
PKP wave
PP wave, SS wave
INNER CORE
OUTER CORE
MANTLE
CRUST
Shadow Zone
SOUTH AMERICA
AFRICA
0 minutes
10 minutes
20 minutes
30 minutes
DISTANCE from earthquake (1° = 111 km)
P wave
S wave
PP wave
surface wave
SS wave
PKP wave
TIME since earthquake occured (travel time)