UNIT-I- PHYSICAL GEOLOGY

1.1. INTRODUCTION OF GEOLOGY

GEOLOGY FOR ENGINEERS

What is Geology?

• Branches of geology:–

Historical Geology – origins and evolution of the Earth, its continents, atmosphere and life
Physical Geology – Rocks, minerals and the processes that affect them.
There are a broad range of sub-disciplines within geology many of which are related to other sciences while others have a direct influence on human activity:

Geochemistry

• By crushing and analyzing rocks we can measure their chemical composition
• This can be used to determine the tectonic setting in which the rocks formed

Geophysics

• We can measure the physical properties of rocks with a variety of methods
a. Seismic waves
b.Gravity
C.Electromagnetic characteristics
• These can be used to investigate the subsurface properties of the planet

Economic Geology

Environmental geology

• Geological, climatic and man-made hazards all fall into this field
• Volcanoes
• Earthquakes
• Landslips
• Meteorites
• Avalanches
• Tsunami
• Floods
• Global warming?
• Pollution

Volcanology

• Monitor active volcanoes
• Predict eruptions
• Hazard mapping
• Dramatic scenery
• High risk/high casualty rate

Structural Geology
• Measuring the orientation of geological structures
• Geological mapping
• Unraveling complex terrenes

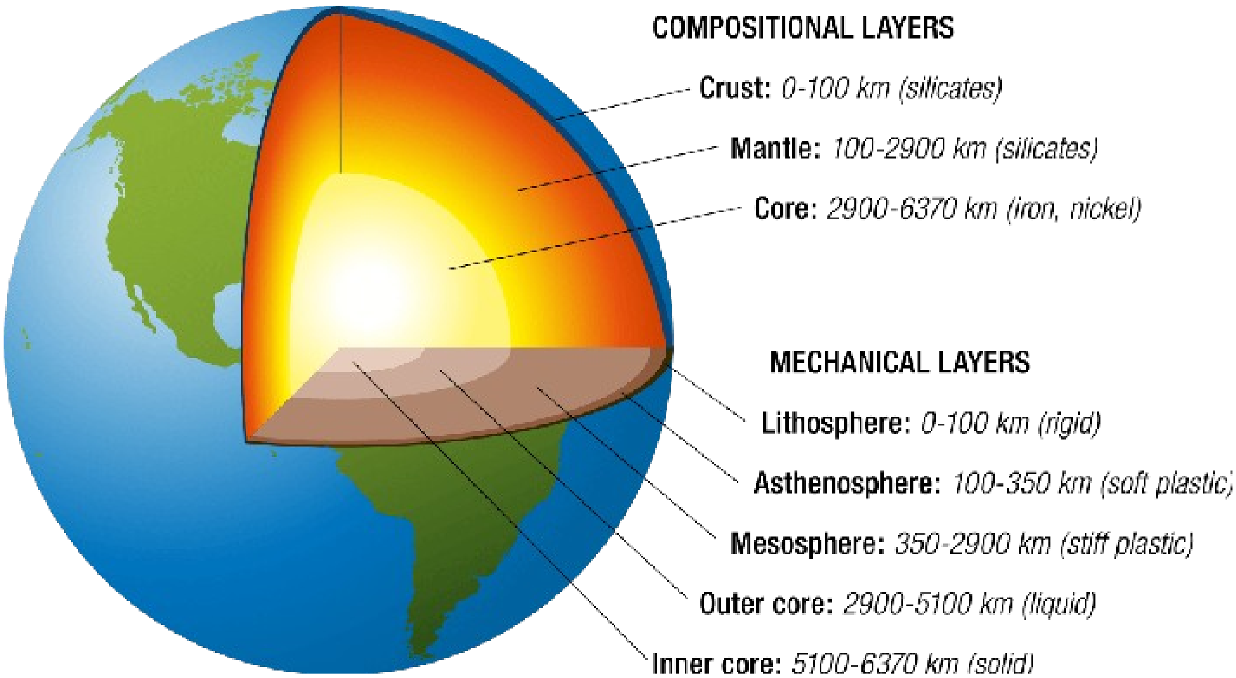
Hydrogeology
• Flood prediction and prevention
• Water resource management
• Groundwater

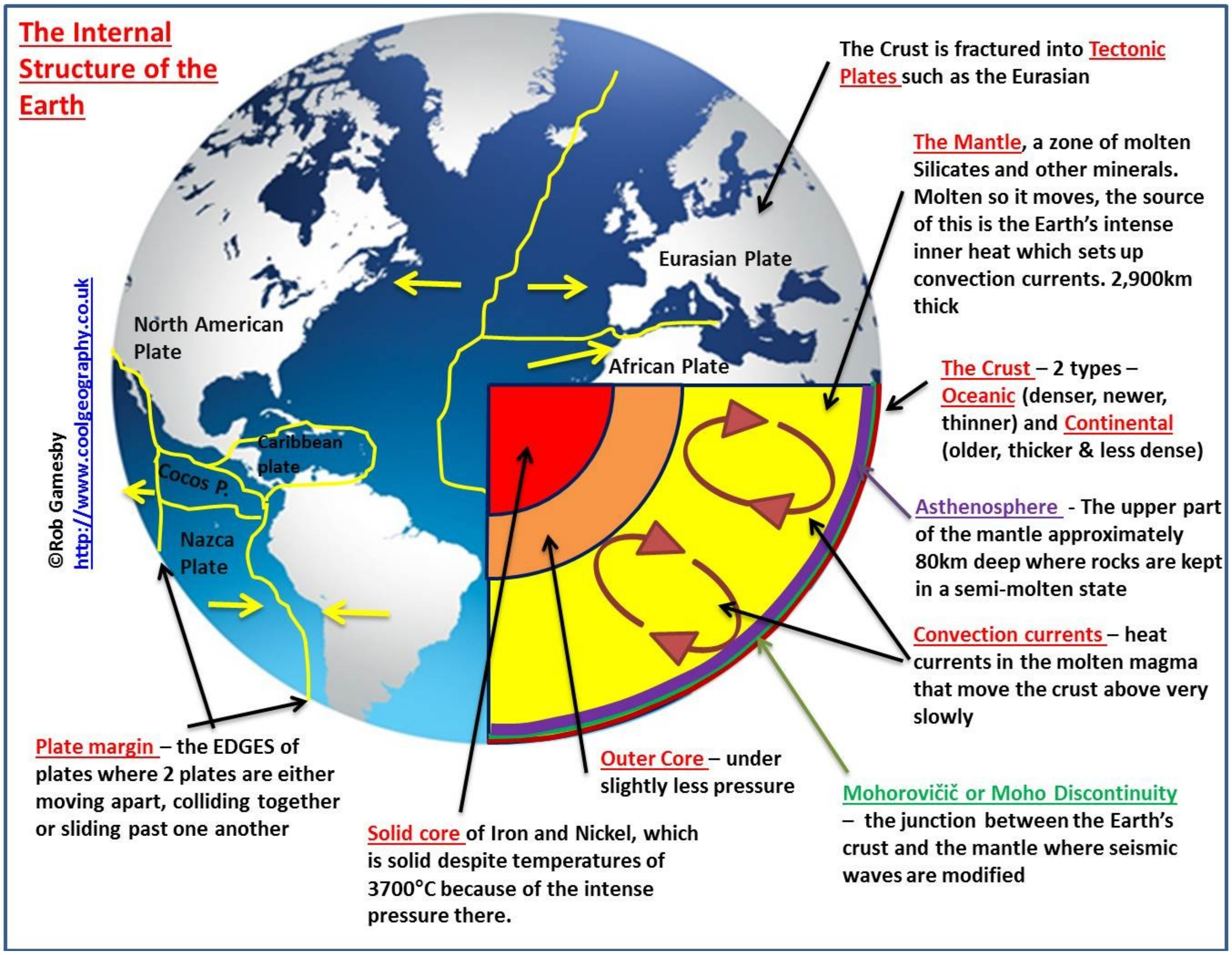
Working as a geologist
• Mining
• Exploration
• Environmental
• Petroleum industry
• Hydrology
• Academic
• Government

Formation of the planets
• Dust particles drawn together by random collisions and gravity
• Particles eventually form planetesimals
• These coalesce by a process called planetary accretion

Formation of the Earth
• Early Earth (4.6 b.ya.) had uniform composition and density.
• Heat generated by gravitational contraction, collisions with debris in its orbital path and decay of radioactive elements results in (partial) melting; during molten phase dense elements (Fe and Ni) sink to collect in core and lighter silicate minerals flow upward to form mantle and crust.
• Differentiation results in layered planet, and emission of gases supplies material for early atmosphere and oceans Crust and Lithosphere.
• The average crustal thickness in continental areas is approximately 35km.
• The Earth's crust ranges from 5-10km thick beneath the ocean basins to in excess of 70km beneath the major mountain ranges.
• The crust rides upon a relatively stiff layer in the upper mantle. The combination of the crust and the stiff upper mantle layer is called the lithosphere.
• Beneath the lithosphere is a weaker mantle layer, the asthenosphere Plates of the Earth.
• The Earth's lithosphere is divided into approximately 15 rigid plates that can move across the underlying asthenosphere.
• The global distribution of earthquakes clearly highlights the tectonic plate boundaries.

Structural layers of the Earth


COMPOSITIONAL LAYERS
Crust: 0-100 km (silicates)
Mantle: 100-2900 km (silicates)
Core: 2900-6370 km (iron, nickel)
MECHANICAL LAYERS
Lithosphere: 0-100 km (rigid)
Asthenosphere: 100-350 km (soft plastic)
Mesosphere: 350-2900 km (stiff plastic)
Outer core: 2900-5100 km (liquid)
Inner core: 5100-6370 km (solid)



The Internal Structure of the Earth
The Crust is fractured into Tectonic Plates such as the Eurasian
The Mantle, a zone of molten Silicates and other minerals. Molten so it moves, the source of this is the Earth's intense inner heat which sets up convection currents. 2,900km thick
Eurasian Plate
North American Plate
African Plate
Caribbean plate
Cocos P.
Nazca Plate
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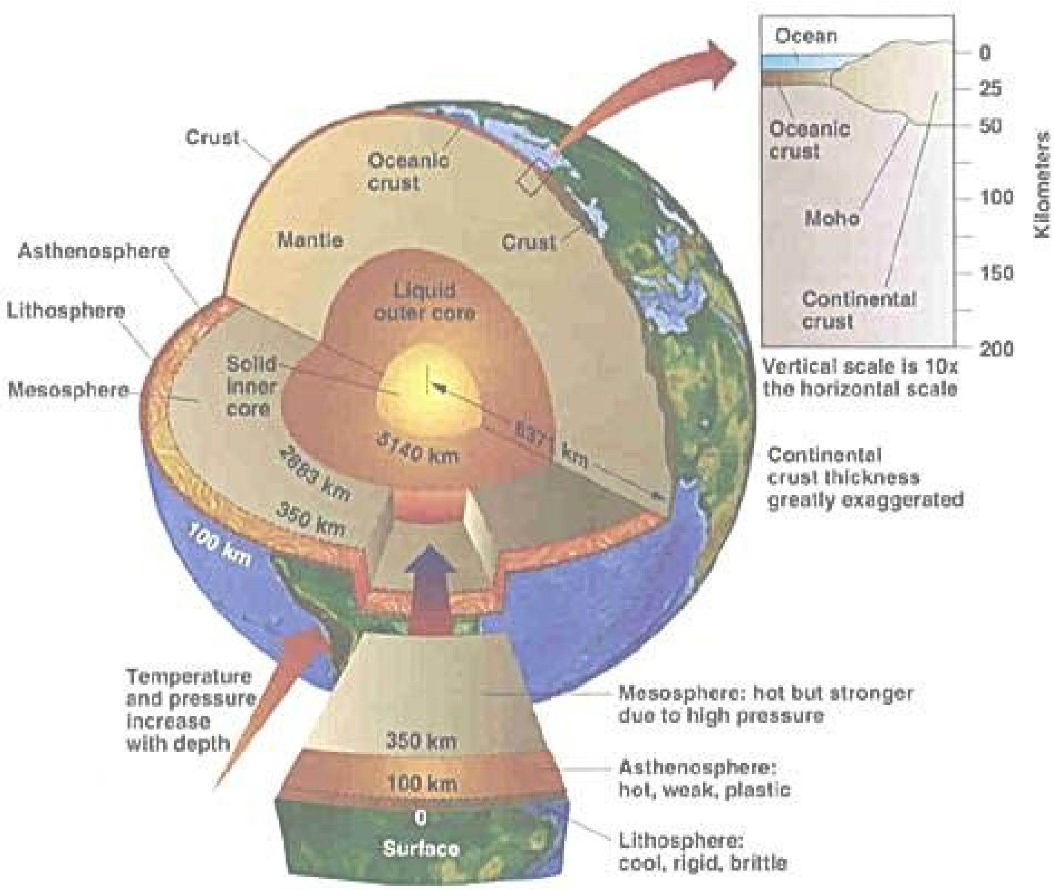
http://www.coolgeography.co.uk
The Crust – 2 types – Oceanic (denser, newer, thinner) and Continental (older, thicker & less dense)
Asthenosphere - The upper part of the mantle approximately 80km deep where rocks are kept in a semi-molten state
Convection currents – heat currents in the molten magma that move the crust above very slowly
Plate margin – the EDGES of plates where 2 plates are either moving apart, colliding together or sliding past one another
Outer Core – under slightly less pressure
Mohorovičič or Moho Discontinuity – the junction between the Earth's crust and the mantle where seismic waves are modified
Solid core of Iron and Nickel, which is solid despite temperatures of 3700°C because of the intense pressure there.



Ocean
0
25
50
100
150
200
Kilometers
Oceanic crust
Moho
Continental crust
Vertical scale is 10x the horizontal scale
Crust
Oceanic crust
Mantle
Crust
Asthenosphere
Lithosphere
Mesosphere
Liquid outer core
Solid inner core
5140 km
6371 km
2883 km
350 km
100 km
Continental crust thickness greatly exaggerated
Temperature and pressure increase with depth
Mesosphere: hot but stronger due to high pressure
350 km
100 km
0
Surface
Asthenosphere: hot, weak, plastic
Lithosphere: cool, rigid, brittle

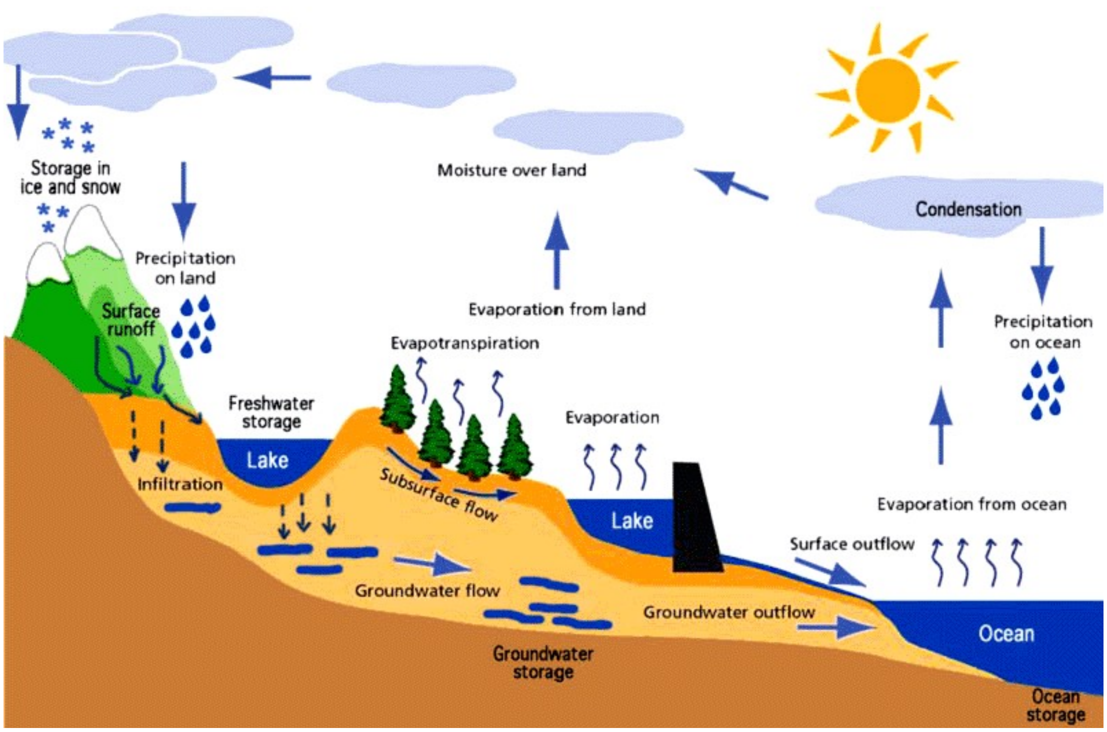
1.2. ACTION OF RUNNING WATER
Why Study Running Water?

• Running water is the single most important geologic agent modifying Earth's land surface.
• Rivers and streams are sources of fresh water for industry, agriculture, and domestic use. They generate electricity and are much agricultural land owes its fertility to annual flooding.

Streams and Flooding

• Flooding is probably the most widely experienced catastrophic hazard. The loss of life in developing countries is typically higher because water plays such an important role in sculpting the earth's surface by eroding mountains, carving valleys and depositing sediment it is necessary to understand the basic characteristics of streams and water movement.
• Water is basically a renewable resource as a result of the hydrologic cycle, which accounts for the movement of water in the hydrosphere. Except for small gains as a result of volcanism and losses through subduction the amount of water in the hydrosphere is constant.

Hydrologic cycle
Streams
• In geological terms a stream is any body of flowing water confined within a channel
• The drainage basin is the area from which a stream draws its water. The larger the drainage basin the larger the stream, although climate, vegetation and geology can all influence this



Running Water

• Runoff, gravity-driven flow across Earth's surface, depends on infiltration capacity of the surface material.
• Infiltration capacity is the rate at which surface materials can absorb water, which depends on duration and intensity of rainfall, permeability of the surface material, and saturation state of surface material.
•Runoff moves downhill as either sheet flow or channel flow.
•Sheet flow occurs when a more-or-less continuous sheet of shallow water moves over the surface.
•Channel flow is confined to long, trough-like depressions ranging in size from tiny rills to huge rivers.
• Rivers and streams receive their water from: rain falling within the channel, sheet flow, and most importantly, groundwater flow into the bottom and sides of the channel.
• Stream discharge is the volume of water passing a particular point in a given period of time. Discharge is measured in ft^3/sec or m^3/sec. Discharge can be calculated using the following formula: (Q) discharge = (V) velocity x (A) cross-sectional area of channel
• Discharge increases downstream, unless evaporation or infiltration through the stream bottom significantly reduces the water volume.

Erosion and transport

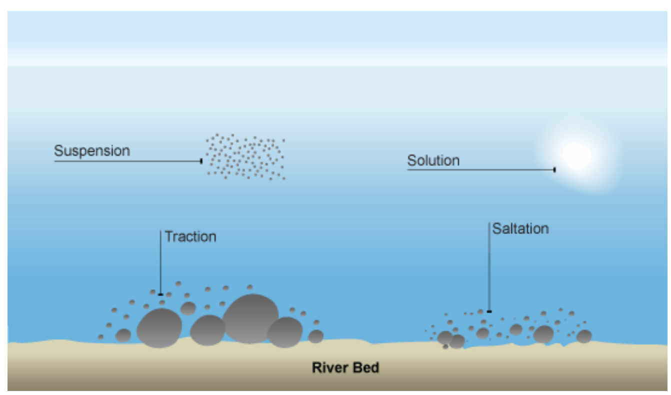
• Erosion involves removal, from a source area, of dissolved substances as well as loose particles of soil, minerals, and rock. Solid particles from channel margins are eroded by hydraulic action, the direct impact of flowing water on loose material. Running water carrying sand and gravel also erodes by abrasion, involving the direct impact of solid particles on exposed rock surfaces.

• With equal discharge a fast flowing stream will erode and carry more material than a slow moving one. Streams move material in a variety of ways
• Bed load

• Suspended load

• Saltation

• Dissolved load



• The dissolved load is invisible & consists of ions taken into solution during chemical weathering.

• Suspended load consists of mud kept in suspension above the channel bed by turbulence.

• Bed load consists of sand and gravel too large for turbulence to suspend.

Deposition by Running Water

• Sediment can be transported great distances by rivers, but it is eventually deposited.
• Deposition may take place within the channel, on the floodplain, at the mouth of the river where it enters a lake or the sea, or where the river flows from the mountains on to a flat valley floor.

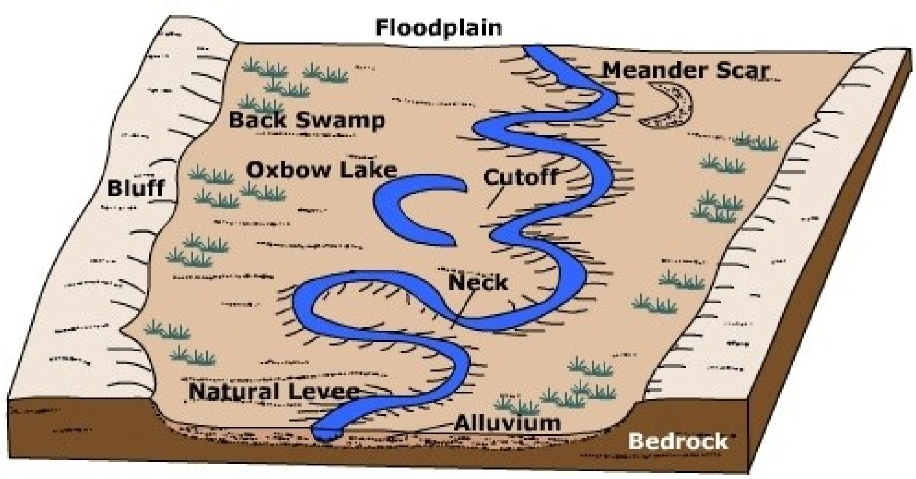
• Most of the geologic work (erosion, transport, and deposition) done by running water takes place during periodic flooding.

• Some sediment carried by rivers and streams makes its way to the ocean where it can be distributed and deposited by currents and tides.

Stream/Features
Streams and rivers with low gradients develop floodplains with a number of characteristic features.

Types of drainage:
Dendritic
Rectangular
Radial
Deranged
Trellis

Floodplain features.



Alluvial fans: Form where mountain streams flow into flat valleys. The change in stream velocity causes the stream to deposit its sediment load. Can be subject to flash floods and debris flows as a result of intense seasonal storms.

Alluvial fans are lobate deposits formed along the boundary between lowlands and mountains. They form in arid and semiarid areas where infrequent runoff is funneled into fast flowing streams in mountain canyons. When such a stream exits its canyon, flow spreads outward from the canyon mouth across the adjacent flats depositing an apron of sediment.

Deltas

• Form where running water moves into standing water (lakes or oceans), typically have low stream gradients and changing channel systems

•Stream dominated (Mississippi)

•Wave dominated (Nile)

•Tide dominated (Ganges)

•Deltas at or near sea level are subject to flooding by tropical storms.

•Coastal flooding is the deadliest of natural disasters.

Deltas

•Sediment accumulates such that the shoreline gradually builds outward by a process called progradation. The simplest deltas have a characteristic vertical sequence of beds: bottom set, fore set, and top set beds. The river divides into a network of channels called distributaries channels as it crosses the delta.

• Deltas forming along sea coasts are often large, complex, and sometimes economically important.

• The Mississippi delta is a bird's-foot delta, the classic shape of river dominated deltas.

• Much of the oil and gas produced in the Gulf of Mexico comes from buried delta deposits.

• The swampy areas typical of most deltas are potential areas of coal formation.

Deltas-Braided Channels

Braided streams possess multiple channels that divide and rejoin, separated by bars of sand and gravel.

They are bed-load dominated, sediment-choked streams with broad shallow channels. Such streams are

especially common in arid and semiarid regions where surface material is easily eroded due to sparse vegetation. Because of the great volume of sediment dumped by melting ice, streams flowing from glaciers are braided.

Meandering Channels

Meandering streams have single, winding channels that form broad looping curves known as meanders. Oxbow lakes are common along meandering streams. They form when individual meanders are abandoned by the stream.

The channel cross-section is asymmetric. The bank on the outside is actively eroding and known as the cut bank. Flow velocity is lower along the inside of the meander so along this bank, sediment is deposited to form a point bar.

Oxbows

Meanders sometimes become so sinuous that the neck of land between them can be eroded away during flooding. As a result, the flow will follow a new, straighter course, and the meander will be cut-off or abandoned by the stream. The abandoned meanders are referred to as oxbow lakes. Oxbow lakes may persist for some time, but are eventually filled with organic matter and mud carried in during flooding of the active stream.

Levees

Floodplains are low-lying, flat areas adjacent to channels (A). When streams overtop their banks, water carrying mud and fine-grained sand spreads across the floodplain (B). As flood water flows from the channel, its velocity and depth rapidly decrease. As a result, the coarser floodplain sediment, fine grained sand, is deposited along the channel margin to form a ridge, a natural levee (C).

Levees

Natural levees build up when a river floods and overflows its banks. At the point of overflow the velocity drops and sediment is deposited. These levees will tend to channelize the flow of future flood. Artificial levees are constructed to mimic this process

When levees do breach then the flooding is often on a large scale and because of levees downstream may take longer to recede.

1.3. ACTION OF WIND/DESERT LAND FORMS

Deserts

- Erosion, transport, and deposition by wind is commonly associated with deserts.
- Deserts are characterized by unique landforms. Understanding the processes by which the wind erodes, transports, and deposits sediment helps explain the distribution and origin of many desert landforms.
- The geographic distribution of deserts is largely controlled by global and regional atmospheric circulation patterns.

Why Study Deserts?

- Deserts cover large regions of Earth and many peoples and cultures are endemic to desert areas.
- The expansion of deserts into formerly productive lands is known as desertification. This process claims 70,000 km2 of productive land each year and extracts a large toll in human suffering.
- Deserts expand and contract naturally, but human activities can greatly accelerate desertification. Understanding the factors that control the distribution of deserts and the geologic processes at work in them is important for identifying areas especially susceptible to desertification and for devising strategies for limiting it.

What Are Deserts?

- Arid regions generally described as deserts receive <25 cm of rainfall annually. Deserts are dry, have high rates of evaporation, poorly developed soils, and are mostly or completely devoid of vegetation.
- Average summer temperature for low-latitude deserts is 32° to 38°C. Daytime winter temperatures average 10° to 18°C.
- Most deserts support at least sparse plant cover. Desert plants are small, widely spaced, and slow growing. Most have wide, shallow root systems to help absorb the dew.

Where Do Deserts Occur?

The distribution of dry climates (semiarid and arid) and deserts is controlled primarily by the general atmospheric circulation pattern which produces arid climates & deserts (such as the Sahara and Arabian) along belts centered roughly on 30° north & south latitude. The remaining deserts of the mid-latitudes are rain shadow deserts (such as the Great Basin of North America).

Four basic desert regions

• Polar deserts – perpetual snow cover, low precipitation and intense cold, e.g. Antarctica and central Greenland

• Subtropical deserts - largest deserts, occur in regions of subsiding high pressure air masses, e.g. Sahara, Kalahari, Australia

•Mid-latitude deserts – located deep within continental interiors e.g. the Gobi desert

•Rain shadow deserts e.g. the Mojave and Death Valley

• Coastal deserts – lie on the coastal side of large land masses, tempered by cold, upwelling ocean currents, e.g. the Atacama Desert, Chile (driest area on earth is a rain shadow & a coastal desert)

Wind Transport

•Wind can transport silt- and clay-size grains as suspended load.

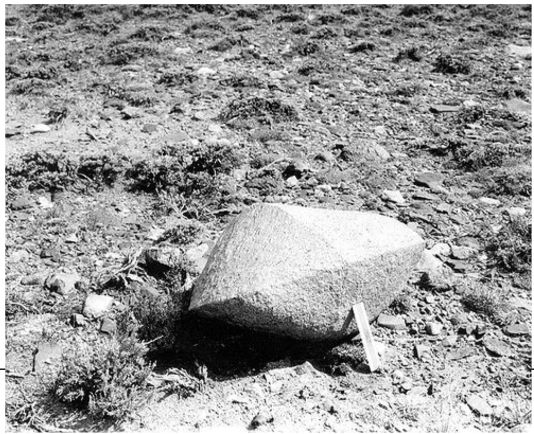
• Sand and larger grains are transported as bed load. Larger grains slide or roll, but sand grains generally move by saltation, intermittent bouncing or hopping. Saltating grains seldom rise more than a meter above the surface.

• Wind is turbulent fluid and transports sediment in much the same way as running water.

How Does Wind Erode Landforms?

• Although running water is responsible for most erosional landforms in arid regions, wind action produces many distinctive erosional features. Largely because of its low density, wind is an extremely efficient sorting agent. Wind erodes material in two ways: abrasion and deflation.

• Abrasion is caused by the impact of saltating grains and is similar to sandblasting. Abrasion etches, pits, smoothes, and polishes, but abrasion of rocks of varying durability can produce features with bizarre shapes.



Abrasion & ventifacts

• Yardangs are elongated, streamlined ridges that look like the hull of an overturned ship. They are often found in clusters aligned parallel to the prevailing wind direction. Yardangs are larger than ventifacts and formed by differential wind erosion and abrasion.

Deflation

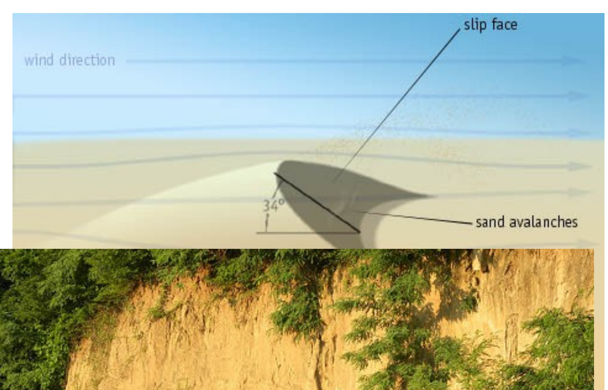
Deflation is a mechanism of wind erosion that removes loose surface sediments. Deflation hollows or blowouts form in arid and semiarid regions where deflation forms removes loose surface sediment to form depressions ranging from kilometers in width and meters in depth to small depressions only a few meters wide and less than a meter deep.

Desert pavements where deflation removes sand size and smaller grains, a surface armored with pebbles, cobbles, and boulders is formed.

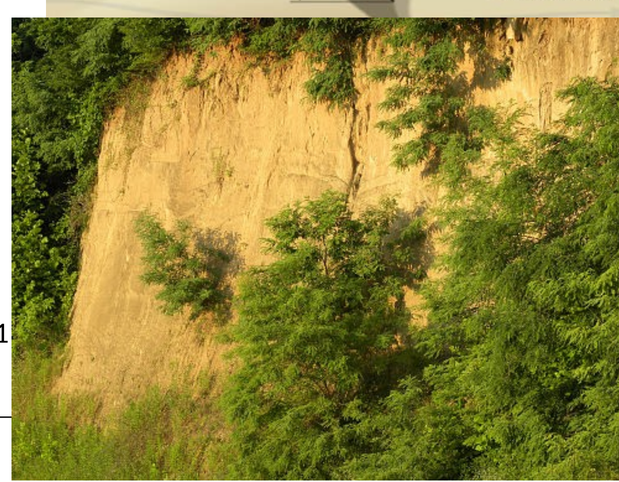
Wind Deposits

• Wind is a major agent of deposition, producing deposits of two general types:
Dunes and loess.

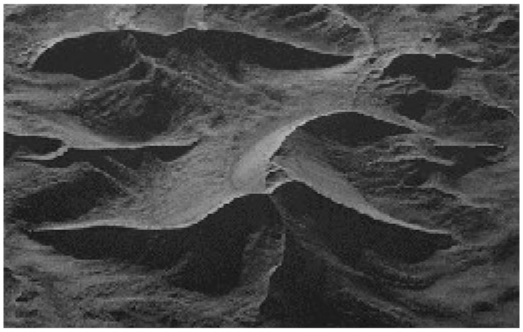
• Dunes are mounds or ridges composed of wind-blown sand-size grains usually deposited near their source.



• There are several types of dunes: barchans, longitudinal, transverse, parabolic, and star. The size, shape, and arrangement of dunes depend on sand supply, direction and velocity of the prevailing wind, and the amount of vegetation.



• Loess consists of layers of windblown silt and clay composed of angular grains of quartz, feldspar, mica, and calcite. Loess is deposited over large areas downwind of and far from its source.



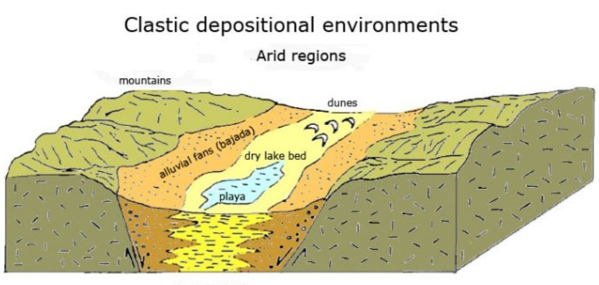
Loess

Star Dunes

Desert landforms produced by water.

• Playa lakes form in low areas of deserts following intense precipitation. They are shallow, often saline, and short-lived, lasting from a few hours to several months.

• When the water of a playa lake evaporates, the dry lake bed is referred to as a playa or salt pan. Playas contain mud cracks and salt deposits, some thick enough to mine.



Playa

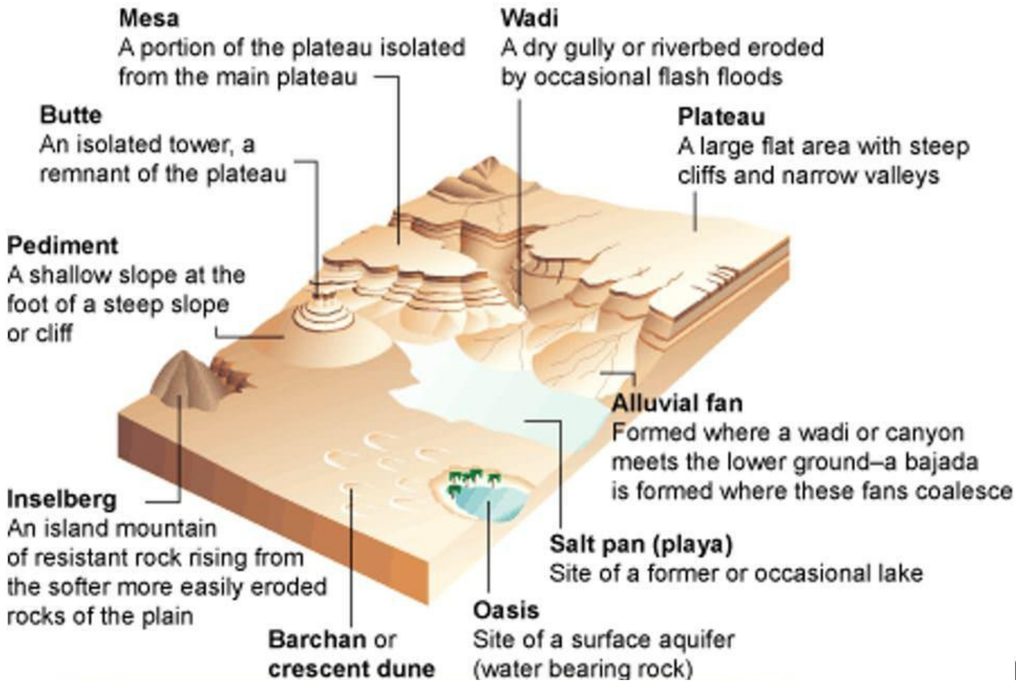
Other Deserts Landforms

• Alluvial fans are common in many deserts, especially the Basin and Range. They form where sediment-laden streams exit steep mountain fronts to deposit their load on the flat desert floor.

• Bajadas are broad aprons of sediment deposited at the foot of steep mountain fronts by coalescing and overlapping alluvial fans. Bajadas and large alluvial fans are sources of groundwater.

• Mesas are broad, flat-topped erosional remnants bounded on all sides by steep slopes.

• Buttes are pillar-like erosional remnants. Both mesas and buttes consist of easily weathered sedimentary rocks capped by more resistant rock.



• Pediments are erosional bedrock surfaces of low relief that slope gently away from mountain bases.
• Most pediments are covered by a thin layer of debris, alluvial fans, and/or bajadas.

1.4. ACTION OF GLACIERS

• A glacier is a mass of ice on land consisting of compacted and recrystallized snow that flows under its own weight.

• The sea ice of the Arctic Ocean, ice shelves adjacent to Antarctica, and icebergs are not glaciers.
• Glaciers cover 1/10 of Earth's land surface
• The vast glaciers of the Pleistocene (1.6 million to 10,000years before present) Ice Age produced many erosional and depositional landforms across much of the Northern Hemisphere.

Glaciers & the Hydrologic Cycle

• Glaciers are one of the several reservoirs of the hydrosphere.
• Glacial ice is formed of the snow that falls over land.
• Freshwater may be stored in glaciers as ice for thousands of years before it is eventually returned to the sea, often passing through other reservoirs on its journey.
• Glaciers help supply streams with water during the dry season.

Origin of glaciers

• Glaciers form in areas where snow fall exceeds snow melt for a number of years (high altitudes and latitudes)
• As the snowpack thickens the air is forced out of the snow at the base of the pile. Eventually blue ice will form.
• Once the snow pack reached ~30m it will begin to behave as a viscous fluid and "flow" downhill. This plastic flow is restricted to the base of the glacier while the upper layers remain brittle.
• Glaciers ablate, or waste away by melting or calving.
• Glaciers move at rates of a few metres to 10s of metres per day depending on the slope, however they also retreat or advance within the valley.
• If the rate of melting is less than the rate of glacier advance then the glacier will advance, if it is not then the glacier will retreat. Glaciers typically retreat in the summer and advance in the winter. Global climate change can modify this process.

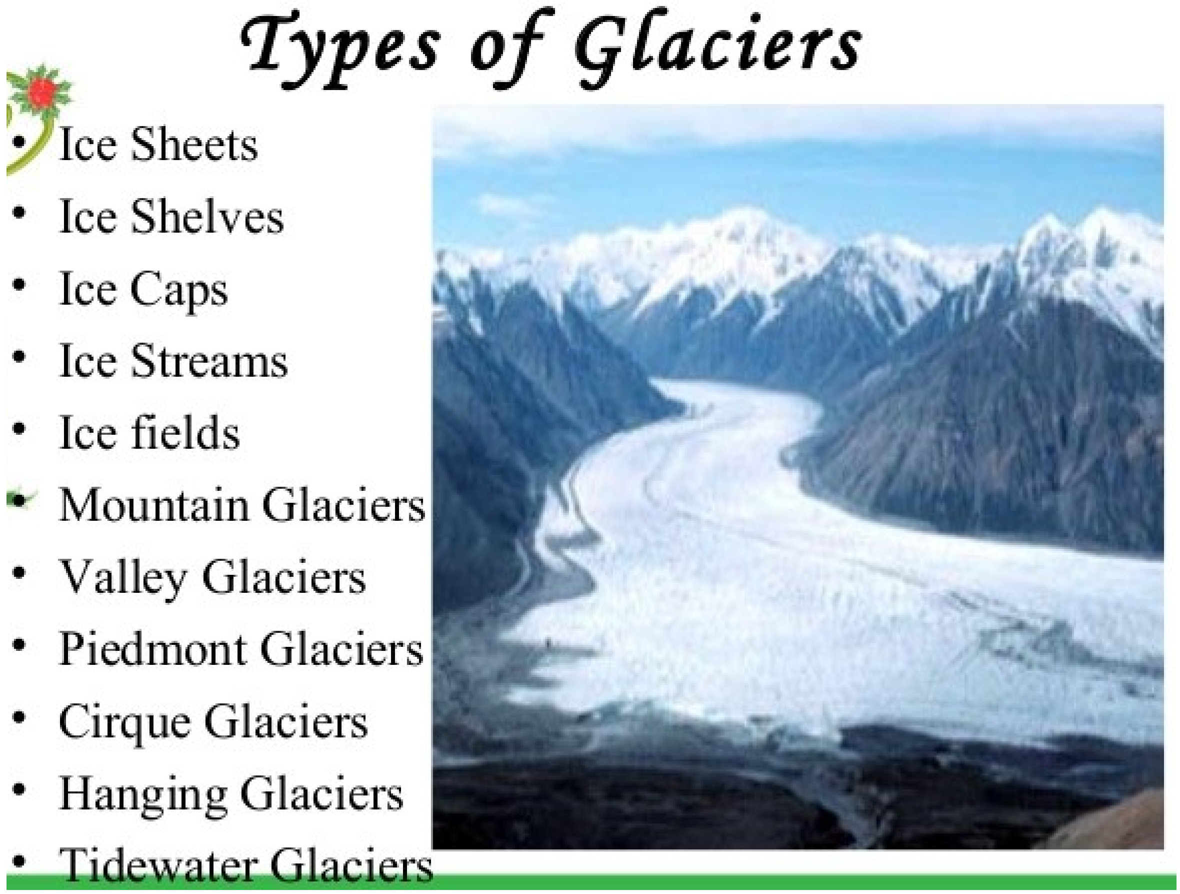
How Do Glaciers Move?

• When snow and ice reach a critical thickness of about 30m, the stress/pressure on the ice at depth is great enough to induce plastic flow. Plastic flow is a type of permanent deformation that involves no fracturing. As the ice deforms by plastic flow, the glacier slowly moves. Glaciers also slide along the surface of the material they overlie in a process called basal slip, which is greatly aided by the lubricating effect of water. Basal slip is sporadic and varies depending on season, but plastic flow is continuous and the primary means by which glaciers move.

How Fast Do Glaciers Move?

• Valley glaciers flow more rapidly than continental glaciers, both ranging from cms to 10s of meters/ day.
• Valley glaciers move faster because basal slip contributes to their movement during the warm season. Continental glaciers are frozen to the underlying surface most of the time and undergo little basal slip.
• Flow rate within ice increases down the glacier toward the firn limit, and then decreases from the firn limit toward the terminus. For valley glaciers, flow velocity is greatest at the top-center of the ice tongue and lowest along the edges and base where friction retards flow.

Types of Glaciers



• **Valley glaciers** are tongues of ice confined to mountain valleys through which they flow from higher to lower elevation. Like streams, many valley glaciers have smaller tributary glaciers.

• Valley glaciers may be several kilometers wide, 200 km long, and hundreds of meters thick.

• Continental glaciers, or ice sheets, cover at least 50,000 km2 and are unconfined by topography. Continental glaciers are blanket-like accumulations of snow and ice that drape the land surface and flow outward in all directions from a central area of greatest thickness toward thinner areas along the argins.

• Continental glaciers are currently found in Antarctica and Greenland where their thickness exceeds 3000 m.

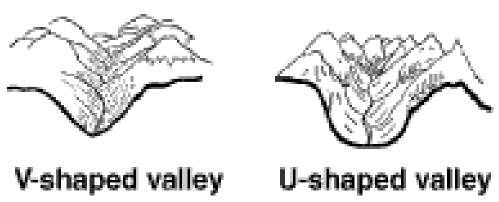
Erosion and Transport

• Glaciers are moving solids and can erode and transport huge amounts of material, especially sediment, and soil.

• Bulldozing takes place as a glacier shoves or pushes unconsolidated material along its path. Plucking results when glacial ice freezes in the crevices of a bedrock projection and eventually pulls loose blocks of the rock. Abrasion takes place as bedrock underlying a glacier is eroded by the flowing sediment-laden ice.
• Most of the sediment carried by continental glaciers is concentrated at the base of the ice and derived from the materials across which they flow. Valley glaciers carry sediment in all parts of the ice. Much of their sediment is supplied by mass wasting along valley walls.
• Abrasion of bedrock by sedimentladen glacial ice produces glacial polish, a smooth surface that glistens in reflected light.
• Abrasion can also produce glacial striations, straight scratches a few mm deep on rock surfaces
• Abrasion grinds rocks to clay- and silt-size particles collectively known as rock flour. This material gives glacial streams a milky look.

Erosion by Valley Glaciers

Some of the world's most inspiring scenery was erosionally sculpted by valley glaciers. When peaks and V-shaped stream-cut valleys of mountain ranges are modified by valley glaciers, a landscape of angular ridges and peaks in the midst of a broad valley is forms. Among these features are horns, aretes, cirques, etc.



U-shaped valleys:U-shaped glacial troughs are one of the most distinctive features of valley glaciation. Glaciers deepen, widen, and straighten V-shaped stream valleys to form broad, steepsided valleys (left). Many glacial troughs contain triangularshaped truncated spurs, cut off ridges that extend into the original valley.

Fjords are glacial troughs that were flooded by the sea.

Hanging valleys: Hanging valleys are glaciated tributary valleys whose floors are higher than that of the main valley. Large glaciers in the main valley erode more vigorously than smaller glaciers in tributary valleys. When the glaciers disappear, the floors of tributary valleys are left high above the floor of the main valley. Streams flowing from these hanging valleys produce beautiful water falls, such as Bridal Veil Falls in Yosemite National

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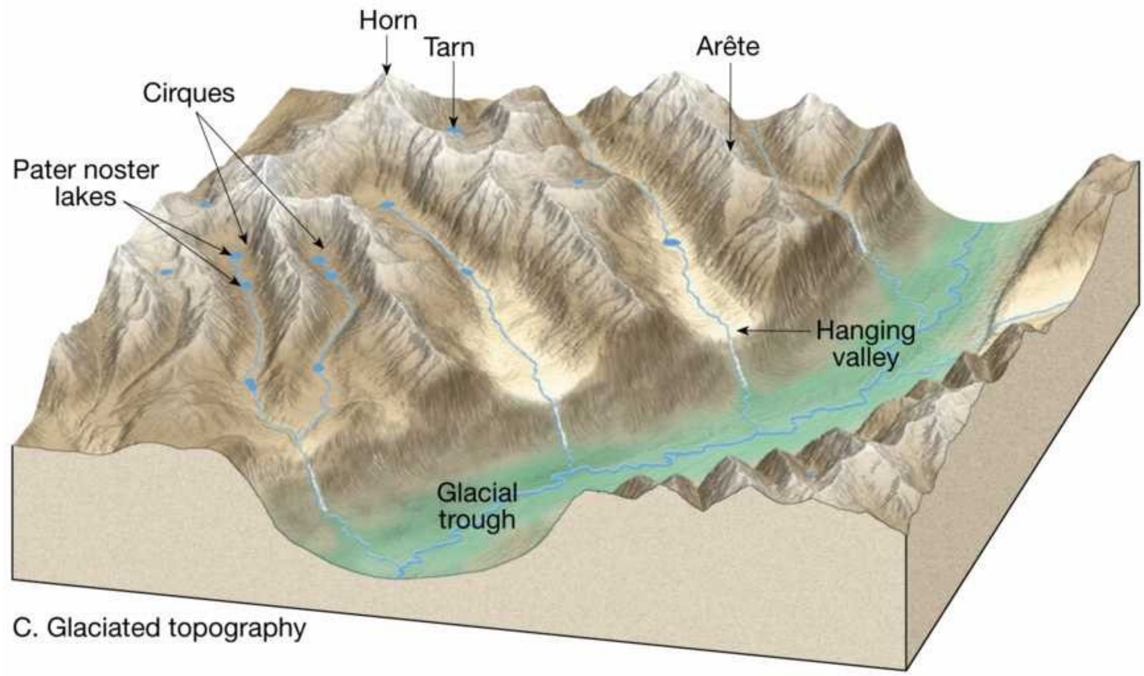


C. Glaciated topography

Cirques are bowl-shaped depressions at the heads of glacial troughs.

• Cirques are steep-walled on three sides, but one side is open and leads to the glacial trough.

•Many cirques contain small lakes known as ***tarns***.

Aretes

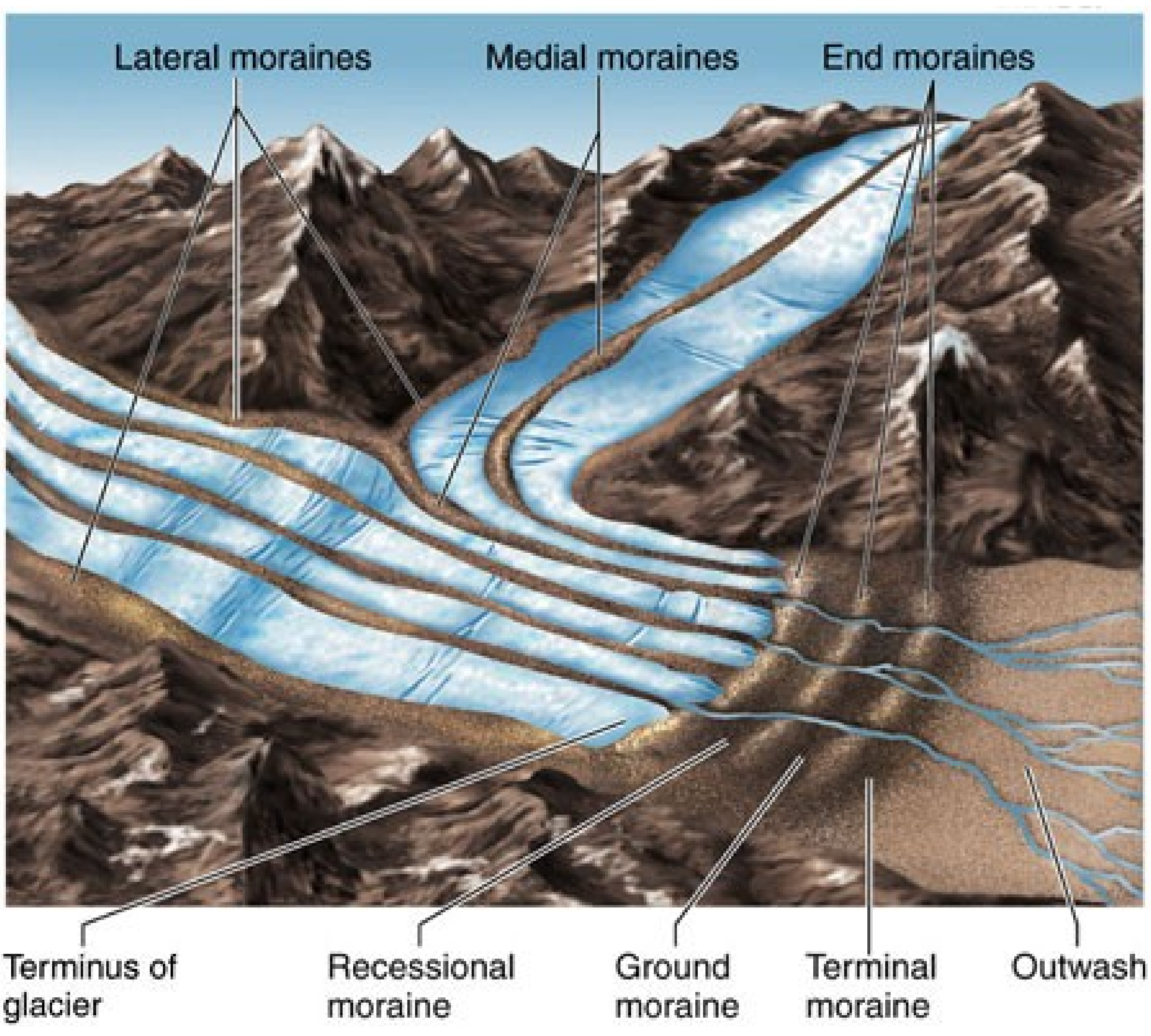
• Arêtes are narrow, serrated, knife-edge ridges forming a thin partition between two cirques or adjacent parallel glacial troughs.

• **Horns** are pyramidal, steep-walled mountain peaks formed by headward erosion of cirques. To form, a horn must have at least three cirques on its flanks Plucking and abrasion .

Glacial Deposits

• Both valley and continental glaciers deposit their sediment load as glacial drift, a general term for glacially deposited material.
• Erratics are boulders eroded and transported by glaciers and deposited in areas from which they were obviously not derived. Till is poorly sorted sediment deposited by glacial ice. Stratified drift is layered, sorted sediment deposited by flowing meltwater.

Moraines.
• End moraines are piles of poorly sorted sediment, till, delivered by flowing ice to the terminus of a stationary glacier. They are deposited by both valley and continental glaciers.
• As the sediment is dumped, an end moraine builds up to form crescent-shapedhills fringing the ice



margin.

• The outermost end moraines deposited when the glacier was at it greatest extent are called terminal moraines. If the glacier recedes and eventually stabilizes at a new location, an end moraine known as a recessional moraine accumulates at the terminus. Ground moraines are deposited as glaciers recede and sediment is liberated form the melting ice. Ground moraines have an irregular, rolling topography.

- Lateral and medial moraines are produced by valley glaciers. Lateral moraines are long ridges of till deposited along the edges of the glacier.

- Medial moraines occupy positions that were near the center of the valley glacier. Medial moraines form by the coalescence of the lateral moraines of two tributary glaciers.

Drumlins

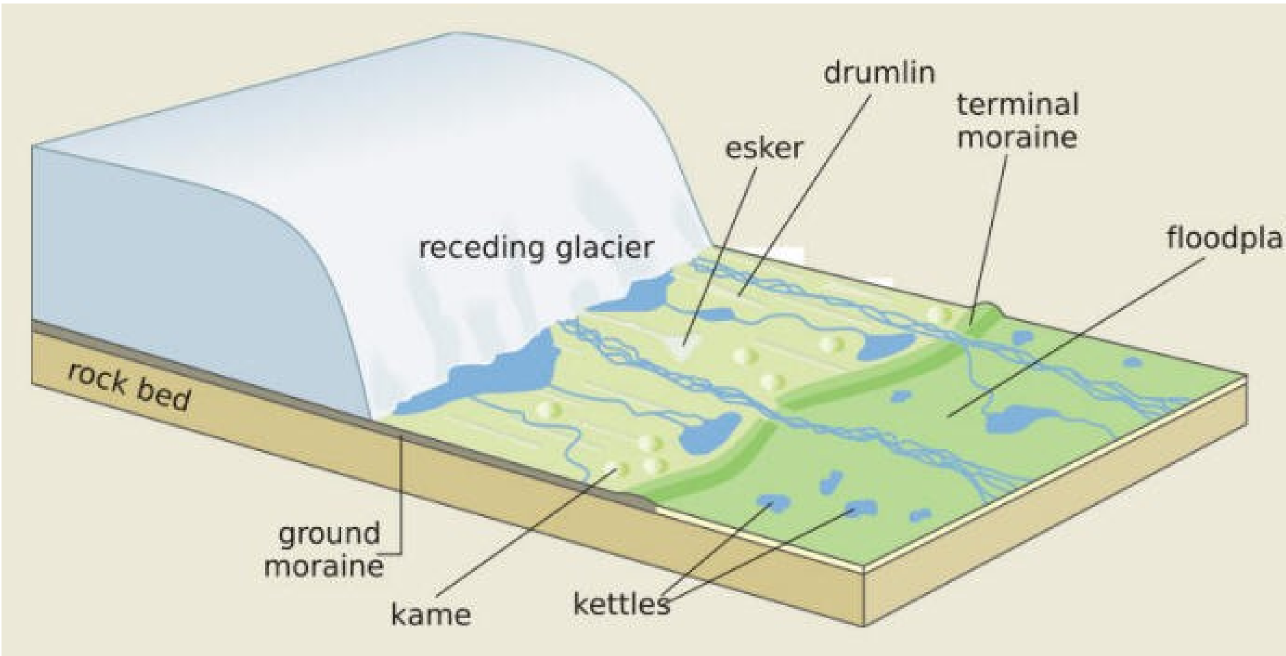
- Drumlins are elongated inverted spoon shaped hills composed of till. Some are 50 m high and 1 km long, but most are smaller. Drumlins occur in drumlin fields containing hundreds or thousands of drumlins.

- Drumlins are depositional landforms constructed by continental glaciers.

Landforms Composed of Drift

• Stratified drift is deposited by both valley and continental glaciers, but is more extensive in areas of continental glaciation.

• Outwash plains, kames, eskers, and kettle lakes are some common landforms formed of or in stratified drift.



• Outwash plains are vast blankets ofstratified drift deposited by braided glacial meltwater streams in front of the terminus of continental glaciers.

• Blocks of ice stranded by receding glaciers are buried by sediments of outwash plains and valley trains. Circular to oval depressions formed when the ice blocks melt are kettles. Kettle lakes result when these depressions fill with water. Some outwash plains have so many kettles they are called pitted outwash plains.

Kames
Kames are conical hills up to 50 m high composed of stratified drift (left). Many form when streams deposit sediment in a depression on a glacier's surface; as the ice melts, the deposit is lowered to the ground surface.

Eskers
Eskers are low, sinuous ridges of stratified drift deposited by streams flowing in tunnels beneath stagnant ice. They range to 100 m in height and 100 km in length.

Effects of Glaciation
The Pleistocene glaciations have had a significant impact on modern society
• Soil distribution
• Groundwater distribution

• Sea level changes
• Pleistocene lakes
• Isostatic rebound
• Drainage patterns
• Glacial outwash is the sediment deposited by rivers originating at the melting edge of a glacier. But Many of these glacial outwash deposits now serve as important groundwater aquifers.

1.5.ACTION OF OCEANS (SHORE LINE FEATURES)

Why Study Shorelines?

• The seafloor is the largest part of Earth's surface. Many seafloor features and processes provide evidence of plate tectonics. Seafloor sediments and rocks are a source of several important natural resources.
• The oceans are the largest reservoir of the hydrosphere. The transfer of energy from the oceans to the shoreline result in erosion and deposition.
• From a practical standpoint, it is important to understand shoreline processes because many major harbours and ports are associated with shoreline.

Oceans and shorelines

The ocean basins are not vast featureless plains, but have greater topographic relief than that of any continent.

Shorelines

• The shoreline is the boundary between ocean and land. It consists of the area between low tide and the highest level of land affected by storm waves.

• Shorelines are dynamic areas where energy is expended, erosion takes place, and sediment is transported and deposited.

Tides

Gravitational attraction to the Moon and Earth's rotational inertia produce bulges on the ocean surface Earth's rotation beneath these bulges causes a cyclic rise (flood tide) and fall (ebb tide) of sea level known as the tides. The Moon orbits Earth as Earth rotates, & so it takes 50 minutes longer each day for a given location to return to the high tide position beneath a tidal bulge. Therefore, high tide occurs 50 minutes later each day.

• In addition to the Moon, the Sun's gravitational attraction also effects tides in Earth's oceans. The Sun's effect, however, is less than half that of the Moon's.

• Due to the Moon's 28-day orbit of Earth, the Sun and Moon align every two weeks and their attractive forces act together to produce spring tides that are about 20% higher than average tides. This occurs in the "new" and "full" moon phases of the lunar cycle

Also at two-week intervals the Sun and Moon are at right angles to each other such that the Sun's tide-generating force is canceled by some of that of the Moon's. This occurs in the firstand third-quarter phases of the lunar cycle. This orientation of Earth and the Sun produces neap tides which have high tides about 20% lower than normal.

Tides have a significant impact on shoreline dynamics because the area of wave attack constantly shifts onshore and offshore as tides rise and fall.

Coastlines – the fundamentals

• Shoreline – the boundary between sea and land that changes with the tides
• Coast – the area extending from the shoreline to the landward limit of features affected by marine processes
• Beach – gently sloping surface washed over by waves and covered by sediment.
• Waves – induced by the flow of wind across the water surface. The size of the waves is dependant upon. Waves are oscillations of a water surface and can erode, transport, and deposit sediment. The highest and lowest parts of a wave are the crest and trough.
• Longshore current – because waves are rarely parallel to the shore these weak currents develop.
• Littoral drift – the transportation of sediment along the beach by longshore currents.

Beaches and erosion

• Basically four types of beach
• Coastal-plain or mainland beaches
• Pocket beaches
• Barrier islands• Sand spit beaches

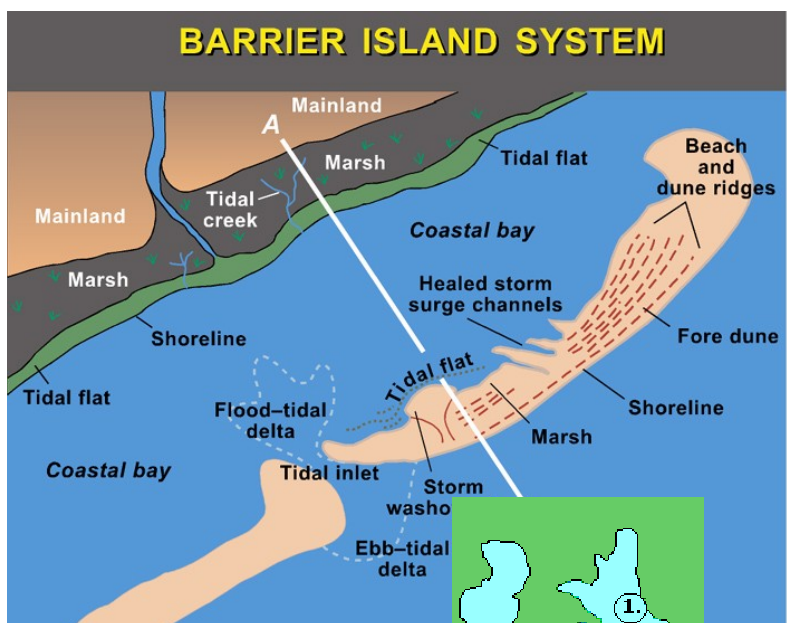
Barrier islands & spits

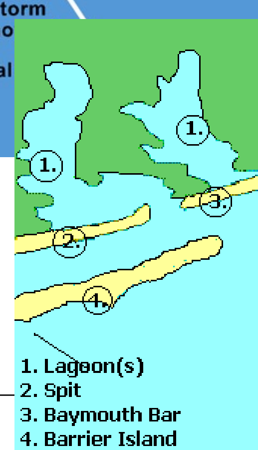
Barrier islands are long, narrow, emergent strips of sand separated from the mainland by lagoons. Formed where beach ridges subside or spits become detached from land, barrier islands shift landward over time.

Barrier beaches are transient features, formed, destroyed and reshaped by wave action.

Spits

Spits are finger-like lateral projections of beaches into bays. Baymouth bars are spits that have grown to close off a bay from the open sea.

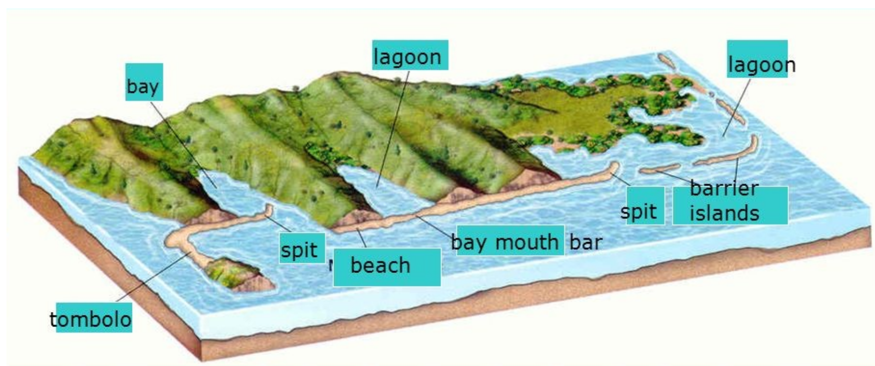




Hook: Wave refraction can occur at the end of a spit, carrying sediment around the end to form a hook or recurved spit.

Tombolos

• Tombolos are a relatively rare type of spit formed where wave refraction around an island combines with longshore drift to build a deposit of sediment that connects the island to the mainland.



1.6.WEATHERING

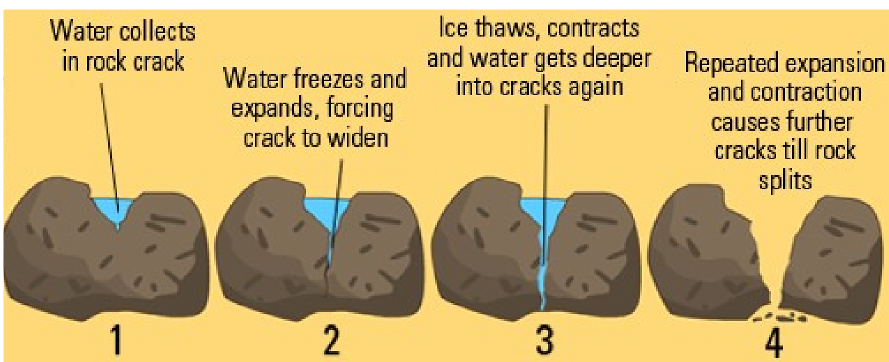
• Weathering is the physical breakdown and chemical alteration of Earth materials at or near the surface.

• Parent material is rock altered by weathering, either broken into smaller pieces or some of its constituent minerals altered or dissolved.
• Erosion refers to the wearing away of soil and rock by water, wind, or ice.
• Transport refers to the movement of eroded material from its place of origin to a new site where it is deposited as sediment.

Why Study Weathering, Erosion & Soils?
• Weathering, erosion, and soil are good examples of the continuous interactions of the atmosphere, hydrosphere, and biosphere with Earth materials.
• Weathering, an essential part of the rock cycle, plays an important role in the formation of sediments, the raw materials for sedimentary rocks.
• Weathering forms soils on which we depend for food production and is important for formation of some mineral resources.
• Erosion degrades soils and eroded sediments degrade rivers and streams.

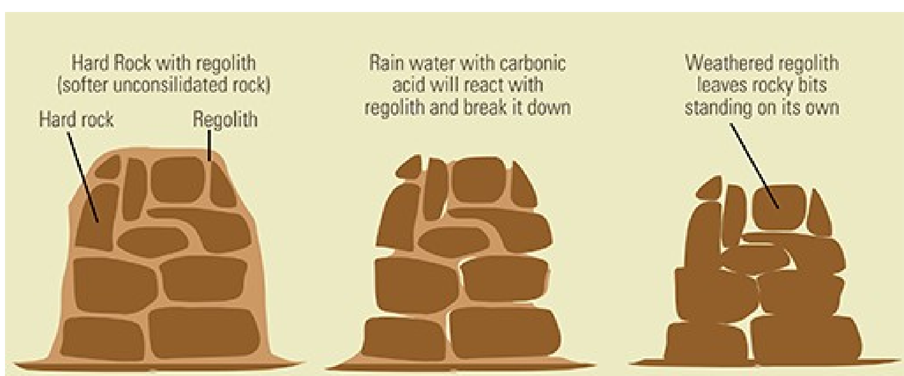
Introduction

• **Two types of weathering are recognized**: (i)*mechanical and (ii)chemical*.
Both proceed at the same time, but at a given site one type will be predominant.
• In their resistance to weathering, rocks are not homogeneous. One may weather faster or slower than another. Parts of the same rock may weather at different rates. This process, known as differential weathering, creates many picturesque and bizarre features, such as arches and honeycomb weathering.



Mechanical Weathering

Chemical Weathering



(Weathering: Mechanical weathering – physical breakdown of rocks without changing the composition (freeze thaw). Mechanical weathering occurs when physical forces break Earth materials into smaller pieces. The granite shown here, for instance, has mechanically weathered to produce smaller pieces of granite and individual grains of the minerals comprising the granite, quartz and feldspars.

Frost Action: Frost action involves the repeated freeze and thaw of water in the cracks and pores of rocks. This results in frost wedging, a very effective process for widening and extending cracks and thereby breaking rocks into smaller pieces. When water freezes, it expands in volume by 9% which exerts great force on the walls of containing cracks and pores.

• Chemical weathering – breakdown of minerals by chemical reactions with air or water.

• Important agents of chemical weathering include atmospheric gases, especially oxygen, water, and organic acids produced by plants and decaying organic matter.

Chemical Weathering – Solution

Solution is a type of chemical weathering reaction wherein interaction of a solid with a liquid separates the ions of the solid such they come to reside in the liquid and the solid is thus dissolved. Water can easily dissolve some minerals because the water molecule has an asymmetric shape. The two hydrogen atoms are not evenly spaced around the oxygen atom to which they are bonded. The side of the water molecule where the hydrogen atoms are located has a slight positive charge and the other side a slight negative charge.

Solution

When soluble minerals such as halite (NaCl) come in contact with water, the positively charged sodium ions are attracted to the negative end of the water molecules, and negatively charged chloride ions are attracted to the positive end of the water molecules . In this way the ions are pulled from the structure of the mineral, surrounded by water molecules, and the solid dissolved.

• Most minerals are not easily dissolved in pure water. Calcite (CaCO3), the mineral in limestone and marble, does not dissolve in pure water, but easily dissolves if a small amount of acid is added to water. Atmospheric carbon dioxide, or that produced by decay of organic matter, reacts with water to form carbonic acid. The acidified water can then dissolve calcite as is shown in the following chemical reaction.

$$CaCO_3 + H_2O + CO_2 \longrightarrow Ca_{2+} + 2HCO_{3-}$$

• Solution chemical weathering forms extensive cave systems in limestone and marble, such as Mammoth Cave and Carlsbad Caverns.

Oxidation

• Oxidation is a chemical weathering reaction whereby metal elements like iron combine with oxygen to form oxides. Oxidation is important for the weathering of ferromagnesian minerals such as olivine, amphibole, and biotite. When the iron in these minerals oxidizes hematite is commonly formed by the following chemical reaction.

$4Fe + 3O_2 \longrightarrow 2Fe_2O_3$

• The acid mine drainage so common in coal mining areas is produced by oxidation of pyrite (FeS2), a mineral common in coal and associated rocks. The resulting iron oxide minerals form a reddish or yellowish sludge, while the sulfuric acid produced acidifies the drainage water.

Hydrolysis

• In the chemical weathering reaction known as hydrolysis, hydrogen ions (H+) contained in water replace positive ions in a mineral. As a result, a new mineral forms and the replaced ions are dissolved in the water. In this way clay minerals, which are sheet silicates, are formed from framework silicates such as feldspars.

$2KAlSi_3O_8 + 2H^+ + 9H_2O \longrightarrow Al2Si2O5(OH)_4 + 2K^+ + 4SiO_2$