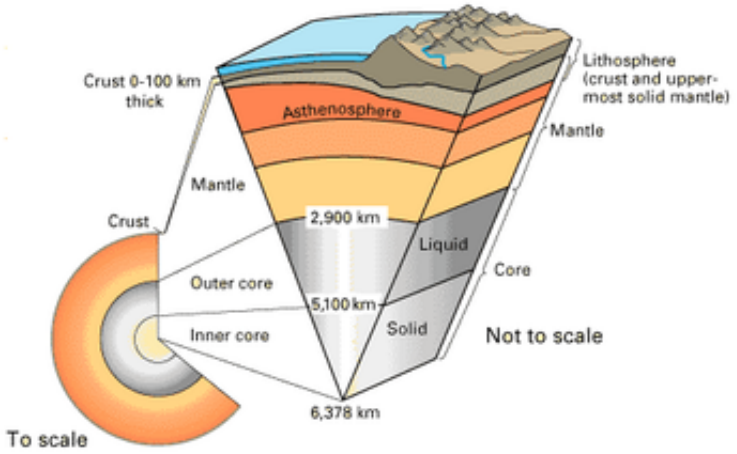
Lithosphere

Friday, April 6 2012, 2:15 PM

Interior of the Earth

Composition

1. Pedosphere: The uppermost part of the lithosphere that chemically reacts with the atmosphere, hydrosphere and biosphere through the soil forming process is called the Pedosphere.
2. Crust: The surface of the crust has mostly sedimentary, igneous and metamorphic rocks. Below them are basalt and ultra-basic rocks. Ocean beds have dark basalt followed by thick greenish hot layer. Ocean layer is also called MAFIC layer (Magnesium & Iron) while continental layer is divided into 2 - (a) FELSIC layer or feldspar + silica which is the topmost. It consists of granitic rocks and is the Sial layer. It is lighter. (b) MAFIC layer which lies below the FELSIC layer. It is denser and is the sima layer.
3. Mantle: The upper mantle is in solid state while the lower mantle is in plastic state. A part of is called Asthenosphere which is the area just below lithosphere (crust + upper solid mantle) and is plastic and involved in plate tectonics. Mantle is the SiMa layer. At lower mantle depths, the pressure is so high that the liquid behaves like a solid and is in a plastic state. It is 2900 km deep.



1. Core: Outer core is Nife layer. It is 2200 km deep and is in liquid state. Inner core is Barysphere layer and is 1200 km deep and is in solid state.

Increase in temperature

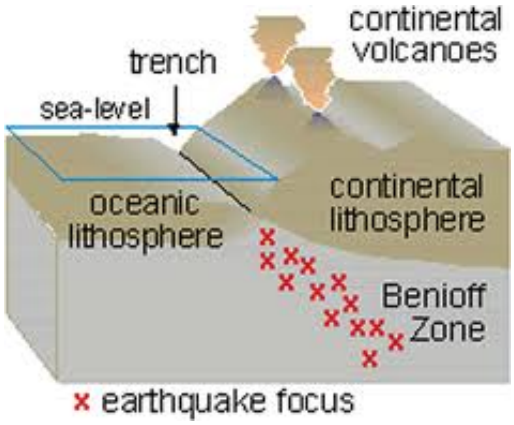
1. In upper 100 km, increase is 12° C per km. For next 300 km it is 2° C per km. Below it the increase is 1° C per km.

Earth Movements

1. Epeirogenic movements vs orogenic movements: Epeirogenic movements are the slow continent building movements. They are because of upward or downward forces. Orogenic movements are on the other hand due to horizontal forces.
2. Orogenic movements: Pre-cambrian: 600-3500 mya. Caledonian: 320 mya. Hercynian: 240 mya. Alpine: 30 mya.
3. Active margins and passive margins: Continental margins are called active types if the oceanic and continental plates are pushing towards each other. Continental margins are called passive types if the

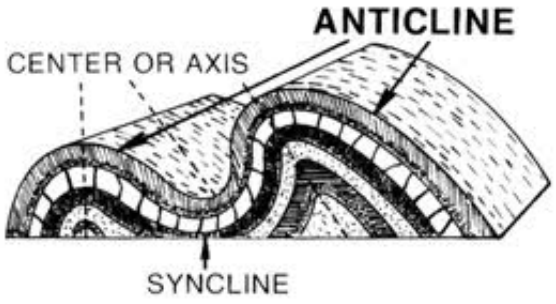
oceanic and continental plates are pulling away from each other.

4. Divergent movement: Both plates pulling apart from each other. It is constructive in nature as it leads to formation of new crust.
5. Continental shields: They are large stable relatively flat expanses of very old rocks. Eg. Deccan plateau.
6. Anti-center and anti-pode: Anti-pode of a point on earth is a point which is diametrically opposite to it. Anti-center is the anti-pode of the epicenter.
7. Magnitude vs intensity of an earthquake: Magnitude refers to the energy released in earthquake. Intensity refers to the impact felt in a locality. Thus an earthquake may have different intensities in different locations. So magnitude scales (like Richter) measure the energy released in the quake. Intensity scales (like Mercalli) measure the impact felt in a location.
8. Seismic scales: Moment magnitude scales consider the area of fault, the displacement of rocks on the fault and the rigidity of earth to arrive at the magnitude. Richter scale is a local magnitude scale. In both scales if we go from 6 to 7 energy released is ~32x and from 6 to 8 is ~1000x. Mercalli scale is an intensity scale.
9. Benioff zones: The subduction zone is inclined and goes inside the continental plate as we go deeper. Deeper earthquakes are confined to the circum-pacific belt and in trans-eurasian belt, only shallow or intermediate earthquakes occur.



1. The 3rd earthquake prone belt is the global system of mid-oceanic ridges with an extension to east African rift valley system.
2. Homoseismal lines vs isoseismal lines: Lines joining places on earth which receive earthquake waves @ the same time are called homoseismal lines. Lines joining places on earth where same intensity of the earthquake is felt are called isoseismal lines.
3. Intra-plate earthquakes: They happen as the stress building on the edges gets transferred inwards and a new fault emerges within a plate or an old one reactivates.
4. Fault scarp: When the surface rocks get displaced and detached from each other due to a fault, it is called fault scarp. It is very prone to erosion.

- Land advancing against sea is -ve movement. Sea advancing against land is +ve movement.
- Anticline & Syncline: After folding rock strata becomes like a wave crest (anticline) and trough (syncline).



Earthquake Waves

There are 3 type of earthquake waves:

1. Primary (P) waves: They are longitudinal waves so can pass through both solids and liquids. But they travel slowly through liquids. Also as the density of medium increases their velocity also increases. At a depth of 2900 km, they reach liquid molten core so their velocity reduces. As they reach inner core (which is a solid) their velocity increases again.
2. Secondary (S) waves: They are transverse waves so can't pass through liquids. They travel to a depth of 2900 km after which they get deflected since they reach outer core which is liquid.
3. Love (L) waves & Raleigh (R) waves: They are surface waves and don't go deeper into the earth. L waves are faster than R waves so the sequence of arrival is PSLR. R waves are analogous to water waves i.e. movement of particles takes place in the vertical plane. In L waves movement of particles takes place in the horizontal plane only but @ 90º to the direction of propagation of the wave. L waves are most destructive. The surface waves get significantly amplified when they pass through a soft ground like alluvial deposits. There is compression and rolling over of soft alluvial deposits which is called liquefaction.

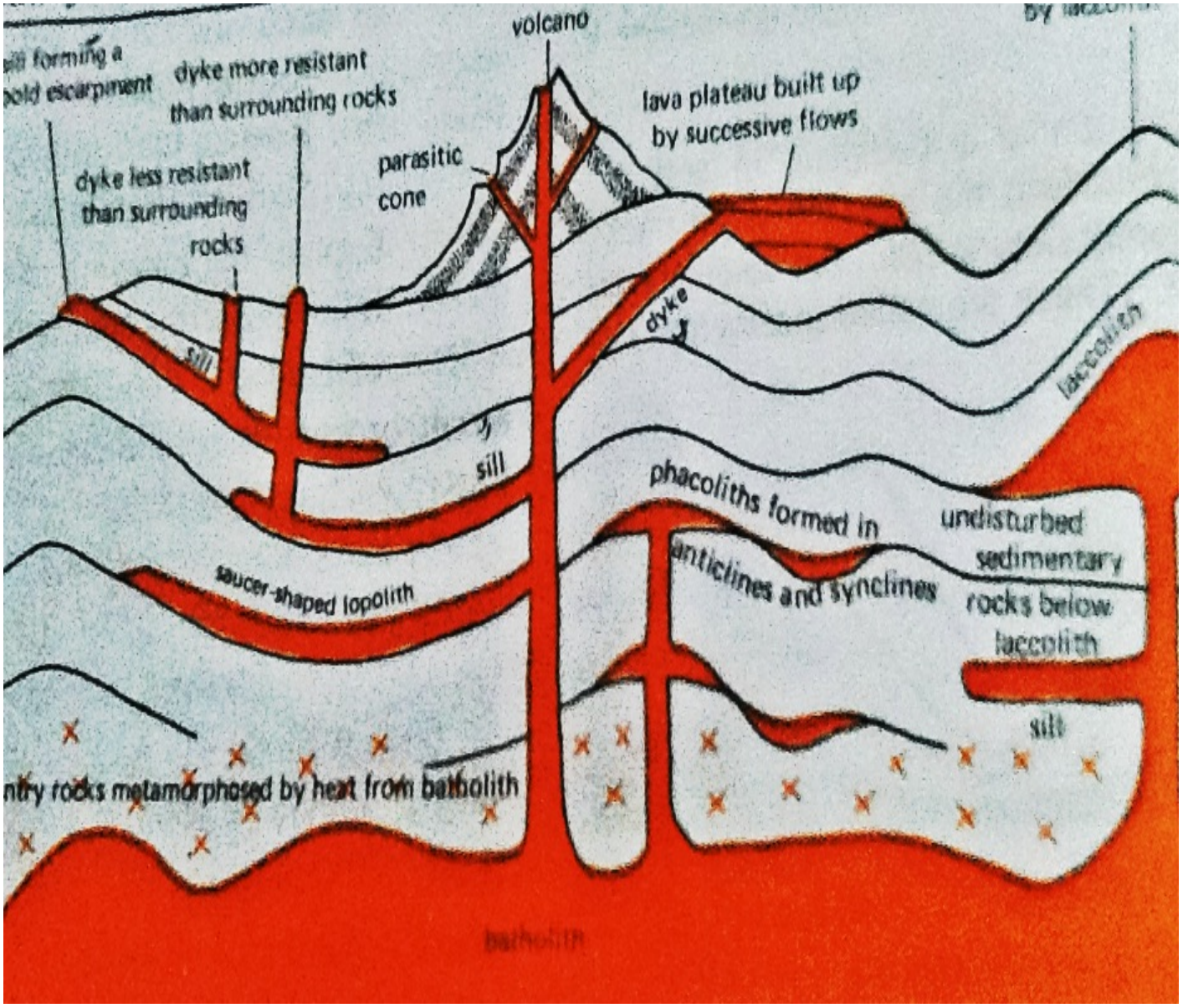
Volcanoes

Intrusive Volcanic Land Formations

1. Sills and dykes: When the intrusive cooling happens horizontally, it is called sill. It may be exposed to the surface upon denudation of above material. If the cooling is vertical, it may be called a dyke. Dykes are narrow. When exposed to denudation, they may appear as upstanding walls (if made of resistant material) or trenches (if made of non-resistant material).
2. Laccoliths, lopoliths, phacoliths, batholiths: Locolith is a large blister with a dome shaped upper surface

and flat lower surface fed by a conduit from below. Lopolith is a saucer shaped intrusive formation. Phacolith is a lens shaped mass of igneous rock occupying the crest of an anticline and trough of a syncline and being fed by a conduit from below. Batholith is the huge mass of bed igneous rocks.

3. Calderas: A violent eruption weakens the structure of the volcano and after the eruption ceases, much of the volcano subsides into the magma beneath. The depression formed in the crater is large and is called caldera.



Types of lava

1. Acidic: It is viscous and rich in silica. It is light colored and flows slowly and cools fast. It comes out with an explosion since the viscous lava blocks the outflow path. The pieces of rocks thrown out by explosion are called pyroclasts. Sometimes the lava is so viscous, it forms a spine or a plug above the crater itself. When it solidifies in a valley it is called lava tongue.
2. Basic: It is fluid, dark colored and rich in iron and magnesium. It is the hottest lava and flows fast (up to 45 kmph). It affects extensive area and spreads out as thin sheets. It doesn't explode rather comes out quietly. Leads to the formation of shield volcano.

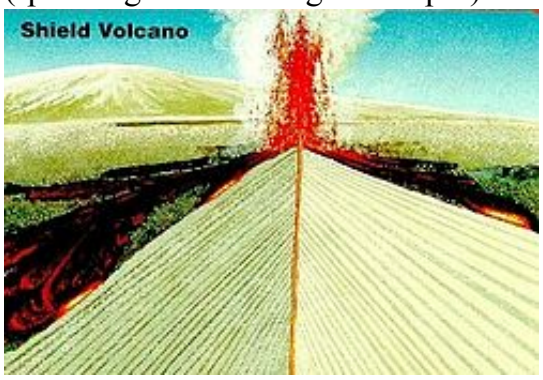
Examples in India

1. Barren Island in Andamans is a dormant volcano.
2. Lake Lonar and Lake Caldera in Maharastra are examples of volcanic craters.

Volcanic Types

1. Volcanic hotspots: Places on earth where volcanic plumes rise through the crust.
2. Crater Volcanoes

Shield Volcanoes: Basaltic lava having low silica content flows out quietly and gives the shape of a shield (spreading out thin and gentle slopes). Volcanoes which form in the mid ocean are basaltic.



Dome Volcanoes: They are formed generally in high silica lava which has high viscosity (thus preventing it from spreading out far). Basaltic lava break apart quickly in weathering or when new lava is added so they typically don't form domes.

Rocks

Igneous Rocks

Rock Formation

1. Extrusive Rocks: When the magma comes out to surface, gases escape and it cools rapidly. So very small grains if anything are formed. Basalt is a common extrusive rocks and constitutes lava flows over Deccan Trap. Such a rock has basic oxide and is basic in nature. Lack of silica gives dark color.
2. Intrusive Rocks: When magma cools below the surface of the earth, cooling is slow and large crystals are formed. Granite and dolerite are examples. Color of granite is because of presence of silica. Silica presence also gives acidic nature to the rock. Granite is an acidic rock.
3. Plutonic Rocks: When solidification takes place deep below the surface, cooling is very slow and crystals are mammoth. Lack of silica gives dark color.

Rock Bodies

1. Mineral lodes: Ores are found in fissures of the rocks. When water containing minerals fills these fissures and evaporates, it leaves behind the minerals leading to ore formation.
2. Batholiths: These are the mammoth granite cores of the fold mountains which are exposed only when a large chunk of rock falls off.
3. Laccoliths: They are miscarried volcanoes, mushroom shaped and are basically igneous rock bodies near but below the earth surface. It is the intrusive equivalent of extrusive volcano.
4. Dykes: They are long, near vertical igneous formations which are formed when magma solidifies in the rock fissures.

5. Sill: When magma solidifies in a thin horizontal sheet between 2 rock layers, it is called a sill.

Sedimentary Rocks

Rock Formation

1. Compaction / mechanical action: Due to pressure of above layers, loose sediments get packed. Sand --> sandstone, clay --> shale. They are found in strata.
2. Cementation: Water carries some sort of cementing material like silica or calcite. It deposits them around the grains and pebbles and binds them together into a solid mass. Conglomerates are collection of round pebbles held together by some cementing material and found @ sea shore or river beds. Breccia are collection of angular pebbles held together by some cementing material and found @ sea shore or river beds. The angular formations indicate work of agents other than water and ice.
3. Organic rocks: Marine animals like corals and algae extract $CaCO_3$ form sea water and deposit it in their skeletons. When they die, their skeletons together form limestone.
4. Chemical action: Such rocks are precipitated chemically from solutions of one kind or another. Gypsum is an example.

Metamorphic Rocks

Rock Formation

1. Dynamic: Rock formation under pressure. Granite ==> gnessis and shale ==> schists.
2. Thermal: Rock formation under heat contact. Sandstone ==> quartzite, clay ==> slate, coal ==> anthracite and graphite, limestone ==> marble.

Landforms

1. Tors: They are the granitic uplands in the form of big sized domes present in Telangana & Rayalseema.

Mountain Types

Fold Mountains / Mountains of Elevation

1. These mountains have granitic core surrounded by metamorphic rocks and sedimentary layers @ the outer.
2. They are formed as sedimentary rock strata, originally laid down in geosynclines (shallow sea / lake depressions) get folded and uplifted.
3. When the crest of a fold is pushed too far, it progresses from simple fold ==> asymmetric fold ==> overfold ==> recumbent fold ==> nappe. In the nappe stage, a fracture occurs, a thrust plane is formed and the overthrust fold portion is called nappe.

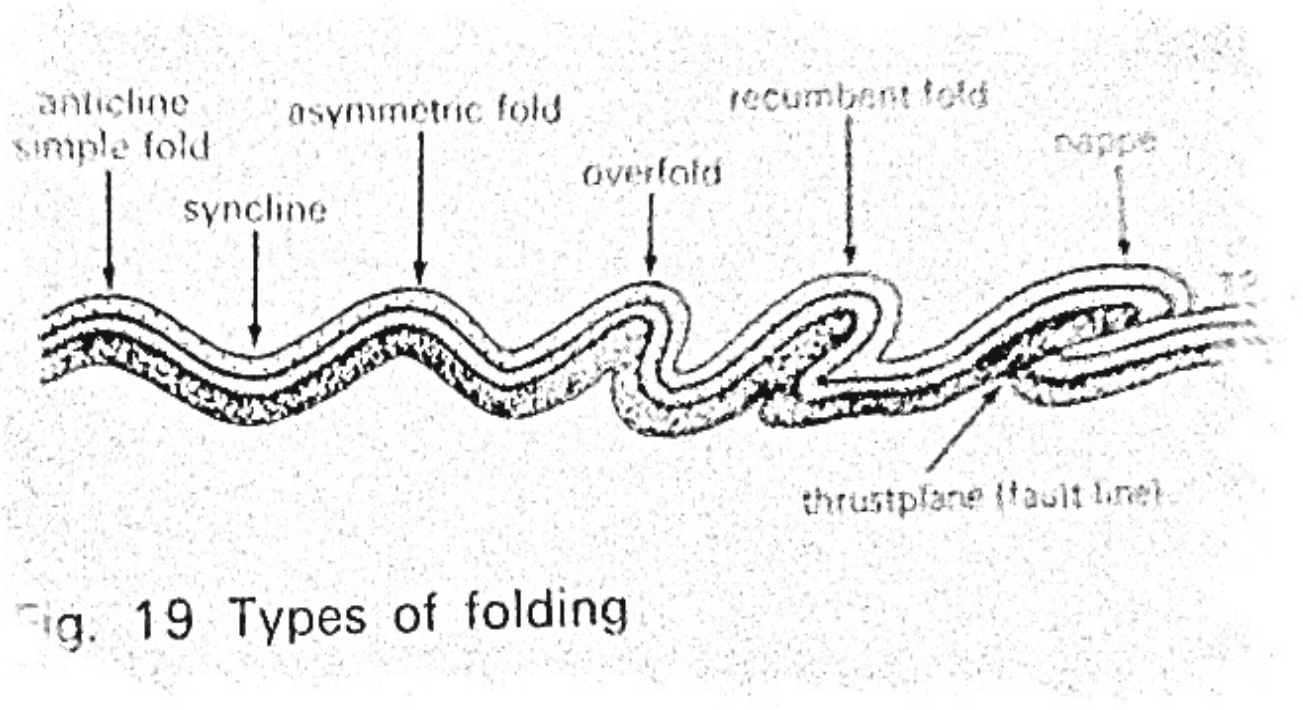
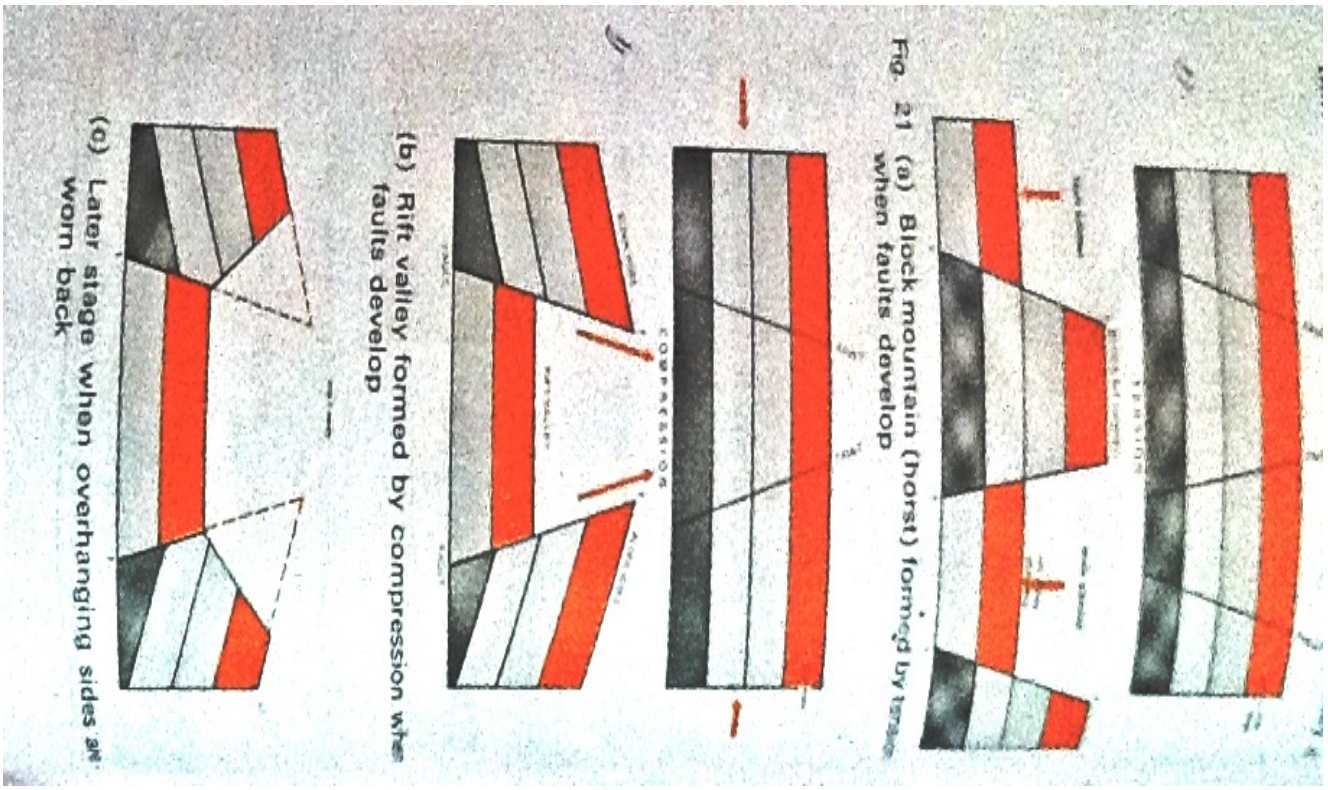


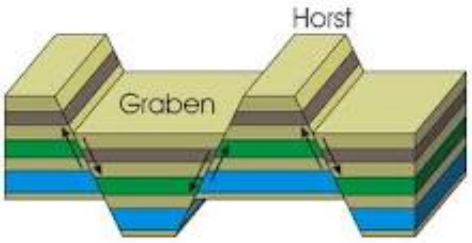
Fig. 19 Types of folding

Block Mountains

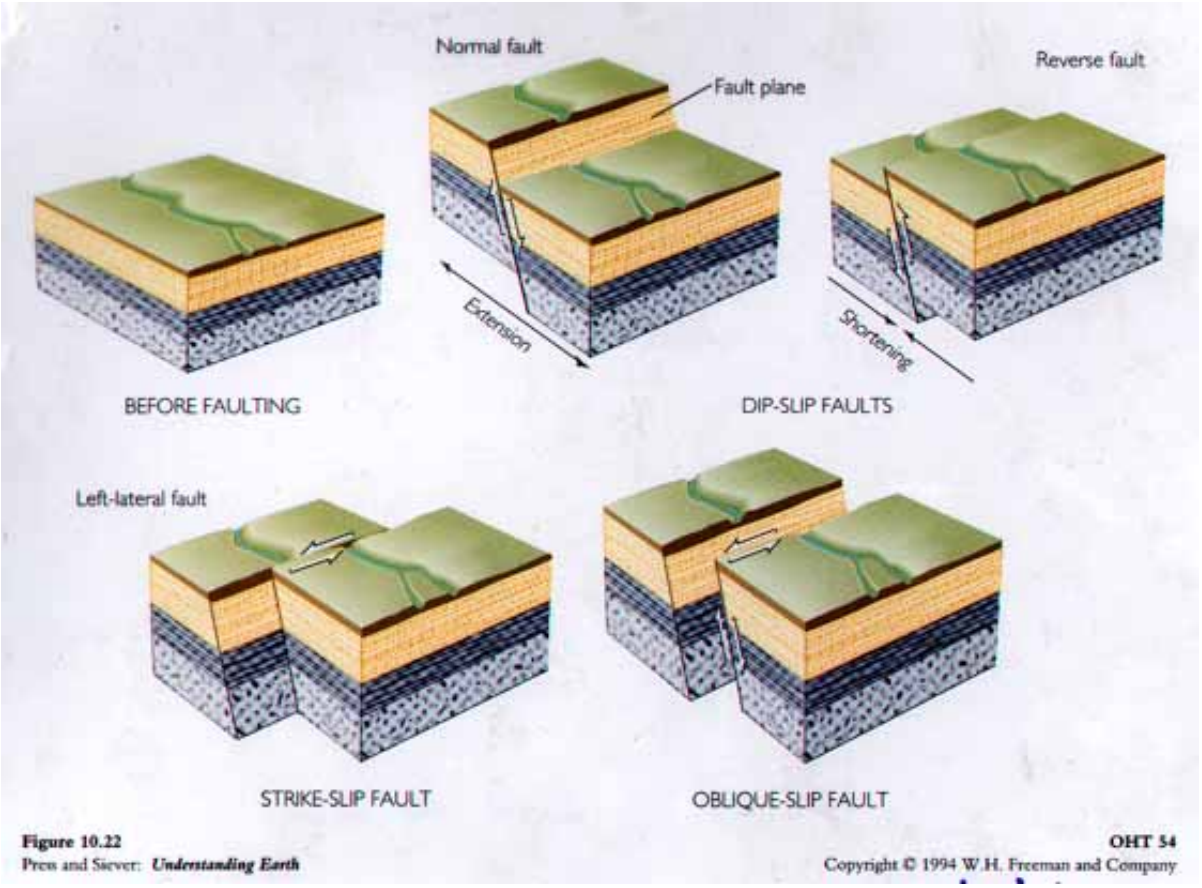
1. They are formed when great blocks of land get uplifted or subside during the late stages of mountain building. During the uplift, sometimes magma flows up. On cooling beneath the surface, it contracts and the overlying rock may crack resulting in vertical movements. The uplands formed are called horsts or block mountains and the lowlands are called rift valleys of graben.
2. Tensional forces tend to pull apart and cause faults. Compressional forces tend to push together and cause reverse-faults.



3. <u>Fractures & Faults:</u> A simple break in rock due to tension without any movement is fracture. When a movement occurs along with the break, it is called a fault. Fault can lead to one side of the land going up (upthrow side) or going down (downthrow side). It can lead to rift valleys (graben) or horst.



1. <u>Strike-slip fault vs thrust fault:</u> In case of strike-slip fault, the fractured crust parts slide past each other laterally. While in thrust fault, they slide past vertically.



Volcanic Mountains / Mountains of Accumulation
Residual Mountains / Mountains of Denudation

1. When the general level of the land has been lowered, some resistant areas may remain as uplands. They may also evolve from a plateau getting dissected.

<u>Plateau Types</u>
Intermontane Plateau

1. They are partly or fully enclosed by mountains. They are a result of mountain building process which was accompanied by a vertical uplift of adjoining lands. Example is Tibetan Plateau.

Piedmont Plateau

1. They have mountain on one side and sea / low plain on the other. Example is Malwa Plateau. They are also called plateau of denudation because they were once high but have been reduced by erosion.

Continental Plateau

1. They rise abruptly from sea coast or low lands as a result of uplifting. Example is Chota Nagpur

Plateau.

Tectonic Plateau
Volcanic Plateau

1. Caused by basaltic lava flow.

Dissected Plateau

1. Formed by erosion.

Plain Types
Structural Plains

1. They are formed as a result of uplifting of continental shelf. They can also refer to structurally low lying areas.

Erosional Plains

1. When a highland gets eroded, it is also called peneplain (almost plains) or erosional plain. Mechanical weathering in arid and semi-arid areas may wear the mountain slopes leading to pediplains.

Depositional Plains

1. The Ganga delta in the west is dying since streams there get choked. So the delta is moving eastward.

Soils

1. The air contained in the soil pores has ore CO_2 as compared to atmosphere.
2. Clay < silt < sand in size.
3. Clay soil has small pore spaces and hence the rate of passage of water through it is low. Hence clay soils are more water retentive. Sandy soil has large pore spaces so water passes down quickly. Loam has a mixture of sand, clay and silt and has good water retentive capacity as well as is easy to plough.
4. Soils with low lime content are acidic and those with high lime content are alkaline.
5. Parent rock, topography and the time period are called passive agents while climate and biological factors are called active agents.
6. Climate tends to reduce the differences caused by the different parent materials. Granite rock gives laterite soil in moist parts of monsoonal regions while non-lateritic soil in drier parts. Hot summer and low rainfall leads to black soil in TN irrespective of parent rock. In Rajasthan both granite and sandstone give sandy soil.
7. Residual soil: On steep rocks, only a thin layer of soil is left after erosion. This is called residual soil.

Soil Classification
Pedalfers

1. This soil is found in humid conditions. They are generally acidic and are deficient in calcium and other mineral salts (due to precipitation leaching takes place).
2. Ash-grey soils / Podosols: Found in high latitude coniferous forests. Winters are long and cold, summers are short and cool, precipitation is moderate throughout the year. There is strong leaching and slow formation of humus (due to scant bio cover). The soils are acidic and have limited agricultural value.

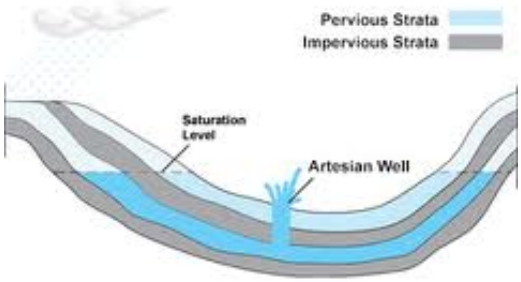
3. Grey-brown soils: They are found in mid latitude deciduous forest regions of US and Europe. They are less leached, have good humus content and fertile.
4. Red & yellow soils: They are found in tropical regions of high rainfall. Leaching is intense, high bacterial activity leaves little humus, they are acidic (lime content is low) and red color is due to iron oxides.

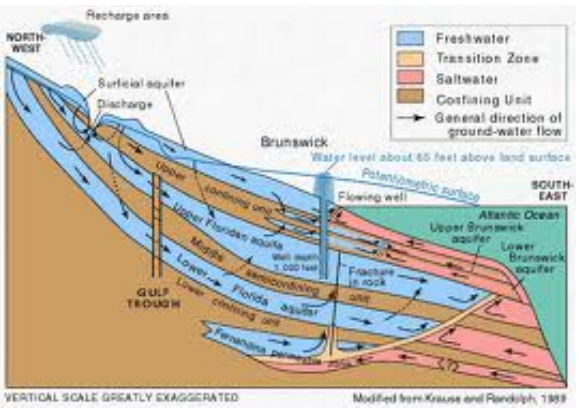
Pedocals

1. They are found in arid conditions. They are rich in calcium and other mineral salts (due to evaporation, water and the dissolved salts move up). Prairies are a region of such soils.
2. Black soils: They are most fertile, rich in humus, rich in calcium, unleached and are crumby. They have higher moisture holding capacity.
3. Desert soils: They are unleached and alkaline but lack humus (due to scant bio cover).
4. Usar: The are patches of barren soil in pedocal belt under dry steppe like conditions. They are found in UP.
5. Reh: Clay soil with bad drainage lying in low-lying areas. Due to bad drainage, salts come up from below and these soils are saline and alkaline. Even canal irrigation can't help due to salt presence.

Underground Water

1. Porosity, permeability & aquifers: Porosity is the water holding capacity of the rocks and depends on the pore spaces. When pore spaces of rocks join together, water can flow through the rock making it permeable. If the pores are not interconnected rock may be porous but not permeable. When such pore spaces are large and connected such that water can flow freely, it is called aquifers. Clay is porous but has a low permeability. Granite is non-porous but permeable because of the joints or cracks through it.
2. Zone of saturation, water table & zone of intermittent saturation: Zone of saturation is when all pore spaces are fully filled by water. Water table is the line which separates zone of saturation and unsaturation. Intermittent saturation zone is the difference between permanent water table and highest water table.
3. Artesian wells: When due to pressure water in a well automatically rises to the ground surface. It occurs in 2 conditions shown below:





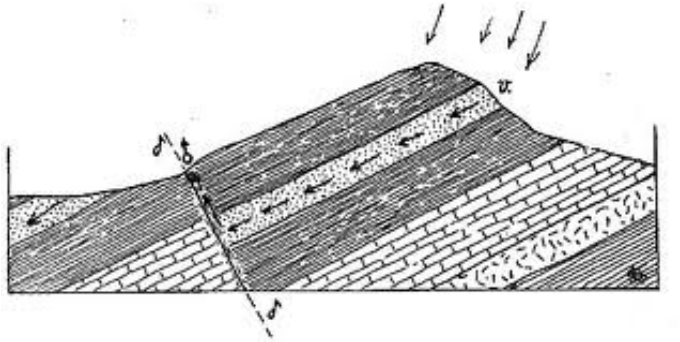
In India, Neyveli lignite mining area suffers from this problem.

Springs

1. They are places when flow of water rises to the surface due to pressure. They open out at the junctions of permeable and impermeable rocks. Basically water falls on the hill top, a layer of impervious rock is below at some depth. At some point on the slope, it comes out and flows on the surface.

2. Pit spring: When the impervious rock is in the form of a flat depression, the spring flows out of the bed's lowest point which reaches the surface.
3. Scarp foot spring: They are marked along the foot of a scarp in the hills up to which level the rain water percolates and cannot move further down due to impervious rock.
4. Fissure spring: In hard rocks, water flows mainly through fissures. When such a fissure reaches the surface on a hill slope, it is called fissure spring.
5. Dyke spring: If the dyke is of impervious nature and it has pervious rocks to both sides, then at a place where it is exposed, water flows out and is called dyke spring.
6. Vauclusion spring: Underground rivers cut across limestone beds and make way. But when the limestone passage is exposed to the surface and there is an impervious bed below, river comes out again as vauclusion spring.

Fault spring: Due to faulting, a pervious bed comes to rest against an impervious bed. So water flows out from the junction and is called fault spring.



Karst Topography

1. It is the topography made by underground water in limestone rock areas. Limestone rocks get readily dissolved by rain water. Water percolates down until it hits an impervious bed and then flows underground dissolving away limestone.
2. Sink hole: It is a funnel shape depression at the surface from where water or running stream percolates down.

1. Blind Valleys: Due to sink holes, sometimes river streams go underground leaving their beds dry. The beds of dry streams are called blind valleys.
2. Swallow Holes: They are like pots and lie below a sink hole when an impervious bed is reached. So water begins to flow in underground caves.
3. Caverns: They are a network of caves and chambers formed underground in a limestone topography.

Gradation Process

Weathering

Mechanical weathering

1. No chemical reaction takes place and rock particles are only separated from each other. It is most

rapid on sedimentary rocks. Temperature induced expansion and contraction is one reason. Dark colored / multi colored rocks are easier to break than light colored ones.
2. Rectangular edges of the rocks are weathered into round edges because the stresses and pressures are highest along sharp angles.
3. Mass movement: Mass movement is the movement of weathered material down the slope due to gravity.
4. Talus / Scree: The angular debris formed as a result of rock weathering which move down the slope and accumulate at the foot under the effect of gravity.
5. Exfoliation: The alternate expansion and contraction of the outer surface sometimes results in its peeling off in the form of concentric shells. It is called exfoliation.
6. Frost weathering: Ice occupies more volume than water. So when inside rock fissures in cold temperatures, ice freezes it expands the fissures leading to breakup of the rock.
7. Soil creep, soil flow and landslides: Soil creep is the slow but steady and barely noticeable movement of soil down the slope under gravity. It is most common in damp soil where water acts as a lubricant. Though the movement can't be seen, it can be inferred as trees having roots or pillars rooted on the soil bend and soil accumulates near the base of a wall on the slope. When soil gets too much water, it flows as a suspension in the water. This is called soil flow. Landslides are common when permeable layers lie above an impermeable layer. Then water accumulates at the base and acts as a lubricant.

Bio weathering

1. It consists of both mechanical (roots, burrowing) as well as chemical (excretions contain acids).

Chemical weathering

1. Here the rocks decompose chemically instead of disintegrating. It is higher in high temperature and moisture. Mechanical action of rain is smaller than its chemical action. Granite is composed of crystals of quarts, felspar and mica. Out of these felspar is quickly weathered in rain and leaves the surface rough. The quartz crystals are loosened subsequently.
2. Regolith: It is the weathered material remains of the rock. It is different from soil because soil has organic content while regolith has no organic content.
3. When a soil cover exists over the rock bed, chemical weathering is generally enhanced and not reduced. This is because water goes down via soil pores and remains there for a long time creating a moist environment. It also absorbs organic acids from the soil making it a stronger weathering agent.
4. Sedimentary rocks are more affected by chemical weathering (specially solution type where rock material gets dissolved in the water) because water can enter the pore spaces in these rocks.
5. Hydration: Aluminum bearing rocks react with rain water and this leads to breaking of the outer shell.

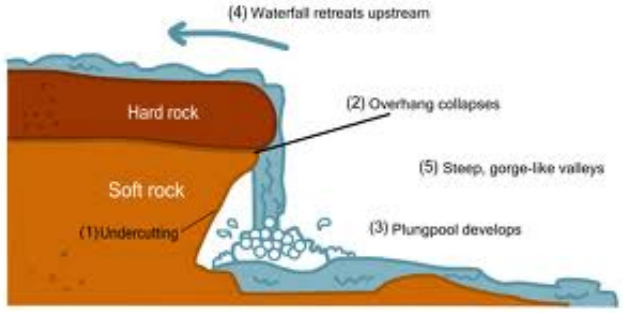
Running Water

1. Carrying capacity of rivers increases 64x if velocity is doubled and only 2x if volume is doubled.
2. Erosion power increases with the amount of sediments already being carried. So during floods when sediment load is high, large boulders stuck in the river bed are moved as well.
3. Corrasion or abrasion: This is the mechanical grinding of river's load against the bed (vertical corrasion) and the banks (lateral corrasion).
4. Corrosion or solution: It is the chemical weathering action of river water.
5. Hydraulic action: This is the mechanical loosening of materials by the river water itself.
6. Attrition: This is the wear and tear of carried load in the river when it rolls or collides with other particles.
7. River capture: Due to head cutting, a river may extend backwards. If it cuts across the watershed, it

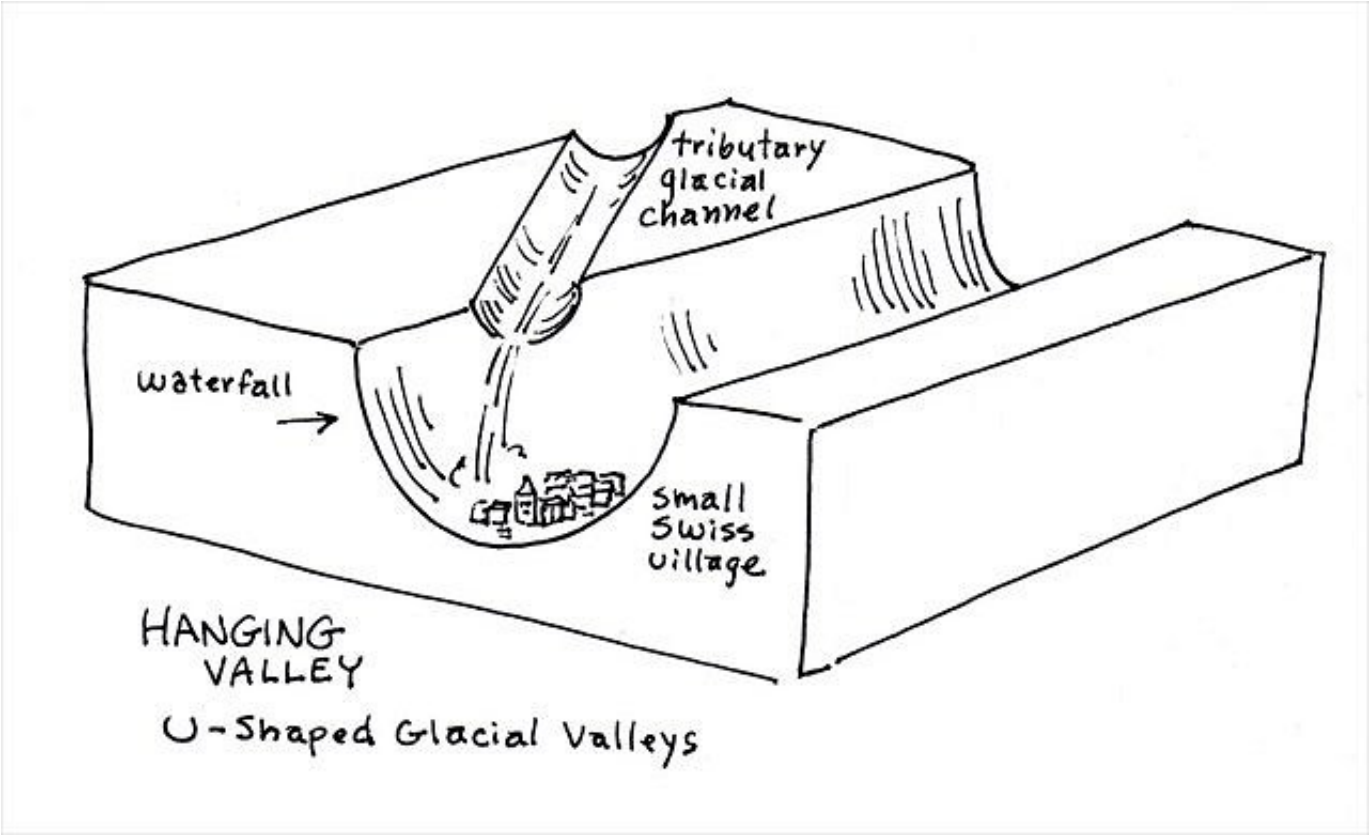
may capture a tributary of another river. The bend at which the other river is captured is called *elbow*. The old main river of the captured tributary is called *misfit*. The dry valley of the captured tributary below the elbow is called *wind gap*.

8. Gorges: They are formed when side rocks are very resistant, the valley becomes low and sides very steep as river cuts down its own bed. Canyons are deepest gorges and are formed in drier areas or areas with limestone beds, river fails to widen and cuts its own bed.

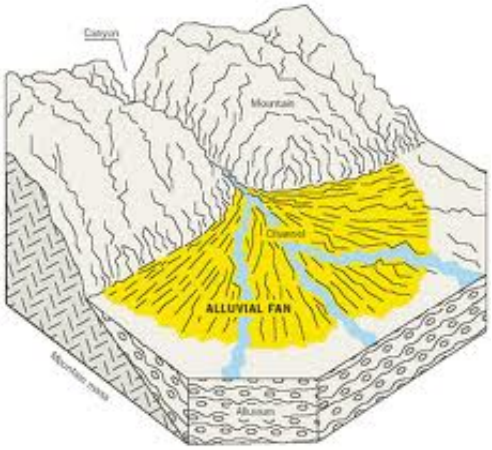
1. Rapids: Occurrence of a band of hard rocks on the river beds makes it go up and down.



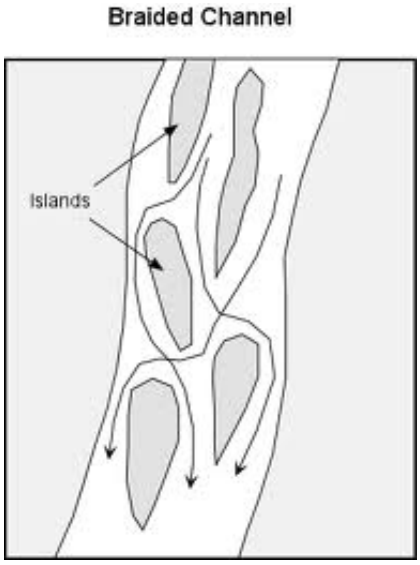
1. Hanging valley: In glaciated areas at points where tributary stream joins the main stream, the over-deepening of the main valley leaves the side valleys hanging high above the main valley. A mini-waterfall emerges where tributaries fall into the main river. This is because the smaller glaciers filling tributary valleys don't erode as deep as that filling the main valley.



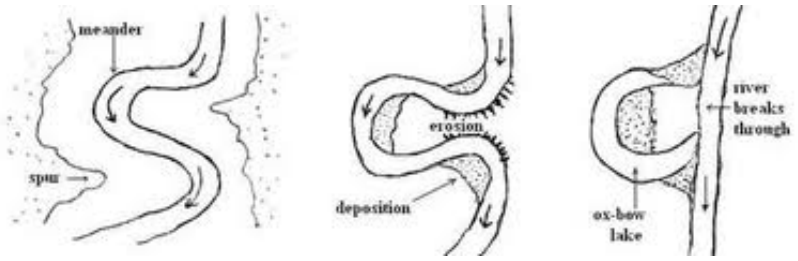
1. Alluvial fans: The merging of adjoining alluvial fans gives rise to bhabhar plain @ the foot of himalyas in Ganga plain.



1. Braided stream: In the lower river basin, deposition is in excess of erosion. So a network of islands emerges in the river course. The stream gets divided into a network of channels flowing between and around these islands.



1. Meanders & oxbow lakes: In a meander, water velocity is higher on the outer side of the bend. So while there is erosion on the outer side, there is deposition on the inner side. Initially due to an obstruction, river bends. Now deposition will take place on the inner side of the bend and erosion on the other side leading to formation of oxbow lake.



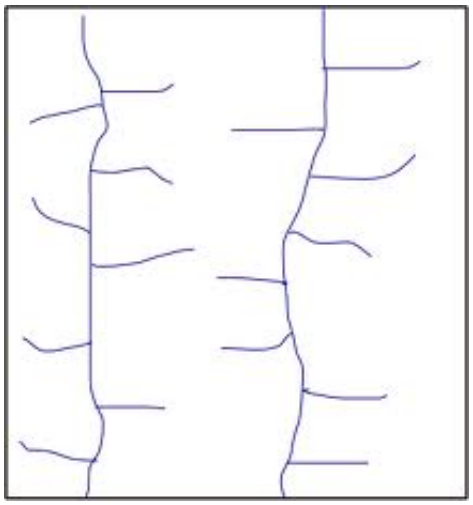
1. Due to continuous deposition on the river bed, the river bed and the levees may rise higher than the adjoining flood plain.
2. Deltas: Large supply of fine alluvium, sheltered coast, absence of large lakes which 'filter' off river's sediments, absence of strong tides, winds, currents is needed @ the river mouth for the formation of deltas.
3. Watershed: The higher ground separating 2 drainage basins is called watershed.
4. Consequent streams vs antecedent streams: Consequent streams are streams whose flow is a result of

the original slope of the land. If continuous downcutting enables the rivers to make their way through the mountain ranges rising subsequently, they are called antecedent streams.

5. River rejuvenation: When there is a negative movement, the river's erosional activities come back to life in the lower course. The point where the new and old profile meet is called *knick point* and river often forms rapids there. It may also lead to vertical downcutting of its meanders and formation of deep gorges and canyons.
6. Subsequent streams vs insequent streams:

1. Dendritic drainage: It is a tree like patter formed by insequent streams. It is formed when the entire bed is of uniform rocks.

1. Parallel drainage: It develops on steep slopes when master stream and tributaries run almost parallel for long distances before merging.
2. Trellis drainage: It develops when tributaries meet main stream almost @ 90º. It develops when the landform has resistant anticline ridges separated by synclinal valleys or where resistant and non-resistant rocks are alternate.



1. Radial drainage: Drainage radiating from a central part to all directions.

Moving Ice

1. Snowline's height depends on latitude as well as amount of precipitation. Higher the precipitation, lower the snowline. It also depends on the slope. Steep slopes lead to snow lines going higher. In N hemisphere, snowlines to the north side are lower than those to the southern side.
2. A glacier erodes via abrasion as well as plucking.
3. Ice caps: They are the covers of snow and ice on mountains from which the valley or mountain glaciers originate.
4. Piedmont glaciers: @ the foot of the mountains several glaciers may converge like in Alaska.
5. Boulder clay: The material carried by glacier is heterogenous and contains both boulders and clay, hence the name.
6. Ice velocity: It increases with thickness of glacial ice. So speed is higher in the middle and lower @ the

edges.

7. Crevasses: The top portion of the glacier moves faster than the bottom due to less friction. So cracks appear on the top specially when the slope of the bed drops suddenly. The ice can't keep pace with its faster movement. Downwards where the gradient is gentler, crevasses unite. Crevasses in the direction of flow generally appear when the glacier becomes wide on leaving a narrow valley.

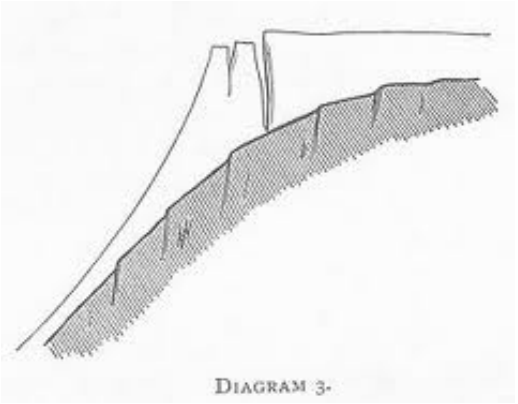
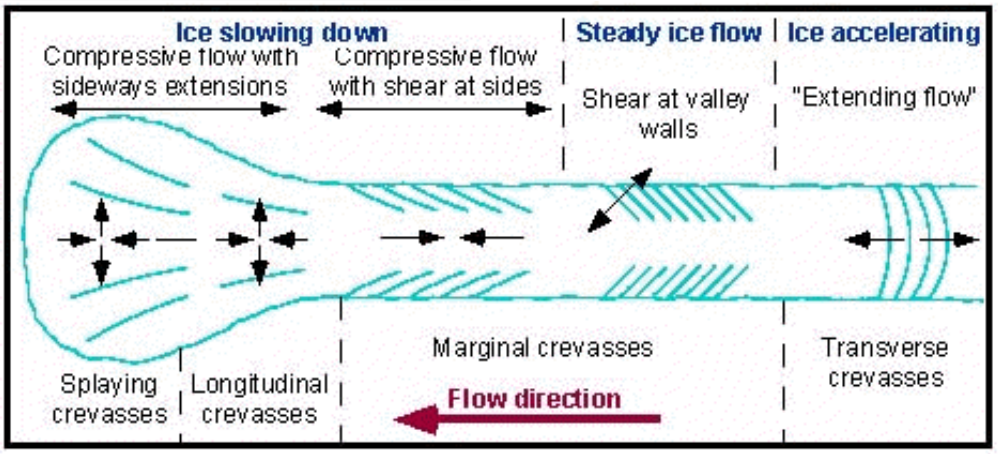
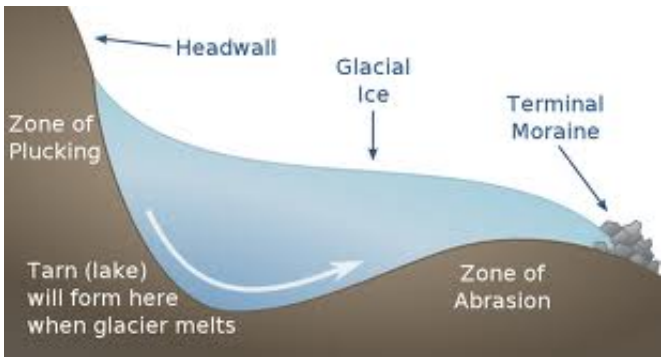


DIAGRAM 3.

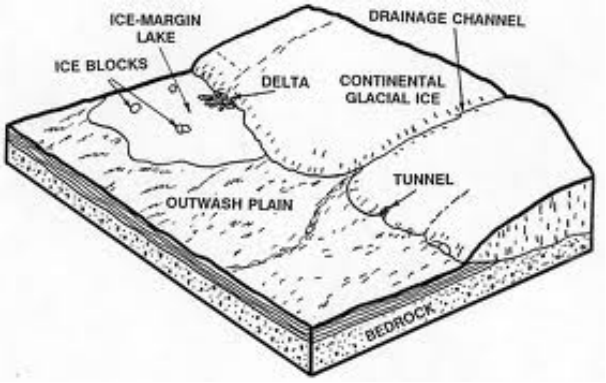


1. Cirque: It is a large arm-chair like hollow cut into the mountain ridge. The edge of the open end is slightly higher. When it melts lakes called *tarn* are formed. On the back wall, plucking occurs steepening it. If cirques occur on 2 sides of the peak, it leads to formation of *aretes*. If cirques occur on 3 sides, it leads to pyramidical peaks. The abrasive action leads to deepening of the cirque floor depression.

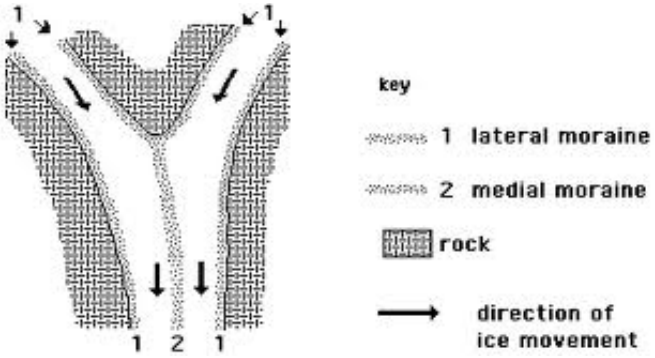


1. Sheep rocks and crags: Ice, unlike water, doesn't avoid obstacles but flows over it. Thus the upward slope becomes smooth and gentler while the other slope becomes steep and rougher. A crag is a rock with a steep side over which the glacier flew and gentle other side.
2. Glacial till: The moraine piles of stones and boulders are called glacial tills.

3. Ground moraine: The excessive load which can't be carried by a glacier and is deposited on its own bed is called ground moraine.
4. Drumlins: If the ground moraine is deposited on a smooth surface, it leads to formation of small hills. These small hills are called drumlins. If deposited on a rough surface, it tends to fill the gaps and make it smooth.
5. Outwash plain, valley trains & eskers: When the glacier melts, the water stream can carry the sediments of the moraine to some distance and sort them. They deposit the material in the shape of alluvial fans, it is called outwash plain. If these sediments are deposited along the river banks, they run parallel and are called valley trains. Long winding and very low ridges of sand and gravel looking like natural embankments and made by these sub-glacial streams are called Eskers.



1.
2. Terminal moraine: The material dropped at the end of the valley in the form of a ridge. Each time a glacier recedes, a fresh terminal moraine is created behind the first one.
3. Lateral moraine: Moraine formed on the sides.
4. Medial moraine: When 2 lateral moraines join, their confluence is called medial moraine.



Wind

1. Barkhan: They are the crescent sand dunes. Extremities of the dune move more rapidly than the middle portion giving rise to the horns. A constant wind direction and limited supply of sand are needed.
2. Seif or longitudinal dunes: Seifs are long narrow ridges of sand running parallel to the direction of wind. The dominant winds blow straight in the corridor between the dunes. Barkhan will be transformed into a Seif if a cross wind blows consistently thus its horns will rearrange.

Sea Waves

1. Coast & shore: Coastline is the high tide level. Shore is the low tide level.
2. Sea-cliffs: The wave initially wears a groove in the rock @ sea level. As the groove deepens, the upper portion falls into the sea and a steep wall of the rock remains which is called sea cliff.
3. Sea-Caves: Caves generally form when the overhanging rock is able to stand without the support from below which has been cut by the sea waves.

4. Sea Arch: When sea waves working from both sides cut through the caves, it is called sea arch.
5. Stack: When the upper portion of the sea arch falls, the remaining portion which stands is called stack.

1. Spit, bar & lagoon: Sea waves deposit their load @ some distance. If a ridge or embankment of such sediments is formed which is attached to land on one side and opens into the open sea on the other and at the same time is also parallel to the coast, it is called a spit. If such a spit is also enclosed by land on the other side such that it works to cordon of a part of the sea it is called a bar. A bar extends between 2 headlands and the sea water so enclosed is called a lagoon.

1. Headlands and bay: Headlands are formed in resistant rocks while bays are formed in non-resistant rocks.

Coastlines

1. Submergence vs emergence coastlines: When sea level rises or the coastal land subsides it is called coastline of submergence. When the sea level falls or the continental shelf adjacent to the coast rises, it is called coastline of emergence.
2. Fiord coastline: It is a coastline of submergence of a glaciated area. They have long and narrow inlets with steep sides (from U shaped valleys) and many tiny islands which were once outlying hills.
3. Ria coastline: It is a coastline of submergence of a non-glaciated area. The slopes of the inlets are gentle (from V shaped valleys) and they become progressively deeper towards sea. Generally there are no islands.
4. Lowland coastline: It is formed by submergence of a low lying area. It is characterized by the presence of bars and lagoons.

5. <u>Dalmatian coastline:</u> It is formed when a mountain range running parallel to the coast subsides.