2018

INTEGRATED LEARNING PROGRAMME, ILP

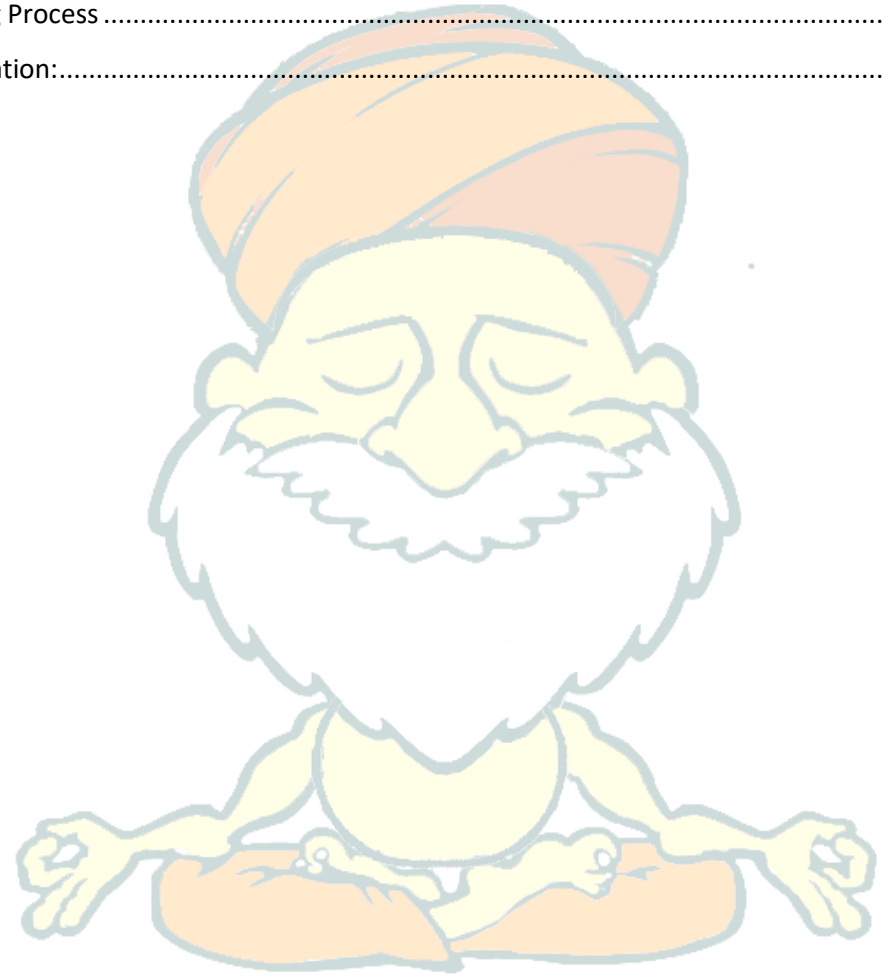
IASBABA



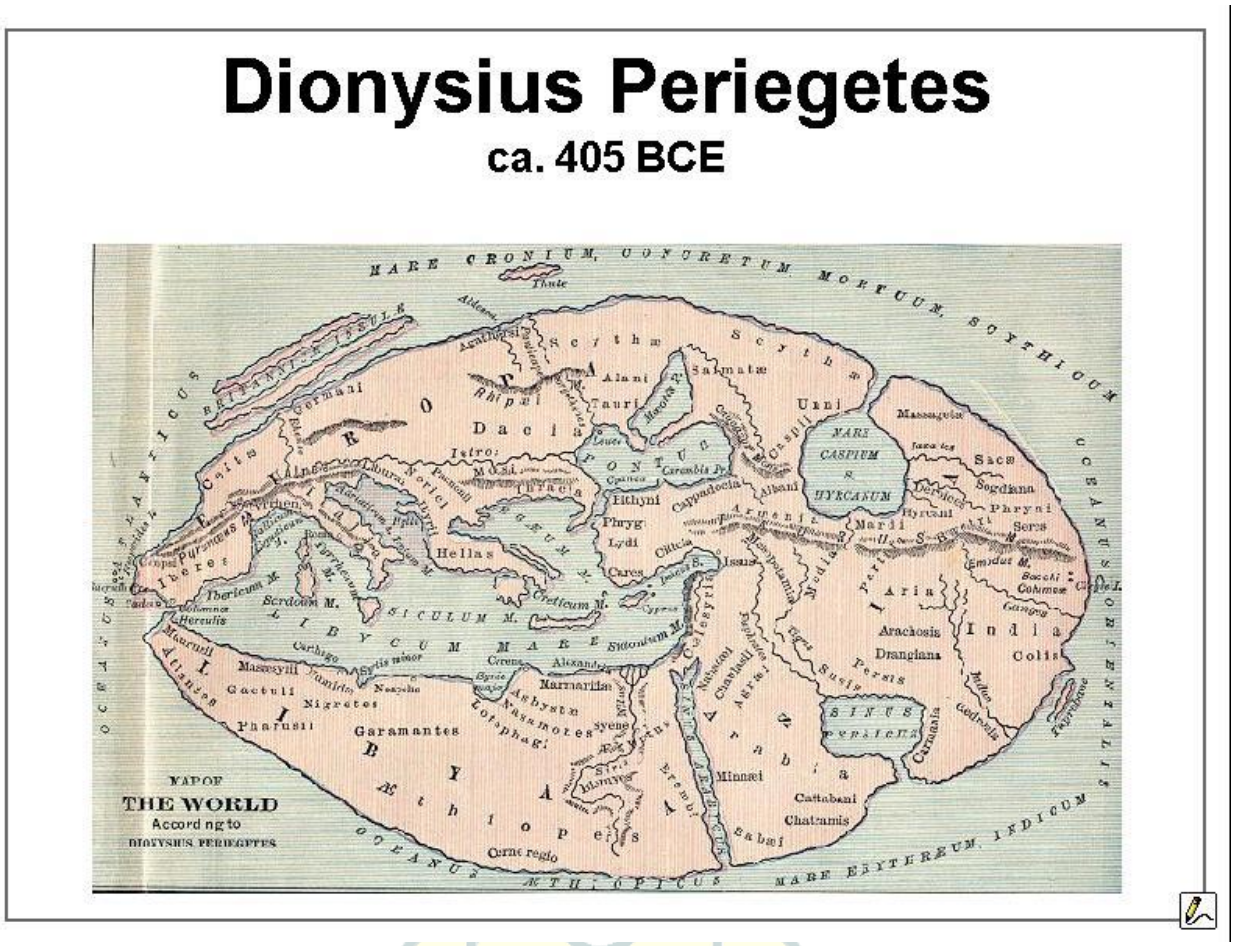
# [GEOGRAPHY-GEOMORPHOLOGY]

**Integrated Learning Programme 2018 is a step towards 'Enabling a person located at the most remote destination a chance at cracking AIR 1 in UPSC/IAS'**

# Contents



# Geomorphology




**One of the earliest maps made by Greeks**

Geography is one of the oldest subjects studied by humans. The early man used to study stars and naturals cycles to seek direction and for survival. Inherent Curiosity of humans lead them to seek answers of natural phenomenon which they could not explain. Later Greeks started a systematic study of landscape started cartography (map making). Voyages and trade later lead to new discoveries and findings. Eventually the spectrum and ambit of geography expanded and not only the natural features but the reasons of their formations were also studied.

**In modern times, four dimensions of earth are studied under physical geography.**

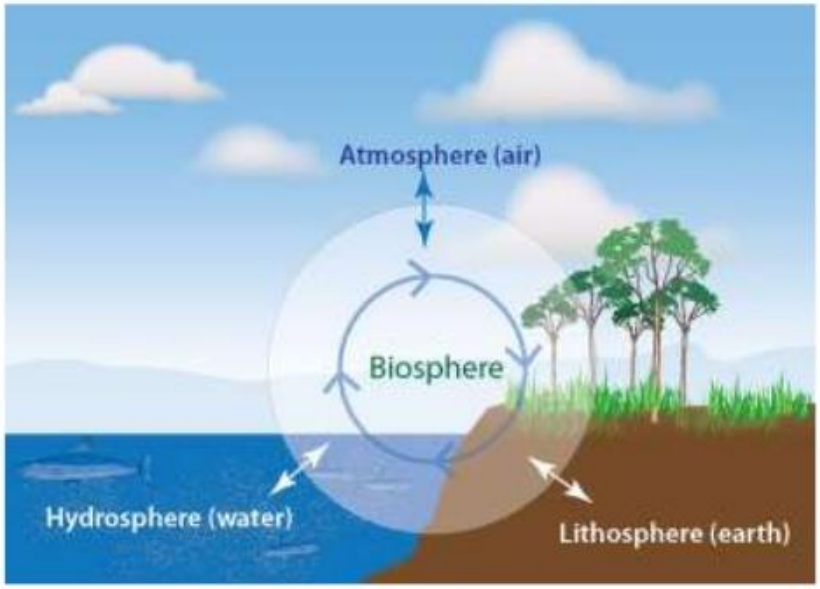
1. Geomorphology
2. Climatology

3. Oceanography
4. Biogeography

Now after the realisation of the impact of humans on the physical environment, Environment geography has also become an integral part of physical geography.

## Four great earth realms:

The natural systems that we study, occurs in four great realms or spheres – atmosphere, lithosphere, hydrosphere and biosphere.




**The atmosphere:** It is the gaseous layer that surrounds the earth. It receives heat and moisture from the surface and redistributes it returning some heat and all moisture to the surface.It also supplies vital elements- carbon, hydrogen, oxygen, nitrogen-that are needed to sustain life forms. Atmosphere and all atmospheric phenomenons are studied under **climatology.**

**The lithosphere**: it is the outer most solid layer of the earth. It provides platform to most earthly lifeforms. The solid rock of lithosphere bears a shallow layer of soil in which nutrient elements become available to the organisms. The surface of lithosphere is sculpted into

different landforms-mountains, valleys, plains etc. providing various habitats to living organisms. The lithosphere and its structure is studied under **Geomorphology.**

**The hydrosphere**: It is the liquid realm, principally the mass of water in oceans. It also includes the solid ice of the mountains and continental glaciers. In atmosphere the water is found as vapours and ice crystals .In lithosphere the water is found in the upper most layers of soil and also underground water. It is studied under **Oceanography**.

**The Biosphere**: It encompasses all the living organisms of the earth. Lifeforms on earth utilises the gases of atmosphere, water of hydrosphere and nutrients of lithosphere. Hence it is dependent on all other three great realms.

## Scales in physical geography:

The process of four realms occur at various scales-

**Global scale**: it considers the planet and its global energy balance as a whole and view the sun and the earth from a vantage point far from the earth itself.

**Continental scale**: the suns energy is not absorbed uniformly by the earth's land and water surface. Unequal solar heating produces currents of water and air. These currents continue the global atmospheric and oceanic circulation system. To study this system we need to look at it at continental scale, where we can distinguish continents and oceans and track winds and ocean currents.

**Regional scale**: study of different climates of the world.

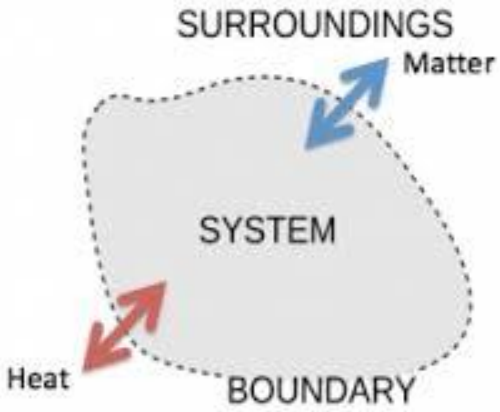
**Local scale**: regional climate influence the natural vegetation but the exact pattern is determined by the local factors.

**Individual scale**: landscape features, type of soils, moss covered bank of rivers etc. can be studied on individual scale.

**Note: In the coming chapters of this study material systematically every chapter will start at the global scale and chronologically will end on an individual scale so that reader can relate the global phenomenon with the local phenomenon. Sometimes a subject becomes difficult when we don't know how to approach it properly. Many books including NCERTs are not written in a lucid and scientific manner. We, at IASbaba, not only want you to learn a subject, but enjoy and appreciate the beauty of it.**

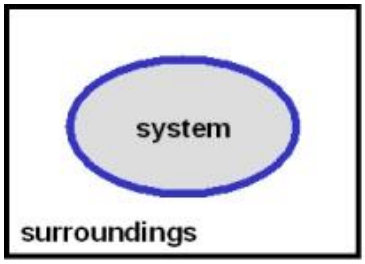
**So from now on in Geography try to relate things from a perspective of scales. ☺**

## Systems in physical geography:

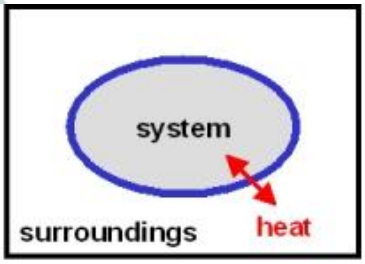



Systems approach is very important for a scientist who studies natural processes – geographers, geologists etc. as their ability to conduct experiments is limited. They must do their work largely by treating earth as their lab, as even the smallest ecosystem is too complex to be replicated in a lab. Using a systems approach they can understand the components and connections with in the systems and can understand and predict the systems as whole.

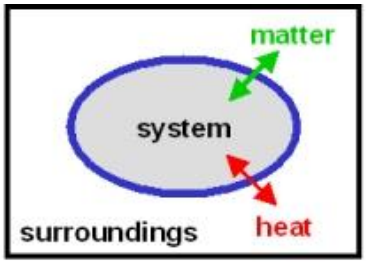
"System" typically means a set or collection of things that are somehow related or organised. Eg. Solar system etc. however, a specific type of system is referred as a flow system in which matter, energy or both move through time from one location to another. Understanding flow system is important as it explains how things are connected and that is how they are related and influence each other.




"Isolated" system:
- no exchange of matter
- no exchange of heat




"Closed" system:
- no exchange of matter
- can exchange heat energy




"Open" system:
- can exchange matter
- can exchange heat energy

# Interior of the earth

**“Curiosity killed the cat”…. but fortunately it made man make amazing Discoveries.**

For a very long time scientists have been trying to find the exact information about the interior of the earth. What is its physical state, chemical composition, density, temperature etc. But till now exact answers of these questions are not known.

To know about the interior of the two approaches have been used-

- Direct
- Indirect

**Direct methods** means physically seeing the internal layers of earth. It includes drilling, mining, volcanic, eruption, oil rigs etc. but none of these methods are conclusive. The deepest hole in the earth surface (a drill hole) is only about 12km deep at the **Akola peninsula near the White Sea in Russia**. This is nothing as compared to the radius of the earth which is estimated to be 6371km.

**Akola peninsular superhole**

**Indirect methods** means extrapolating the interior of the earth by indirect study. It includes study of meteorites and seismic waves.

Our earth is made up of the same material of the cosmos, the chemical structure and compounds found in the meteor can help in understanding the structure of earth or how was the structure of earth in the early period of its formation.

The most important and reliable method to understand and predict the interior of earth is through the study of **seismic waves.**

**Siesmic waves:** Seismic waves are generated due to release of energy during an earthquake. They behave differently in different physical mediums and provide a good idea how the interior of earth must be.

Broadly three types of waves are generated during an earthquake-

1. Primary (P) waves
2. Secondary (S) waves
3. Surface waves

Before we study the action of seismic waves, let's understand what exactly waves are!!

The most common example of waves observed by us is the waves on the surface of Water. It we hit surface of water (which is at rest) in a swimming pool with our hand, waves are generated on the surface. This happens as energy is transferred from our hand to the water. This energy is transferred from a medium in the form of waves. Hence we can conclude that **through any medium energy is transferred in the form waves.**

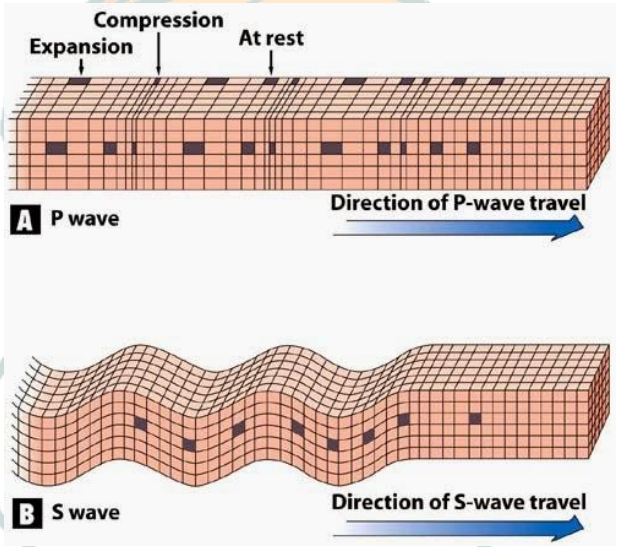
Also in this case if we put some paper pellets on the surface of the water we will observe that the particles are moving up and down with crest and trough of wave but they are not moving forward with the wave. This shows **that in propagation of wave the actual particles of the medium are not transported. They merely oscillate at their own place and transfer the energy.**

In similar fashion when an earthquake occurs, a large amount of energy is released. It comes out in the form of sound and seismic waves. The seismic waves transport the energy in the earth from one point to other.

Primary waves: P – waves are longitudinal waves. i.e. The motion of particles is in the direction of the propagation of the wave. These waves are the fastest of the three and are detected first. They have the shortest wavelength and highest frequency. They can travel in solid, liquid and gaseous medium.

Secondary waves: They are transverse waves i.e. the motion of the particles is perpendicular to the direction of the propagation of the waves. They are slower than P –waves. They have relatively longer wavelength and lower frequency than P – waves. These waves can travel only in solid medium.

Surface waves: they are the slowest and are detected quite late. They travel only in upper layer or earth surface. They are the most destructive of the three waves. Even the surface waves are of two types – the one travelling in upper crust are called LOVE waves and the one travelling in lower crust are called RAYLEIGH waves.

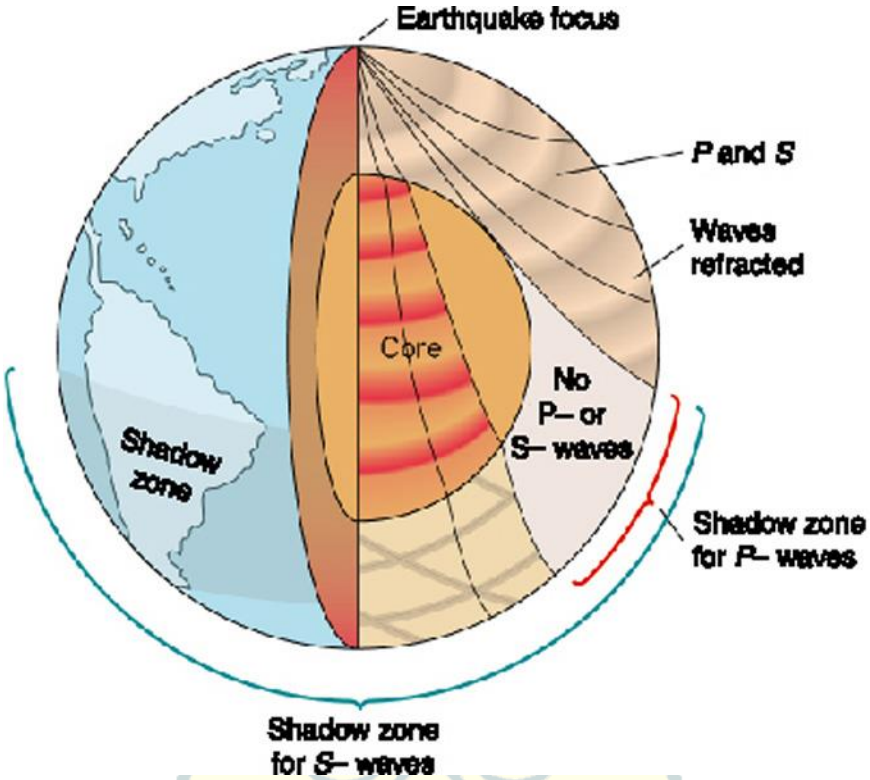



## Seismic Wave model:

Following points show how seismic waves contributed to our current model of layered earth –

a) If the earth were homogenous throughout, seismic waves would travel in straight line paths at constant speed. But as it is observed the waves travel in a curved path showing an increase of density as we move in. Also the waves travel much faster than the predicted speed, again showing the increase in density.

b) The earth has a dense core producing a shadow zone in which no seismic wave are detected. Shadow zone of P- waves are detected from 103 to 143 degrees, while shadow zone for S-waves is detected above 103 degrees as shown in the figure.




c) The pattern of the reflection and refraction of waves shows the presence of layers of different discontinuities of different densities and states. They also show marked discontinuities.

Analysing the above results, model of earth is predicted.

**The Following Video will help you understand the interior of earth nicely. Do watch it.**

**https://www.youtube.com/watch?v=sKZELJDr-4k**

**Classification based on chemical composition and density**

**(1) Crust:** The outer most layer or shell of the earth is known as earth's crust. On an average it is 30km deep. It can be up to 70km under high mountains and up to 8km under ocean. It represents less than 1% of earth's total volume and its average density is 2.7 gm/cm3. It is known as 'sial' because of abundance of silicon and aluminium. It is also divided into upper and lower crust divided by **Connard discontinuity.**

(2) **Mantle:** The second layer of earth is called mantle. It is separated from crust by **Mohorovicic discontinuity**. Its density ranges from 3.3 to 5.7. It is made of dense and rigid rocks which have the predominance of magnesium and silicon, known as

'sima'. It is also separated as upper mantle up to 700km and lower mantle from 700 to 2900 km. The upper and lower mantle is separated by **Repetti discontinuity**.

**(3) Core:** The innermost layer is called core. It is separated from mantle by **Gutenberg** discontinuity. It lies from 2900 km to 6371 km. The density of core varies from 9.5 to 14.5gm/cm3. It is called 'nife' as it probably contains alloy of Nickle and iron. It also has two parts – a liquid outer core separated by inner solid core at 5150km by **Lehman discontinuity.**

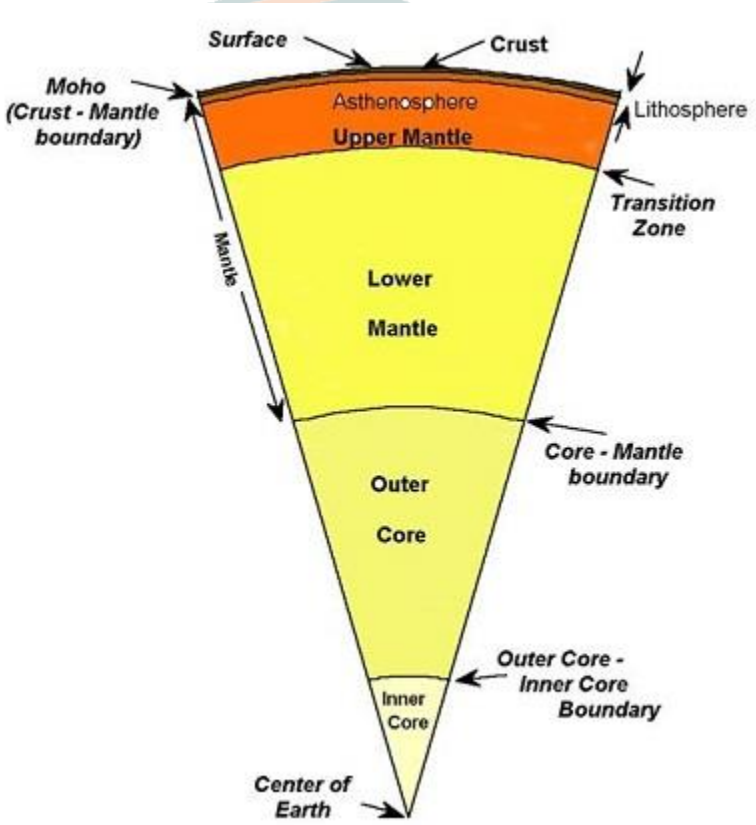



**Fig: interior of the earth.**

**Classification based on physical state:**

1. **Lithosphere:** The top most solid layer is called lithosphere. It is up to 100 km deep including crust and some portion of upper mantle.
2. **Aesthenosphere:** It is the second plastic layer under lithosphere. It stretches from 100 km to 400km.
3. **Mesosphere:** It is an intermediate layer lying from 400km to 700km in depth.

4. **Pyrosphere:** It includes semi solid lower mantle and outer liquid crust. Because of very high temperature it gets its name. 'Pyros' means fire.
5. **Barrysphere:** It is the inner most solid core of the earth stretching from 5150km to 6371km.

# Shape of the Continents

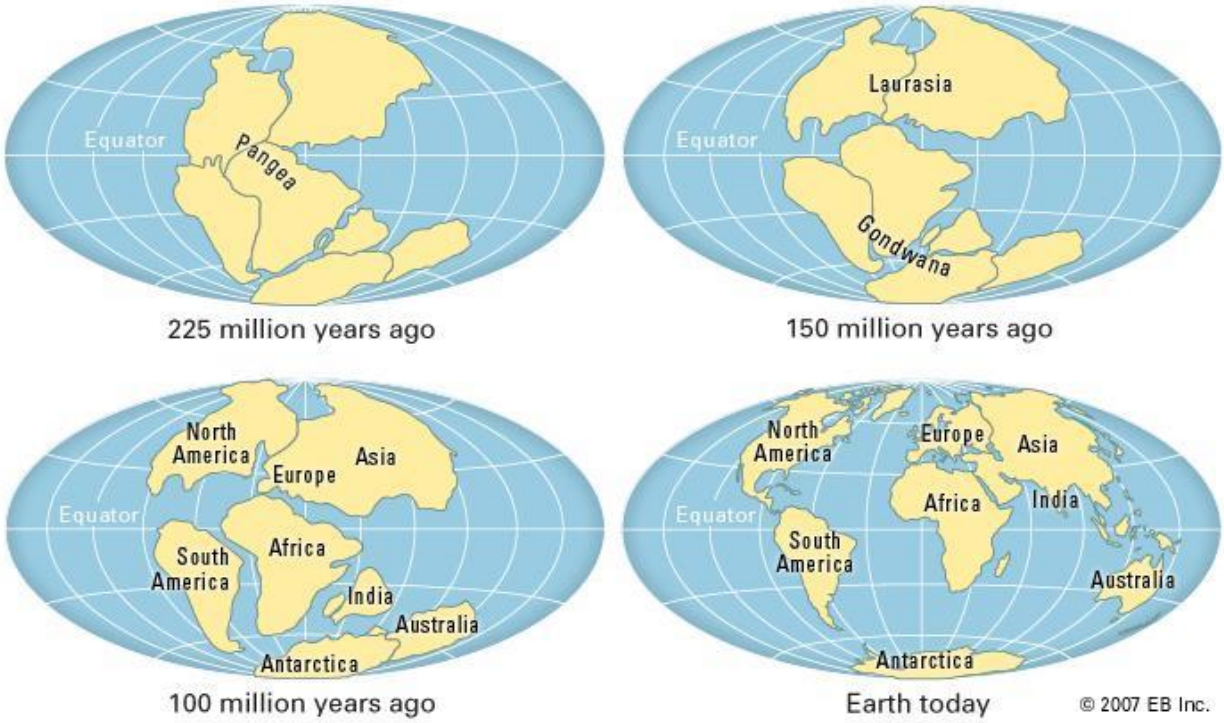
## Continental drift

The theory of continental drift was put forth by Alfred Wegener, a German meteorologist, polar explorer, astronomer and a geologist. He is in fact known as the father of continental drift.

In a lecture in 1912, Wegener proposed a startling theory of 'continental drift'.

**Postulate:**

He postulated that all the earth's land had once been joined into a single supercontinent surrounded by an ocean. He named this land mass **"Pangaea" (** pan = all, gaea = earth) and the ocean **"Panthalassa" (**pan = all, thalassa = ocean). According to the theory this continental mass started breaking up about **200 million years ago**. Since then the pieces had moved to their present positions and are still moving.



Wegener was drawn to this idea because of the puzzling questions he had in his mind.

(i) How could tropical ferns have grown in London, Paris, bonn and even in Greenland?
(ii) Why are the coal belts found in extremely cold regions of tundra?
(iii) How are glacial evidences found in tropical regions of Brazil, Indian peninsula, Australia and Congo basin.

While pondering over these points he came up with two possibilities:

(i) The climatic zones might have shifted from one region to another while the continents stayed at their places.
(ii) If the climatic zones stayed stationary but the continents changed their places.

**As it was difficult for the climatic belts to shift as they are controlled by the position of the sun i.e. tilt of the earth, it appeared more probable that the land masses were shifted.**

**Direction of drift**

According to Wegener, the continents drifted in two directions:

- Towards the equator
- Towards the west

**Towards the Equator:** The reason of the equator ward drift was attributed to the rotation and the equatorial bulge of earth while the westward movement was due to the gravitation pull of the moon and the sun.

On account of equator ward drift ,Africa and Eurasia were pushed closer together and the Tethys sea deposits located in between the two were raised in the form of folded mountains of Alps, atlas, teinshan, Zagros, Hindukush and Himalayas. The peninsula of India and Africa was separated from Australia and Antarctica.

**Towards the west:** On account of the westward drift, north America and south America got separated from Europe and Africa and Atlantic ocean came into existence.

**Evidences in support of continental Drift**

(i) **"Jig saw" fit-** Wegener was struck by the geographical similarity between the opposite coasts of the Atlantic Ocean. The outlines of the two coasts appears to be the detached portion of the other ie. The east coast of north and South America can be exactly fit into the left coast of Africa and Europe.

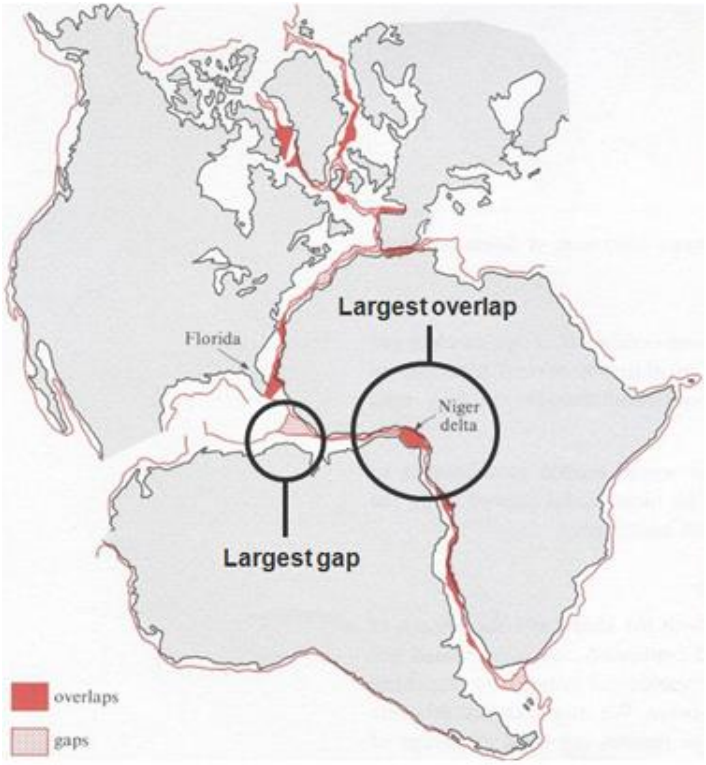



**Fig: showing the Jig – saw fit**

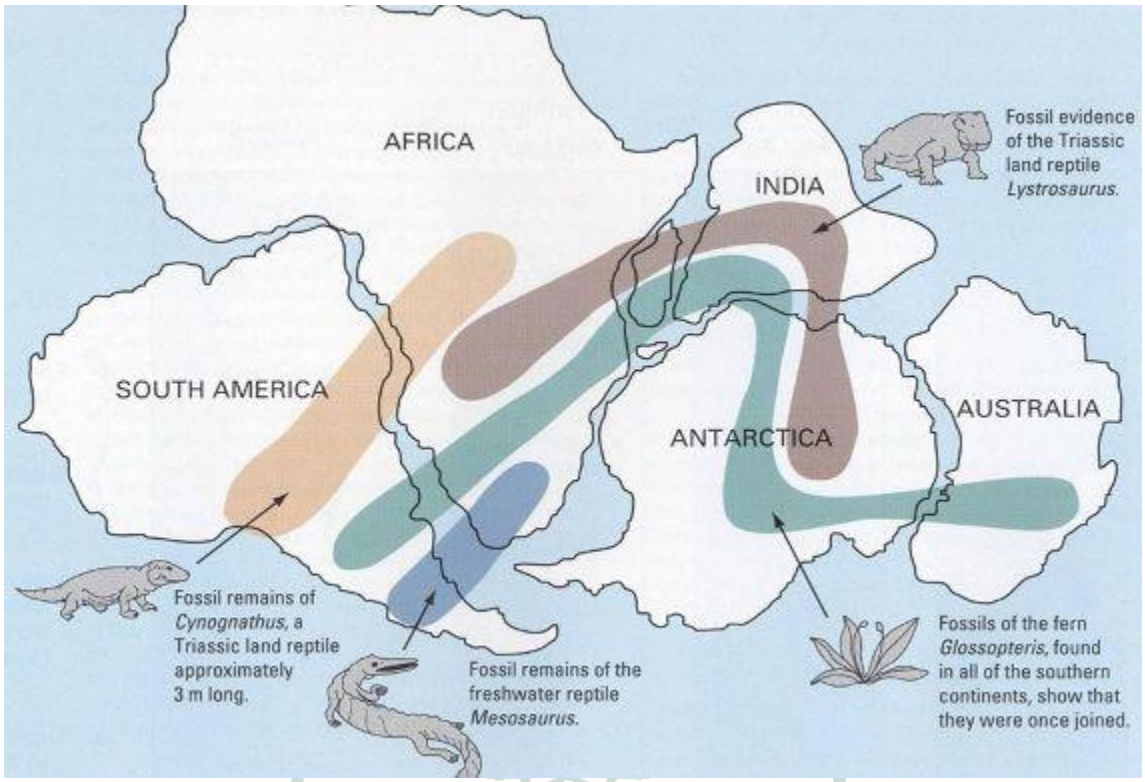
(ii) **Geological structure-** there is remarkable similarity in geological structure along the two coasts of Atlantic. The best example is provided by the Appalachian mountains of North America which come right up to the coast and continue their trend across the ocean in old Hercynian Mountains of south west Ireland, Wales and central Europe. The opposite coasts of Africa and Brazil display even greater resemblance in their structure and rocks.


**Fig: Similar Geological structure**

(iii) **Permo-carboniferous glaciations-** it presents a strong proof that at one point of time these land masses were assembled together , since the evidences of this glaciation are found in Brazil, Falkland island, South Africa, Indian peninsula as well as Australia. It is difficult to explain these extensive glaciations on the basis of existing distribution of landmass and water. According to Wegener at the time of Pangaea, the South Pole was situated near Durban of the present coast of South Africa.

(iv) **Similar Fossil** remains of terrestrial animals are found on both coasts of the Atlantic. This cannot be possible if the two landmasses were not joined as it quite impossible for these animals to swim across the Atlantic.

**Note: Here the term 'terrestrial' is important. Had they been marine they would have swam across the ocean. But it is hardly possible for a terrestrial animal to swim across the ocean to die on the other coast.**




(v) The migratory pattern of some animal species also hints towards the joined land mass. For example the entire lemming (a rodent) population crosses the North America and falls in the Atlantic. This is estimated that they have not forgotten their route, when the landmasses were joined, the might have travelled to Europe and central Asia.

**Criticism of Continental Drift**

The continental drift theory was undeniably convincing. But so much of the theory was based on speculation and inadequate evidence. It provoked a lot of criticism and controversy.

The greatest criticism of this theory was due to the controversial forces which were stated to have caused the drift.

- According to experts had the gravitational force of moon or sun was so strong to cause the landmass to break, than it would have stopped the rotations of the earth and made it stationary.

- Also in order to cause a drift in landmass the rotations required should be at such a high speed that it would have thrown the atmosphere (the gases) and everything else in the outer space away from the earth's gravitational pull.

**A beautiful Video to understand the Continental Drift:**

**https://www.youtube.com/watch?v=Wq9kLzm36h0**

## Sea – floor spreading:

The hypothesis of sea floor spreading was put forward by H. Harry Hess in 1960. This was a new development which again proved the theory of continental drift.

**Note: Before you read further, just think of an answer to this question. Where do you think you will find the oldest rocks, continent or the Ocean floor?**

**90% of you will think that they are found on the ocean floor.**

It was believed that the age of the rocks of the ocean bed is greater than the age of the rocks found on continents. But in reality it was the other way round. The age of the oldest rock has been estimated to be 3.9 billion years in Canada. On contrary, the age of the oldest rock in the sea bed has been found to be not more than 200 million years which is relatively very young.

Also a remarkable feature of the oceanic surface was the interconnected mountain ranges (ridges) whose formation was not explained till then.

In the opinion of Hess, the submarine ridges or the mid oceanic ridges were the direct result of the upwelling flows of the magma from hot areas in the upper mantle and perhaps deeper sources. When the mantle convection brings magma up to the crust, the crust is fractured and magma spills out and cools to form a new sea floor, building the ridges and spreading laterally.

**Some important facts were established by the geologists about the floors of the ocean-**

(i) The crust below the ocean floor was found only 7-8 km thick.

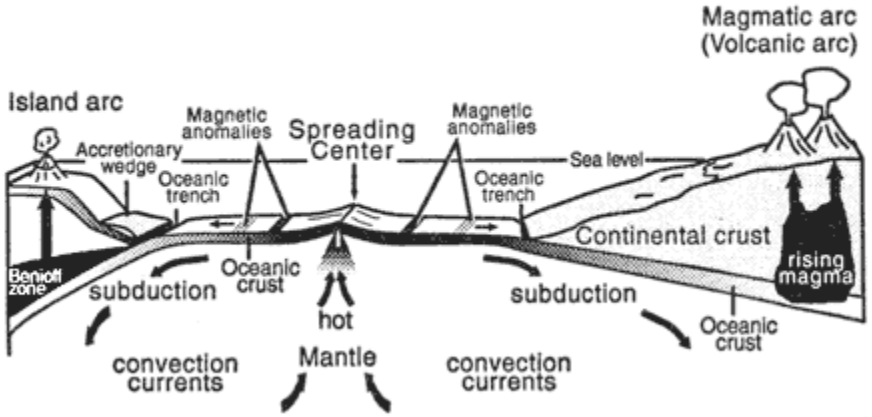
(ii) The existence of mid Atlantic ridge was known, but it was found that mid oceanic ridges are present in every ocean and they are subjected to earthquakes and volcanic eruptions.

(iii) The rocks of the ocean floor were found not older than the cretaceous period anywhere (about 200 million years).

(iv) The normal and reverse magnetic anomalies are found in alternate manner on either side of the mid- oceanic ridges.

(v) The youngest crust is at the mid oceanic ridge. With increasing distance from these centers, earth's surface is increasingly older. The oldest seafloor is found near Japan in western pacific called the Pigafetta basin.

**Sea Floor Spreading**




On the basis of the above discoveries, Hess postulated that the ocean floor is moving. The hot magma rises up along the mid oceanic ridges due to convection currents and the floor moves away on either side of the ridges and finally gets lost in the ocean trenches situated along the continental margins. It is through this process of spreading that the ocean floor has been built. In other words, the ocean floor is relatively new feature which is constantly being built , regenerated , subjected to constant lateral spreading and finally is destroyed in trench systems and becomes re-incorporated in to the mantle.

**A conversation between a Trench and a Ridge:**

**Trench**: Hey Ridge!! Watsupp dude??

**Ridge**: Nothing.. same old.. same old.

**Trench**: What are you up to these days?

**Ridge**: As usual.. I am making new oceanic crust. See I am getting taller every day. What are you doing?

**Trench**: Nothing dude.. I am busy eating the old crust.. You see it has to be recycled.. to maintain the balance. Sometimes when I am not able to digest it, I throw it out from a Volcano.
**Ridge**: Ohh you are doing a brilliant job!! What are people doing these days??

**Trench**: Well, 99.99% of them, those who have got a life, they don't care about us. The rest who are burning their jawani for UPSC are reading our conversation… :P :P

## Plate Tectonic Theory:

The term plate tectonics was first used by Tuzo Wilson of the University of Toronto but the theory of plate tectonics was first published by **W.J Morgan** of the Princeton University in 1962. This theory is based on the concept of 'sea- floor spreading' advocated by Hess. It is an improvement over the Wegener's continental drift theory and has been considered as the most sophisticated and comprehensive theory about the drift of continents and expansion of sea floors.

According to this theory **the lithosphere is believed to have been broken into fragments which are in constant movement with respect to each other**. The movement of these plates is attributed to the convention currents being generated in upper mantle. The margins of the plates are the sites of considerable geologic activity such as sea floor spreading, volcanic eruptions, crustal deformation, mountain building and continental drift.

Tectonics is derived from the world *tektonikos (greek)*, meaning building or construction, refers to deformation of the earth's crust as a result of internal forces.

**Lithospheric plates:**

A plate is a broad segment of the lithosphere (crust + rigid upper mantle), that floats on the underlying asthenosphere and move independently of the other plates. Broadly they can be

classified into continental plates and oceanic plate. La Pichon divided the earth into seven major and nine minor plates.

| Major plates | Minor plates |
|---|---|
| African Plate | Arabian plate |
| North American plate | Bismark plate |
| South American plate | Caribbean plate |
| Antarctica Plate | Carolina plate |
| Australian plate | Cocos Plate |
| Eurasian plate | Juan de Fuca Plate |
| Pacific plate | Nazca plate |
| | Philippines plate |
| | Persian Plate |
| | Anatolian Plate |
| | China plate |
| | Fiji plate |

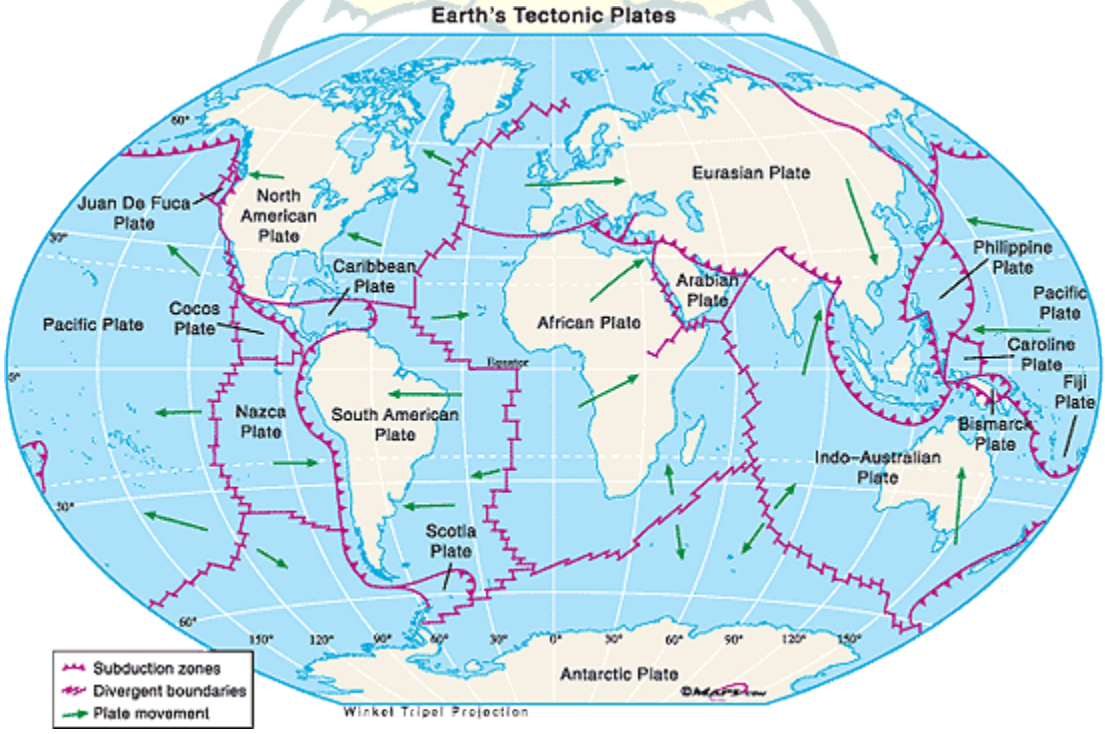



**Fig: showing the global plates**

Most of the plates include both continental and oceanic crusts. The area of the places is fairly large in comparison to their depth and thickness. It has also been established that the depth of the plates is even less under the oceanic crust.

Three types of motion are possible between the plates:

(i) **Separation or divergent or constructive plate margins**
(ii) **Closing together or convergent or destructive plate margins**
(iii) **Transform or conservative plate margin**

## Different types of plate boundaries

| Type of Margin | Divergent | Convergent | Transform |
|---|---|---|---|
| **Motion** | Spreading | Subduction | Lateral sliding |
| **Effect** | Constructive (oceanic lithosphere created) | Destructive (oceanic lithosphere destroyed) | Conservative (lithosphere neither created or destroyed) |
| **Topography** | Ridge/Rift | Trench | No major effect |
| **Volcanic activity?** | Yes | Yes | No |

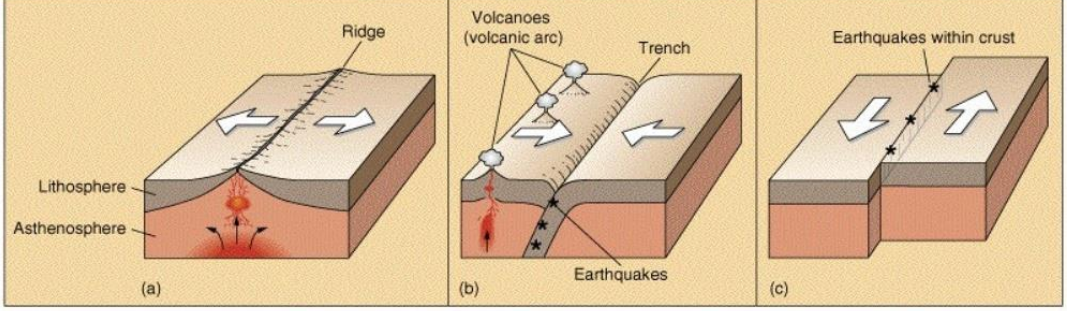


**Plate margins or boundaries and related landforms:**

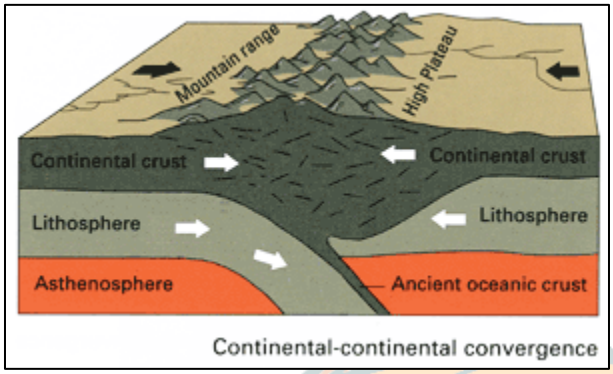
**Note: Study the following table very carefully. If you can understand and remember the following table, you will be able to explain the formation of all the secondary reliefs.**

| **Plate boundary** | | **Plate movement** | **seafloor** | **Events observed** | **examples** |
|---|---|---|---|---|---|
| Divergent plate boundaries | Ocean - ocean | apart | Forms by seafloor spreading | Ridge forms at spreading center. Plate area increases. Many small volcanoes and earthquakes | Mid Atlantic ridge, east pacific rise |
| | Continent -continent | | New ocean basin may form as the continent split | Continent drifts apart, ocean may intrude. Formation of rift valleys and block mountains | East African rift. |
| Convergent plate boundary | Ocean - continent | together | Destroyed at subduction zones | Dense oceanic lithosphere plunges beneath less dense continental crust. Earthquake traces path of down moving plate as it descends into asthenosphere. A trench is formed. Subducted plate partially melts and | Western South America |

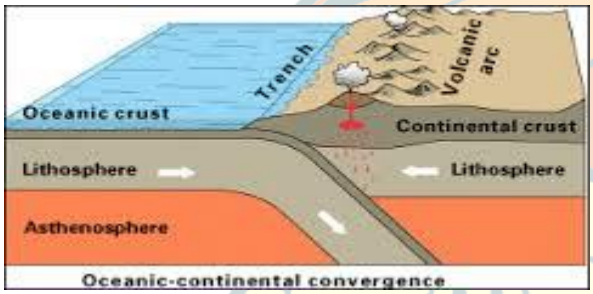
| | | | | | |
|---|---|---|---|---|---|
| | | | | magma rises to form continental volcanoes. | |
| | Ocean - ocean | | Destroyed at subduction zone | Denser crust plunges into lighter crust and is subducted forming a curved trench and a volcanic arc. | Aleutians |
| | Continent-continent | | **NA** | Collision between masses of gigantic continental lithosphere. Neither mass is subducted. Plate edges are compressed, folded and uplifted | Himalayas, alps |
| Transform plate boundary | | Past each other | Neither created nor destroyed | A transform fault is formed where plates move past each other. Strong earthquakes along the fault | San Andreas fault. |

**Table: Characterstics of plate boundaries.**

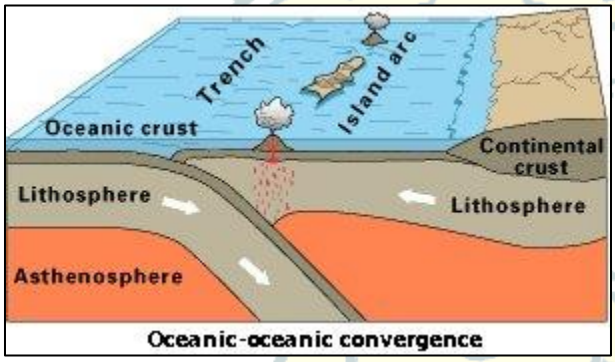
**Convergence:**



Continental-continental convergence



Oceanic-continental convergence

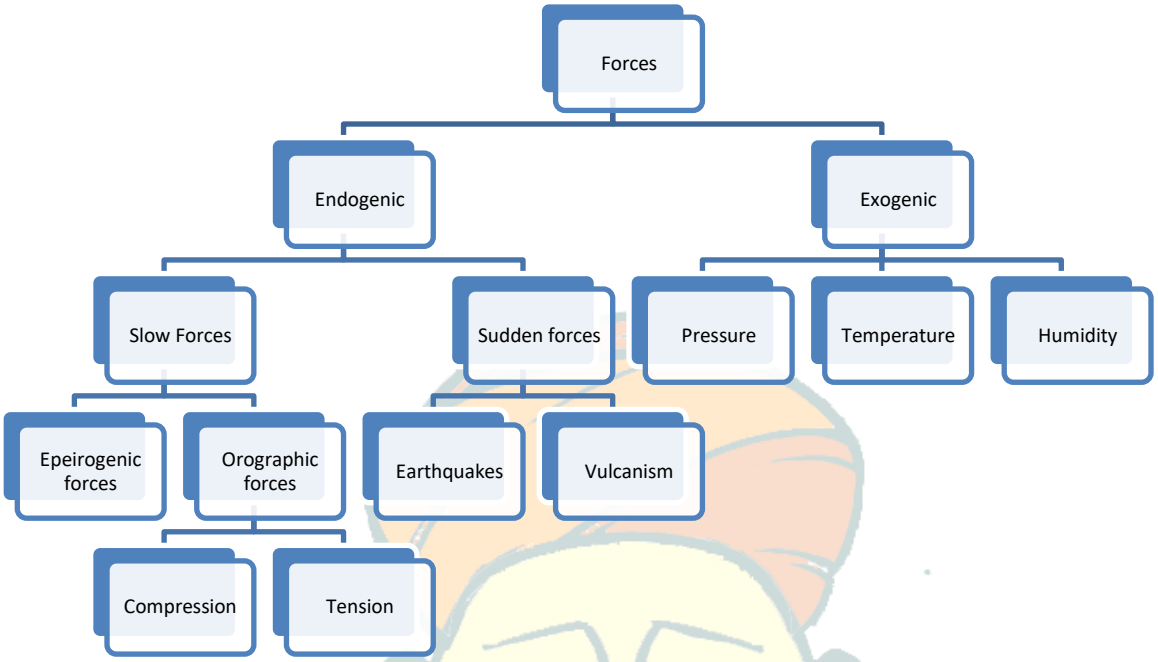


Oceanic-oceanic convergence

**National Geographic has come for our rescue once again. Watch the following video.**

**https://www.youtube.com/watch?v=QDgskltCixA**

# Forces responsible Geomorphic Processes:




**The above table will make you understand the type of forces acting together to shape our earth.**

Broadly the geomorphic forces are classified as Endogenic forces and Exogenic forces.

## Endogenic Forces:

Endogenic forces are the **internal forces** which are responsible for the formation of new undulations on the surface of the earth. Since they create new landforms they are also known as the **Forces of Construction.**

**They are the result of the convectional currents formed in the mantle. The source of this heat is the primordial heat of the interior and radioactive decay of elements.**

They can be broadly classified into slow forces and sudden forces.

**Slow forces are of two types – Epierogenic and Orographic.**

**Epeirogenic Forces:** These forces acts vertically and leads to upwarping and downwarping of the continents i.e. a large continental mass is pushed upwards and downwards. They are extremely slow forces. The landforms created by them are called Primary reliefs.

**Orogenic Forces:** These forces are mountain building forces. They act horizontally (Compression and tension) and causes folding, faulting and Vulcanism. The landforms created by these forces are called secondary reliefs. There are three types of mountains found on earth on the basis of formations, Fold Mountains, Block Mountains and Volcanic Mountains. Where these features are found and how have they formed can be explained with the help of plate tectonic theory which has already been discussed. The individual processes of folding, faulting and volcanism are discussed in the next section of this module.

## Exogenic Forces:

These are the external forces which degrades the existing landforms. As the role of endogenetic forces is to create new undulations, the role of exogenic forces is to remove them and make the surface planar. Three factors acts simultaneously – **pressure, temperature and humidity** to break the uplifted areas and fill the low lying areas. The landforms created by them are called tertiary reliefs. Endogenetic and Exogenetic forces keep working together to maintain the equilibrium.

Exogenic Forces are responsible for three types of processes:

- **Weathering**
- **Mass wasting**
- **Erosion and decomposition**

# Folding and faulting:

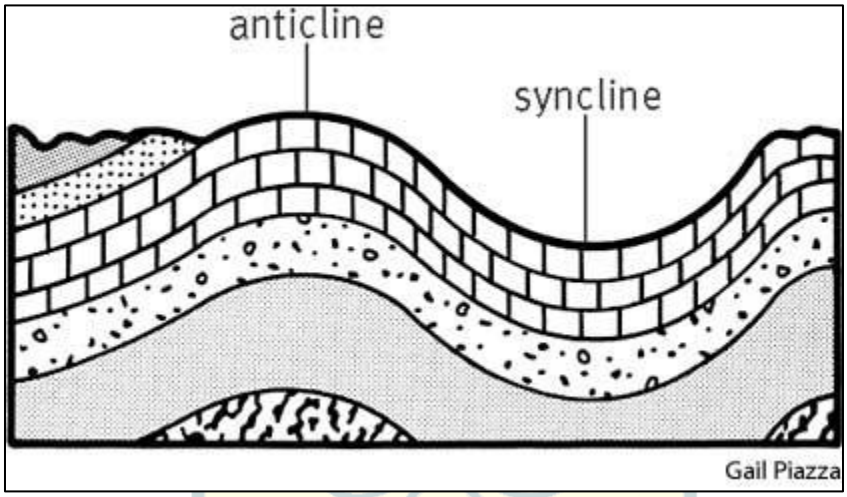
All types of rocks (igneous, sedimentary and metamorphic) can be subjected to powerful stress by tectonic forces. There are three types of stresses

1. Compression
2. Tension
3. Shearing

The strain that results from these stresses takes the shape of folding or faulting.

## Folds:

Due to heavy compression, the crust bends in a zigzag wavy fashion. This is called a fold. If the bending is upwards forming a crest it is called anticline. On contrary if it results into a trough it is called a syncline. It should be noted that folding is found in sedimentary and igneous rocks and not in metamorphic rocks as they crumble under compressive force.




**Well this is where we will take our funkyness to exponential heights :P Watch this amazing Video.**

**https://www.youtube.com/watch?v=Jy3ORIgyXyk**

**This is how a folding mountain chain looks like..**

## Types of folds

- Symmetrical fold- it is the most simple kind of fold where both the limbs are inclined uniformly, making same angle with the horizontal. They are an ideal case and generally not found. They are formed when equal and gradual force act from both sides of the crust.
- Asymmetric fold- in this fold one limb dips more steeply than the other i.e. both the limbs are inclined at different angles.
- Monoclinic fold- in this case one limb inclines steeply at right angle from the horizontal i.e. the slope is almost vertical.
- Isoclinic fold- they are formed when compressive forces are so strong that both the limbs of the fold become parallel but not horizontal.
- Recumbent fold- compressive force are so strong that the limbs become parallel as well horizontal.
- Nappe- the compressive forces are strong enough that one limb is fractured along the axis and is thrust upon the other .
- Fan fold or anticlinorium- it is an extensive and broad fold consisting of several minor anticlines and synclines. Such folds resemble to a fan.
- Synclinorium- it is a folded structure which includes an extensive syncline having numerous minor anticlines and synclines. They are formed due to irregular compressive forces.

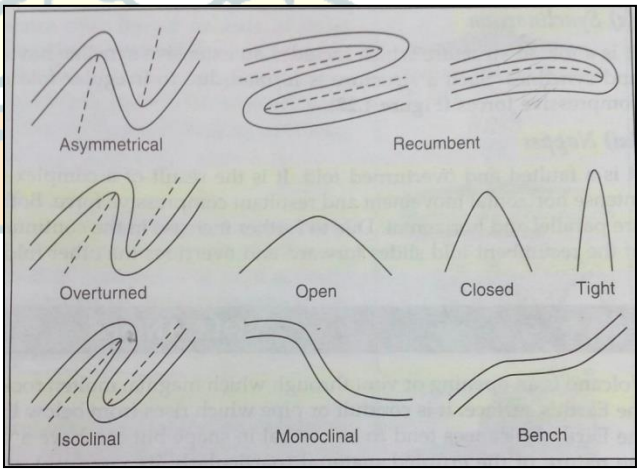
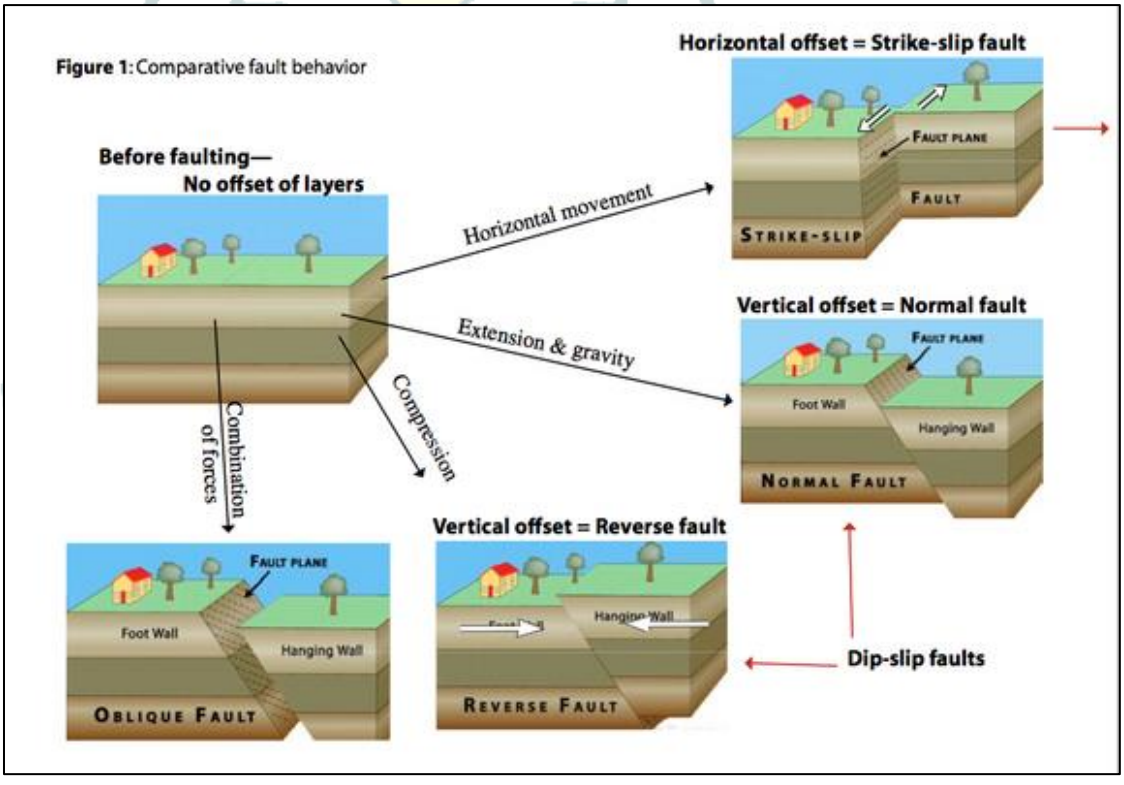



**Figure showing different types of folds**

## Faults:

A fault is a fracture in the earth's crust due to tension force. It can also occur due to compression in hard and brittle rocks.

- When there is tension the crust ruptures. One block is thrown upwards and the other downwards. The upthrown block is called **Horst** while the downthrown block is called **Graben**. The line along which the fault occurs is called strike. This fault is called normal fault and is most common. In case of a normal fault, new surface is generated in the form of scarp.
- When there is compression, in case of hard rocks instead of folding, the faulting occurs. The block with hanging wall is thrown upwards while the one with footwall is thrown downwards. This is called a reverse fault. In case of a reverse fault there is net destruction of the surface.
- When the forces are acting parallel to each other, along the line of fault the blocks move past each other without being upthrown or downthrown. This is called lateral fault.



The landforms formed due to faulting of land are block mountains, rift valleys, step mountains, hinge faults, scissors fault etc.

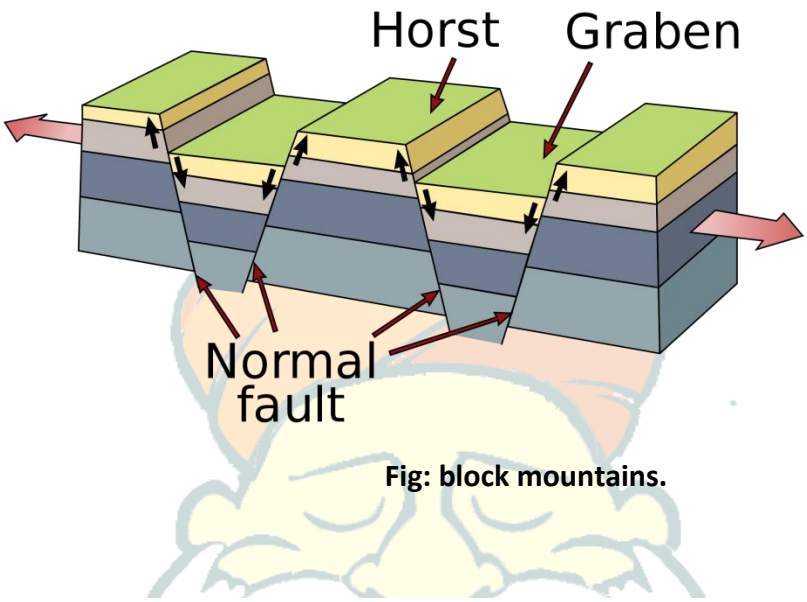



**Fig: block mountains.**

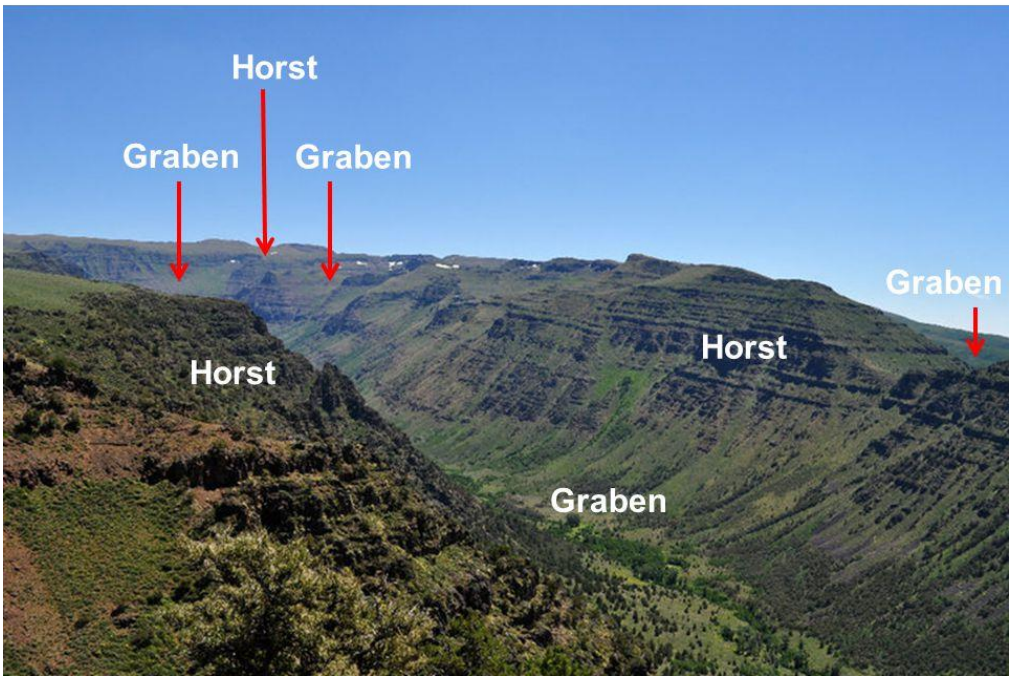



**Fig: Block Mountain ranges**

**For Better understanding of Faults, watch the following Video:**

**https://www.youtube.com/watch?v=A_ZRtS3QGHw**

# Volcanoes:

Volcano is an opening or vent through which molten lava, ash, gases etc comes out from the earth's interior. Most of the volcanoes are concentrated at convergent and divergent plate boundaries but others, located in the interior of plates are associated with hot spots.

**Here is the most exciting Video which will give you an experience that you have never had before:**

https://www.youtube.com/watch?v=Be7o6BYVOzA

**Types of volcanic eruptions:**

- **Icelandic:** it flows as fissure eruption. The lava is basaltic and has less viscosity. It flows quietly and in large quantities forming plateaus. There is no violent activity or cone formation. ex. Columbia (USA), Deccan plateau (India) etc.
- **Hawaiian:** there can be fissure, crater or caldera eruptions. It forms small domes from which mobile lava and gases erupt. It produces fire fountains and only minor amount of gases.
- **Stambolian:** they form stratocones, i.e. lava comes out and solidifies in a layered structure. They have rhythmic to continuous explosions resulting from spasmodic gas escape. Sometimes clots of lava are ejected producing bombs and scoria. It can have periodic more intense activity with outpouring of lava.
- **Vulcanian:** they are also stratocone volcanoes. The associated lavas are more viscous. Sometimes the lava solidifies over the vent forming a crust resulting into gas pressure buildup leading to violent explosions. After a long quite period eruption occurs ejecting bomb, pumice and ash. Lava flows from the top of the flank after main explosive eruption. Dark ash laden clouds, convulated, cauliflower shaped, rises to moderate heights more or less vertical depositing tephra along the flanks of volcano.
- **Vesuvian:** it throws extremely violent explosive gas charged magma from stratocone vent. Eruption occurs after a long period of quite or mild activity. Vent tend to be emptied to considerable depth. The lava erupts in explosive spray and gas cloud reaches to great height and deposits tephra.

- **Pilian:** it is more violent form of visuvian eruption. Last major phase is uprush of gas that carries clouds rapidly upward in vertical coloumn for miles. It is narrow at base but expands outward at upper elevations. But the clouds are generally low in tephra.
- **Pelean:** it results from high viscosity lava and delayed explosiveness. Conduit of stratovolcano usually gets blocked by dome or plug , some gas escapes from lateral opening or by destruction or uplift of plug.
- **Katmaian:** it is a variant of Pelean eruption characterised by massive outpourings of fluidized ash flows accompanied by widespread explosive tephra. Ignimbrites are common end products. Also hot springs and fumaroles are formed

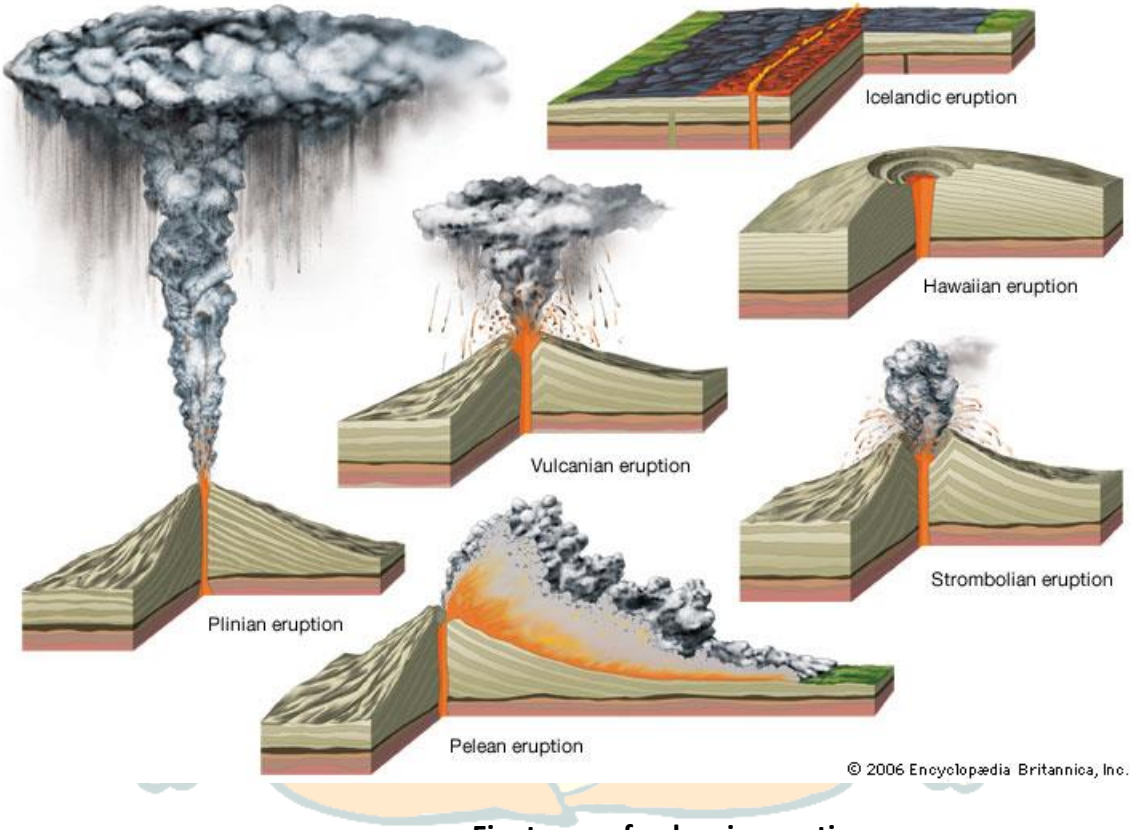



**Fig: types of volcanic eruptions.**

## Classification of volcanoes:

**On the basis of material erupted:**

1. Basalt cone: basalt cones are very rare. They are low rather than high because of fluidity of basaltic lava. Ex- Rangitoto (New Zealand) and Skjaldbreit (Iceland) are most suitable examples.
2. Basalt dome: basalt domes are flat domes formed by fluid basalt lava. They are less in height and broad. Hawaiian volcanoes are the best example.
3. Ash and cinder cones: these are high volcanoes formed by high viscous lava. Ash and cinder cones are built where eruptions are explosive type with predominance of pyroclastic material. Growth of an ash or cinder cone begins around a crater.
4. Composite or strato cone: they are formed by alternate sheets of lava and pyroclastic material. It is formed by alternate periods of explosive and quite eruptions. Most of the largest volcanoes of the world falls under this category. Mt Fujiyama of Japan, Vesuvian of Italy, Cotapaxi and Chimbrazo of Equador are good examples.

**On basis of periodicity:**

- Active volcanoes: volcanoes which constantly eject lava, gases, ash, cinder etc are known as active volcanoes. There are about 600 active volcanoes in the world, most of them being around pacific “ring of fire”. The Stramboli volcano erupts so much fire that it has been termed as the lighthouse of the Mediterranean.
- Dormant volcano: A volcano which has not erupted for a long time but still has probability of eruption is called dormant volcano. Mt Kilimanjaro is one such volcano.
- Extinct volcano: a volcano which functioned in long geological past but is no longer active is called extinct volcano. They are only the remnants of the volcanoes. In many of the cases crater lakes are formed by filling of water into craters. Acancagua of andes is a typical example of extinct volcano.

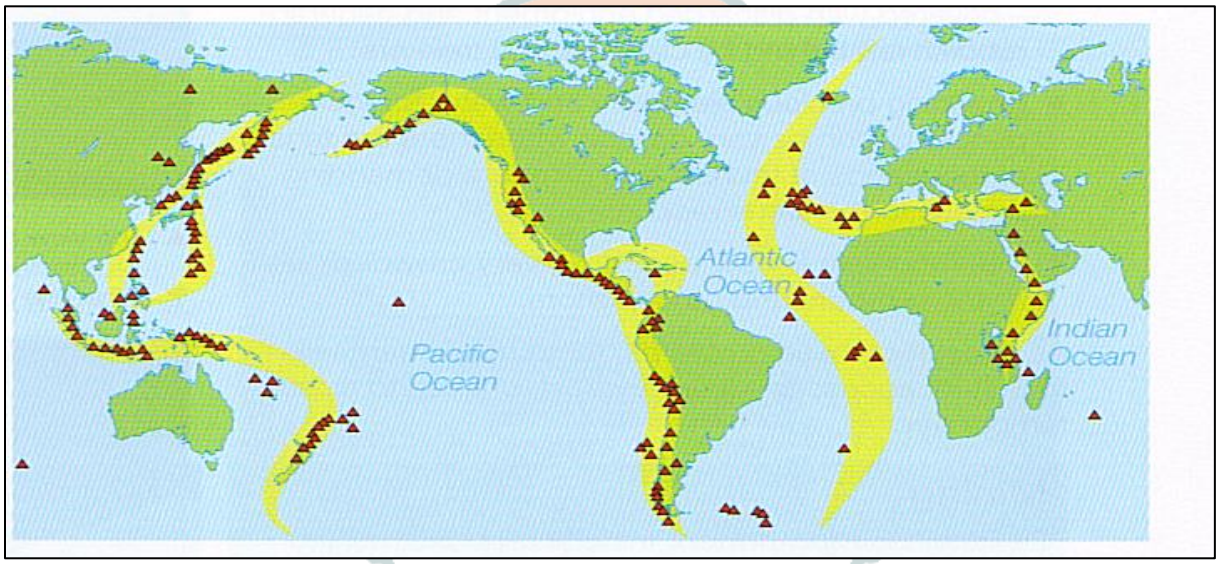
## Distribution of Volcanoes in the world:

The distribution of volcanoes on earth is a function of plate tectonics and hot spot activity. Volcanic activity occurs in three major areas:

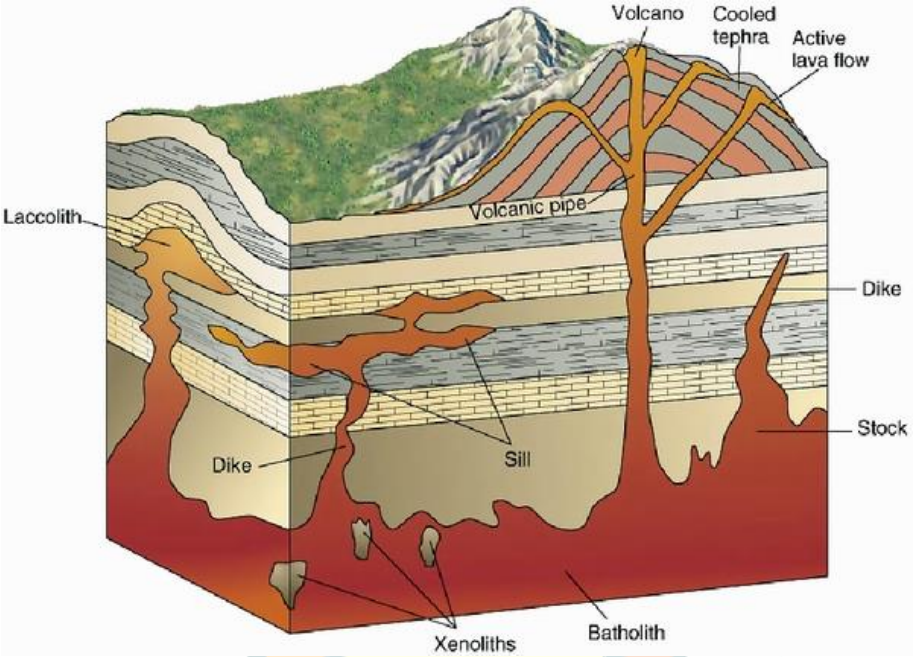
i) Along subduction boundaries at continental- oceanic plate convergence or oceanic-oceanic plate convergence.

ii) Along sea floor spreading centers on the oceans floor and areas of rifting on continental plates (the rift zone in east Africa) .

iii) At hot spots where individual plumes of magma rise through the crust eg. Hawaii.




**Intrusive volcanic landforms:**




Rocks formed by cooling of magma within the crust are called **'Plutonic rocks' or 'Intrusive' landforms.**

**Batholith:** Batholiths are formed deep below the surface when large masses of magma cool and solidify. As the magma cools slowly, large crystals are formed in the rock (e.g. granite). Batholiths are often dome-shaped and exposed by later erosion.

**Laccolith:** Sometimes smaller injections of magma form a lens shape that is intruded between layers of rock. This then forces the overlying strata (layers of rock) to arch upwards, forming a dome. This feature is known as a laccolith, and it may be exposed by later weathering and erosion to form a small range of hills, for example the Eildon Hills on the Scottish Borders.

**Dykes:** These are vertical intrusions with horizontal colloing cracks. They cut across the bedding planes of the rocks into which they have been intruded. Dykes often occur in groups where they are known as dyke swarms.

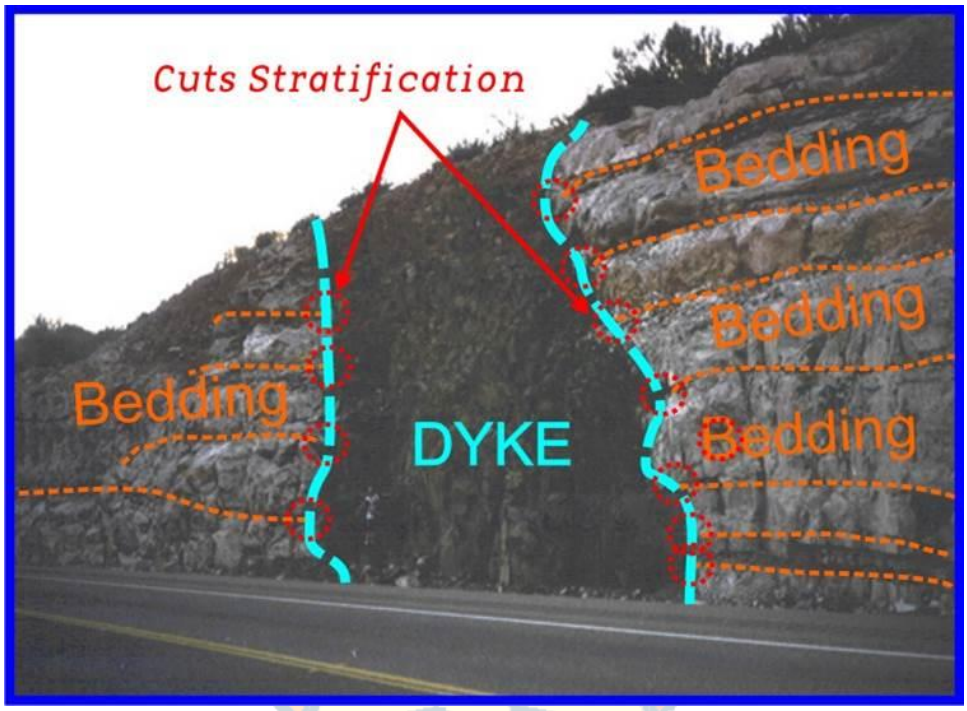



**Fig: Dyke**

**Sill:** These are horizontal intrusions along the lines of bedding planes. Sills have vertical cooling cracks.


**Fig: Sill**

**Lapolith*:*** This is an intrusion of a saucer-shaped feature in between rock strata of sedimentary rocks.

# Earthquakes:

Earthquakes are vibrations of the earth caused by sudden movement of rocks that have been strained beyond their elastic limit. Main causes of the earthquake are plate tectonics, volcanic eruption or anthropogenic activities like explosions, reservoir induced seismicity etc. There is a release of huge amount of energy in the form of sound and seismic waves causing shaking of earth's surface. The point where earthquake generates is called focus and the point just above the focus on the surface is called epicenter. The magnitude of earthquake is estimated by Richter scale, while intensity is described Mercalli scale. The magnitude of the earthquake remains same everywhere while intensity decreases going away from the epicenter.

**Depth of focus:**

The depth of an earthquake generally varies from about 10-700 km below the surface of the earth. Although the movement of material within the earth occurs throughout the mantle and core, earthquakes are concentrated only in its 700 km. Within this range earthquakes can be grouped according to depth of focus.

i) Shallow focus earthquake: These earthquakes occur from the surface to the depth of 70km, they occur in all seismic belts and produce the largest percentage of earthquakes.
ii) Intermediate focus earthquake: They occur between 70 and 300km below the surface of the earth.
iii) Deep focus earthquake: They occur in the range of 300 to 700km of depth.

Both the intermediate and deep focus earthquakes are limited in number and distribution. The maximum energy released by an earthquake decreases with increase in depth. Hence most of the large and destructive earthquakes have shallow focus.

## Consequences of earthquakes:

The main consequences of earthquake are:

i) Rise and subsidence of land surface. High magnitude earthquakes can create fissures and embankments and thus results into new landforms deforming the ground surface.
ii) Enormous Damage to property.
iii) Loss of human and animal life.
iv) Devastating fires, floods and landslides.

v) Flash floods. Many a times due to earthquake the dams and embankments gets ruptured and causes flash floods resulting in loss of life and property.
vi) Landslides
vii) Tsunamis.

## Tsunamis:

The seismic waves travelling through the ocean and sea water results into high sea waves which are known as tsunamis. 'Tsunami' is a Japanese term which has been universally adopted to describe a large seismically generated sea wave. These waves are responsible for causing considerable destruction in certain coastal areas where submarine earthquakes occur.

**Pre – conditions for Tsunami:**

For a Tsunami to occur, two conditions are required:

- There should be an earthquake from which energy can be transferred.
- There should be a vertical displacement of the water. i.e. during earthquake the crust should move vertically. That's why Tsunamis are originated near oceanic trenches where plates are being subducted. In Atlantic Ocean, a number of earthquakes occur on Mid – Oceanic ridge but since there is no sudden vertical movement, Tsunamis are not formed. Tsunamis can also be triggered if seamounts break. This can cause vertical displacement of water.

**Process of Generation of Tsunami:**

When a tsunami is generated, its steepness i.e. height to length ratio, is very less. This enables it to pass unnoticed beneath the ships in the sea. As the wave approaches shore, the height of the wave rapidly increases because of rebound from the shallow surface. The period of the wave remains constant, velocity drops and the height increases. In confined coastal waters relatively close to their point of origin, tsunamis can reach a height of more than 30m. Tsunamis travels at the speed of 100 -150 km/h which may pick up 650-900 km/h.

It may travel considerable distance. The frequency of tsunami is highest in Pacific Ocean.

Since 1948, an International Tsunami Warning Network has been in operation around the Pacific Ocean to alert coastal residents to possible danger.

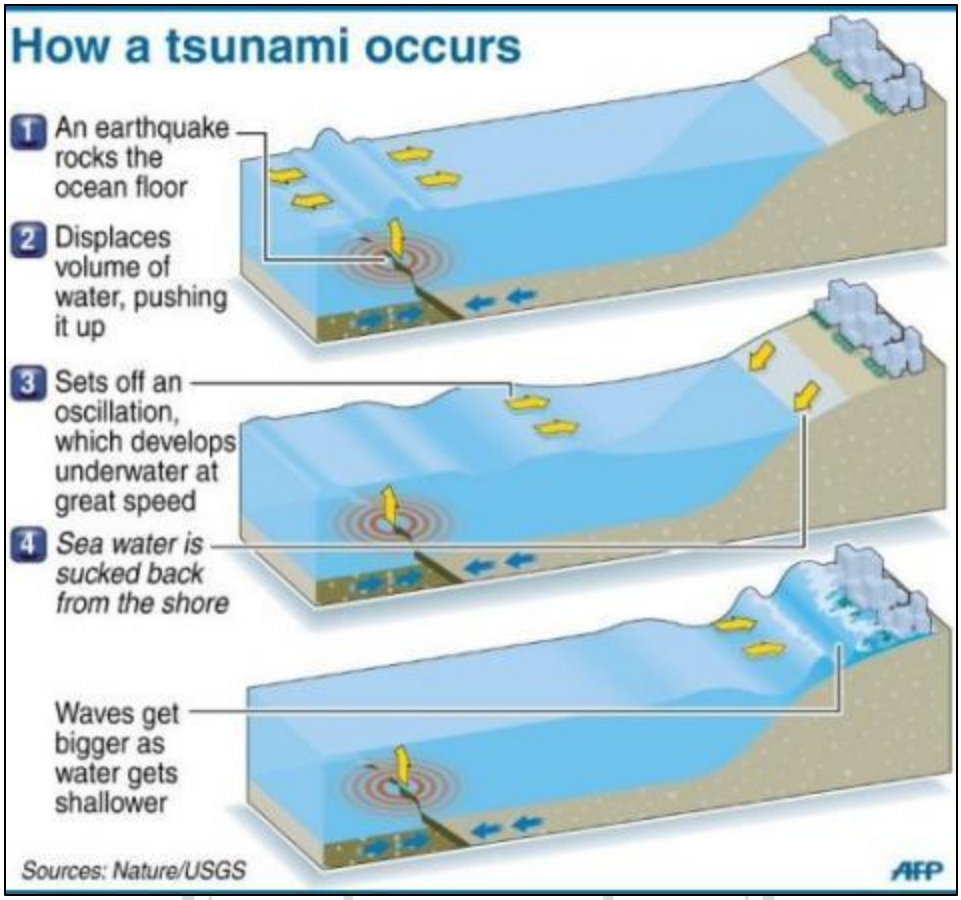



**Fig: tsunami formation.**

# Processes Due to Exogenic Forces

**Weathering**

Weathering is the process of disintegration of rocks near the surface by the action of temperature, pressure and humidity. It can also be due to Chemical changes. Weathering is an in situ process i.e. it occurs at its own place and an external agent is not required. The broken rock is called the regolith.

Broadly Weathering can be of two types:

1. **Physical Weathering**
2. **Chemical Weathering**

Biological weathering is considered to be the third type, but actually it is a part of Physical and chemical weathering.

## Physical Weathering:

Physical weathering produces regolith from massive rock by the action of forces strong enough to fracture the rock. Some of the most important process of physical weathering are:

**Frost Action:**

It is generally found in colder climates. During the day the water enters the pores and joints between the rocks. During night, as the temperature drops, this water freezes and expands. The expansion of water in freezing can fragment even the hardest rocks, given many cycles of freeze and thaw.

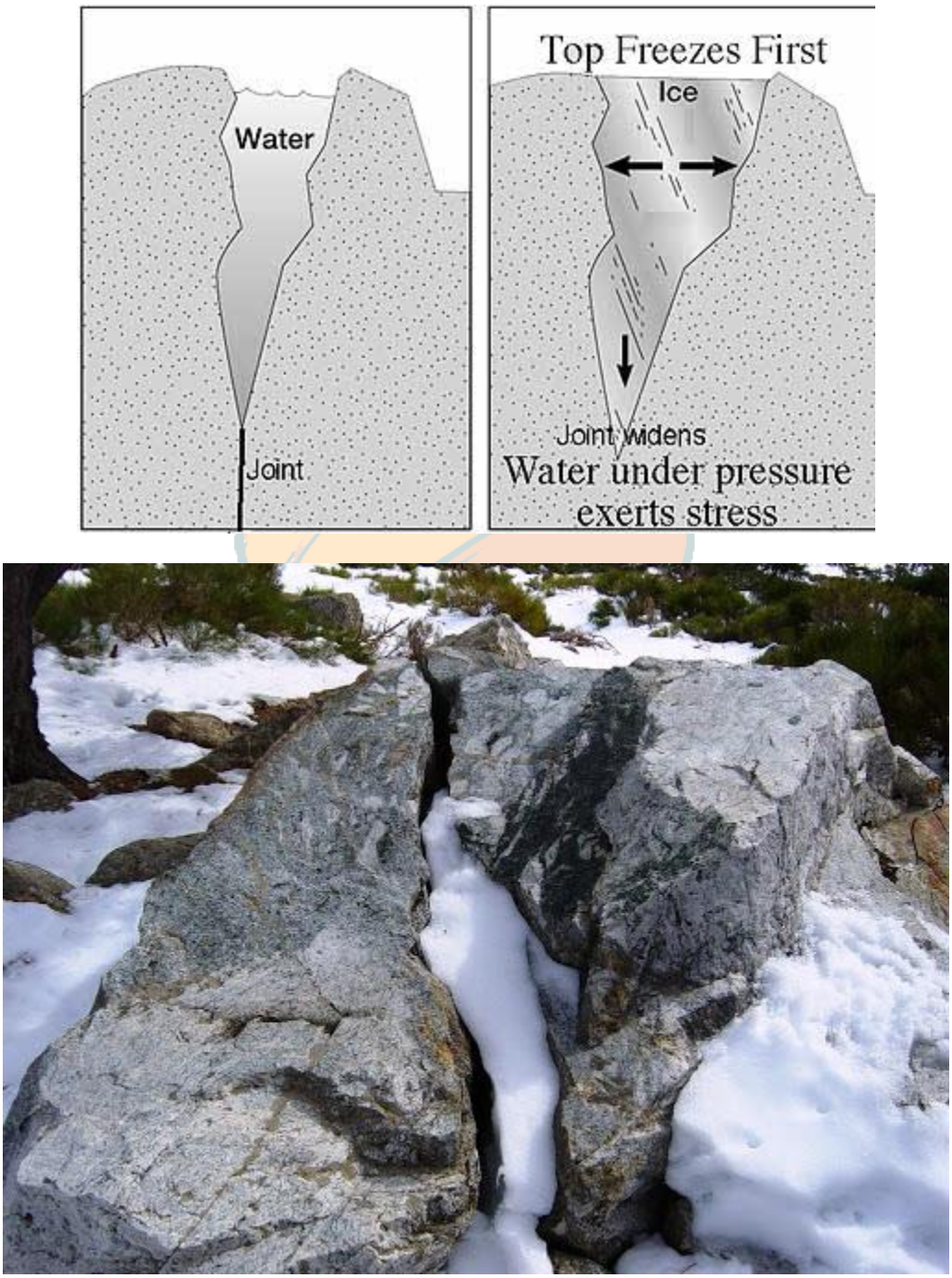



**Fig: Frost action during winter**

**Salt Crystal growth:**

Similar to the process of ice crystal growth, the rocks also gets disintegrated by the growth of salt crystals in the pores. This process is dominant in the dry area.

During long drought periods, the ground water is moved to the surface of the rock by capillary action. As the water evaporates from the surface, tiny salt crystals are left behind. As the salt crystals grow in the pores, they push the rocks and break them in the form of granules. This is called granular disintegration.

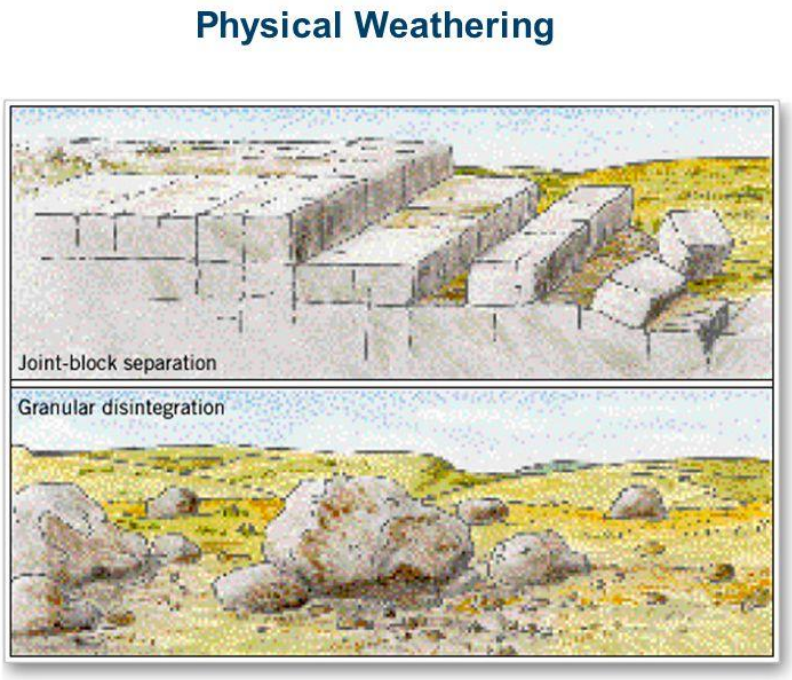



**Fig: Difference between block disintegration and granular disintegration**

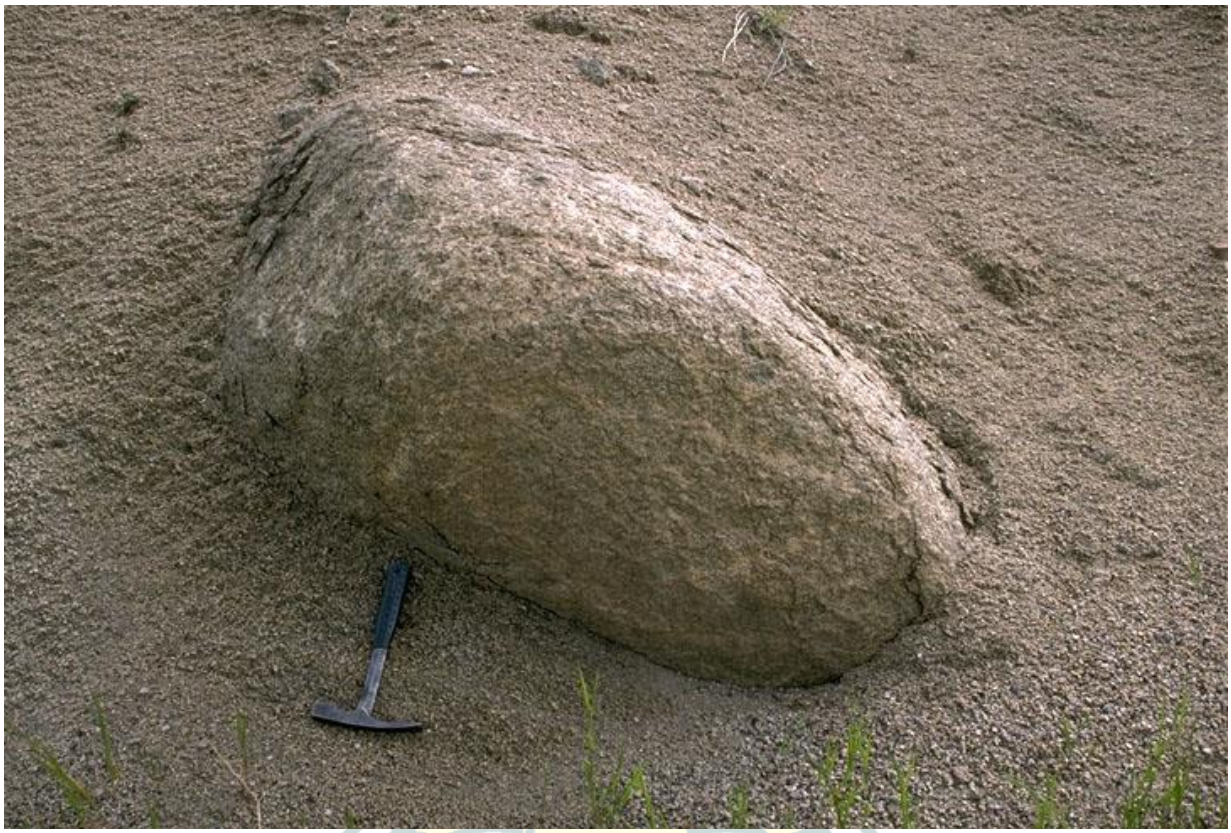


**Fig: Granular weathering due to salt crystal growth**

**Unloading and exfoliation:**

Unloading is the process that relieves the confining pressure on the underlying rock. As the rock above is slowly worn away, the pressure is reduced and rock expands slightly in volume. These rocks crack in layers that are more or less parallel to the surface creating a type of jointing called the 'Sheeting Structure'. The layer of rocks breaks in concentric slices like the onion peel.

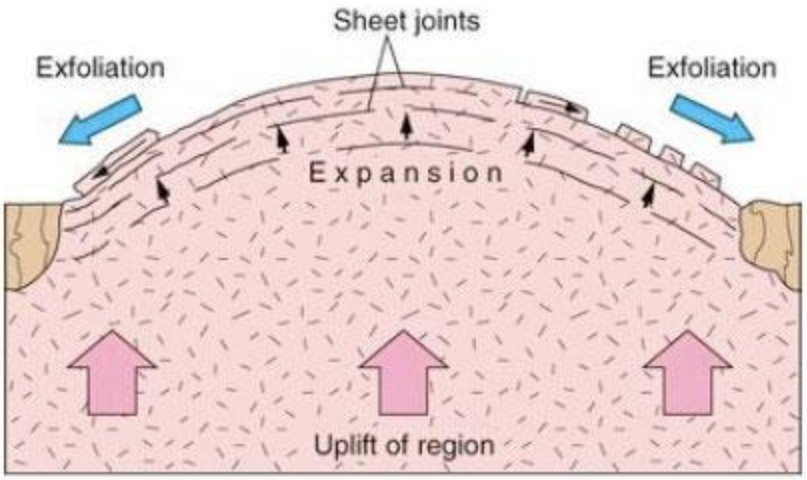



Fig: Explaining the process of exfoliation

Fig: Top view of rock showing exfoliated sheets

**Thermal expansion and contraction:**

This process takes place where diurnal range of temperature is high i.e. there is a large difference in the daily highest and the lowest temperatures. Because of these temperature changes a lot of stress develops in the rock. They expand when the temperature rises and contracts when temperature drops. This causes fractures in the rocks and they ultimately break down.

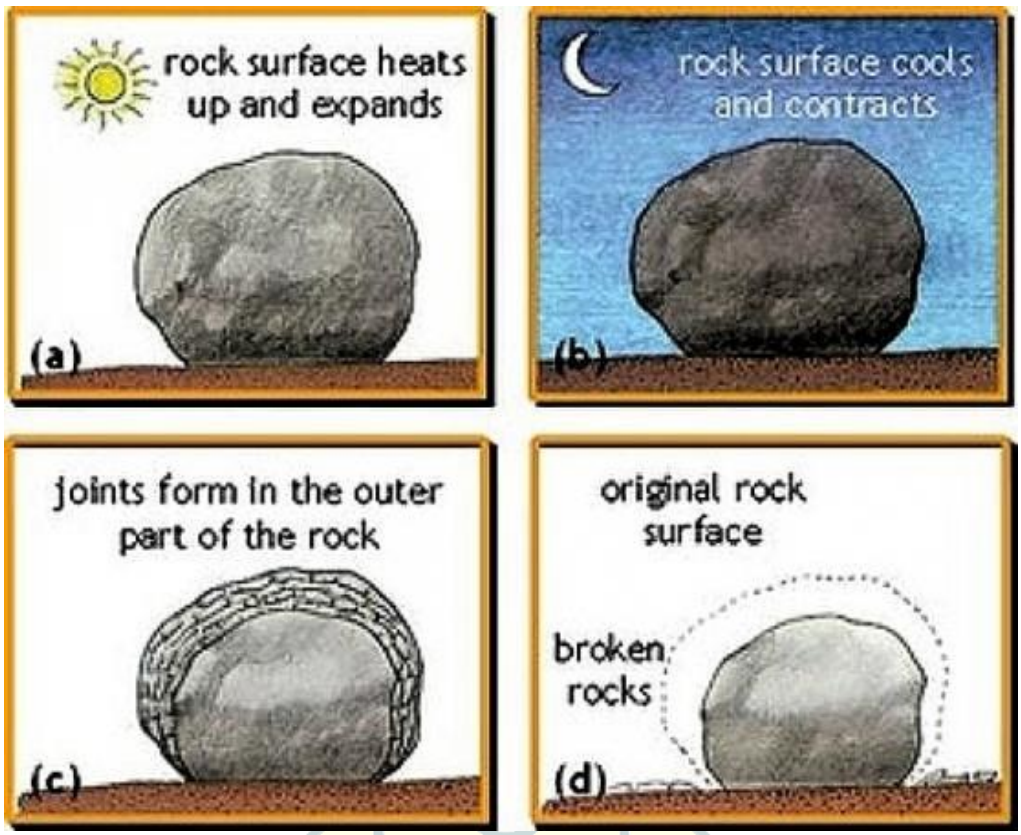



**Fig: explaining the process of thermal expansion weathering**

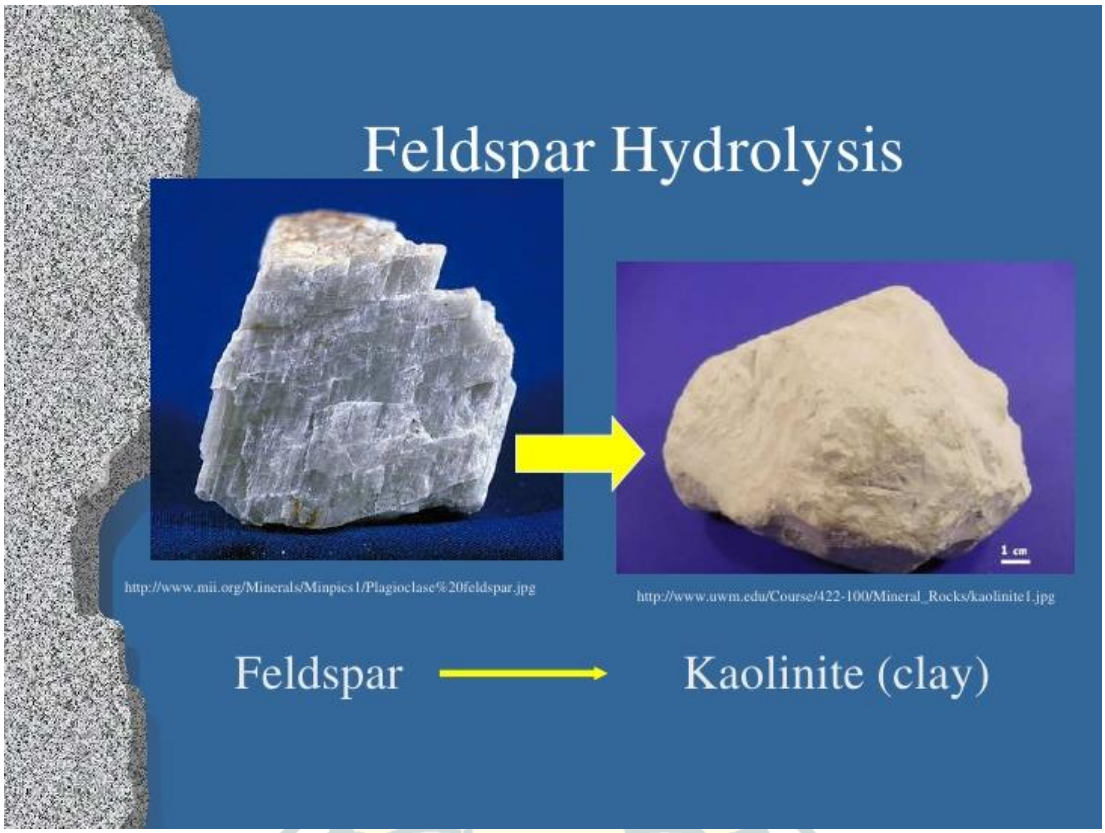
## Chemical Weathering:

The erosion or disintegration of rocks, building materials, etc., caused by chemical reactions (chiefly with water and substances dissolved in it) rather than by mechanical processes. There are several types of Chemical Weathering.

**Hydrolysis and oxidation:**

Hydrolysis is the most important process in chemical *weathering*. It is due to the dissociation of H2O into H+ and OH- ions which chemically combine with minerals and bring about changes, such as exchange, decomposition of crystalline structure and formation of new compounds. Water acts as a weak acid on silicate minerals.

Oxidation is the reaction of a substance with Oxygen.




**Acid Action:**

Chemical weathering is also produced by acid action, most commonly Carbonic Acid. Carbon dioxide gets dissolved in water to form a weak acid. Now a day since the concentration of Sulphur oxides and Nitrogen oxides is increasing in atmosphere because of the burning of the fossil fuels, the acidity of the rain has also increased. Carbonate sedimentary rocks, especially limestone and marble are highly susceptible to this type of weathering.

Acid rain is also harmful for architectural structures, especially made of marble.

**Fig: Weathered statue due to Acid Action**

## Biological Weathering:

**Biological weathering** is the weakening and subsequent disintegration of rock by plants, animals and microbes. It can occur due to physical stress like in case of penetration of plant's roots, physical impact of the hooves of the animal etc. or due to chemical changes caused by them like action of worms, lichens etc.

**Fig: A rock getting physically weathered by a tree**

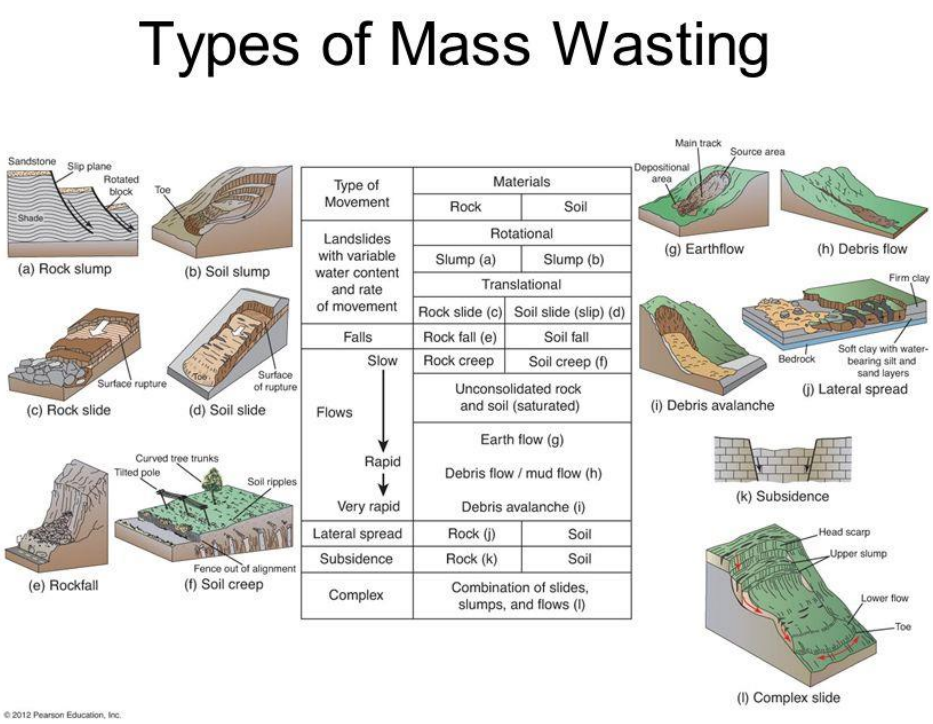
**Fig: These lichens can cause chemical changes on the rock's surface**

# Mass Wasting:

**Mass wasting**, also known as slope movement or **mass** movement, is the geomorphic process by which soil, sand, regolith, and rock move downslope typically as a **mass**, largely under the force of gravity, but frequently affected by water and water content as in submarine environments and mudflows.

**Note: Point to be considered is that that Mass wasting is only because of the gravitational pull and not due to any other external agent.**

The following figure will help you revise the concept of Mass wasting:

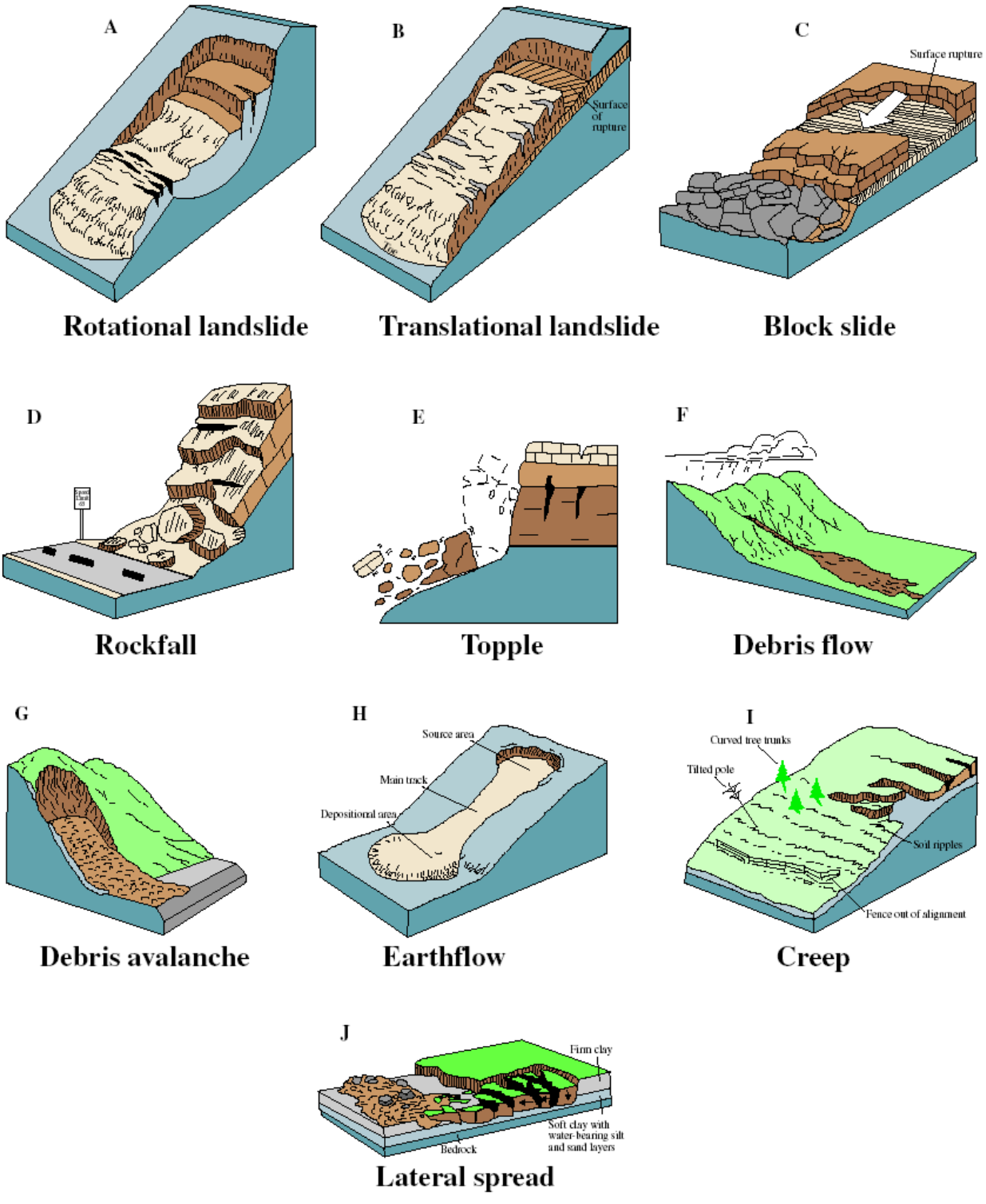


# Landslides

A *landslide* is the movement of rock, debris or earth down a slope. They result from the failure of the materials which make up the hill slope and are driven by the force of gravity. *Landslides* are known also as landslips, slumps or slope failure.

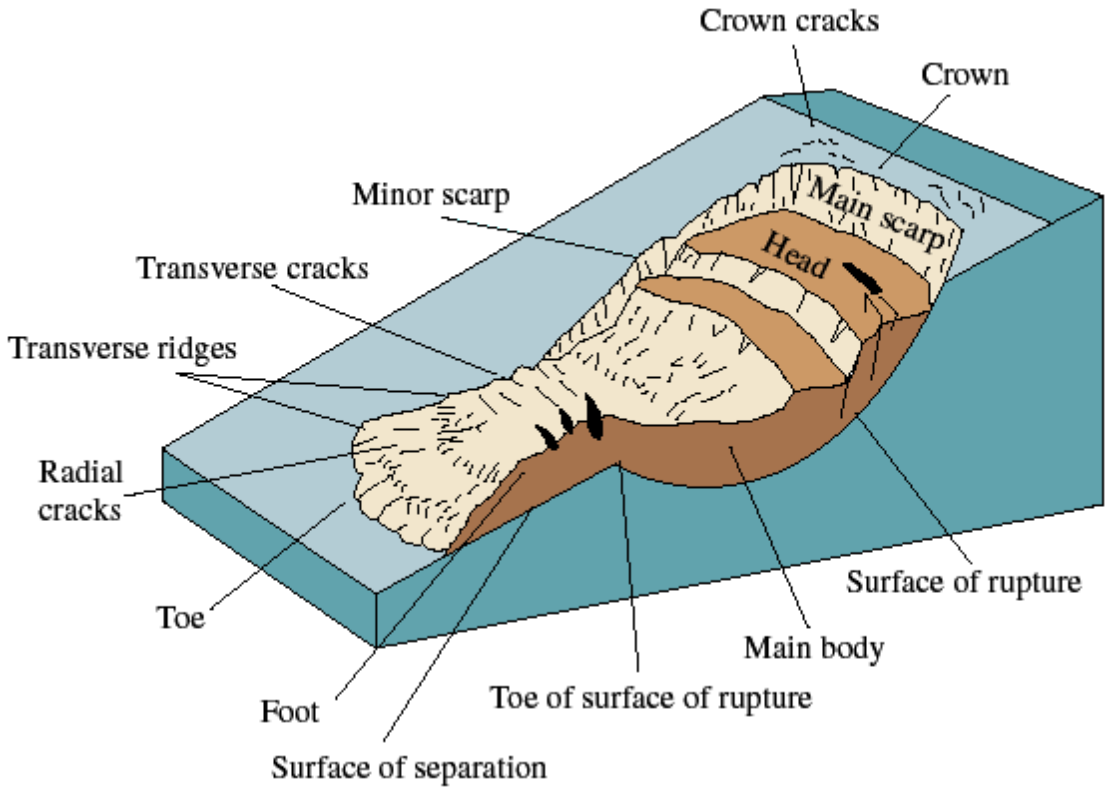
## Types of landslide Movements:

- **Falls** are masses dislodged from very steep slopes or escarpments which then free-fall, bounce, or roll downslope. Falls usually move extremely rapidly.
- **Topples** are a forward rotation around a pivot point low or below one or more masses.
- **Lateral spreads** are the result of movement involving lateral extension accommodated by shear or tensile fractures. This type of movement is earthquake-induced.
- **Slides** displace masses along one or more discrete planes. Slides may either be rotational or translational in their movement.
- **Rotational movement** is where the plane is curved. The mass rotates backwards around a common point with an axis parallel to the slope.
- **Translational movement** is where the plane is more or less planar or gently undulating. The mass moves roughly parallel to the ground surface.
- **Flows** are masses moving as a deforming, viscous unit without a discrete failure plane.
- More than one form of movement may be represented in some landslides. Movement in this case is often described as **complex.**




**Types of Land Slides**

## Parts of Landslide:




## Causes of Landslides:

**Natural Causes:**

- Ground water pressure acting on the slope.
- Loss of vegetation
- Weakening of slope due to melting of glacier or heavy rainfall
- Earthquakes
- Volcanic eruptions

**Human Causes:**

- Vibrations from machinery
- Blasting of mines
- Earthwork which alters the slope
- Construction, agriculture or forestry activities which can affect the amount of water entering the soil

## Prevention of Landslides:

Many methods are used to remedy landslide problems. The best solution, of course, is to avoid landslide-prone areas altogether.

Listed below are some common remedial methods used when landslide-prone slopes cannot be avoided.

**Improving surface and subsurface drainage**: Because water is a main factor in landslides, improving surface and subsurface drainage at the site can increase the stability of a landslide-prone slope. Surface water should be diverted away from the landslide-prone region by channeling water in a lined drainage ditch or sewer pipe to the base of the slope. The water should be diverted in such a way as to avoid triggering a landslide adjacent to the site. Surface water should not be allowed to pond on the landslide-prone slope.

**Excavating the head**: Removing the soil and rock at the head of the landslide decreases the driving pressure and can slow or stop a landslide. Additional soil and rock above the landslide will need to be removed to prevent a new landslide from forming upslope. Flattening the slope angle at the top of the hill can help stabilize landslide-prone slopes.

**Buttressing the toe**: If the toe of the landslide is at the base of the slope, fill can be placed over the toe and along the base of the slope. The fill increases the resisting forces along the failure surface in the toe area. This, in turn, blocks the material in the head from moving toward the toe.

**Constructing piles and retaining walls**: Piles are metal beams that are either driven into the soil or placed in drill holes. Properly placed piles should extend into a competent rock layer below the landslide. Wooden beams and telephone poles are not recommended for use as piles because they lack strength and can rot.

**Removal and replacement**: Landslide-prone soil and rock can be removed and replaced with stronger materials, such as silty or sandy soils.

**Preserving vegetation**: Trees, grasses, and vegetation can minimize the amount of water infiltrating into the soil, slow the erosion caused by surface-water flow, and remove water from the soil.

**Rock fall protection**: Rock falls are contained by (1) ditches at the base of the rock exposure, (2) heavy-duty fences, and (3) concrete catch walls that slow errant boulders that have broken free from the rock outcrop.

# Erosion:

Erosion is the act in which earth is worn away, often by water, wind, or ice. It is an ex situ process where an external agent is involved. The fragments break because of external impact i.e. kinetic energy. Unlike weathering where only gravity is involved.

The rocks are broken at one place and the broken particles are carried by the agents to far distances and are deposited.

It is the most destructive process shaping the tertiary reliefs.

## Agents of Erosion:

There are broadly five agents which cause erosion and carve distinct landforms:

- Running surface water – The landforms made by surface streams are called fluvial landforms.
- Wind – these landforms are formed in arid and semi – arid regions where the action of wind is dominating. These landforms are called Aeolian.
- Glaciers – These landforms are carved by Glaciers in high alpine mountains.
- Waves – They are formed by the action of waves on the edge of the continent.
- Karst – These landforms are formed by the action of underground water on Karst or Lime stone region.

**Note: It has been observed that a direct question on this topic is rarely asked in GS. Also it is very nicely covered in G C Leong. Covering the same topic again will over burden you with unnecessary details. Do read the NCERT and G C Leong.**

**Fig: Meandering River - An example of fluvial erosion.**

# SOIL

Soil can be defined as the organic and inorganic materials on the surface of the Earth that provides the medium for plant growth.

## Nature of the Soil:

Soil consists of matter in all the three states – solid, liquid and gaseous.

Mineral Matter: Inorganic materials, or those materials that are not living, include weathered rocks and minerals.

Organic matter: Organic matter has biological origin and can be living or dead.

**Humus**

Finely divided, partially decomposed organic matter in soil is called humus. (Note: This is the complete definition of humus. learn it this way.) When abundant, humus particles can give the soil brown or black coloration.

Both air and water are found in soil. Water may tend to contain high levels of dissolved nutrients.

Air in soils may have high levels of $CO_2$ and methane and low $O_2$.

Solid, liquid and gaseous matter in soil are constantly changing and interacting through physical and chemical processes. This makes the soil a very dynamic layer. The soil science is called **'Pedology'.**

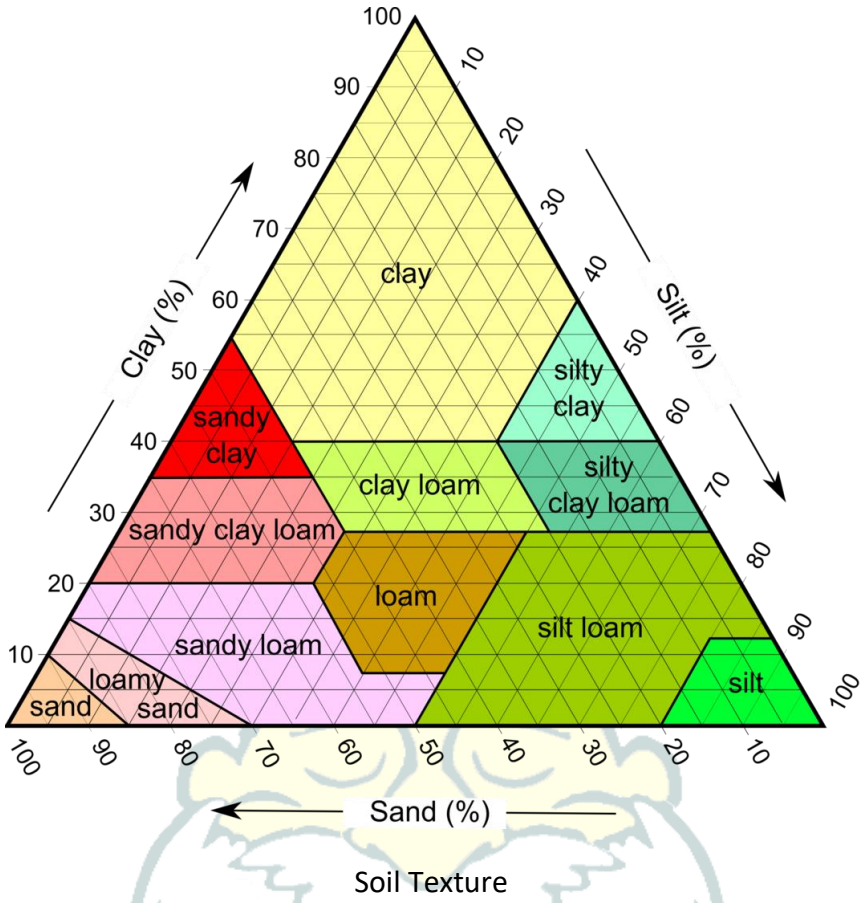
## Characteristics of Soil

### Soil Texture:

It refers to the proportion of particles that fall into the three size grades – sand, silt and clay.

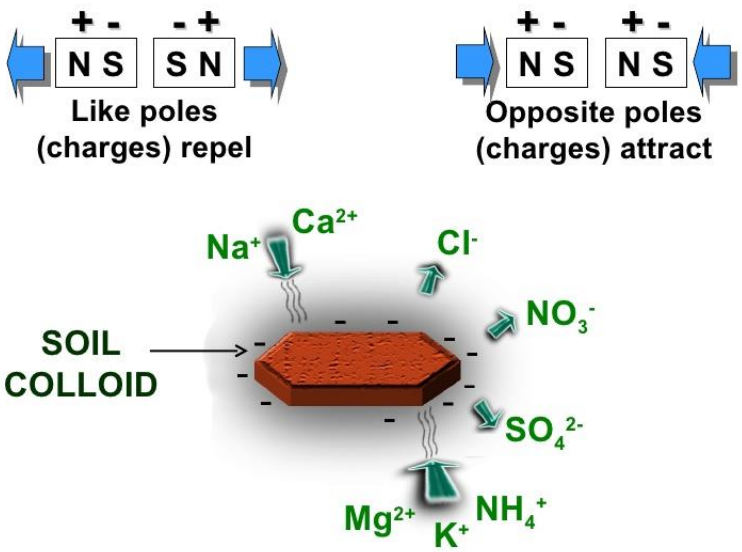
A soil with a significant proportion of all the three grades is called loamy soil. Otherwise it is called sandy, clayey or silty depending on the domination of each size.

Texture largely determines the ability of the soil to retain water.




Soil Texture

**Soil Colloids:**



They consist of the particles which are smaller than $1 * 10^{-5}$ mm. They can be mineral or organic particles. They are thin plate like bodies, when mixed in water; they remain suspended infinitely giving water a murky appearance.

Organic colloids are tiny bits of organic material that are resistant to decay.

Soil colloids are important because they attract minerals which are in the form of ions. Colloid particles then to be negatively charged because of their molecular structure and thus attract and hold positively charged ions (basis).

Colloids not only hold these items but give them up to the plants when in close contact with the plant membrane.

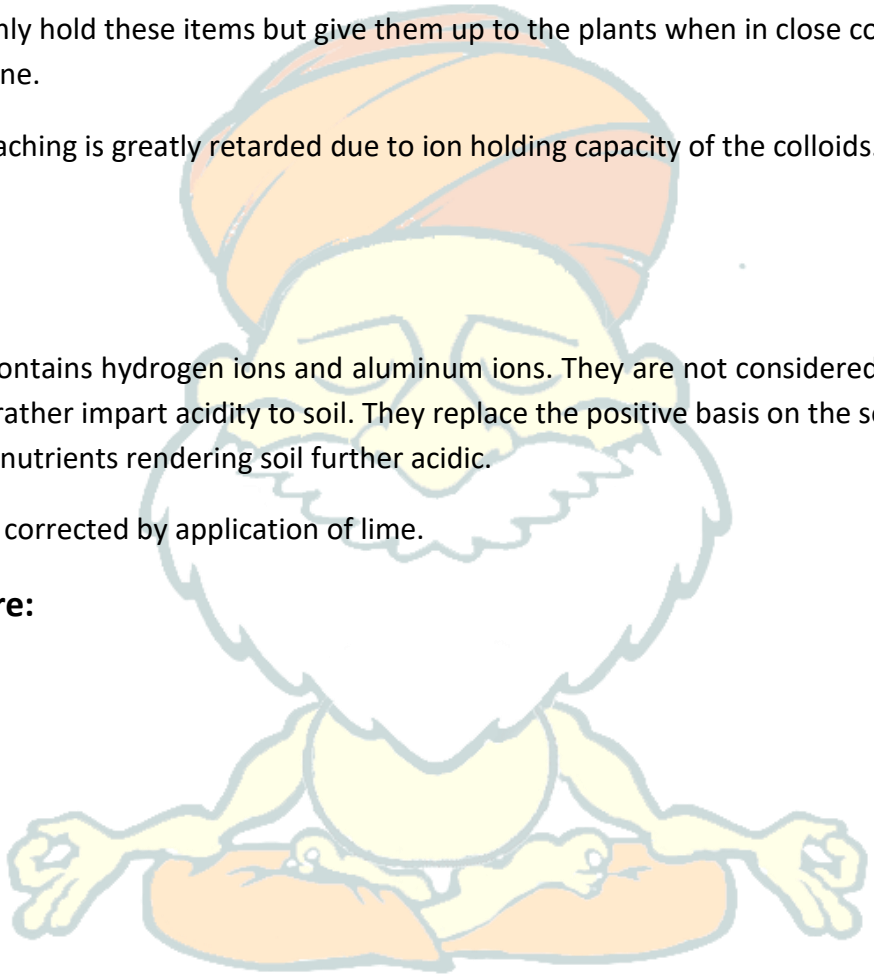
Loss due to leaching is greatly retarded due to ion holding capacity of the colloids.

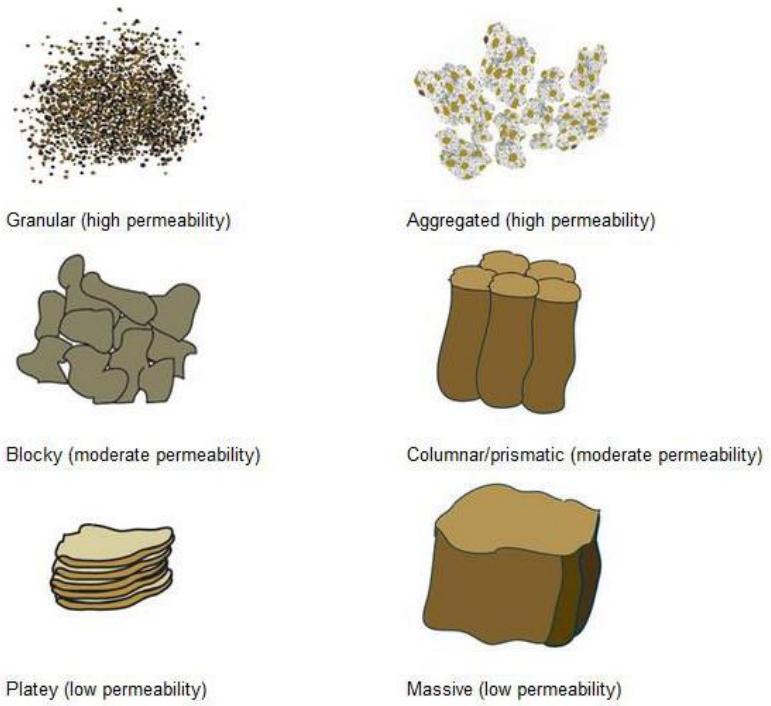
## Soil Acidity:

Soil solution contains hydrogen ions and aluminum ions. They are not considered basis or plant nutrients but rather impart acidity to soil. They replace the positive basis on the soil which leads to wash away nutrients rendering soil further acidic.

Acidity can be corrected by application of lime.

## Soil Structure:






Soil Structure

It refers to the way soil particles are grouped together into larger masses called peds. These are bound by soil colloids.

This defines the workability of the soil. i.e. How easily one can plough/turn it.

## Soil Minerals:

Soil minerals are classified into two categories – Primary minerals and Secondary Minerals.

Primary Minerals – They are compounds present in unaltered rocks. They are mostly silicate minerals. Primary minerals form a large fraction of the solid matter of many kinds of soils but their direct role is very limited in sustaining plant or animal life.

Secondary minerals – when primary minerals are exposed to air and water near the surface, they are slowly altered in chemical composition. They process is a part of mineral alteration. The primary minerals are altered into secondary minerals, essential for soil development and soil fertility.

The most important secondary minerals are clay minerals from the point of soil fertility. The ability of clay minerals to the basis is the most important property. If clay minerals can hold abundantly base ions the soil is of high base status and generally will be highly fertile.

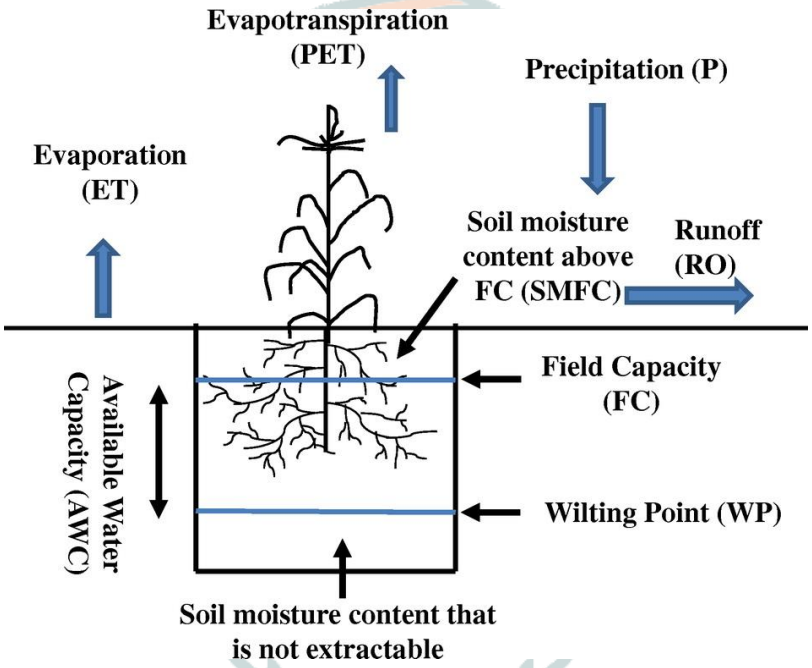
Mineral oxides are also important secondary minerals. If they are abundant, they are mined.

## Soil Moisture:

It is a key factor in determining how the soils of a region support vegetation and crops.

After precipitation, water infiltrates the soil. This process is called soil water recharge.

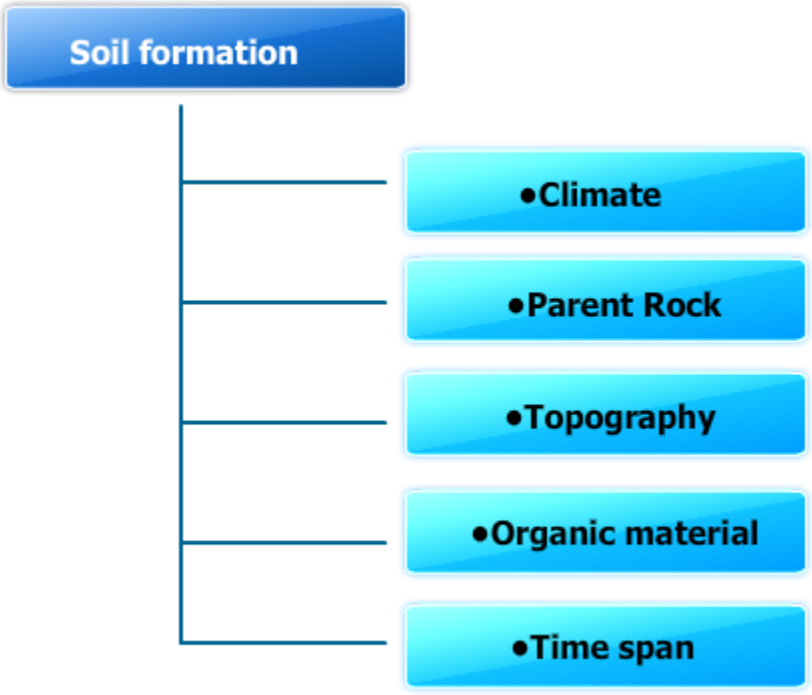
Excess soil water continues to drain downwards but some water clings to the soil particles. This water remains until it is evaporated or absorbed by the plant rootlets.




When a soil has been saturated by water and then allowed to drain under gravity until no more water moves downward, the soil is said to be holding its storage capacity. Fine textures hold more water than coarser textures.

Wilting Point – Storage level below which the plant will wilt. Wilting point depends upon soil texture. As fine particles hold water more tightly, it is more difficult for plants to extract moisture from fine soils. Thus plants can wilt in fine textured soils even though more soil water is present than coarse textured soils.

## Factors of Soil formation:




Formation of soil is a very slow process and it takes thousands of years for the formation of one cm soil.

**Climate:** Temperature and humidity decides the rate of weathering of rocks and amount of humus in soil.

**Parent Rock**: Decides the color, minerals and grain size of soil.

**Topography:** Slope and altitude decides the accumulation of soil on the surface. Slopes usually have thin layer of soil.

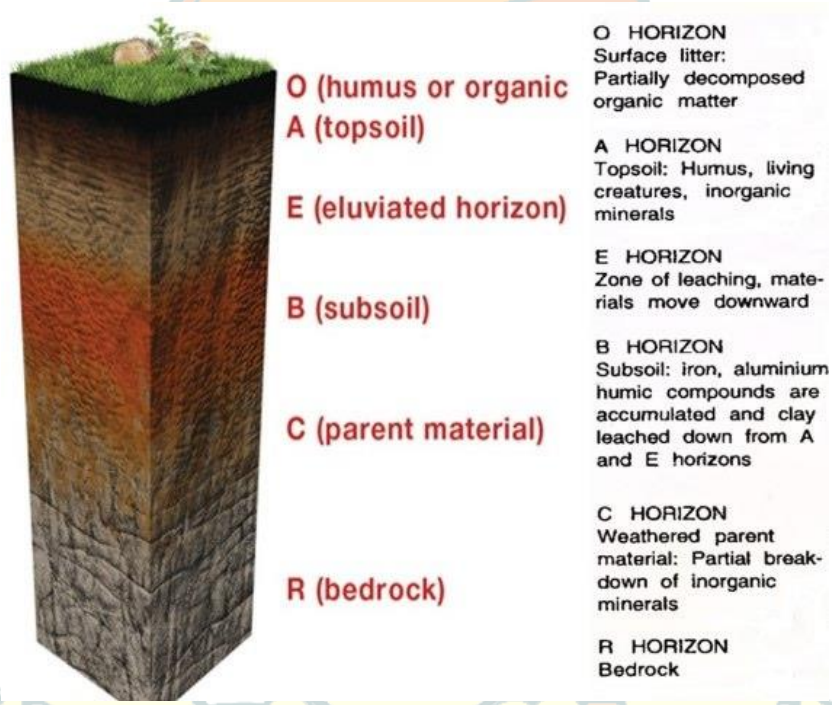
**Organic Material:** flora, fauna and microorganisms decide the formation of humus in the soil.

**Time:** Time is the most important factor for the soil formation. Time decides the formation of zones in soil. It also decides it thickness.

## Soil Profile:

If you look in a soil pit or on a roadside cut, you will see various layers in the soil. These layers are called **soil horizons**. The arrangement of these horizons in a soil is known as a **soil profile**. Soil scientists, who are also called pedologists, observe and describe soil profiles and soil horizons to classify and interpret the soil for various uses.

Soil horizons differ in a number of easily seen soil properties such as color, texture, structure, and thickness. Other properties are less visible. Properties, such as chemical and mineral content, consistence, and reaction require special laboratory tests. All these properties are used to define types of soil horizons.




Soil scientists use the capital letters **O**, **A**, **B**, **C**, and **E** to identify the master horizons, and lowercase letters for distinctions of these horizons. Most soils have three major horizons -- the surface horizon (**A**), the subsoil (**B**), and the substratum (**C**). Some soils have an organic horizon (**O**) on the surface, but this horizon can also be buried. The master horizon, **E**, is used for subsurface horizons that have a significant loss of minerals (eluviation). Hard bedrock, which is not soil, uses the letter **R**.

## Soil Forming Process

Soil formation goes through different stages before it gets mature. We can divide the process in following four stages.

**Soil Enrichment** – It add mineral to soil body eg. Inorganic enrichment occurs when sediment is brought from higher to lower areas. Organic enrichment occurs when humus accumulating in O – Horizon percolates to enrich A horizon below.

**Removal** – this is the process that removes material from soil body eg. Surface erosion.

It also involves leaching. It is the process when seeping water dissolves soil material and moves them to deeper levels or to ground water.

**Translocation** – Materials are moved within the soil body, usually from one horizon to another. It includes the process of eluviation and illuviation, described in soil profile.

It also includes salinisation. (The process of salinisation is explained in soil degradation.)

**Transformation** – It is the process of conversion of primary to secondary minerals.

It involves conversion of organic materials into humus.

## Soil Degradation:

Soil degradation is the decline in soil quality caused by its improper use, usually for agricultural, pastural, industrial or urban purposes.

Soil degradation is a serious global environmental problem and may be exacerbated by climate change. It encompasses physical, chemical and biological deterioration. Examples of soil degradation include

- Loss of organic matter
- Decline in soil fertility
- Decline in structural condition
- Erosion
- Adverse changes in salinity
- Acidity or alkalinity
- The effects of toxic chemicals, pollutants or excessive flooding.

Soils host the majority of the world's biodiversity and healthy soils are essential to securing food and fibre production and providing an adequate water supply over the long term. Ecosystem services provided by soils are integral to the carbon and water cycles and include cultural functions. There are strong links between climate change and soil condition.

**Some factors leading to Soil degradation are:**

- Deforestation
- Overgrazing
- Overuse of Chemical fertilizers and pesticides
- Rain
- Landslides
- Floods

**Some of the methods used across the world to conserve soil are:**

- **Mulching:** The bare ground between plants is covered with a layer of organic material like straw. This helps to retain soil moisture.

Mulching

- **Contour Barriers:** Stones, soil, grass are used to build barriers along the contours. Trenches are made in front of the barrier to collect water.
- **Rock Dam:** Rocks are piled up to slow down the flow of water which prevents gully formation.

Rock Dam

- **Terrace Farming:** The terraces are cut on the slopes to provide a flat surface for farming. This also prevents the direct flow of water down the slope.

Terrace Farming

- **Intercropping:** Different crops are grown in the same field in different rows and at different times to avoid exposing the bare land to water or wind.

Intercropping

- **Crop Rotation:** It is a practice of growing different crops in systematic succession. This helps in maintaining the level of nutrients in the soil and also pest control.
- **Contour Ploughing:** In slopes farmers plough the land across the slope rather than up and down the slope.
- **Shelter belts:** In coastal and dry regions, rows of trees are planted to check the wind movement to protect soil cover.

Shelter belts

- **Afforestation:** Planting of trees on a large scale to create a barrier against flowing water and wind. It also increases water penetration in soil.
- **Prevention of overgrazing.**