UNIT – IV

GEOMORPHIC PROCESSES: DAVISIAN'S NORMAL CYCLE OF EROSION:

1. INTRODUCTION

i. This is the most important concept develop in geomorphology between 1890-1900.
ii. It was proposed by W.M. Davis.
iii. It explains evolution of landforms in a region.
iv. Davis got the idea from many scholars they include work of Brothers of purity in Dark Ages, Hutton, Powell, Hilbert and many others.
v. Davis synthesized the earlier ideas put them in a logical frame work and explained the concept. So, he has not given any new idea but only terms like pheneplain.
vi. The terms "cycle" is used because the beginning and the end have same condition the end may be the beginning for next cycle.
vii. The term "Normal" indicate temperate humid climate which is Normal for Davis.
viii. Davis calls Glacial and Arid conditions as "climatic accident".
ix. Since, the temperate humid condition is normal, river is the major processes. Therefore it is also known as "Fluvial cycle of Erosion" (Fluv means water).

2. BASIC POINTS TO REMEMBER

A few basic points should be kept in mind when explanation is given for cycle of erosion. They are,

1. They cycle concept is an idealized modal.
2. Stages in the cycle of erosion do not undergo the same rate of development.
3. Stages in the cycle of erosion cannot be equated with specific amount of time.
4. The theoretical final stage of the cycle, pheniplain is not absorbed any were in the world. One possible area may be the Siberian plain.

3. BACKROUND

Brothers of purity, Hutton, school of denudation.

In addition to the above views, Davis was influenced by theory of evolution of life by Charles Darwin.

If organic forms can have a process of evolution, the same principle may be applicable to landform evolution also. In the case of living organism, the evolution is "orderly, continuous, progressive broadly irreversible, sequents".

Davis indicates that landforms in a region also evolved in a similar sequent's and calls this idea as a cycle of erosion.

4. ASSUMPTION BY DAVIS

For his cycle of erosion concept Davis has few assumption.

1. Real world surface is complex and cannot be taken for model. Davis required a vast area with re relief. This is possible by assuming a recently uplifted area from beneath the sea.
2. The second assumption is that the uplift is sudden. So that is no time for exogenic process to act upon the land during uplift.

5. STATEMENT & EXPLANATION

Davisian cycle of erosion concept explains evolution of landforms in an area. According to Davis "Land form is a function of structure, process and stage". The structure here means geological structure of the rock.

Process refers to the major geomorphic agents. In the case of Normal cycle of erosion river is the process.

Stage here refers to identifiable sequents in the cycle. Davis considered three stage namely youth, maturity, and old stage.

According to Davis evolution of landforms in any area takes the following conditions "An initial set of land forms pass through a series of sequential land forms to an ultimate land form". According to Davis ultimate land form is called "peneplain". Therefore this concept also known a concept of "peneplanation".

Even though there is a Triology Davis does not give important to process. This is because the cycle considered evolution of landforms which takes millions of years. Therefore process is less significant because it may be modified.

Davis gives more important to stages. It is possible to explain initial stage, youthful stage, mature stage and old stage in the cycle of erosion.

1. INITIAL STAGE

In the initial stage the main features are;

1) Large area which is recently uplifted from blow the sea.
2) The area has no relief but an initial slope.
3) Area has no proper drainage. Therefore many marshy areas are found.
4) The surface has small depression here and there.
5) When rainfalls on the area, the depression are filled and water overflows. This water follows initial slope and so we have few consequent streams.

2. YOUTHFUL STAGE

1) Drainage develops well.
2) River start erosional work.
3) Vertical erosion is more than lateral erosion leading to formation of "V" shaped valley.
4) Relief increases gradually.

5) Inter flow ridges are broad in the beginning and become smaller and smaller with development of youthful stage.
6) Youthful stage ends when initial surface is totally remove.

3. MATURITY STAGE

1) Maturity is said to have reach when relief is maximum.
2) Initial surface is totally removed.
3) In the area any part is only a part of valley slope.
4) Then with development of maturity vertical erosion stops and lateral erosion becomes more important.
5) Meanders, Ox-bow Lake and flood plain occur.
6) Lateral erosion, reduces the interflow it just further.
7) These finally lead to old stage.

4. OLD STAGE

1) The upper uplifted area is almost removed.
2) The region becomes a vast erosional plain.
3) This is called peneplain "which means almost a plain".
4) The region is covered with thick Alluviam.
5) Slope is very low and so drainage becomes poor.
6) Marshy areas again occur.
7) Residual rock stand out and residual hills which are called monad nocks.

Peneplain has similar conditions to the initial (condition) surface this can form there beginning are initial surface of next cycle.

6. CRITICISM

1) The first criticism is that the sudden uplift assumption of Davis is not accepted. We have no evidence in the world were. There was a sudden uplift of large land areas.
2) It is generally said that stages in the cycle of erosion do not have fixtured amount of time. However we can take any particular region and estimate time for completion of one cycle of erosion. For example it is estimated that it will take a minimum of 15 million years for completion of one cycle of erosion with North American rates of erosion. During this 15 millions year period there should be no disturbance to the process however we know that in the last one million year itself we had four glacial and four inter glacial period. Because of this process will be affected. If that is case, it is not possible cycle of or cycle of erosion to complete.
3) The third criticism is against peneplain. Nowhere in the world, we have evidence of peneplain one possible area is the Siberian plain. Davis himself accepts this but gives examples of uplifted peneplain. He takes the Basins and Ridges province of Appalachians

as example for uplifted peneplain. The support this argument, he gives the evidence of "Accordant summit level" (same height of mountain ridge) and older Alluvium at the head of the valley. One or two peaks which are higher than the others have been considered as monad nocks by Davis.

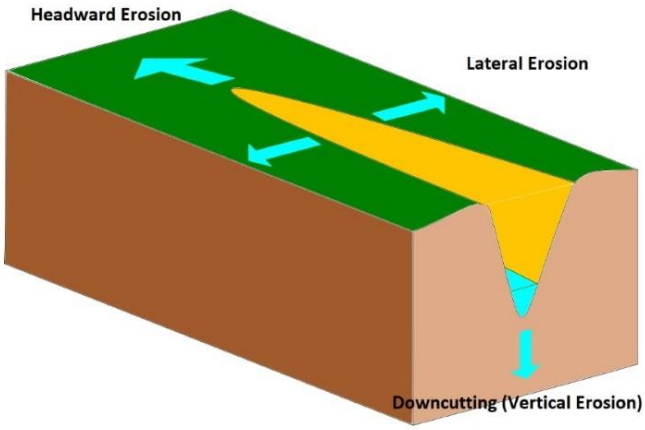
However this cannot be accepted completely. For example the highe3r peaks are not made up of resistant rocks and so cannot be monad nocks. If that is case uplifted peneplain can be questioned.

Fluvial – Erosional and Depositional landform features

Fluvial Erosional Landforms are landforms created by the erosional activity of rivers.
Various aspects of fluvial erosive action include:

- **Hydration**: the force of running water wearing down rocks.
- **Corrosion**: chemical action that leads to weathering.
- **Attrition**: river load particles striking, colliding against each other and breaking down in the process.
- **Corrasion or abrasion**: solid river load striking against rocks and wearing them down.
- Downcutting (vertical erosion): the erosion of the base of a stream (downcutting leads to valley deepening).
- **Lateral erosion:** the erosion of the walls of a stream (leads to valley widening).
- **Headward erosion:** erosion at the origin of a stream channel, which causes the origin to move back away from the direction of the stream flow, and so causes the stream channel to lengthen.

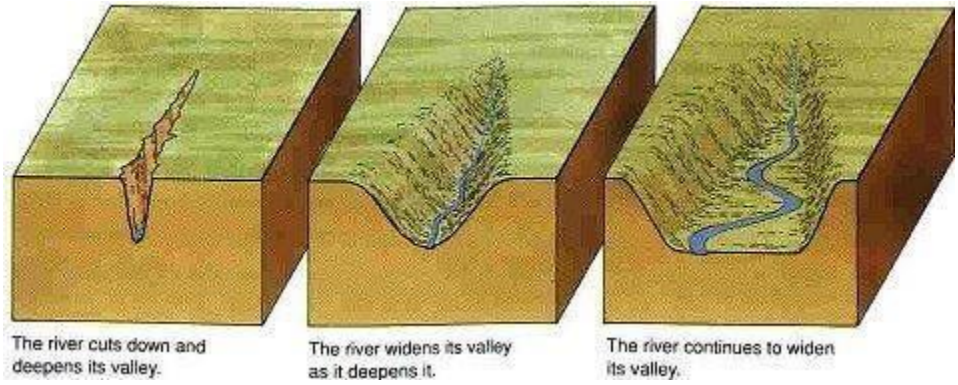
Vertical, Lateral and Headward Erosion (Kayau, from Wikimedia Commons)



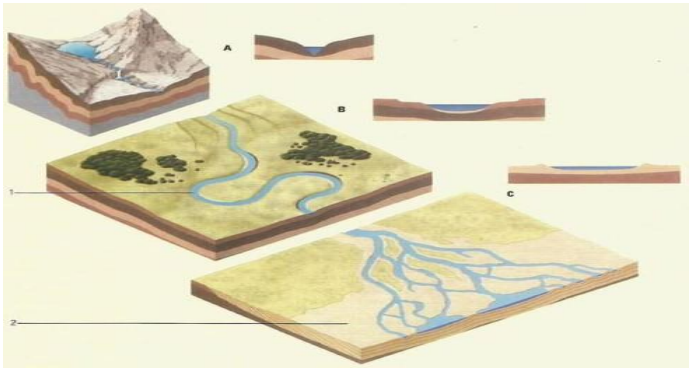
Braiding: the main water channel splitting into multiple, narrower channel. A braided river, or braided channel, consists of a network of river channels separated by small, and often temporary, islands called braid bars. Braided streams occur in rivers with low slope and/or large sediment load.

River Valley Formation

- The extended depression on the ground through which a stream flows is called a river valley.
- At different stages of the erosional cycle, the valley acquires different profiles.
- At a young stage, the valley is deep, narrow with steep wall-like sides and a convex slope.
- The erosional action here is characterized by predominantly vertical downcutting nature.
- The profile of valley here is typically 'V' shaped.
- A deep and narrow 'V' shaped valley is also referred to as gorge and may result due to downcutting erosion or because of the recession of a waterfall (the position of the waterfall receding due to erosive action).
- Most Himalayan rivers pass through deep gorges (at times more than 500 metres deep) before they descend to the plains.
- An extended form of the gorge is called a canyon. The Grand Canyon of the Colorado River in Arizona (USA) runs for 483 km and has a depth of 2.88 km.
- A tributary valley lies above the main valley and is separated from it by a steep slope down which the stream may flow as a waterfall or a series of rapids.
- As the cycle attains maturity, the lateral erosion (erosion of the walls of a stream) becomes prominent and the valley floor flattens out (attains a 'V' to 'U' shape).
- The valley profile now becomes typically 'U' shaped with a broad base and a concave slope.



River course



Youth

- Young rivers (A) close to their source tend to be fast-flowing, high-energy environments with rapid headward erosion, despite the hardness of the rock over which they may flow.
- Steep-sided "V-shaped' valleys, waterfalls, and rapids are characteristic features.
- E.g. Rivers flowing in the Himalayas.

Maturity

- Mature rivers (B) are lower-energy systems.
- Erosion takes place on the outside of bends, creating looping meanders in the soft alluvium of the river plain.
- Deposition occurs on the inside of bends and on the river bed.

E.g. Rivers flowing in the Indo-Gangetic-Brahmaputra plain.

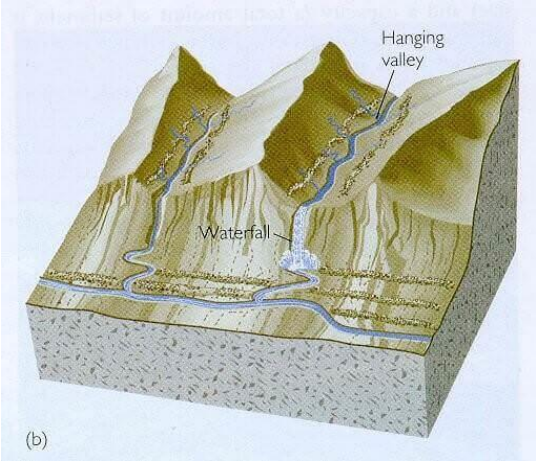
Old Age

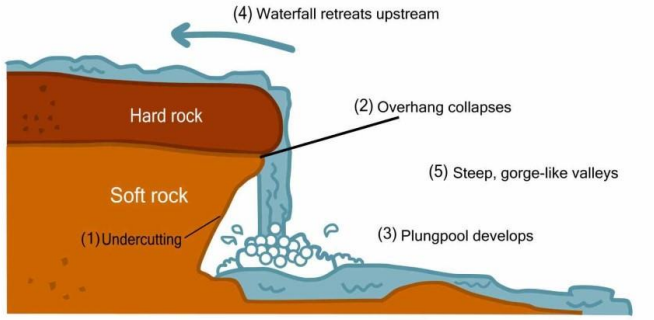
- At a river's mouth (C), sediment is deposited as the velocity of the river slows.
- As the river becomes shallower more deposition occurs, forming temporary islands (Majuli, a river island in the Brahmaputra River, Assam is currently the world's largest river island) and braiding (e.g. braided channels of Brahmaputra river flood plain in Assam) the main channel into multiple, narrower channels.
- As the sediment is laid down, the actual mouth of the river moves away from the source into the sea or lake, forming a delta.

E.g. Ganga-Brahmaputra delta.

Waterfalls

- A waterfall is simply the fall of an enormous volume of water from a great height.
- They are mostly seen in the youth stage of the river.
- Relative resistance of rocks, the relative difference in topographic reliefs, fall in the sea level and related rejuvenation, earth movements etc. are responsible for the formation of waterfalls.





- Kunchikal Falls (it is a cascade falls — falls with many steps) formed by Varahi river in Shimoga district, Karnataka is the highest waterfall in India (455 m).
- Nohkalikai Falls (340 m) is the tallest plunge waterfall in India. The waterfall is located near Cherrapunji.
- Jog or Gersoppa falls (253 m) on Sharavati river (a tributary of Cauvery), Karnataka is the second-highest plunge waterfall in India.
- Angel Falls in Venezuela is the world's highest waterfall, with a height of 979 metres and a plunge of 807 metres.
- Tugela Falls (948 m) in the Drakensberg mountains, South Africa is the world's second highest waterfall.

Potholes

The small cylindrical depressions in the rocky beds of the river valleys are called potholes.

Potholing or pothole-drilling is the mechanism through which the fragments of rocks when caught in the water eddies or swirling water start dancing circularly and grind and drill the rock beds.

They thus form small holes which are gradually enlarged by the repetition of the said mechanism.

Terraces

Stepped benches along the river course in a flood plain are called terraces.

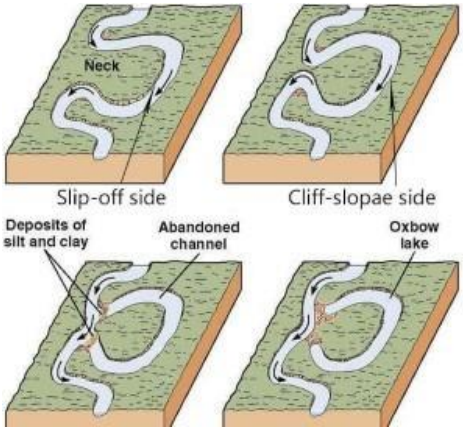
Terraces represent the level of former valley floors and remnants of former (older) floodplains.

Gulleys/Rills

- Gulley is a water-worn channel, which is particularly common in semi-arid areas.
- It is formed when water from overland-flows down a slope, especially following heavy rainfall, is concentrated into rills, which merge and enlarge into a gulley.
- The ravines of Chambal Valley in Central India and the Chos of Hoshiarpur in Punjab are examples of gulleys.

Ravines of Chambal Valley in Madhya Pradesh

Meanders



A meander is defined as a pronounced curve or loop in the course of a river channel.
The outer bend of the loop in a meander is characterized by intensive erosion and vertical cliffs and is called the cliff-slope side. This side has a concave slope.
The inner side of the loop is characterized by deposition, a gentle convex slope, and is called the slip-off side.
The meanders may be wavy, horse-shoe type or oxbow type.

Oxbow Lake

Sometimes, because of intensive erosion action, the outer curve of a meander gets accentuated to such an extent that the inner ends of the loop come close enough to get disconnected from the main channel and exist as independent water bodies called as oxbow lakes.

These water bodies are converted into swamps in due course of time.
In the Indo-Gangetic plains, southwards shifting of Ganga has left many oxbow lakes to the north of the present course of the Ganga.

Peneplane (Or peneplain)

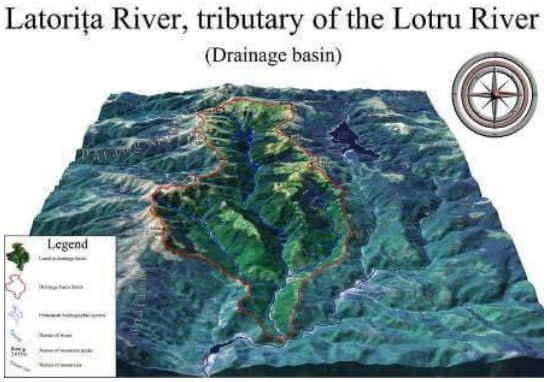
This refers to an undulating featureless plain punctuated with low-lying residual hills of resistant rocks. It is considered to be an end product of an erosional cycle.

Uluru or Ayers Rock in central Australia standing on a peneplane

Fluvial erosion, in the course of geologic time, reduces the land almost to base level (sea level), leaving so little gradient that essentially no more erosion could occur.

Drainage Basin

Other terms that are used to describe drainage basins are catchment, catchment area, catchment basin, drainage area, river basin, and water basin.
The drainage basin includes both the streams and rivers and the land surface.



The drainage basin acts as a funnel by collecting all the water within the area covered by the basin and channelling it to a single point.

In closed (endorheic) drainage basins the water converges to a single point inside the basin, known as a sink, which may be a permanent lake (e.g. Lake Aral, also known Aral Sea, Dead Sea), dry lake (some desert lakes like Lake Chad, Africa), or a point where surface water is lost underground (sinkholes in Karst landforms).

Drainage Divide

Adjacent drainage basins are separated from one another by a drainage divide.
Drainage divide is usually a ridge or a high platform.
Drainage divide is conspicuous in case of youthful topography (Himalayas), and it is not well marked in plains and senile topography (old featureless landforms — rolling plateaus of Peninsular region).

KARST TOPOGRAPHY

Karst Landforms:
Karst topography is named after the typical topography developed in limestone rocks of Karst region in the Balkans adjacent to the Adriatic Sea. Karst topography includes typical landforms in any limestone or dolomitic region, produced by the action of groundwater through the processes of solution and deposition.

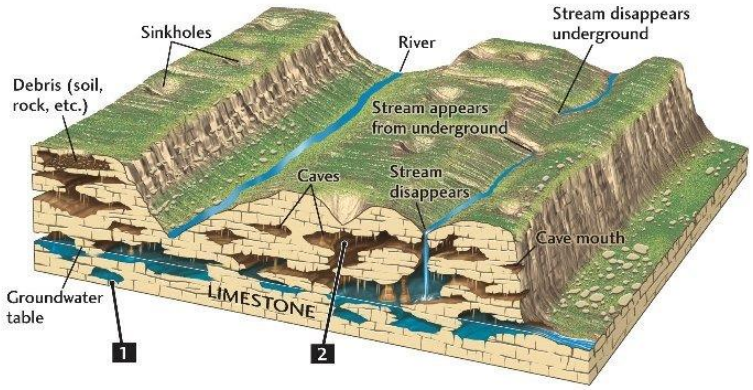
Karst Topography: Limestone is an organically formed sedimentary rock. In its pure state, limestone is made up of calcite or calcium carbonate but where magnesium is also present it is termed as dolomite. Limestone is soluble in rainwater.

Conditions for the formation of Karst Topography

- A region with a large stretch of water-soluble rocks such as limestone at the surface or sub-surface level
- Limestones should not be porous
- These rocks should be dense, thinly bedded and well jointed
- A perennial source of water and a low water table to allow the formation of conspicuous features.
- Moderate to abundant rainfall to cause the solvent action of water i.e. solution of rocks.

Mechanism of erosion in Karst region

- In Karst regions, rocks are permeable, thinly bedded and highly jointed and cracked.
- Thus there is the general absence of surface drainage as the surface water has gone underground
- After vertically going down to some depth, the water under the ground flows horizontally through the bedding planes, joints or through the materials themselves.
- Rocks are eroded due to this downward and horizontal movement of water.
- It is through the chemical process of solution and precipitation deposition by surface water and groundwater, varieties of landforms are developed in rocks like limestones or dolomites rich in calcium carbonate.



Karst Landforms

Erosional Landforms

Sinkhole

- Small to medium-sized round to sub-rounded shallow depressions called swallow holes form on the surface of limestones through solution where rainwater sinks into the limestone at a point of weakness
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  - They are also known as sinkholes
  - Sinkholes are a common feature in limestone/karst areas.
  - A sinkhole is an opening more or less circular at the top and funnel-shaped towards the bottom.
  - There is a great variation in sizes of Sinkholes with areas from a few sq. m to a hectare and with depth from a less than half a metre to thirty metres or more.
- These holes grow in size through continuous solvent action
- They are also referred to as solution sinks.

Doline

- They are also referred to as Collapse sinks .
- They are less common than sinkholes
- They might start as solution forms first, and if the bottom of a sinkhole forms the roof of a void or cave underground, it might collapse leaving a large hole opening into a cave or a void below

Uvalas

- They are long, narrow to wide trenches, also referred to as Valley sinks .
- Several sinkholes and dolines may merge together as a result of subsidence to form a large depression called an Uvala.

Lapies/ Karren

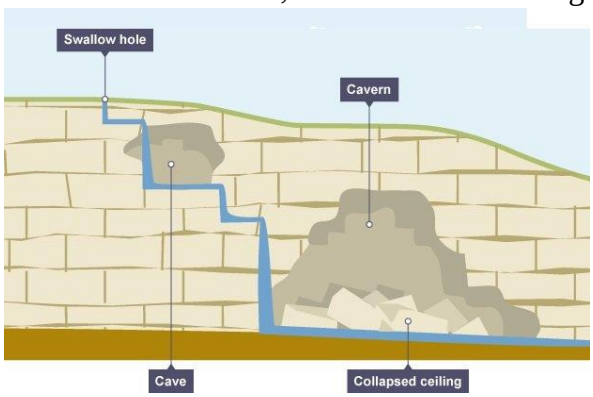
- These are grooved, fluted and ridge-like features in an open limestone field.
- These ridges or lapies form due to differential solution activity along parallel to sub-parallel joints.
- Eventually, the lapie field may transform into smooth limestone pavements.

Limestone Pavements

- A limestone pavement is a natural karst landform consisting of a flat, incised surface of exposed limestone that resembles an artificial pavement.
- These are formed by the solvent action of underground water in the limestones, causing progressive widening and enlargement of joints and cracks in the trenches.
- The enlarged joints are called grikes and the isolated, rectangular blocks are termed as clints.

Caves

- Cave formation is prominent in areas where there are alternating beds of rocks (sandstone, shale, quartzite) with limestone or dolomite in between or in areas where limestones are dense, massive and occurring as thick beds.



- Water percolates down either through the materials or through cracks and joints and moves horizontally along bedding planes.
- Gradually, the limestone dissolves along these bedding planes resulting in the creation of long and narrow gaps called caves.

Polije

- A polije is a very large, flat-floored depression in the karst region.
- They are often formed by merging of several uvalas or partly due to faulting
- They are commonly found in subtropical and tropical latitudes
- Some of these may also appear in the temperate region. They may also be found in boreal regions, though very rarely.
- During the rainy season, parts of the floor which are at or near the water table may become temporary lakes
- Drier areas are fertile. Usually covered with thick sediments, they are used extensively for agricultural purposes

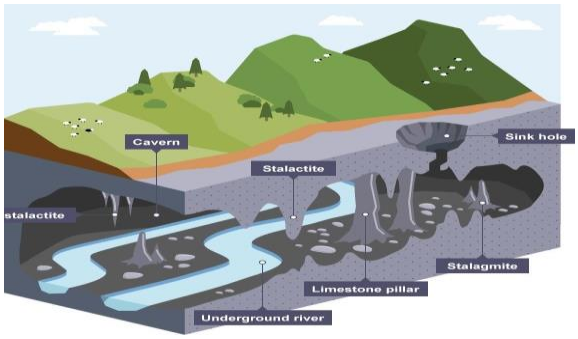
Ponor

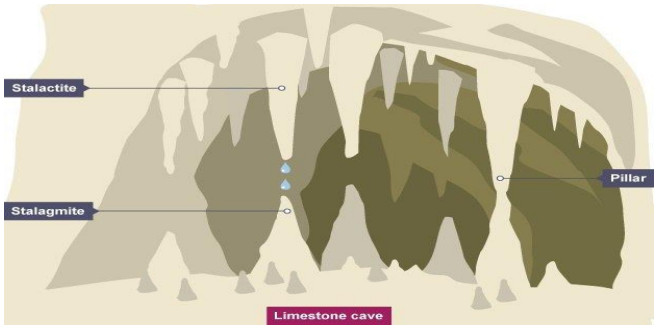
- A ponor is a natural surface opening in the karst regions
- They are found directly underneath the sinkholes
- A ponor is kind of a portal where a surface stream or lake flows either partially or completely underground into a karst groundwater system.

Landforms due to depositions

Depositional landforms in karst region are developed due to the deposition of calcium carbonate. The calcium carbonate dissolved during the erosional process starts to precipitate when the water evaporates or when the solution is super-saturated.

Stalactites, Stalagmites and Pillars are the most spectacular underground features, found in the limestone caves.





Stalactites

- Stalactites are the sharp, slender, downward-growing icicles of different diameters that hang from the cave roofs.
- Stalactites have a variety of forms
- Their bases are normally broad which taper towards the free ends.

- The water carries calcium in solution and when this lime-charged water evaporates, it leaves behind the solidified crystalline calcium carbonate.

Stalagmites

- Stalagmites form due to dripping water from the surface or through the thin pipe, of the stalactite, immediately below it
- Moisture dripping from the roof trickles down the stalactite and drops to the floor where stalagmites are formed due to deposition of calcium
- Stalagmites may take the shape of a column, a disc, with either a smooth, rounded bulging end or a miniature crater-like depression.

Pillars

- Over a long period, the stalactite is eventually merged with the stalagmite
- Thus, the pillars or columns of different diameters are formed.

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