EWCE 203

Geology and Geomorphology

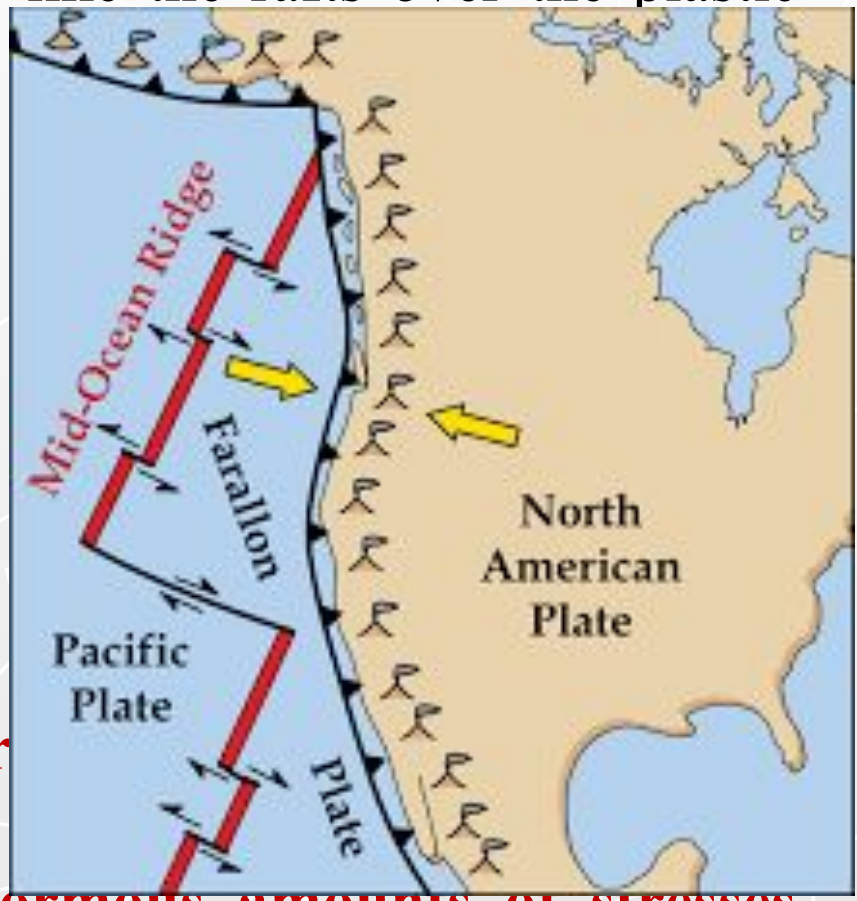
Earthquake Theory & Earthquake Waves

Earthquake Theory & Earthquake Waves

Plate Tectonic Theory:

- Most of the EQs **occur in narrow belts** which mark the **edges of crustal plates.**

- These **plates move about the earth** like the rafts over the plastic materials of the asthenosphere.



- These plates **collide, separate** or **simply slide past** each other.

- **EQs frequently accompany these plate interactions**.

- American and pacific plates are **converging at a rate** of about **5cm/year**

- As Plates slide past each other, **enormous amounts of stresses builds** up within the plates.

Plate Tectonic (cont..)

- **A fault line**, a break in the Earth's crust **where blocks of crust are moving** in different directions, **will form.**

- Most, though not all, earthquakes happen along **transform boundary fault lines**.

- These **stresses are commonly released in sudden slipping action and producing numerous EQs along the fault zone**.

- EQs are known as **Inter-plate** Boundary EQ.

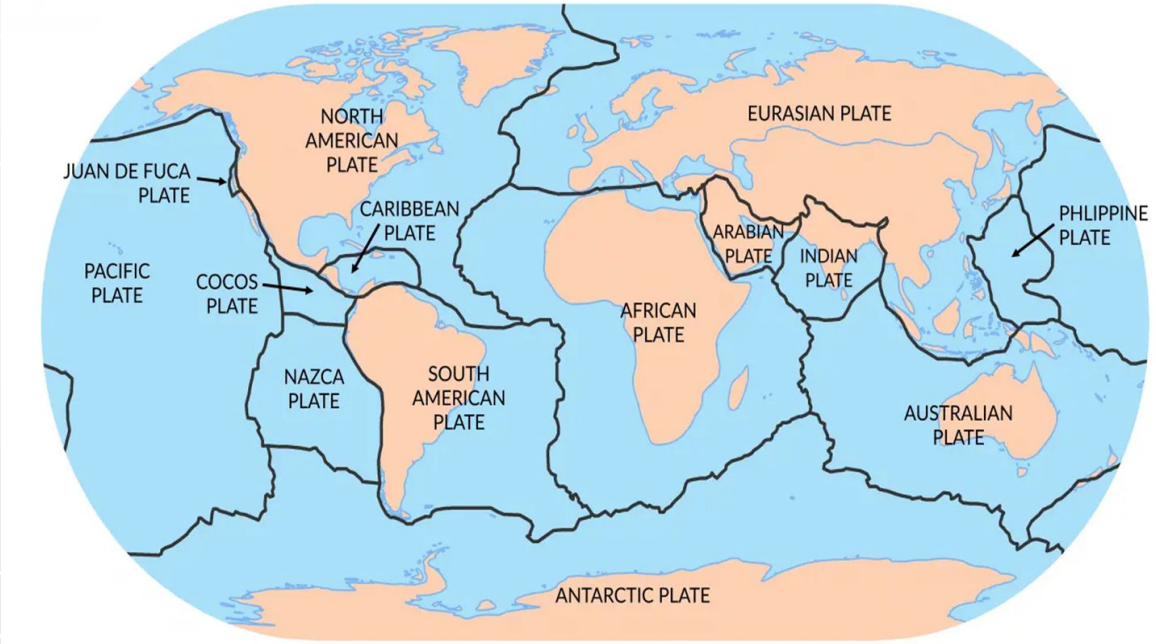


Railroad tracks shifted by the 1976 Guatemala earthquake

Plate Tectonic Theory

Plate tectonics, theory deals with **the dynamics of earth's outer shell—the lithosphere** by providing a uniform context for understanding **mountain-building processes**, **volcanoes** and **earthquakes** as well as the **evolution of Earth's surface** and **reconstructing its past continents and oceans**.

- Pacific Plate
- North American Plate
- South American Plate
- African Plate
- Eurasian Plate
- Australian Plate
- Antarctica Plate



Concept of plate Technics

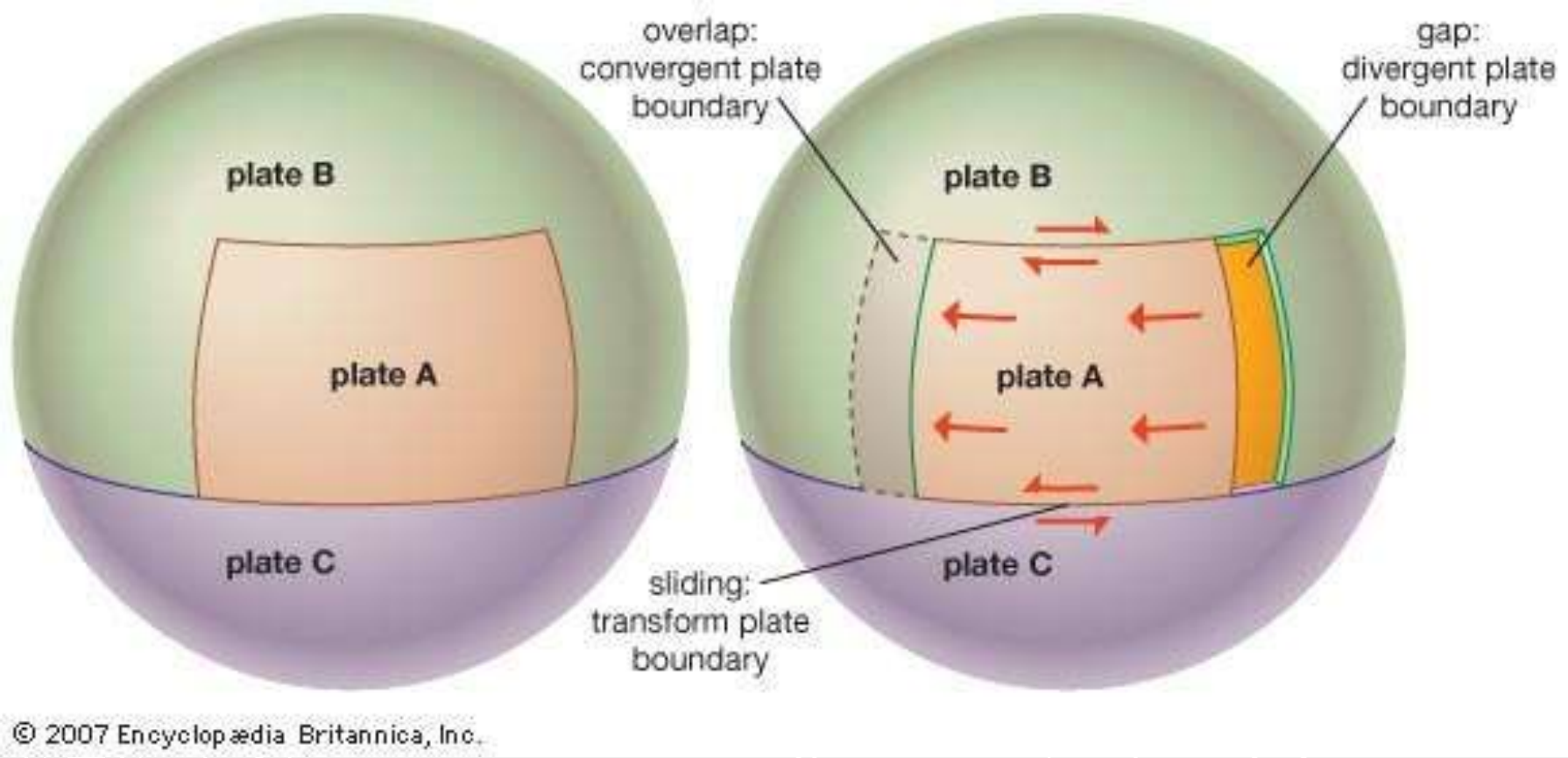
- Formulated in the **1960s.**

- According to the theory, Earth has a **rigid outer layer**, known as the **lithosphere**, which is typically about 200kms thick and overlies a plastic (moldable, partially molten) layer called the **asthenosphere**.

- Lithosphere is broken up into **seven very large continental-** and ocean-sized plates, **six or seven medium-sized** regional plates, and **several small ones**.

- **Plates move relative to each other**, typically at **rates of 5 to 10 cm** (2 to 4 inches) per year, and interact along their boundaries, where they **converge, diverge, or slip past (transform) one another**

Plate Boundary:



Divergent Plate Boundary- constructive boundary:

- As plates move apart at a **Divergent Plate Boundary,** the **release of pressure** produces partial melting of the underlying mantle is buoyant.

- As a result, it wells up from below and cools close to the surface to **generate new crust**.

- Because new crust is formed, divergent margins are also called **constructive boundary**.



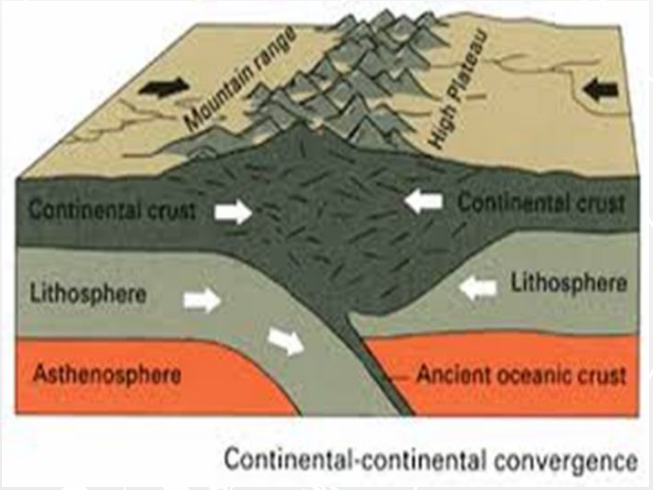
- Given **that earth is constant in volume**, the continuous formation of Earth's new crust **produces an excess** that must be **balanced by destruction of crust** elsewhere.

- **Destruction of crust** is **accomplished at convergent plate boundaries**, also known as destructive plate boundaries, where one plate descends at an angle—that is, is sub-ducted beneath the other.

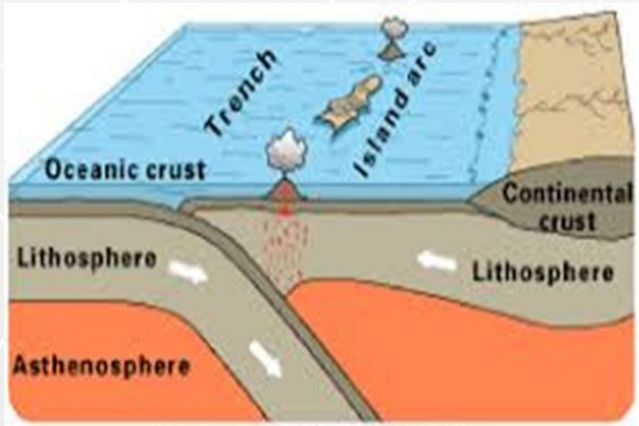
Convergent plate boundary

- Where **two oceanic plates meet**, the older, **denser plate is preferentially sub-ducted** beneath the younger, warmer one.

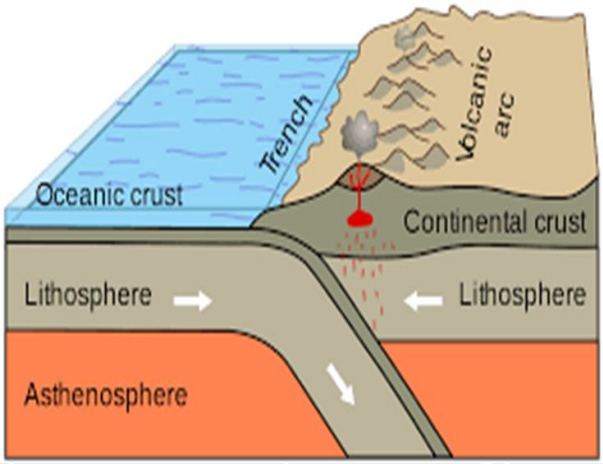
- Where one of the plate is **oceanic and the other is continental,** the greater buoyancy of continental crust prevents it from sinking, and the **oceanic plate is preferentially sub-ducted.**

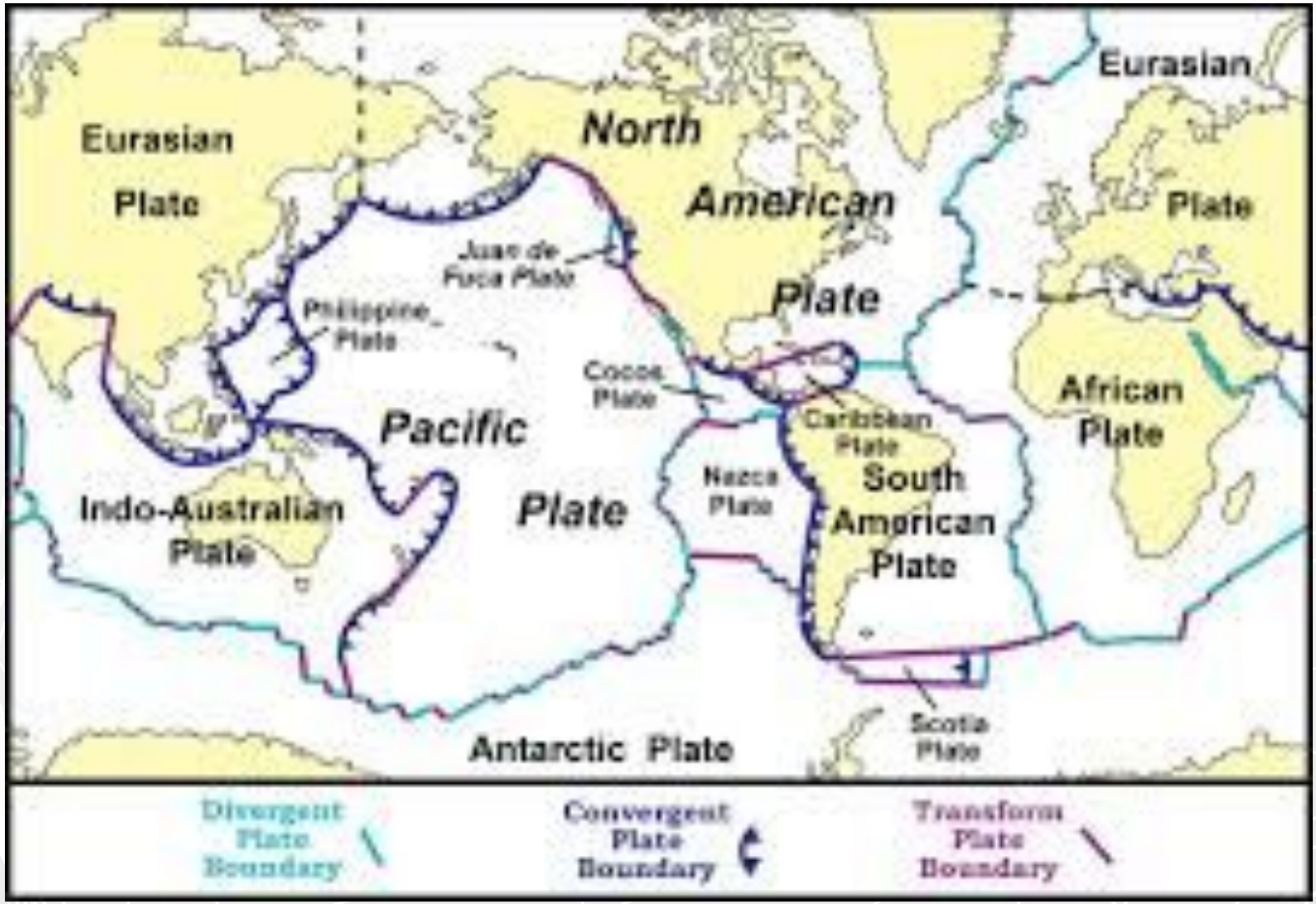


Continental-continental convergence



Oceanic-oceanic convergence




Eurasian
Plate
North
American
Plate
Eurasian
Plate
Juan de
Fuca Plate
Philippine
Plate
Cocos
Plate
Pacific
Plate
Caribbean
Plate
African
Plate
Nazca
Plate
South
American
Plate
Indo-Australian
Plate
Antarctic Plate
Scotia
Plate
Divergent
Plate
Boundary
Convergent
Plate
Boundary
Transform
Plate
Boundary

Transform Plate Boundary

- **Two plates move laterally** and pass each other along giant fractures in Earth's crust.

- Are so named because they are linked to other types of plate boundaries.

- Majority of transform faults link the offset segments of oceanic ridges.

- Transform plate boundaries **are conservative because** plate interaction occurs without creating or destroying crust.

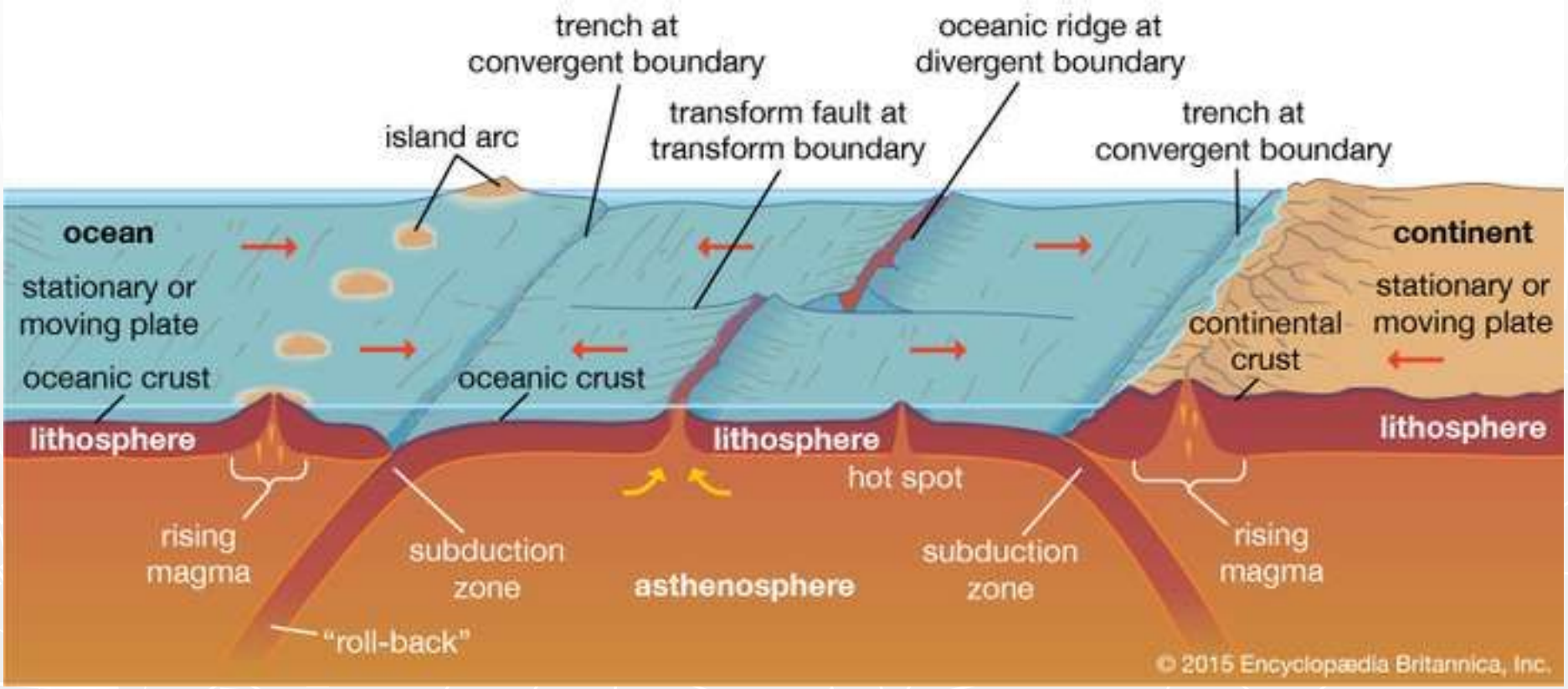
- Because the only motion along these faults is the **sliding of plates past each other**, the horizontal direction **along the fault surface** must parallel the direction of plate motion.

- **Fault surfaces are rarely smooth**, and **pressure may build up when the plates on either side temporarily locked.**

- This **buildup of stress** may be suddenly released in the form of an **earthquake**.



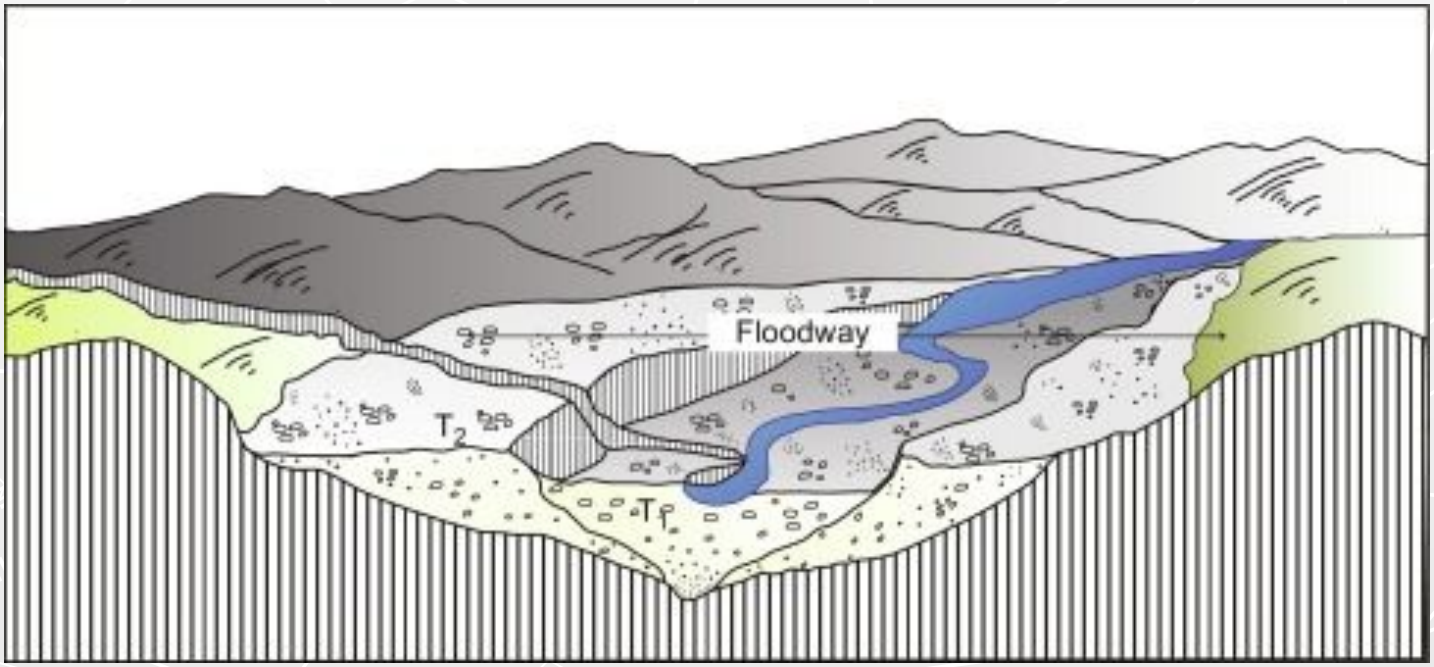
Section of the San Andreas Fault in the Carrizo Plain, western California. *U.S. Geological Survey*


trench at
convergent boundary
oceanic ridge at
divergent boundary
island arc
transform fault at
transform boundary
trench at
convergent boundary
ocean
continent
stationary or
moving plate
stationary or
moving plate
continental
crust
oceanic crust
oceanic crust
lithosphere
lithosphere
lithosphere
hot spot
rising
magma
subduction
zone
asthenosphere
subduction
zone
rising
magma
"roll-back"
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Neotectonic Process of EQ

What is Neotectonic?

- Neotectonics, a **subdiscipline of tectonics**, is the **study of contemporary motions and deformations of Earth's crust** including those of the very recent geologic past.



Fault /Crack line which control the river flow

Neotectonic process for EQs

Mild EQ on 05 may 2023

- M_L=**4.3** as per USGS

  Time= 5:57 AM

  Focus/Hypocenter Depth= 10 kms

  Epicenter: Dohar, 14 km from Dhaka.

- There are **several geological cracks** that **controls the small narrow rivers and canals in around Dhaka.**
- EQ that jolted Dhaka, may result from such cracks; in geological terms, this earthquake **process is called 'neotectonic'**.
- Cracks in earth's crust may **result from the displacement** of one side with respect to other side like fault.
- Crack means split without breaking apart.

- There are **several small rivers in Dohar** and its surrounding areas that are controlled by the (geological cracks) faults. **Such cracks may result in mild earthquakes.**

- In geological terms, this earthquake process is called 'neotectonic‘.

- **Mild EQs are the result of neotectonic process**. Generally, **large-scale quakes do not occur** from neotectonic faults.

- When an **earthquake originates from the faultline/crack that controls the river route,** there is no fear of the quake being large-scale.

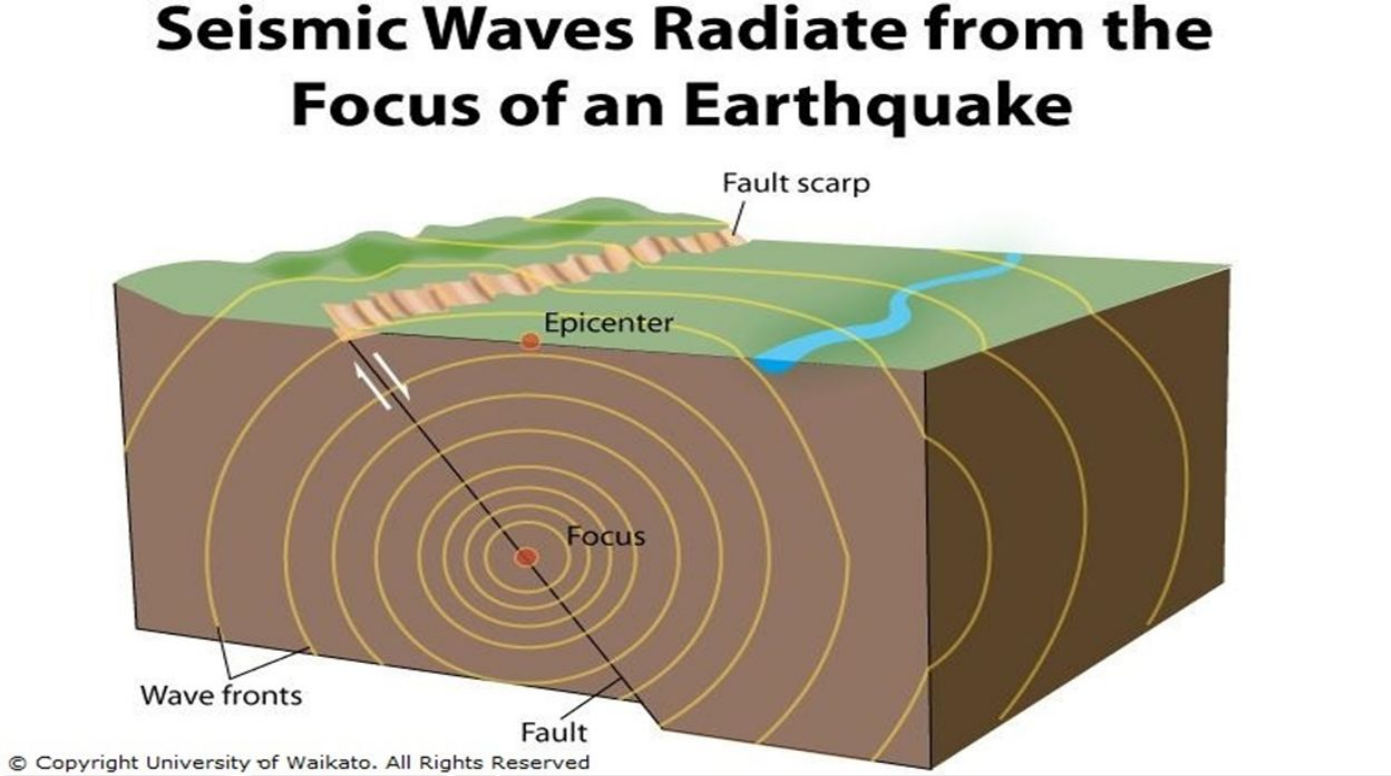
- Region has had two major earthquakes so far – one in 1918 in Srimangal (**M_L=6.9)** and another in 1885 in Manikganj (**M_L=6.9),**

Earthquake Waves

What are seismic waves? Describe the different types of waves generated during EQ.

Seismic Waves:

- When the earth materials rupture and cause an EQ, some of the **energy released**, **travels away by means of waves** called **seismic waves** or earth waves.



Types of Seismic Waves:

Two basic two types of seismic waves –**Body Waves**: P-waves, S-waves and **Surface Waves**: Rayleigh waves, Love waves.

Body Waves

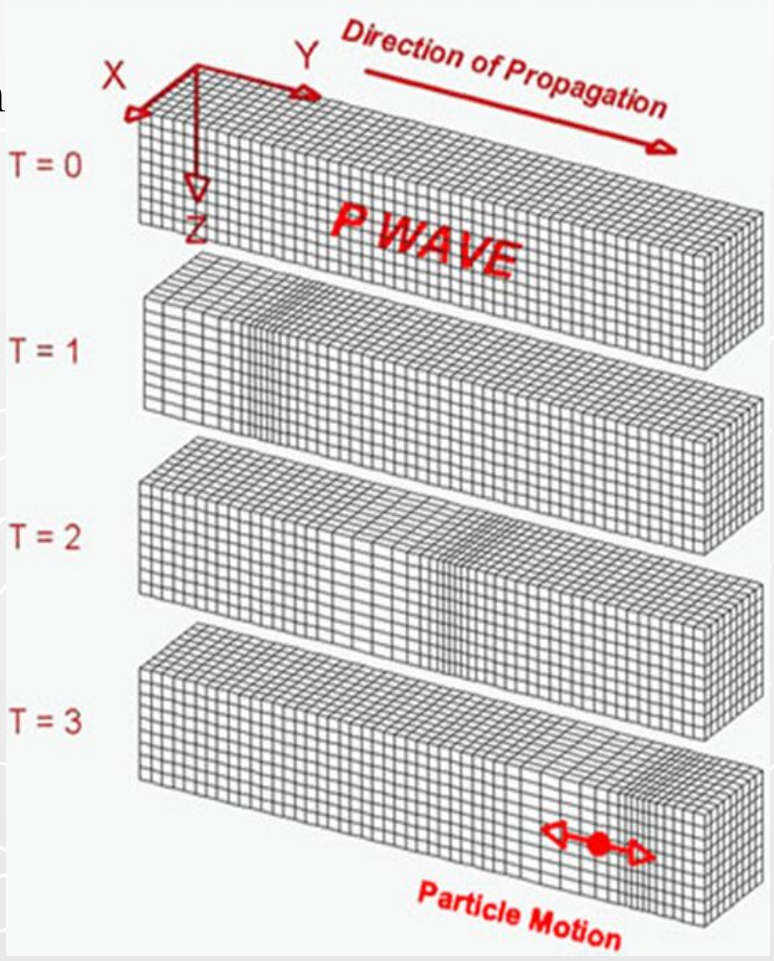
P-waves (or Primary waves or pressure waves)

- **Travel at the greatest velocity** through the Earth

- When **travel through air**, take the form of sound waves (330 ms^{-1}) but may travel at 5000 ms^{-1} in granite.

- Propagate through a material by **alternately compressing and expanding the medium**, where particle motion is **parallel to the direction of wave propagation**.

- Because of their speed, they are the **first waves to be recorded by**

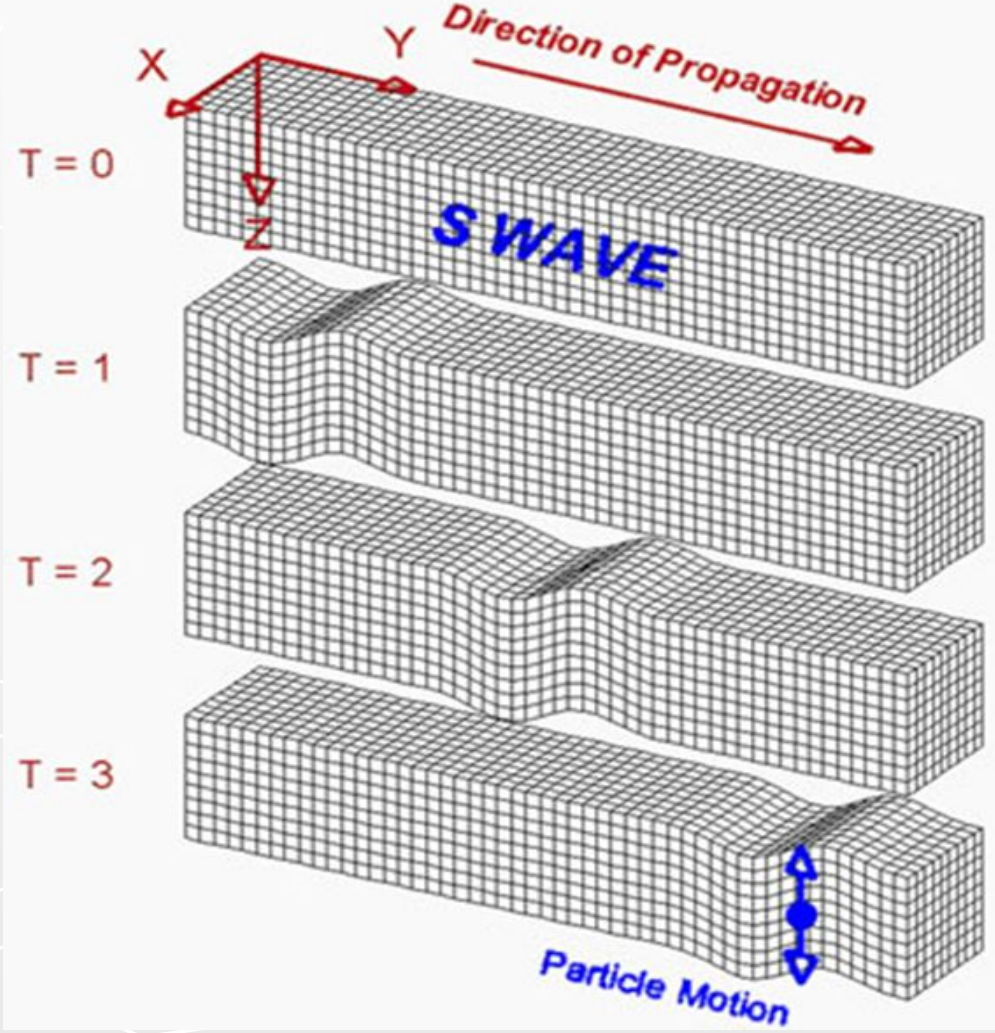


S-waves (or **Secondary waves or shear waves or shaking waves)**

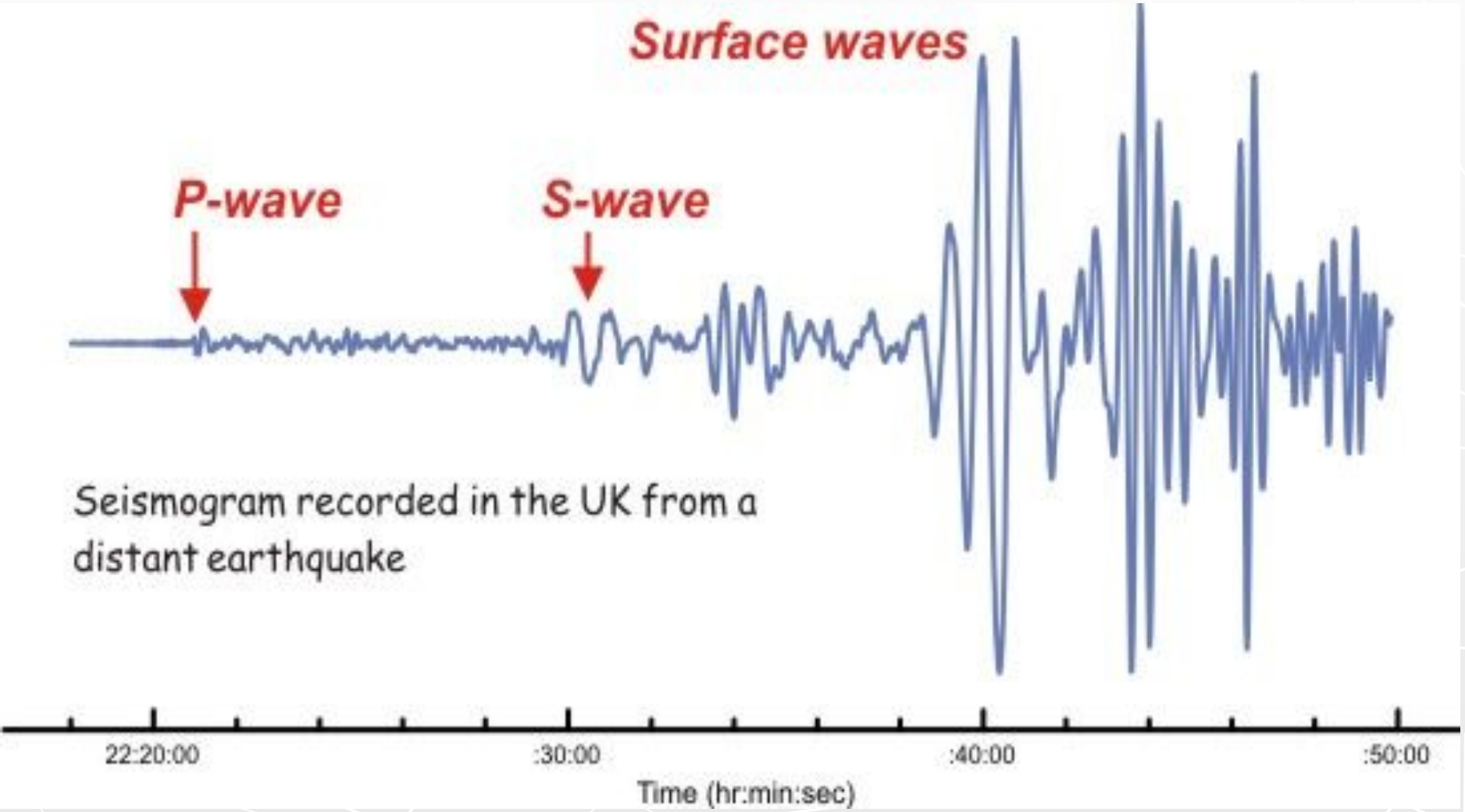
- **Transverse waves that travel slower than P-waves.**

- Particle motion is **perpendicular to the direction** of wave propagation.

- S-waves **cannot travel through air or water** but are **more destructive** than P-waves because of their larger amplitudes

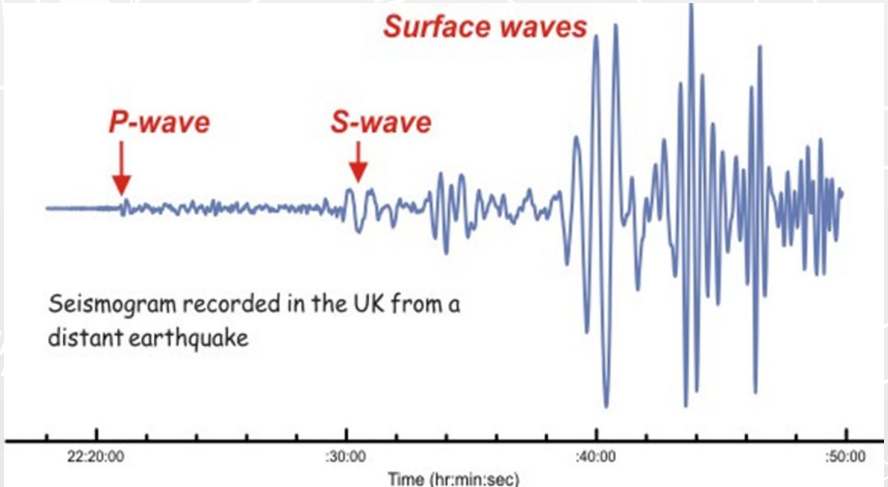


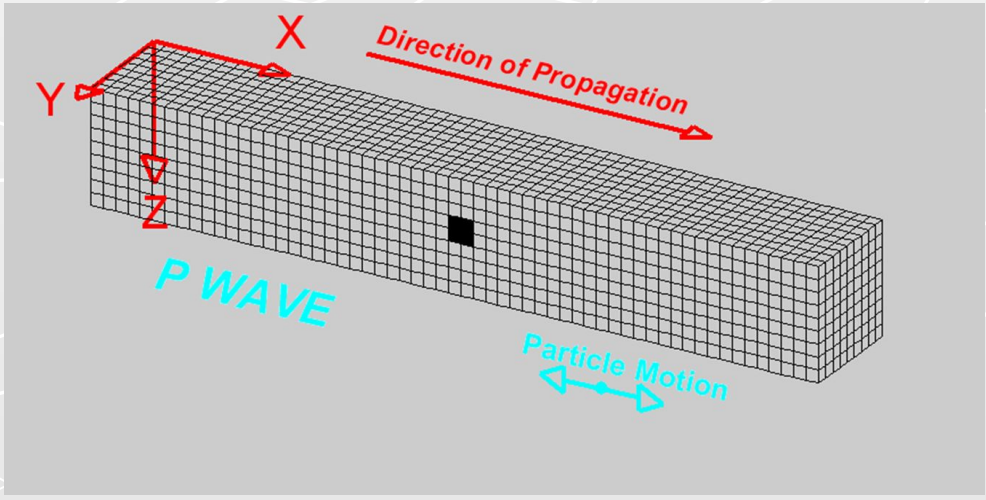
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Surface waves
P-wave
S-wave
Seismogram recorded in the UK from a distant earthquake
22:20:00
:30:00
:40:00
:50:00
Time (hr:min:sec)

Specifications of P- waves

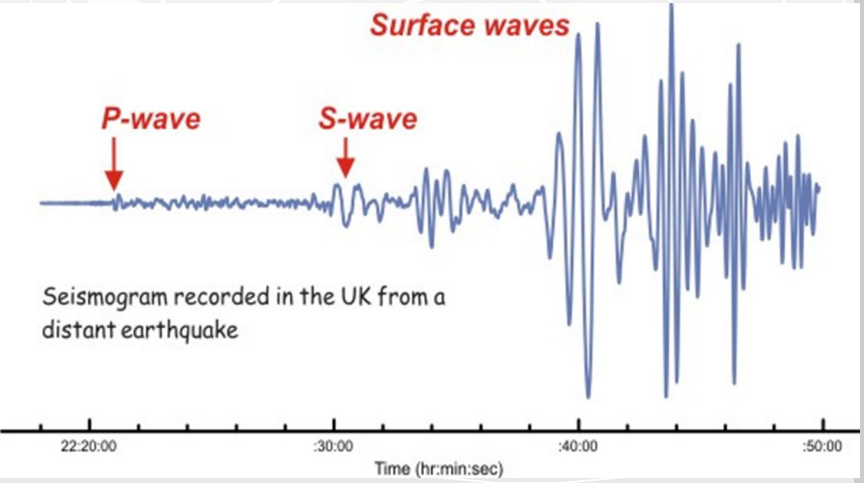
- P- waves can run in **solid and liquid**.
- Out of P, S and L types of seismic waves, **P- waves do the least harm to infrastructure, human being, nature, etc.**
- Maximum speed of P- waves is around **14 Km/sec**. Their average speed is 8 km/sec.
- On seismograph **firstly plotted** waves are the P- waves.
- When these waves go from **solid to liquid**, then their speed decreases and direction changed.
- P- Waves act like **sound waves**.

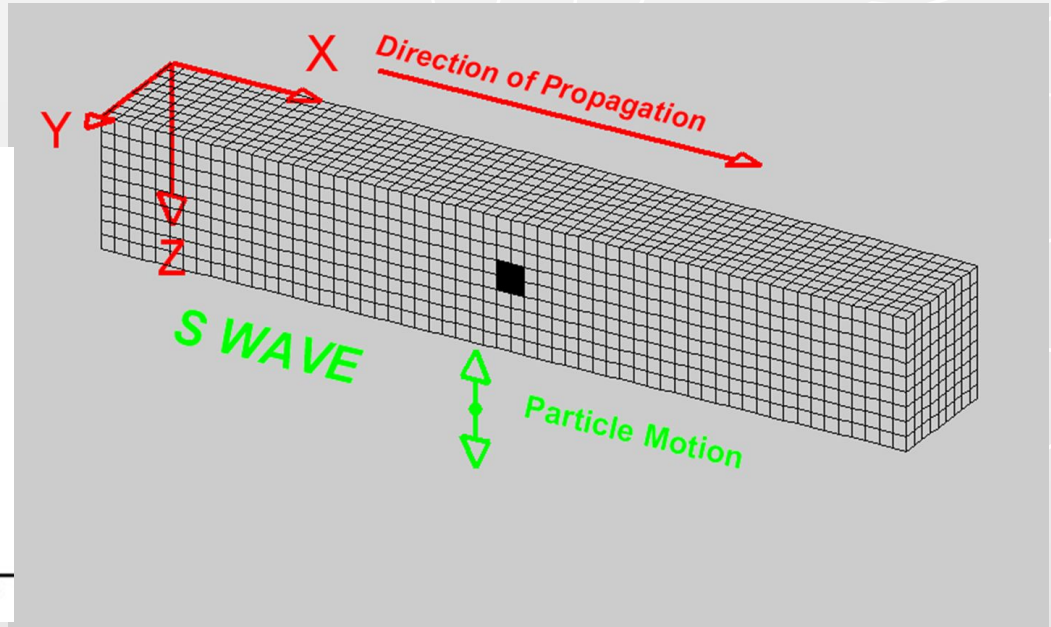




Specifications of S- waves

- Can **only run in solid**, not liquid.
- Speed of these waves is **4 to 6 km/ sec**. These waves move at moderate speed.
- **After P- waves, S- waves plot** on the seismograph.
- We know that the **outer core** of the earth is made up of liquid so these waves **cannot penetrate the outer and inner core.**



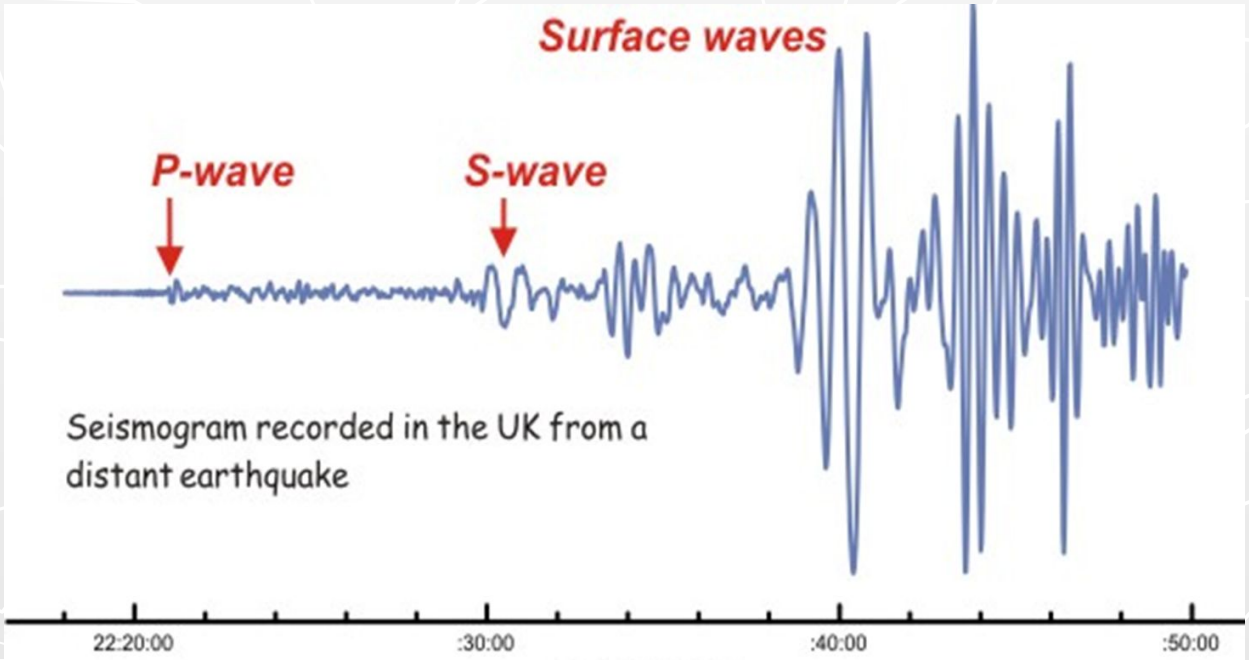


Surface waves

- **Similar in nature to water waves** and **travel just under the Earth's surface**.

- Typically **generated** when the **source of the earthquake is close to the Earth's surface**.

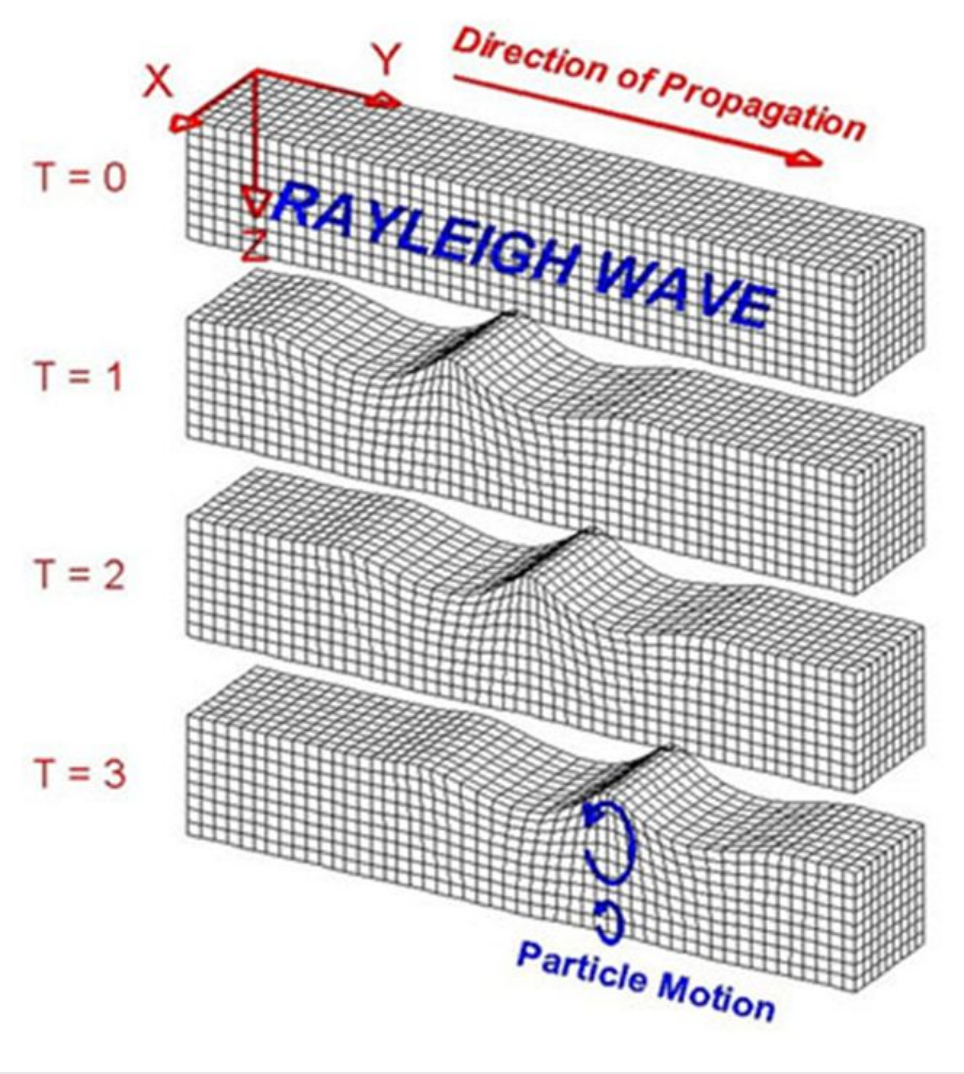
- **Travel more slowly than S-waves**, can be much **larger in amplitude** and the **most destructive** type of seismic wave.



Types of surface waves:

Rayleigh waves:

- Also called **ground roll**, travel as **ripples** similar to those on the surface of water.
- **People have claimed to have observed** Rayleigh waves during an earthquake in open spaces, such as parking lots where the cars move up and down with the waves.

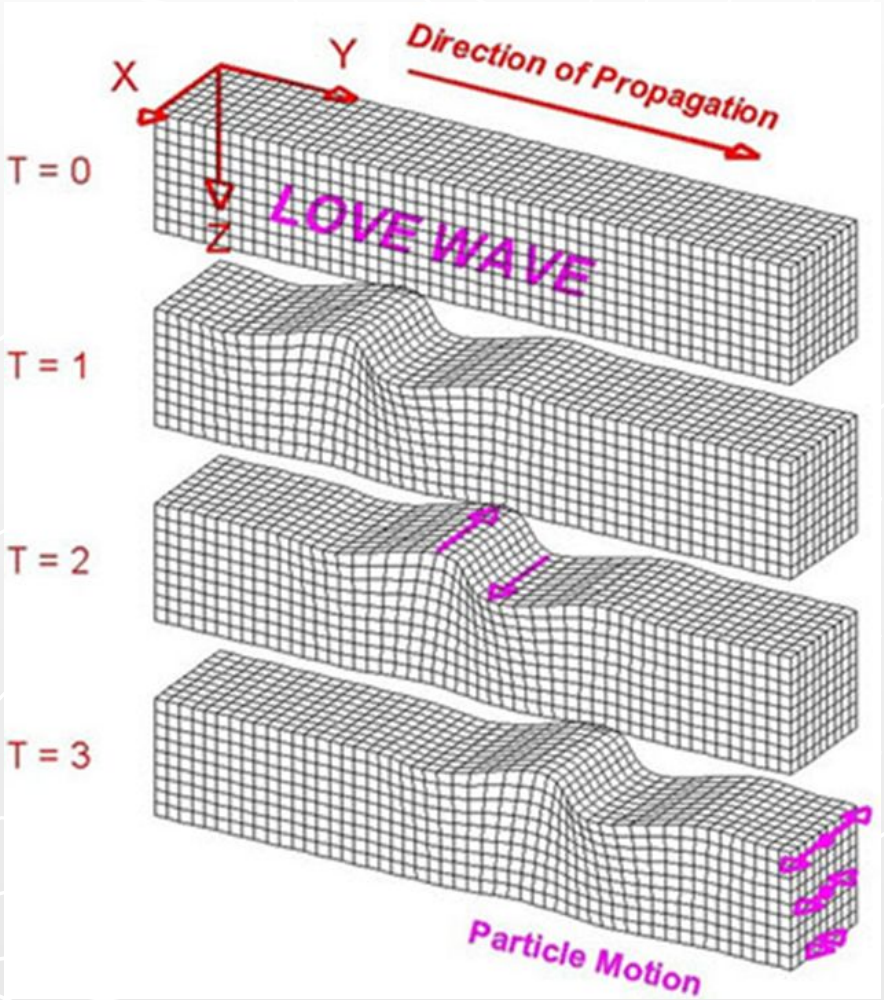


Types of surface waves:

Love waves:

- **Cause horizontal shearing** of the ground.

- Usually **travel slightly faster** than Rayleigh waves



Characteristics of Raleigh Wave

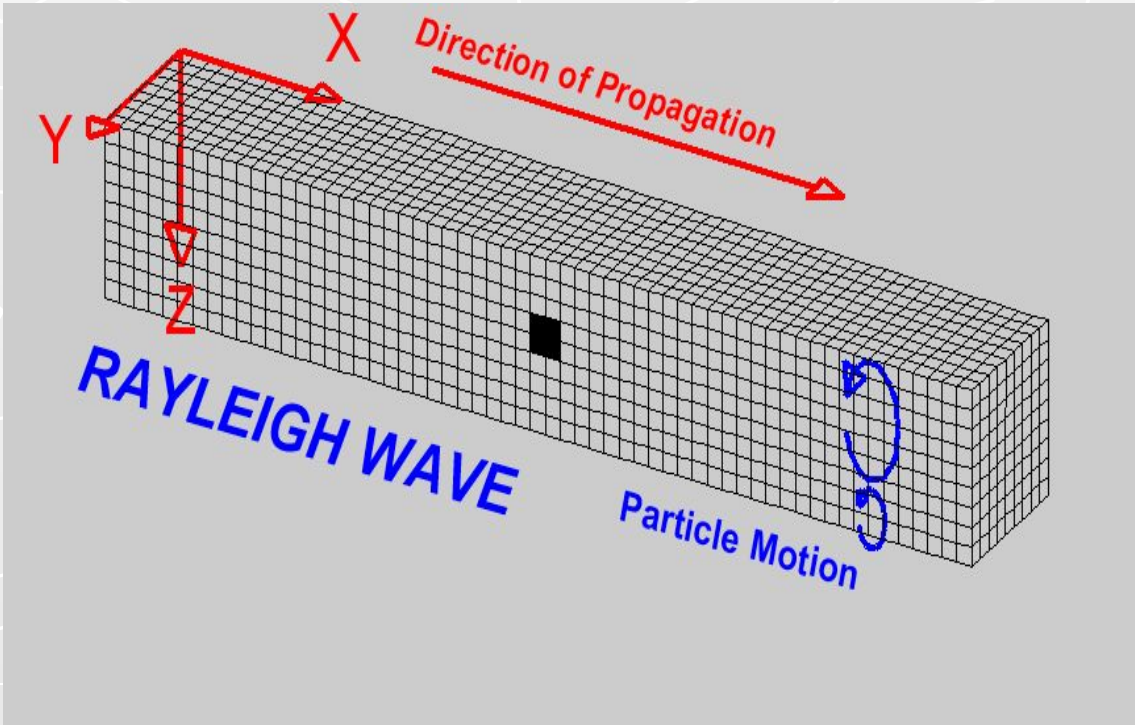
•Rayleigh waves are slower than shear waves, and their speed depends on the material's elastic constants.

• Cause the ground to **tremble similar to ocean waves**.

•Have very **large amplitudes**.

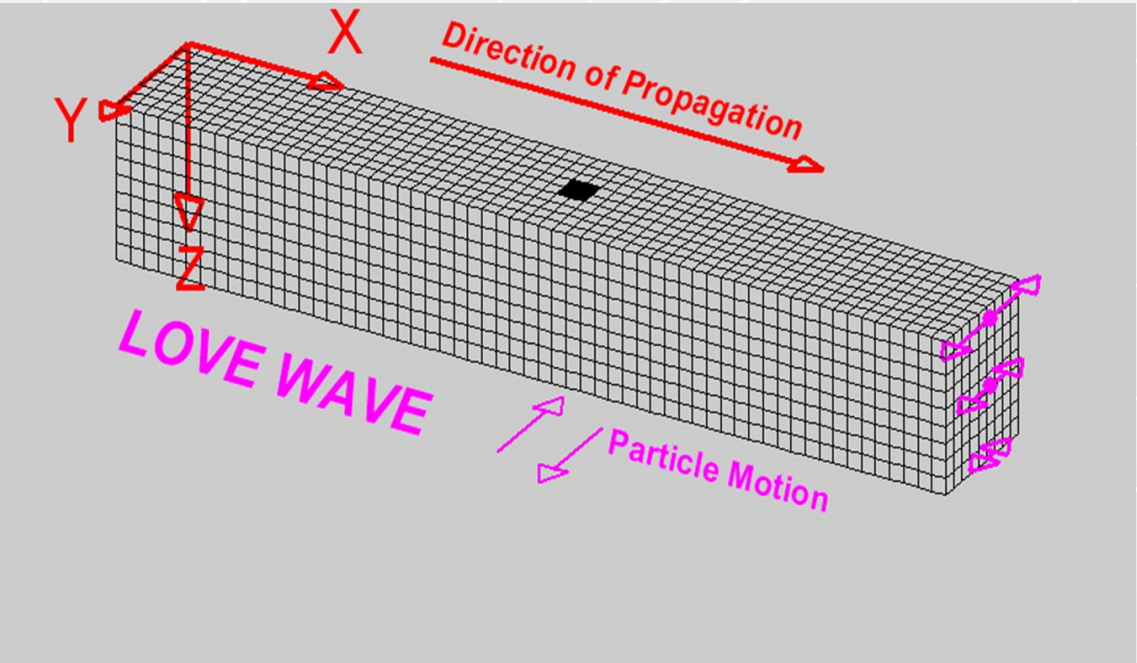
•Rayleigh waves have strong energy.

•More likely to be produced by seismic sources close to the Earth's surface.



Specification of L-waves: Also known as **love waves** but their work is opposite to their name and are highly destructive waves.

- **Speed** of these waves is around **2 to 3 km/sec.**
- **Path** of surface waves is **convex and can pass through solid not liquid.**
- **Move at the slowest speed and cause the most damage.**
- **Remain on the surface of the earth**; that is why these waves can destroy big buildings.



Thank You