LAND FORMS

UNIT II : Land Forms Created By Rivers: Erosion processes, erosional features: Potholes, Waterfalls, River valleys, Gorges, Canyons, Escarpments, Hogback, Cuesta, Mesa, Butte, Peneplain, Pediments, River terraces, Badlands. Transportation – Deposition: Depositional features: Alluvial fans, and cones, Flood plains, Meanders, Ox – bow lakes, Braided rivers, and Delta. Cycle of erosion, River patterns, Drainage patterns. Outline of Rivers of India with special reference to Tamil Nadu. Land Forms derived from Underground Water: Definition and sources of groundwater. Erosional features of groundwater: dolines, sink, caverns, solution valley, stylolite, depositional features: stalactites, stalagmites, siliceous sinter and travertine, geode, and concretionary structures.

This is a list of rivers of India, starting in the west and moving along the Indian coast southward, then northward. Tributary rivers are listed hierarchically in upstream order: the lower in the list, the more upstream.. .

THE MAJOR RIVERS OF INDIA ARE:

Flowing into the Bay of Bengal: Brahmaputra, Yamuna, Ganga (with its main tributaries Ramganga, [Gangan], Kali or Sharda, Gomti, Yamuna, Chambal, Betwa, Ken, Tons, Ghaghara, Gandaki, Burhi Gandak, Koshi, Mahananda, Tamsa, Son, Bagmati), Meghna, Mahanadi, Godavari, Krishna (and their main tributaries), Kaveri

Flowing into the Arabian Sea: Narmada, Tapi, Sindhu, Sabarmati, Purna.

There are 8 major river systems in India, with more than 400 rivers in total.[1] Rivers play an important role in the lives of the Indian people due to their crucial importance in sustenance and their place in Indian religions. The table below lists the rivers of India with their average annual discharge into either the Bay of Bengal and Arabian Sea. Only rivers with discharging into the sea are listed, so no tributaries are listed, some of which can have flow rates much higher than some of the rivers listed

TAMILNADU RIVERS

This page lists the main rivers of Tamil Nadu. Out of the below rivers, Kaveri, Thenpennai, Palar, are the three largest rivers of Tamil Nadu followed by Vaigai River, Noyyal River, Cheyyar River, Then Pennai, Vellar River (Northern Tamil Nadu), Vellar River (Southern Tamil Nadu), Moyar River, Pampar River, Bhavani River, Thamirabarani River, Vaippar River are the major rivers in Tamil Nadu. (Listed in the order of longest rivers first). Sarabanga nadhi (Idappadi) Nallaru (Aninasi) Kausika nadhi (Periyanaickan palayam.

UNDERGROUND WATER

Groundwater is the water present beneath Earth's surface in soil pore spaces and in the fractures of rock formations. A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a usable quantity of water. The depth at which soil pore spaces or fractures and voids in rock become completely saturated with water is called the water table. Groundwater is recharged from the surface; it may discharge from the surface naturally at springs and seeps, and can form oases or wetlands. Groundwater is also often withdrawn for agricultural, municipal, and industrial use by constructing and operating extraction wells. The study of the distribution and movement of groundwater is hydrogeology, also called groundwater hydrology.

The entire surface water flow of the Alapaha River near Jennings, Florida, going into a sinkhole leading to the Floridan Aquifer groundwater

Typically, groundwater is thought of as water flowing through shallow aquifers, but, in the technical sense, it can also contain soil moisture, permafrost (frozen soil), immobile water in very low permeability bedrock, and deep geothermal or oil formation water. Groundwater is hypothesized to provide lubrication that can possibly influence the movement of faults. It is likely that much of Earth's subsurface contains some water, which may be mixed with other fluids in some instances. Groundwater may not be confined only to Earth. The formation of some of the landforms observed

on Mars may have been influenced by groundwater. There is also evidence that liquid water may also exist in the subsurface of Jupiter's moon Europa.[1]

Groundwater is often cheaper, more convenient and less vulnerable to pollution than surface water. Therefore, it is commonly used for public water supplies. For example, groundwater provides the largest source of usable water storage in the United States, and California annually withdraws the largest amount of groundwater of all the states.[2] Underground reservoirs contain far more water than the capacity of all surface reservoirs and lakes in the US, including the Great Lakes. Many municipal water supplies are derived solely from groundwater.[3]

Use of groundwater has related environmental issues. For example, polluted groundwater is less visible and more difficult to clean up than pollution in rivers and lakes. Groundwater pollution most often results from improper disposal of wastes on land. Major sources include industrial and household chemicals and garbage landfills, excessive fertilizers and pesticides used in agriculture, industrial waste lagoons, tailings and process wastewater from mines, industrial fracking, oil field brine pits, leaking underground oil storage tanks and pipelines, sewage sludge and septic systems. Additionally, groundwater is susceptible to saltwater intrusion in coastal areas and can cause land subsidence when extracted unsustainably, leading to sinking cities (like Bangkok)) and loss in elevation (such as the multiple meters lost in the Central Valley of California). These issues are made more complicated by sea level rise and other changes caused by climate changes which will change precipitation and water scarcity globally.

Origin and quantity of groundwater on the earth

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Origin and quantity of groundwater on the earth

Origin

Most groundwater originates as meteoric water from precipitation in the form of rain or snow. If it is not lost by evaporation, transpiration or to stream runoff, water from these sources may infiltrate into the ground. Initial amounts of water from precipitation onto dry soil are held very tightly as a film on the surfaces and in the micro pores of soil particles in a belt of soil mixture. At intermediate levels, films of water cover the solid particles, but air is still present in the voids of the soil. This region is called unsaturated zone or zone of aeration, and the water present is vadose water. At lower depths and in presence of adequate amounts of water, all voids are filled to produce a zone of

saturation, the upper level of which is the water table. Water present in a zone of saturation is called groundwater [3].

The porosity and structure of the ground determine the type of aquifer and underground circulation. groundwater may circulate and be stored in the entire geological stratum: this is the case in porous soils such as sand, sandstone and alluvium. It may circulate and be stored in fissures or faults in compact rocks that are not themselves permeable, like most of volcanic and metamorphic rocks. Water trickles through the rocks and circulates because of localized and dispersed fissures. Compact rocks of large fissures or caverns are typical of limestone.

QUANTITY IN THE EARTH

On the earth, approximately 3% of the total water is fresh water. Of this groundwater comprises 95%, surface water 3.5% and soil moisture 1.5%. Out of all the fresh water on the earth, only 0.36% is readily available to use (Leopold, 1974).

Groundwater is an important source of water supply. 53% of the population of US receives its water supply from groundwater sources. Groundwater is also a major source of industrial and agricultural uses.

We are withdrawing water from underground aquifers at a faster rate that it can be replenished. Although immense, world's aquifers are not bottomless and in many areas water levels are sinking fast. The water in some aquifers is millennia old and lies beneath what are now some of the driest regions on Earth. Although people have drown water from from springs and wells since the earliest civilizations, in the past 50 years multiplying populations have needed more food and water and the rate of withdrawal has increased drammatically.

In some coastal areas so much fresh water has been withdrawn from aquifers that saltwater has started to intrude, turning well water brackish and unusable

EROSIONAL FEATURES OF GROUNDWATER

We have also seen that erosion and deposition are some of the exogenic processes. In this post, we are dealing with the geomorphic agents – running water and groundwater, which causes erosion and deposition. They form various erosional (destructional) and depositional (constructional) landforms.

Even though we are considering the erosional and depositional activities and their landform creation, it should be kept in mind that they are always aided by weathering and mass movements. There are some other independent controls like (i) stability of sea level; (ii) tectonic stability of landmass; (iii) climate etc. which influence the evolution of these landforms.

Upper Course / Stage of Youth (Erosion dominates):

It starts from the source of the river in hilly or mountainous areas.

The river flows down the steep slope and, as a result, its velocity and eroding power are at their maximum.

Streams are few, with poor integration.

As the river flows down with high velocity, vertical erosion or downward cutting will be high which results in the formation of V-Shaped Valleys.

Waterfalls, rapids, and gorges exist where the local hard rock bodies are exposed.

Middle Course/ Stage of Maturity (Transportation dominates):

In this stage, vertical erosion slowly starts to replace with lateral erosion or erosion from both sides of the channel.

Thus, the river channel causes the gradual disappearance of its V-shaped valley (not completely).

Streams are plenty at this stage with good integration.

Wider flood plains start to visible in this course and the volume of water increases with the confluence of many tributaries.

The work of river predominantly becomes transportation of the eroded materials from the upper course (little deposition too).

Landforms like alluvial fans, piedmont alluvial plains, meanders etc. can be seen at this stage.

Lower Course/ Stage of Old (Deposition dominates):

The river starts to flow through a broad, level plain with heavy debris brought down from upper and middle courses.

Vertical erosion has almost stopped and lateral erosion still goes on.

The work of the river is mainly deposition, building up its bed and forming an extensive flood plain. Landforms like braided channels, floodplains, levees, meanders, oxbow lakes, deltas etc. can be seen at this stage.

Upper Course, middle course and lower course of a river

Running water: erosion, transportation, and deposition

Erosion occurs when overland flow moves soil particles downslope.

The rock materials carried by erosion is the load of the river.

This load acts as a grinding tool helping in cutting the bottom and sides of the river bed, resulting in deepening and widening of the river channel.

Erosion Types

The work of river erosion is accomplished in different ways, all of which may operate together. They are corrasion, corrosion, hydraulic action etc.

Corrasion or Abration: As the rock particles bounce, scrape and drag along the bottom and sides of the river, they break off additional rock fragments. This form of erosion is called corrasion or abration. They are two types: vertical corrosion which acts downward and lateral corrosion which acts on both sides.

Corrosion or Solution: This is the chemical or solvent action of water on soluble or partly soluble rocks with which the river water comes in contact.

Hydraulic Action: This is the mechanical loosening and sweeping away of material by the sheer force or river water itself. No load or material is involved in this process.

Transportation types

After erosion, the eroded materials get transported with the running water. This transportation of eroded materials is carried in four ways:

Traction: The heavier and larger rock fragments like gravels, pebbles etc are forced by the flow of the river to roll along its bed. These fragments can be seen rolling, slipping, bumping and being dragged. This process is called as traction and the load transported in this way are called traction load.

Saltation: Some of the fragments of the rocks move along the bed of a stream by jumping or bouncing continuously. This process is called as saltation.

Suspension: The holding up of small particles of sand, silt and mud by the water as the stream flows is called suspension.

Solution: Some parts of the rock fragments dissolved in the river water and transported. This type of transportation is called solution transportation.

traction, saltation, solution, suspension

When the stream comes down from the hills to plain areas with the eroded and transported materials, the absence of slope/gradient causes the river to lose it energy to further carry those transported materials.

As a result, the load of the river starts to settle down which is termed as deposition.

Erosion, transportation, and deposition continue until the slopes are almost completely flattened leaving finally a lowland of faint relief called peneplains with some low resistant remnants called monadnocks.

EROSIONAL LANDFORMS DUE TO RUNNING WATER

1. Valleys, Gorges, Canyon

As we discussed above, valleys are formed as a result of running water.

The rills which are formed by the overland flow of water later develop into gullies.

These gullies gradually deepen and widen to form valleys.

A gorge is a deep valley with very steep to straight sides.

A canyon is characterized by steep step-like side slopes and may be as deep as a gorge.

A gorge is almost equal in width at its top as well as bottom and is formed in hard rocks while a canyon is wider at its top than at its bottom and is formed in horizontal bedded sedimentary rocks.

Gorge and canyon2. Potholes, Plunge pools

Potholes are more or less circular depressions over the rocky beds of hills streams.

Once a small and shallow depression forms, pebbles and boulders get collected in those depressions and get rotated by flowing water. Consequently, the depressions grow in dimensions to form potholes.

Plunge pools are nothing but large, deep potholes commonly found at the foot of a waterfall.

They are formed because of the sheer impact of water and rotation of boulders.

Potholes - erosional landform due to running waterPlunge pool - erosional landform due to running water

3. Incised or Entrenched Meanders

They are very deep wide meanders (loop-like channels) found cut in hard rocks.

In the course of time, they deepen and widen to form gorges or canyons in hard rock.

The difference between a normal meander and an incised/entrenched meander is that the latter found on hard rocks.

entrenched meander - running water erosion4. River Terraces

They are surfaces marking old valley floor or flood plains.

They are basically the result of vertical erosion by the stream.

When the terraces are of the same elevation on either side of the river, they are called as paired terraces.

When the terraces are seen only on one side with none on the other or one at quite a different elevation on the other side, they are called as unpaired terraces.

river terraces - running water landfrom due to erosion

DEPOSITIONAL LANDFORMS DUE TO RUNNING WATER

1. Alluvial Fans

They are found in the middle course of a river at the foot of slope/ mountains.

When the stream moves from the higher level break into foot slope plain of low gradient, it loses its energy needed to transport much of its load.

Thus, they get dumped and spread as a broad low to the high cone-shaped deposits called an alluvial fan.

The deposits are not roughly very well sorted.

alluvial fan - running water deposition2. Deltas

Deltas are like an alluvial fan but develop at a different location.

They are found in the mouth of the river, which is the final location of depositional activity of a river.

Unlike alluvial fans, the deposits making up deltas are very well sorted with clear stratification. The coarser material settle out first and the finer materials like silt and clay are carried out into the sea.

3. Flood Plains, Natural Levees

Deposition develops a flood plain just as erosion makes valleys.

A riverbed made of river deposits is the active flood plain and the flood plain above the bank of the river is the inactive flood plain.

Natural levees are found along the banks of large rivers. They are low, linear and parallel ridges of coarse deposits along the banks of a river.

The levee deposits are coarser than the deposits spread by flood water away from the river.

4. Meanders and oxbow lakes

Meanders are loop-like channel patterns develop over the flood and delta plains.

They are actually not a landform but only a type of channel pattern formed as a result of deposition. They are formed basically because of three reasons: (i) propensity of water flowing over very gentle gradient to work laterally on the banks; (ii) unconsolidated nature of alluvial deposits making up the bank with many irregularities; (iii) Coriolis force acting on fluid water deflecting it like deflecting the wind.

The concave bank of a meander is known as cut-off bank and the convex bank is known as a slip-off As meanders grow into deep loops, the same may get cut-off due to erosion at the inflection point and are left as oxbow lakes.

For large rivers, the sediments deposited in a linear fashion at the depositional side of a meander are called as Point Bars or Meander Bars.

oxbow lake and a meanderbraided channels due to running water deposition5. Braided Channels When selective deposition of coarser materials causes the formation of a central bar, it diverts the flow of river towards the banks, which increases lateral erosion.

Similarly, when more and more such central bars are formed, braided channels are formed.

Riverine Islands are the result of braided channels.

What does Groundwater do?

The part of rain or snow-melt water which accumulates in the rocks after seeping through the surface is called underground water or simply groundwater.

The rocks through which water can pass easily are called as permeable rocks while the rocks which do not allow water to pass are called as impermeable rocks.

After vertically going down to some depth, the water under the ground flows horizontally through the bedding planes, joints or through the materials themselves.

Although the amount of groundwater varies from place to place, its role in shaping the surface features of the earth is quite important.

The works of groundwater are mainly seen in rocks like limestone, gypsum or dolomite which are rich in calcium carbonate.

Any limestone, dolomite or gypsum region showing typical landforms produced by the action of groundwater through the process of solution and deposition is called as Karst Topography (Karst region in the Balkans)

The zones or horizons of permeable and porous rocks which are fully filled with water are called as the Zones of Saturation.

The marks which show the upper surface of these saturated zones of the groundwater are called as the Water Tables.

And these rocks, which are filled with underground water, are called as aquifers.

The water table is generally higher in the areas of high precipitation and also in areas bordering rivers and lakes.

They also vary according to seasons. On the basis of variability, water tables are of two types: (i) Permanent water table, in which the water will never fall below a certain level and wells dug up to this depth provide water in all seasons; (ii) Temporary water tables, which are seasonal water tables. Springs: They are the surface outflow of groundwater through an opening in a rock under hydraulic pressure.

When such springs emit hot water, they are called as Hot Springs. They generally occur in areas of active or recent volcanism.

When a spring emits hot water and steam in the form of fountains or jets at regular intervals, they are called as geysers.

In a geyser, the period between two emissions is sometimes regular (Yellowstone National Park of USA is the best example).

EROSIONAL LANDFORMS DUE TO GROUNDWATER

Sinkholes and caves are erosional landforms formed due to the action of ground water.

1. Sinkholes

Small to medium sized rounded to sub-rounded shallow depressions called swallow holes forms on the surface of rocks like limestone by the action of the solution.

A sinkhole is an opening more or less circular at the top and funnel-shaped towards the bottom.

When as sinkhole is formed solely through the process of solution, it is called as a solution sink. Some sinkhole starts its formation through the solution process but later collapse due to the presence of some caves or hollow beneath it and becomes a bigger sinkhole. These types are called as collapse sinks.

The term Doline is sometimes used to refer collapse sinks.

Solution sinks are more common than collapse sinks.

When several sink holes join together to form valley of sinks, they are called as valley sinks or Uvalas. Lapies are the irregular grooves and ridges formed when most of the surfaces of limestone are eaten by solution process.

sinkholes - groundwater -erosioncollapse sink - groundwater - erosion2. Caves

In the areas where there are alternative beds of rocks (non-soluble) with limestone or dolomite in between or in areas where limestone are dense, massive and occurring as thick beds, cave formation is prominent.

Caves normally have an opening through which cave streams are discharged

Caves having an opening at both the ends are called tunnels.

DEPOSITIONAL LANDFORMS OF GROUNDWATER

1. Stalactites and stalagmites

They are formed when the calcium carbonates dissolved in groundwater get deposited once the water evaporates.

These structures are commonly found in limestone caves.

Stalactites are calcium carbonate deposits hanging as icicles while Stalagmites are calcium carbonate deposits which rise up from the floor.

When a stalactite and stalagmite happened to join together, it gives rise to pillars or columns of different diameters.

limestone caves- stalagmite-stalactite

Siliceous sinter (geyserite; fiorite) is a deposit of opaline or amorphous silica that occurs as an incrustation around hot springs and geysers and sometimes forms conical mounds (geyser cones) or terraces.

Travertine, dense, banded rock composed of calcite (calcium carbonate, $CaCO_3$). Formed by the evaporation of river and spring waters, it is a variety of limestone that has a light colour and takes a good polish; it is often used for walls and interior decorations in public buildings. Travertine deposits along the Aniene River, near Rome, are several metres thick. In the United States the Mammoth Hot Springs in Yellowstone National Park, Wyoming, are actively depositing travertine. It also occurs in limestone caves in the form of stalactites and stalagmites, as, for example, in Carlsbad Caverns, New Mexico.

Geodes (derived from the Greek "γεώδης", meaning "Earth-like") are geological secondary formations within sedimentary and volcanic rocks. Geodes are hollow, vaguely spherical rocks, in which masses of mineral matter (which may include crystals) are secluded. The crystals are formed by the filling of vesicles in volcanic and sub-volcanic rocks by minerals deposited from hydrothermal fluids; or by the dissolution of syn-genetic concretions and partial filling by the same, or other, minerals precipitated from water, groundwater or hydrothermal fluids.

concretion is a hard, compact mass of matter formed by the precipitation of mineral cement within the spaces between particles, and is found in sedimentary rock or soil.[1] Concretions are often ovoid or spherical in shape, although irregular shapes also occur. The word 'concretion' is derived from the Latin con meaning 'together' and crescere meaning 'to grow'. Concretions form within layers of sedimentary strata that have already been deposited. They usually form early in the burial history of the sediment, before the rest of the sediment is hardened into rock. This concretionary cement often makes the concretion harder and more resistant to weathering than the host stratum.

There is an important distinction to draw between concretions and nodules. Concretions are formed from mineral precipitation around some kind of nucleus while a nodule is a replacement body.

Descriptions dating from the 18th century attest to the fact that concretions have long been regarded as geological curiosities. Because of the variety of unusual shapes, sizes and compositions, concretions have been interpreted to be dinosaur eggs, animal and plant fossils (called pseudofossils), extraterrestrial debris or human artifacts.

Transportation:

Transportation of material in a river begins when friction is overcome. Material that has been loosened by erosion may be then transported along the river. There are four main processes of transportation. These are:

suspension / suspended load;

solution / solution load;

saltation; and

traction.Suspension is when material made up of very fine particles such as clay and silt is lifted as the result of turbulence and transported by the river. Faster-flowing, turbulent rivers carry more suspended material. This is why river appear muddy as they are approaching bankfull discharge and towards the mouth of the river (where velocity is greater as is the occurrence of finer sediment).

Solution is when dissolved material is carried by a river. This often happens in areas where the geology is limestone and is dissolved in slightly acidic water.Saltation is when material such as pebbles and gravel that is too heavy to be carried in suspension is bounced along the river by the force of the water.

Traction is when large materials such as boulders are rolled and pushed along the river bed by the force of the river.

The video below shows transportation in a river in the form of traction, saltation and suspension.The capacity of a river is the total load a river can transport at a given point

DEPOSITION:

Deposition is the process of the eroded material being dropped. This happens when a river loses energy. A river can lose its energy when rainfall reduces, evaporation increases, friction close to river banks and shallow areas which leads to the speed of the river reducing and therefore the energy reduces, when a river has to slow down it reduces its speed (and ability to transport material) and when a river meets the sea.

DEPOSITIONAL FEATURES:

Depositional landforms are the visible evidence of processes that have deposited sediments or rocks after they were transported by flowing ice or water, wind or gravity. Examples include beaches, deltas, glacial moraines, sand dunes and salt domes.

ALLUVIAL FANS:

alluvial fan is a triangle-shaped deposit of gravel, sand, and even smaller pieces of sediment, such as silt. This sediment is called alluvium. Alluvial fans are usually created as flowing water interacts with mountains, hills, or the steep walls of canyons.

CONES:

A conical hill (also cone or conical mountain) is a landform with a distinctly conical shape. It is usually isolated or rises above other surrounding foothills, and is often, but not always, of volcanic origin.

FLOODPLAIN:

Most simply, a flood-plain is defined as "a strip of relatively smooth land bordering a stream and overflowed [sic] at a time of high water" (Leopold et al, 1964). ... A "100-year flood" or "100-year floodplain" describes an event or an area subject to a 1% probability of a certain size flood occurring in any given year.

MEANDER:

A meander is a bend in a river channel. Meanders form when water in the river erodes the banks on the outside of the channel. The water deposits sediment on the inside of the channel. Meanders only occur on flat land where the river is large and established.

OXBOWLAKE:

oxbow lake is a U-shaped lake that forms when a wide meander of a river is cut off, creating a freestanding body of water. In south Texas, oxbows left by the Rio Grande are called resacas. In Australia, oxbow lakes are called billabongs. The word "oxbow" can also refer to a U-shaped bend in a river or stream, whether or not it is cut off from the main stream.[1][2]

There has also been a possible oxbow lake postulated in Saraswati Flumen near Ontario Lacus on Saturn's moon Titan.[3]

BRAIDED RIVER:

braided river is a network of small channels separated by islands that are often not fixed. In other words, the river channels wander across a flat area. Braided rivers are found in places where the river carries a lot of sediment, and when it slows down and spreads out.

DELTA:

When a river reaches a lake or the sea the water slows down and loses the power to carry sediment. . The sediment is dropped at the mouth of the river. Some rivers drop so much sediment that waves and tides can't carry it all away. It builds up in layers forming a delta.

CYCLE OF EROSION:

geographic cycle, or cycle of erosion, is an idealized model that explains the development of relief in landscapes.[1] The model starts with the erosion that follows uplift of land above a base level and ends, if conditions allow, in the formation of a peneplain.[1] Landscapes that show evidence of more than one cycle of erosion are termed "polycyclical".[1] The cycle of erosion and some of its associated concepts have, despite their popularity, been a subject of much criticism.

originator of the model, divided it into stages whose transition is gradual. The model begins with an uplifted or to-be-uplifted landscape. Then Davis defined a youthful stage where river incision is the dominant process shaping the landscape. During the youthful stage height, differences between uplands and valley bottoms increase rapidly. The youthful stage is followed by a mature stage in

which height differences between valley bottoms and uplands are at their greatest. In the mature stage, slope decline becomes a more important phenomenon, and uplands lose height more rapidly than rivers incise, effectively diminishing relief. In the very latest stage, erosion has acted so long that the landscape, despite its original height, is reduced into a rolling lowland. That landscape of low relief is called a peneplain and may contain residual heights standing out from the general level. The peneplain can be uplifted, which starts a second erosion cycle.[2]

Davis acknowledged that a full cycle was a special case and that initial uplift was not necessarily rapid or followed by a prolonged period of quiescence. However, as Walther Penck pointed out, Davis and his followers usually used a rapid uplift and quiescence approach to explain landscapes.[3]
This means that the model, as understood by most, assumes rapid and episodic tectonic uplift.[4] Another characteristic of the model is that slopes evolve by decline, with initially-steep slopes worn out by erosion forming successively-gentler slopes.[4][A] Weaknesses of the model are that it is mostly theoretical and deductive in nature and it does not take into account the complexity of tectonic movements or climate change. The nature of surface processes is also poorly represented by the model.[4] The model in its original form is intended to explain relief development in temperate landscapes in which erosion by running water is assumed to be of prime importance.[2][4] Nevertheless, the cycle of erosion has been extended, with modifications, into arid, glacial, coastal, karst and periglacial areas.[4]

Environment Proposed by Details

Arid Davis, 1905 At the beginning of the cycle of erosion in arid climate there are numerous small basins to where material is washed during the scarce rainfall events. In the next stage (youthful stage) valleys are developed and highlands dissected by these. Gentle slopes and basins accumulated material derived from the highlands. In the mature stage drainage basins coalesce. At the end, a stage is reached in which the terrain has lost much of its relief and deflation hollows interfere with the drainage systems, breaking it up into local systems. During all stages sand and dust might be exported by wind to other landscapes.[7]

Coastal Johnson, 1919 Alternate models are proposed for shore profiles: one for shore profiles of emergence and another for shore profiles of submergence. A complementary model can be applied to shore lines where different parts might have undergone submergence and emergence.[8] Glacial Davis, 1900 The glacial cycle of erosion deals with mountainous regions and lacks an old stage since Davis argues that nothing more developed than mature glacial landscapes exists at present. A glacial cycle of erosion begins with a pre-glacial landscape. Over time valley glaciers erode the underlying rock at different rates, creating valleys and glaciers that are more entrenched than others. As time passes the less-entrenched glaciers reach the same levels of entrenchment as the more entrenched ones, since the deeper a glacier erodes, its erosive power diminishes. In a mature stage, valleys form smooth-sided troughs.[9]

Karst Cvijić, 1918 The cycle of erosion in karst regions has three phases. At first, the upper parts of fractures are dissolved, enlarged and filled with water. Normal fluvial valleys develop on the surface, small poljes might exist. Subsequently, re-routing of water by the growth of a karst system disorganizes the fluvial drainage pattern, with valley bottoms developing large dolines and uvalas. Ridges between uvalas gradually disappear as those landforms coalesce. If the bedrock is underlain by insoluble rock, normal fluvial valleys will slowly re-appear once the underground river systems reach the insoluble rock. In the end, soluble rocks appear only as isolated hills. Contrary to Davis's
original cycle of erosion, the karst cycle does not end in the formation of a peneplain.[10]
Periglacial Peltier, 1950 The periglacial cycle of erosion begins with a non-periglaciated landscape. Once-periglaciated mass wasting of regolith exposes bedrock in the upper slopes. The outcrops are then subject to frost weathering that makes slopes retreat forming extensive blockfields at the base of the bedrock areas. At a later stage, solifluction wears down summits and fills in topographic lows.

DRAINAGE PATTERNS:

drainage systems, also known as river systems, are the patterns formed by the streams, rivers, and lakes in a particular drainage basin. They are governed by the topography of the land, whether a particular region is dominated by hard or soft rocks, and the gradient of the land. Geomorphologists and hydrologists often view streams as part of drainage basins (and sub-basins). This is the topographic region from which a stream receives runoff, throughflow, and its saturated equivalent, groundwater flow. The number, size, and shape of the drainage basins varies and the larger and more detailed the topographic map, the more information is available.

Per the lie of channels, drainage systems can fall into one of several categories, known as drainage patterns. These depend on the topography and geology of the land.[2]

All forms of transitions can occur between parallel, dendritic, and trellis patterns.

Accordant versus discordant drainage patterns

A drainage system is described as accordant if its pattern correlates to the structure and relief of the landscape over which it flows.[2]

A discordant system or pattern does not correlate to the topography and geology of the area. Discordant drainage patterns are classified into two main types: antecedent and superimposed,[2]

while anteposition drainage patterns combine the two. In antecedent drainage, a river's vertical incision ability matches that of land uplift due to tectonic forces. Superimposed drainage develops differently: initially, a drainage system develops on a surface composed of 'younger' rocks, but due to denudative activities this surface of younger rocks is removed and the river continues to flow over a seemingly new surface, but one in fact made up of rocks of old geological formation.

Dendritic drainage patterns

Dendritic drainage systems (from Greek δενδρίτης, dendrites, "of or like a tree") are not straight and are the most common form of drainage system. In this, there are many sub-tributaries (analogous to the twigs of a tree), which merge into tributaries of the main river (the branches and the trunk of the tree, respectively). They are seen to feed a river channel that matches and is strongly accordant to the overriding gradient of the land. Truly dendritic systems form in V-shaped valleys; as a result, the rock types must be quite impervious and non-porous.[3]

Parallel drainage pattern

A parallel drainage system occurs on a common slope down linear ranges (or of rivers between linear series of escarpments, parallel, elongate landforms like outcropping resistant rock bands), typically following natural faults or erosion (such as prevailing wind scars). The watercourses run swift and straight, with very few tributaries, and all flow in the same direction. This system forms on very long, uniform slopes, for instance, high rivers flowing southeast from the Aberdare Mountains in Kenya and many rivers of Myanmar.

This sometimes indicates a major fault that cuts across an area of steeply folded bedrock.

Trellis drainage pattern

The geometry of a trellis drainage system is similar to that of a common garden trellis. Along a strike valley, smaller tributaries feed into from the steep slopes of mountain sides. These tributaries enter the main river about perpendicular, causing a trellis-like appearance of the system. They form where hard and soft formations exist on both banks of the main river, and are reflective of height, accentuated by erosion. Trellis drainage is characteristic of folded mountains, such as the Appalachian Mountains in North America and in the north part of Trinidad.[2]

Rectangular drainage pattern

Rectangular drainage develops on rocks that are of approximately uniform resistance to erosion, but which have two directions of jointing at approximately right angles or 90 degrees. The joints are usually less resistant to erosion than the bulk rock so erosion tends to preferentially open the joints and streams eventually develop along the joints. The result is a stream system in which streams consist mainly of straight line segments with right angle bends and tributaries join larger streams at right angles.[2] This pattern can be found with the Arun River in Nepal.

Radial drainage pattern

In a radial drainage system, the streams radiate outwards from a central high point. Volcanos usually have archetypal features on which this commonly develops are modest or hard domes pattern develops when streams flow in many general directions (meaning quite long-term)

In India, the Amarkantak range and Ramgarh crater are most archetypal; and Dogu'a Tembien in Ethiopia.[4]

Centripetal drainage pattern

The centripetal is the inverse to the radial, ending with a depression, sea, or its inland form, an endorheic basin.

Deranged drainage pattern

A deranged drainage system is a drainage system in drainage basins where there is no coherent pattern to the rivers and lakes. It happens in areas where there has been much geological disruption. The classic example is the Canadian Shield. During the last ice age, the topsoil was scraped off, leaving mostly bare rock. The melting of the glaciers left land with many irregularities of elevation and a great deal of water to collect in the low points, explaining the large number of lakes which are found in Canada. The drainage basins are young and are still sorting themselves out. Eventually the system will stabilize.

Annular drainage pattern

In an annular drainage pattern streams traces a tangential or greater concentric path along a belt of weak rock so, with others, a roughly traced out ring can be seen. It is best displayed by streams draining a maturely dissected structural dome or basin where erosion has exposed rimming sedimentary strata of greatly varying degrees of hardness, as in the Red Valley, which nearly encircles the domal structure of the Black Hills of South Dakota.

Angular drainage pattern Edit

Angular drainage patterns form where bedrock joints and faults intersect at angles other than rectangular drainage patterns. Angles can be more or less than 90 degrees.

LANDFORMS CREATED BY RIVER:

The work of the river is mainly deposition, building up its bed and forming an extensive flood plain. Landforms like braided channels, floodplains, levees, meanders, oxbow lakes, deltas etc. can be seen at this stage.

Types of erosion

Erosion is the process that wears away the river bed and banks. Erosion also breaks up the rocks that are carried by the river.

There are four types of erosion:

Hydraulic action - This is the sheer power of the water as it smashes against the river banks. Air becomes trapped in the cracks of the river bank and bed, and causes the rock to break apart.

Abrasion - When pebbles grind along the river bank and bed in a sand-papering effect.
Attrition - When rocks that the river is carrying knock against each other. They break apart to become smaller and more rounded.

Solution - When the water dissolves certain types of rocks, eg limestone.

EROSIONAL FEATURES:

Vertical erosion has almost stopped and lateral erosion still goes on. The work of the river is mainly deposition, building up its bed and forming an extensive flood plain. Landforms like braided channels, floodplains, levees, meanders, oxbow lakes, deltas etc. can be seen at this stage.

POTHOLES:

A pothole is a depression in a road surface, usually asphalt pavement, where traffic has removed broken pieces of the pavement. It is usually the result of water in the underlying soil structure and traffic passing over the affected area. Water first weakens the underlying soil; traffic then fatigues and breaks the poorly supported asphalt surface in the affected area. Continued traffic action ejects both asphalt and the underlying soil material to create a hole in the pavement.

WATERFALLS:

The waterfall model is a classical model used in system development life cycle to create a system with a linear and sequential approach. It is termed as waterfall because the model develops systematically from one phase to another in a downward fashion. This model is divided into different phases and the output of one phase is used as the input of the next phase. Every phase has to be completed before the next phase starts and there is no overlapping of the phases.

RIVER VALLEY:

A valley is an elongated low area often running between hills or mountains, which will typically contain a river or stream running from one end to the other. ... Some valleys are formed through erosion by glacial ice. These glaciers may remain present in valleys in high mountain or polar areas.

GORGE:

a narrow passage through land especially : a narrow steep-walled canyon or part of a canyon. 2 : throat —often used with rise to indicate revulsion accompanied by a sensation of constrictionMy gorge rises at the sight of blood. 3a : a hawk's crop. b : stomach, belly.

CANYON:

canyon (Spanish: cañón; archaic British English spelling: cañon)[1] or gorge is a deep cleft between escarpments or cliffs resulting from weathering and the erosive activity of a river over geologic time scales.[2] Rivers have a natural tendency to cut through underlying surfaces, eventually wearing away rock layers as sediments are removed downstream. A river bed will gradually reach a baseline elevation, which is the same elevation as the body of water into which the river drains. The processes of weathering and erosion will form canyons when the river's headwaters and estuary are at significantly different elevations,[3] particularly through regions where softer rock layers are intermingled with harder layers more resistant to weathering.

ESCARPMENT:

An escarpment is an area of the Earth where elevation changes suddenly. Escarpment usually refers to the bottom of a cliff or a steep slope. (Scarp refers to the cliff itself.) Escarpments separate two level land surfaces. ... Escarpments are formed by one of two processes: erosion and faulting.

HOGBACK:

In geology and geomorphology, a hogback or hog's back is a long, narrow ridge or a series of hills with a narrow crest and steep slopes of nearly equal inclination on both flanks. ... One side of a hogback (its backslope) consists of the surface (bedding plane) of a steeply dipping rock stratum called a dip slope.

CUESTA:

cuesta (from Spanish cuesta "slope") is a hill or ridge with a gentle slope on one side, and a steep slope on the other. ... Where erosion has exposed the frontslope of this, a steep slope or escarpment occurs. The resulting terrain may be called scarpland.

MESA:

A mesa is a flat-topped mountain or hill. It is a wide, flat, elevated landform with steep sides. Mesa is a Spanish word that means table. Spanish explorers of the American southwest, where many mesas are found, used the word because the tops of mesas look like the tops of tables.

BUTTE:

Butte is a conspicuous isolated hill with steep, often vertical sides and a small, relatively flat top. The word “butte” comes from a French word meaning “small hill”.

PENEPLAIN:

Peneplain, gently undulating, almost featureless plain that, in principle, would be produced by fluvial erosion that would, in the course of geologic time, reduce the land almost to baselevel (sea level), leaving so little gradient that essentially no more erosion could occur.

PEDIMENT:

pediment, also known as a concave slope or waning slope, is a very gently sloping (0.5°–7°) inclined bedrock surface. ... Pediments are erosional surfaces. A pediment develops when sheets of running water (sheet floods) wash over it in intense rainfall events.

RIVERTERRACE:

river terrace(stream terrace) A fragment of a former valley floor that now stands well above the level of the present flood-plain and is usually covered by fluvial deposits. It is caused by stream incision, which may be caused by uplift of the land, a fall in sea level, or a change in climate.

BEDLAND:

Badlands are a type of dry terrain where softer sedimentary rocks and clay-rich soils have been extensively eroded by wind and water. They are characterized by steep slopes, minimal vegetation, lack of a substantial regolith, and high drainage density.

BY

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