7 A CLASSIFICATION OF FORCES AFFECTING THE LANDFORMS

Landforms

There are many forms of land on the surface of the earth. Continents, oceans, mountains, plateaus, valleys, deltas, etc., are some of the examples of landforms.

Landforms can be divided into three orders. First Order landforms are continents and oceans. The Second Order Landforms are mountains, plateaus and plains. The Third Order Landforms include mountain sections hills, valleys, deltas, etc.

All these landforms change with time. The areas where there is now land was once sea. For example, 200 million years ago there was a sea called Tethys in the areas where the splendid Himalyas with their sky touching peaks presently exists.

Besides these slow changes, there are some violent changes in the form of explosions ofvolcanoes and of earthquakes. In 1872, a hill 7 metre high, was formed in Obens Valley (California) due to an earthquake. Similarly, a 14.3 metre high hill was suddenly formed in the Gulf of Yakutsh (Alaska) in 1899.

Usually the landforms change at a very slow pace. Sometimes the changes are violent and fast but these changes are comparatively less important than the slow changes.

The Forces Affecting Changes in the Landforms can be Divided into the Following Two Categories-

(1) Endogenetic Forces- These forces are generated in the interior of the earth and cause mountains, plateaus, etc. These forces cause the parts of earth to rise or subside.

(2) Exogenetic Forces- These forces are produced and act on the surface of the earth. Wind, water and snow are such forces which erode the surface of the earth or make depositions on it. These external (exogenetic) forces are also called processes.

Endogenetic Forces (Tectonic Forces)

These forces are known as earth building forces (origin-'ends' within, 'genera' -origin). We have no direct knowledge of the generation of these forces because the field of their activities is in the interior parts of the earth. Some scientists think that these forces are caused by contraction of earth on cooling, change in the rotation of the earth or due to the action of the radioactive elements.

On the Basis of Intensity, these Forces can be Divided into Two Subgroups-

(i) Sudden Endogenetic Forces-

The main forces in this sub-group are volcanic or of earthquake. Landscape suddenly undergoes disintegration. For example, production of deep fissures in plain areas, the sudden changes in the routes of river, the formation of small hills, etc. are some of the effects of these forces.

(ii) Diastrophic Forces-

These forces act very slowly. Their effect becomes discernible after thousands of years. For example, the coast of the Baltic sea rises by 1.3 metres in a century. There are a large number of places where the coast is either rising or sinking. The diastrophic forces from the point of view of areal distribution can be divided into two further sub-groups.

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(a) Vertical Movements - Vertical movements originate from the centre of the earth and affect its surface. Consequently large scale uplift or subsidence of a part of the earth's surface takes place. These movements are slow and wide spread and do not bring changes in the horizontal rock strata. These movements are mainly associated with the formations of continents and plateaus, hence these are also known as continent building or plateau building movements. Besides, these movements are also called epeirogenetic movements. 'Epeiros' in Greek language means 'continent'.

The sedimentary rocks are deposited and formed in the oceans and seas. The presence of these sedimentary rocks is wide-spread in continents. This clearly shows that these were uplifted or raised to form continents.

Contrary to the above, there are countless evidences of submerged buildings, river -valleys and cities due to subsidence into the sea. Some of such examples include the submerged ancient buildings in Mediterranean in its Crete Island and the ancient city of Dwaraka in Saurashtra, India. These changes clearly point out the downward movement of the Earth's surface.

(b) Horizontal Movements - There are forces which act on the earth's crust from side to side i.e. horzontally or tangentially. Naturally, they cause a lot of disruption in the horizontal layer of strata as they do involve a good deal of compression and tension of the preexisting rocks since these forces act horizontally or tangentially to the earth's spherical surface. These are known as horizontal or tangential movements.

Structures Produced by Endogenetic Forces

Endogenetic forces create deformation in the earth's crust. This distortion takes place more in sedimentary and metamorphic rocks than in igneous rocks. As the former rocks are usually horizontal, a little deformation becomes easily discernible. Weathering and erosion smoothens away the deformation over the crust after some time but the deformation produced in the interior areas are not affected by the exogenetic forces (wind, water, ice, etc.). Hence, the deformation created by the endogenetic forces in the interior part of the crust is more distinct than on the upper part of the crust. The deformations created by the endogenetic forces can be grouped into two divisions:-

(1) Crustal Bending

(2) Crustal Fracture

Both of them are responsible for creating a variety of landscape which are immediately subjected to exogenetic forces.

(1) Crustal Bending

Diastrophic forces raise an area at a place. Broad domes are created in this process. The diameters of these domes range from 160 to 325 km. The process of dome formation is known as warping. Domes are formed by slow warping. Water, wind, ice, etc., begin to work on them as soon as the domes begin to rise. After some time, the raised portion of the domes is eroded away but the harder rocks which resist erosion appear in a circular from.

When the endogenetic forces, instead of raising the area force it down, the rocks become concave and a broad basin is formed. These basins are thus formed by a process which is opposite to dome formation. These basins are filled in by sediment.

If warping makes a broad sedimentary area to subside down, the subsided area of the sedimentary rocks is known as Geosyncline. In the ancient times there was a great geosyncline situated between the Gondwana land and the Angara land. The Appalachian and the Alpines were born in this geosyncline.

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Fold- When compression takes place on the crust due to endogenetic forces, a part of the crust is raised up in the form of folds. The Area is contracted in this process. Due to the forces acting upon it, the crust takes a wave like form. The up-fold part is known as anticline. The down fold-part between two anticlines is called syncline.

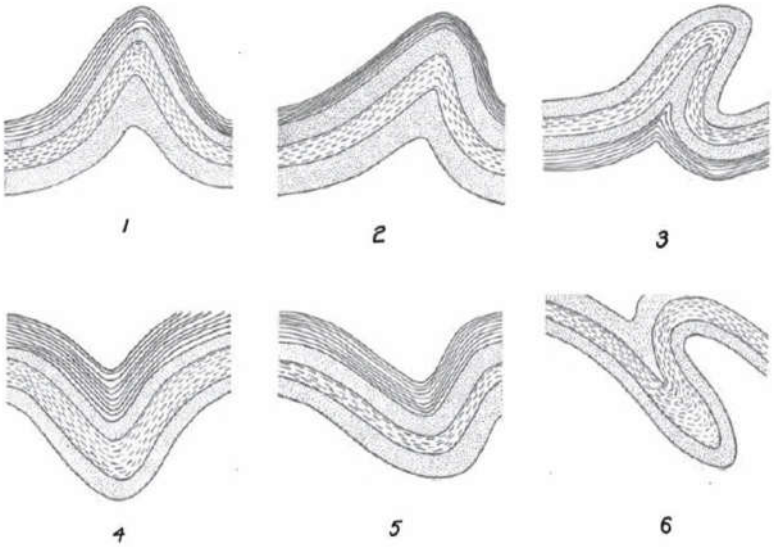

Figure 11. Various types of Folds. 1. Symmetric Anticline. 2. Asymmetric Anticline. 3. Overturned Anticline. 4. Symmetric Syncline. 5. Asymmetric Syncline. 6. Overturned Syncline.

Types of Folds- According to shape, the folds are of many types:-

(1) Symmetrical Folds- These are ordinary folds. The limbs of the folds are equally inclined on either sides.

(2) Asymmetrical Fold- One of the limbs is more inclined than the other.

(3) Monoclinal Fold- In this fold, one limb makes a right angle with the surface but the other limb is ordinarily inclined.

(4) Isoclinal Fold- The two limbs are so much inclined in such a way that they appear equally inclined and parallel to each other.

(5) Recumbent Fold- In this fold the two limbs are so much inclined that they become horizontal.

There are some other types of folds in addition to these mentioned above. The following folds are worth mentioning:

(i) Overturned Fold- In this fold one limb is overturned over the other limb. The difference between the overturned and recumbent folds is that the overturned limbs are not horizontal like those of recumbent fold.

(ii) Plunging Fold- If the axis of the fold is not parallel to the horizontal but makes an angle with it, it is known as Plunging Fold.

(iii) Fan Fold- It is a great anticline which has many small anticlines and synclines. It is also known as Anticlinorium. A great syncline having many small anticlines and synclines is called Synclinorium.

(iv) Open Fold- If the angle between the limbs of a fold is obtuse, the fold is called Open Fold. (v) Closed Fold- If the angle between the limbs of a fold is acute, it is called Closed Fold.

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In recumbent folds, one limb lies over the other in a horizontal position. If the endogenetic force is very strong and active, the inverted limbs is so much bent that it breaks along its axis. In this position the lower layers come up and the whole order of the layers is inverted. If the tension continues, the limb separates and moves a few km away. Now, there are other types of rocks below this separated limb which have no relation with this limb. This broken and separated limb of recumbent fold when found away from its place is known as Nappe. Many nappes are found in the Alps and the Himalayas. In the Himalayas Jaunsar Nappe lies to the west and Krol Nappe lies to the east of river Yamuna.

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(2) Crustal Fracture

The crust is being acted upon by tension, compression, rotation, etc., which cause the fracture of the crust. If these forces are weak, only cracks are formed. If the forces are strong, joints and faults are formed. Tension is more active than compression in breaking down the crust of the earth. The joints and faults are usually attributed to tension.

(a) Cracks-Tension and compression produce cracks. Due to tension the volume of rocks is reduced and the rocks shifts to left or right. Cracks are formed whereever there are weak areas. Cracks are only seen on the upper part of the crust. They are not deep. The evaporation of water in sedimentary rocks creates contraction of the layers and consequently produces cracks. Contraction due to cold of winter also produces cracks even in the igneous rocks.

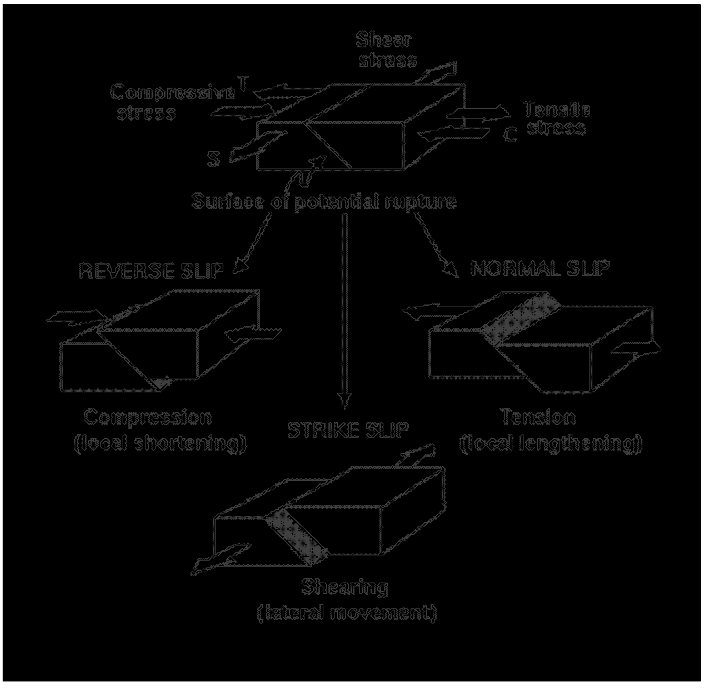
(b) Joints-When a rock is subjected to great pressure, it breaks down. The place where it breaks down is called Fracture. If the broken blocks do not have any displacement parallel to the fracture, the fracture is called a Joint. In fact there is no joint which is without any absolute displacement but if the movement is negligible the fracture is called a joint.

Usually, there are parallel joints is rocks. Many types of joints intersect one another at different angles. The group of these joints are known as Joint-System. If one type of joints arc more distinct than those of other types, the joint system is called Master Joint.

(c) Faults-If the blocks along the surface of fracture have significant movement, the feature is called Fault. The surface of fracture where movement takes place is called Fault Plane. When the fault plane becomes smooth on account of movement of blocks, it is called Slicken side. If the movement of blocks produces scratches on the fault plane, the scratches are known as Fault Strike. A study of these scratches gives an idea of the direction of movement. Sometimes the scratches are found in different directions and at different depths. This shows that the blocks had different movements in different directions at different times.

Types of Faults

In a fault, the movement takes place along the fault plane. The block that moves up is called Upthrust side of the fault and that which has moved down is called down-throw side. Upthrust side is also known as Hanging Wall and the down throw side is called foot Wall. The miners usually use these terms. When a block slips down along the fault plane, it creates a scarp of steep slope. It is called Scarp or Escarpment. From the consideration of position & movement, faults can be divided into -



(1) Normal Fault- The blocks on either side of the fault move in opposite directions. The foot wall slips downward. Sometimes it is difficult to know which side is displaced. The fault plane is either vertical or its slope is very steep. The fault is often called dip-slip fault when the rock above the fault plane moves down relative to the rock below. The scarp formed in this way is called Fault Scarp and has steep slope. The fault, in fact, is due to tension in upper part of the crust.

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(2) Reverse Fault or Thrust Fault- In this fault, the blocks along the fault plane move towards each other. The block above the fault plane moves up relative to the rock below. The hanging wall slips up. The slope of the fault plane is gentle. The fault scrap produced by this fracture are like normal faults.

(3) Oblique or Slip Fault- In these faults, both horizontal and vertical movements take place.

(4) Lateral or Strike-Slip Faults- The fault in which the movement is mainly in the horizontal direction is called a lateral fault. There is no scarp in the fracture or very low scarp is formed. Rivers sometime flow in the scarp line to some distance or a long canyon is formed.

(5) Transform Fault-When tectonic plates slide past each other this fault formed is called transform fault. It creates oceanic crust in Oceanic trenches.

(6) Overthrust Fault- In these faults, one block rides over the other block. The fault plane is almost horizontal of very gentle slope. The block which rides over may be thousands of metres thick but its width is never more than 80 km. Such faults are produced by compression and are accompanied by folds. The scarp in the fault is usually irregular.

(7) Step Faults- When an area suffers several parallel faults in such a way that the crust is broken into thin strata and slope is on one side, the fault looks like a flight of stairs. It is called step-fault.

(8) Pivot Fault- It is produced by rotational movement. Here one block appears to have rotated about a point on the fault plane such that for part of its length the fault is normal with decreasing throw, the position of no displacement being the point around which rotation appears to have taken place.

(9) Hinge Fault-These are created when a rotational movement between two fault blocks increases from zero to a maximum along the strike.

(10) Tear Fault- It is horizontal displacement of a series of rocks along more or less vertical plane. This fault is also known as Wrench Fault on Transform Fault.

Land forms Related to Faults

Faults produce many types of landforms. The following landforms are important:

(1) Rift Valley or Graben- If a block between two normal faults is depressed, the valley formed in the faults is called Rift valley or Graben. The River Rhine flows from Basel to Bingen in a rift valley. The greatest rift valley of the world starts from the south of Toros mountain and passing through Jordan valley and Red Sea it extends to Zambesi river in Africa. Besides, the central plain of Scotland, the Spencer Gulf of Southern Australia and Torrance lake are all situated in rift valleys.

The floors of rift valleys are not plain as is evidenced by the rift valley of Africa. The existence of many deep lakes is a proof of this fact. For example, Lake Tanganyika situated in this African rift valley has its bottom 530 metres below sea level. Though the walls of the rift valley have steep slopes yet weathering and erosion have reduced their slopes. The reason that the walls of the Great African Rift valley have steep slopes is that this rift valley is a new one.

Wegener has put up another cause for the formation of rift valley. In his opinion, the faults are usual occurrences on the earth's surface. When the blocks around a fault move away from each other, the faults become broad and turn into a rift valley. The process is called Block Faulting with the formation of Horsts and Grabens.

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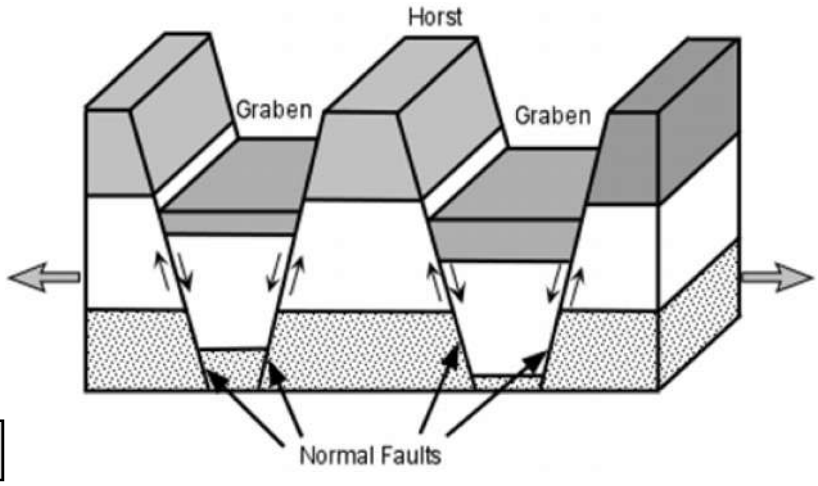

(2) Horst or Block Mountain-When a block between two normal faults is raised up, the raised block is known as Bloch mountain or an Horst. Its surface is like a plateau but its edges have steep slopes.

(3) Drag-When there is a movement in a fault, the rocks get bent. The bending gives direction of movement. This bending of rocks is called Drag.

Work of Exogenetic Forces

Exogenetic forces produce a lot of uneveness on the land surface. Mountains, rift valleys, etc., are caused by endogenetic forces. Nature is changing. The moment unevenness is produced, forces get into action to remove it. The forces which start to destroy the unevenness are known as Exogenetic forces. These forces start their destructive work and convert mountains into plateaus, plains, etc. They fill the pits and depressions with sediment and make it plane. In short, the exogenetic forces go on working to destroy the uneven nature of the land surface.

The relief produced by endogenetic forces in a short time takes a long time to be destroyed by exogenetic forces. In other words, the exogenetic forces are always lagging behind the endogenetic forces. Had it not been so, the earth would have been a dull plane devoid of any relief and the animals and vegetation would have been long extinguished.

The Following are the Main Exogenetic Forces-

(1) Rivers (2) Glaciers (3) Underground water (4) Sea (5) Wind (6) Temperature (7) Rain (8) Frost (9) Vegetation (10) Animals (11) Man.

The exogenetic forces do not only do the destructive work but are also engaged in constructive work. Construction and destruction both are necessary for the smoothening of relief. These activities are known as Denudation and Deposition.

Denudation-The process of wearing away o frocks and levelling them is called denudation. This process is two fold.

(i) Weathering- It is the disintegration and decay of rocks, in situ, by chemical and mechanical activities. Transportation of rocks is possible only after weathering. Temperature, rainfall, frost, water, vegetation, animal and man help in this process of weathering.

(ii) Erosion- It is the process of disintegration rocks by abrasion, solution, etc. The main agents of erosion are flowing water, moving ice, winds, currents and waves of sea, etc.

The process of weathering and erosion have been dealt with in detail in the following chapter.

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