EARTHQUAKE

INTRODUCTION

- Earthquakes constitute one of the worst natural hazards which often turn into disaster causing widespread destruction and loss to human life.
- The effects of earthquake vary upon the magnitude and intensity. Earthquakes occur every now and then all round the world, except in some places where earthquakes occur rarely. The devastation of cities and towns is one of the effects of earthquake.

What is Earthquake?

An Earthquake is the result of a **sudden release of energy** in the earth's crust that creates seismic waves.

The seismic activity of an area refers to the frequency, type and size of earthquakes experienced overa period of time

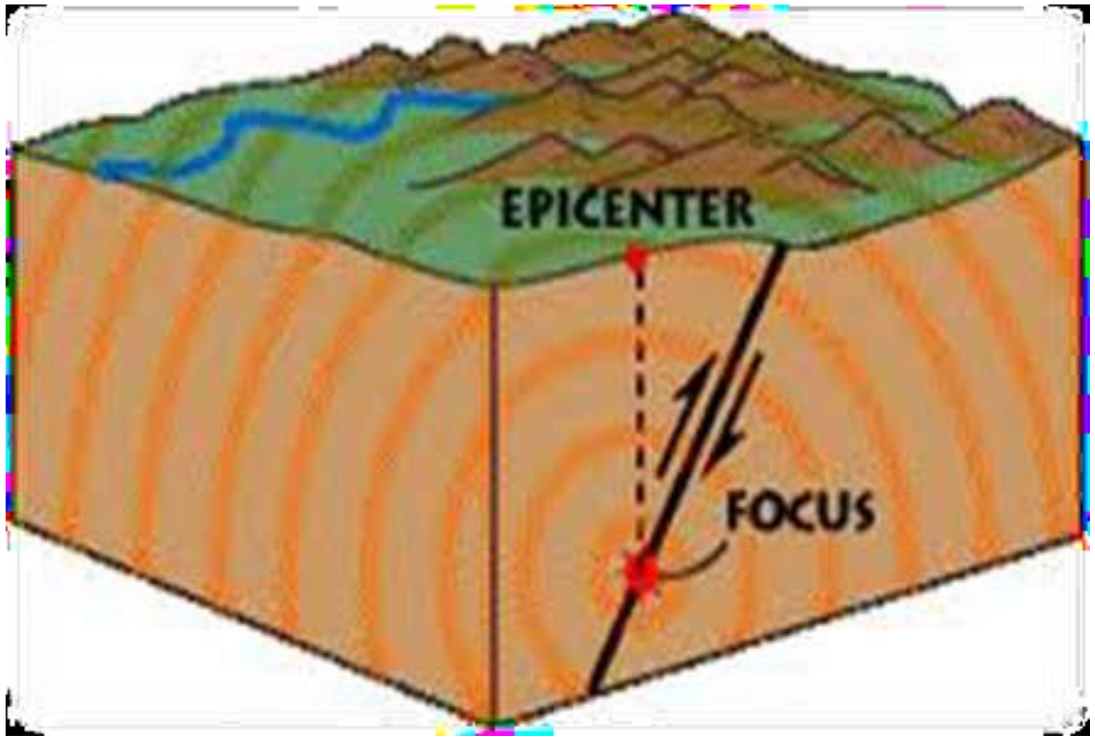
DEFINITION

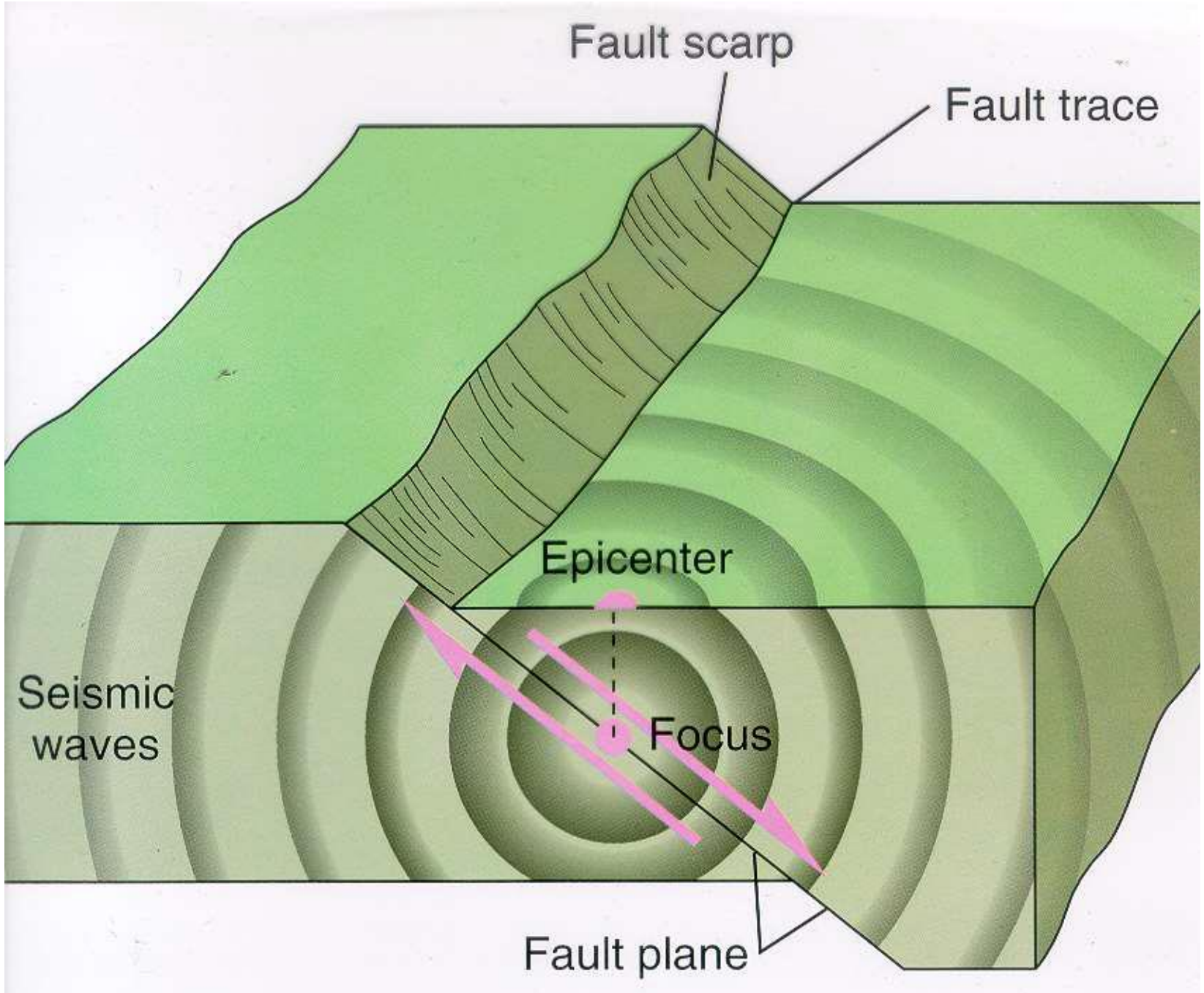
Earthquake = Vibration of the Earth produced by the rapid release of energy

Seismic waves = Energy moving outward from the focus of an earthquake

Focus(Hypocenter):
Focus is the point on the fault where rupture occurs and the
location from which seismic waves are released.

Epicenter:
Epicenter is the point on the earth's surface that is directly
above the focus ,the point where an earthquake or underground explosion originates.




Fault scarp
Fault trace
Epicenter
Seismic
waves
Focus
Fault plane

Causes Of Earthquake

The primary cause of an earthquake is faults on the crust of the earth.
“A Fault is a break or fracture b/w two blocks of rocks in response to stress.”

- This movement may occur rapidly, in the form of an earthquake or may occur slowly, in the form of creep.
- Earth scientists use the angle of the fault with respect to the surface (known as the dip) and the direction of slip along the fault to classify faults.

Some major causes of earthquakes on basic of its causes are:

- Surface causes
- Volcanic causes
- Tectonic causes

Surface cause:

Great explosions, landslides, slips on steep coasts, dashing of sea waves , avalanches , railway trains, heavy trucks, some large engineering projects cause minor tremors. some of them are man made, other are natural.

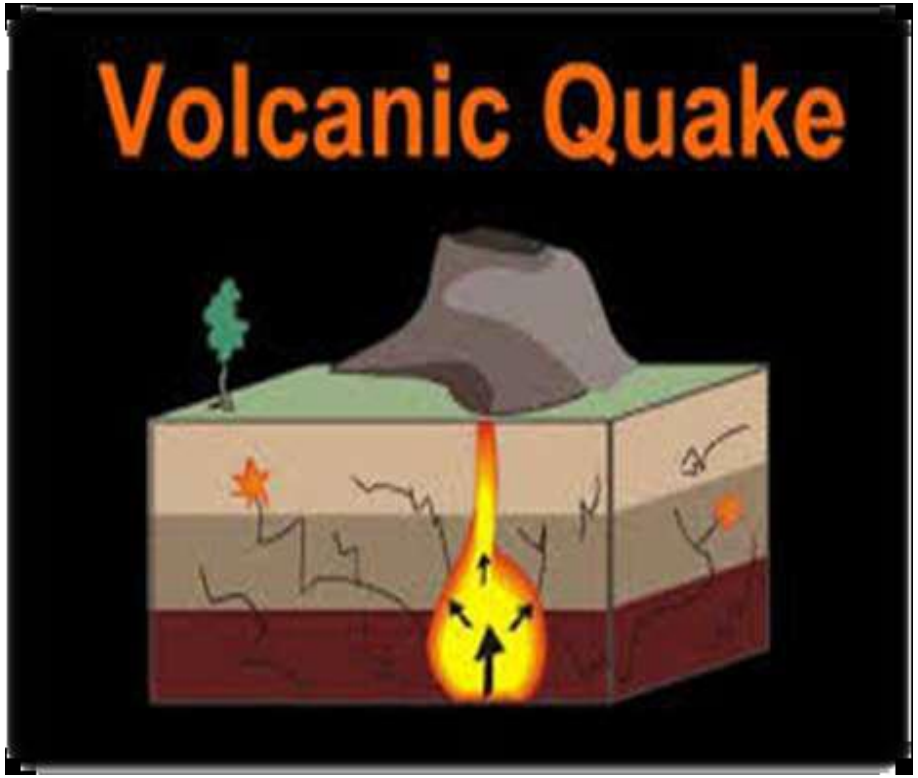
Volcanic cause:

Volcanic eruptions produce earthquakes. Earthquakes may precede, accompany and frequently follow volcanic eruptions.

They are caused by sudden displacements of lava within or beneath the earth crust.

There are two general categories of earthquakes that can occur at a volcano:

- **volcano-tectonic earthquakes**
- **long period earthquakes**



Tectonic cause:
Structural disturbances resulting in the parts of the lithosphere is the main cause of this type of earthquake. Most of the disastrous earthquakes belong to this category and occur in areas of great faults and fractures. Sudden yielding to strain produced on the rocks of accumulating stress causes displacements especially along old fault zones known as great transform faults.

Seismic waves produced due to earthquake are basically

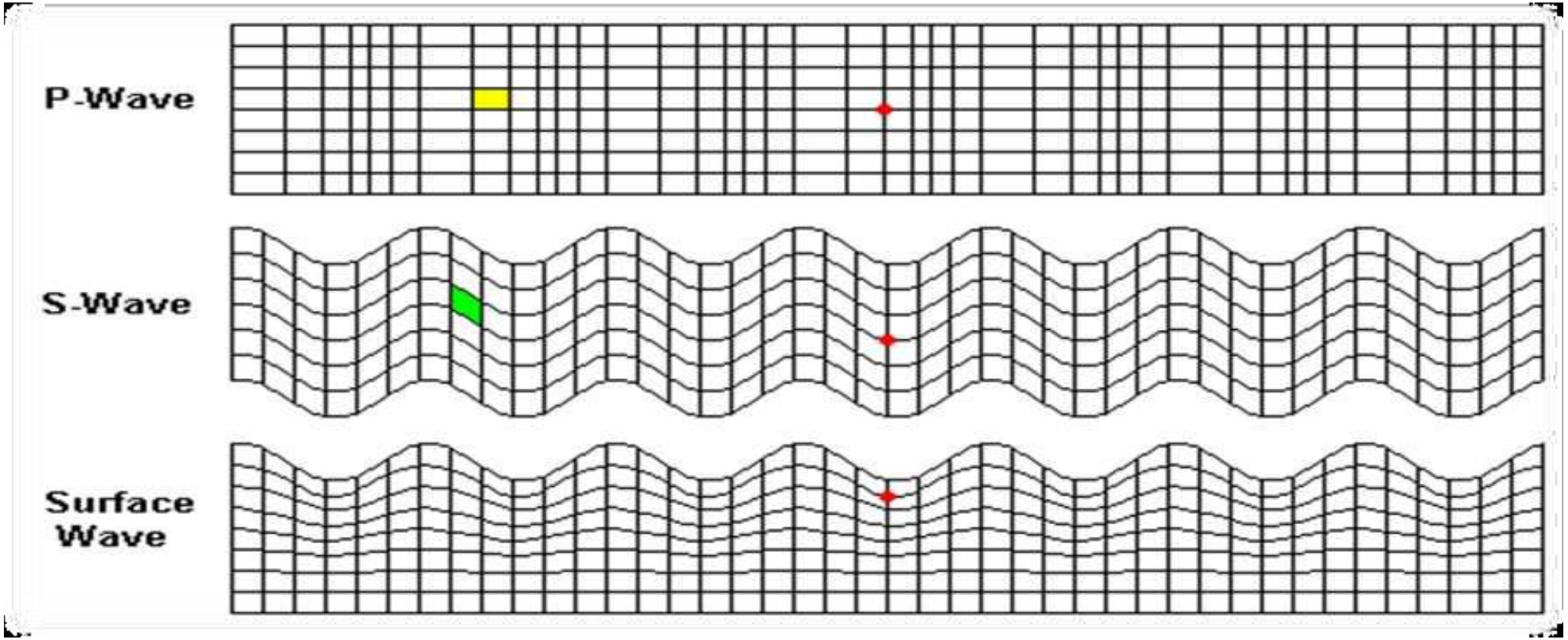
divided into two major types:

- Body waves
- Surface waves

Body waves:

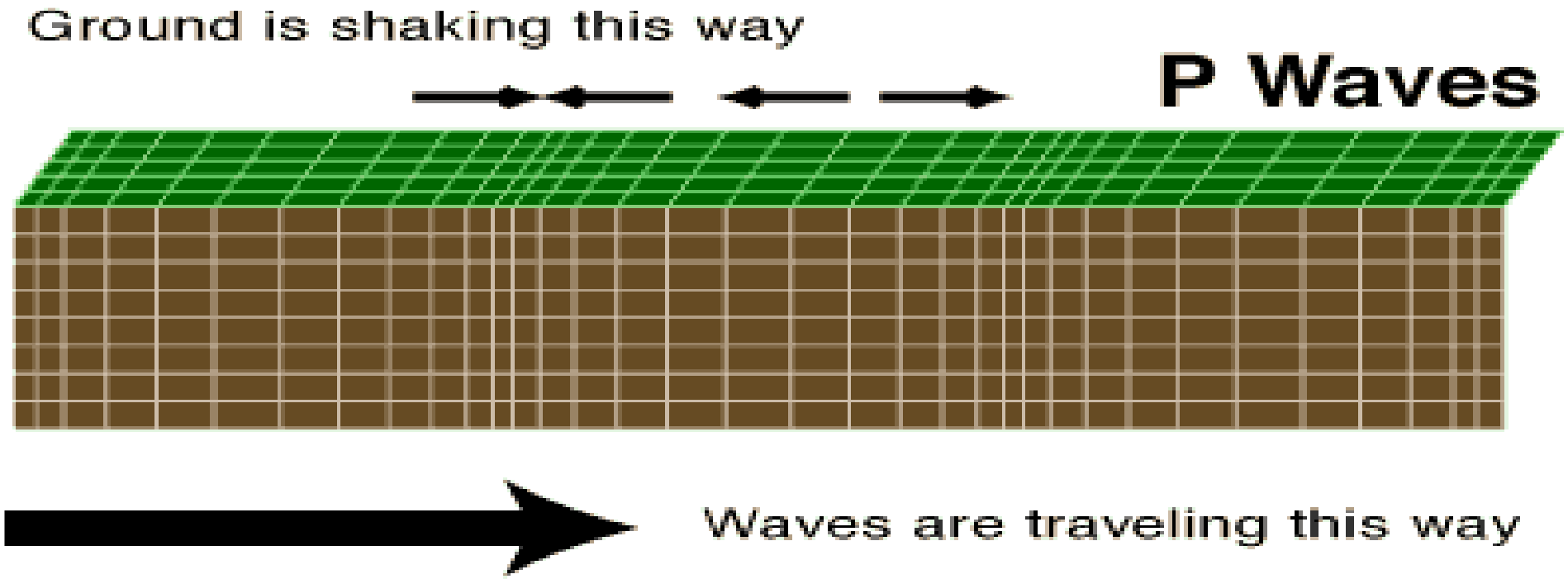
Body waves travels through the interior(body) of earth as they leave the focus. Body waves are further divided into following types:

- Primary (P) waves
- Secondary(S) waves



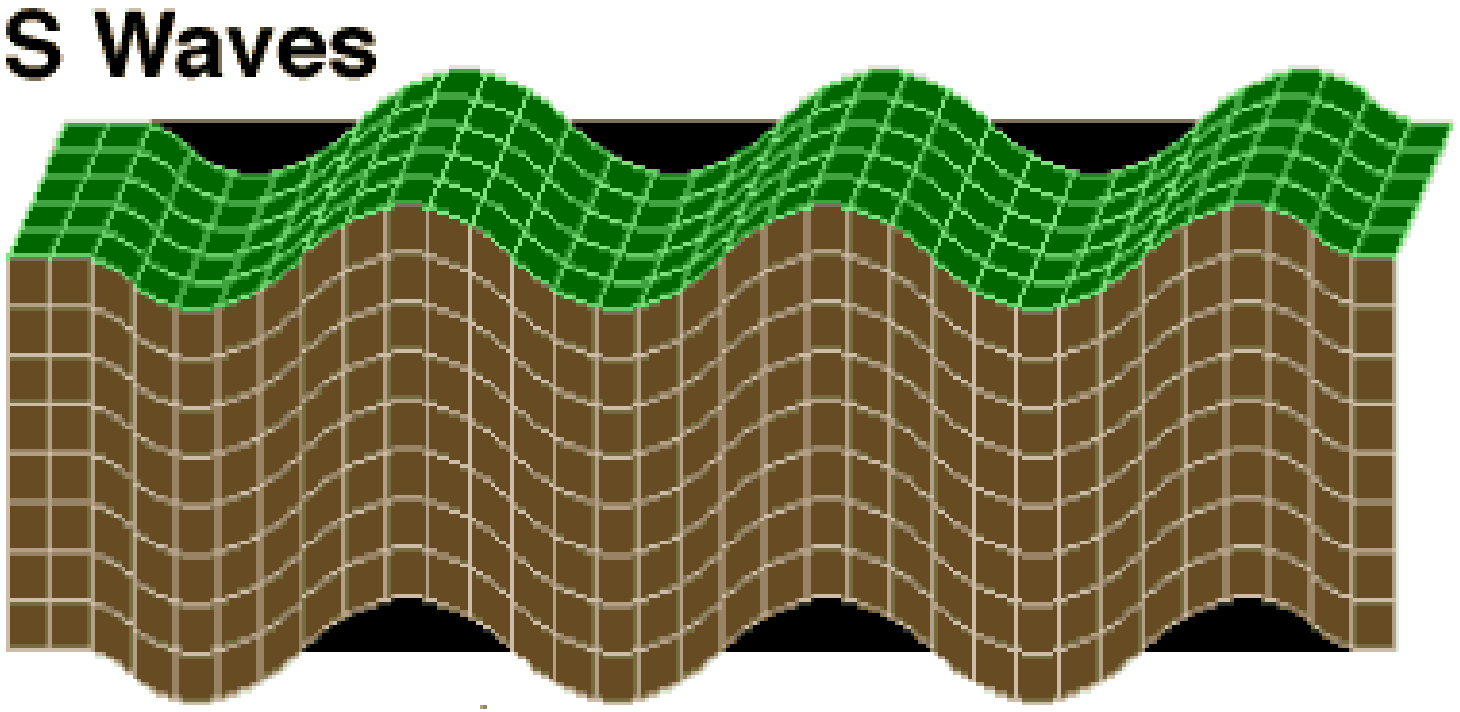
Primary Waves:

- called compressional, or push-pull waves.
- Propagate parralel to the direction in which the wave is moving.
- Move through solids, liquids



Secondary Waves (S);

- Called shear waves.
- Propagate the movement perpendicular to the direction in which the wave is moving.



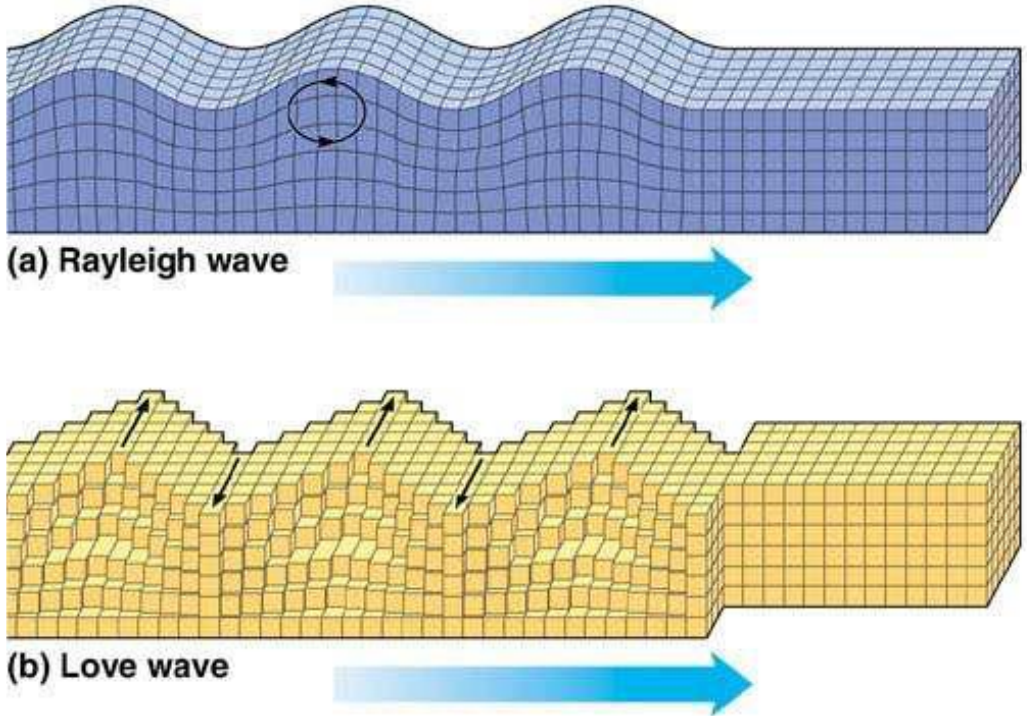
Primary Waves (P-waves)	Secondary Waves(S-wave)
High frequency	High frequency
Short Wavelength	Short Wavelength
Longitudinal waves	Transverse waves
Pass trough both solids and liquids	Can not move through liquids
Move forwards and backwards as it compressed and decompressed	Move in all direction from their source
P-wave is faster	S-wave is more slower than P-wave
First P-wave arrive	After P-wave,S-wave is arrive

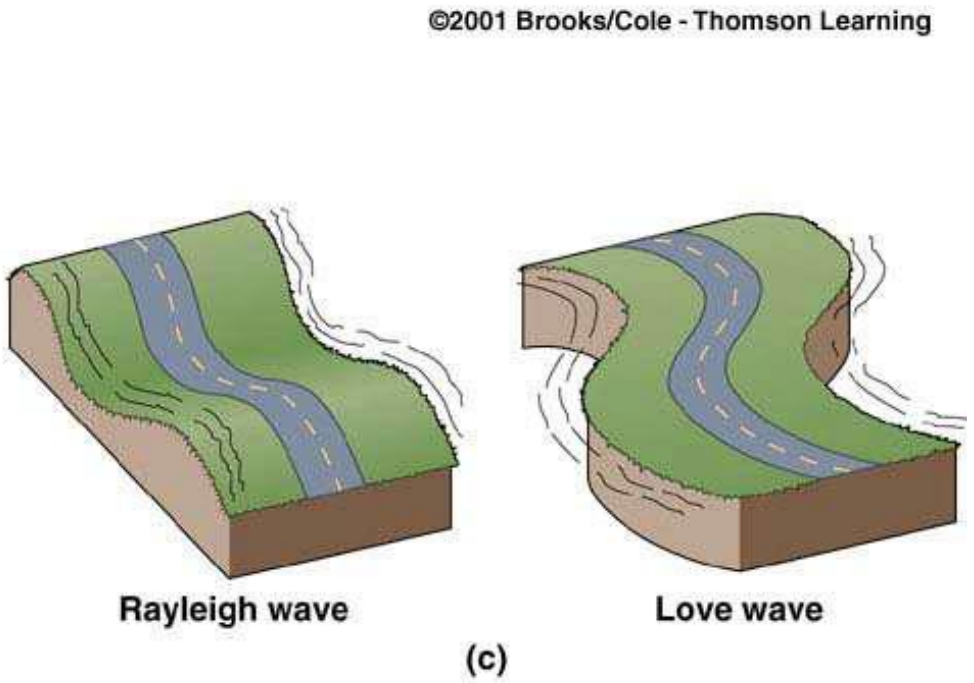
Surface Wave:

Surface waves travels parallel to the earth's surface and these waves are slowest and most damaging.

Surface wave are divided into following types:

- Love waves
- Rayleigh waves



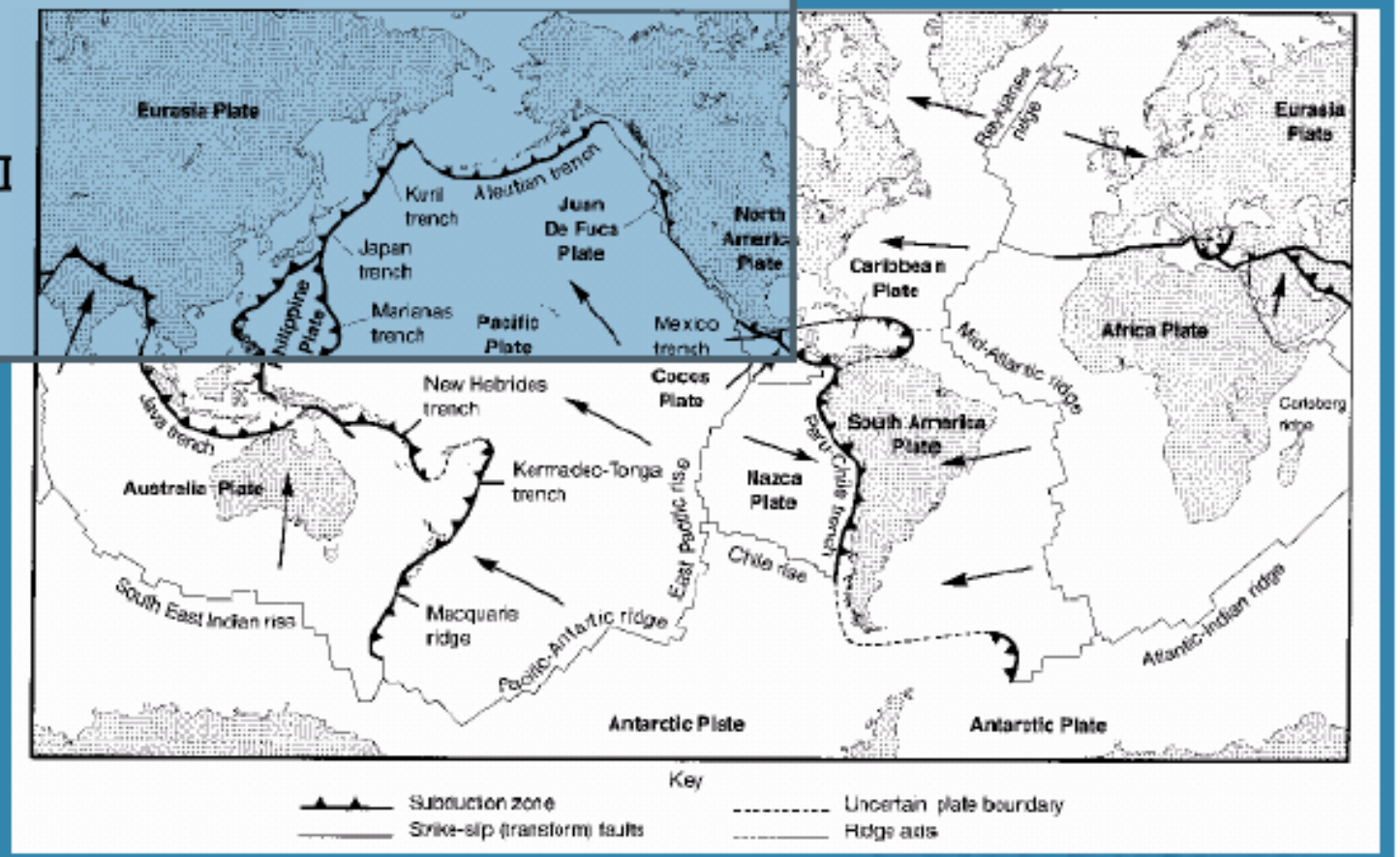


Love Waves	Rayleigh wave
Guided waves	Guided waves
Displacement is parallel to the free surface	Displacement is perpendicular to love-wave displacement
Love wave is faster	Rayleigh wave is slower
Causes horizontal shifting of the earth surface.	Ground move in circular motion.

Plate Tectonics

The earth's crust is divided into six continental-sized plates

- African
- American
- Antarctic
- Australia-I
- Eurasian
- Pacific



Convection Currents in Mantle

- Near the bottom of the crust, horizontal component of convection currents impose shear stresses on bottom of crust, causing movement of plates on earth's surface.
- The movement causes the plates to move apart in some places and converge in others.

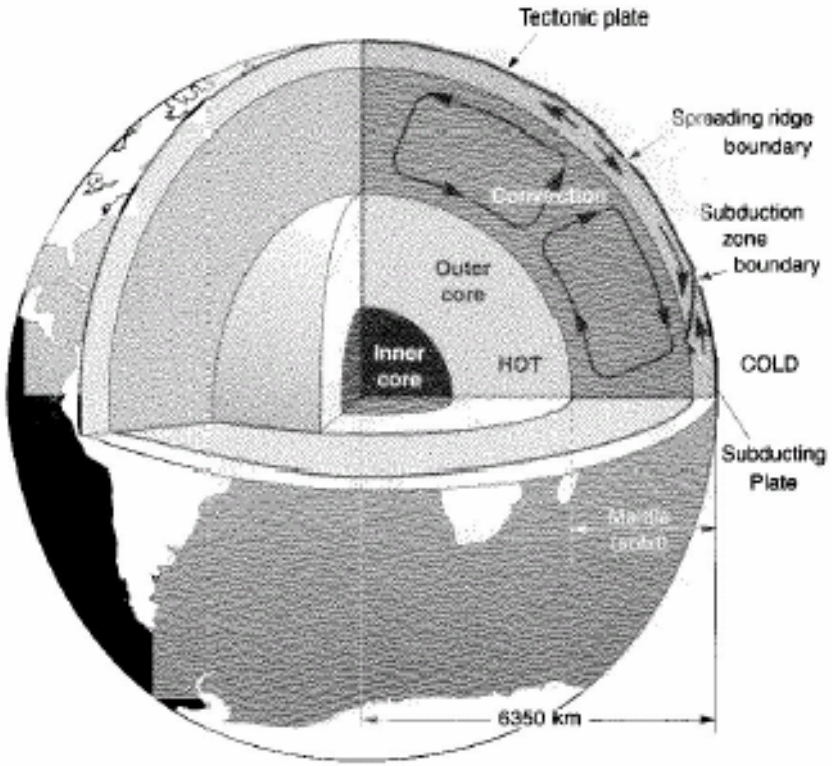


Plate Tectonics: The crust in motion

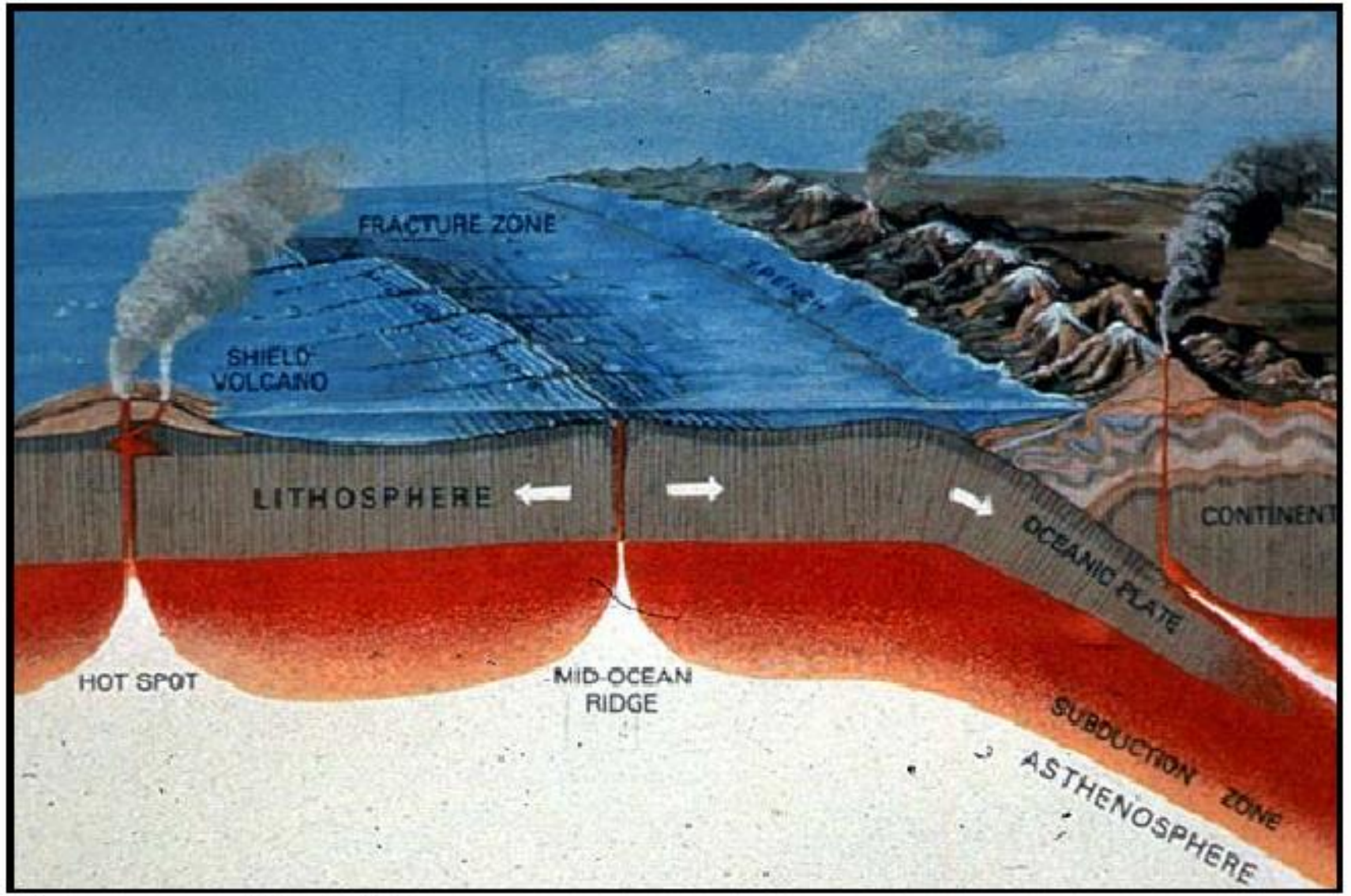
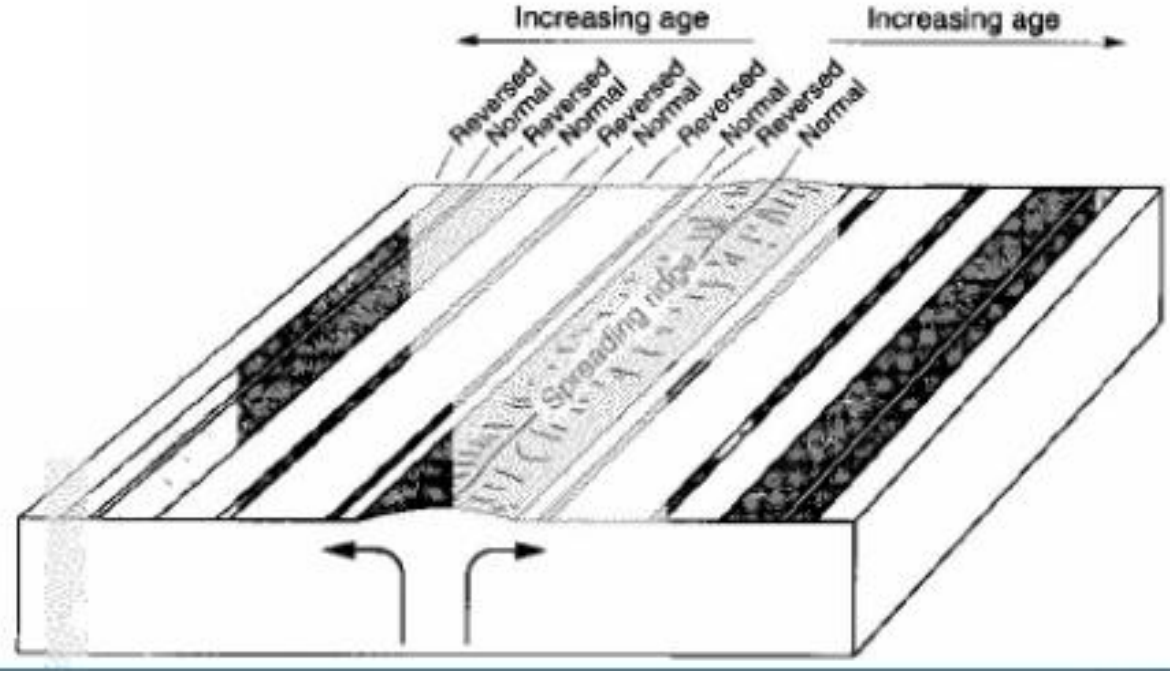


Photo courtesy of the USGS

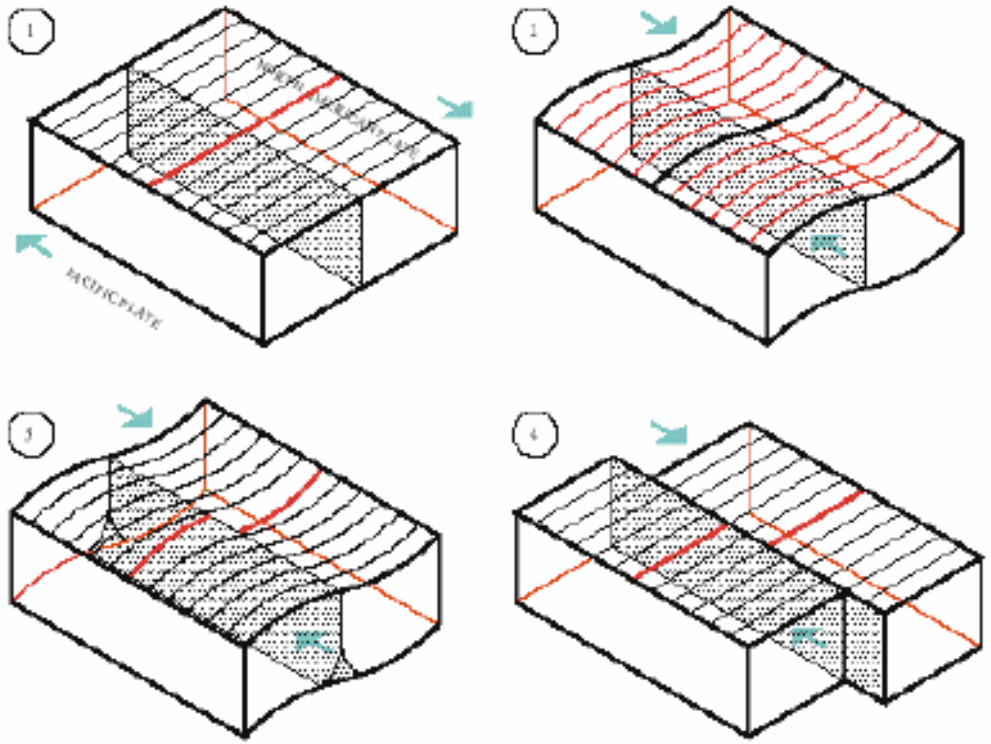
Spreading Ridge Boundaries

- Magma rises to surface and cools in gap formed by spreading plates.
- Magnetic anomalies are shown as stripes of normal and reversed magnetic polarity



Elastic Rebound Theory of Earthquakes

Rocks are elastic, and mechanical energy can be stored in them just as it is stored in a compressed s
When the two blocks for
the opposite sides of the
move by a small amount, t
motion elastically strains
rocks near the fault. Wh
stress becomes larger th
frictional strength of the
the fictional bond fails a
weakest point. That poin
initial rupture, called the
hypocenter, may be near the
surface or deep below it.



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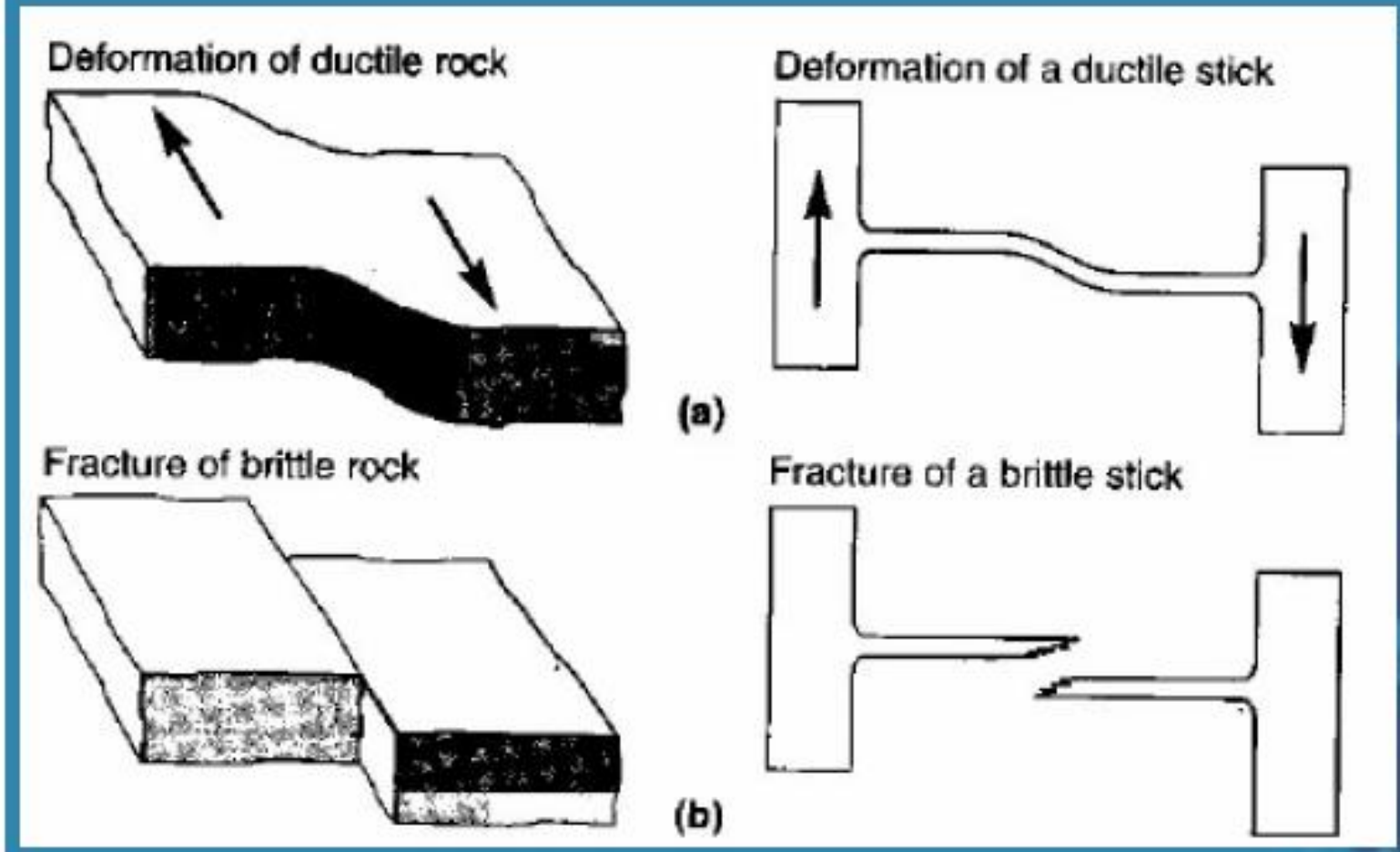

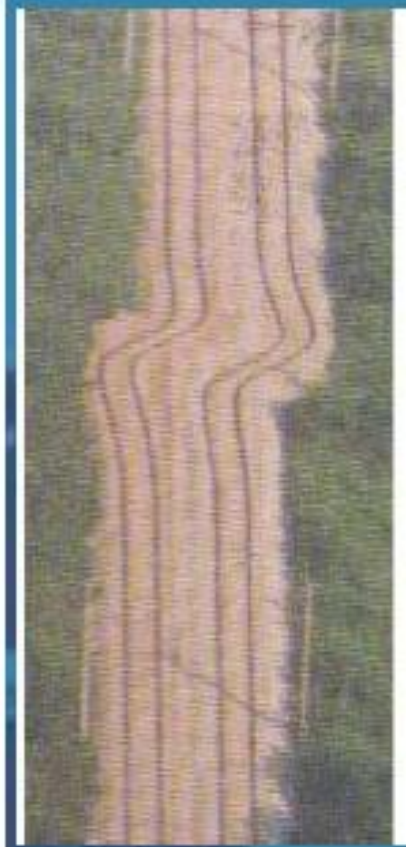

Magnitude and Intensity

Magnitude is directly related to energy release due to plate movement. It has a unique value for an earthquake.

It varies from 1 to 10.

Intensity is related to *human feelings, behavior of secondary structures and structural behavior*. It has different values at different locations for a particular earthquake.

It varies from I to XII.

Magnitude and Intensity of Some Historical Earthquakes in Bangladesh

Event Name	M	I_{Dhaka}	Distance
1869 Cachar	**7.5**	**V**	**250 km**
1885 Bengal	**7.0**	**VII**	**170 km**
1897 Great Indian	**8.7**	**VIII+**	**230 km**
	8.0 Ambraseys, 2000		
1918 Srimangal	**7.6**	**VI**	**150 km**
1930 Dhubri	**7.1**	**V+**	**250 km**

Trifunac and Brady (1975): $\log(PGA) = 0.014 + 0.3 * I$

EMS VIII

a) Many people find it difficult to stand, even outdoors.

b) Furniture may be overturned. Waves may be seen on very soft ground.

c) Many buildings of **class B (Unreinforced brick)** and a few of **class C (Unreinforced with RC floors/Frame with no antiseismic design)** suffer damage of **grade 3**.

Many buildings of **class A (Mud house)** and a few of **class B** suffer damage of **grade 4**; a few buildings of **class A** suffer damage of **grade 5**.

VULNERABILITY TABLE

Type of Structure		Vulnerability Class A B C D E F
MASONRY	rubble stone fieldstone	○
	adobe (earth brick)	○--
	simple stone	--○
	massive stone	--○--
	unreinforced brick / concrete blocks	--○--
	unreinforced brick with RC floors	--○
	reinforced brick (confined masonry)	--○----
REINFORCED CONCRETE (RC)	RC without antiseismic design (ASD)	----○--
	RC with mininum level of ASD	--○----
	RC with moderate level of ASD	----○
	RC with high level of ASD	--○
WOOD	wooden structures + Bamboo	--○----

DAMAGE GRADE

Table 2: Classification of damage to masonry buildings

Grade 1: Negligible to slight damage (no structural damage)
hair-line cracks in very few walls; fall of small pieces of plaster only. Fall of loose stones from upper parts of buildings in very few cases only.

Grade 1

Grade 2: Moderate damage (slight structural damage, moderate non-structural damage)
cracks in many walls; fall of fairly large pieces of plaster; parts of chimneys fall down.

Grade 2

Grade 3: Substantial to heavy damage (moderate structural damage, heavy non-structural damage)
large and extensive cracks in most walls; pantiles or slates slip off. Chimneys are broken at the roof line; failure of individual non-structural elements.

Grade 3

Grade 4: Very heavy damage (heavy structural damage, very heavy non-structural damage).
serious failure of walls; partial structural failure.

Grade 4

Grade 5: Destruction (very heavy structural damage)
total or near total collapse.

Grade 5

Richter Magnitude

- In 1935, Charles Richter used a Wood-Anderson seismometer to define a *magnitude* scale for shallow, local (epicentral distances less than about 600 km (375 miles)) earthquakes in southern California.

- The Richter Magnitude, M, is calculated from the maximum amplitude, A, of the seismometer trace (Wood-Anderson Seismometer, T_0 = 0.8sec and h=0.80) at a distance of 100 km from the epicenter.

$$M = \log A$$

however, a standard seismometer is not always at 100 km from the epicenter, in which

$$M = \log A - \log A_0$$

A_0 = maximum recorded amplitude for a particular earthquake selected at a site, generally A_0 = 0.001 mm for 100 km distance.