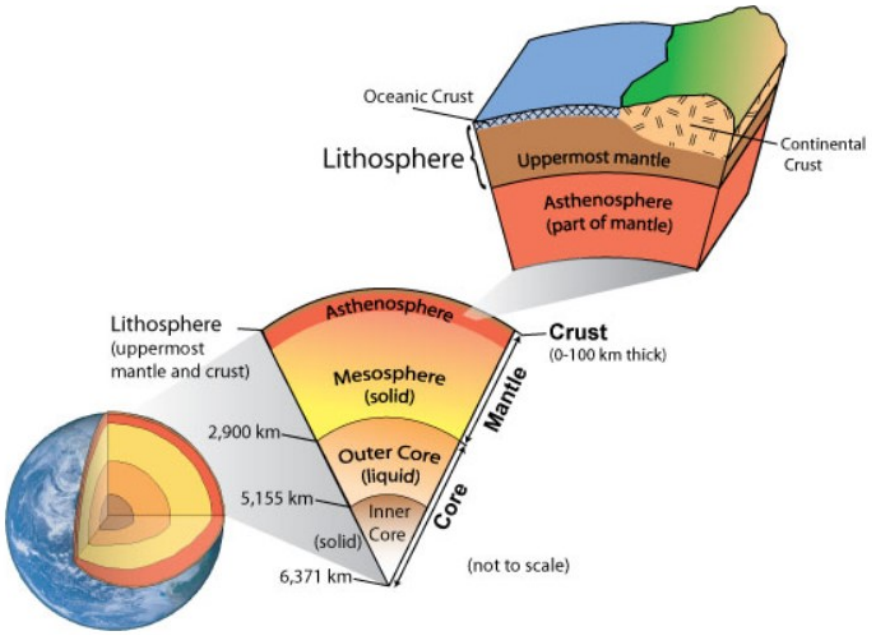
Earth’s Shifting Forces and Natural Disasters

Mains: *GS I – Salient features of World’s Physical Geography*

Why in News?

Apart from anthropogenic factors which cause disasters, it is also important to understand the role of earth’s shifting forces.

What consists of Earth’s interior?



- **The crust (5-70 km thick)** – The uppermost layer where all forms of life and relief features are located.
- **The mantle (extends to ~2,900 km depth)** – It is divided into the upper mantle (~700 km) and lower mantle (700-2,900 km).
- The upper mantle has been further subdivided into
  - lithosphere – Rigid, up to ~100 km
  - Asthenosphere - Below lithosphere up to ~700 km depth.
  - The asthenosphere is a ductile, semi-molten zone where convection currents move plates.
- **The core (~2,900-6,371 km)** – It extends to the Earth’s centre and is composed of iron and nickel.

How plates move?

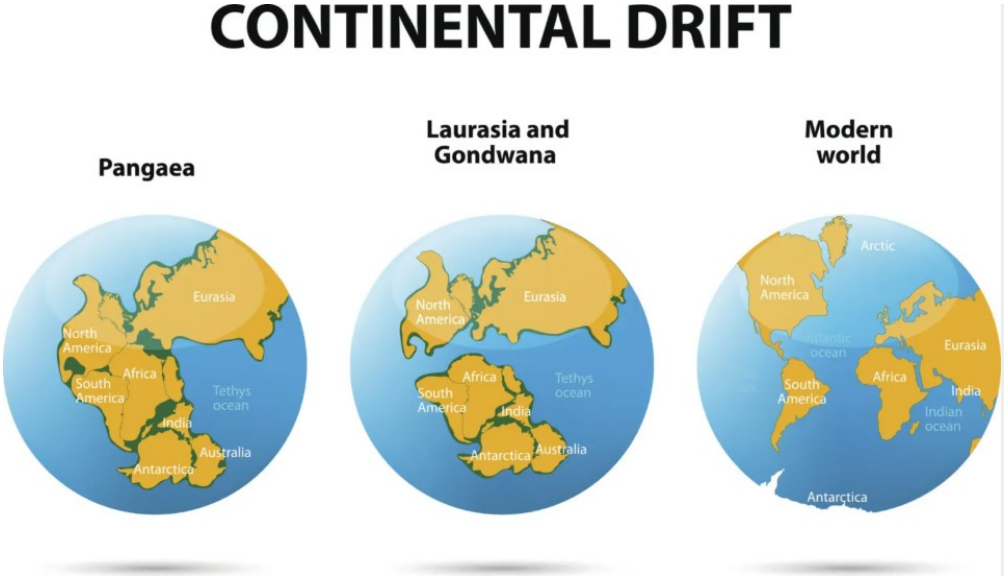
- **Rigid plates** – The Earth's surface is a mosaic of tectonic plates of various sizes.
- At present, there are seven major plates and a number of minor ones, all moving independently (floating) over a softer asthenosphere.
- **Asthenosphere** – The rigid masses (plates) are in continuous motion as they are floating over a semi-liquid surface below, known as the asthenosphere.
- These interactions lead to the formation of relief features such as mountains, plateaus, plains, etc.
- At the same time, they also cause destruction through tsunamis, volcanoes or earthquakes, as recently witnessed in Afghanistan.
- **Convergent boundaries –** At Convergent boundaries, crust is destroyed as denser plate sinks under less denser plate.
- This process is called subduction.
- Oceanic Plates are denser compared to continental plates and can form the deepest Earth features called trenches.
- **Divergent boundaries –** At divergent boundaries, tectonic plates pull away from each other, giving rise to new crust.
- **Transform boundaries –** They are formed when two plates move horizontally and slide past one another.

What are forces shaping the Earth's surface?

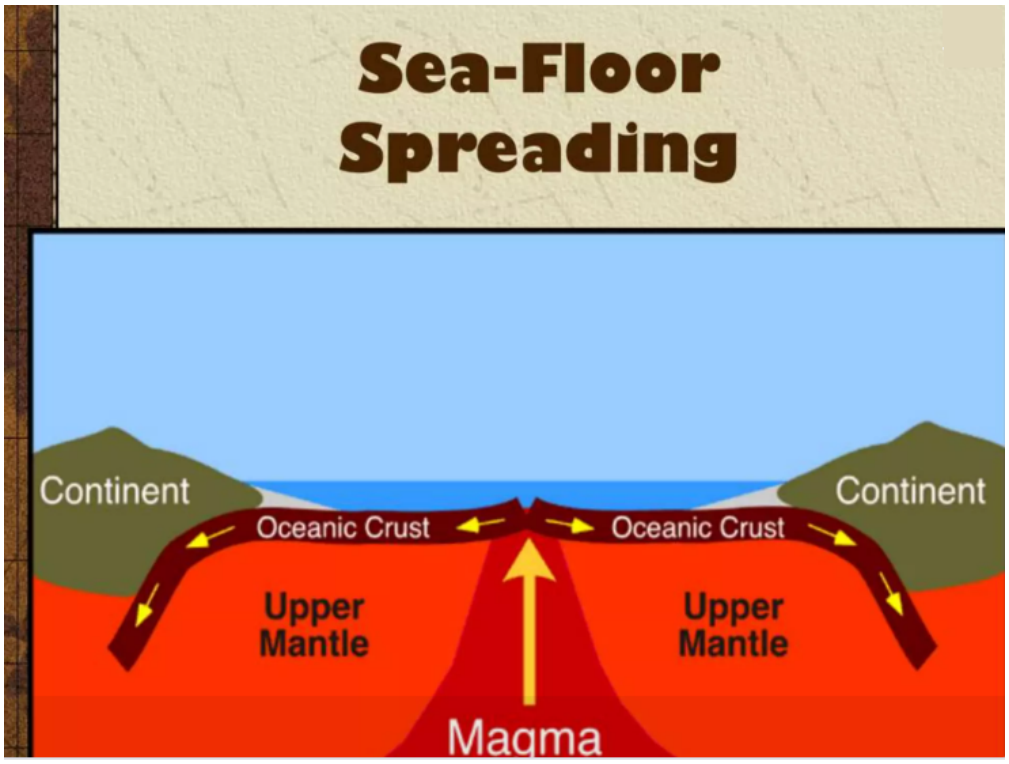
- **Forces** – The Earth's surface and its relief features are the result of the forces working on lithospheric plates.
- **Two types** – Based on their origin, these forces are known as endogenetic (internal) or exogenetic (external) forces.
- **Endogenetic forces** – They are constructive, creating relief features by altering surface shape and size.
- Based on the intensity, endogenetic forces could be sudden or diastrophic.
- Sudden forces cause immediate effects such as seismic activities, tsunamis and volcanic eruptions, creating faults, rift valleys, volcanic mountains, etc.
- **Exogenetic forces** – These are destructive, continuously breaking down relief features through weathering, erosion, mass wasting, and deposition.
- Notably, there are theories that help understand these tectonic movements and forces causing changes to the Earth's surface.

What are the different theories of evolution of earth?

- **Continental drift theory** – In 1912, German Meteorologist Alfred Wegener proposed the theory of 'continental drift'.
- It revealed that the position of these continents is not stationary and continuously changing with varied rates over millions of years.
- This change is driven by forces like pole-fleeing force and the tidal force.



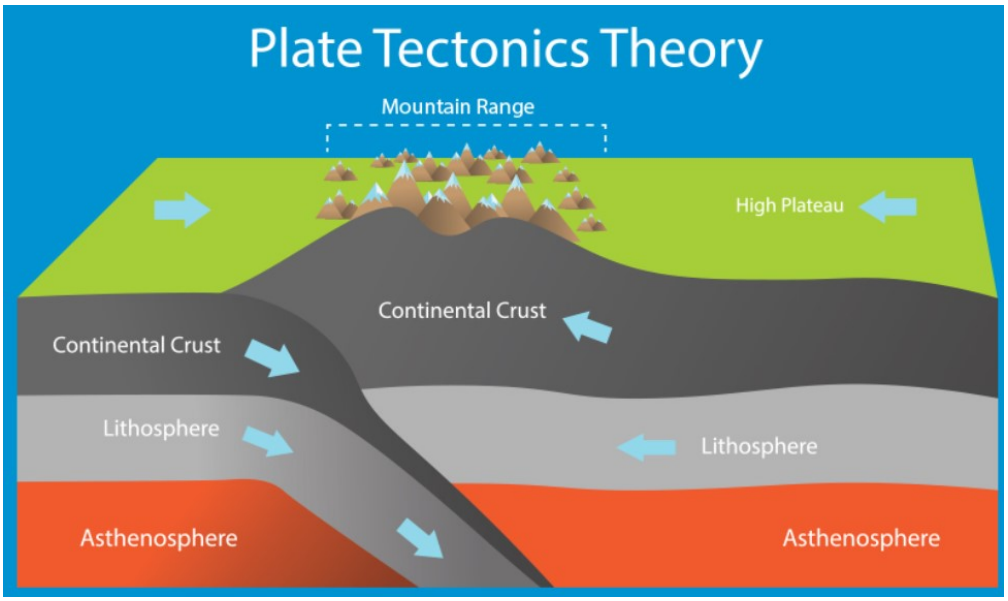
- While continental drifting was widely accepted, critics found these forces insufficient to move massive landmasses.
- **Role of convection currents** – In the 1930s, Arthur Holmes suggested that convection currents are operating in the entire mantle due to thermal differences of radioactive elements, causing continental drift.
- It may be noted here that during World War II, ocean exploration also revealed complex seafloor relief features.
- **Sea floor spreading** – In the 1960s, Harry Hess, a US Navy officer during the war, gave the hypothesis of 'sea-floor spreading'.
- Based on detailed mapping of the ocean floor and studies of paleomagnetic properties of rocks on either side of mid-oceanic ridges.
- Hess showed that new crust is formed at ridges and spreads outward.



- **Plate tectonics theory** – In 1967, Dan P. McKenzie, Robert L. Parker, and W. Jason

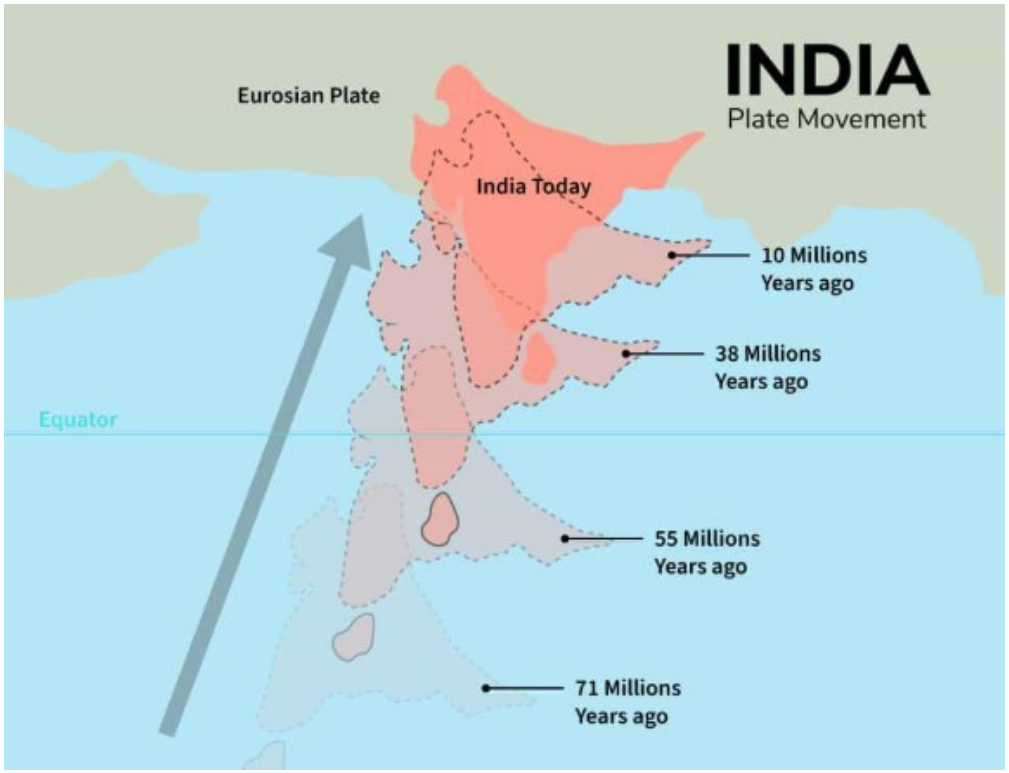
Morgan independently integrated all the available information at that time and came up with the concept called ‘plate tectonics’.

- It efficiently explains the changes occurring on the Earth surface at present or that occurred in the past.



What was the supercontinent and its breaking?

- The Earth formed 4.6 billion years ago and has been continuously changing ever since.
- **Pangea** – Around 300-200 million years ago (mya), there was a supercontinent called Pangaea.
- **Panthalassa** – The Pangea was surrounded by a mega-ocean known as Panthalassa.
- **Breaking of Pangea** – Later, due to plate movements, Pangaea broke into two parts
  - Lauratia – Present North America, Europe and Asia.
  - Gondwanaland – Present South America, Africa, Peninsular India, Australia and Antarctica.
- **Tethys Sea** – The space between these two landmasses was filled with water, which was named the Tethys Sea.
- **Cretaceous period** – During the cretaceous period (145-66 mya), Peninsular India, Madagascar, Australia and Antarctica were broken and drifted away from Gondwanaland.
- South America and Africa were separated during the middle cretaceous period and the southern part of the present Atlantic Ocean formed.
- **Late cretaceous period** – The North Atlantic Ocean was formed with the separation and opposite movement of the North American continent from Eurasia and Greenland.
- **Movement of Indian plate** – The present Indian plate consists of Peninsular India, which was earlier part of the Australian continent.



- It started moving northward around 71 million years ago, collided with the Eurasian plate, and created a continent-continent convergent boundary.
- Earlier, these two plates were separated by the Tethys Sea.
- **Origin of Himalayas and Indian Ocean** – The collision gave rise to the great Himalayan mountain ranges around 40 million years ago**,** and to the Indian Ocean.

Why there is a need to understand disaster preparedness with earth's natural process?

- **Dynamic nature of earth** – Evidence of Paleomagnetism from sea-floor spreading shows that oceans and continents have never been stationary.
- **Atlantic Ocean** – It has divergent boundaries between the North American and Eurasian plates in the north, and between the South American and African plates in the south.
- The ocean is expanding (~2.5 cm/yr), increasing the distance of the Americas from Europe and Africa, while new oceanic crust is also continuously being formed.
- **Pacific Ocean** – Eastern and western coastal areas of the Pacific Ocean have active convergent boundaries and often witness active volcanic activities thus called the Pacific Ring of Fire.
- Due to this convergence, oceanic plates are subducting and the Pacific basin is continuously shrinking.
- **Rise of Himalayas** – The Himalayas continue to rise as the Indian plate moves northward at approximately 5 cm/yr.
- This also means that the region is tectonically active and poses seismic risks to the region.
- It threatens infrastructure and lives, particularly in the Himalayan belt, northeastern states, and densely populated Indo-Gangetic plains, as seen during the 2015 Nepal earthquake and more recent seismic events in Afghanistan.

- Hence, balancing disaster preparedness with resource utilisation should remain a national priority.

Reference

The Indian Express| Shifting Forces of Earth