EARTHQUAKE – AN INTRODUCTION

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INTRODUCTION

- Man is unable to prevent the natural disasters like earthquake.
- Earthquake is vibration and shaking of the earth and so tremors are felt on the earth.
- All individuals, households and communities are exposed to the risks of earthquake.
- It is indispensable to know Geology of the Earth so as to understand the Whys and the Hows of the Seismic Activities / earthquake.

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The EARTH consists of the following:

1. Inner Core (radius 1290km),
2. Outer Core (thickness 2200km),
3. Mantle (thickness 2900km) and
4. Crust (thickness 5 to 40km).

Figure 1 shows these layers:

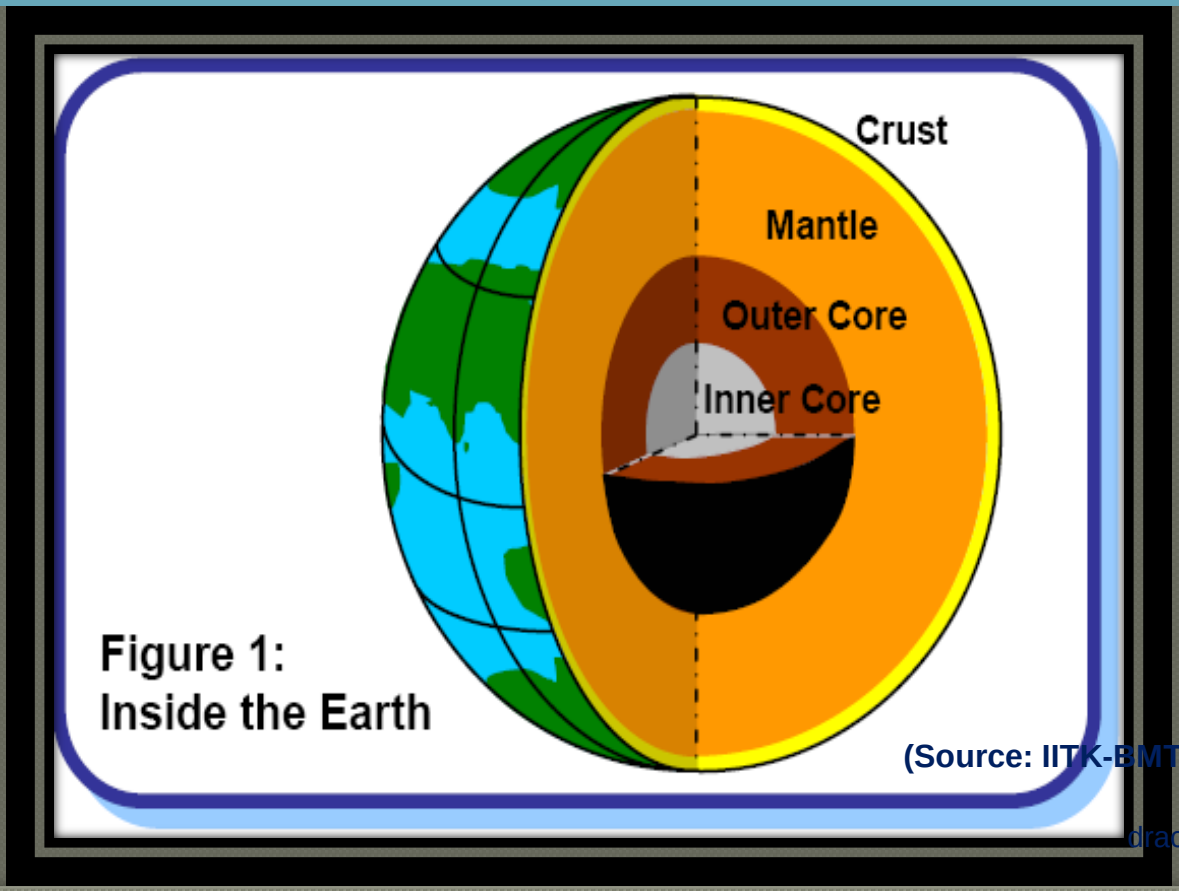

Figure 1:
Inside the Earth

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The **Inner Core** is solid and consists of heavy metals (*e.g., nickel and iron), while the Crust consists of light* materials (*e.g., basalts and granites).*

*The **Outer Core** is* liquid in form and the **Mantle** has the ability to flow.

At the Core, the temperature is estimated to be 2500°*C, the pressure 4 million atmospheres and* density 13.5 *gm/cc;*

in contrast to 25°C, 1 atmosphere and 1.5 gm/cc on the surface of the Earth.

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- Convection currents develop in the viscous **Mantle**, because of prevailing high temperature and pressure gradients between the Crust and the Core, like the convective flow of water when heated in a beaker.
- These convection currents result in a *circulation of the earth's mass*; ***hot*** **molten lava comes out** and the cold rock mass goes into the Earth as shown in Fig. 2.

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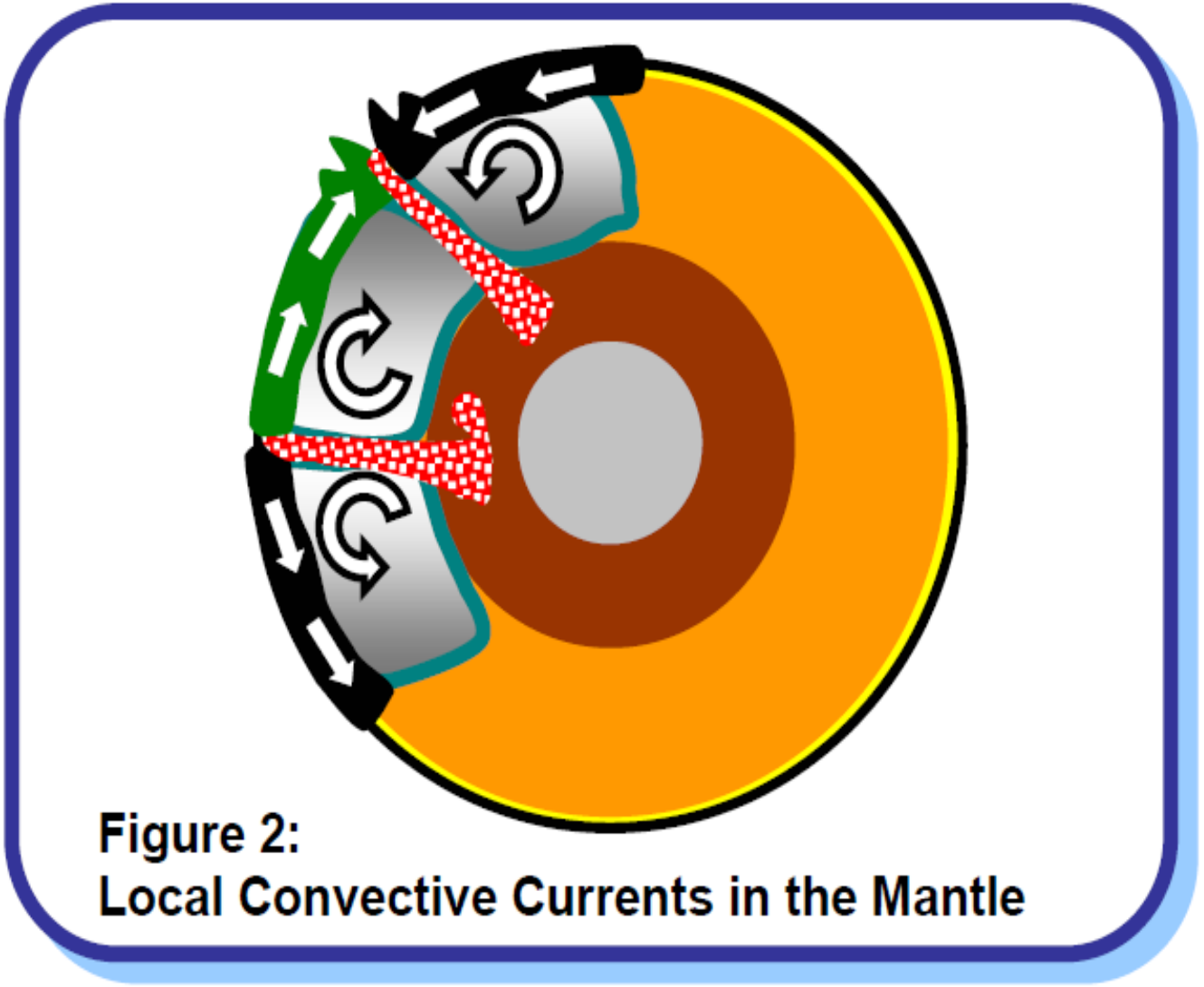

Figure 2:
Local Convective Currents in the Mantle

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- The convective flows of Mantle material cause the Crust and some portion of the Mantle, to slide on the hot molten outer core.
- This sliding of Earth's mass takes place in pieces called Tectonic Plates.
- *The* surface of the Earth consists of seven major tectonic plates and many smaller ones (Figure 3).
- The relative movement of these plate boundaries varies across the Earth; on an average, it is of the order of a couple to tens of centimeters per year.

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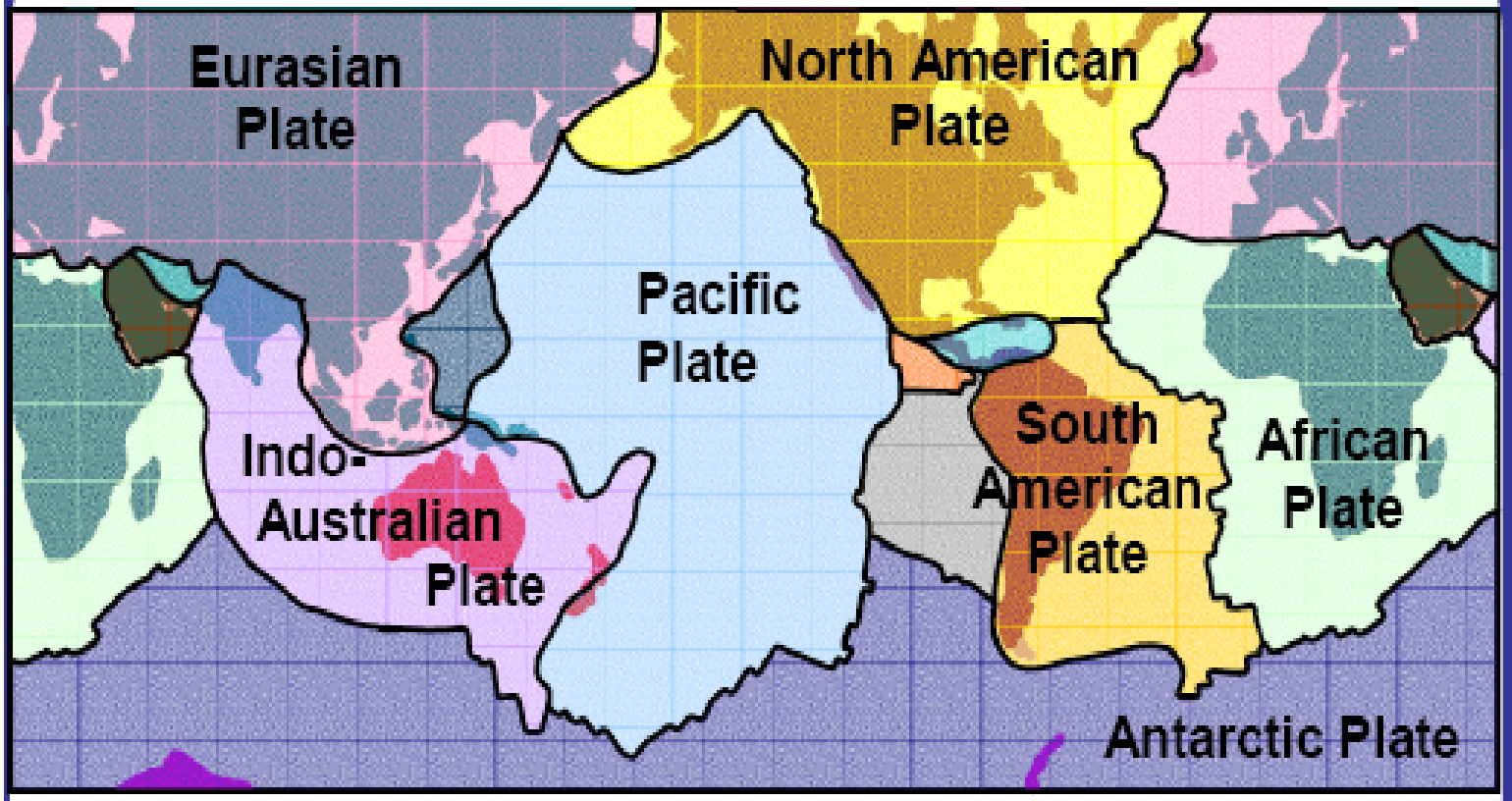

Figure 3:
Major Tectonic Plates on the Earth's surface

(Source: IITK-BMTPC-EQTip01.pdf)

What Causes Earthquakes ?

- Rocks are made of elastic material, and so elastic strain energy is stored in them during the deformations that occur due to the gigantic tectonic plate actions that occur in the Earth (Figure 4)
- When the rocks along a weak region in the Earth's Crust reach their strength, a sudden movement takes place there (Figure 5)

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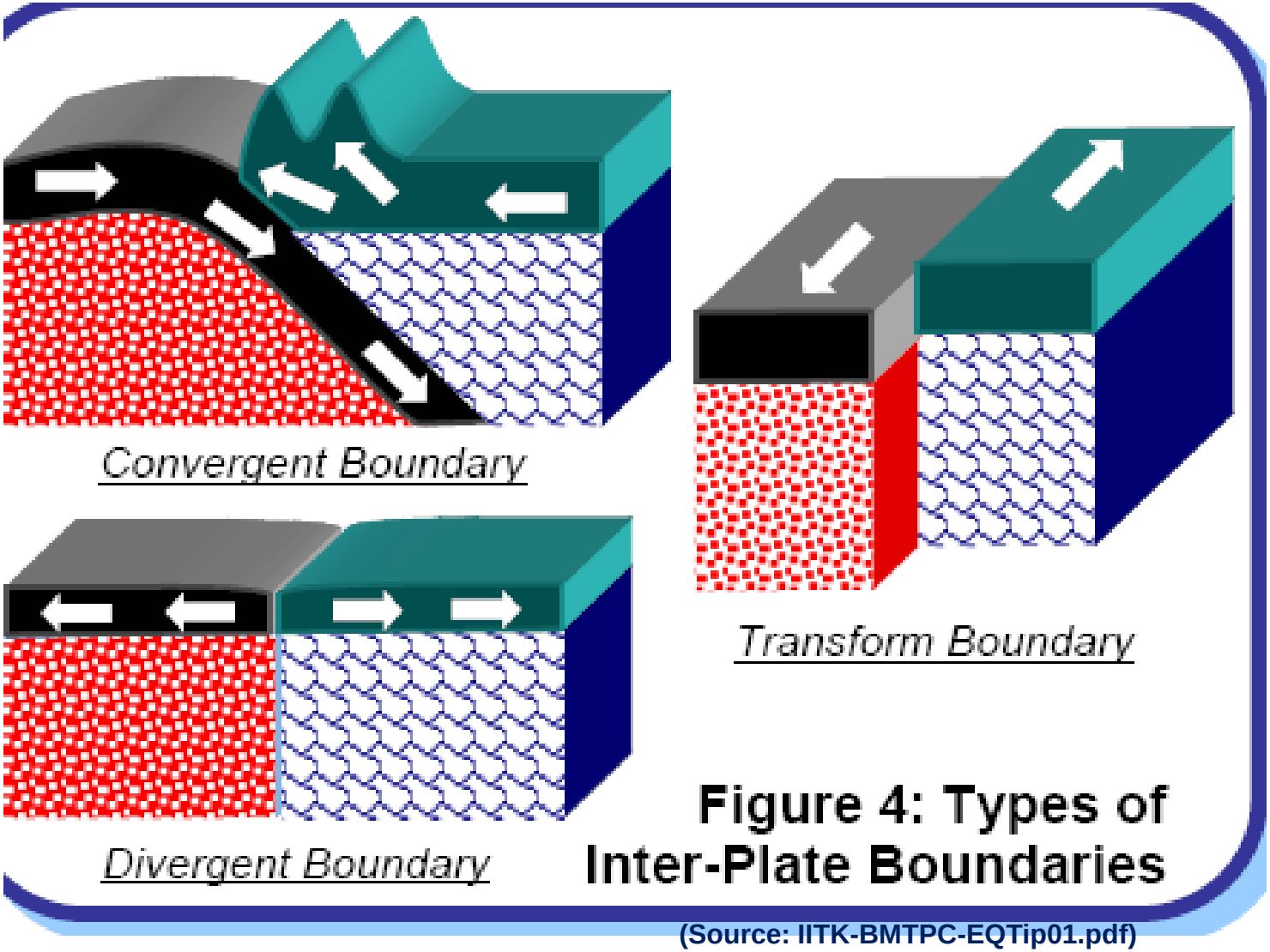

Figure 4: Types of Inter-Plate Boundaries

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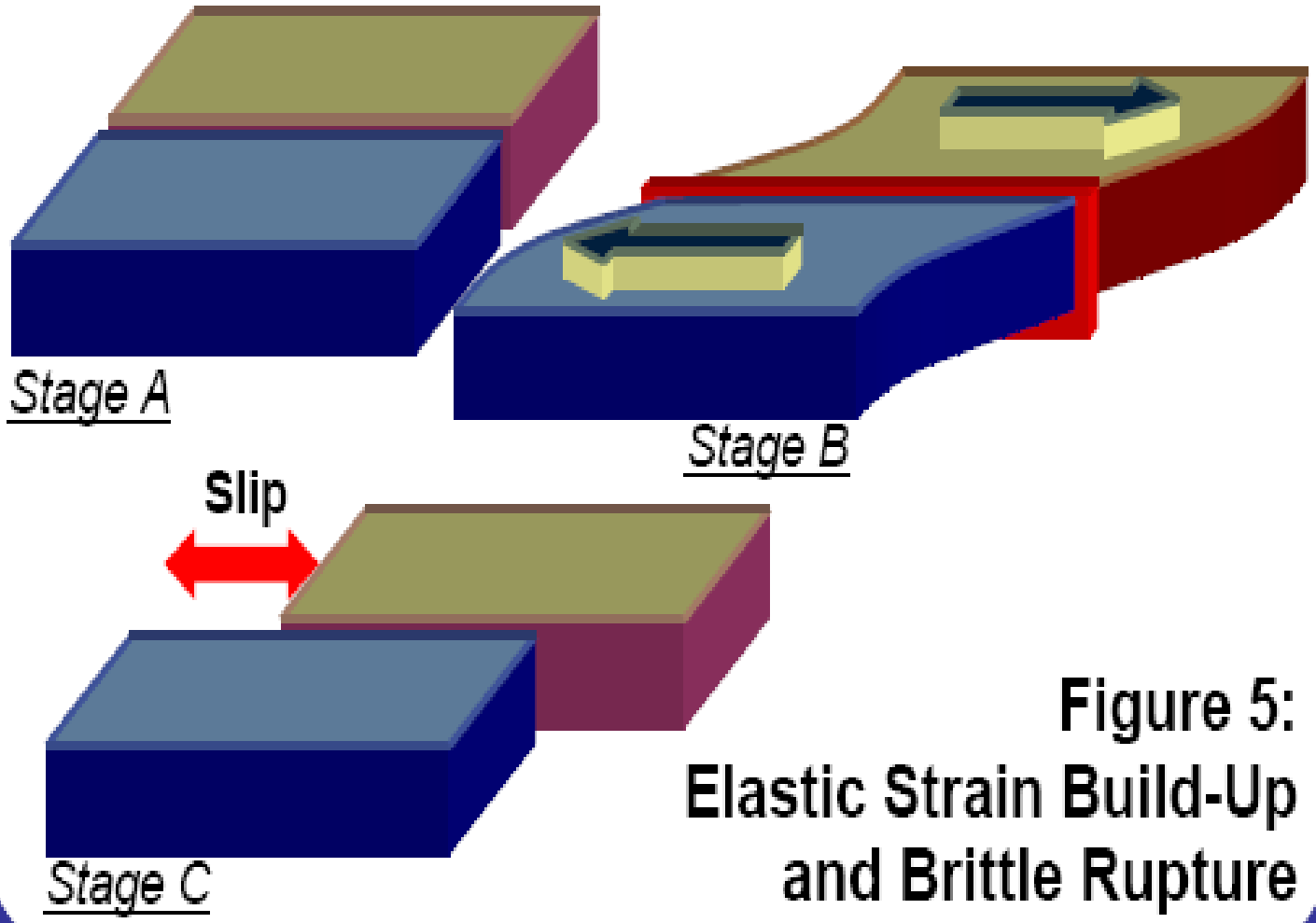

Figure 5:
Elastic Strain Build-Up
and Brittle Rupture

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- Opposite sides of the FAULT (a crack in the rocks where movement has taken place) suddenly slip and release the large elastic strain energy stored in the interface rocks.
- For example, the energy released during the 2001 Bhuj earthquake is about 400 times (or more) than that released by the 1945 Atom Bomb dropped on Hiroshima!

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- THE SUDDEN SLIP AT THE FAULT CAUSES *THE* ***EARTHQUAKE****....*
- **A violent shaking of the Earth when large elastic strain energy released spreads out through seismic waves that travel through the body and along the surface of the Earth.**
- **And, after the earthquake is over, process of strain build-up at this modified interface between the rocks starts all over again (Figure 6).**

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Earthquake Engineers and Geologists know this as the *Elastic Rebound Theory*

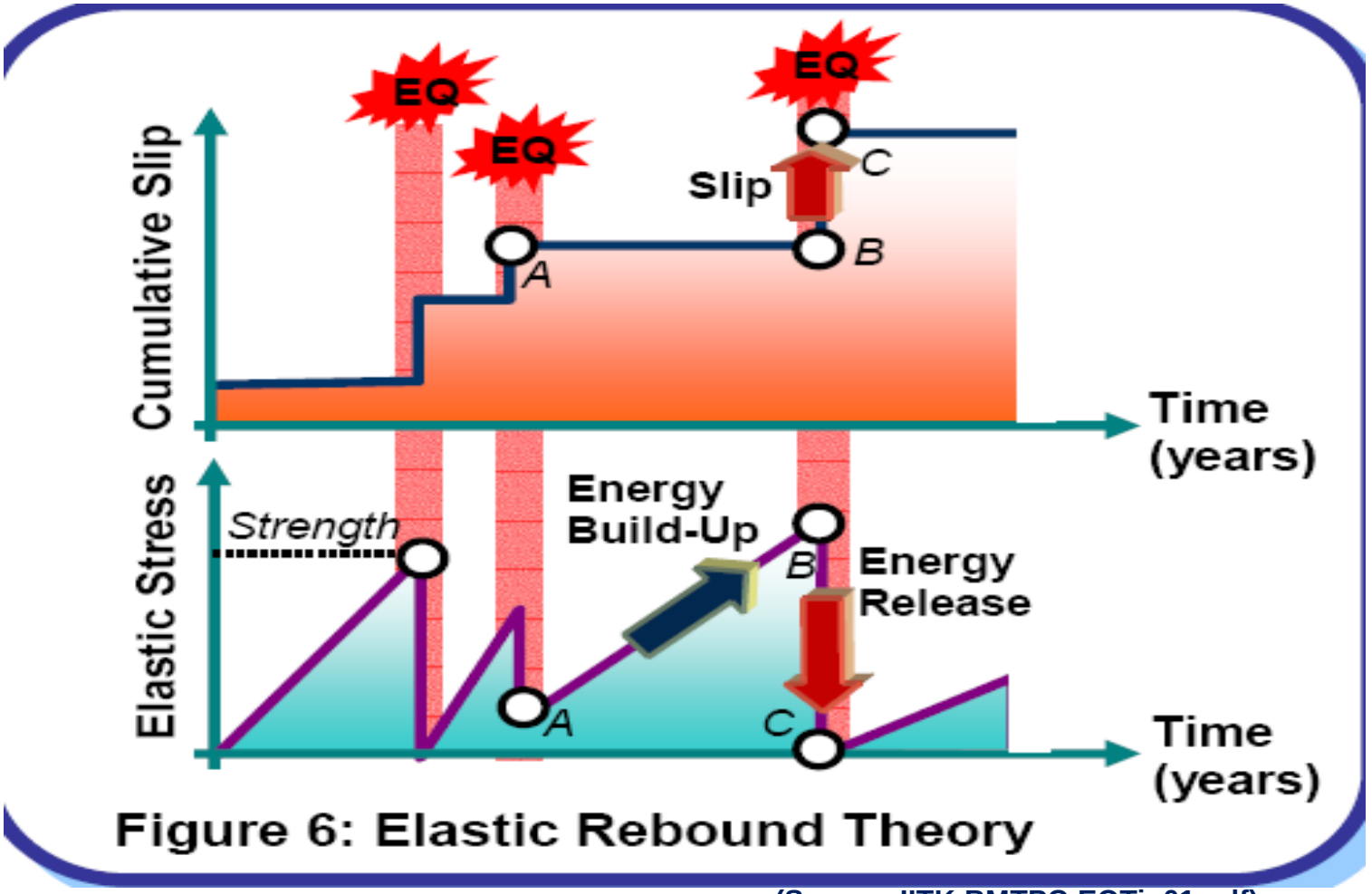

Figure 6: Elastic Rebound Theory

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- **Most earthquakes in the world occur along the boundaries of the tectonic plates and are called Inter-plate Earthquakes (e.g. 1897 Assam Earthquake).**
- A number of earthquakes also occur within the plate itself away from the plate boundaries (e.g., 1993 Latur Earthquake); these are called **Intra-plate Earthquakes**.

In both types of earthquakes, the slip **generated at the fault during earthquakes is along both vertical and horizontal directions (called Dip Slip)** ***and*** **lateral directions (called Strike Slip) (Figure 7), with one of them dominating sometimes.**

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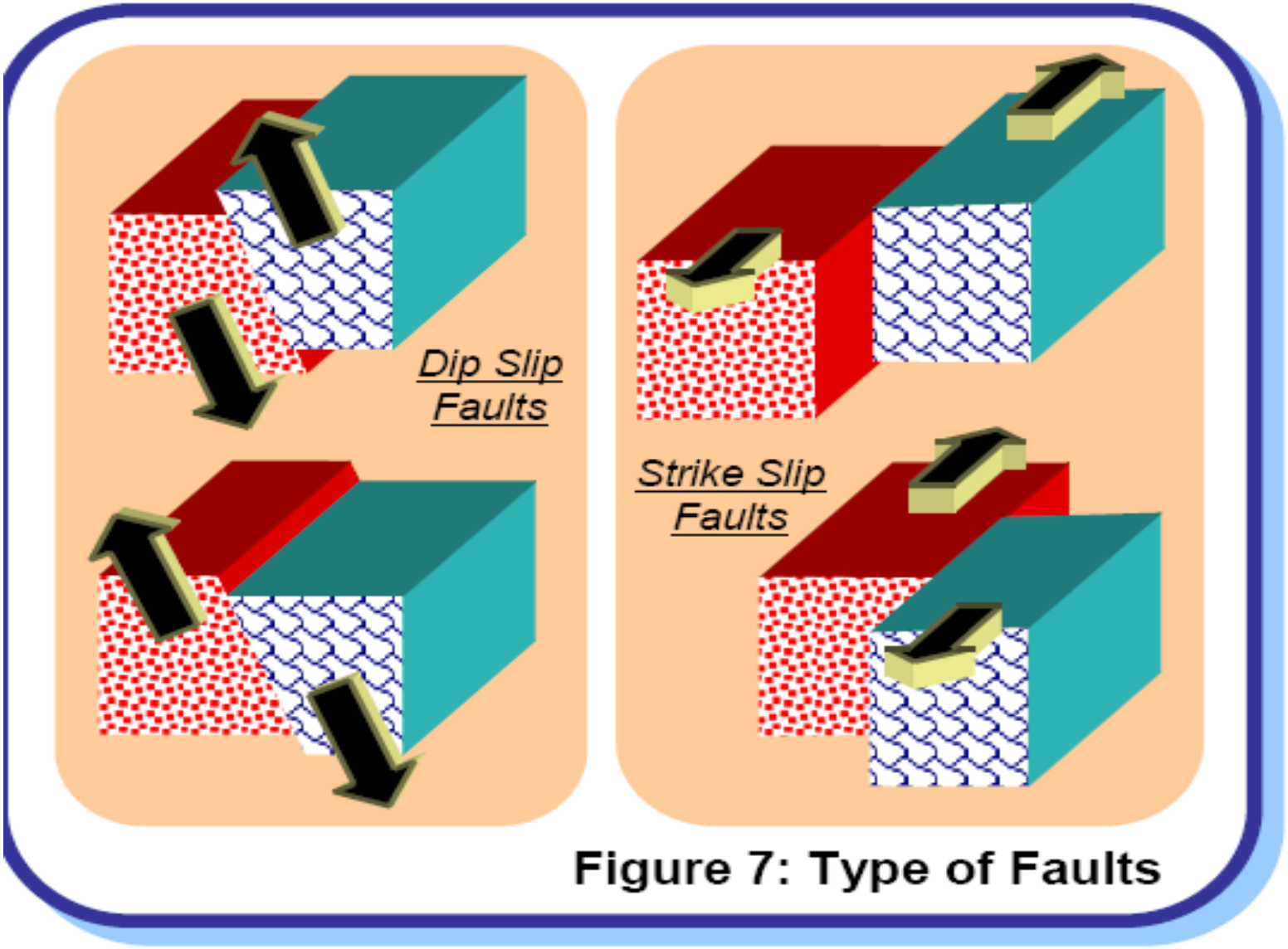

Figure 7: Type of Faults

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JARGON USED IN EARTHQUAKE

Focus or Hypocentre – The point inside the earth where vibration of earthquake begins is known as Focus or Hypocentre of earthquake.

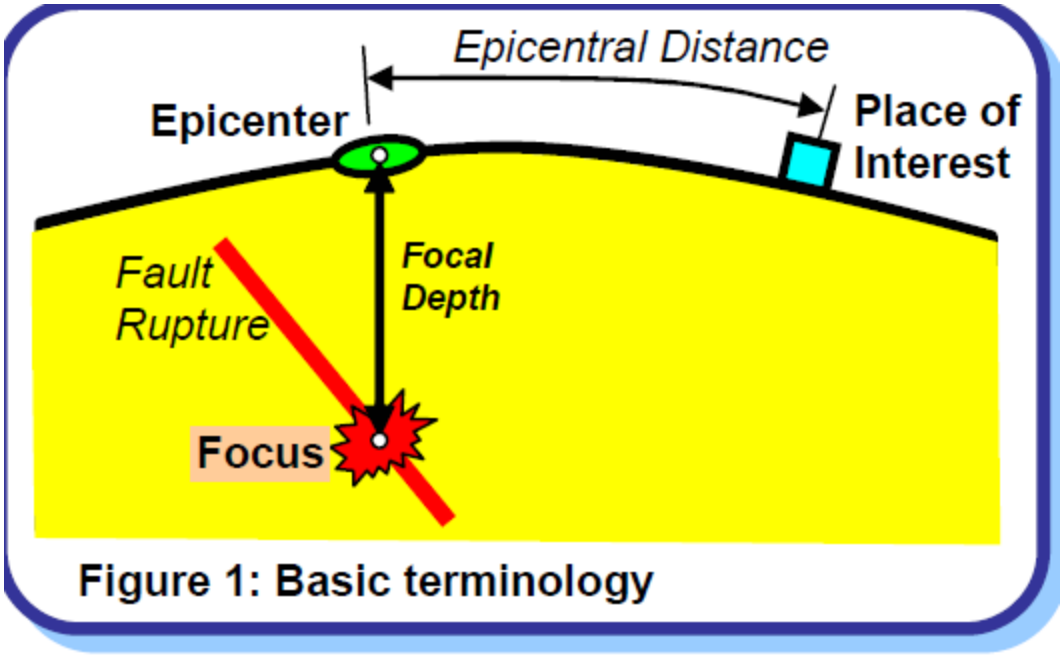

Figure 1: Basic terminology

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- **Epicentre –** The point vertically above Focus or Hypocentre on the earth's surface is known as Epicentre as shown in preceding slide.
- **Focal Depth –** Depth of Focus from the Epicentre is termed as Focal Depth. The assessment of damaging potential of earthquake is made from Focal Depth.

  If Focal Depth is less than 70 km, it is known as Shallow Focus and if more than 70 km, it is Deep Focus.
- **Epicentral Distance –** Distance fro Epicentre to a point of interest or under discussion on the earth's surface is known as Epicentral Distance. This is normally measured in *Nautical Mile*.

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- A number of small size earthquakes takes place before and after the Main Earthquake (Main Shock).
- **Foreshocks** – Smaller earthquakes occurring before the main earthquake (main shock) is known as Foreshocks.
- **Aftershocks** – Smaller size earthquakes occurring after the main earthquake (main shock) is known as Aftershocks.
- **Isoseismals –** The points or places of equal seismic intensity are known as Isoseismals and the line joining the points of equal intensity is known as Isoseismal Line or Isoseismal Map.

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Magnitude *versus* Intensity

Magnitude of an earthquake is a measure of its size. For instance, one can measure the size of an earthquake by the amount of strain energy released by the fault rupture. This means that the magnitude of the earthquake is a *single* value for a given earthquake. On the other hand, *intensity* is an indicator of the severity of shaking generated at a given location. Clearly, the severity of shaking is much higher near the epicenter than farther away. Thus, during the same earthquake of a certain magnitude, different locations experience different levels of intensity.

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SEISMIC WAVES

- Large strain energy released during an earthquake travels as seismic waves in all directions through the Earth's layers, reflecting and refracting at each interface.
- These waves are of two types - *body waves* and *surface waves; the latter are restricted to near the* Earth's surface (Figure 8).

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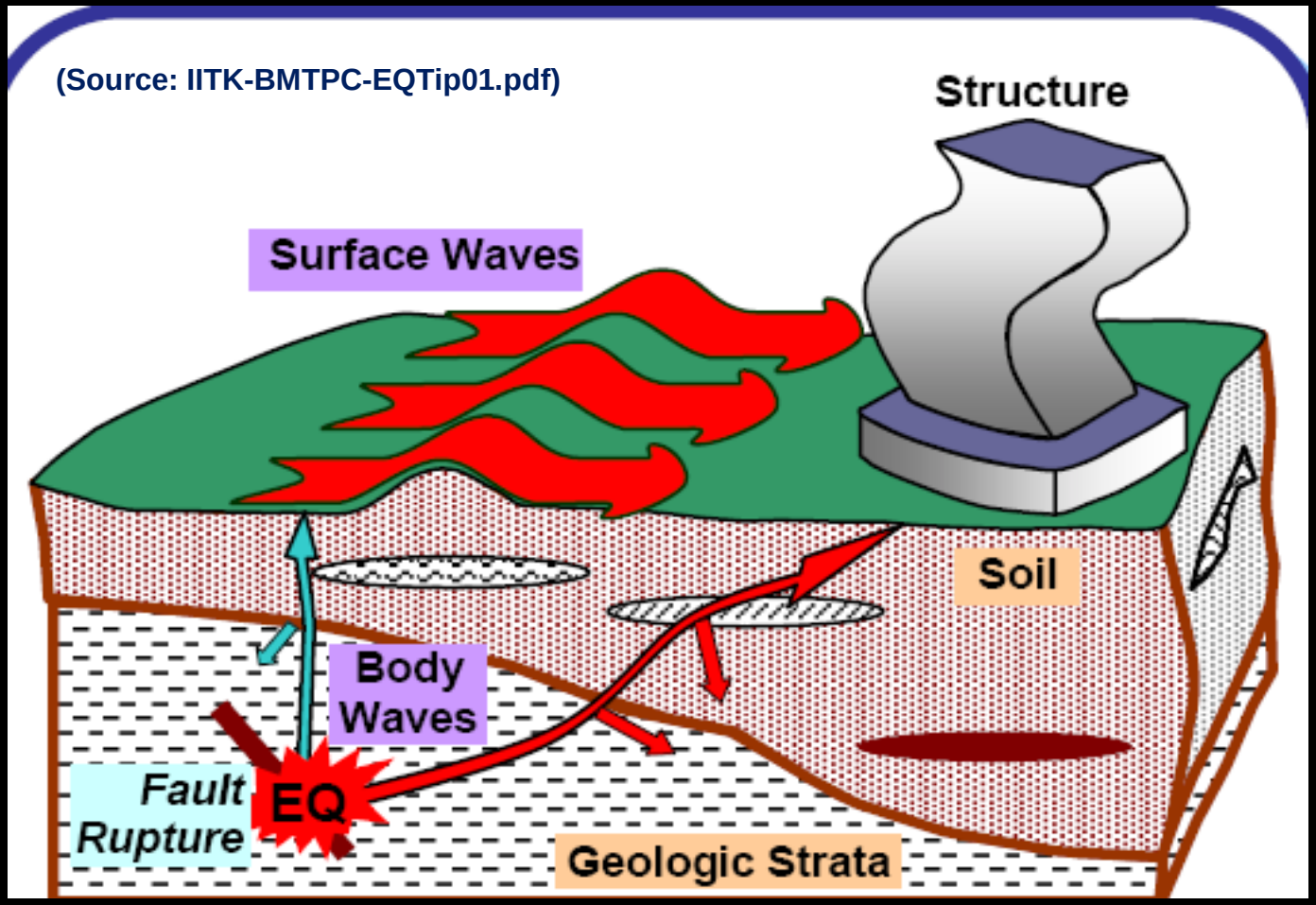

Figure 8: Arrival of Seismic Waves at Site

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- **Body waves consist of *Primary Waves (P-waves) and* Secondary Waves *(S-waves),* and surface waves consist of *Love waves and Rayleigh waves.***
- ***Under P-waves, material particles* undergo extensional and compressional strains along direction of energy transmission, but under S-waves, oscillate at right angles to it (Figure 9).**

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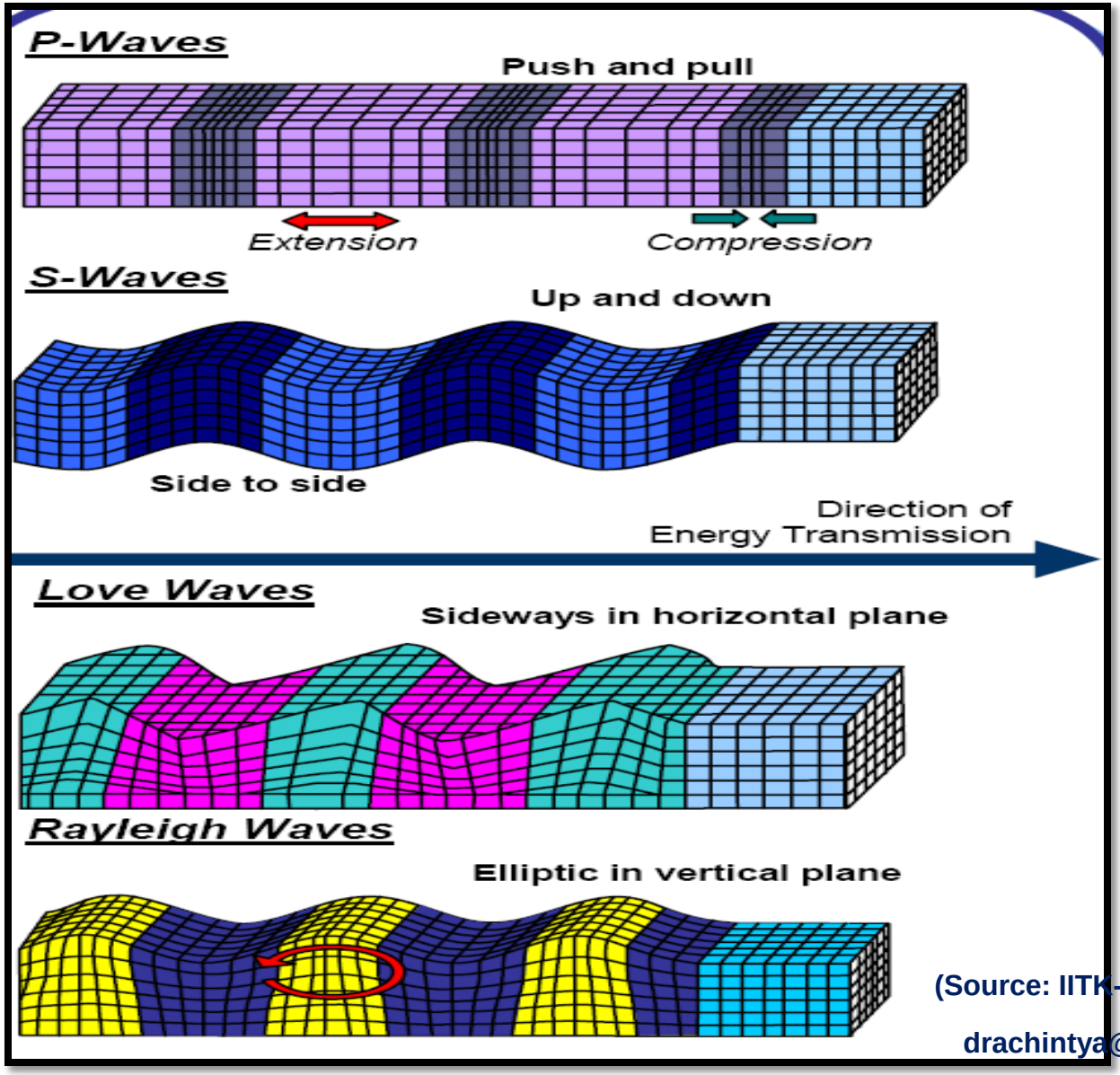
Figure 9: Motions caused by Body Waves and Surface Waves



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CONCLUSION

- The earthquake is the only natural disaster today which is unpredictable. But it is known to occur in places where it has already occurred in the past.
- Indian lore is full of references to earthquakes since the dim dawn of history.
- Whether history is important to sort out our geo-political issues or not, it is indispensable to realize the risk to several parts of our country earthquake activities and