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Geomorphology Part I

PDF

Geography is the study of

1. the **physical features** of the earth and its atmosphere,
2. **human activity which affects and is affected by the physical features** of the earth and its atmosphere. (Definition from Oxford Dictionary)

- Human activity which affects and is affected by the physical features include the distribution of populations, distribution of resources and economic activities, and changes in the environment.

Geography, the natural science, is divided into two main branches:

1. **Physical geography:** deals with the study of processes and patterns in the natural environment like the atmosphere, hydrosphere, biosphere, and geosphere.
2. **Human geography:** deals with the environment shaped by human activity.

Physical Geography can be divided into several sub-fields, as follows:

- **Geomorphology** ('geo' meaning earth, 'morphe' meaning form and 'logos' meaning discourse) is the field concerned with understanding the surface of the Earth and the processes by which it is shaped.
- **Climatology** is the study of the climate (weather conditions averaged over a long period).
- **Meteorology** focuses on weather processes and short-term forecasting (in contrast with climatology).
- **Oceanography** is the branch of physical geography that studies the Earth's oceans and seas.
- **Hydrology** is concerned with the amounts and quality of water moving and accumulating on the land surface and in the soils and rocks near the surface and is typified by the hydrological cycle.
- **Biogeography** deals with geographic patterns of species distribution and the processes that determine these patterns.
- **Environmental geography** analyses the spatial aspects of interactions between humans and the natural environment. The branch bridges the divide between human and physical geography.
- **Geomatics** is the field of gathering, storing, processing, and delivering geographic information.

There are many other sub-branches in physical geography.

1. Interior of The Earth

- Understanding the structure of the earth's interior (crust, mantle, core) and various forces (heat, seismic waves) emanating from it is essential to understand the evolution of the earth's surface, its current shape and its future.

1.1 The study of the earth's interior is essential

- to understand the earth's surface
- to understand the geophysical phenomenon like volcanism, earthquakes, etc.
- to understand the earth's magnetic field
- to understand the internal structure of various solar system objects
- to understand the evolution and present composition of the atmosphere
- for mineral exploration

Earth's surface

- Many different geological processes shape the Earth's surface.
- The forces that cause these processes come from both above and beneath the Earth's surface.

- Processes that are caused by forces from within the Earth are **endogenous processes** (Endo meaning "in").
- By contrast, **exogenous processes** (Exo meaning "out") come from forces on or above the Earth's surface.
- The major geological features of the earth's surface like mountains, plateaus, lakes are mostly a result of endogenous processes like folding, faulting that are driven by forces from inside the earth.

Geophysical phenomenon like volcanism, earthquakes

- The forces that cause catastrophic events like earthquakes, volcanic eruptions come from deep below the earth's surface.
- For example, earthquakes occur due to the movement of the tectonic plates and the energy required for this movement is supplied by the **conventional currents in the mantle**.
- Similarly, volcanism occurs through the vents and fissures created by the tectonic movements.

Earth's magnetic field

- Earth's magnetic field is a result of **convection currents in the outer core** of the earth.
- Life on earth would not have been possible if not for the earth's magnetic field which protects the earth's atmosphere from the harmful **solar wind**.

The internal structure of various solar system objects

- The entire solar system was formed from a single nebular cloud, and the process of the formation of every solar system object is believed to be similar to that of the earth.

Evolution and present composition of the atmosphere

- For life to flourish on the surface of the earth, the atmosphere needs to have essential components like oxygen for respiration, CO_2 and other greenhouse gases to maintain the temperature on the surface, ozone to protect life from ultraviolet radiation and the right atmospheric pressure.
- All these components of the earth's atmosphere owe their existence to the **volcanic eruptions** that unlock them from the earth's interior.

Mineral exploration

- Understanding volcanic activity and the nature of rocks is essential for mineral exploration.
- Most of the minerals like **diamonds (form at a depth of 150-800 km in the mantle)** that occur on the earth's surface are formed deep below the earth's surface. They are brought to the surface by **volcanic activity**.

1.2 Direct Sources of information about the interior

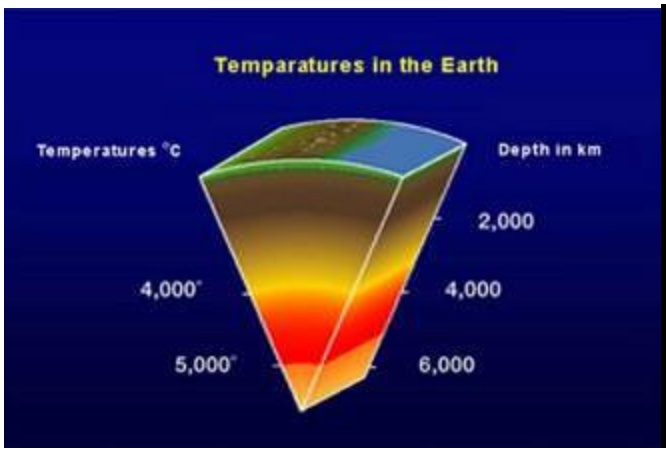
- Deep earth mining and drilling reveal the nature of rocks deep down the surface.
- But as mining and drilling are not practically possible beyond a certain depth, they don't reveal much information about the earth's interior.
- **Mponeng gold mine** (deepest mine in the world) and **TauTona gold mine** (second deepest mine in the world) in South Africa are deepest mines reaching to a depth of only 3.9 km.
- And the deepest drilling is only about 12 km deep hole bored by the Soviet Union in the 1970s over the **Kola Peninsula**.

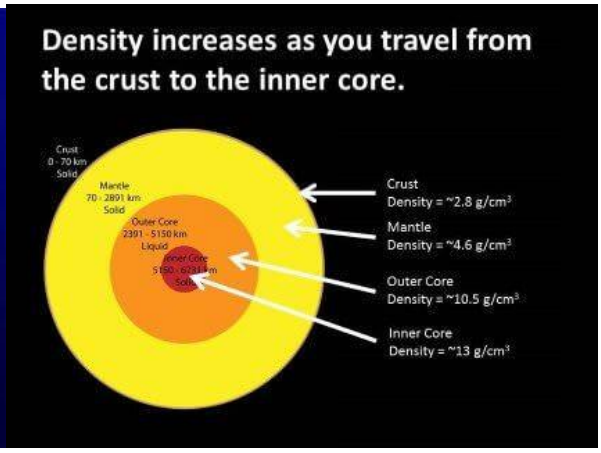
The Kola Peninsula in north-west Russia. (TUBS, from Wikimedia Commons)

- Volcanic eruption forms another source of obtaining direct information.

1.3 Indirect Sources of information about the interior

- Gravitation and the diameter of the earth help in estimating pressure deep inside.
- Volcanic eruptions and existence of hot springs, geysers etc. point to an interior which is very hot.



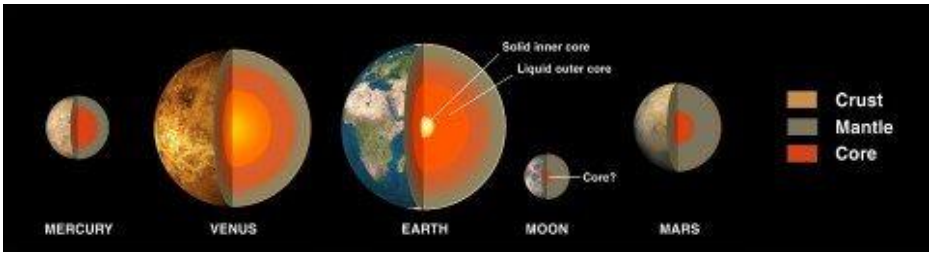


Seismic waves

- They are the most important source available to understand the layered structure of the earth.
- The velocity of seismic waves changes as they travel through materials with different **elasticity** and **density**.
- The **more elastic and denser the material is, the higher is the velocity**.
- They also undergo **refection or refraction** when they come across materials with different densities.
- Earth's internal structure can be understood by analysing the patterns of reflection, refraction and change in velocity of the seismic waves when they travel through it.

Meteorites

- Meteorites and Earth are born from the same nebular cloud. Thus, they are likely to have a similar internal structure.
- When meteoroids they fall to earth, their outer layer is burnt during their fall due to extreme friction and the inner core is exposed.
- The heavy material composition of their cores confirms the similar composition of the inner core of the earth.



Gravitation

- The gravitation force differs according to the mass of material. The uneven distribution of mass of material within the earth influences this value. Such a difference is called **gravity anomaly**.
- Gravity anomalies give us information about the **distribution of mass** in the crust of the earth.

Magnetic field

- The geodynamo effect helps scientists understand what's happening inside the Earth's core. Shifts in the magnetic field also provide clues to the inaccessible iron core.

Sources of earth's heat

Radioactive decay

- The high temperature below the crust is attributed to the **disintegration of the radioactive substances**.
- **The nuclear decay happens primarily in the crust and the mantle**.

- Scientists believe that uranium could become sufficiently concentrated **at the base of Earth's mantle** to ignite self-sustained **nuclear fission**, as in a human-made reactor.
- The new measurements suggest **radioactive decay provides more than half of Earth's total heat**.

Nuclear fusion doesn't occur inside the earth*. For nuclear fusion to occur there must be far more pressure and temperature inside the earth. The earth is not massive enough to cause such conditions.*

Primordial heat

- The rest is the heat left over from Earth's formation known as the **primordial heat**.
- Primordial heat is the kinetic energy transferred to Earth by external impacts of comets and meteorites and the subsequent effects (**friction** caused by sinking of heavy elements like Fe, rising light elements like Si) and **latent heat of crystallisation released as the core solidified**.

Tidal friction

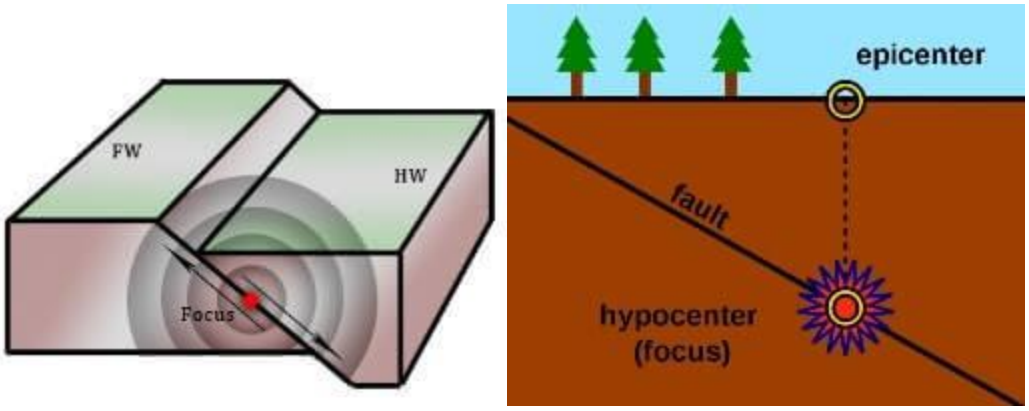
- The ocean tides are not the only effect of tidal forces (gravitational influence of the moon and the sun on earth; tides are explained in oceanography). The solid body of the Earth also bulges slightly in this way.
- The daily flexing of the Earth (both solid body and the oceans) cause loss of energy of the Earth's rotation, due to friction.
- This energy goes into heat, leading to miniscule increase in the Earth's internal temperature.
- The loss of rotational energy means that the **Earth is slowing down in its rotation rate**, currently by about 0.002 seconds per century.

1.4 Seismic waves

- Seismic: relating to earthquakes or other vibrations of the earth and its crust.
- Seismic waves are waves of energy that travel through the Earth's layers and are a result of earthquakes, volcanic eruptions, magma movement, large landslides and large human-made explosions.
- The refraction or reflection of seismic waves is used for research into the structure of the Earth's interior.
- The terms seismic waves and earthquake waves are often used interchangeably.

How are earthquake waves produced?

- The abrupt release of energy along a fault (sharp break in the crustal layer) causes earthquake waves.
- Rock layers along a fault tend to move in opposite directions due to the force excreted on them but are held in place by counteracting frictional force exerted by the overlying rock strata.

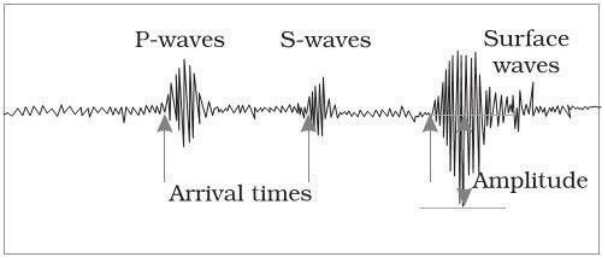


The Focus of an Earthquake (Eround1); Epicentre (AnsateSam, via Wikimedia Commons)

- The pressure on the rock layers builds up over a period and overcomes the frictional force resulting in a sudden movement generating shockwaves (seismic waves) that travel in all directions.
- The point where the energy is released is called the **focus** or the **hypocentre** of an earthquake.
- The point on the surface directly above the focus is called **epicentre**.
- An instrument called 'seismograph' records the waves reaching the surface.

1.5 Types of Seismic waves or earthquake waves

- The seismic waves or earthquake waves are basically of two types — **body waves** and **surface waves**.

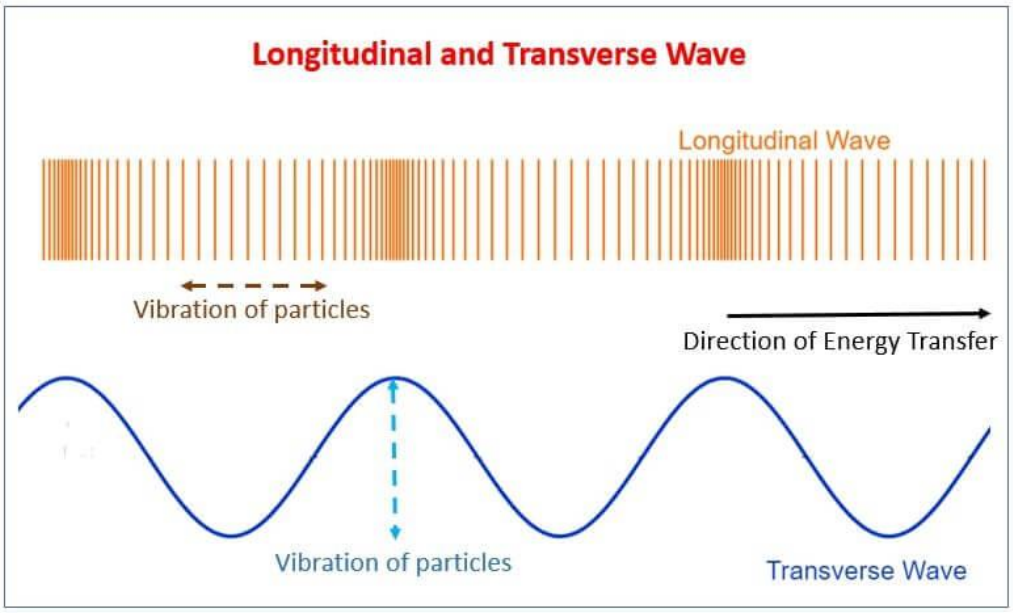


Body waves

- Body waves are generated due to the release of energy at the focus and **move in all directions** travelling through the interior of the earth. Hence, the name body waves.
- There are two types of body waves:
  1) the **P-waves or primary waves** (**longitudinal** in nature — wave propagation is similar to sound waves), and
  2) the **S-waves or secondary waves** (**transverse** in nature — wave propagation is similar to ripples on the surface of the water).

Primary Waves (P-waves)

- Primary waves are called so because they are the **fastest** among the seismic waves and hence are **recorded first on the seismograph**.
- P-waves are also called as the
  - **longitudinal waves** because the displacement of the medium is in the same direction as, or the opposite direction to, (parallel to) the direction of propagation of the wave; or
  - **compressional waves** because they produce compression and rarefaction when travelling through a medium; or
  - **pressure waves** because they produce increases and decreases in pressure in the medium.
- P-waves creates density differences in the material leading to stretching (rarefaction) and squeezing (compression) of the material.



The vibration of particles in Longitudinal wave and Transverse wave (Source)

- These waves are of relatively high frequency and are the **least destructive** among the earthquake waves.
- The trembling on the earth's surface caused due to these waves is in the **up-down direction (vertical)**.
- **They can travel in all mediums,** and their velocity depends on **shear strength (elasticity)** of the medium.
- Hence, the velocity of the P-waves in **Solids > Liquids > Gases**.
- These waves take the form of **sound waves** when they enter the atmosphere.
- P-wave velocity in earthquakes is in the range 5 to 8 km/s.
- The precise speed varies according to the region of the Earth's interior, from less than 6 km/s in the Earth's crust to 13.5 km/s in the lower mantle, and 11 km/s through the inner core.

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Geomorphology Part II

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1. Volcanism

- A volcano is a vent or a fissure in the crust from which lava (molten rock), ash, gases, rock fragments erupt from a magma chamber below the surface.
- Volcanism is the phenomenon of eruption of molten rock, pyroclastics and volcanic gases to the surface through a vent.

1.1 Causes of Volcanism

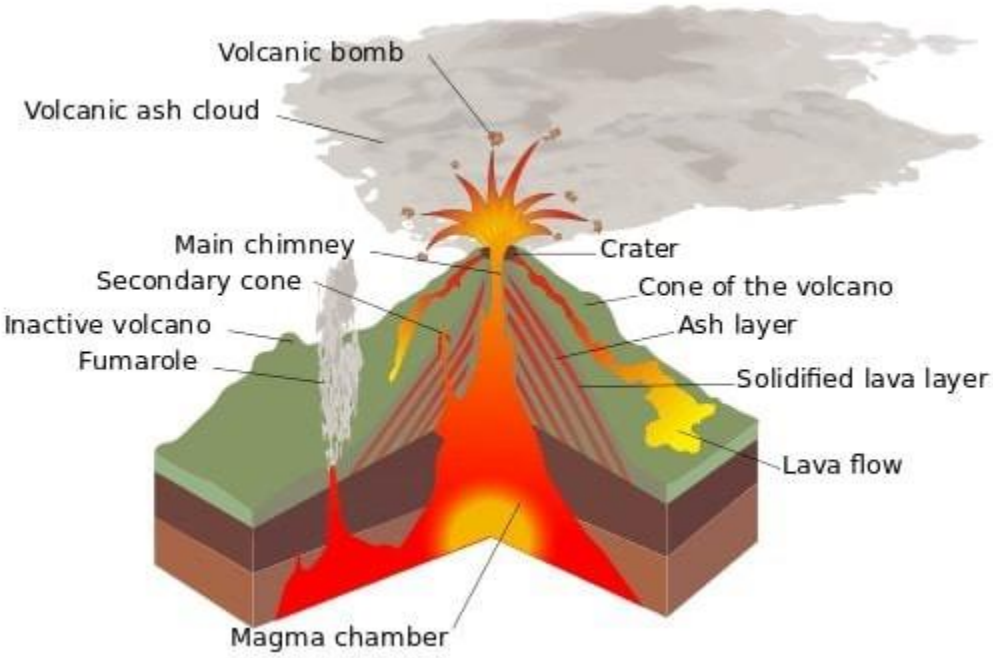
- There is a **huge temperature difference** between the inner layers and the outer layers of the earth due to the differential amount of radioactivity.
- This temperature difference gives rise to **convectional currents** in the mantle.
- The convection currents in the mantle create convergent and divergent boundaries (weak zones).
- At the divergent boundary, molten, semi-molten and sometimes gaseous material appears on earth at the first available opportunity.
- The earthquakes here may expose fault zones through which magma may escape (**fissure type volcano**).

- At the convergent boundary, the subduction of denser plate creates magma at high pressure which will escape to the surface in the form of violent eruptions.

1.2 Lava types

- Magma is composed of molten rock and is stored in the Earth's crust. Lava is magma that reaches the surface through a volcano vent.

Andesitic or Acidic or Composite or Stratovolcanic lava



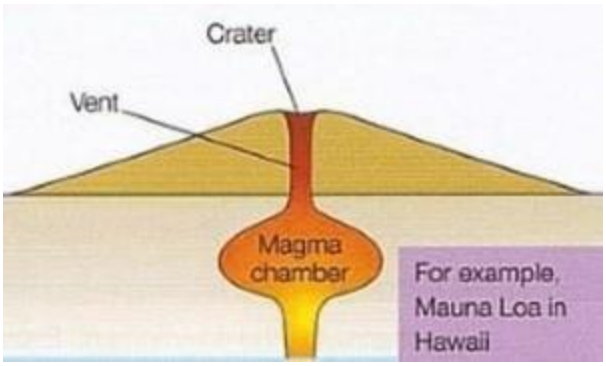
Volcano (Medium69.Cette William Crochot, via Wikimedia Commons)

- These lavas are **highly viscous** with a high melting point.
- They are **light-coloured, of low density, and have a high percentage of silica**.
- They **flow slowly and seldom travel far** before solidifying.
- The resultant volcanic cone is therefore stratified (hence the name **stratovolcano**) and steep-sided.
- The **rapid solidifying of lava** in the vent obstructs the flow of the out-pouring lava, resulting in **loud explosions**, throwing out many volcanic **bombs or pyroclasts**.
- Sometimes the lavas are so viscous that they form a **lava plug** at the crater like that of **Mt. Pelée** in Martinique (an island in the Lesser Antilles, Caribbean Islands).
- Andesitic lava flow occurs mostly along the **destructive boundaries** (convergent boundaries).

Lava Plug at the crater

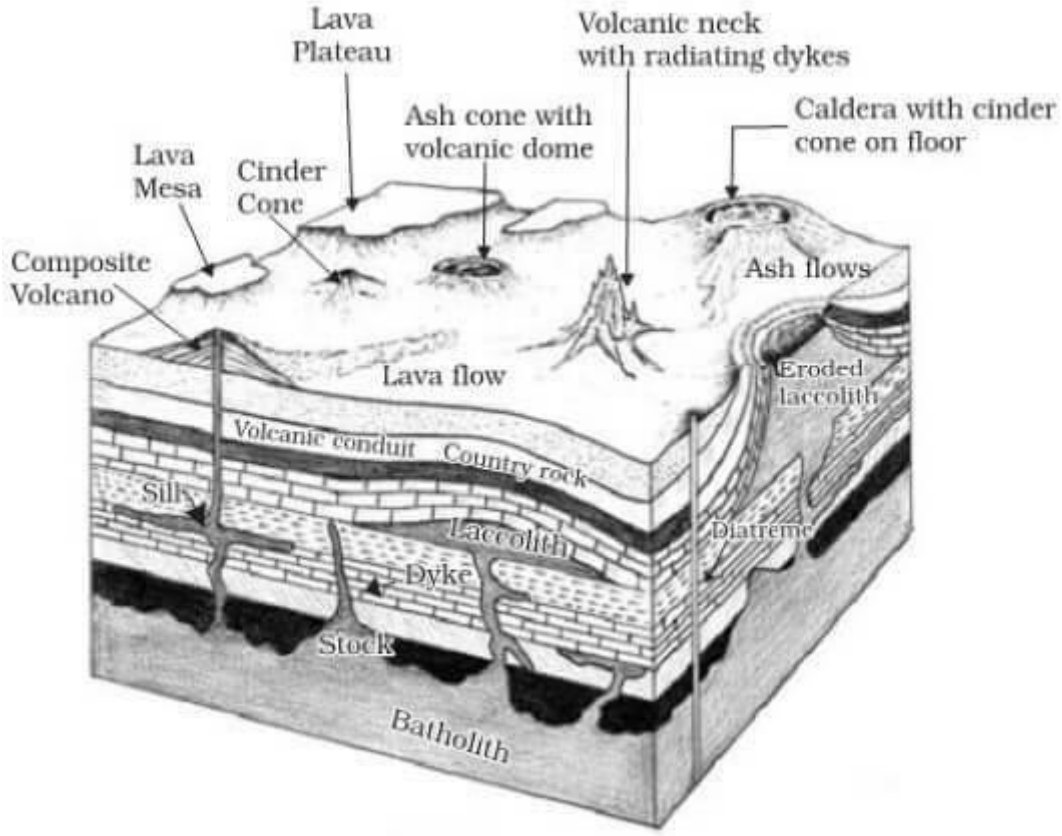
Basic or Basaltic or Shield lava

- These are the **hottest lavas**, about 1,000 °C and are **highly fluid**.
- They are **dark coloured basalt, rich in iron and magnesium but poor in silica**.
- They flow out of volcanic vent **quietly** and are **not very explosive**.
- Due to their **high fluidity**, they flow readily with a speed of 10 to 30 miles per hour.
- They affect extensive areas, spreading out as **thin sheets** over **great distances** before they solidify.
- The resultant volcano is **gently sloping** with a wide diameter and forms a flattened shield or dome.
- Shield type lava flow is common along the **constructive boundaries** (divergent boundary).



1.3 Volcanic Landforms

- Volcanic landforms are divided into **extrusive and intrusive landforms** based on whether magma cools within the crust or above the crust.
- Rocks formed by cooling of magma within the crust are called **Plutonic rocks.**
- Rocks formed by cooling of lava above the surface are called **Igneous rocks**.
- In general, the term 'Igneous rocks' is used to refer all rocks of volcanic origin.



Extrusive and Intrusive volcanic landforms

Extrusive Volcanic Landforms

- Extrusive landforms are formed from material thrown out to the surface during volcanic activity.
- The materials thrown out include lava flows, pyroclastic debris, volcanic bombs, ash, dust and gases such as **nitrogen compounds, sulphur compounds** and minor amounts of **chlorine, hydrogen** and **argon**.

Conical Vent and Fissure Vent

Fissure vent

- A fissure vent (volcanic fissure) is a narrow, linear volcanic vent through which lava erupts, **usually without any explosive activity**.
- The vent is often a few meters wide and may be many kilometres long.
- Fissure vents are common in **basaltic volcanism** (**shield type volcanoes**).

Conical vent

- A conical vent is a narrow cylindrical vent through which magma flows out violently.
- Conical vents are common in **andesitic volcanism** (**composite or stratovolcano**).

Mid-Ocean Ridges

- The system of mid-ocean ridges stretches for more than 70,000 km across all the ocean basins.
- The central portion of the mid-ocean ridges experiences frequent eruptions.
- The lava is **basaltic** (less silica and hence less viscous) and causes the **spreading of the seafloor**.

Composite Type Volcanic Landforms

- They are conical or central type volcanic landforms.
- Along with andesitic lava, large quantities of pyroclastic material and ashes find their way to the surface.
- **Andesitic lava** along with pyroclastic material accumulates in the vicinity of the vent openings leading to the formation of layers, and this makes the mounts appear as a **composite volcano or a stratovolcano** (divided into layers).

- The highest and most common volcanoes have composite cones.
- **Mount Stromboli (the Lighthouse of the Mediterranean)**, Mount Vesuvius, Mount Fuji are examples.

Shield Type Volcanic Landforms

- The **Hawaiian volcanoes** are the most familiar examples.
- These volcanoes are mostly made up of **basaltic lava** (very fluid).
- These volcanoes are not steep.

- They become explosive if somehow water gets into the vent; otherwise, they are less explosive.
- Example: Hawaiian volcanoes **Mauna Loa** (active shield volcano) and **Mauna Kea** (dormant shield volcano).

Fissure Type Flood Basalt Landforms (Lava Plateaus)

- Sometimes, a very thin magma escapes through cracks and fissures in the earth's surface and flows after intervals for a **long time**, **spreading over a vast area**, finally producing a **layered, undulating (wave-like), flat surface**.
- Example: **Siberian Traps**, **Deccan Traps**, **Snake Basin, Icelandic Shield, Canadian Shield**.

Crater

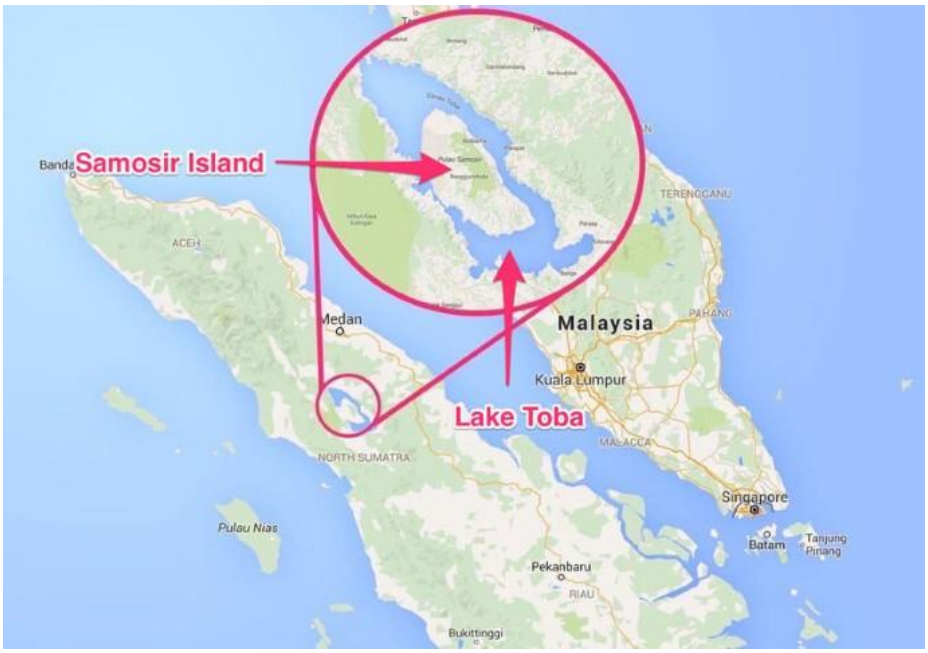
- A crater is an inverted cone-shaped vent through which the magma flows out. When the volcano is not active the crater appears as a bowl-shaped depression.

The crater of Mount Fuji, Japan

- When water from rain or melted snow gets accumulated in the crater, it becomes a **crater lake**.

Caldera

- In some volcanoes, the magma chamber below the surface may be emptied after volcanic eruptions.
- The volcanic material above the chamber **collapses** into the empty magma chamber, and the collapsed surface appears like a large cauldron-like hollow (tub shaped) called the caldera.
- When water from rain or melted snow gets accumulated in the caldera, it becomes a **caldera lake** (in general, the caldera lakes are also called crater lakes).
- Due to their unstable environments, some crater lakes exist only intermittently. Caldera lakes, in contrast, can be quite **large and long-lasting**.
- For example, **Lake Toba (Indonesia)** formed after its supervolcanic eruption around 75,000 years ago. It is the **largest crater lake in the world**.



- Mount Mazama (Cascade Volcanic Arc, USA) collapsed into a caldera, which was filled with water to form Crater Lake (the literal name of the lake formed by the collapse of Mount Mazama is 'Crater Lake'!).

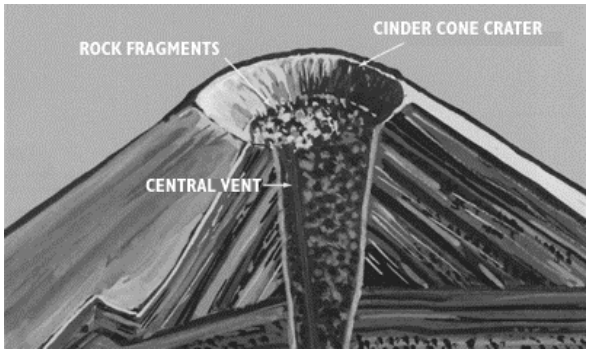
Caldera lake of Mount Mazama

A crater lake, in general, could be of volcanic origin (volcanic crater lake, volcanic caldera lake) or due to a meteorite impact (meteor crater or impact crater), or in the crater left by an artificial explosion caused by humans.

Lonar Lake, also known as Lonar crater (Lonar, Buldhana district, Maharashtra) was created by a meteor impact during the Pleistocene Epoch.

Cinder cone

- A cinder cone is a **steep circular or oval-shaped hill of loose pyroclastic fragments** that have been built around a volcanic vent.



Lava Dome

- A lava dome (volcanic dome) is a mound-shaped protrusion (a structure that extends outside the surface) resulting from the slow extrusion (coming out) of viscous lava from a volcano.
- In Lava domes, viscous **magma piles up** around the vent.
- The magma does not have enough gas or pressure to escape, although sometime later after sufficient pressure builds up, it may erupt explosively.

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Climatology Part I

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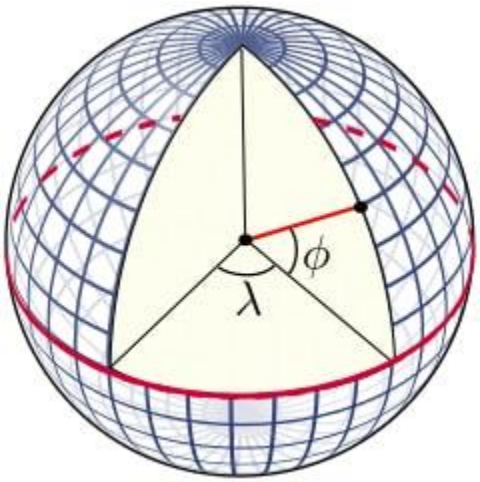
1. Latitudes and Longitudes

- Latitudes and Longitudes (coordinate system) are imaginary lines used to determine the location of a place on earth.
- Example: The location of New Delhi is 28° N Latitude, 77° E Longitude.

1.1 Latitude or Parallel

- Latitude is the angular distance of a place north or south of the equator measured in degrees from the centre of the earth.



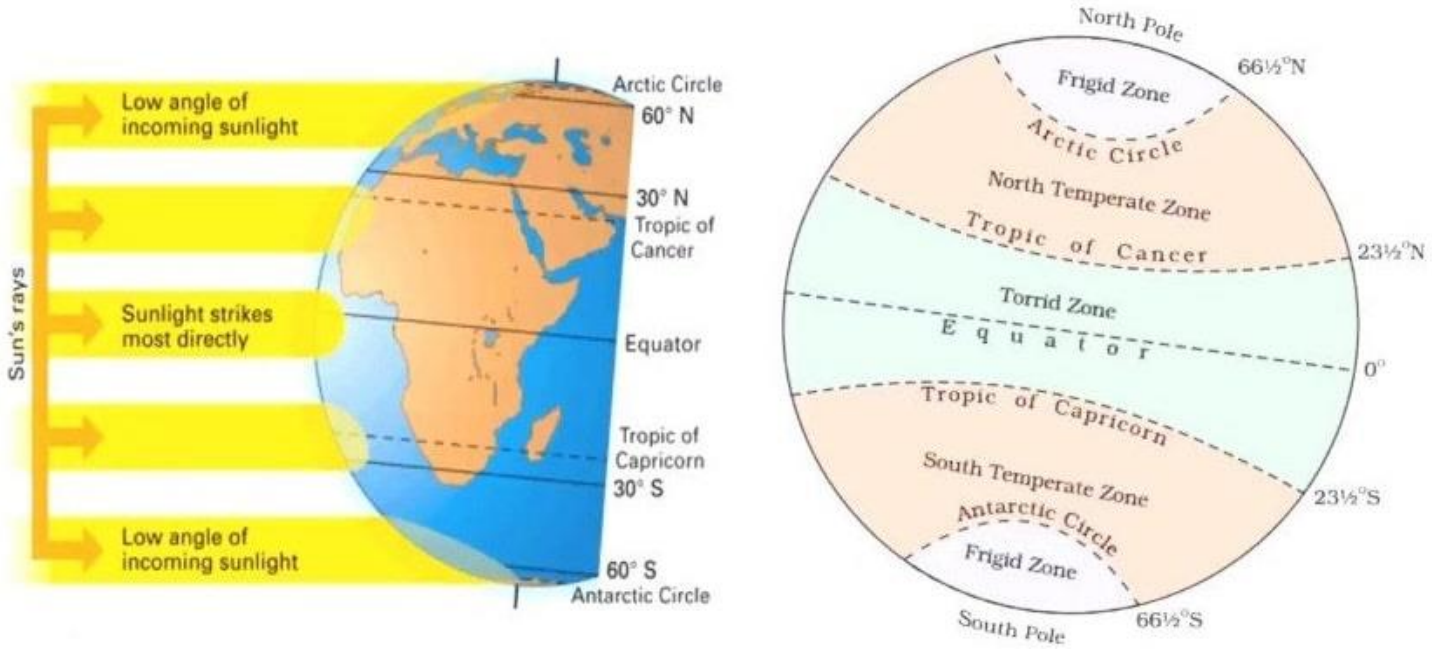
Latitude (ϕ) and longitude (λ) are defined on a perspective spherical modal (Wikipedia)

- As the earth is **slightly flattened at the poles**, the **linear distance of a degree of latitude at the pole is a little longer than that at the equator**.
- For example, at the equator linear distance of a degree of latitude is 110.57 km (68.7 miles), at 45° it is 111.13 km (69 miles), and at the poles, it is 111.7 km (69.4 miles). The average is taken as **111 km (69 miles)**.

Important parallels of latitudes

- Besides the **equator (0°)**, the **north pole (90° N)** and the **south pole (90° S)**, there are four important parallels of latitudes:
    1. The **Tropic of Cancer (23½° N)** in the northern hemisphere.
    2. The **Tropic of Capricorn (23½° S)** in the southern hemisphere.
    3. The **Arctic circle (66½° N)** in the northern hemisphere.
    4. The **Antarctic circle is (66½° S)** in the southern hemisphere.

Latitudinal Heat zones of the earth



Latitudinal Heat zones of the earth

- The mid-day sun is exactly overhead at least once a year on all latitudes in between the Tropic of Cancer and the Tropic of Capricorn. This area, therefore, receives the maximum heat and is called the **torrid zone**.
- The mid-day sun never shines overhead on any latitude beyond the Tropic of Cancer and the Tropic of Capricorn. The angle of the sun's rays goes on decreasing towards the poles.
- As such, the areas bounded by the Tropic of Cancer and the Arctic circle, and the Tropic of Capricorn and the Antarctic circle, have moderate temperatures. These are, therefore, called **temperate zones**.
- Areas lying beyond the Arctic circle and the Antarctic circle are very cold. Here the sun does not rise much above the horizon. Therefore, its rays are always slanting. These are, therefore, called **frigid zones**.

1.2 Longitude or Meridian

- Longitude is an angular distance of a place east or west of the **Prime (First) Meridian** measured in degrees from the centre of the earth.

- On the globe, longitude is shown as a series of semi-circles that run from pole to pole passing through the equator. Such lines are also called **meridians**.
- It was decided in 1884 to choose the meridian which passes through the Royal Astronomical Observatory at **Greenwich, near London**, as the **zero meridian or prime meridian**.
- All other meridians radiate eastwards and westwards of the prime meridian up to 180°.
- Unlike the parallels of latitude, the meridians of longitude are of **equal length**.
- The meridians of longitude have one very important function; they determine local time in relation to **Greenwich Mean Time (GMT)**, which is sometimes referred to as **World Time**.

Longitude and Time

- Since the earth makes one complete rotation of 360° in one day or 24 hours, it passes through **15° in one hour** or **1° in 4 minutes**.
- The earth rotates from west to east, so **every 15° we go eastwards, local time is advanced by 1 hour**.
- Conversely, **if we go westwards by 15°, local time is retarded by 1 hour**.
- Thus, the **places east of Greenwich gain time**, whereas **places west of Greenwich lose time**.
- A traveller going eastwards gains time from Greenwich until he reaches the meridian 180° E when he will be 12 hours ahead of GMT (GMT+12).
- Similarly, in going westwards, he loses 12 hours when he reaches 180° W. There is thus a total difference of 24 hours or a whole day between the two sides of the 180° meridian.

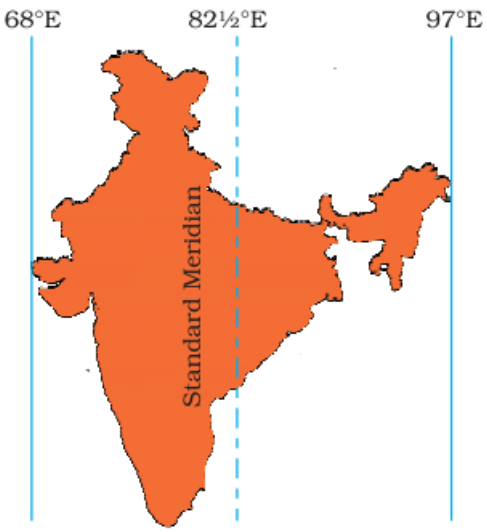
180° E and 180° W correspond to the same longitude. The difference is the direction of travel.

Standard Time and Time Zones

- Standard Time is the time corresponding to a certain longitude or longitudes as chosen by a country.
- Most countries adopt their standard time from the central meridian of their countries. E.g. **IST corresponds to the time at 82.5° E longitude**.
- In countries that have a very **large longitudinal extent** (**large east-west span**), such as Canada, USA, Russia, it would be inconvenient to have a single time zone. So, such countries have multiple time zones.
- For example, Russia has nine time zones, and Canada and USA have six time zones each.

Indian Standard Time

- Indian Standard Time (IST) is taken as the time at **82.5° E longitude** (passing close to the east of **Prayagraj or Allahabad**). Which means, **IST is 5 hours 30 mins ahead of GMT** (**IST = GMT+5:30**).



Longitudinal extent of India

Chaibagaan Time

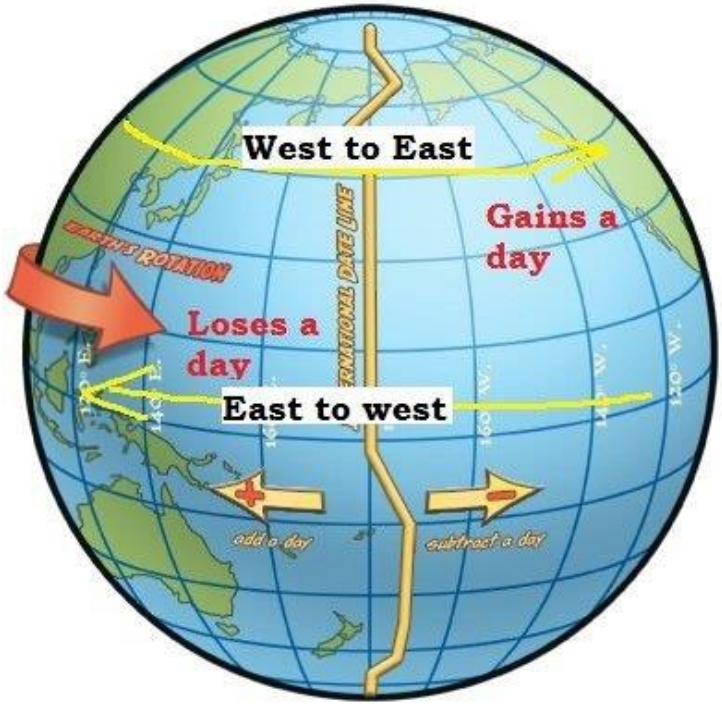
- One hundred fifty years ago, British colonialists introduced "Chaibagaan time" or "Bagaan time", a schedule observed by tea planters, which was **one hour ahead of IST**.
- This was done to improve productivity by optimising the usage of daytime.
- After Independence, Assam, along with the rest of India, has been following IST.
- The administration of the Indian state of Assam put forward a proposal to change its time zone back to Chaibagaan time to conserve energy and improve productivity.
- Indian government refused to accept such a proposal.

The International Date Line

- The International Date Line (IDL) an imaginary line that passes through the Pacific Ocean.
- **Along the International Date Line, the date changes by exactly one day when it is crossed**.
- A traveller crossing the date line from east to west loses a day, and while crossing the dateline from west to east, he gains a day.

Explanation:

- 180° E is GMT+12 and 180° W is GMT-12, hence the difference between 180° E and 180° W is 24 hours.
- That is, time difference on either side of IDL is 24 hours. So, the date changes as soon as one crosses IDL.

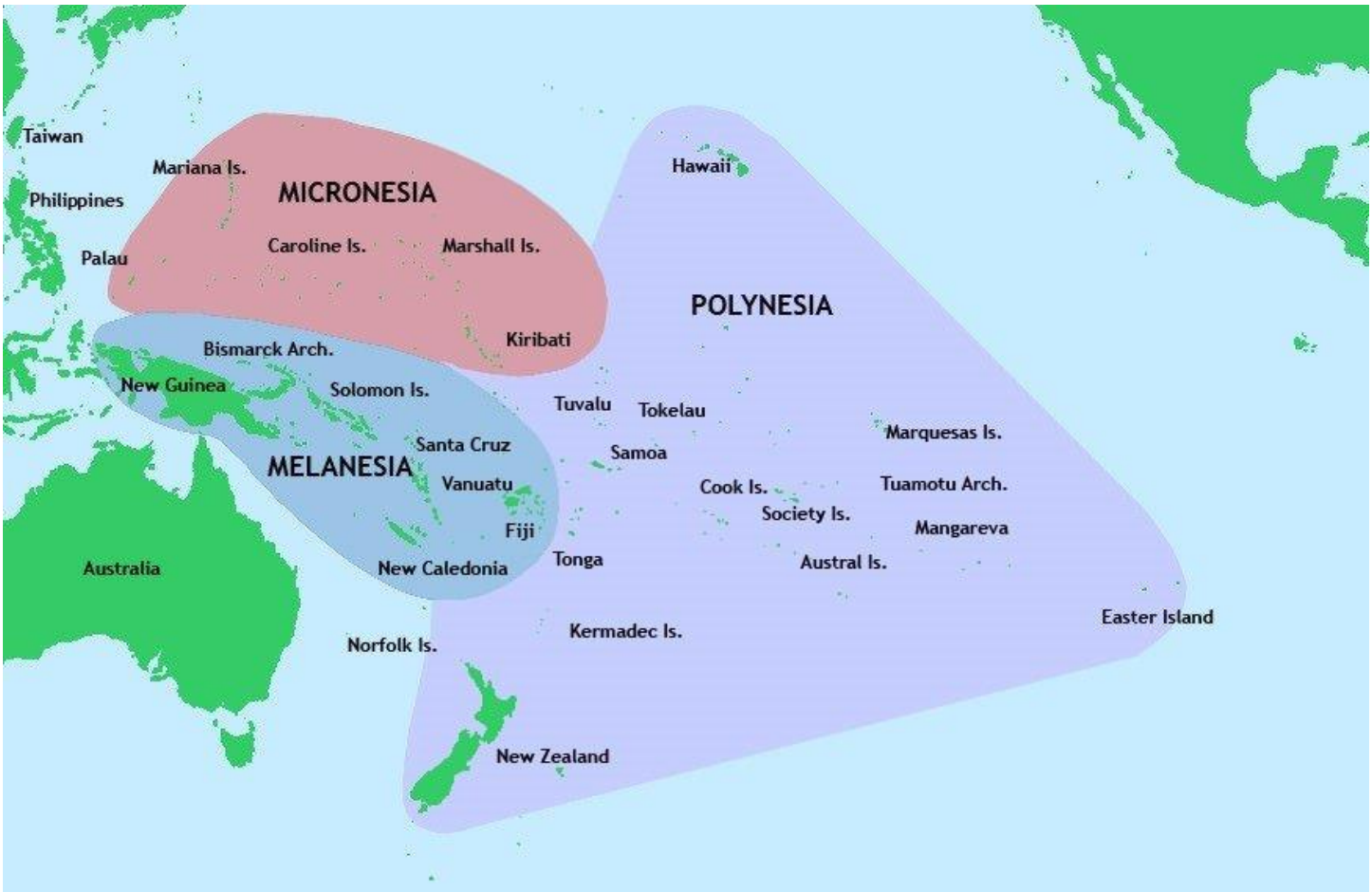


International Date Line

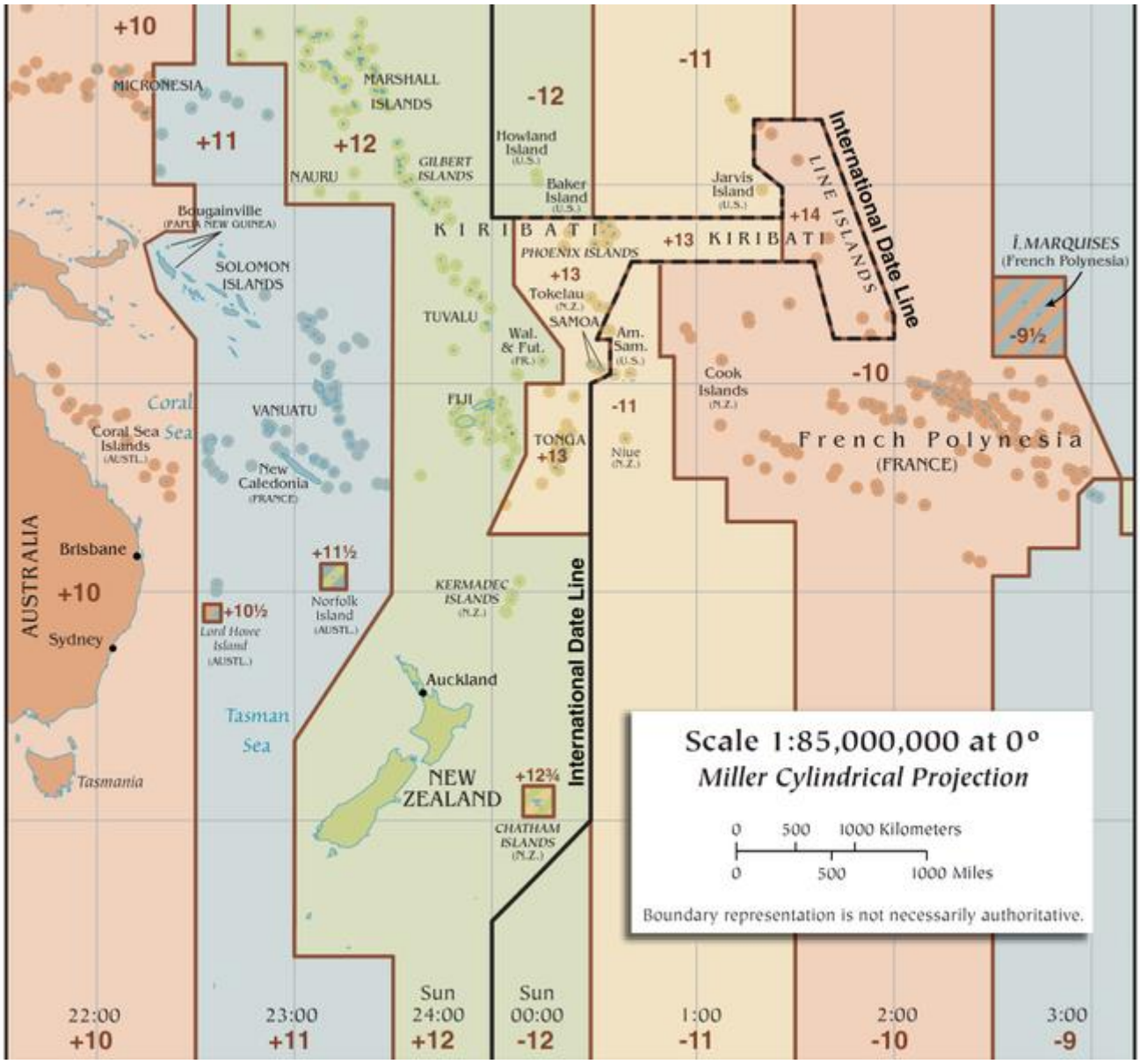
Why is the international dateline drawn in a zigzag manner?

- The International Date Line curves from the normal 180° meridian at the **Bering Strait**, and at the island groups of **Polynesia, Melanesia and Micronesia**.
- If the dateline was straight, then two regions of the same Island Country or Island group would fall under different date zones. Thus, to avoid any confusion of date, this line is drawn in a zig-zag manner.
- Some of regions along the dateline keep Asiatic, or New Zealand standard time, others follow the American date and time.

Time Zones and International Date Line



The Island Groups of Australia, Polynesia, Melanesia and Micronesia



IDL cutting across Oceania (Australia, Melanesia, Micronesia and Polynesia) (Jailbird, via Wikimedia Commons)

Samoa, Christmas Island (Kiribati) and Tonga are the first places that welcome a New Year.

Baker Island (USA) and Howland Island (USA) are the last to celebrate a new year.

1.3 Comparison: Latitude vs Longitude

Latitude	**Longitude**
• Angular distance of a point measured along the north or south of the equator	• Angular distance measured along the equator
• Latitudes are named south and north of Equator	• Longitudes are named east or west of Prime Meridian
• Also called as Parallels	• Also called as Meridian

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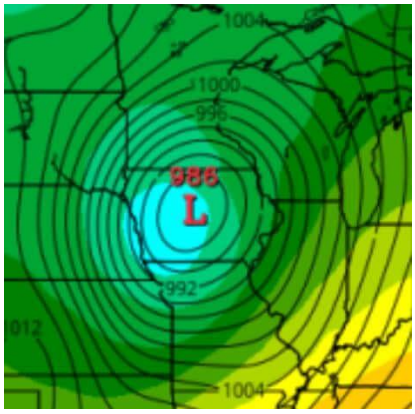
Climatology Part II

PDF

1. Tropical Cyclones

- Tropical cyclones originate over oceans in **tropical areas in late summers**.
- They are rapidly rotating violent storms characterised by
  - ✓ a **closed low-pressure centre with steep pressure gradients** (category 1 cyclones have a barometric pressure of greater than 980 millibars; category 5 cyclones can have central barometric pressure of **less than 920 millibars**),



Closed Isobars in a Tropical Cyclone

- ✓ a **closed low-level atmospheric circulation** (winds converging from all directions — cyclonic circulation),
- ✓ **strong winds** (squalls — a sudden violent gust of wind), and
- ✓ a **spiral arrangement of thunderstorms** that produce very heavy rain **(torrential rainfall**).

- The low-pressure at the centre is responsible for the wind speeds.
- The closed air circulation (cyclonic circulation) is a result of **rapid upward movement of hot moist air** which is subjected to **Coriolis force**.

1.1 Conditions necessary for the Formation of a Tropical Cyclone

- **Large sea surface with temperature higher than 27° C.**
- **Presence of the Coriolis force enough to create a cyclonic vortex.**
- **A pre-existing weak low-pressure area or low-level-cyclonic circulation.**
- **Low wind shear.**
- **Upper-level divergence.**

Good Source of Latent Heat

- Ocean waters having temperatures of **27° C** and depth of warm water extending for **60-70 m** deep supply enough moisture, and hence **latent heat of condensation**, to generate and drive a tropical storm.
- Thick layer of warm water ensures that the deep convection currents within the water do not churn and mix the cooler water below with the warmer water near the surface.

Why tropical cyclones form mostly on the western margins of the oceans?

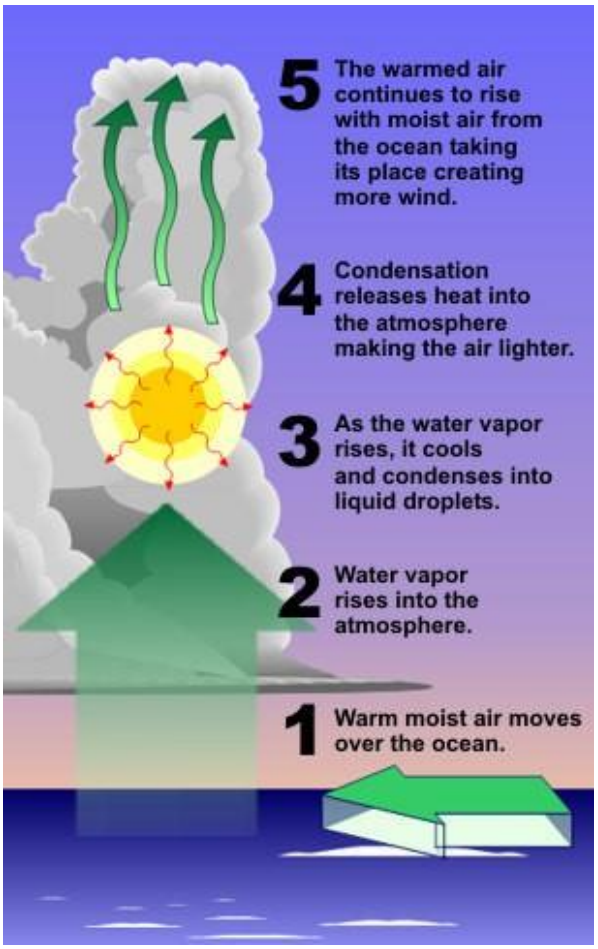
- Because of **warm ocean currents** (easterly trade winds drag ocean waters towards west) that flow from east towards west forming a thick layer of warm water with temperatures greater than 27°C.

Why are tropical cyclones very rare on the eastern margins of the oceans?

- The **cold currents** lower the surface temperatures of the eastern parts of the tropical oceans making them unfit for the breeding of cyclonic storms.

*Exceptional case: During **strong El Nino years**, strong hurricanes occur in the eastern Pacific. This is due to the accumulation of warm waters in the eastern Pacific due to **weak Walker Cell**.*

Why do tropical cyclones weaken on landfall?



- On landfall, the storm is cut-off from adequate moisture supply and hence it is deprived of latent heat of condensation. Thus, the storm dissipates (weakens or dies off) on landfall.

Rising of humid air parcel ➔ ambient pressure on the air parcel decreases with altitude ➔ adiabatic lapse rate (fall in temperature of air parcel) ➔ condensation of moisture in air parcel due to low temperature ➔ ***latent heat of condensation*** *is released in the process ➔ air parcel is heated further due to the release of latent heat of condensation and becomes less denser ➔ air parcel is further uplifted ➔ more air comes in to fill the gap ➔ new moisture is available for condensation ➔ latent heat of condensation is released.* ***The cycle repeats as long as there is enough supply of moisture****.*

Coriolis Force

- The **Coriolis force is zero at the equator,** but it increases with latitude.
- Coriolis force at 5° latitude is significant enough to create a storm (cyclonic vortex).
- About 65 per cent of cyclonic activity occurs between **10° and 20° latitude**.
- The cyclonic circulation is **anti-clockwise (counterclockwise) in the northern hemisphere** and **clockwise in the southern hemisphere**.

Why cyclones occur mostly in late summers?

1. Due to high specific heat of water, and mixing, the **ocean waters in northern hemisphere attain maximum temperatures in August** (in contract continents attain maximum temperatures in June-July).
2. Whirling motion (cyclonic vortex) is enhanced when the **doldrums** (region within ITCZ) over oceans are farthest from the equator (**Coriolis force increases with distance from the equator**).

Why do 'tropical cyclones' winds rotate counter-clockwise in the Northern Hemisphere?

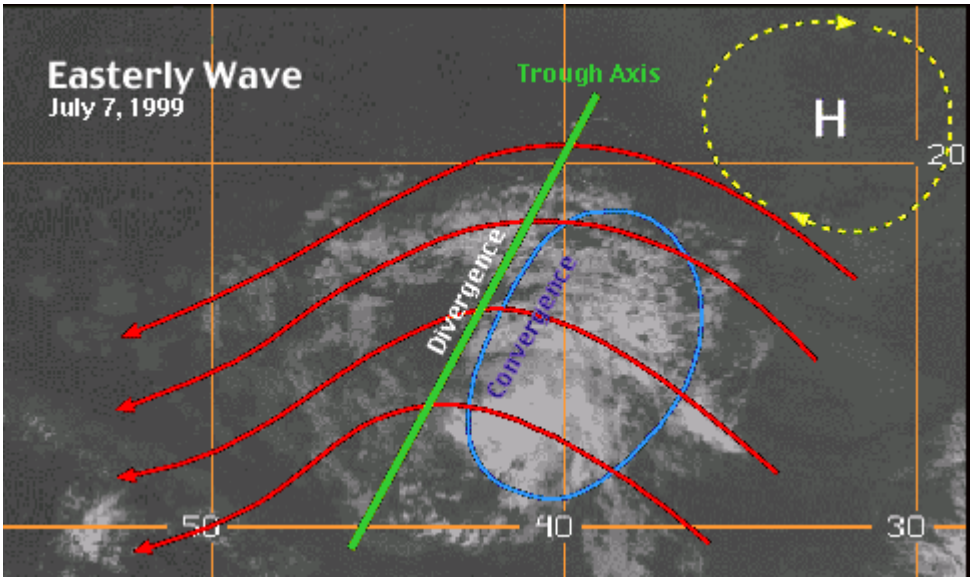
- As the earth's rotation sets up an apparent force (called the Coriolis force) that pulls the winds to the **right** in the Northern Hemisphere (and to the left in the Southern Hemisphere).
- So, when a low-pressure starts to form over north of the equator, the surface winds will flow inward trying to fill in the low and will be deflected to the right, and a **counter-clockwise rotation** will be initiated.
- The opposite (a deflection to the left and a clockwise rotation) will occur south of the equator.

Coriolis force is too tiny to effect rotation in water that is going down the drains of sinks and toilets.
The rotation in those will be determined by the geometry of the container and the original motion of the water.

Low-level Disturbances

- Low-level disturbance is a **low-pressure trough (an extended region of low-pressure)** that moves from east to west in the form of **easterly wave disturbances** in the Inter-Tropical Convergence Zone (ITCZ).

A disturbance is a persistent group of thunderstorms with heavy rains and strong wind gusts.
Easterly wave disturbances: *it is a convective trough (thermal origin) — a persistent group of thunderstorms travelling together in east to west direction (westward traveling disturbances) under the influence of trade winds.*



Easterly wave disturbances

- Easterly wave disturbances act as **seedling circulations (birthplace)** for a large number of tropical cyclones. However, not all disturbances develop into cyclones.

Temperature Contrast Between Air Masses

- The convergence of air masses of different temperatures results in instability causing low-level disturbances which are a prerequisite for the origin and growth of violent tropical storms.
- Trade winds from both the hemispheres meet along the inter-tropical front (ITCZ). Temperature contrasts between these air masses must exist when the ITCZ is farthest from the equator so that the low-level disturbances can intensify into a depression (intensifying low-pressure cell).

Wind Shear

- Wind Shear is the difference between wind speeds at different altitudes.
- Tropical cyclones develop when the wind is uniform.

Why is convective cyclogenesis (tropical cyclogenesis) confined to tropics?

- **Because of weak vertical wind shear, cyclone formation processes are limited to latitude equatorward of the subtropical jet stream.**
- In the temperate regions, wind shear is high due to westerlies, and this inhibits convective cyclogenesis.

Why there are very few Tropical Cyclones during southwest monsoon season?

Large vertical wind shear

- The southwest monsoon is characterized by the presence of strong westerly winds (south-west monsoon winds) in the lower troposphere (below 3 km) and strong easterly winds in the upper troposphere (above 9 km). This results **in large vertical wind shear**. **Strong vertical wind shear inhibits cyclone development**.

Less time for development

- The potential zone for the development of cyclones shifts to North Bay of Bengal during southwest monsoon season.
- Low-pressure system up to the intensity of depressions form along the monsoon trough (along ITCZ), which extends from northwest India to the north Bay of Bengal.
- The Depression forming over this area crosses Orissa-West Bengal coast in just a day or two as the bay is narrower to the north.

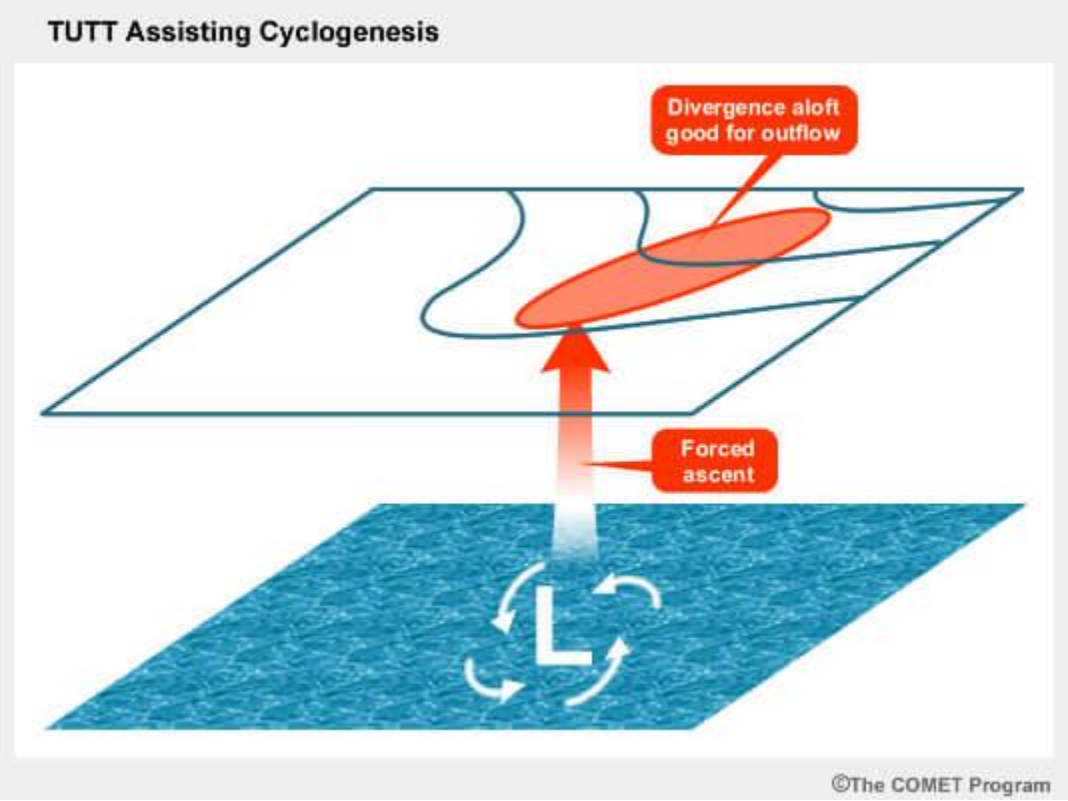
- These systems thus have shorter oceanic stay (they make landfall very quickly) and hence cannot intensify beyond the depression stage.

Upper Air Disturbance

- An **upper tropospheric cyclone** usually moves slowly from east to west and is prevalent in summer.
- Its circulations generally do not extend below 6000 m in altitude.
- The remains of this cyclone (**upper tropospheric westerly trough or tropical upper tropospheric trough**) from the westerlies move deep into the tropical latitude regions.

Troughs may be at the surface, or aloft. They may be convective (thermal origin — tropics), or frontal (dynamic origin — temperate regions).

- These troughs can assist tropical cyclogenesis and intensification by providing additional forced ascent.



Upper tropospheric westerly trough assisting convective cyclogenesis

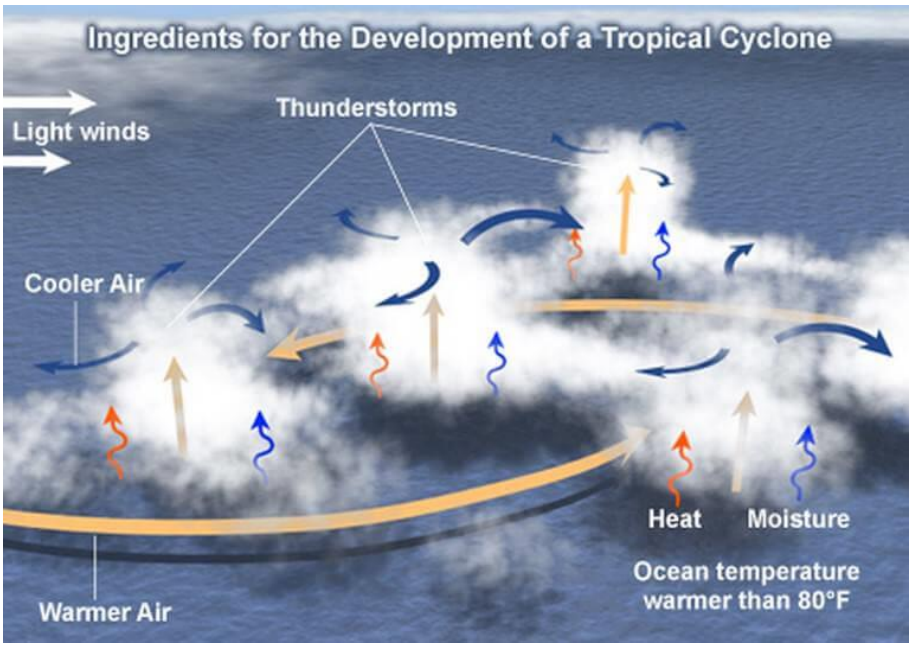
- As divergence prevails (upper tropospheric divergence) on the eastern side of the **troughs**, a rising motion occurs at the surface; this leads to the development of thunderstorms or intensification of existing storms.
- Further, these **abandoned troughs (remnants of temperate cyclones)** usually have cold cores, suggesting that the environmental lapse rate is steeper. Such instability encourages thunderstorms.
- An upper tropospheric westerly trough is important for **tropical cyclone forecasting**. This is because,

1. Fast moving upper tropospheric westerly troughs can create **large vertical wind shear** over tropical disturbances and tropical cyclones which may inhibit their strengthening.
2. Slow moving upper tropospheric westerly troughs can drive the tropical cyclones eastward or north-eastward.

Upper tropospheric trough can influence the Direction of a tropical cyclone

1.2 Convective Cyclogenesis (Development of Tropical Cyclones)

- **Cyclogenesis** is the development or strengthening of cyclonic circulation in the atmosphere.
- Cyclogenesis involves any of these three processes:
  1. **Convective cyclogenesis or tropical cyclone formation**.
  2. **Frontal cyclogenesis of extratropical cyclone formation**.
  3. **Mesocyclones forming as warm core cyclones giving rise to tornadoes and waterspouts**.
- The tropical cyclones have a **thermal origin**, and they develop over tropical seas during **late summers (August to mid-November)**.
- At these locations, under favourable conditions, **multiple thunderstorms** (strong local convectional currents) merge and create an intense **low-pressure system (low-level disturbance)**.



Multiple thunderstorms

Tropical depression (maximum sustained wind speed < 63 kmph)

- The intense low-pressure system might acquire a whirling motion because of the **Coriolis force** giving rise to a tropical depression.
- A tropical depression has sustained winds below 63 kmph.

Tropical storm (63 kmph < maximum sustained wind speed < 119 kmph)

- Tropical depression develops into a tropical storm when the cyclonic circulation becomes more organised with maximum sustained winds at or above 63 kmph but below 119 kmph.
- At this point, the distinctive cyclonic shape starts to develop, although an **eye is not usually present**.

Tropical cyclone (maximum sustained wind speed > 119 kmph)

- As the tropical storm intensifies and acquires a maximum sustained wind speed of 119 kmph it develops into a tropical cyclone.
- A cyclone of this intensity (119 kmph) **tends to develop an eye, an area of relative calm (lowest surface atmospheric pressure in a tropical cyclone) at the centre of circulation**.

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Oceanography

DOC

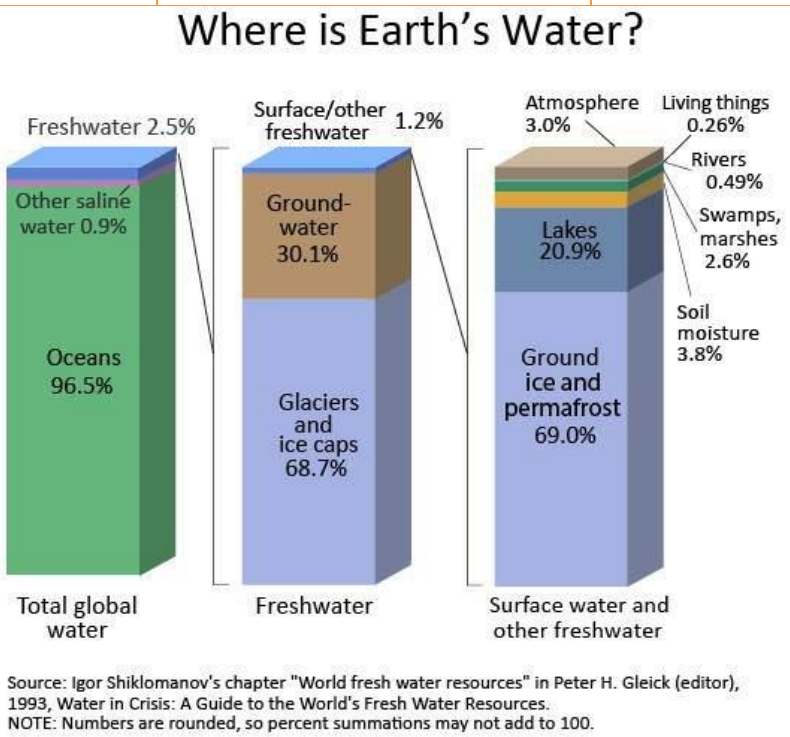
World Water Day – March 22

- Water on earth in liquid form came into existence in Hadean Eon (4,540 – 4,000 mya).
- During the Hadean Eon, temperature on earth was extremely hot, and much of the Earth was molten.
- **Volcanic outgassing** created the primordial atmosphere which consisted of various gases along with water vapour.
- Over time, the Earth cooled, causing the formation of a **solid crust**.
- The water vapour condensed to form rain and rainwater gradually filled the depressions on the newly solidified crust.
- The water in the depressions merged to give rise to mighty oceans.
- During the Hadean Eon, the atmospheric pressure was **27 times greater** than it is today and hence even at a surface temperature of close to 200° C water remained liquid in the oceans.
- Over time, both temperature and atmospheric pressure dropped, and water continues to stay as liquid in the oceans.

Water on the Earth's surface

Reservoir	Volume (Million Cubic km)	% of the Total
Oceans	**1,370**	**97.25**
Icecaps and Glaciers	**29**	**2.05**

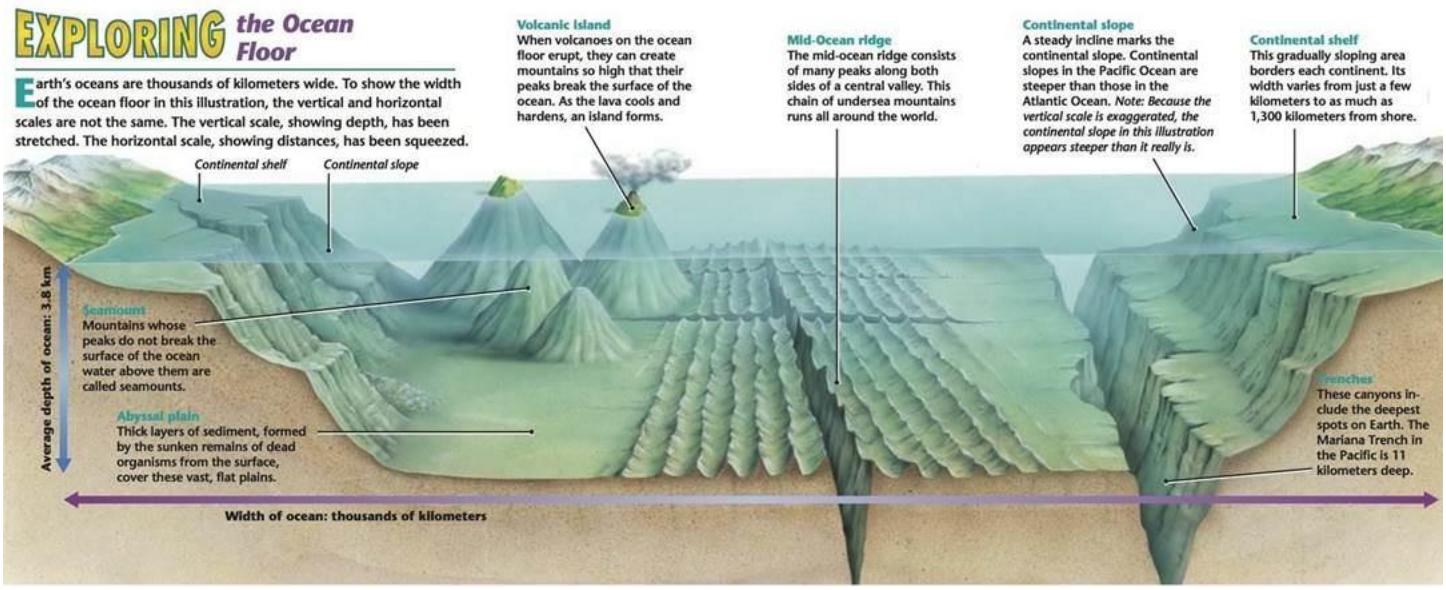
Groundwater	**9.5**	**0.68**
Lakes	**0.125**	**0.01**
Soil Moisture	**0.065**	**0.005**
Atmosphere	**0.013**	**0.001**
Streams and Rivers	**0.0017**	**0.0001**
Biosphere	**0.0006**	**0.00004**



1. Ocean Relief

- Ocean relief is largely due to **tectonic, volcanic, erosional and depositional processes and their interactions.**
- Ocean relief controls the **motion of seawater.**
- The oceanic movement in the form of currents, in turn, causes many variations in both oceans and atmosphere.
- The bottom relief of oceans also influences **navigation and fishing.**

Ocean relief features are divided into major and minor relief features:



Ocean Relief Features

1.1 Major Ocean Relief Features

Four major divisions in the ocean relief are:

1. the continental shelf,
2. the continental slope,
3. the continental rise,
4. the Deep Sea Plain or the abyssal plain.

Continental Shelf

- Continental Shelf is the gently sloping (**gradient of 1° or less**) seaward **extension of a continental plate**.
- Continental Shelves cover **7.5%** of the total area of the oceans.
- **Shallow seas** and **gulfs** are found along the continental shelves.
- The shelf typically ends at a very steep slope, called the **shelf break.**
- Examples of continental shelves: Continental Shelf of South-East Asia (Sunda Plate), Grand Banks around Newfoundland, Submerged region between Australia and New Guinea, etc.

Formation

- The shelf is formed mainly due to
    1. **submergence of a part of a continent**
    2. **relative rise in sea level**

3. **Sedimentary deposits brought down by rivers, glaciers**

- There are various types of shelves based on different sediments of terrestrial origin —
  1. **glaciated shelf (e.g. Shelf Surrounding Greenland),**
  2. **coral reef shelf (e.g. Queensland, Australia),**
  3. **shelf of a large river (e.g. Shelf around Nile Delta),**
  4. **shelf with dendritic valleys (e.g. shelf at the Mouth of Hudson River)**
  5. **shelf along young mountain ranges (e.g. Shelves between Hawaiian Islands).**

Various types of shelves

Width and depth of continental shelves

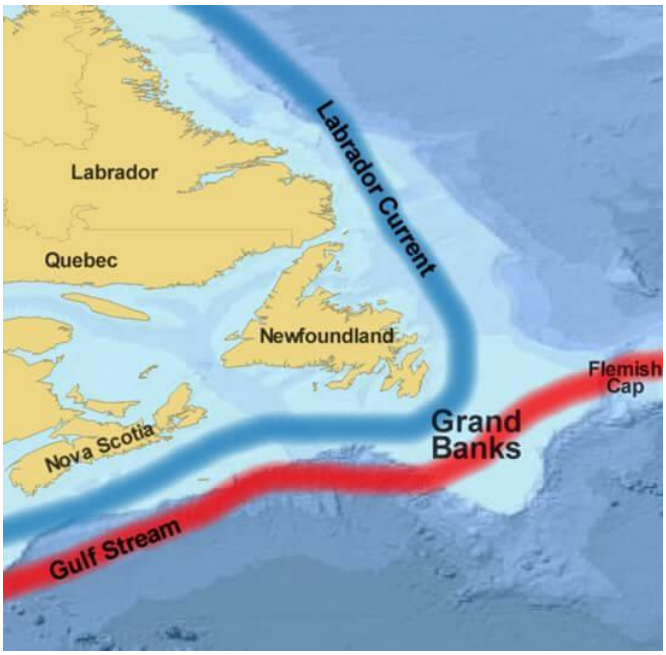
- Continental shelves have an average width of **70-80 km.**
- The shelves are almost absent or very narrow along a convergent boundary. E.g. coasts of Chile.
- The width of continental shelf of eastern coast of USA varies between 100-300 km.
- **Siberian shelf** in the Arctic Ocean is the largest in the world and stretches up to 1,500 km from the coast.

Width of various continental shelves

- Continental shelves may be as shallow as 30 m in some areas while in some areas it is as deep as 600 m.

Importance of continental shelves

- 20% of the world production of **petroleum** and gas comes from shelves.
- Continental shelves form the richest fishing grounds. E.g. Grand Banks around Newfoundland.



Grand Banks, the richest fishing grounds on earth

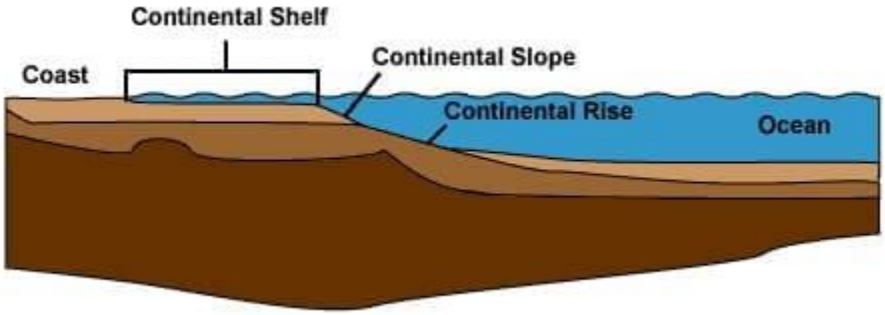
- Marine food comes almost entirely from continental shelves.
- They are sites for **placer deposits** and **phosphorites** (explained in Ocean Resources).

Continental Slope

- The gradient of the slope region varies between **2-5°.**
- The continental slope connects the continental shelf and the ocean basins.
- The depth of the slope region varies between 200 and 3,000 m.
- The seaward edge of the continental slope loses gradient at this depth and gives rise to **continental rise.**
- The **continental slope boundary indicates the end of the continents**.
- Canyons and trenches are observed in this region.

Continental Rise

- The continental slope **gradually** loses its steepness with depth.
- When the slope reaches a level of between **0.5° and 1°**, it is referred to as the continental rise.
- With increasing depth, the rise becomes virtually flat and merges with the **abyssal plain.**



Shelf, Slope and Rise (Wikipedia)

Deep Sea Plain or Abyssal Plain

- Deep sea planes are gently sloping areas of the ocean basins.
- These are the **flattest** and smoothest regions of the world because of **terrigenous** (marine sediment eroded from the land) **and shallow water sediments** that buries the irregular topography.
- It covers nearly **40%** of the ocean floor.
- The depths vary between 3,000 and 6,000 m.
- These plains are covered with fine-grained sediments like clay and silt.

1.2 Minor Ocean Relief Features

- Ridges (along a divergent boundary),
- Abyssal Hills (submerged volcanic mountains): Seamounts and Guyots,

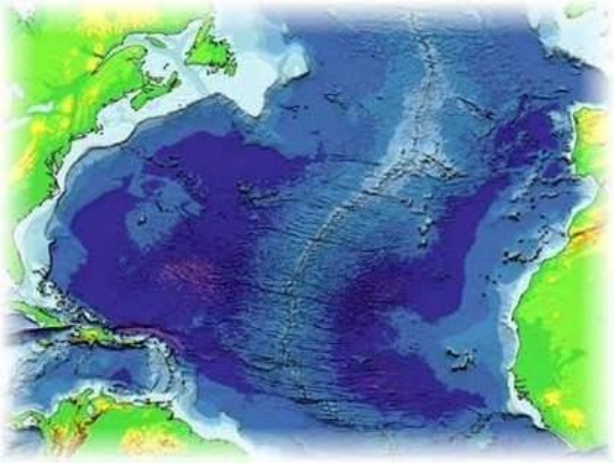
- Trenches (along a convergent boundary),
- Canyons (erosional landform),
- Island arcs (formed due to volcanism along a convergent boundary or hotspot volcanism),
- Atolls and Coral reefs.

Oceanic Deeps or Trenches

- The trenches are relatively steep-sided, narrow basins (Depressions).
- These areas are the deepest parts of the oceans.
- They are of tectonic origin and are formed during ocean-ocean convergence and ocean-continent convergence.
- They are some 3-5 km deeper than the surrounding ocean floor.
- The trenches lie **along the fringes of the deep-sea plain** at the bases of continental slopes and along island arcs.
- The trenches run **parallel to the bordering fold mountains** or the **island chains**.
- The trenches are very common in the Pacific Ocean and form an almost continuous ring along the western and eastern margins of the Pacific.
- The **Mariana Trench off the Guam Islands** in the Pacific Ocean is the deepest trench with, a depth of more than **11 kilometres.**
- Trenches are associated with **active volcanoes** and **strong earthquakes** (like in Japan).
- Majority of the trenches are in the Pacific Ocean followed by the Atlantic Ocean and Indian Ocean.

Mid-Oceanic Ridges or Submarine Ridges

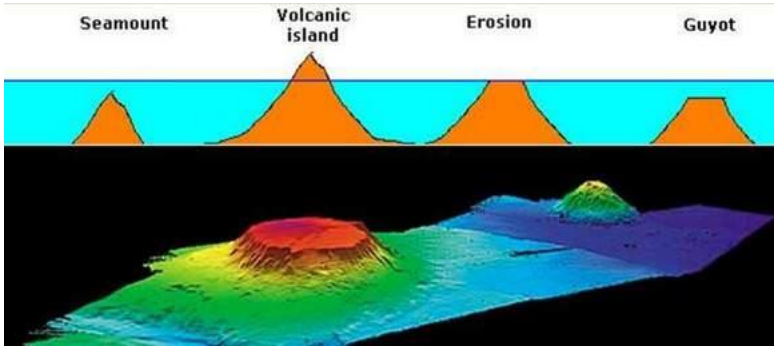
- A mid-oceanic ridge is composed of two chains of mountains separated by a large depression (divergent boundary).
- The mountain ranges can have peaks as high as 2,500 m and some even reach above the ocean's surface.
- Running for a total length of **75,000 km**, these ridges form the **largest mountain systems on earth.**



Mid Ocean Ridge

- The ridges are either broad, like a plateau, gently sloping or in the form of steep-sided narrow mountains.

Abyssal Hills



Abyssal Hills

- **Seamount:** It is a mountain with pointed summits, rising from the seafloor that **does not reach the surface** of the ocean. Seamounts are volcanic in origin. These can be 3,000-4,500 m tall.
- The **Emperor seamount**, an extension of the **Hawaiian Islands** in the Pacific Ocean, is a good example.
- **Guyots:** The flat-topped mountains (seamounts) are known as guyots.
- Seamounts and guyots are very common in the Pacific Ocean.

Submarine Canyons

Canyon: a deep gorge, especially one with a river flowing through it.

Gorge: a steep, narrow valley or ravine.

Valley: a low area between hills or mountains typically with a river or stream flowing through it.

Canyon, George, Valley

- Submarine canyons are deep valleys often extending from the mouths of the rivers to the abyssal plains.
- They are formed due to erosion by sediments brought down by rivers that cut across continental shelves, slopes and rises. The sediments are deposited on the abyssal plains.
- Submarine canyons can be far higher in scale compared to those that occur on land.

Submarine Canyon

Broadly, there are three types of submarine canyons:

- Small gorges which begin at the edge of the continental shelf and extend down the slope to very great depths, e.g., **Oceanographer Canyons** near New England.
- Those which begin at the mouth of a river and extend over the shelf, such as the **Indus canyons**.
- Those which have a dendritic appearance and are deeply cut into the edge of the shelf and the slope, like the canyons off the coast of southern California.
- The **Hudson Canyon** is the best-known canyon in the world.
- The largest canyons in the world occur in the **Bering Sea** off Alaska.

Atoll

- These are low islands found in the tropical oceans consisting of coral reefs surrounding a central depression.

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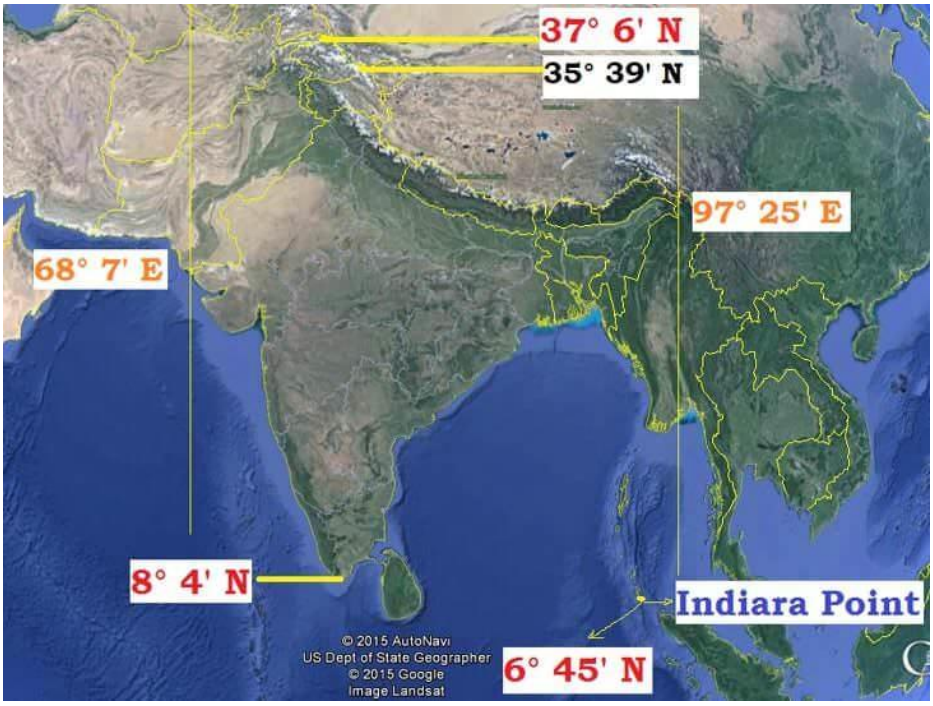
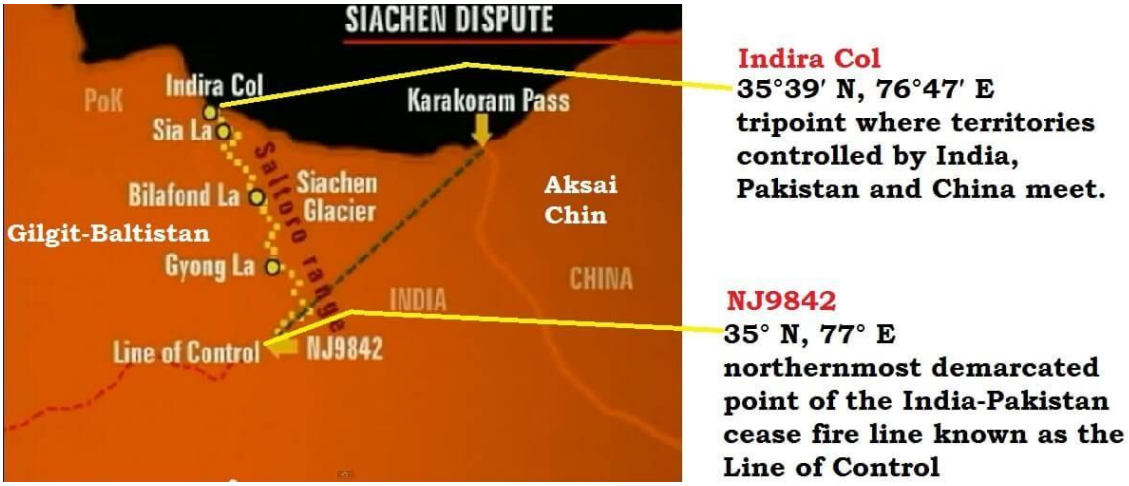
1. India as a Geographical Unit



Locational Extent of India

East-West Extent (~30°)	**68° 7' East to 97° 25' East longitude**
South-North Extent of mainland India (Including POK) (~29°)	**8° 4' North to 37° 6' North latitude**
South-North Extent of India (Including POK and the Andaman and Nicobar Islands) (~31°)	**6° 45' North to 37° 6' North latitude**

Map of Jammu and Kashmir showing the occupied regions



Location: Indira Col and NJ9842

- The southernmost point of the country is the **Pygmalion Point, or Indira Point** is located at **6° 45' N latitude**.
- North-south extent from **Indira Col** in Kashmir to Kanyakumari is **3,214 km**.
- East-west width from the Rann of Kutch to Arunachal Pradesh is **2,933 km**.
- With an area of **32,87,263 km^2**, India is the **seventh largest** country in the world.
- India accounts for about **2.4 per cent** of the total surface area of the world.

Top 10 Largest Countries in the World by Area

Rank	Country	Capital City	Continent	Area (km^2)
1	Russia	Moscow	Europe	1,70,98,242
2	Canada	Ottawa	North America	99,84,670
3	USA	Washington DC	North America	98,26,675
4	China	Beijing	Asia	95,96,961
5	Brazil	Brasilia	South America	85,14,877
6	Australia	Canberra	Oceania	77,41,220
7	**India**	**New Delhi**	**Asia**	**32,87,263**
8	Argentina	Buenos Aires	South America	27,80,400
9	Kazakhstan	Astana	Asia	27,24,900
10	Algeria	Algiers	Africa	23,81,741

- The Tropic of Cancer passes through the middle of the country dividing it into two latitudinal halves.
- The area to the north of Tropic of Cancer is **near twice** the area which lies to the south of it.
- South of 22° north latitude, the country tapers off over 800 km into the Indian Ocean as a peninsula.

- East-West time difference is nearly **2 hrs**. (A difference of 1° longitude will make a difference of 4 minutes in time. ~30 x 4 = ~120 minutes or ~2 hours).

India, Tropical or Temperate Country?

- The temperate part (north of Tropic of Cancer) is twice the area of the tropical part.
- But India has always been treated as a tropical country for two different reasons – physical and cultural.

Physical Geographical (Climatic) Reasons

- The country is separated from the rest of Asia by the Himalayas.
- The tropical monsoons dominate its climate.
- Himalayas blocks the cold temperate air masses.
- Although winter night temperatures are low, yet clear skies and intense insolation raise the day temperatures to a tropical level.

Cultural Geographical Reasons

- Settlements, diseases, agricultural and primary economic activities are all tropical in nature.

It is primarily because of the Himalayas that India is a predominantly tropical country.

1.2 India's Frontiers

Data from the **Ministry of Home Affairs (Department of Border Management)**

- India has **15106.7 Km** of land border running through **17 States**.
- Indian has a coastline of **7516.6 Km (6100 km of mainland coastline + coastline of 1197 Indian islands)** touching 13 States and Union Territories (UTs).
- Barring Telangana, Madhya Pradesh, Chhattisgarh, Jharkhand, Delhi and Haryana, all other States in the country have one or more international borders or a coastline and can be regarded as **frontline States** from the point of view of border management.
- India's **longest border** is with **Bangladesh** while the shortest border is with Afghanistan.
- The length of India's land borders with neighbouring countries is given in the table below.

Neighbour	Length of the border (in Km)
1) Bangladesh	4,096.7

2) China	**3,488**
3) Pakistan	**3,323**
4) Nepal	1,751
5) Myanmar	1,643
6) Bhutan	699
7) Afghanistan	106
	15,106.7

Border with China

- This is the **second longest border of India**, next only to its border with Bangladesh.
- Five Indian states, namely Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh touch the Indian boundary with China.
- The Sino-Indian border is generally divided into three sectors namely: (i) the Western sector, (ii) the Middle sector, and (iii) the Eastern sector.

The Western Sector

- Separates Jammu and Kashmir state of India from the Xinjiang province of China.
- The western sector boundary is largely the outcome of the British policy towards the state of Jammu and Kashmir.
- China claims the **Aksai Chin, the Changmo valley, Pangong Tso and the Sponggar Tso area of north-east Ladakh**.
- China also claims a part of **Huza-Gilgit** area in **North Kashmir** (**ceded to it in 1963 by Pakistan**).

The Middle Sector

- Two Indian states of Himachal Pradesh and Uttarakhand touch this border.

The Eastern Sector

- The 1,140 km long boundary between India and China runs from the eastern limit of Bhutan to a point near **Diphu pass (Talu-Pass)** at the **tri-junction of India, Tibet and Myanmar**.

Diphu Pass *is a mountain pass around the area of the disputed tri-point borders of India, China, and Myanmar. It is* ***Talu pass*** *on the Burmese side, and* ***Diphu pass*** *on the Indian (Tibetan) side.*

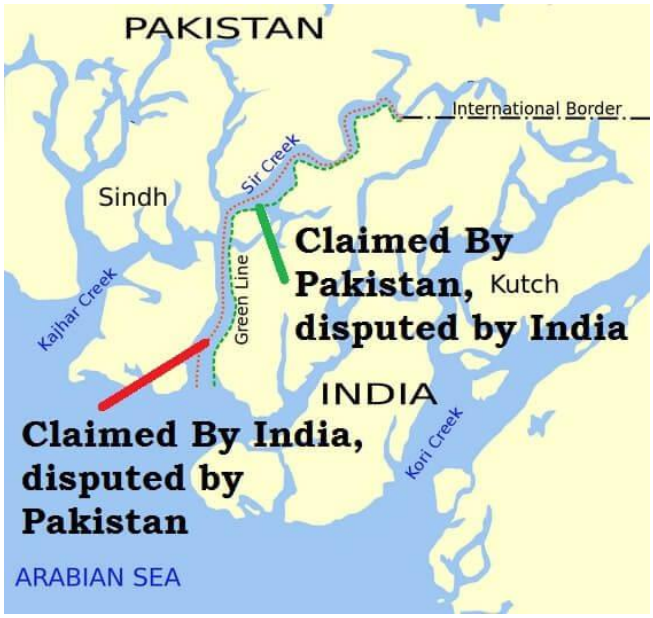
- This line is usually referred to as the **Mc Mahon Line** after Sir Henry Mc Mahon, then foreign secretary of British India, who negotiated the boundary agreement between Great Britain and Tibet at **Shimla accord in 1913-14**.

The India-Nepal Boundary

- Five states of India, namely Uttarakhand, Uttar Pradesh, Bihar, West Bengal and Sikkim touch the Nepalese border with India.
- The border is a **porous** one with an unrestricted movement of goods and people between Indian and Nepal.
- Major portion of Indo-Nepalese border runs in the east-west direction almost along the foothill of the **Shiwalik Range**.

The Indo-Pakistan Boundary

- The Indo-Pakistan boundary is the result of the partition of the country in 1947 under the **Radcliffe award** of which Sir Cyril Radcliffe was the chairman.
- Jammu and Kashmir, **Sir Creek** are the major disputed regions.



Creeks in the Kutch Region

The India-Bangladesh Border

- India's 4,096 km long border with Bangladesh is the **longest**.

- This boundary has been determined under the **Radcliffe Award** which divided the erstwhile province of Bengal into two parts.

India-Myanmar Boundary

- This boundary runs roughly along the watershed between the Brahmaputra and Irrawaddy rivers.
- It passes through thickly forested regions, with Mizo Hills, Manipur and Nagaland on the Indian side and Chin Hills, Naga Hills and Kachin state on the Myanmar side.

India-Sri Lanka Boundary

- India and Sri Lanka are separated from each other by a narrow and shallow sea called **Palk Strait**.
- **Dhanushkodi** on the Tamil Nadu coast in India is only 32 km away from Talaimanar in Jaffna peninsula in Sri Lanka. These two points are joined by a group of islets forming **Rama Setu (Adam's Bridge)**.

1.3 Major Physical Divisions of India

1. **The Himalayas (young fold mountains),**
2. **Indo-Gangetic Plain (monotonous topography – featureless topography),**
3. **The Peninsular Plateau (one of the most stable landmasses; one of the oldest plateaus of the world),**
4. **Coastal Plains (sedimentation due to fluvial action).**
5. **The Indian Islands (Coral Islands ➔ coral reef built up on atolls. E.g. Lakshadweep Islands. Tectonic ➔ Andaman and Nicobar Islands – Interaction between the Indian Plate and Eurasian plate).**

Economic Geography for General Studies UPSC Civil Services Exam

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Economic Geography Part I

Distribution of key natural resources across India and the World

PDF

Source for most of the facts and statistics: Indian Bureau of Mines Reports.

Economic Geography

- Economic geography is the study of patterns of humans' economic activities ranging from production to consumption of various goods and services across the world.
- By 'human economic activities' we mean, production, location, distribution, consumption, exchange of resources, spatial organization of economic activities, etc.
- Different subject matters of economic geography include the distribution of mineral resources, location of industries, economies of agglomeration (economies of urbanization), transportation, international trade, the relationship between the environment and the economy, etc.

1. Iron

1.2 Types of Iron Ore

- Based on the amount of ore and iron content, iron ore is classified into various types.
- Magnetite (Fe_3O_4) and Haematite (Fe_2O_3) are fine quality ores.
- Limonite, siderite, etc. are inferior ores that have their own unique characteristics.

Magnetite (Fe_3O_4)

- Magnetite has excellent **magnetic qualities**, hence the name.
- It is black in colour and has **very high content of Iron – upto 72 per cent (best quality iron ore)**.
- Magnetite has higher iron content than hematite (60-70 per cent); therefore, its **quality is higher**.
- However, unlike haematite ore, magnetite ore is **not found in high grades**.
- That is, while hematite ore generally contains large concentrations of hematite, magnetite ore generally holds low concentrations of magnetite.
- Hence the ore needs to be **beneficiated** (treat to improve its properties) for magnetite recovery.
- End products (e.g. steel) made from magnetite ore are typically of **higher quality** than those made from hematite ore. That's because **magnetite has fewer impurities than hematite**.
- Magnetite with less iron content (25% to 30%) is known as **Taconite**.
- A naturally magnetized content of magnetite is called **lodestone**.
- Distribution of magnetite ore in India: Dharwad and Cuddapah systems – **Karnataka (73%), Andhra Pradesh (14%), Tamil Nadu (5%), Rajasthan (5%)**, etc.

Haematite (Fe_2O_3)

- Reddish ore with naturally high iron content – **60 to 70 per cent**.
- Because of its high iron content, hematite ore can be used in steel production **without benefaction**.
- Hematite is the most abundantly available ore in India.
- Distribution: **Odisha, Jharkhand, Chhattisgarh, Andhra Pradesh, Karnataka, Maharashtra and Goa**.

Limonite

- Limonite is inferior iron ore that is yellowish in colour with **40 to 60 per cent iron content**.
- Limonite mines are **open cast mines**; hence mining is **easy and cheap**.

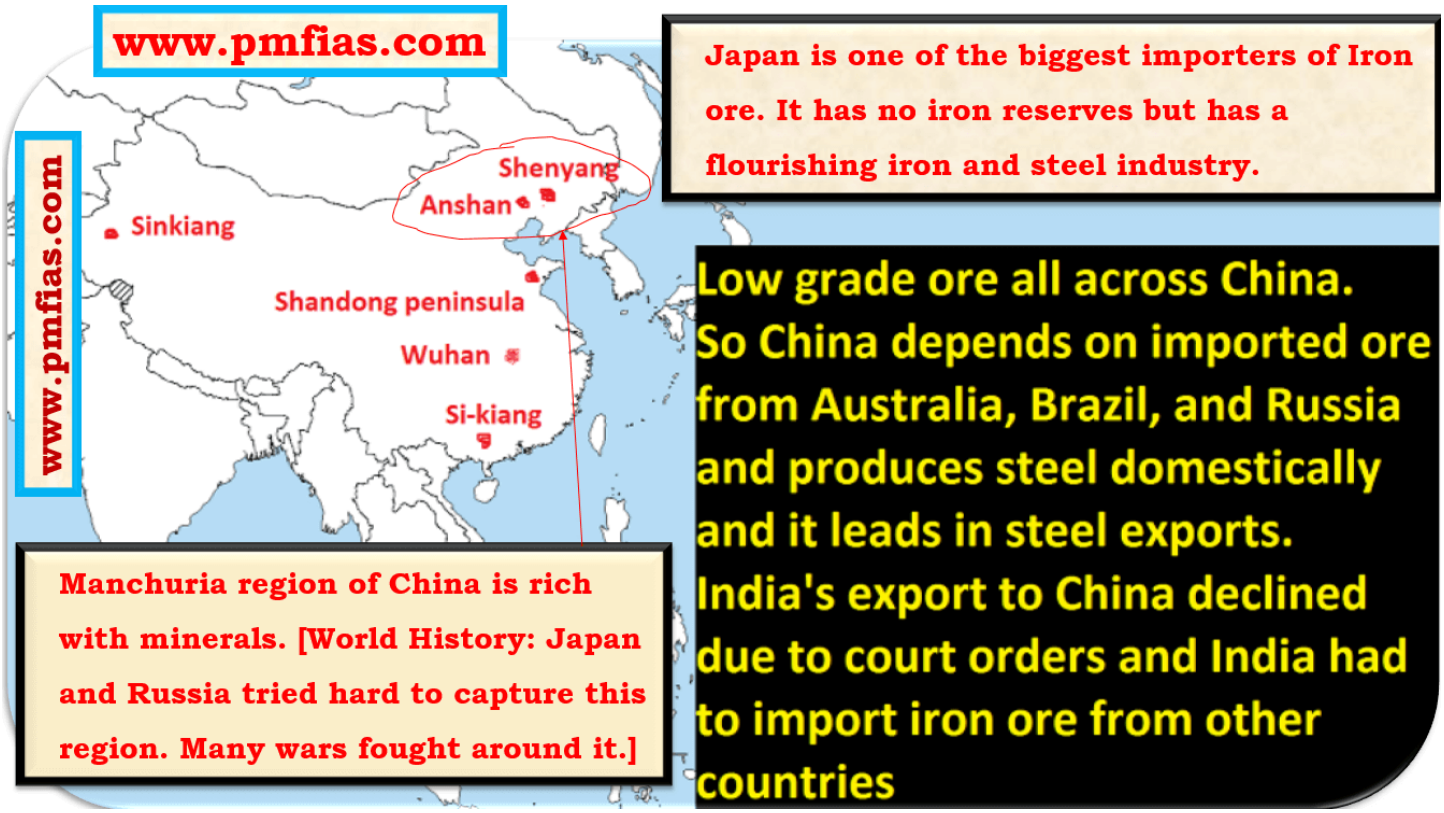
- Distribution: **Damuda series in Raniganj coal field**, Garhwal in Uttarakhand, Mirzapur in Uttar Pradesh and Kangra valley of Himachal Pradesh.

Siderite ($FeCO_3$)

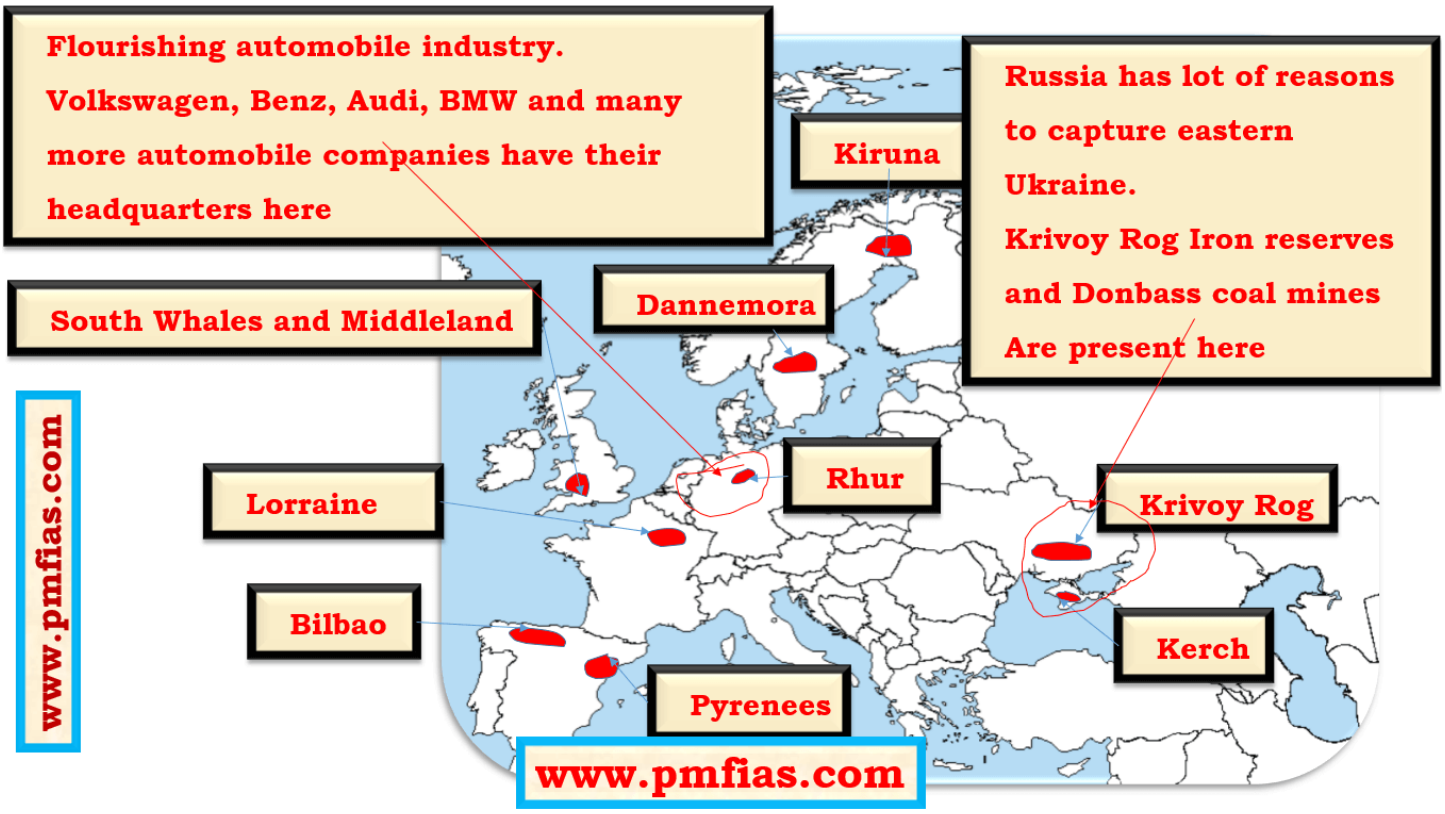
- It is **iron carbonate ore** of inferior quality with **less than 40 per cent iron content**.
- It contains many impurities and hence mining, in many places, is economically unviable.
- However, one good quality of the ore is that it doesn't contain sulphur or phosphorus.
- And also, it is **self-fluxing** due to the presence of lime.

1.3 Iron Ore Distribution Across the World

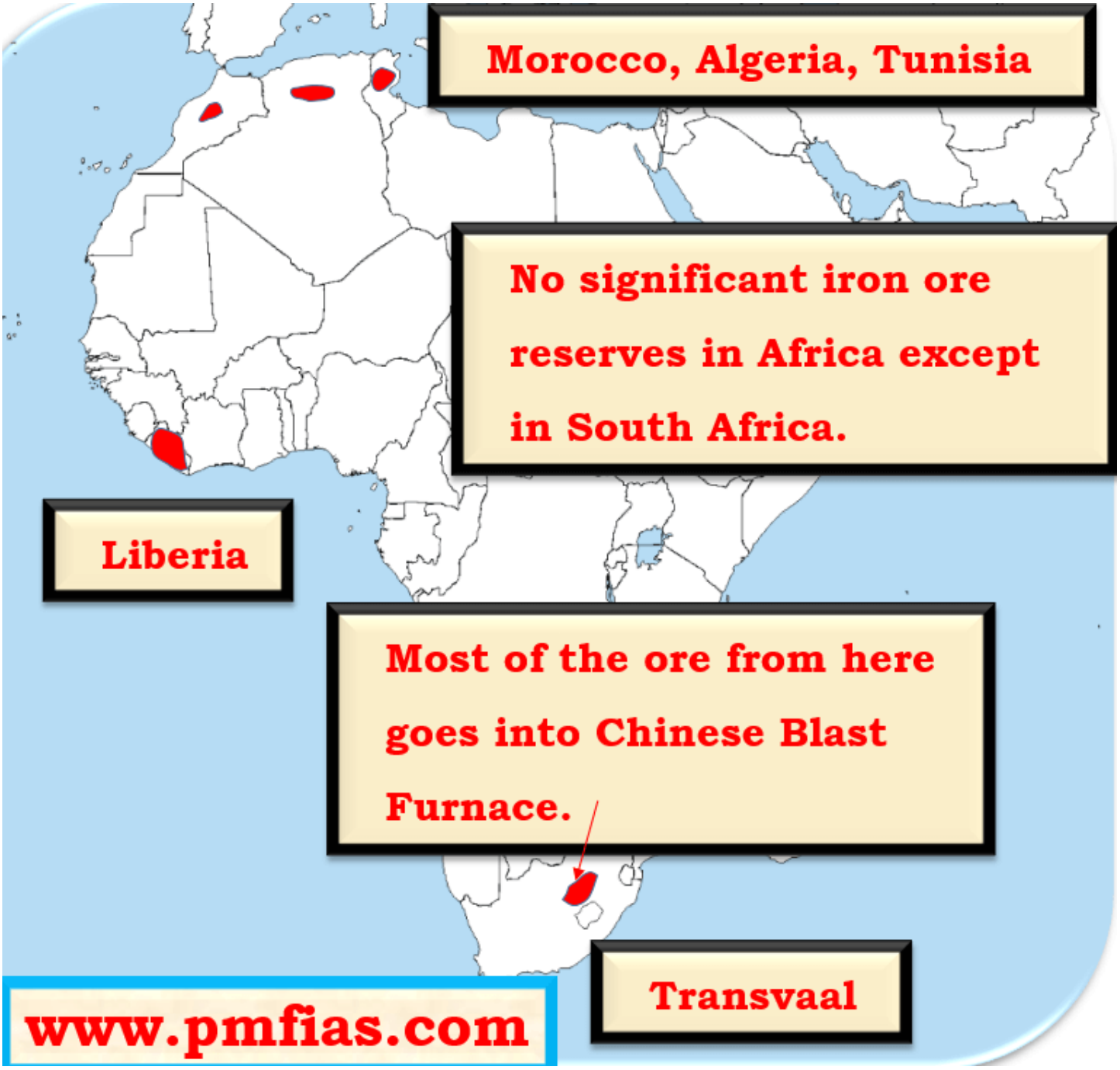
Iron Ore in China: Manchuria, Sinkiang, Si-kiang, Shandog Peninsula



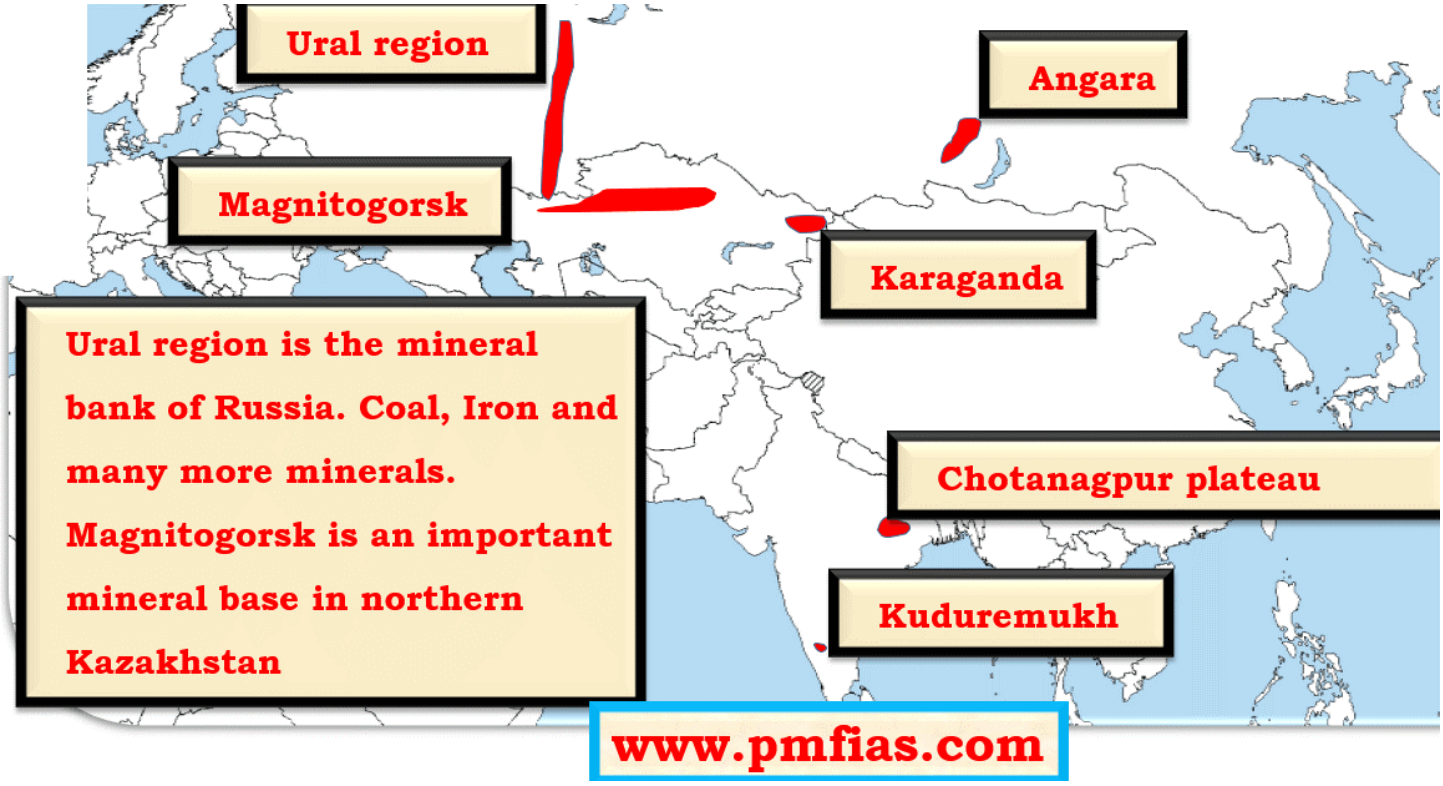
Iron Ore in Europe: Ruhr, South Whales, Krivoy Rog, Bilbao, Lorraine



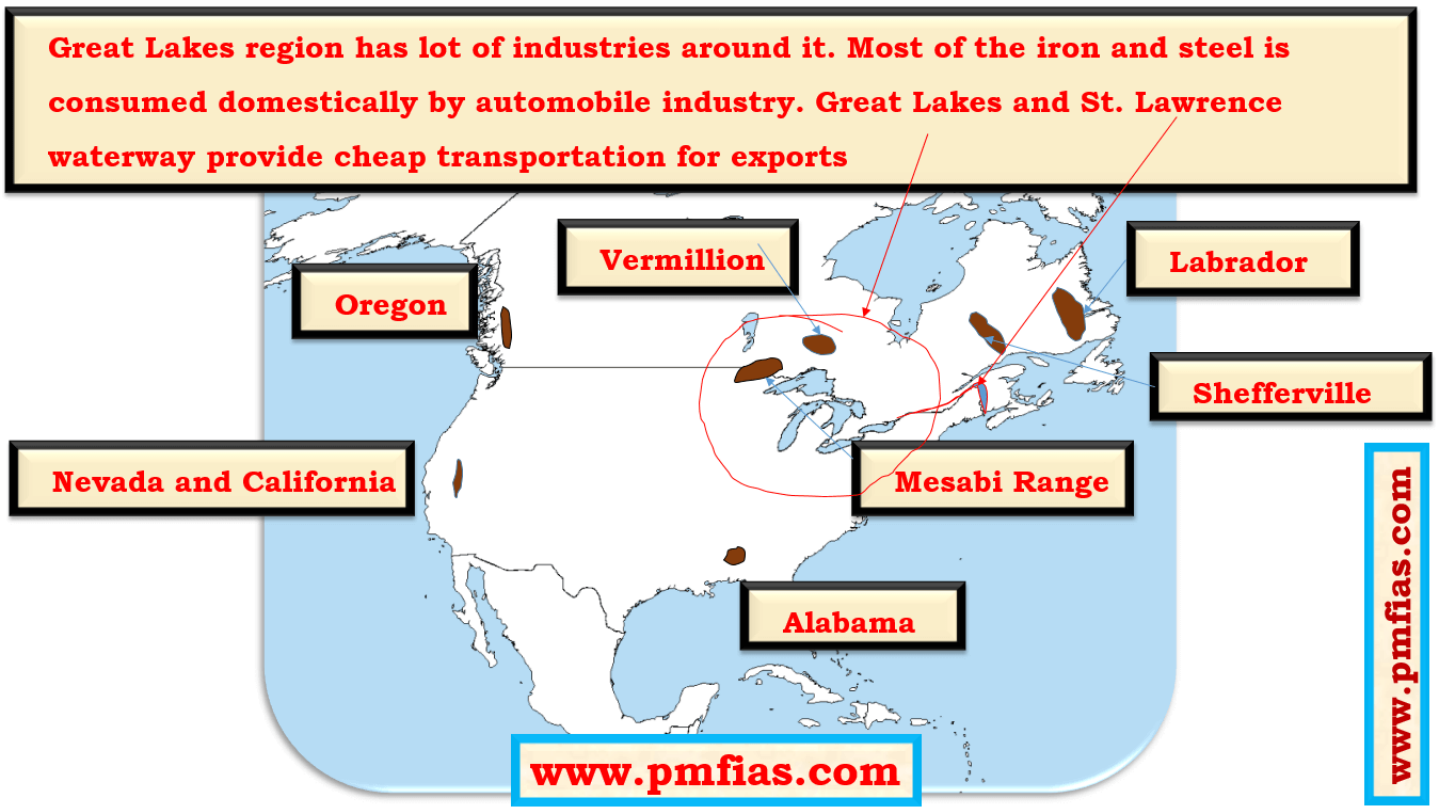
Iron ore in Africa: Transvaal, Liberia



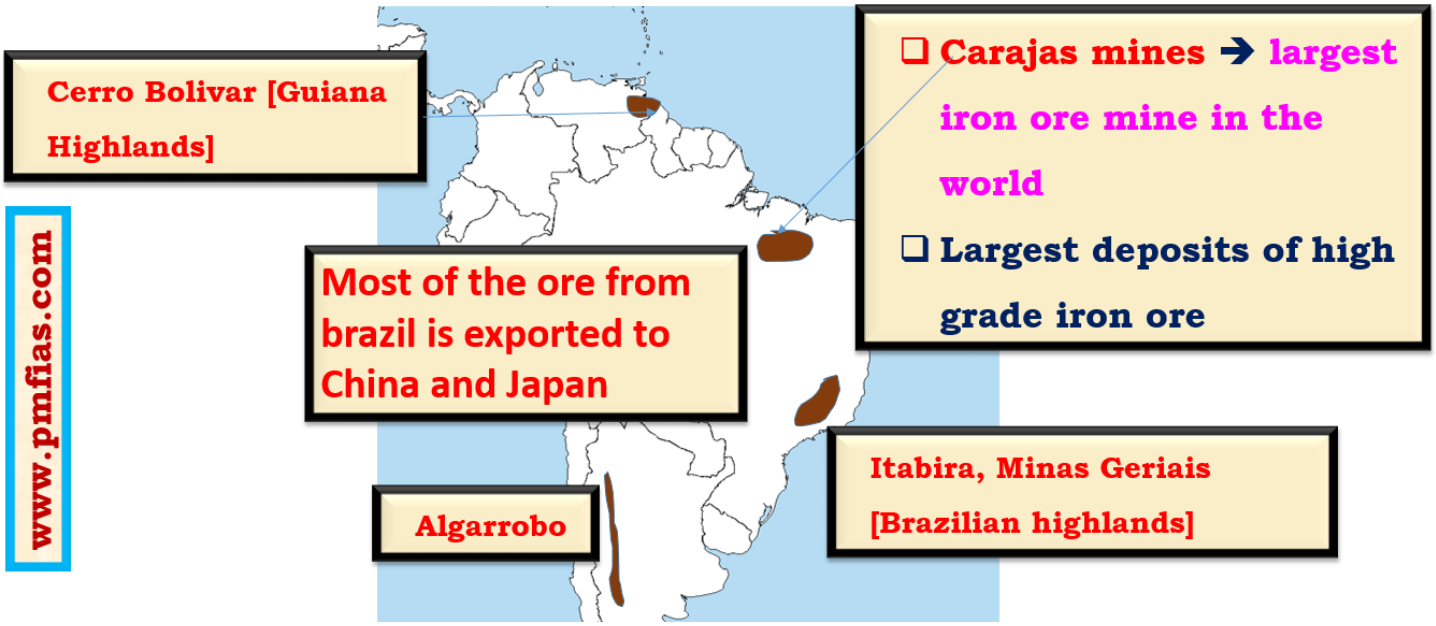
Iron ore in Russia, Kazakhstan: Ural region, Magnitogorsk



Iron Ore in North America: Great Lakes (Mesabi Region), Labrador

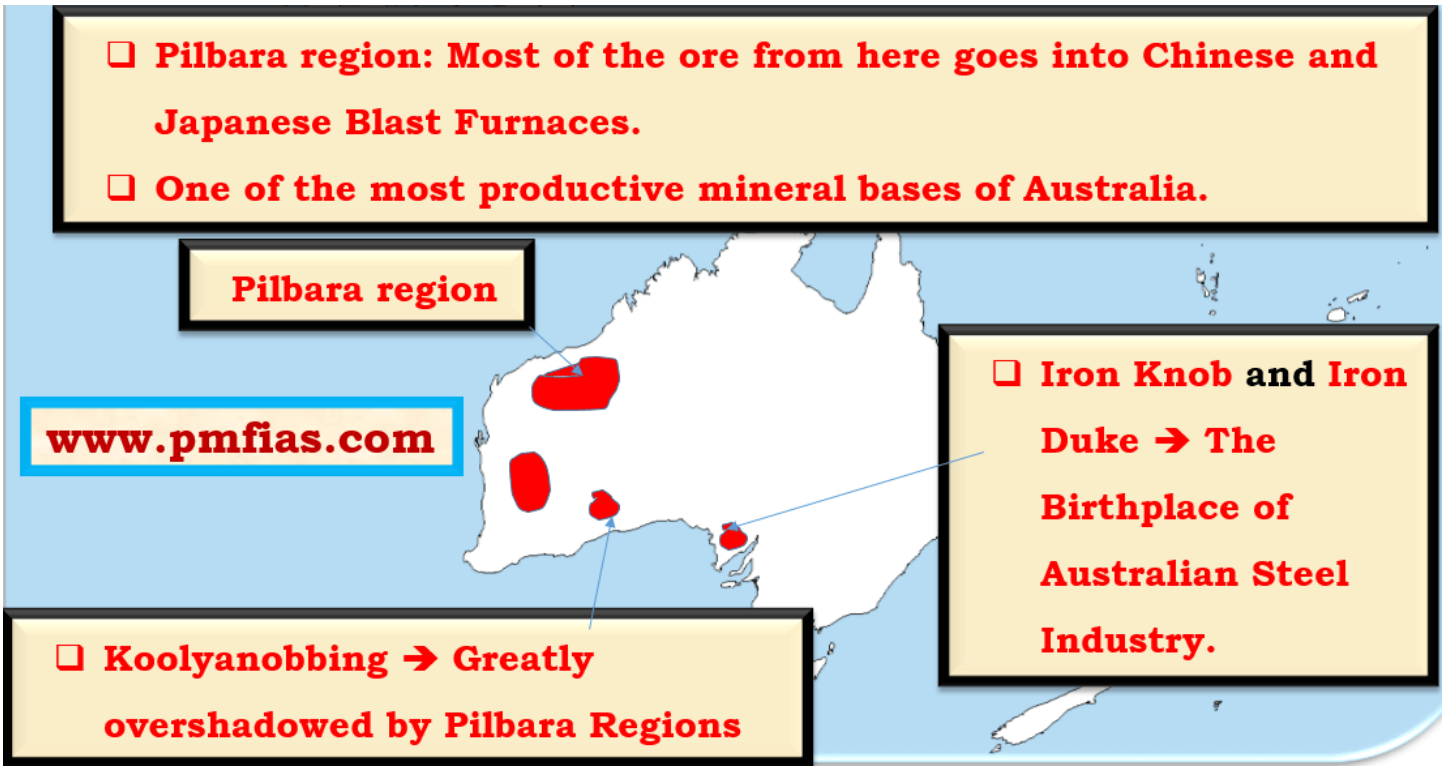


Iron Ore in South America: Carajas, Itabira, Minas Geriais



- Brazil has one of the largest reserves of high grade hematite ore.

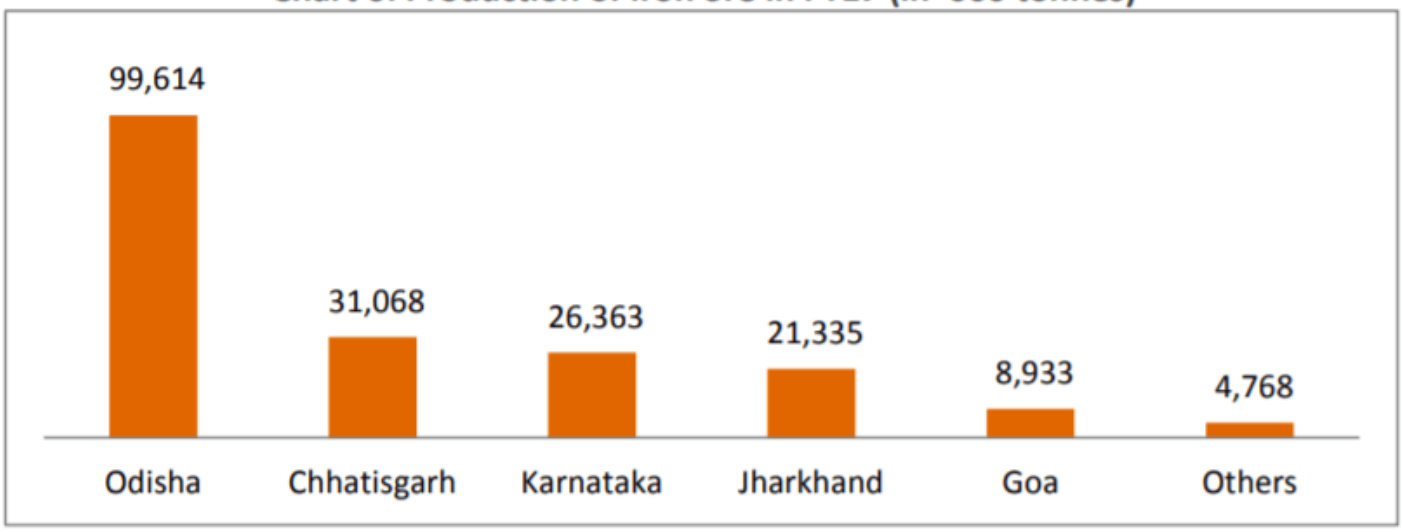
Iron Ore in Australia: Pilbara Region, Koolyanobbing, Iron Duke, Iron Knob



Largest iron ore producers

Country	Iron Ore Production
1. Australia	900 Million tonnes – most of the ore is exported to China.

Chart 6: Production of iron ore in FY17 (in '000 tonnes)



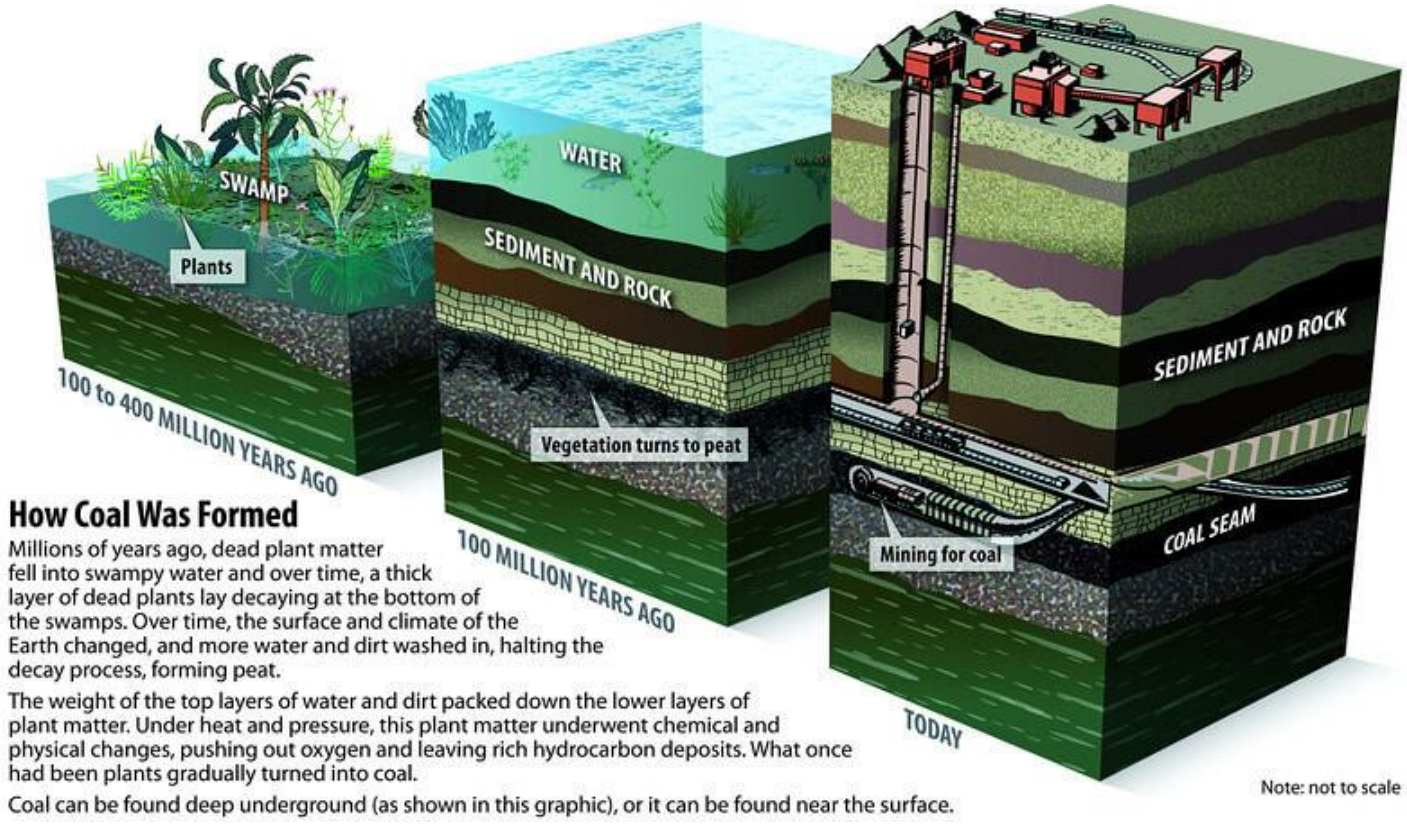
Others include: Andhra Pradesh, Madhya Pradesh, Maharashtra and Rajasthan
Source: CMIE

- The total iron ore production in India in FY17 stood at ~192mn tonnes.
- Indian exports of iron ore stood at 24.1 mn tonnes and imports were 8.7 mn tonnes in FY18.
- Sale of iron ore from Karnataka mines had fallen sharply with domestic steel producers buying the ore from Chhattisgarh and Odisha due to better quality at cheaper price.

2. Coal

- Coal is also called **black gold**. It is found in sedimentary strata (layers).
- Coal contains **carbon, volatile matter, moisture** and **ash** (in some cases **Sulphur** and **phosphorous**).

2.1 Formation of Coal



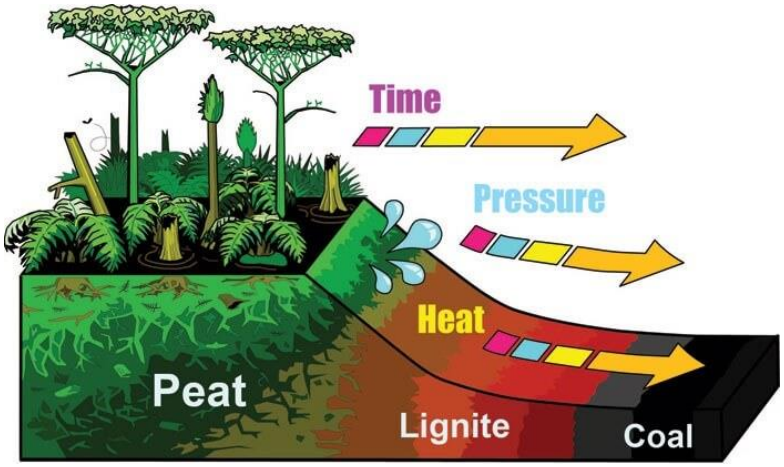
How Coal Was Formed

Millions of years ago, dead plant matter fell into swampy water and over time, a thick layer of dead plants lay decaying at the bottom of the swamps. Over time, the surface and climate of the Earth changed, and more water and dirt washed in, halting the decay process, forming peat.

The weight of the top layers of water and dirt packed down the lower layers of plant matter. Under heat and pressure, this plant matter underwent chemical and physical changes, pushing out oxygen and leaving rich hydrocarbon deposits. What once had been plants gradually turned into coal.

Coal can be found deep underground (as shown in this graphic), or it can be found near the surface.

- Most of the world's coal was formed in **Carboniferous age (350 million years ago – Best quality coal).**
- The name Carboniferous refers to coal-bearing strata.
- Coal formed millions of years ago when the earth was covered with huge swampy (marshy) forests.
- As the plants grew, some died and fell into the swamp waters.
- New plants grew up to take their places and when these died still more grew.
- In time, there was thick layer of dead plants rotting in the swamp.
- The surface of the earth changed, and water and dirt washed in, **stopping the decaying process**.
- More plants grew up, but they too died and fell, forming separate layers.
- After millions of years many layers had formed, one on top of the other.
- The weight of the top layers and the water and dirt packed down the lower layers of plant matter.
- Heat and pressure produced chemical and physical changes in the plant layers which **forced out oxygen and left rich carbon deposits**. In time, material that had been plants became coal.

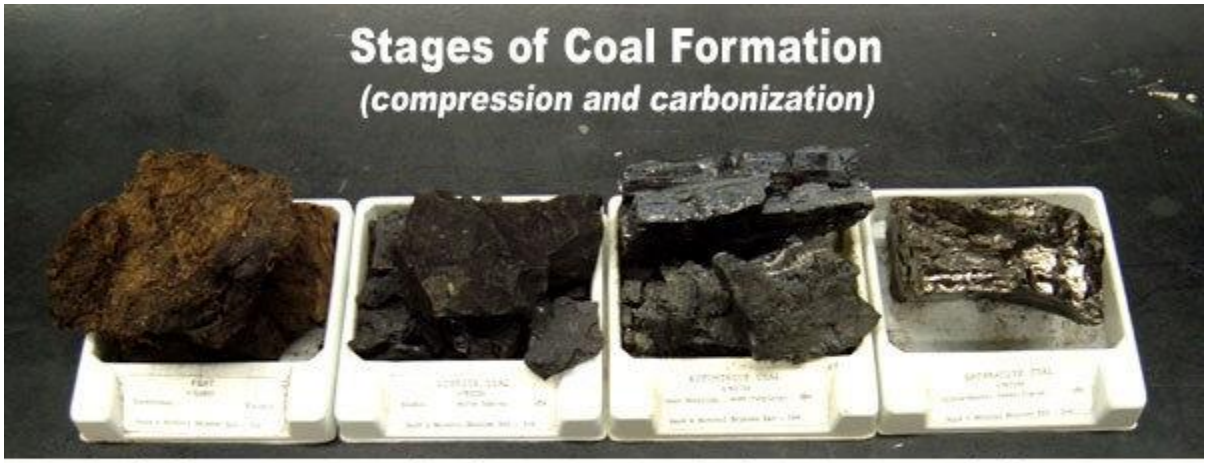


Older the coal, better the carbon content

- Capacity of coal to give energy depends upon the percentage or carbon content (**Older the coal, higher the carbon content**).
- Percentage of carbon in coal depends upon the duration and intensity of heat and pressure on wood (**More depth == more pressure and heat == better carbon content**).
- **Oxygen, nitrogen and moisture content decreases** with time while the **proportion of carbon increases** (The quantity of carbon doesn't increase, only its proportion increases due to the loss of other elements).

Stages of coal formation

- In the process of transformation (coalification),
  1. ***Buried plants turn into peat,***
  2. ***Peat is altered to lignite,***
  3. ***lignite is altered to sub-bituminous,***
  4. ***sub-bituminous coal is altered to bituminous coal, and***
  5. ***bituminous coal is altered to anthracite (oldest, best quality coal)***.



2.2 Classification of coal

- Coals are classified into **peat, lignite, bituminous coal, and anthracite.**
- These classifications are based on the **amount of carbon, oxygen, and hydrogen present in the coal.**
- Coal's other constituents include **hydrogen, oxygen, nitrogen, ash, and sulphur.**
- Some of the undesirable chemical constituents include **chlorine and sodium**.

Peat

- Contains **less than 40 to 55 per cent carbon (has more impurities)**.
- Contains sufficient volatile matter and **lots of moisture** (gives out a lot of smoke when burnt ➔ **pollution**).
- Left to itself, it burns like **wood**, gives less heat, **emits more smoke** and **leaves a lot of ash**.

Lignite (brown coal)

- Contains **40 to 55 per cent carbon.**
- Moisture content is high (over 35 per cent).
- It undergoes **spontaneous combustion** (this is undesirable because it creates **fire accidents in mines**).
- Distribution: Rajasthan, Lakhimpur (Assam), and Tamil Nadu.

Bituminous Coal (black coal)

- Bituminous Coal is soft, dense, compact coal with **40 to 80 per cent carbon**.
- Bituminous Coal is the **most widely available and used coal**.
- It derives its name after a liquid called **bitumen.**
- Moisture and volatile content are low (15 to 40 per cent).
- **It does not have traces of original vegetable material.**
- Calorific value is **very high** due to high proportion of carbon and low moisture.
- It is used in the production of **coke and gas**.
- Distribution: Jharkhand, Odisha, West Bengal, Chhattisgarh and Madhya Pradesh.

Anthracite Coal (Semi-metallic lustre)

- **Anthracite coal is the best quality**, hard coal with **80 to 95 per cent carbon**.
- It has very little moisture and volatile matter.
- It **ignites slowly** and hence there is less loss of heat (highly efficient).
- It burns with a short **blue flame (Complete combustion ➔ Flame is blue ➔ very few pollutants)**.
- In India, it is found only in **Jammu and Kashmir** and that too in small quantity.

Coking Coal vs. Non-Coking Coal (Thermal Coal)

Coking Coal or Metallurgical Coal	Thermal Coal or Non-Coking Coal or Steaming coal
• High carbon content, less moisture, **less sulphur**, less ash.	• **Sulphur content is high and hence cannot be used in iron and steel industry**. **(Sulphur reacts with iron to from iron sulphide (FeS)**. Iron sulphide is brittle (hard but easily breakable) and makes the whole metal and its alloys brittle.)
• Used to create **coke.** • Coke is produced by heating bituminous coal without air to extremely high temperatures. • **Coking** ➔ flushing out impurities and improving the concentration of carbon.	• Creating coke using this coal is not economical. • Moreover, traces of sulphur will remain even after coking.
• Coking coal is an essential ingredient in steel production.	• Thermal coal is used to **generate power.**

• Major producers: Australia, Canada, United States. • Major exporters: Australia, Canada, United States. • China imports huge amount of coking coal from Australia. • India also imports coking coal.	• Major producers: China, Australia, USA, Russia. • Major exporters: Australia, South Africa.

2.3 Distribution of Coal in India

- Coal reserves are six times greater than oil and petroleum reserves.
- In India, during the year 2016-17, about 82% coal and lignite got despatched to the Power Sector.

Gondwana Coal (formed 250 million years ago)

- Around 98 per cent of India's coal reserves and 99% of total coal production are from Gondwana fields.
- The carbon content in Gondwana coal **(250 million years old)** is less compared to the Carboniferous coal **(350 million years old – almost absent in India)** because of its much younger age.
- The volatile compounds and ash (~ 30%) don't allow carbon percentage to rise above **60%.** (It requires a few million years more for the quality has to get better).
- Gondwana coal is **free from moisture**, but it contains **Sulphur** and **phosphorus.**
- Coking as well as non-coking coal and bituminous coal are obtained from Gondwana coal fields.
- **Anthracite** is **generally not found** in the Gondwana coal fields.
- The **Damuda series (i.e. Lower Gondwana)** possesses the best worked coalfields accounting for 80 per cent of the total coal production in India.
- Gondwana coal occur in the valleys of certain rivers viz., the **Damodar (Jharkhand-West Bengal)**; the **Mahanadi (Chhattisgarh-Odisha)**; the **Son (Madhya Pradesh Jharkhand)**; the **Godavari and the Wardha (Maharashtra-Andhra Pradesh)**.

Jharkhand	• Most of the coal fields in the state of Jharkhand are located in a narrow belt running in the east-west direction almost along 24 degrees north latitude. • The main coal fields at **Bokaro, Jharia**, **Deltenganj, Dhanbad**, **Auranga (Palamu), Giridh, Karanpura, Ramgarh, Hutar, Devgarh and Rajmahal coalfields**. • **Jharia coalfield** is one of the oldest and richest coal fields of India. • It stores the **best of metallurgical coal (bituminous coking coal)** in the country.

	• Bokaro coalfield lies in Hazaribagh district. It is a long but narrow strip in the catchment area of the Bokaro river. • **Girdih (Karharbari) coalfield** gives out of the finest coking coal in India. **Coking Coal Production by State** **1) Jharkhand (More than 90% of India's Coking coal comes from Jharkhand)** 2) West Bengal 3) Madhya Pradesh
Odisha	• Most of the coal deposits of the state are found in **Sambalpur, Dhenkanal, and Sundargarh districts**. • **Talchar coalfield** of Odisha stretch over Dhenkanal and Sambalpur districts covers an area of about 500 sq km. • **Talcher field ranks second in reserves** after **Raniganj**. • Coal from this field is most suitable for steam and gas production. • Most of the coal is utilised in **thermal power and fertilizer plants at Talcher**. • Other coalfields of the state include **Rampur-Himgir** and **Ib river**.
Chhattis-garh	• **Korba coalfield** lies in the valley of river Hasdo (tributary of Mahanadi). • Other coalfields of the state include **Hasdo-Arand, Chirmiri, Jhimli, Johilla, Birampur, Lakhanpur, Sonhat, Tatapani-Ramkota,** etc.
West Bengal	• First coal mine of India was opened in 1774 at **Raniganj** (largest coalfield of West Bengal). • Raniganj coalfield is the most important coal reserve and mining coalfield of West Bengal. • It stretches across **Bardhman, Birbhum, Bankura and Purulia districts** to the northwest of Kolkata. Small part of this field is in Jharkhand state. • It is known for good quality coal with about 50 to 65 per cent carbon content. • **Darjeeling** (Dalingkot coalfield) and **Jalpaiguri** are the chief producing districts.
Madhya Pra-desh	• The main coal deposits of the state lie in **Singrauli, Muhpani, Satpura, Pench Kanhan and Sohagpur.** • **Singrauli (Waidhian)** is the largest coalfield of MP. • It supplies coal to the thermal power plants at Singrauli and Obra. • Jhingurda, Panipahari, Khadia, Purewa and Turra are important coal seams • **Jhingurda** with a total thickness of 131 m is the richest coal seam of the country. • Pench-Kanhan-Tawa in Godavari seam in **Kanhan field** contains coking coal

Telangana & Andhra Pradesh	• Godavari valley holds the coal of Telangana and **Singareni coalfield** is the main mine. • Most of the coal reserves are in the **Godavari valley:** Adilabad, Karimnagar, Warangal, Khammam, East Godavari (AP), and West Godavari (AP). • Almost the entire coal is of **non-coking variety.** • These are the southernmost coalfields of India and a **source of coal supply to most of south India.**

Tertiary Coal (formed 60 – 15 million years ago)

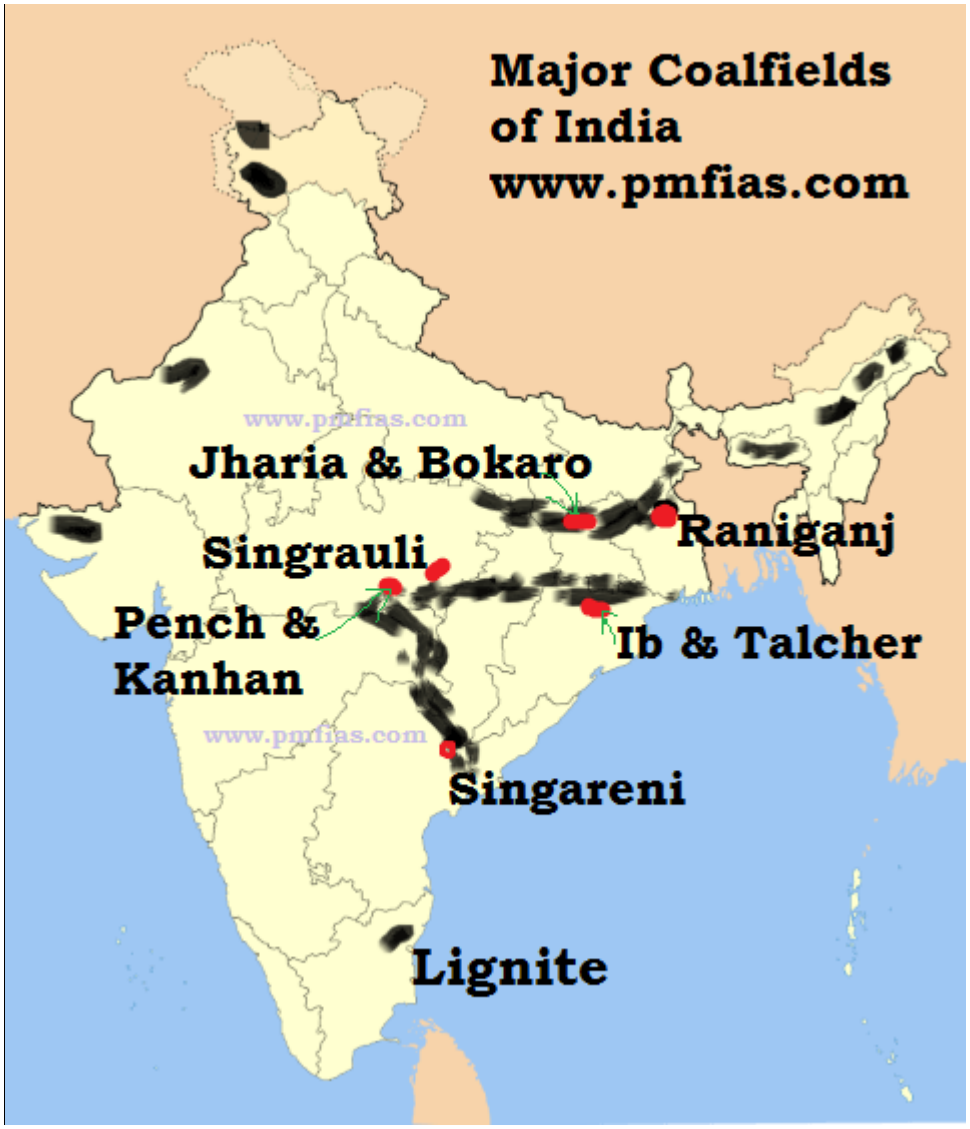
- Tertiary coal generally has **low carbon** and **high percentage of moisture** and **Sulphur**.
- **Lignite deposits** occur in the tertiary sediments in the extra-peninsular region particularly in **Tamil Nadu**, **Kerala, Gujarat & Rajasthan** and also in **Jammu & Kashmir**.
- The total known geological reserves of lignite as of 2017 is 44.7 billion tonnes, of which 80% reserves are located in **Tamil Nadu**.
- Peat deposits occur in **Nilgiri hills** and **Kashmir valley** (in the alluvium of the Jhelum).

Maharashtra	• **Kamptee coalfields** (in Nagpur district) and **Wardha valley** (stretched over Nagpur and Yavatmal districts) carry most of the coal deposits in the state. • The coal deposits of Maharashtra mainly belong to the **Tertiary period**.
Tamil Nadu	• The coal deposits of **Tamil Nadu (80% lignite coal reserves)** are found in Neyveli in the South Arcot district.
Rajasthan	• **Palana and Khari mines of Bikaner district** in Rajasthan carry **Lignite deposits** (inferior quality of coal). The coal produced is mainly used in the thermal power plants and railways.
Gujarat	• The coal found in Gujarat is of poor quality and contains only about 35 per cent of carbon. • The moisture content in this coal is quite high.
Jammu & Kashmir	• Coal in the state is of inferior quality and is found at Shaliganga, Handwara, Baramulla, Riasi, and Udhampur districts along with the Karewas of Badgam and Srinagar.
Assam	• **Makum coalfield** in Sibsagar district is the most developed field. • Assam coals contain very **low ash and high coking qualities,** but the **sulphur content is high**, as a result of which this coal is not suitable for metallurgical purposes. • The coal is best suited for **hydrogenation process** and is used for **making liquid fuels**. • Upper Assam Coal belt extends eastwards as Namchick-Namrup coalfield (Arunachal Pradesh).

Meghalaya	• Garo, Khasi and Jaintia hills. • Darrangiri field is in Garo hills. • Cherrapunji and Langrin coalfields are in Khasi and Jaintia hills.

Major Coalfields in India

1. **Singrauli**
2. **Karanpura Bokaro**
3. **Jharia**
4. **Raniganj**
5. **Ib & Talcher**
6. **Pench & Kanhan**
7. **Singareni – Godavari Velley**
8. **Lignite: TN, Gujrat And Rajasthan**



State-wise coal reserves and coal production in India

- India has a total of **319 billion tons** of coal reserves of which **148.8 billion tons are proven reserves.**

State-wise coal reserves in India			State-wise raw coal production in India		
State	**Reserves (billion tons)**		**State**	**2016-17**	**2017-18**
1. Jharkhand	**80.71**	**26.8 %**	1. **Odisha**	139	143
2. Odisha	**75.07**	**24.9 %**	2. **Chhattisgarh**	128	132
3. Chhattisgarh	**52.53**	**17.4 %**	3. **Jharkhand**	118	112
4. West Bengal	**31.31**	**10.4 %**	4. **Madhya Pradesh**	85	91
5. Madhya Pradesh	**25.67**	**8.5 %**	5. **Maharashtra**	40	41
6. Telangana & AP	22.48	7.5 %	6. West Bengal	25	26
7. Maharashtra	10.98	3.6 %	7. Uttar Pradesh	16	18

Source

The demand of coal, production, supply and import of coal in India

Data in Million Tons (MT)				India's coal imports country-wise		
Year	2015-16	2016-17	2017-18	**Country**	**FY 2016-17**	**FY 2017-18**
Total domestic Production	639.23	657.87	**676.48**	**1. Indonesia**	117	97
Total domestic Supply	632.44	644.56	**691.42**	**2. Australia**	46	46
Total Import (MT)	203.95	190.95	**208.27**	**3. South Africa**	38	35

- Coal India Ltd (CIL) has planned to increase coking coal output from **34.12 MT** to 52.95 MT by 2019-20.

In Million Tons (MT)	**FY 2018-19**	**Non-coking coal imports**
Total coal imports	220	**1. Australia (~ 70%)**
Non-coking coal imports	164	**2. Canada (~ 10%)**
Coking coal imports	52	**3. USA (~ 7%), Mozambique (~ 5%)**

Why does India import coal although it has enough reserves?

Inability to exploit reserves

- Unavailability of technology to mine coal from deep underground coal mines (40% of total coal reserves are located at a deeper depth which cannot be extracted using opencast mining).
- Significant portions of Indian coal reserves are in Maoist affected regions and densely populated areas.

Short supply of coking coal (metallurgical coal)

- Coke is an important ingredient in the manufacture of iron (coke acts as fuel in a blast furnace).
- India has very few coking coal sources and hence it has to import it from **Australia, Canada, South Africa, Indonesia**, etc.

Environmental concerns

- India's coal has high ash content and low caloric value. Hence burning it causes a lot of pollution.
- Previously, due to shortage of coal and pollution concerns, many Indian power plants had been designed to run on superior quality imported coal.
- Clean coal technology used to clean coal to reduce emissions is expensive and complex to setup.

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Economic Geography Part II (Industrial Locational Factors Part I)

Factors responsible for the location of primary, secondary, and tertiary sector

PDF

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1. Primary, Secondary and Tertiary Sectors

- Economic activities are broadly grouped into **primary, secondary, tertiary** and **quaternary activities**.

1.1. Primary Activities

- Primary activities are **directly dependent on the environment** as these refer to utilisation of earth's resources such as land, water, vegetation, building materials, minerals, etc.
- It thus includes hunting, gathering, pastoral activities, fishing, forestry, agriculture, **mining, quarrying, etc**.
- Industries that are involved in primary economic activities are called as primary industries.

1.1.1 Hunting and Gathering

- Gathering is practised in regions with harsh climatic conditions.
- It involves primitive societies that extract from both plants and animals to satisfy their basic needs.
- The yield per person is meagre and little, or no surplus is produced.
- Gathering is practised in:
  - ✓ high latitude zones which include northern Canada, northern Eurasia and southern Chile.
  - ✓ Low latitude zones such as the Amazon Basin, tropical Africa, Northern fringe of Australia and the interior parts of Southeast Asia.
- They use various parts of the plants, e.g., the bark is used for **quinine, tanin** extract and tree trunk yield rubber, gums and resins.
- The chewing gum after the flavour is gone is called Chicle — it is made from the juice of **zapota tree**.
- In modern times some gathering is market-oriented and has become commercial.
- However, synthetic products often of better quality and at lower prices have replaced many items supplied by the gatherers in tropical forests.

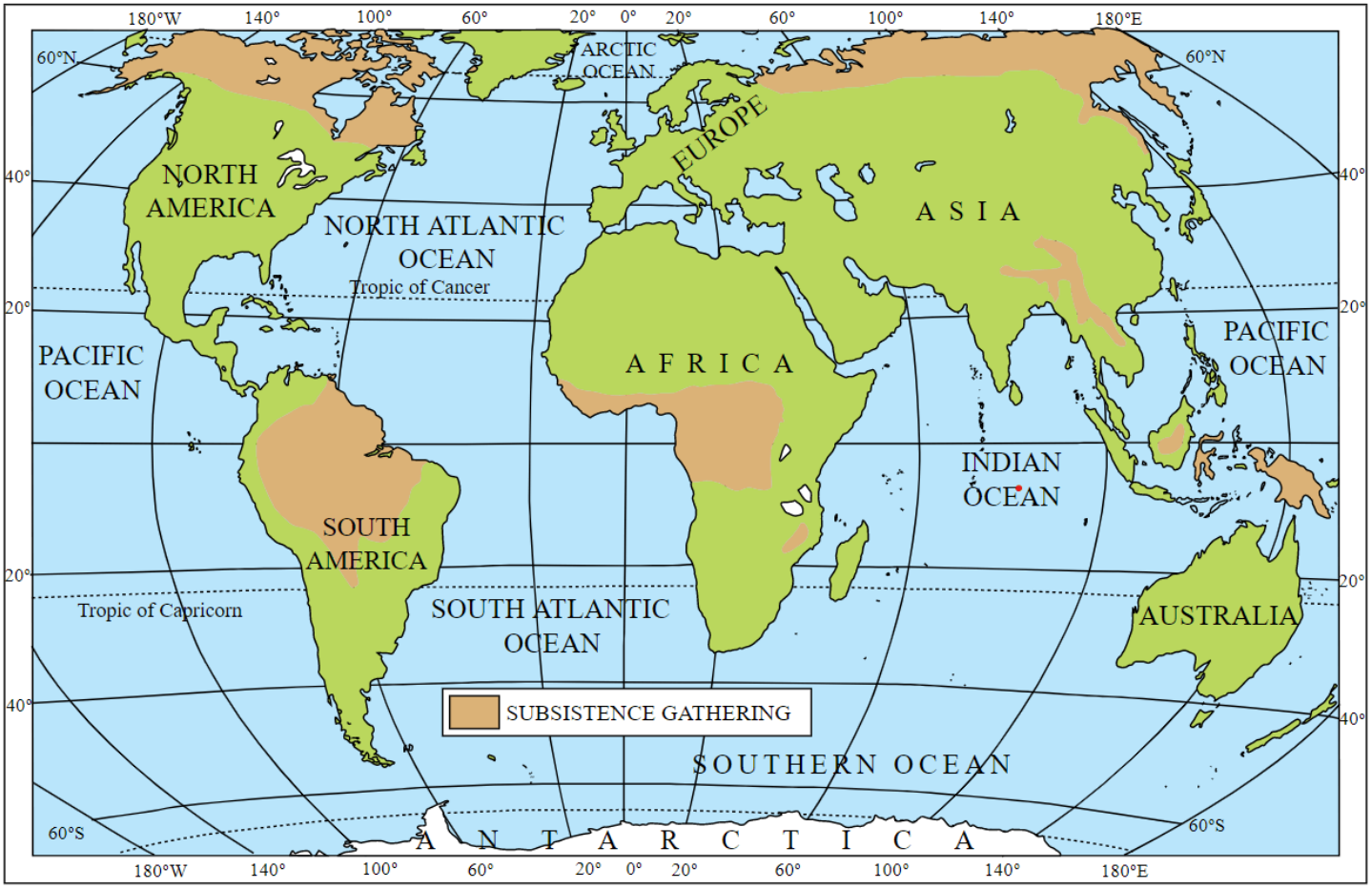


Image Source: NROER

1.1.2 Pastoralism

- At some stage in history, as hunting was unsustainable, humans began the domestication of animals.
- People living in different climatic conditions selected and domesticated animals found in those regions.

Nomadic Herding (pastoral nomadism)

- Nomadic herding is a primitive subsistence activity.
- They move from place to place along with their livestock, depending on the availability of pastures & water.
- A wide variety of animals is kept in different regions.
- In tropical Africa, cattle are the most important livestock, while in Sahara and Asiatic deserts, sheep, goats and camel are reared.
- In the mountainous areas of Tibet and Andes, yak and llamas and in the Arctic and sub-Arctic regions, reindeer are the most important animals.
- Pastoral nomadism is associated with three important regions.
- The core region extends from the Atlantic shores of North Africa eastwards across the Arabian Peninsula into Mongolia and Central China.

- Africa has immense natural resources and yet it is industrially the most backward continent. Comment.
- Which one of the following is a tertiary activity? (a) Farming (b) Trading (c) Weaving (d) Hunting
- Which one of the following activities is NOT a secondary sector activity? (a) Iron Smelting (b) Catching fish (c) Making garments (d) Basket Weaving
- Which one of the following sectors provides most of the employment in Delhi, Mumbai, Chennai and Kolkata? (a) Primary (b) Quaternary (c) Secondary (d) Service
- Jobs that involve high degrees and level of innovations are known as: (a) Secondary activities (b) Quaternary activities (c) Quinary activities (d) Primary activities
- Which one of the following activities is related to the quaternary sector? (a) Manufacturing computers (b) Paper and Raw pulp production (c) University teaching (d) Printing books
- Which one out of the following statements is not true?
  a) Outsourcing reduces costs and increases efficiency.
  b) At times engineering and manufacturing jobs can also be outsourced.
  c) BPOs have better business opportunities as compared to KPOs.
  d) There may be dissatisfaction among job seekers in the countries that outsource the job.

2. Iron and Steel Industry

- The iron and steel industry forms the base of all other industries and, therefore, it is called a **basic industry**.
- It may also be called a heavy industry because it uses large quantities of bulky inputs and outputs.
- Iron is extracted from iron ore by smelting (heating, melting & separation of impurities) in a blast furnace with carbon (coke) and limestone.
- The molten iron is cooled and moulded to form **pig iron**.
- The pig iron is used for converting into steel by adding strengthening materials like **manganese**.

2.1. Smelting of Iron Ore

- Of the impurities in iron ore, some are beneficial when present in small quantities while the others are harmful no matter what their proportion is.
- So, the unwanted impurities must be removed, and this is done by **smelting iron ore in a blast furnace.**

Harmful impurities in Iron Ore

Sulphur

- A **very harmful** element.
- It reacts with iron to form **iron sulphide,** which is a very **brittle** substance.
- Iron sulphide greatly reduces the strength of steel.

Tin

- It forms a low melting point brittle film round the grain boundaries making the steel **practically useless**.

Oxygen

- Has a bad influence on the properties of steel (**Oxides make Iron and steel weak**).

Other impurities

Silicon

- Silicon is found in small quantities, and it slightly raises the strength and hardness of steel.
- It acts as a **de-oxidizing agent** (Oxides decrease the strength of Iron. Hence, they must be removed).

Lead

- Added to all classes of steel to improve the **machinability of the Steel**.
- When added in small quantities, it **improves tool life**.

Manganese

- A powerful and most effective de-oxidant.
- Small quantities is good as it can deoxidize sulphur.

2.1.2 What exactly happens in a blast furnace?

- **Coke (fuel & reducing agent)**, **iron ore**, & **limestone (flux)** are continuously added to the blast furnace.
- A hot blast of air is blown into the lower section.

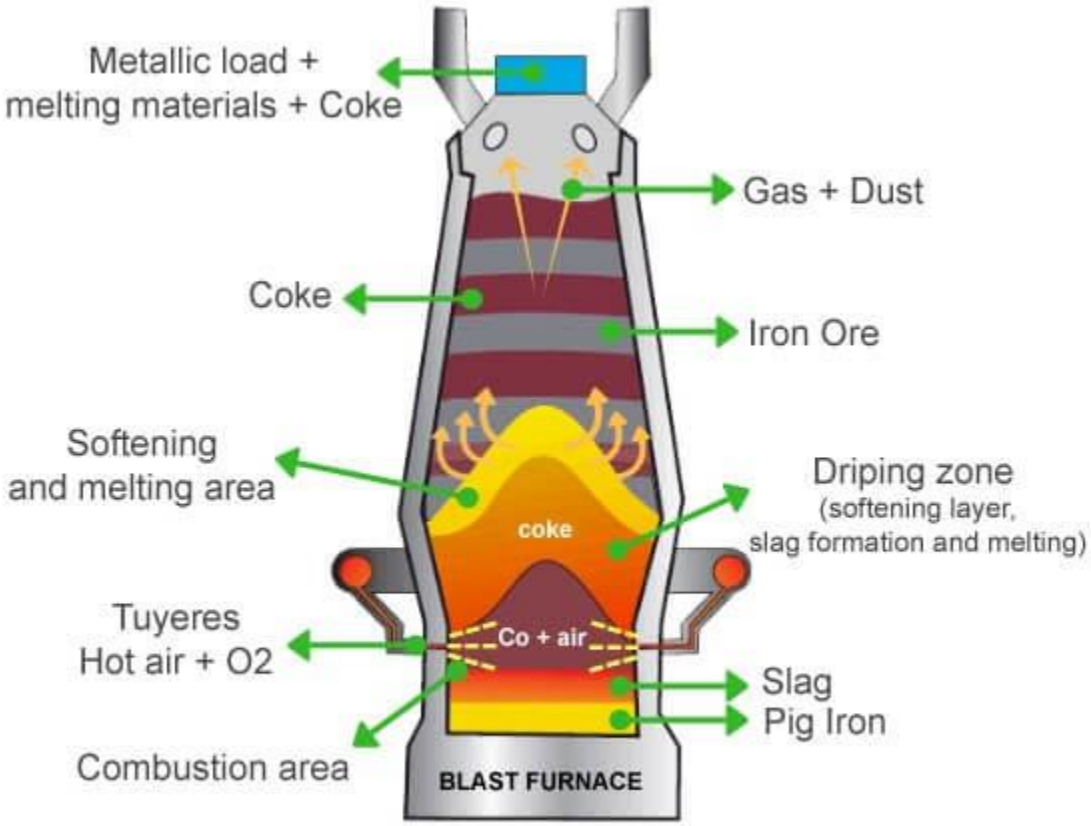


Figure 1 - Blast Furnace Operation

- Final product ➔ **liquid slag**, **liquid iron (pig iron)** and gases (CO & CO_2).

Why coke and not coal in smelting?

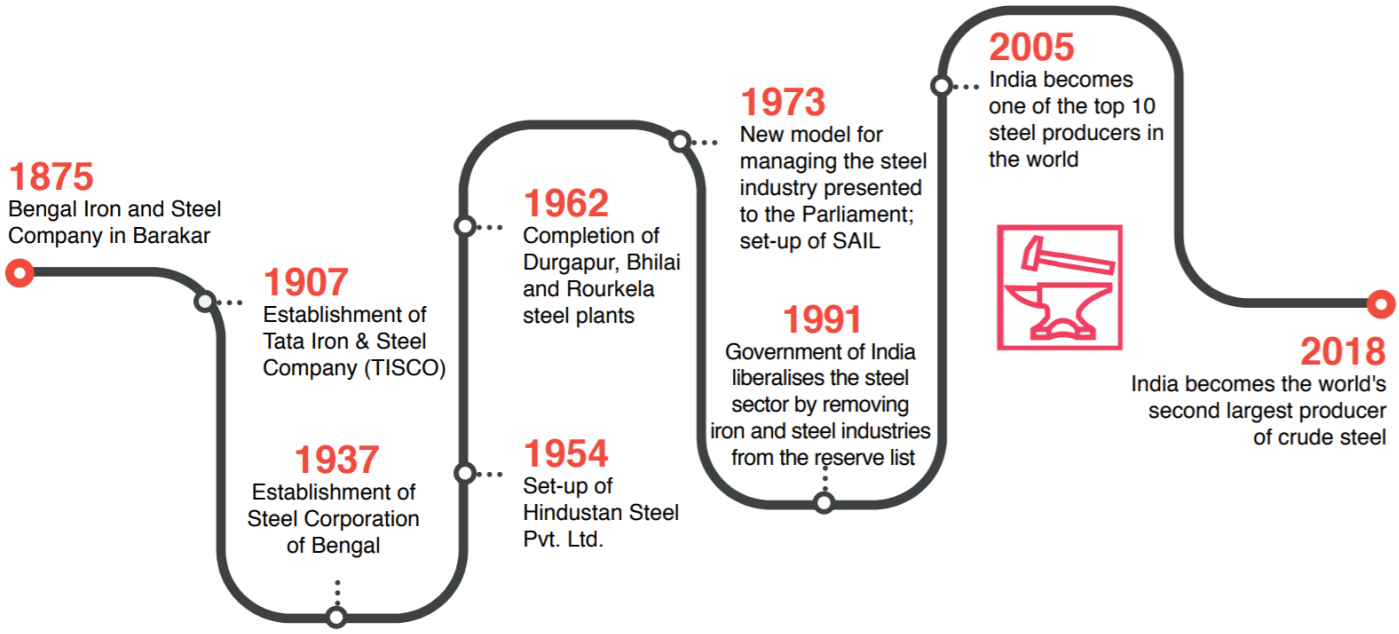
- To separate impurities, iron needs to be melted.
- The **coke is the fuel** that melts iron. (Coal is cooked through **destructive distillation** to produce coke.)
- Coal has many impurities, and the most dangerous one is **sulphur**.
- Coke is a fuel with **few impurities** and **high carbon content** (90%).

Reduction ➔ Remove Oxygen

- Oxygen in the iron oxides is reduced (removed) by a series of chemical reactions.
  1) $3Fe_2O_3$ + CO (**obtained by burning coke**) ⟶ CO_2 + $2Fe_3O_4$
  2) Fe_3O_4 + CO ⟶ CO_2 + 3FeO
  3) FeO + CO ⟶ CO2 + Fe (pure metal)
- So, **carbon monoxide (CO) & CO_2** are the gaseous pollutants coming out of blast furnace.

Is there no alternative to highly polluting coke fuel?

- Melting iron ore can also be done with the help of electricity (electric smelting).



- At 51.3%, China is the world's largest producer of steel.
- India has overtaken Japan to become the second-largest producer of steel.
- India's steel production in 2018-19 stood at 111 million tonnes.
- The construction industry is the largest consumer of steel in India.
- The National Steel Policy, 2017, has envisaged 300 million tonnes of production capacity by 2030-31.

3. Cotton Textile Industry

(This topic is important for 'Modern World History: Industrial Revolution' also)

- A cotton mill houses spinning or weaving machinery for the production of yarn or cloth from cotton.
- Till the industrial revolution, cotton cloth was made using hand-spinning techniques (wheels) and looms.
- In 18th century, power looms facilitated the development of cotton textile industry, first in Britain and later in other parts of the world.

- In India, the cotton textiles industry is the single largest organised industry.
- Being labour intensive at all stages, it employs a large number of people.

3.1. Factors that affect the location of the cotton textile industry

Raw material	• In India and the U.S., the industry is coterminous with the cotton-growing tracts. • For example, **Ahmedabad (Manchester of India)**, Solapur, Nagpur & **Coimbatore (Manchester of South India)** are located in the areas of large-scale cotton cultivation. • In the U.S., the industry is concentrated in the cotton-growing southern states. • Since the cotton industry is **not a weight losing industry**, it isn't always necessary to set up the industry close to the cotton-producing areas. • E.g. Cotton textiles industry in **Kanpur (market, local investment), Kolkata (port), Manchester (market, coal, water) & Bangladesh (cheap labour**, government support).
Transportation linkages	• The most favourable location for setting up the cotton textile industry is the one that is **well connected with cotton-producing areas and markets**. • This is because raw cotton and finished cloth can be transported without adding much to the total cost of production. • In India, dispersal of the industry from the **old nuclei (Mumbai, Ahmedabad)** started after 1921 with railway lines penetrating into the **peninsular region (Madurai, Bengaluru)**. • The industry reached Nagpur due to its nearness to coal. • The industry reached **Kolkata** — broad market with port facilities — even though it was located far away from the major cotton-producing belt.
Access to market for the cotton textiles	• The cotton industry is primarily a **market-oriented industry**. • For example, in the 1800s, the British (**Lancashire** and **Manchester**) imported raw cotton from far away regions like **West Indies, U.S., Egypt and India** and exported cloth to countries in Europe and other parts of the world (mostly to its **colonies** like India, Bangladesh, Egypt, etc.). • With a tropical and sub-tropical climate, all parts of India provide vast market potential for the cotton textile industry. • For example, **West Bengal, Bihar, Uttar Pradesh, Kerala** and **Odisha** do not grow cotton and still has cotton textile industry.

Access to market for the by-products of cotton textile industry	• The good thing about the cotton industry is that nothing goes as a waste. • Cottonseed provides about 12-15 per cent of the total farm value of cotton production. • Cottonseed can be fed directly to dairy cattle or crushed to produce **cottonseed meal** and oil (nowadays, vegetable oils are preferred over animal fats). • As a **protein-rich feed, cottonseed meal** is extensively used as a feed in **poultry and livestock industry**, notably in cotton-producing areas such as India, China and the U.S. • All these **auxiliary industries** (poultry, cottonseed oil extraction) are located close to the market.
Power	• The first modern cotton mills were powered by constant flow of water. • Such mills were built in **Lancashire** and its neighbouring rural locations. • They faced issues of labour supply and access to urban markets. • From the 1780s onwards, steam engines drove the cotton mills. • This enabled new mills to be built in urban contexts. E.g. **Manchester**. • The development of **hydro-electricity** favoured the location of the cotton textile mills away from the cotton-producing areas. • For example, the growth of this industry (away from Mumbai) in **Tamil Nadu (Coimbatore, Madurai and Tirunelveli)** is largely due to the availability of hydroelectricity from **Pykara dam**.
Climate	• The air in the cotton mill has to be **hot and humid** (18°C to 26°C and 85% humidity) **to prevent the thread from breaking**. • Hence the coastal regions in the tropics and subtropics are preferred locations. E.g. Mumbai and Southeastern U.S. • However, electricity-based temperature and humidity controllers enable the mills to be set up in a wide range of locations.
Labour	• The industry has shifted from areas of **high labour cost (UK, Germany, Japan)** to those with **low labour cost (India, China and Bangladesh)**. • **Bangladesh** has very little cotton production but is a significant producer of textiles mainly due to the availability of **very cheap labour** (poverty & poor working conditions). • The labour cost factor played a crucial role in establishing the industry at **Madurai, Tirunelveli** and **Coimbatore**.

	of the world rubber market.	

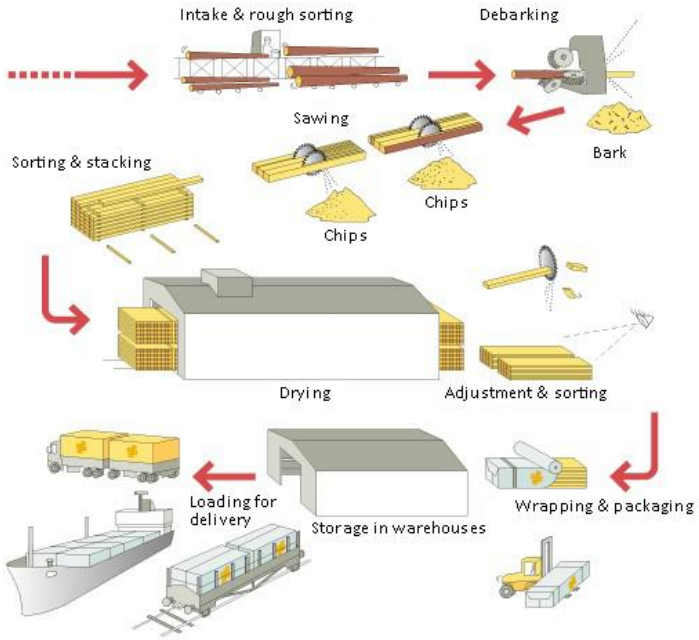
The future

- With the growing environmental consciousness, the share of the synthetic rubber would ultimately decline, and the natural rubber would gain back its prominence.
- Brazil might again play an essential role as a significant natural rubber exporter.

- The Natural Rubber Industry of Kerala is very much similar to that in Southeast Asia.
- The significant difference is that the plantations in Kerala are much smaller in size.

11. Lumbering, Pulp and Paper Industry

- In North America, timber processed into beams and planks in a sawmill is called lumber.
- Lumbering is an economic activity of cutting and preparing lumber.



11.1. Lumbering Industry in the Temperate Regions vs Lumbering Industry in the Tropical Regions

Mains Practise: Despite the presence of dense forests, countries in the equatorial regions are net importers of timber and timber products. Comment.

Lumbering Industry in Temperate Regions	Lumbering Industry in Tropical Regions
• **North-western Russia, U.S.A., Canada, Fennoscandian countries (Finland, Norway and**	• Teak in Myanmar and hardwoods of Amazon, Congo, Southeast Asia, etc.

Sweden), New Zealand, etc.	
• **Softwoods** like conifers (**pines, spruces, cedar, Douglas fir, yew, larch, hemlock**, etc.) are obtained from the temperate forests. • Softwoods are in general less dense and less hard than hardwood trees, but with a few exceptions. • Softwood is the source of about **80% of the world's production of timber**.	• **Hardwoods** are obtained from the tropical and subtropical evergreen and deciduous forests. • The tropical evergreen and semievergreen hardwood species: **mahogany, ebony, rosewood, dyewood**, etc. • The tropical deciduous hardwood species: **teak, axlewood, rosewood, red sanders**, etc. • Subtropical hardwood species: **oak, eucalyptus**, etc.
• Very little softwood is burnt as fuel as its industrial uses are far more significant. • They are mainly used in construction materials and to produce **paper pulp** and papercard products. • Softwoods are less expensive than hardwood.	• Hardwoods are mostly used to make **durable, high-quality furniture**, flooring, and construction. • E.g. **Burma teak**. • Most of the hardwood is wasted as fuel in the poor tropical countries.
• The softwoods are limited in species. • They occur in **homogeneous or pure stands** (the same kind of species are distributed over a large area) making commercial exploitation easy and profitable.	• Multiple species of trees occur in a particular area making commercial exploitation a laborious task.
• Softwoods **readily float on water,** and hence they can be easily transported with the help of water bodies. • In winters, the snow makes haulage (commercial transport of goods) easy.	• Many of the tropical hardwoods (very heavy) do not float readily on water, and this makes transportation an expensive matter. • Teak logs are so heavy that they will not float readily on water. • It is therefore necessary to 'poison' the tree several years before actual felling so that it is dry and light enough to be floated down the **Chindwin** and the **Irrawaddy** to reach the sawmills at Rangoon.
• The open forests with sparse undergrowth mean that logging and haulage can be easily mechanized.	• The dense undergrowth in tropical evergreen forests makes it challenging to mechanize logging and haulage.

• Also, less dense forests and low population densities make it easy to build the necessary infrastructure.	• The construction and maintenance of roads and railways in tropical forests comes at a high social (tribal uprising) and economic costs (labour costs).
• High labour productivity: temperate regions have the optimum climate for maximum human output.	• Low labour productivity: excessive heat (sunstroke), high humidity (communicable diseases) and poisonous snakes and insects create severe physical and mental handicaps.
• Capital: lumbering is a highly profitable and very well organized industry. Investments are easy to secure in the region that has a relatively high per capita income.	• Capital: lumbering is expensive, and capital inflows come with many social (persecution of tribals) and political costs (**neo-colonialism** by China in African countries).
• Market: most of the nearby regions have developed economies with major urban and industrial hubs.	• Market: countries in the region are mostly underdeveloped or developing. • Most of the expensive hardwood is exported to the developed world.
Sustainable lumbering • Softwood trees grow much quicker, sometimes in as little as 25 years. • **Silviculture**: As the temperate forest soils and climate are less suitable for agriculture, the governments are actively involved in regenerating the lost forest. • After a patch of the forest is cleared, it is quickly replanted and just within a couple of decades, the forests can be harvested again. • The vast reserves of replenishable softwood forests (including Siberian Taiga belt) mean that the prospects for the industry are encouraging.	**Unsustainable lumbering** • Hardwood trees are slow-growing and take many decades to fully mature. • Once the forest is cleared, the chances of regenerating the forest are bleak due to economic, social, and political pressures. • The forests would be permanently replaced by plantations (e.g. **palm in Indonesia, soya in Brazil**), agriculture, cattle ranching (e.g. Brazilian Amazon), mineral exploration (e.g. oil exploration in Colombia), etc. • Quickly depleting tropical forests offer no hope for the future.

11.2. Factors affecting the location of the sawmills (lumbering) industry

Raw material	• Roundwood (wooden logs) being a bulky and **weight losing raw material** (less than 60% of the roundwood is turned into lumber), the sawmills need to be located closer to

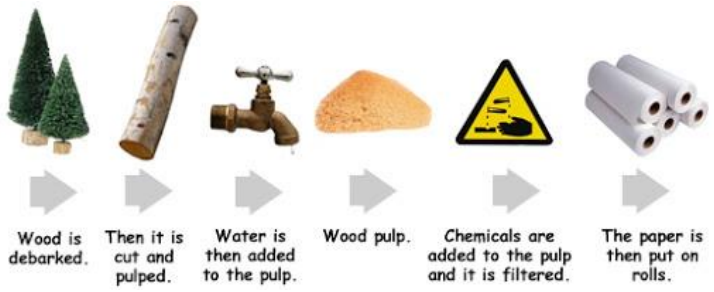
	the forests.
Power	• Lumbering is an energy-intensive industry. • Availability of cheap, uninterrupted electricity is essential for the economic success of a sawmill. • Cheap hydroelectricity from the mountainous uplands of North America and Europe has greatly assisted the lumbering industry there.
Transportation	• The means and modes of transportation need to be economical both for importing roundwood and for exporting lumber. • Slippery (snowy) surfaces (e.g. winters in the temperate region), rivers (e.g. teak transport by Irrawaddy river) and lakes (e.g. **Lake Ladoga** and **Lake Onega** in Western Russia) reduce the transportation cost of the raw material. • Well-connected roads, railways and waterways make the export of lumber profitable. E.g. **Saint Lawrence Waterway** connecting the **Great Lakes region** with the Atlantic Ocean.
Labour	**Temperate Region** • In the earlier times, contract labourers called lumberjacks used to temporarily move with their families to the forest regions in winters to fell the trees. • In the modern times, logging (felling of trees) and delimbing (the process of removing branches from a tree trunk) is carried out by a feller buncher (harvester used in logging).   • The roundwood is loaded into trucks by forestry cranes (log loaders) and carried to the sawmills. • The sawmills are highly mechanized, and most of the operations from sawing to grading are computerized. • Hence, the labour force required is minimal. **Tropical Region** • In the tropics, most of the industry is based on obsolete technology and manual labour.

Capital	• Lumbering is a capital intensive industry. It is well-developed in the prosperous North American Region.
Market	• The presence of markets near sawmills is useful but not essential as lumber can be economically transported worldwide with the help of a good transportation network.

- Hence, the availability of timber resources, excellent transportation facilities and cheap electricity are the major factors that determine the location of a sawmill.

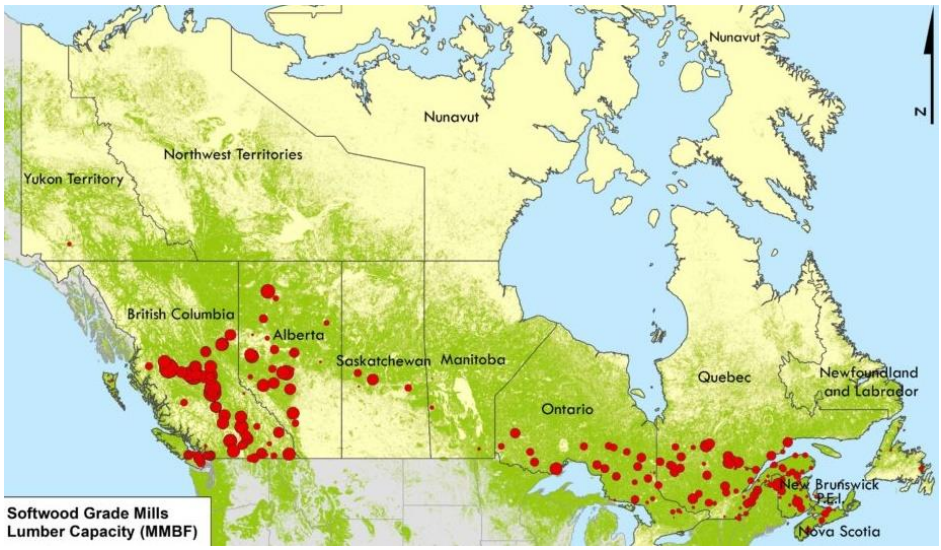
11.3. Factors affecting the location of paper pulp industry

- Pulp is fibrous material prepared by separating cellulose fibres from wood, fibre crops, wastepaper, etc.
- Pulp is the primary raw material used in paper, paper cardboard and newsprint making.



- Softwoods & wood chips from sawmills are the basic raw materials for the paper pulp mills in the mid-latitudes.
- Imported softwoods & wood chips, imported softwood pulp, hardwoods like eucalyptus, bamboo, some grasses, etc. are the basic raw materials for the paper pulp mills in the tropics.
- Additionally, the pulp mills use a **lot of chemicals** for pulping the wood, bleaching the pulp and for producing paper of various quality and finish.
- Chemicals are needed in small quantity and can be economically transported even over long distances.
- The locational factors for the paper pulp industry are similar to that for the sawmills industry.
- One additional requirement is the availability of **abundant unpolluted water** for the paper pulp industry.
- Water quality determines the quality of the pulp & the additional purification costs.
- Hence the paper **pulp mills tend to be upstream** from cities to avoid the polluted waters.
- In an integrated unit, pulp and paper are produced at one single factory setup.
- But in many pulp mills, only the pulp is produced and is exported to paper mills located far away.
- For example, wood pulp is produced in Canada and exported to the U.S.A., Europe & Asia for paper, papercard and newsprint (inexpensive, low-quality paper for newspaper printing) making.

11.4. Lumbering, Pulp and Paper Industry in Canada

Raw material	• Coniferous forests cover as much as 60 per cent of Canada. • Although timber is exploited in almost every province, there are only two important areas of production — **Quebec and Ontario in the east** and **British Colombia in the west**. • Modern systems of forest management are organized in such a way as to produce a constant supply of timber for the mills. 
Transport	• Quebec and Ontario: numerous rivers and **St. Lawrence-Great Lakes Waterway**. • British Columbia: numerous rivers and lakes and proximity to the west coast.
Water	• The rivers provide clear, unpolluted water for soaking and bleaching the paper pulp.
Power	• Quebec and Ontario: Cheap hydroelectricity from numerous rivers falling from the highlands to the lowlands of St. Lawrence valley. • British Columbia: Cheap hydroelectricity from rivers flowing down the western slopes of the Rockies.
Capital	• The U.S. and the British have significant investments in Canadian forest industries.
Mechanization	• Lumbering in Quebec and Ontario was traditionally a seasonal occupation. • The trees were felled and dragged over the frozen ground in winter to the riversides. • The logs were then floated downstream in the spring when the rivers thawed. • However, mechanization has reduced the dependence on seasonal climatic conditions, and the occupation is becoming more of a permanent activity.
Market	• Because of its small population, Canada has a large surplus of timber products for export. • **Canada is the largest newsprint producer in the world**. • Canada's pulp and newsprint production find ready markets in north-eastern U.S.A (long-established publishing industries; high consumption rate of pulp and paper products; relatively little newsprint is made as the production of packaging materials and quality paper

	are more important). • Lumber, pulp & newsprint are also exported to U.K. & Germany where timber is in short supply. • Pulp is also used in the St. Lawrence-Great Lakes industrial belt of Canada, in the northern U.S.A. and New England for making **rayon**, since the spruce wood pulp is particularly suitable for this purpose.

- The forests of the Prairie provinces (Alberta, Saskatchewan & Manitoba) and other interior regions are little utilized because they are far from the sea.
- Eastern Canada makes all types of paper and also produces sawn wood, furniture, and other timber products, but the most important product is still newsprint.
- The main producing centres are **Quebec, Montreal, and Toronto** (all located along the **Saint Lawrence Waterway**).

11.5. Lumbering, Pulp and Paper Industry in Russia

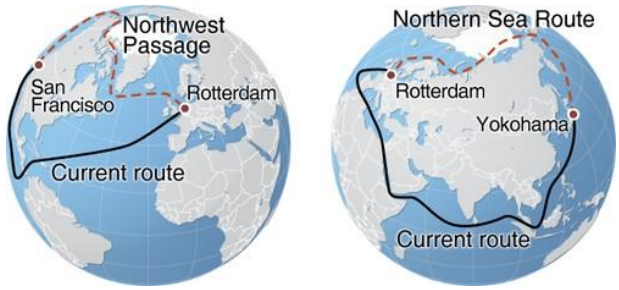
- The greatest single band of the coniferous forest is the **taiga** in Siberia.
- However, Russia is only able to exploit northern European Russian Taiga.
- Logs from these areas are floated to sawmills and pulp mills in
  - **Arkhangelsk (Archangel —** Northern Dvina River**) on the White Sea**,
  - Petrozavodsk on **Lake Onega** (Svir River connects it to **Lake Ladoga**), and
  - **Saint Petersburg** (Neva River connects **Lake Ladoga with the Baltic Sea**) on the **Gulf of Finland (in Baltic Sea)**.

- Russia lags behind the west in the development of timber industries such as pulp and paper.
- Most of Russia's timber production is still in the log or sawn wood form.

11.5.1 What are the challenges faced by Russia in exploiting its vast Siberian Taiga forests?

- Despite the recent developments in Siberian Taiga, only northern European Russian Taiga (north-western Russia) supports the sawmilling and timber processing plants.
- This is because of the **rivers of the Siberian Taiga that flow away from the markets into the Arctic Sea** which is **frozen for the most part of the year** (**the Barents Sea and the White Sea are ice-free only in Summer** — due to **North Atlantic Drift**; the rest of the seas are ice-bound for most of the year).
- The rivers are frozen in winter, and in summer months they experience severe flooding.

- Nowadays, however, timber is cut and floated down the **Ob and Yenisei rivers** in summer for export via the **Northern Sea Route**, which is kept open by ice-breaker fleets.



11.6. Lumbering, Pulp and Paper Industry in U.S.A.

- Though the U.S.A. has relatively fewer forest resources, its forests are much more exploited than those in Canada.

Raw material	• With the depletion of forest resources around the Great Lakes region, lumbering has moved into the western states of Washington, Oregon, and California.
Transport	• The Rockies and the absence of connecting rivers make it hard to export sawn wood from west to east. • Hence U.S.A exports sawn wood from the west coast to Japan and China and **imports paper pulp and newsprint from Canada**.
Water	• Lack of abundant water resources in north-west means that the sawmills far outnumber

	the pulp mills.
Power	• The Colombia River supplies power for the sawmills.
Market	• The U.S.A. (north-eastern region) is the largest per capita consumer of pulp and paper products in the world.

11.7. Lumbering, Pulp and Paper Industry in other regions

Scandinavian countries	• The Scandinavian countries (**Norway, Sweden, and Finland** — small populations) have a surplus of timber which they export to the rest of Europe. • In Sweden, matches form a major export item. • The lumbering industry here has similar advantages like that in Canada.
U.K. & Germany	• In many parts of Europe, e.g. Britain, Ireland, the Netherlands, and Denmark almost all the original forest cover has long been removed. • The lack of local timber has not prevented the development of paper and newsprint making industry in Britain and Germany. • The pulp industry has grown up on the major estuaries and in coastal locations. • Pulp is **imported from Canada and the Scandinavian countries** and made into paper in Britain and Germany and exported to the rest of Europe.
China	• In the late 1990s, after depleting much of their own timber stocks, Chinese logging companies began moving into the **tropical rainforest areas (Chinese Neo-colonialism)**. • Chinese timber firms have been particularly active after the government banned domestic logging in much of the country following catastrophic flooding in 1998. • China feeds its highly subsided pulp and paper industry by importing timber, wood chips, pulp and recovered paper from North America, Southeast Asia, tropical Africa & America.
Brazil	• **Brazil** is one of the important producers and exporters of paper pulp. • The Brazilian industry is fuelled by the Chinese appetite for paper pulp. • But it comes at a high cost of **deforestation in the Amazons**.
Japan	• Japan is a major producer of both coniferous timber and hardwood timber. • As a major industrial region, it imports a large volume of timber from Russia (softwood) and Southeast Asia (hardwood).
Malaysia & Philippines	• **Malaysia and the Philippines have many advantages**. • Their luxuriant forests are found on islands or peninsulas and are at no point very distant from the sea.

	• **This is in contrast to the forest resources of Thailand or Myanmar where the best forests are found well inland and logs have to be transported by river to the coast**. • Malaysia and the Philippines also have the further advantage of being near the major timber markets of Japan and Australia, both of which are short of local timber. • The timber industry has been encouraged by the governments in both countries. • The clearance of large areas of land for plantation agriculture has also promoted the timber industry.
Australia & New Zealand	• Australia has natural eucalyptus forest in the moister south-east and in Tasmania. • Eucalyptus yields rather poor quality timber. • New Zealand has softwood reserves, mostly in the South Island.

11.8. Lumbering, Pulp and Paper Industry in India

- In India, lumbering is discouraged for the sake of conserving the environment.
- Sal, teak, neem, rosewood are the few species exploited for furniture making.
- Eucalyptus plantations are nowadays discouraged due to their groundwater depleting potential.
- A favourable tariff structure supports log imports from Southeast Asia, U.S.A, New Zealand, etc.
- However, due to poor levels of processing by domestic sawmills, India imports more lumber than logs (lost employment and wealth generation opportunities).

11.8.1 Paper Industry in India

- The first successful paper mill in the country was set up at Ballygunj near Kolkata in 1870.
- The raw materials for the industry include **bamboo, sabai grass**, wastepaper, imported pulp and bagasse.
- 60-70 per cent of the total requirements of cellulosic raw material is met by bamboo.
- Bamboo has the advantage of the possessing **long fibre, dense stands and quick regeneration**.
- It reaches maturity in 2-3 years and provides a continuous flow of renewable source of raw material.
- **Assam, Odisha, Andhra Pradesh**, Telangana, Madhya Pradesh, etc. are important producers of bamboo.
- **Sabai Grass** mainly grows in the sub-Himalayan tracts of Shiwaliks and **Terai area**.
- It is hence the chief raw material in the paper mills of Uttar Pradesh.
- Although sabai grass has long fibre and requires low chemical consumption, it is intermixed with other vegetation, and it is often difficult to separate impurities from it.
- Only half of the bagasse produced in the sugar industry is used for manufacturing paper.

Localization of the Industry

- The location of the industry is influenced by **raw materials** and to a lesser extent by market.

- Therefore, there is a strong tendency among the paper mills to be located near the forest tracts along the Western Ghats, the Eastern Ghats, central India and the **Terai-Bhabar** area.

Geographical Distribution

- Maharashtra, Andhra Pradesh, Gujarat, UP and W.B. are the main producers of paper and paper board.
- Mills located in Maharashtra use rags, wastepaper or pulp imported from Sweden and Canada as the principal cellulosic raw material. Hydroelectricity is used as a power resource in place of coal.
- The paper industry in West Bengal is based on bamboo which is available locally or is obtained from Assam, Odisha and Jharkhand, and sabai grass which is obtained from Chhattisgarh and Madhya Pradesh.
- Coal is abundantly available from Jharia and Raniganj.
- Ganga and other rivers provide sufficient water for processing.
- The high density of population along the Hugli river provides cheap labour.
- Madhya Pradesh has large tracts under bamboo, sabai grass, eucalyptus, etc.

No paper mills in the Himalayan Region

- The vast temperate forests in the Himalayan region hold large quantities of softwood.
- But because of the rugged terrain and poor means of transportation, these areas are inaccessible.
- Moreover, the costs of environmental damage outweigh the economic benefits.
- Also, the regeneration of softwood forests takes more than two decades, while **bamboo forests are replenished within 2-3 years**.
- Hence, no paper mill has been set up in the Himalayan region.

11.8.2 Problems of Indian Paper Industry

- There is a shortage of raw material, including bamboo and sabai grass.
- Cost of production is high due to labour troubles, low grade of coal used and high transportation costs.
- The current per capita consumption of paper and newsprint in India is too meagre.
- Only 15 per cent of the total output of paper and paper board is based on recycled material against the world average of 30-35 per cent.
- Even now, large quantities of bagasse used as fuel in the sugar industry is not made available to the paper industry.
- The small size of the manufacturing units with obsolete technology makes them uneconomic.
- The cost of imported wood pulp and wastepaper is ever increasing.
- The production of paper, paper board and above all, newsprint has always fallen short of the demand.

- This has forced the country to resort to heavy imports. Pulp, paper, paper board, newsprint and wastepaper are imported from **Norway, Sweden, Canada**, etc.
- Effluents released by the paper mills into open drains and rivers cause severe environmental issues.

11.9. International lumber, pulp and paper imports and exports

Major exporters of forest products (2018)

- Sawn wood: Russia (20%); Canada (19%); Sweden (8%); Germany (6%); Finland (6%); U.S.A. (5%).
- Pulp for paper: Brazil (24%); Canada (15%); U.S.A. (11%); Chile (8%); Indonesia (7%); Finland (6%).
- Recovered paper: U.S.A. (34%); United Kingdom (8%); Japan (7%); Netherlands (5%); Germany (5%).
- Paper and paperboard: Germany (12%); U.S.A. (10%); Finland (9%); Sweden (8%); Canada (6%); China (4%).

Major importers of forest products (2018)

- Sawn wood: China (25%); U.S.A. (18%); United Kingdom (5%); Japan (4%); Germany (4%).
- Pulp for paper: China (35%); U.S.A. (9%); Germany (7%); Italy (6%).
- Recovered paper: China (31%); India (12%); Germany (9%); Indonesia (6%).
- Paper and paperboard: Germany (10%); U.S.A. (8%); China (5%); Italy (5%); United Kingdom (4%).

Source

12. Commercial Marine Fishing Industry

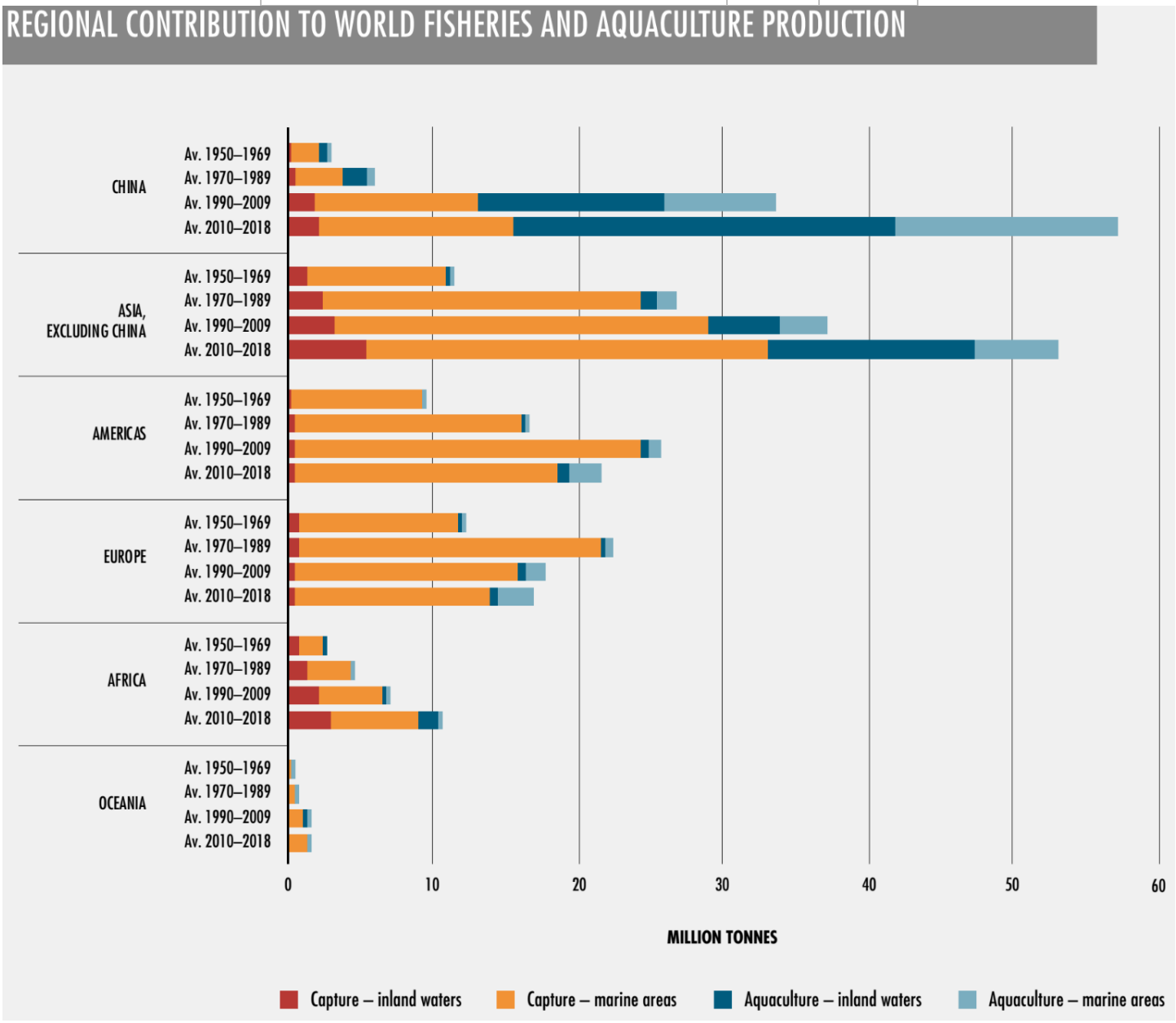
- **Aquaculture** involves cultivating aquatic (freshwater and saltwater) populations (fish, crustaceans, molluscs, shrimp, crab, etc.) under controlled conditions, and can be contrasted with **commercial fishing**, which is the harvesting of wild fish (fish, whales, seals, etc.).
- In 2018, an estimated 59.5 million people were engaged in the primary sector of fisheries and aquaculture.
- In total, about 20.5 million people were employed in aquaculture and 39.0 million in fisheries.
- World aquaculture production of farmed aquatic animals has been dominated by **Asia** (89 per cent share).
- **China, India, Indonesia**, Vietnam, Bangladesh, etc. are the major aquaculture producers.

12.1. Marine Capture Fisheries

- Commercially, marine fisheries are a lot more important than freshwater (inland) fisheries.

Production of fisheries & aquaculture	**2017**	**2018**
Capture		
Inland	11.9	12.0

Marine	81.2	84.4
Total capture	93.1	**96.4**
Aquaculture		
Inland	49.6	51.3
Marine	30.0	30.8
Total aquaculture	79.5	**82.1**
Total world fisheries and aquaculture	**172.7**	**178.5**

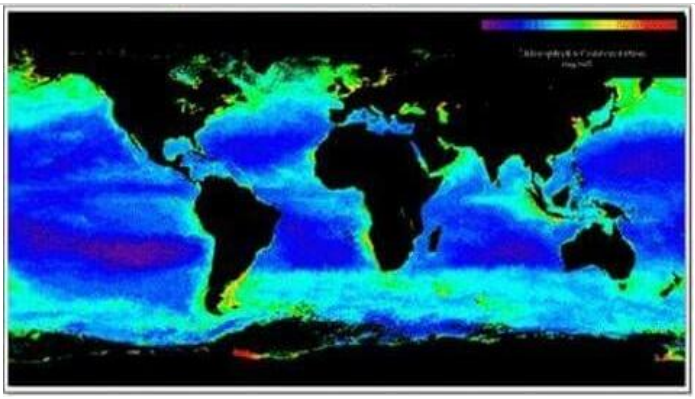


- **China, Indonesia, India, U.S.A., Russia, Peru, Japan, Vietnam, Norway**, Denmark, Canada, etc. are the major marine fishing nations.
- Tropical countries like Indonesia, India, Vietnam, etc. are mostly involved in intensive **inshore (near the shore)** fishing by small fishers and small to medium scale fishing trawlers.

- **China, U.S.A., Russia, Japan, Norway, Denmark**, etc. are focused on **both inshore and deep-sea fishing**.
- The deep-sea fishing operations are carried out by highly mechanized trawlers.
- Modern canning and **refrigeration** facilities have greatly helped the fish export trade of these countries.
- Canada, the U.S.A., Greenland, Norway, South Africa and Argentina are the major sealing nations.
- Japan, Norway & Russia are the leading whaling nations. Most of the whaling happens in the North Pacific.
- In recent years, whaling and sealing have decreased due to pressure from conservationists.

12.2. Factors that create the most fertile marine fishing grounds

Water temperature	• Marine life is best developed in oceans of the **high latitudes** whose waters are at temperatures lower than 20 °C. • This is because the fish feed on minute marine organisms called **plankton**, and the plankton multiplies best in **colder waters**. • **In the tropics, the warmer waters significantly inhibit the growth rate of the plankton population**. • Hence the **temperate and sub-polar seas (seas in the higher latitudes)** offer better fishing grounds compared to the tropics.
Ocean topography	• Plankton of all kinds are abundantly available in **shallow waters (continental shelves)** where they have **access to both sunlight as well as nutrients** (brought by rivers). • Hence the most exceptional fishing grounds are found above **continental shelves in the higher latitudes**.
Ocean water mixing and upwelling zones	• Plankton need both sunlight and nutrients (such as **nitrate** and **phosphate**) to be able to photosynthesize. • Sunlight is only available in the uppermost layers. • During photosynthesis, the nutrients are quickly used up by phytoplankton, so they are not available for long periods in the upper layers under normal circumstances. • To escape this problem, the seawater needs to be **mixed regularly** to bring the **nutrient-rich deep waters** up to the sunlight zone.

	 *Phytoplankton production is highest at high latitudes* • Furthermore, in surroundings where atmospheric temperatures are often colder than oceanic temperatures, the top layers of the ocean are cooled by the atmosphere. • This increases the density of the surface waters and causes them to sink and therefore causes mixing (nutrient-deficient water sinks and nutrient-rich water is upwelled). • Hence the **cold & warm current mixing zones (e.g. Grand Banks)** and **nutrient-rich cold water upwelling zones (e.g. upwelling near Peruvian coast)** form fertile fishing grounds.

12.3. Factors that determine the location of the commercial fishing industry

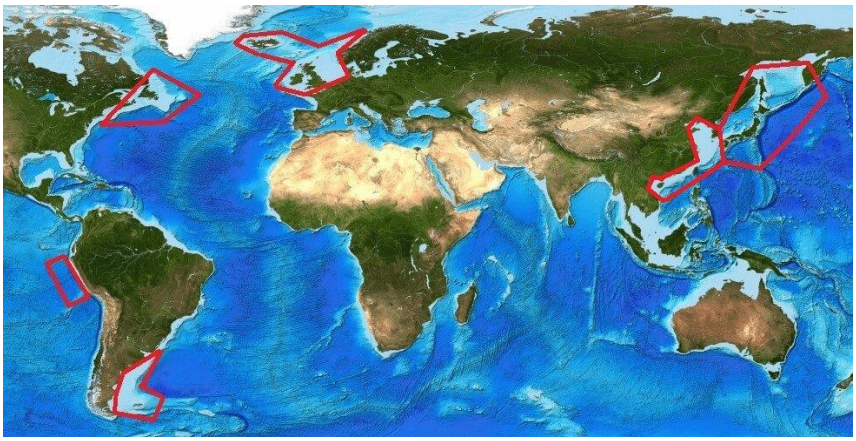
Proximity to the fishing grounds	• Proximity to the fishing grounds reduces refrigeration and transportation costs. • However, with the highly mechanized modern trawlers, proximity to the fishing grounds is no longer a significant factor. • For example, Japanese trawlers venture into waters as far as Antarctica & Grand Banks.
Climate	• The cold climate of the higher latitudes makes refrigeration (preservation and storage of fish) economical. • Whereas in tropics, the **warmer climate and higher humidity** (fungal and bacterial attacks) make preservation and storage (refrigeration) more expensive. • Hence the commercial marine fishing industry is less viable in tropics.
Ports	• Sheltered inlets and estuarine coasts make ideal sites for **fishing ports** and villages. • Both the **Atlantic and Pacific coastlines** of the middle and high latitudes in the northern hemisphere are very much **indented** and are backed by strong relief. • Here, ports exclusively for fishing industry are developed. The fishing ports have all the necessary infrastructure from processing to canning units. • Fishing ports make the fishing industry efficient and cost-effective.

Capital	• The commercial success of marine fishery depends on the cost optimization with the help of efficient technology. • Hence a lot of capital is required for R&D, mechanization and infrastructure. • Europe, Japan, U.S.A. and Canada have the requisite capital and well established financial services for the cost-intensive and risky marine fishery industry.
Market	• Fish are used as food, and raw material for fertilizers, lubricants, cosmetics, etc. • Seals and whales are hunted for meat, fur and oil. • Fish, fish meal, and fish waste are widely used as **animal feed and feed for aquaculture** and as **fertilizer** for paddy fields. • **Fish oil** represents the richest available source of **long-chain polyunsaturated fatty acids (PUFAs)**, which perform a wide range of critical functions for human health. **Fish as a primary food source** • Europe is a **net exporter of horticulture products** and a **net importer of food grains and meat**. • Fish meat is the most affordable option in many countries like **Norway** (hilly terrain; ice-covered land; little scope for agriculture and dairying; **most of the population living along the coast**). • Just like **Norway, Japan** has very few dietary alternatives to fish. **Fish as an essential part of the diet** • There is a great demand for fish along the North American coasts which are mostly inhabited by European settlers. • With the rapid economic development in Asia since the 1990s, fish is gaining a lot of importance as an inexpensive alternative to meat in the densely populated coastal regions. **The insignificant market in the southern hemisphere** • On the other hand, commercial fishing is not of prime importance in the southern hemisphere (**Peru, Falkland Islands are an exception**) where cattle rearing and dairying are more economical options. • (**Cattle rearing in Pampas of South America and Eastern Australia**, **dairying in New Zealand** and agriculture in South Africa).

Employment	• Lack of viable alternate employment opportunities in the primary sector since time immemorial has played a significant role in high dependence of **Japan** and **Norway** on the fishing industry. • Japan has high population pressure, hilly terrain & forests and very little cultivable land. • Norway is mostly hilly and experiences long, harsh winter months. • Hence, venturing into deep-sea fishing has remained the most practical and feasible primary economic activity for these countries.

12.4. The major commercial marine fishing grounds of the world

- The **continental shelves** of **North-East Atlantic, North-West Atlantic** and **North-West Pacific** are the most important global commercial fishing grounds.
- The **continental shelf around the Falkland Islands** and **upwelling zones** along the **Peruvian and Chilian coast** are other major fishing regions.



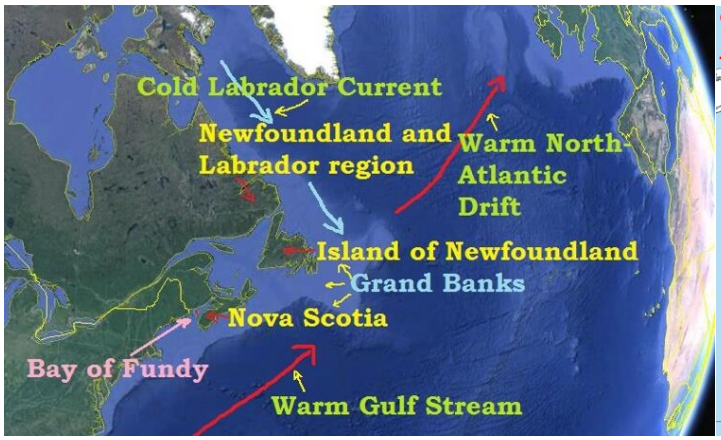
12.4.1 North-East Atlantic Region

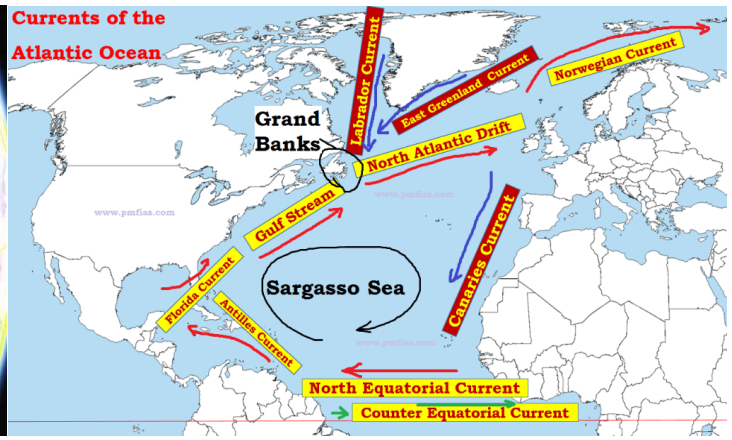
- Colder atmospheric temperatures, and warmer oceanic temperatures (influenced by warm **North Atlantic Drift**), cause mixing and nutrient upwelling in the North-East Atlantic Region.
- This explains the abundant fish resources in the region (**Iceland continental shelf & North Sea continental shelf**).
- Fishing is done on a highly organized basis by **Norway, Denmark, Spain, Iceland and the U.K**.
- Fishing goes on all round the year in the shallow waters of the North Sea.
- **Dogger Bank** is the most vigorously exploited region.

12.4.2 North-West Atlantic Region

- The North-West Atlantic Region extends from Newfoundland to the New England states of the U.S.A.

- Mixing of **warm Gulf Stream** and **cold Labrador currents** and **gently sloping continental shelves** makes the region around the **Grand Banks of Newfoundland** the **world's largest fishing ground.**





- The gently sloping continental shelves stretch for over 200 miles south-east of Newfoundland.
- Fish of all types and sizes feed and breed here and support a **thriving fishing industry.**
- In Newfoundland, the fishing industry employs almost the entire population.
- All the fishing activities are carried out by highly mechanized trawlers which can store fish in refrigerated chambers for months.
- **St. John's, chief port of Newfoundland** is the headquarters of the Grand Banks fishing industries.
- All processing activities like cutting, gutting, cleaning, packing (canning) are done at the ports itself.
- Along with Canada and U.S.A., countries like Norway, U.K., Portugal, Denmark, Russia and Japan, also send fishing fleets to the Grand Banks.

12.4.3 North-West Pacific Region

- The North-West Pacific Region extends from the **Bering Sea** to the **East China Sea**.
- **China** leads in the catch, followed by **Russia, Japan**, South and North Koreas.
- Within the enclosed seas — the **Sea of Okhotsk, Sea of Japan, Yellow Sea** and the **East China Sea** — intensive forms of inshore (close to the shore) as well as deep-sea fishing are carried out.
- In the case of inshore fishing, processing (gutting to meat cuts) and canning is done at the fishing ports.
- In deep-sea fishing, processing happens on the vessel, and the meat is **refrigerated** for canning at the ports.
- Commercial fishing is best developed in **Japan**, where the industry is very highly organized.

Pearl Fishery in Japan

- Natural pearls are derived mainly from oysters.
- It was the Japanese that invented cultured pearls in 1913.

- Young oysters are first collected, and grains of mother-of-pearl (the inner lining of oyster shells) are inserted into them. They are then placed in wire cages and lowered into shallow coastal waters.
- After about two to five years, these oysters will be collected, and the artificial pearls will be extracted.
- **Japan** is the leader in the production of artificial pearls.

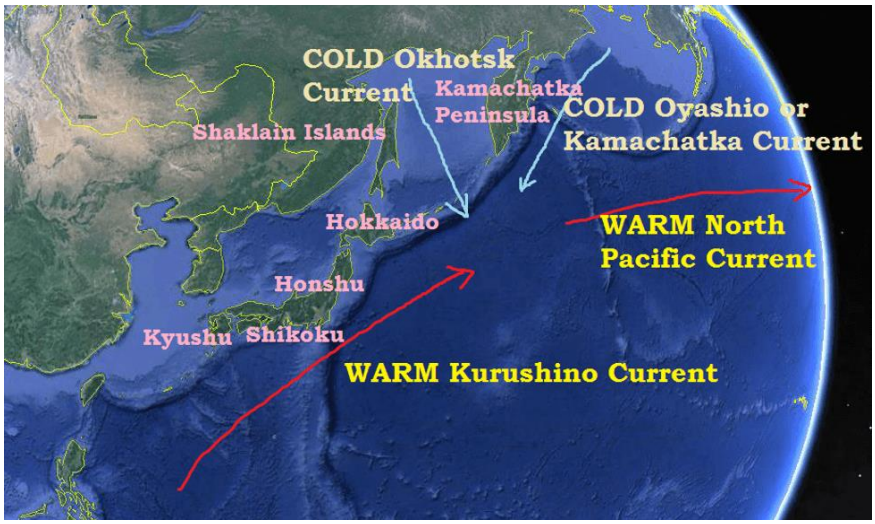
Why is fishing the dominant primary sector occupation of Japan?

Fishing is the only reliable primary sector activity

- The **rugged (mountainous) nature of Japan** and parts of mainland eastern Asia support little agricultural activity (80 per cent land in Japan is classified as 'non-agricultural'. Around 50% is covered by forests).
- Japan is **not well endowed with natural resources**.
- Hence fishing forms a dominant aspect of the primary economy.

Geographical advantage

- The continental shelves around the islands of Japan are rich in plankton, due to the meeting of the **warm Kuroshio** and the **cold Oyashio currents** and provide excellent breeding grounds for all kinds of fish.



Cold and warm ocean current mixing zone off Japan

- The **indented coastline of Japan** provides **sheltered fishing ports**, calm waters and safe landing places, ideal for the fishing industry.
- **Hakodate** and **Kushiro** are large fishing ports with complete refrigeration facilities.

Ready market

- The scarcity of meat (there is little pasture in Japan for livestock farming of any kind) popularised fish as the principal item of diet and the chief protein food of the Japanese and the Chinese as well.