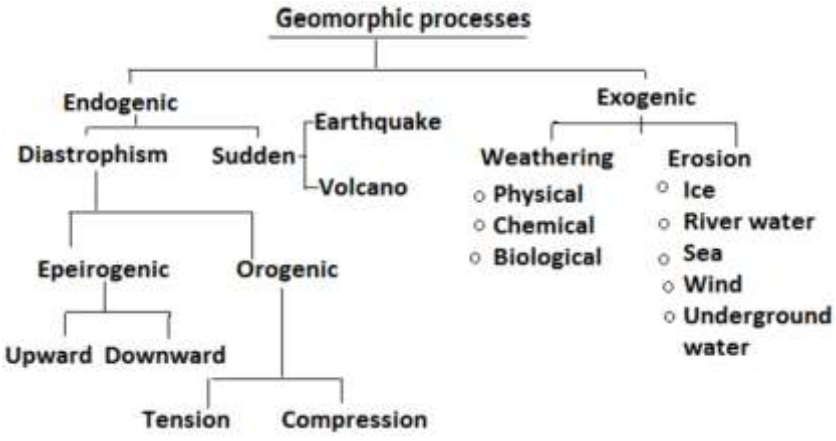
CLASS NOTES
ENDOGENETIC & EXOGENIC FORCES

ENDOGENETIC FORCES

- An important feature of the Earth's crust is that it is not static.
- The movement of different components of the Earth's crust is one of the causes for generating forces in the interior of the Earth. These forces are known as endogenetic forces.
- Although the endogenetic forces are active inside the Earth, some of its consequences are observed on the Earth's surface.
- For example, the relief and other topographical features of the Earth such as mountains, plateaus, cliffs, valleys and ravines are formed due to endogenetic forces.

CLASSIFICATION OF ENDOGENETIC FORCES

- The topographic features of the Earth have evolved over time and have been mainly caused due to forces active in the Earth's crust. These forces are called endogenetic forces.
- It changes the Earth's topography through the process of creation, destruction, recreation, and maintenance of geomaterials
- These forces produce various types of vertical irregularities on the surface of the Earth in the form of mountains, ridges, plateaus, valleys, and plains, etc.
- The volcanic activity and Earthquake events are also the expressions of endogenetic forces called sudden forces
- As the name suggests, the sudden forces arise due to sudden movements of the interior components of the Earth.
- Although it is generally believed that the movement of the Earth's interior components is the major cause of endogenetic forces, the precise cause of endogenetic forces is not yet known.
- Some Earth scientists assume that endogenetic forces are related to thermal conditions in the Earth's interior.
- The variation in temperature in different regions of the Earth's interior may cause contraction and expansion of rocks, and thereby generating endogenetic forces.
- The endogenetic forces are classified into two types, namely diastrophic forces and sudden forces.
- The diastrophic forces can cause a component of the Earth's interior to move vertically or horizontally.
- The vertical movement is called epeirogenic movement and horizontal movement is called orogenic movement.
- Whereas sudden forces occur due to sudden & rapid movements that results a massive destruction in the interior of the Earth.
- The effects of diastrophic forces are not even visible after thousands and millions of years.
- Geologically, some changes are long period changes and are unable to recognize during our life time because they operate very slowly.
- Short term changes can be identified within few seconds to hours, for example volcanic eruptions and Earthquakes.



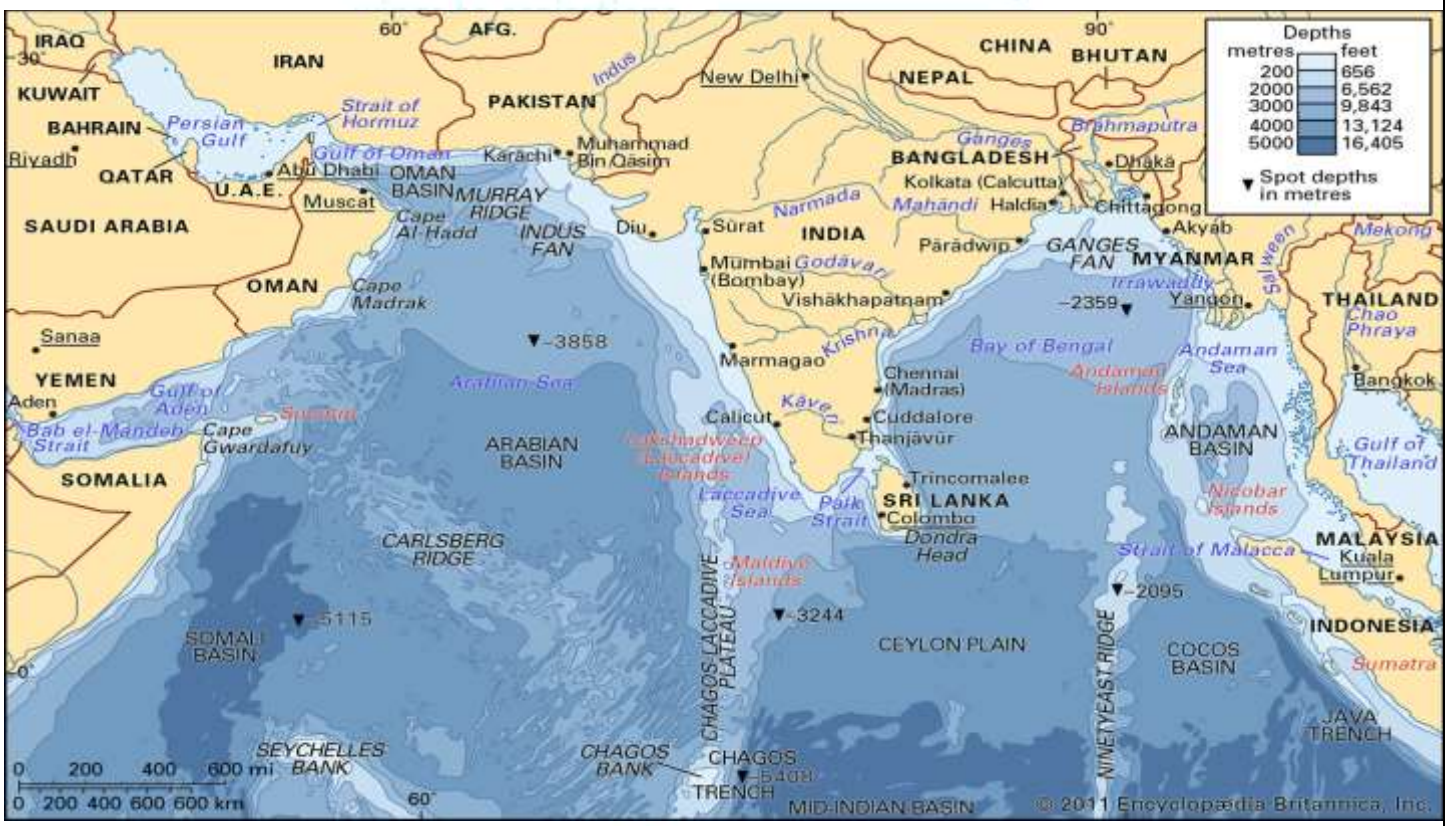
DIASTROPHIC FORCES

- The diastrophic forces are a type of endogenetic forces and originate at some depth within the Earth's crust.
- Diastrophic forces include both vertical and horizontal movements.
- These are constructive forces, operate very slowly and are responsible for the formation of primary landforms such as mountain peaks, plateaus, valleys, plains, etc.
- Diastrophic forces can be classified into two types; (a) epeirogenic movements and (b) orogenic movements.

EPEIROGENIC MOVEMENT

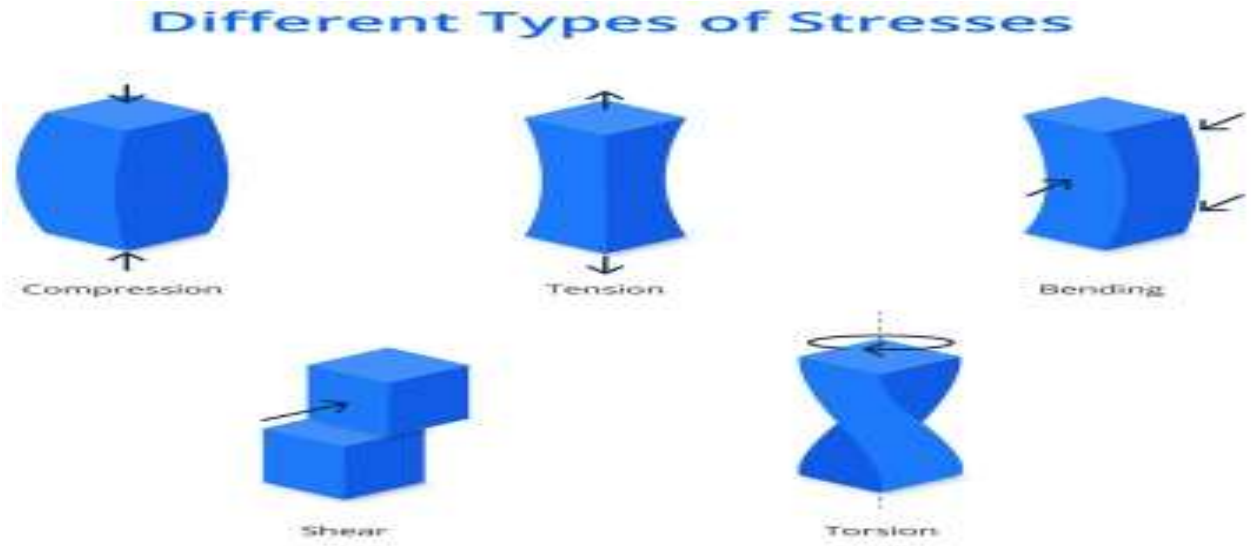
- The continental crust comprises of low-density silicate minerals such as aluminum and potassium, whereas, the oceanic crust is rich in iron; therefore it is denser than continental crust.
- The continental crust is thicker than oceanic crust but has a lower density.
- Because of this property, continents float on mantle just like icebergs that float on the ocean.
- The deepest and inaccessible zone of the Earth is called core which is surrounded by a shell silicate minerals-rich rock called as the mantle.

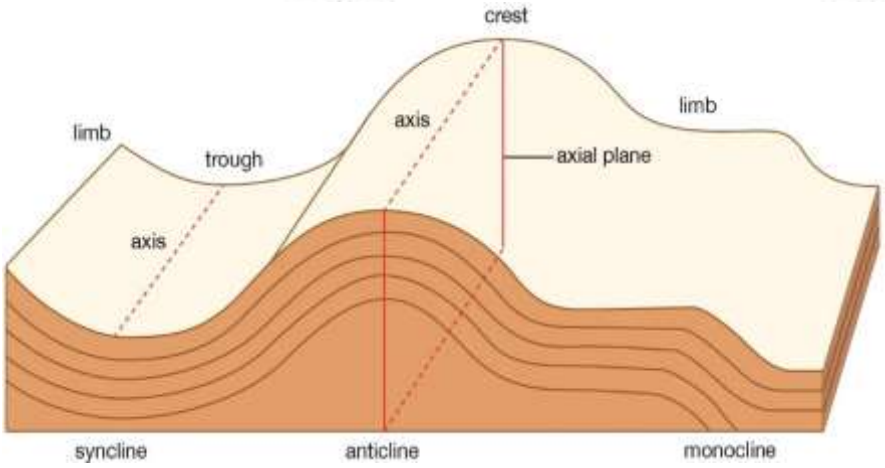
- These movements cause upliftment & subsidence of continental crust through upward & downward movements, respectively.
- Both upward & downward movements are in fact vertical movements caused by a set of forces acting along the Earth's radius.
- These affect the broad regions of the crust without causing significant folding or faulting.
- Epeirogenic movements are also known as continent building movements as these movements affect the large scale land masses.
- It causes the upliftment of whole continent or a part of it.
- Due to this activity, part of continents may rise (uplift) or sink (subsidence).
- The upliftment of a coastal land of the continents is called emergence.
- Some important examples of upliftment are Deccan Plateau, upliftment of submerged coastal Florida and West Coast Islands.
- Downward movement causes the subsidence of continental land area, and the land area near the coast submerged under the sea is called submergence.
- Due to the subsidence, Andaman and Nicobar islands are separated from Arakan Coast.



OROGENIC MOVEMENT

- Orogenic movements occur mainly along the plate boundaries or plate margins that produce intense folding and faulting.
- The force is working on Earth's mantle in a horizontal manner cause to the orogenic movements.
- These horizontal forces act in three ways: towards each other, opposite one another and parallel to each other.
- The two forces operate face to face or towards each other are called compressional forces or convergent forces.
- The rocks are squeezed or crushed when compressional force applies on it
- The forces act on the rock in opposite direction leading to rupturing of the rock.
- These forces are called tensional forces or divergent forces.
- Under shearing forces, the stresses act parallel to each other but in opposite directions like the motion of scissors.
- These forces can produce transform faults.
- Tensional and shearing forces create faults or fractures.
- If there is compression on one end, there may be tension on the other end.
- Hence, it is understood that folding & faulting often act together.



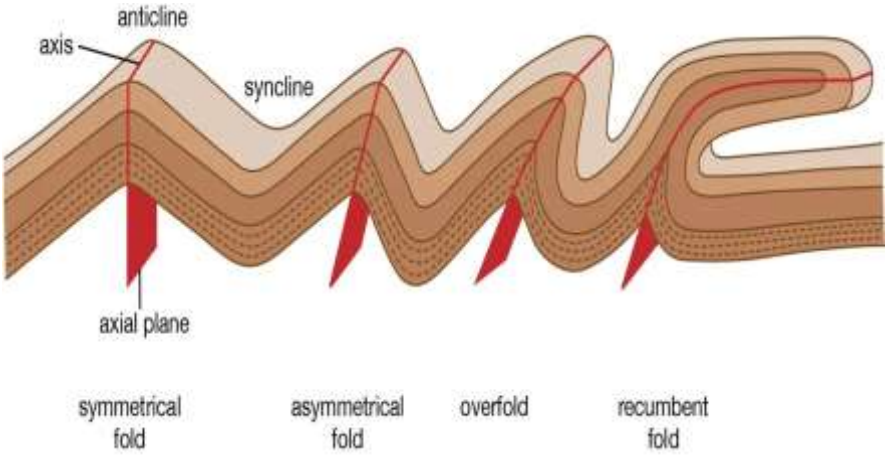


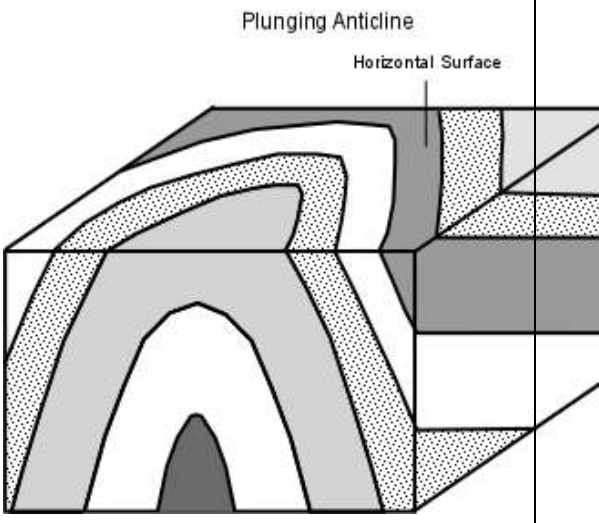
FOLDING

- When two continents collide, the intervening sedimentary rocks of continental margins come under strong forces of compression.
- The wavelike undulations imposed on the horizontal strata comprise of alternating archlike upfolds, called anticlines and trough like downfolds, called synclines.
- A monocline is a single bend in or otherwise horizontal formation.
- The initial landform associated with an anticline is a rounded mountain ridge, and the landform associated with syncline is an elongated open valley.
- The size and shape of folds depend upon various factors such as the nature of rock, intensity, and direction of compressive forces, etc.
- Folds in some rock layers measured from few centimetres to kilometres, and are tight or broad, symmetrical or asymmetrical.
- Most of the mountain systems exhibit some degree of folding.
- There are large scale folding structures in the mountains of Appalachian and Himalaya, etc.
- The two sides or flanks of folds are called limbs.
- The central line between the limbs, along the crest of anticline or trough of syncline is termed as the axis of fold.
- An imaginary plane drawn between the limbs, which divide the fold in half, is called the axial plane.
- If the axis is inclined from the horizontal, the fold is said to plunge.
- If the axial plane is vertical and the axis is horizontal, then the fold is termed as symmetrical whereas the axial plane is inclined, the fold is inclined.

- The compressive forces work regularly or more or less equal from both sides with moderate intensity known as symmetrical or simple or open folds.
- These are very rarely found. Few examples of these folds are Jura Mountains of France and Switzerland.
- Asymmetrical folds are formed when both the limbs are unequal and irregular with different angles of inclination.
- With the strong compressive forces both the limbs of fold become parallel called Isoclinal folds.
- In this type, both the limbs dip at equal angles in the same direction

Recumbent folds are formed when the intensity of compression over both the limbs of fold may be parallel as well as horizontal.





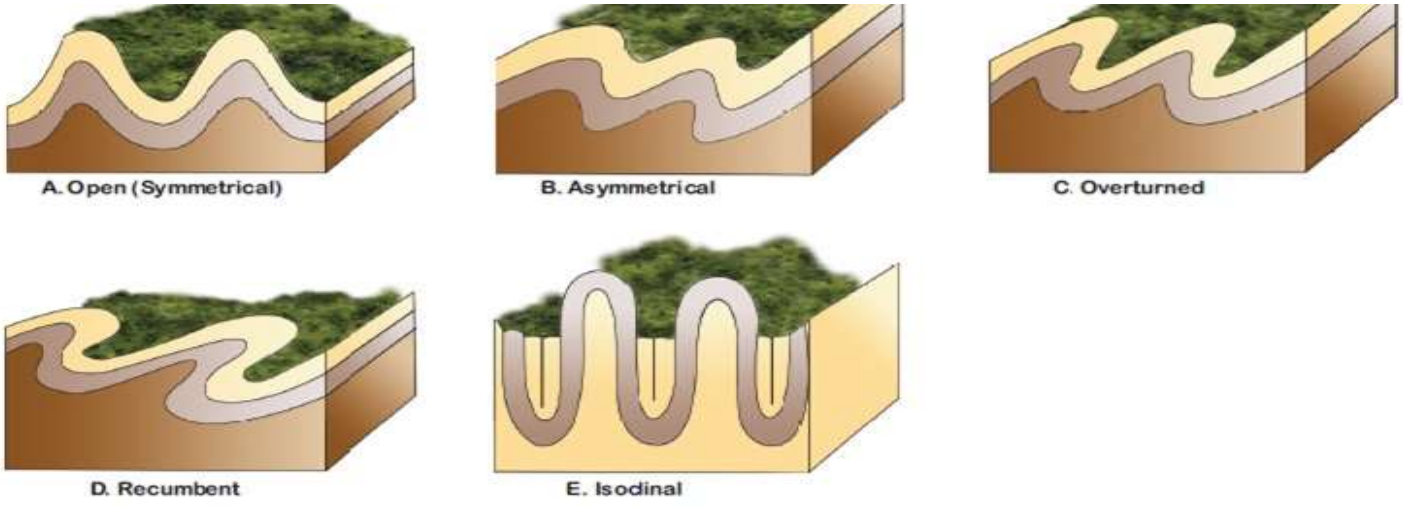


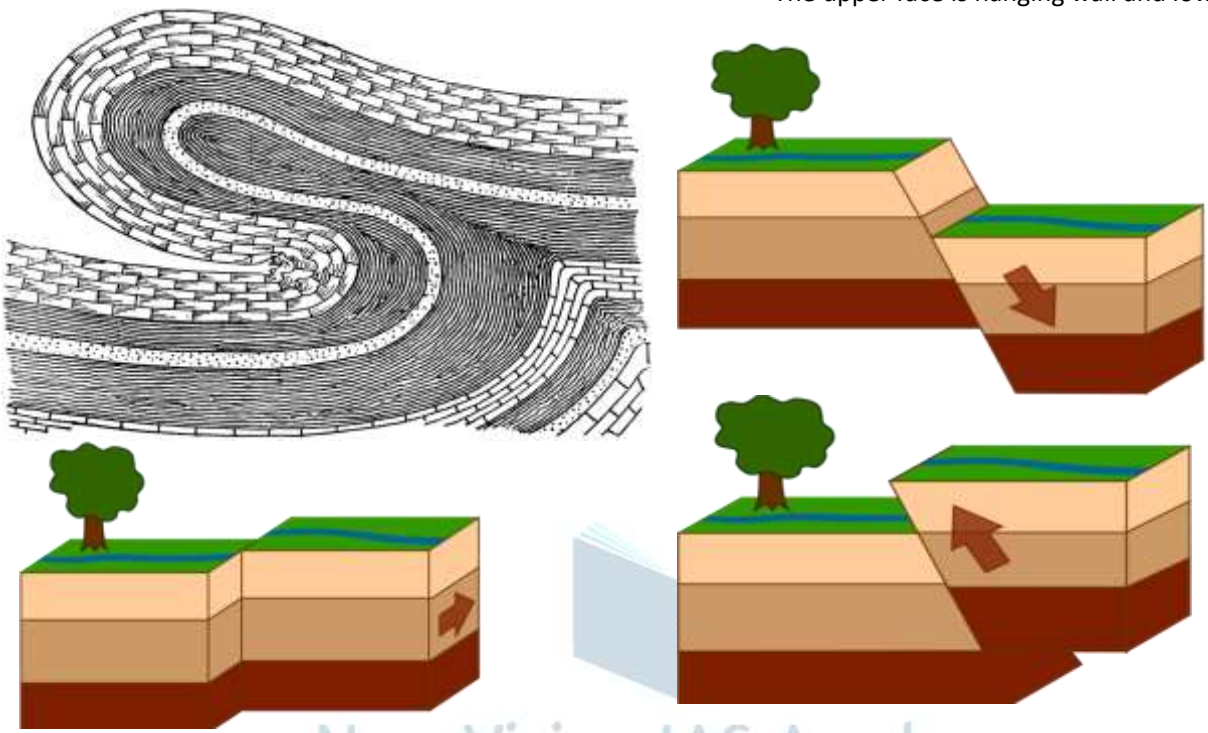
Figure 3.15 Types of Fold

- With further increase in pressure, the recumbent folds may be sliced or sheared in which the slices of rock moves over the underlying rock on flat surfaces of low inclination is called as overthrust faults. The plane of shearing is a thrust plane and the structure is Overthrust fold.
- Individual rock slices or thrust sheets are carried horizontally for several tens of kilometers over the underlying rock strata.
- These kinds of thrust sheets are called nappes, meaning from the French word "cover sheet" or "table cloth".
- A nappe & a recumbent fold are both geological structures related to folding, but nappe is a larger-scale, often thrust-faulted, sheet of rock that has been moved from its original position, while a recumbent fold is a type of fold where the axial plane is nearly horizontal.

FAULTING & THRUSTING

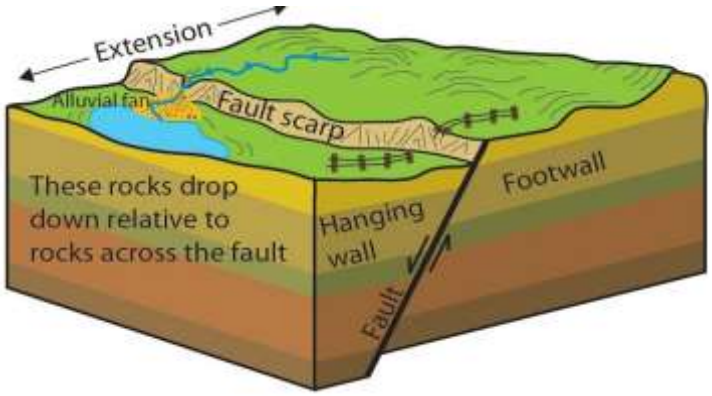
- Fault is a fracture in the crustal rock, which forms mainly due to tensional forces caused by the endogenetic forces.
- The plane along which the rock blocks are displaced is called fault plane. Faults are formed when rocks on both sides of the plane have moved relative to each other, or parallel to the plane.
- Due to tensional forces, rock layers can be dislocated.
- During the formation of fault, the vertical displacement of rock blocks may take place up to several hundred meters & horizontal displacement may extend up to several kilometers.

- When faults are of great horizontal extent, the surface trace or fault line can sometimes be followed along the ground for several kilometers.
- Detailed study of faults helps geoscientist to understand how the tectonic plates move relative to each other.
- The four basic types of faults are classified based on the angle of inclination and the direction of displacement of one wall relative to the other
- If the displacement is up or down along the fault plane, it is called a dip-slip fault; whereas a strike slip fault is formed when the displacement is parallel to the fault line; and the displacement that combine both strike and dip-slip are said to be oblique slip faults.
- The faces of the blocks on either side of the fault are termed as the walls.
- The surface is separating the walls in the fault plane is called fault scarp.
- The upper face is hanging wall and lower face is footwall.



NORMAL FAULT

- Faults having primarily vertical movement are called as normal faults.
- A normal fault has a steep or nearly vertical dip.
- The direction of the movement is vertical & as a result one side is thus raised or upthrown relative to the other, that is downthrown.
- Normal faulting is an expression of the extension of faulted beds of the crust.
- In this type of fault, the lateral movement is in the opposite direction.
- Steep wall-like slope, escarpment or scarp, produced by a normal fault is called fault scarp.
- The height of fault scarp ranges from few meters to several hundred meters. Their length often attains 100 kms or more.
- Normal faults commonly occur as multiple & parallel series of faults.



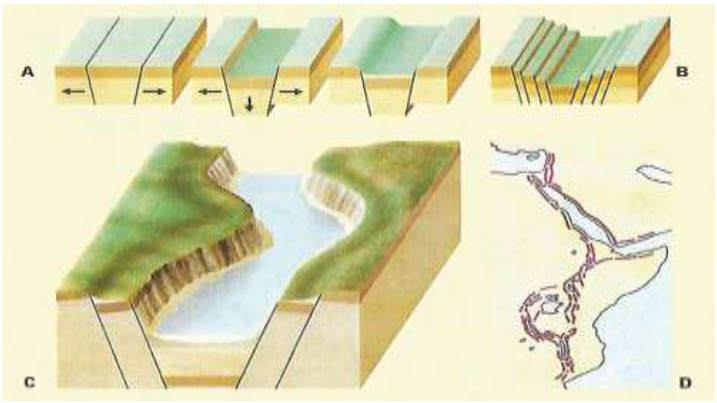
REVERSE FAULT

- The steep, high angle fault resulting from compressional forces is said to be a reverse fault.
- The opposite displacement leads to formation of a reverse fault in which the hanging wall moves up relative to the footwall.
- One shall remember that both normal and reverse faults form fault scarps at the margins of uplifted or down drifted block
- The reverse fault causes shortening of the faulted area while normal faulting results in the extension of the faulted area.
- If a reverse fault is subjected to great compressional force, the upthrown block override the downthrown block at a relatively low angle, the resultant movement would be mainly horizontal.
- The rock slabs move laterally for tens of kilometres.

- Landslides often accompany reverse faulting.

STRIKE - SLIP FAULT

- When the rock blocks are displaced horizontally along the fault plane due to the horizontal movement wherein no fault scarps are produced, lateral or strike-slip faults are formed.
- These are highly complex faults.
- Only a thin fault line is traceable across the surface.
- These are also named as shear faults, transcurrent faults, transform faults or wrench faults
- Some important examples are the Alpine Fault in New Zealand, the Great Glen Fault in Scotland and the Lorch-Alhama Fault or the Alhama de Murcia Fault in Spain.
- Thrust and reverse faults are generally observed in subduction and continental zones.



GRABEN / RIFT

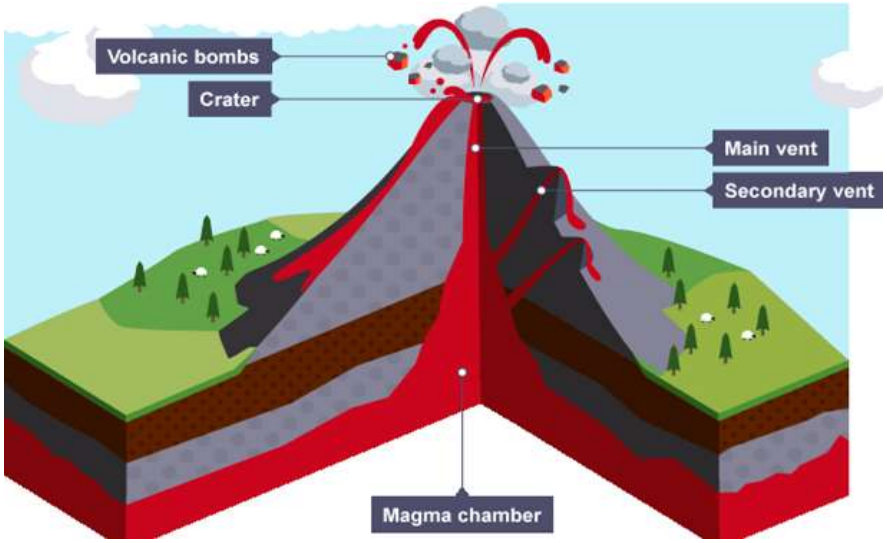
- A graben or rift forms where a block is displaced downward between two normal faults.
- A narrow fault block elevated between two normal faults is called a horst.
- Topographically, horsts form block like plateaus or mountains with flat top, steep and straight sides.
- A graben is a valley or trench like structure bordered by steep and parallel walls.
- Best examples of the horst are Shillong Plateau in India, and the Rhine graben (East African Rift Valley System) which stretches for 600 kms in length and 70 kms in width.

VOLCANISM

- Volcanism is one of the endogenic processes capable of rendering sudden and massive changes in the surface features of the Earth.
- It represents processes and features related to the movement and solidification of magma both within the crust and on the surface.
- Surface processes include the formation of volcanoes.
- Volcanism can be observed mainly in the interiors of oceanic plates.
- The activity of molten magma is defined as extrusive volcanism whereas magma solidifying below the surface is called intrusive volcanism or plutonic activity.

NATURE & CHARACTERISTICS

- A volcano has a deep vent, or opening, usually circular, through which heated materials consisting of gases, ash, water, liquid lava and molten rock are ejected from the Earth's interior to the surface of the Earth.
- The ejection of the heated materials from a volcano through the vent is called eruption.
- Magma extruded onto the Earth's surface is referred to as lava.
- The magma commonly consists of molten rock, hot liquids, gases, water vapour and other materials that force towards the Earth's surface with high pressure.



- The erupted lava and other materials accumulate close to the vent leading to formation of a conical hill.
- The crater is created at the top of the cone as funnel-shaped depression.
- The base of the crater is connected with the interior part of the Earth by volcanic pipe through which the lava rises to the top

TYPES OF VOLCANOES

- The nature of volcanic eruption whether explosive or quite, depends upon the type of magma.
- On the basis of mode of eruption, volcanoes are categorized into two principal classes such as central or explosive eruption and fissure or quiet eruption.
- The explosive eruption of a volcano is an awesome spectacle.
- It erupts pyroclastic materials including lava & rock fragments that consist of solidified lava blobs, ashes and dust.
- There is generally do not find any intensive explosion activity in the fissure volcanoes.
- Volcanoes are further classified into active, dormant and extinct based on the frequency or periodicity of the eruption

VOLCANOES OF CENTRAL OR EXPLOSIVE ERUPTIONS

- It erupt the liquid lava, rock fragments, as and lapilli through pipe-like central vent or mouth.
- After the eruption, these materials accumulate around the volcanic vent, and form the cone and crater like structures.
- The nature and intensity of the eruption is dependent on the ejected amount, pressure of gases and the viscosity of lava.
- Basic lava is also called mafic lava or basaltic lava which is less viscous and highly fluid in nature.
- If the lava is basic, it expresses low rate of eruption and absence of explosion.
- Whereas the lava is acid in nature, therefore more viscous, the eruption will be highly explosive.
- Volcanoes of central eruption type may be subdivided into five major types such as Hawaiian, Strombolian, Vulcanian, Vesuvian and Pelean.

HAWAIIAN TYPE OF VOLCANOES

- Less explosive activity & erupts quietly due to less viscosity of lava & non-violent nature of gases.
- They are effusive eruptions that feed much larger lava flows through time. There is little or no tephra (fragments of rock, minerals, and volcanic glass)
- Sometimes fountains of highly fluid basaltic spray rise up with the gases & when caught by strong wind, these lava pieces are stretched into long glassy threads known as "Pele's Hair'"(Pele is the goddess of fire in Hawaiian islands).
- These eruptions commonly occur in Hawaii islands and hence, named as Hawaiian type.
- Examples of these eruptions are Kilauea Iki (1959) in Hawaii island and Krafla (1975-83) in Iceland.

STROMBOLIAN TYPE OF VOLCANOES

- These are the most picturesque volcanic styles named after volcano formed the island of Stromboli, one of Lipri group of islands in the Mediterranean Sea.
- Strombolian is characterised by relatively mild explosion.
- It ejects liquid lava fragment materials like pumice, scoria, and bombs of hot materials as the bubble bursts.
- These eruptions are regular, rhythmic in intervals varying from few minutes to about an hour.
- Such volcanoes eject hundreds of meters to kilometres in height characterized by unusual lava flows.
- Strombolian eruption in the Mediterranean looks somewhat like an energetic Roman candle firework when viewed at night known to be the "Lighthouse of the Mediterranean".

VULCANIAN TYPE OF VOLCANOES

- Vulcanian eruptions, named after eruptions on Volcano island of the Aeolian Islands in the Mediterranean, are more explosive.
- Having more viscous magma — lava quickly solidifies and seals the mouth of the crater in between two eruptions.
- Due to this obstruction, the trapped gas in the underlying magma try to expand its space & subsequently, they force with high pressure and come out with explosion through the solidified vent.
- A much larger amount of ash & dust are emitted than their Strambolian counterparts.
- These can fill the atmosphere for many hundreds of square kilometres.

VESUVIAN TYPE OF VOLCANO

- This type of volcanic eruption occurs with a very violent explosion considered as similar to Vulcanian & Strombolian.
- The lava mainly comes out with great forces from the lateral cracks, and intense gases keep on accumulating in the main vent.
- When build-up the high pressure, the explosion occurs rapidly and these ashes and gases form thick mushroom-like shaped clouds.
- These clouds can rise to greater heights in the sky.
- The Vesuvian eruption, also called Plinian type, was recorded by Pliny at Vesuvius in 79 A.D.
- These are the most spectacular eruption styles which can be seen on the Earth.

PELEAN TYPE OF VOLCANO

- These eruptions are named after the explosive eruption of Mt. Pelee (1902) in Martinique Island in the Caribbean Sea.
- It engulfed the town of St. Pierre, killing all of its 30,000 inhabitants.
- These are highly explosive and eject highly viscous lava.
- These volcanoes are characterised by hot glowing clouds (termed nuee ardente, means glowing cloud).
- The emitted viscous lava forms a dome in the volcano's crater.
- The intensely hot glowing cloud travels rapidly down the flank of the volcanic cone searing everything in its path.

QUIET ERUPTION

- In this type, vents form as linear features on the Earth's surface and the lava erupts out of faults or cracks without any explosive activity in the Earth's crust.
- Fissure-fed eruptions often start as a sheet of magma which erupts along the fault.
- There is no pipe or central vent leading directly to the magma in the Earth's interior.
- So that it gets quickly localized to create a number of more discrete vents along the fissure.

- Low viscous lava i.e. basaltic lava comes out from the lateral cracks along the hillslope, which leads to the formation of small hillocks and cinder cone
- A huge volume of lava ejected about 14 km3 of magma from a 28 kilometers long fissure. This type of eruption also took place in Tavera, New Zealand in 1886.

DISTRIBUTION OF VOLCANOES

- At present more than 1500 active volcanoes are distributed over the globe.
- The volcanic activity is strictly confined to certain limited sectors of the crust.
- These are mostly found on the marginal parts of the continents, and in the littoral zones of oceans and seas.
- This information can be utilized to locate the edges of plates.
- Volcanic activity is mainly associated with plate boundaries
- The most notable area of volcanism in the world is around the margin of the Pacific Ocean known as the Pacific Ring of Fire.

EXOGENIC PROCESSES

- Exogenetic processes are active and visible on the Earth's surface.
- There are three basic types of exogenic processes namely weathering, mass wasting and erosion – occurs on the Earth's surface
- Weathering simply refers to disintegration and decomposition of rocks in-situ by weather phenomena i.e. temperature, precipitation, freezing and thawing, etc.
- Mass wasting or mass movement is a process by which the weathered material moves downslope under the force of gravity

WEATHERING & MASS WASTING

- The Earth has been evolved 4.6 billion years ago, and the Earth's features are continually succumbing to the exogenic processes of weathering, mass wasting and erosion along with the effect of climate change.
- The processes lead to alter the topography are mostly working slow and ongoing.
- But, some processes reveal change with sudden effect for example events like Earthquake, flood, landslides, etc
- Earth is a dynamic planet, and the behaviour of the external processes on the Earth's surface is more predictable.
- Exogenetic/ exogenic/epeirogenic forces are also called as denudational or destructional processes originated within Earth's atmosphere.
- These are operated largely by the force of gravity.
- Various geomorphic agents such as running water, groundwater, glaciers, wind and waves remove the disintegrated rock materials from one part of the Earth's crust, and transport as well as deposit them elsewhere.
- These processes are continuously engaged in the rock wastage, land destruction or land sculpture that may collectively be defined as denudation or degradation.
- Weathering is a static process. It continuously engages in the process of disintegration or decomposition of rock in-situ, that means, it does not involve in the process of removing rock materials by a transporting agency.
- The products of weathering, e.g. sand, clay, and rock fragments etc., tend to accumulate on the spot as soft surface layer called regolith, which covers the bed rock.
- Scientific definition of weathering involves mechanical fracturing or chemical decomposition of rocks by natural agents at surface of the Earth
- Weathering process is of mainly two types- (i) physical or mechanical weathering (ii) chemical weathering.
- The nature and intensity of weathering vary from place to place and from region to region.
- There are four variable factors influencing the type and rate of weathering namely rock structure, climate, topography and vegetation
- The physical structure of the rock includes rock massiveness, porosity, permeability, joint patterns, bedding planes, faults, fractures, etc., and mineral composition of the rock involves chemical composition, grain size, crystallinity etc., largely affect the nature and intensity of weathering.
- The minerals forming the rock determine whether rock is more susceptible to chemical or physical weathering.
- Rocks have high percentage of carbonates, which consist of more soluble minerals those can easily be affected by the chemical weathering
- Rocks with numerous joints allow the entry of water, air, and roots of the trees, etc. and are more subjected to mechanical disintegration.
- Horizontal bedded rocks are affected by the mechanism of disintegration and decomposition, whereas vertical strata is broken down due to frost action and ice.
- The major climatic factors include temperature and humidity that play an important role in determining the rate of weathering.
- Topographical factors responsible for weathering include elevation, slope and rock exposure
- The nature of weathering is largely determined by natural vegetation cover & its type in a particular region.

- Vegetation covers and protects the rock outcrops from the direct impact of sun rays but at the same time the roots penetration breaks down the rocks which leads to the disintegration of rocks.
- Physical weathering is more effective in warm and wet environments, whereas chemical weathering is apparently more effective in cold and dry environments.
- Usually, in most places both physical and chemical weathering processes operate considerably at a time and are difficult to separate them for ascertaining the work that has been carried out individually.

PHYSICAL OR MECHANICAL WEATHERING

- It is the breakdown of massive bedrock into smaller fragments by various physical stresses.
- It involves mechanical disintegration of rocks without any change in its chemical composition through frost action, salt-crystal growth, thermal expansion and contraction and the mechanical action of plants and animals
- It begins with the formation of cracks in bedrock.
- When cracks widen and deepen, the rock becomes susceptible to disintegration.
- Frost action or ice wedging is one of the most effective types of mechanical weathering.
- Water in the rock periodically freezes and thaws during night and day.
- The water entered into the joints freezes and forms ice, which causes the joints deepening and widening.
- When the ice thaws, the water flows further deep into the rock.
- Generally, when water freezes, it increases about nine percent in volume.
- This repeated expansion activity of water can cause pressure in rock pores, cracks and crevices leading to the disintegration of rocks.
- This process is found to be most effective in well-bedded or jointed rocks, and very common in cold climatic regions (5° to 15°C).
- Frost action is responsible for the rock debris that accumulates at the base of mountain slope which is called talus slope.
- Salt crystal growth is caused by the crystallization of salts from evaporating water.
- In arid regions, dry weather draws moisture to surface through rock openings by capillary action of water, which may contain salts.
- As the water evaporates, the salts are left behind as tiny crystals.
- These crystals expand as they heat up or dry, and exert a force or enough pressure towards breaking up the rocks.
- Thermal stress weathering results from the expansion and contraction of bedrock which is caused by rapid temperature changes.
- This type of weathering is mostly found in desert regions where there is very hot in the day and cold in the night.
- Some rocks such as shales and sandstones are less affected by temperature changes because the particles between the rock layers are separated by the silica.
- Whereas crystalline rocks like granites in which particles are closely associated with each other so that they gets affected by expansion and contraction due to temperature variations.
- In the hot desert areas, the outer layers of the rock expand from heat in the day, and contract from rapid cooling during the night.
- Differential expansion and contraction due to diurnal range of temperature causes the tension and stresses leading to the formation of parallel joints in the rocks. This process is termed as exfoliation.
- Physical weathering along with the chemical weathering processes further weaken the joints – the layers thereby start peeling off in sheets or slabs of rock rather than eroding grain by grain
- Expansion process can also be observed in rock quarrying where rock explodes and breaks after blasting operations.
- Plants and animals are also direct contributors to the mechanical weathering.
- The penetration of plant roots into cracks exert expansive force that widens joints and other fractures.
- This can lead to the eventual disintegration of an entire rock mass.
- Furthermore, the activities of dead organism also significant factor in rock disintegration where they promote chemical weathering processes.

CHEMICAL WEATHERING

- It is the breakdown of rocks by the alteration of rock-forming minerals.
- Chemical alteration of minerals involves many types of reactions between the atmospheric and biotic agents.
- Some minerals (e.g. olivine & augite occur in basalt) are far more alterable than others like quartz.
- Quartz is extremely resistant to chemical change and slightly soluble in water and more in saline water.
- Many minerals soluble in rainwater are usually acidic in nature & leach rocks quite actively.
- Chemical weathering is most effective in warm and humid climates compared to cold and dry regions, where heat & moisture are in abundance.
- Chemical weathering involves a number of processes, all associated with moisture, disintegrate the minerals in rock.
- Most significant among the processes of chemical weathering are carbonation, hydrolysis, and oxidation.
- Carbonation starts in the atmosphere, which involves the condensed vapor in the cloud and carbon dioxide.

- The carbon dioxide (CO_2) in the atmosphere combines with rainwater forms a weak carbonic acid (H_2CO_3).
- When rainwater infiltrates into the ground, it takes on more carbonic acid.
- For instance, carbonate rocks such as limestone and dolomite are altered by the dissolving action of H_2CO_3.
- From this reaction, a very soluble product i.e. calcium bicarbonate is produced that can be easily removed by runoff or groundwater.
- In other words, the seepage of acidic water in the limestone region leads to the rock corrosion and leaching.
- This is more prominent in karst topography regions.
- Karst landforms are developed by various chemical weathering processes where underground water widens the cracks of limestone rock through carbonation.
- One set of these reactions is hydrolysis – a process involving chemical combination of water and a mineral.
- The process involves active participation of water in chemical reactions to produce a new mineral compound.
- The significant result of hydrolysis is that it produce a weaker or soft mineral, which results to disruption of the rock.
- For example, silicate minerals like potassium feldspar present in many igneous rocks are weathered and a clay mineral, Kaolinite, is formed that is susceptible to disintegration.
- Most of the minerals, except highly resistant mineral like quartz, are very susceptible to chemical change when exposed to atmospheric and biotic agents.
- Hydrolysis is mostly observable in weathering of granite and igneous rocks that alters the minerals irreversibly.
- The oxidation process commonly occurring in the natural environment. It is a process, in which the dissolved oxygen in water comes into contact with certain rock minerals, especially iron, to form oxides.
- Oxidation generally accompanies hydrolysis and is the most apparent in rocks containing iron.
- When oxygen combines with iron, the reddish iron blisters are formed which is probably the most common oxidation effect in the lithosphere.
- This process is known as rusting, and is responsible for an initial indication of chemical weathering in many rocks due to their discolouration as brownish-red to red.
- When the iron is oxidized, it forms ferric iron, which in turn is transformed into limonite.
- Limonite is a mineral that resembles with rust.
- We can see colourful stains on rock faces where groundwater is supposed to seeps from rock faces mixing with iron and other oxides.

MASS WASTING

- The weathered material is moved relatively for a short distance down the slopes under the influence of gravity with or without the assistance of running water called mass wasting or mass movement.
- There are several factors favoring mass wasting such as structure (closely spaced joints, faults, etc.), composition and permeability of rocks, topography (steep slopes and cliffs), climatic factors (large variations in temperature, heavy rainfall, etc.), vegetation cover, and also the role of slope gradient is another more important factor of mass wasting
- Rugged young mountains are the sources where rapid mass wasting events can be observed.
- Generally, young mountains are eroded by rivers and glaciers into regions characterized by very steep and unstable slopes that result in sudden destructive slides and falls.
- When pores in the sediment are filled with water, they cause the materials slide past one another due to loss of bonding among the sediment particles.
- Normally water adds considerable weight to a mass of materials.
- When heavy rainfall occurs, the added weight sometimes may cause the material to slide or flow down slope.
- Deforestation leads to more frequent mass wasting
- The trees protect against erosion and contribute to slope stabilization due to their root system, which holds the soils and regolith.
- Due to an Earthquake and its aftershocks particularly faulting and jointed bed rocks can dislodge enormous volume of rock materials
- There are mainly three basic classes of mass movement such as falls, slides and flows.
- The sliding occurs where the velocity at the base is similar to that at the top, so the material behaves as a rigid solid that detaches along a basal surface e.g. slumps and landslides.

MASS WASTING : FALLS

- In flowage, the material behaves as a fluid because the velocity of flow is maximum at the surface for example soil creep, Earthflows and mudflows.
- Falls refer to the free falling of pieces of rock over any steep slope.
- In this process, the rock blocks or fragments are dislodged from a cliff or steep slope, and fall, roll or bounce down to the cliff foot.
- These falls mostly occur in the mountainous region due to frost action and other weathering processes.
- The resultant broken rock material accumulates at the foot slope forming steep ramp-like incline and are collectively referred to as talus or scree

MASS WASTING: SLIDES

- Slides occur when the large masses of rock as a unit or block moves downslope abruptly.
- This type of mass wasting where in a mass of rock or soil material slips downhill over a slippage surface is called failure plane.
- It is an instantaneous collapse of a slope sometimes happens without water lubricant or clay.
- It occur in a sudden movement of slope in a fraction of time – in a series of minor displacements over days and more, or even a long period of time.
- In slides, the displacement can be of one meter to several meters or more downslope.

MASS WASTING : FLOWS

- Plastic nature of materials that may have liquid or non liquid stability are in flowing motion termed as flows.
- The most common slower flow type of mass movement is creep or soil creep.
- The slowest and imperceptible downhill movement of debris and soil is described as creep.
- The mechanism involves freeze/thaw and wet/dry conditions contributing to soil creep by progressively moving soil particles down the hill.
- The rate of creep is very slow.
- The evidence of this process in the field through downward curvature of trees and gravestone, the tilt of fencing posts, electric and telephone poles, and inclined structures on creeping slopes, etc.
- Vegetation cover can help to reduce the rate of soil creep.
- Some flows are characteristically rapid movement, and occur when the soil mass is being saturated with the water.
- The most common type of flow movements are Earthflow and mudflow.
- The rapid movement of water-laden soil material flowing down on low-angle terraces or hill sides is known as Earthflow.
- This can happen on any steep slopes when the underlying rocks are in saturated condition during or after rainfall.
- At the top of the area, a steep scarp is developed where the moving debris is pulled away from the upper slope.
- The flow effect is very clear in the lower portion; where a toe of material pushes out over the valley floor.
- On the other hand, a mudflow is a mass of saturated rock particles of all sizes soaked with sudden heavy rainfall and/or shallow groundwater.
- The runoff waters carry the soil and rock debris from a large slope area, and wash them to a valley or canyon.
- Mudflows are very common in the arid and semi-arid regions.
- They often begin as slides or slumps, emerging from failure mass, and moving long distances downslope.
