GLACIATION

Introduction

- **Glaciation**: - is the action of moving ice on the surface of the earth. It involves erosion, deposition and transportation. i.e. the process by which landscape is sculptured by the action of moving ice
- **Ice**: - refers to solid water formed by freezing and condensation of atmospheric water vapour
- **Snow**: - are falling pellets of frozen water from the atmosphere
- **Glacier**: - is a mass of ice of limited width moving outwards from an area of accumulation
- **Ice sheet**: - is a large and continuous mass of ice that covers a large area of a lowland
- **Ice cap**: - is a permanent cover of ice on earth's surface covering smaller sections of land
- **Ice berg**: - permanent floating ice in large water bodies e.g. oceans

Movement of Ice

- Ice moves outwards from its area of accumulation through the following processes: -
  - **a.** Basal slip
  - **b.** Extrusion flow
  - **c.** Plastic flowage

a. Basal slip

- The weight of ice causes the ice layer in contact with the rocks beneath to melt slightly.
- This creates a film of water which acts as a lubricant between the ice and rock surfaces.
- The force of gravity then causes the ice to slip and slide over the underlying rock.

b. Extrusion flow

- When ice accumulates, it builds up to great thickness at the centre.
- The resultant weight compresses the layers of ice beneath forcing them to spread out where there is less pressure.

c. Plastic flowage

- Within a mass of ice, great pressure is exerted on the layers at the bottom, sides and centre.
- This pressure causes some ice particles to melt slightly thereby shift their position slightly downhill before refreezing

Factors influencing the rate at which ice moves.

i. **Gradient of the land**- Ice moves faster on steep slopes compared to gentle slopes due to the influence of the force of gravity

ii. **Thickness and weight of ice -** Thick glacier moves faster as a result of own weight exerting pressure at the bottom. This induces slight melting hence faster movement

iii. **Friction** - Movement of ice within a valley glacier is faster at the centre where friction is least than at the sides and at the bottom.

iv. **Season** – movement of ice is faster during summer because the ice thaws more frequently

Processes of Glaciation

- This involves glacial erosion, glacial transportation and glacial deposition

Glacial Erosion

- This involves plucking, abrasion and sapping

(a) Plucking/Quarrying

- This occurs when ice at the base and the sides of a glacier freeze onto the rocks
- The rocks are then pulled and carried away by the moving ice
- It is common in well jointed or faulted rocks

(b) Abrasion

- This is caused by rock debris that is embedded in a glacier.
- These debris scratch , scrape and polish the rock surfaces over which the glacier moves

(c) Sapping

- This refers to the breaking of rocks through alternate freezing and thawing of the water contained in the cracks between the glacier and the floor/side of the mountain

Factors influencing glacial erosion

i. **Nature of the underlying rock**
   - Well jointed/faulted rocks are easily eroded by plucking process since the joints allow water to enter into the rock.
   - Soft rocks are eroded faster by abrasion compared to hard/resistant rocks.

ii. **Availability of debris**
   - Debris acts as erosive tools. The more the debris embedded in the ice the more effective is abrasion process.

iii. **Speed of the glacier**
   - The faster the speed the greater the erosive energy.

iv. **The thickness and weight of the glacier**
   - A thick glacier exerts great pressure on the underlying rock causing weathering.
   - The rock debris embedded in the glacier is pressed down by the thick glacier to erode by abrasion.

Glacial Transportation

- Materials transported by a glacier is called **moraine**. It consists of a variety of materials such as rock fragments, sand, gravel and boulders
- Moraines are of the following types:
  a. ***Ground moraine***: - load carried at the base or beneath a glacier
  b. ***Lateral moraine***: - load carried along the sides of the glaciers
  c. ***Medial moraine***: - load carried on the surface but at the centre
  d. ***Terminal moraine***: - material deposited by the glacier at the point where it melts

Drawing

Glacial Deposition

- Sometimes, parts of a glacier may become so heavily ladened that its ability to transport its sub glacial moraine is reduced or stop, deposition then occurs
- Glacial deposits are divided fluvio-glacial and till deposits
- Fluvio – glacial deposits are materials deposited by water from melting ice in a glacier whereas tills are moraines/materials deposited by ice on melting

Factors influencing glacial deposits

a. **Gradient or slope of the area: -** gentle slopes allow for the accumulation of large sheets of ice and subsequent deposition of fluvio-glacial material (materials deposited by melt water).
b. **Stagnation of glacier: -** leads to pressure being exerted at the base of the glacier which in turn leads to melting of the base. The melt water then carries and deposits materials underneath the ice.
c. **Friction** between the moving ice and the rock surface leads to deposition of the heavy materials underneath the ice.
d. **Weight of the glacier**: - heavy glaciers tend to be deposited faster/more
e. **Amount of glacial drift** (till and fluvio glacial deposits). When a glacier has so much sub glacial moraines, it becomes too heavy forcing it to deposit some of its load.

Resultant features of glaciation in highlands/highland areas

i. **Cirques/corries**

- These are deep and wide hollows at the head of glaciated valley or high up above the sides of the valley
- It is formed due to interchanging processes of freeze and thaw of snow in winter and summer respectively
- When snow accumulates in a shallow and pre – existing depression on the mountain side or at the head of the valley forming a glacier
- During summer, the snow melts and freezes again during winter
- Glacial abrasion deepens the hollow
- Plucking process steepens the back walls of the depression
- This actions are repeated over time to form a depression known as a ***cirque***
- When the cirque is filled up with melt water/rain water it forms a ***corrie lake/tarn***

Diagrams

ii. Arêtes

- These are narrow sharp edged steep ridges that separates two corries/cirques
- They form when two cirques cut back to back through headward recession i.e. backward cutting of the walls of a cirque through plucking and nivation
- This results into very steep and sharp ridges called ***arêtes***

iii. Pyramidal peak

- This is a sharp and steep sided peak surrounded by cirques/corries
- It forms when cirques develop on all sides of a mountain
- Frost action (through freeze and thaw/plucking) causes blocks of rocks on the mountain to be broken down resulting in the back walls of the cirque to be steepened and deepened
- The cirques then start to cut back simultaneously and form a sharp peak called a ***pyramidal peak***

  Diagram

- Examples of pyramidal peaks include Corynder and Delamere on Mt. Kenya. Also Albert, Margherita and Alexandria peaks on Mt. Ruwenzori

iv. U shaped valleys/glacial trough

- These are flat and nearly flat bottomed valleys with steep sides and a U shaped cross sectional profile
- A pre-existing river valley is filled with ice/glacier
- As ice moves downstream, tributary glaciers increase the amount of ice in the main valley
- Glacier erodes the V-shaped valley by plucking and abrasion
- The interlocking spurs are trimmed into truncated spurs.
- The glacier deepens, widens and straightens the valley floor forming a ***U-shaped glacial trough***
- Other erosional and depositional features formed within the glacial trough are alluvial fans and lateral moraines

Diagram on long profile section of a glacial trough

v. Hanging valleys

- During the formation of a glacial trough, a small valley is left hanging above the major or over deepened valley called a hanging valley
- Initially there is a main valley and a tributary valley
- Ice fills into these valleys
- The main valley is eroded faster as it contains more ice compared to the tributary valleys. The floor of the main valley thus it at a much lower level than the tributary valleys.
- The ice melts and the tributary valleys are left at a higher level than the main valley
- They are seen to hang above the main valley as ***hanging valleys.***

Diagram

- Hanging valleys are common on the middle slopes of Mt. Kenya where they form waterfalls e.g. Vivienne falls

vi. Fjords/fiords

- This is a submerged glacial trough on a highland coast formed after a glaciated valley is drowned/submerged by sea/ocean
- Action of ice through plucking and abrasion results in the widening and deepening of the lower sections of an already existing river valley
- With time, glacier disappears after melting leaving behind a steep sided valley.
- When there is a rise in the sea level, the straightened and deep glacial valley is drowned/submerged by the sea water to form ***fiords/fjords***
- They are mainly found in temperate lands along the Scandinavian countries

vii. Rock basin

- This is a depression within a glacial trough where differential erosion has taken place especially areas that have less resistant rocks.
- At the point where two glaciers converged erosion is greater resulting in the formation of a glacial depression called a ***rock basin***.
- They also form in areas with less resistant rocks where the glacier removes these (less resistant rocks) through abrasion and plucking; leaving behind a shallow depression called a ***rock basin***

- Later, during the post glacial period, water may accumulate in the rock basin/depression/hollow to form lakes called ***finger*** or ***ribbon lakes***

Resultant features of glaciation in lowland areas

- These include both erosional and depositional features

Erosional features

i. Ice eroded plains

- These are extensive and almost level lowlands that were previously under ice sheets
- During glacial transportation, ground moraine erodes the rocks on the existing landforms through abrasion and plucking to form long and extensive plains called ***ice eroded plains***

ii. Depressions

- Lowland glacial areas may comprise of less resistant rocks that are easily eroded by ice sheets/glacier
- The glacier scoops out the materials from the surface through plucking and then lowers it to form shallow ***depression***.
- This depression may later fill with melt water to form a glacial lake

iii. Roche Mountonee

- This is a rock outcrop that has been eroded by the glacial processes of abrasion and plucking.
- Abrasion polishes and smoothens the upstream side of the rock outcrop whereas plucking will make the downstream end to steep and rugged

  Diagram

- They are common in mounts Kilimanjaro and Ruwenzori

iv. Crag and tail

- A crag is a steep-edged rocky outcrop or a hill side rock projection which protects a mass of less resistant/softer rock (tail) on the downstream side of the glacier from ice erosion.
- The crag usually lies on the path of oncoming ice; the ice moves over and around the crag but only slightly erodes its sides. The material that was being carried by the glacier is deposited on the downstream/leeward side.
- Such deposits and the softer rocks form an elongated tail

Diagram

Depositional features

i. Erratics

- This is a large boulder rock which has been transported by a glacier so that it rests on a country rock which is different from it i.e. it has no relationship with the rock material found in the area of deposition
- They are deposited on the inlands when the ice melts

ii. Boulder trains

- This is a group of erratics obtained from the same bedrock and which are deposited with their apex pointing to the origin of the deposited materials in a linear form

iii. Tills

- This refers to unsorted and heterogeneous mixture of rocks, clay and sand that are transported and deposited by the ice sheet on melting.
- They are of two types namely: lodgment and ablation tills
- Lodgment tills are deposited over the ice at the base as a glacier reaches its melting point and the ice moves. The moving ice aligns the debris onto the sub glacial surface
- Ablation tills are deposited when the ice melts

iv. Kames and eskers

- Kames are isolated hills made of sand and gravel which have been deposited in layers by glacial water

- They are built by streams emerging at high levels from temporary and stagnant ice covers.
- As the glacier front recedes, unsupported back of deposits collapses leaving a steep faced hill called ***kames***
- Eskers are long winding ridge of coarse sand and gravel that is formed by streams that flow continuously beneath/within the ice but in a parallel direction to the moving ice
- As the ice front recedes, the streams continuously deposit the materials to form a long winding ridge called ***eskers***

v. Terminal moraines

- This is a long ridge of moraine formed by extensive deposition of moraine along the edge of an ice sheet.
- It is formed when the ice remains stagnant for a long time causing the ice at the edges of the ice sheet to melt

vi. Outwash plain

- This is a wide and gently sloping plain of gravel, fine sand and clay
- It forms when large ice sheets stagnate on a gently sloping landscape and start melting along the edges.
- The sub glacial melt water spreads out carrying fine materials which are deposited further down slope as the ice retreats.
- Pre-existing valleys are buried by these fluvio-glacial materials.
- The unconsolidated clay, silt, sand and gravel are deposited in mass covering a wide area forming an undulating plain called an ***outwash plain***

vii. Drumlins

- These are smooth and long hills deposited and shaped under an ice sheet or a very broad glacier
- They are formed beneath the ice due to friction between the bedrock and the boulder clay.
- This results to deposition of clay at the valley bottom.
- Further deposition leads to large mounds of till forming
- The moving ice streamlines the till that had been deposited irregularly resulting into elongated egg-shaped hills called ***drumlins***

Diagram

Significance of Glaciation

i. Outwash plains, old glacial beds and tills are at times very fertile thus leading to the development of agriculture e.g. wheat producing regions within the Canadian prairies
ii. Some glacial lakes provide natural waterways e.g. the Great Lakes of Canada and North America thus facilitates transport and communication
iii. Glaciers on highlands may form sources of river e.g. R. Tana on Mt. Kenya
iv. Waterfalls resulting from hanging valleys provide suitable sites for the generation of HEP
v. Glaciated mountain regions and their resultant features e.g. cirques, pyramidal peaks, etc. attracts tourists during winter for games/sports hence earning foreign exchange
vi. Sheltered waters in the fiords provide suitable breeding grounds for fish and sites for construction of natural harbours
vii. Sand for building and construction can be harvested from outwash plains, kames and eskers
viii. Glaciation results into rugged landscape that makes settlement and construction of transport and communication difficult
ix. Extensive areas of land are sometimes turned into glacial lakes by deposits from moraine thus reducing the amount of land available for settlement
x. Some outwash plains may contain infertile sandy soils that hinder agricultural practices