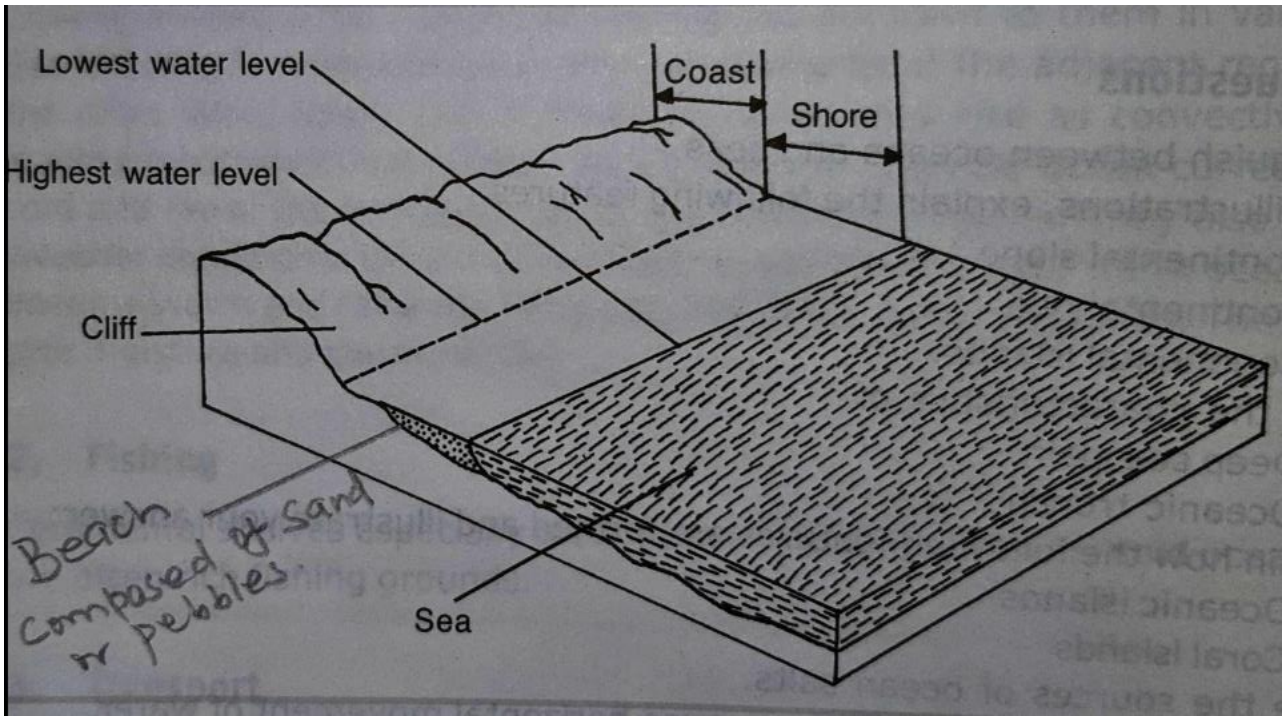
S6 GEOGRAPHY 1

COASTAL GEOMORPHOLOGY

Coastal geomorphology is the study of coastal landforms and the processes involved in their formation along the coastlines.

Definition of terms :-

i) **Coast** : This refers to the strip of land bordering the sea.
ii) **Coastline** : This is the border (margin) between the land and the sea i.e the limit at which wave action on the land.
iii) **Shore** : Refers to the strip of land that lies between high water and low water levels.
iv) **Shoreline** : This is the line where the shore meets the sea (water)
v) **Beach** : This is the accumulation of sand, shingle, pebbles and mud on the shore.



Factors influencing the shape (nature) of the coasts.

There are several factors influencing the nature of the coastline and the related land forms and these include;

i) Waves

These are sea oscillations that develop on the surface of the water as a result of transferring atmospheric energy onto the sea surface.
Waves are caused by winds when there is a frictional force between the winds and the open water surface. The friction generated makes the water to move in relation to the direction of the wind.
Waves are more experienced on wider water surfaces and they cause coastal land erosion through hydraulic action, abrasion and solution.
Waves may deposit materials when they break down. The deposition and erosion modify the coastline.

ii) Nature of rocks

The nature of rocks bordering the sea affects the coastline. Resistant rocks tend form coastal uplands that project into the sea i.e headlands. The weaker rocks usually appear as coastal lowlands i.e bays.

iii) Sea level changes

A fall/rise of water level in the sea influences landform evolution. Sea level changes create land forms of emergence and sub- mergence depending on the fall or rise respectively. However such movements cause waves to work at different levels hence limiting wave erosion.

iv) Special climate

Climatic conditions either in the past or present have caused development of particular features i.e coral reefs only develop under tropical climate and fiord coasts occur under cool conditions.

v) **Man**

Man has constructed artificial harbours , towns and industries along the coast, he has built canals , reclaimed land from sea and has got involved in onshore mining. All these activities of man have greatly influenced landform evolution at the coast.

vi) **Height of the land**

It influences type of low land coast leading to formation of depositional features while highland coasts are associated with erosional features.

WAVES

Waves are oscillations or undulations in the surface of the sea/lake/ocean caused by the friction of the wind on the water surface. The stronger the winds, the stronger the waves. Winds that travel longer distances over open water also cause bigger and stronger waves. Waves may also be caused by marine – earth quakes, marine volcanic eruptions, sub marine ships, large aquatic animals such as whales etc.

Waves advance towards the shore as **swash** and then move back to the sea as **back wash**.

Types of waves. (bold)

There are two major types of waves;

i) **Constructive waves:**

These are waves with a stronger swash than the back wash and are responsible for building features along the coast i.e depositing materials along the coast.

ii) **Destructive waves**

These are waves with a more powerful backwash than the swash resulting into the removal of materials from the shore.

NB : Waves are major agents of **erosion**, **transportation** and **deposition** along the coast.

COASTAL LAND FORMS

These are physical features found along the coast i.e along the marine shoreline and the inland water bodies. Coastal landforms in East Africa are more developed along the inland lakes. Coastal landforms are produced mainly by **action of waves.** Other land forms result from and **eustatism (sea level changes**) and **coral reef formation.**

WAVE EROSION

Wave erosion is responsible for the formation of erosion/ features along the coast. Erosive waves have a strong backwash which is more powerful than the swash such that the pebbles and sand are removed from coast. These are termed as **destructive waves.**

Factors affecting the rate of Wave Erosion

The effectiveness of wave erosion mainly depends on;

i) Wave strength

The stronger the waves, the more erosive they are and the weaker the waves the less erosive they will be. Powerful waves drag materials against the coast causing more erosion in form of abrasion. Also the force of the water loosen rocks for removal from the coast by hydraulic action.

ii) Nature of coastal rocks

Soft, well jointed and unconsolidated rocks are more susceptible to wave erosion through process of hydraulic action and abrasion compared to hard, massive and consolidated rocks. Limestone rocks are also more vulnerable to chemical erosion by solution.

iii) Availability of load as abrasive tool

A good supply of boulders and coarse sand accelerate wave erosion by abrasion while absence of such abrasive tools limit wave erosion along the coast.

iv) Exposure of the coast to wave attack

More exposed coasts experience greater wave erosion while those protected by coral reefs and islands are less attacked by wave erosion.

v) The work of man

Human activities such as building of artificial harbours, drainage canals, weaken the underlying rock structures making them susceptible to wave erosion. Removal of beach material such as sand exposes the coastal cliffs or rocks to more rapid wave erosion.

vi) Orientation of the coastline

Straight coastlines are less eroded by waves while the more indented coastlines are rapidly eroded by waves. An indented coastline has projections of land towards the sea (head lands) on which waves break causing destruction.

vii) Slope of the coastline

Steep sided coastlines slow down wave movements abruptly leading to rapid erosion by hydraulic action and abrasion.

Coasts whose slope dips seawards experience more wave erosion than those dipping towards the land.

viii) Depth of the sea

Coasts with shallow offshore zones experience reduced wave erosion due to waves being forced to break some distance from the shore.

Processes of wave erosion

Wave erosion takes place in four forms;

i) **Abrasion;**
This is where boulders, pebbles and sand are pounded/dragged against beds of coastal rocks by waves causing under cutting and rock breakdown.

ii) Hydraulic action
This is where wave pressure breaks down the rocks through lines of weakness as waves compress and expand air in the cracks of the rock shattering it down.

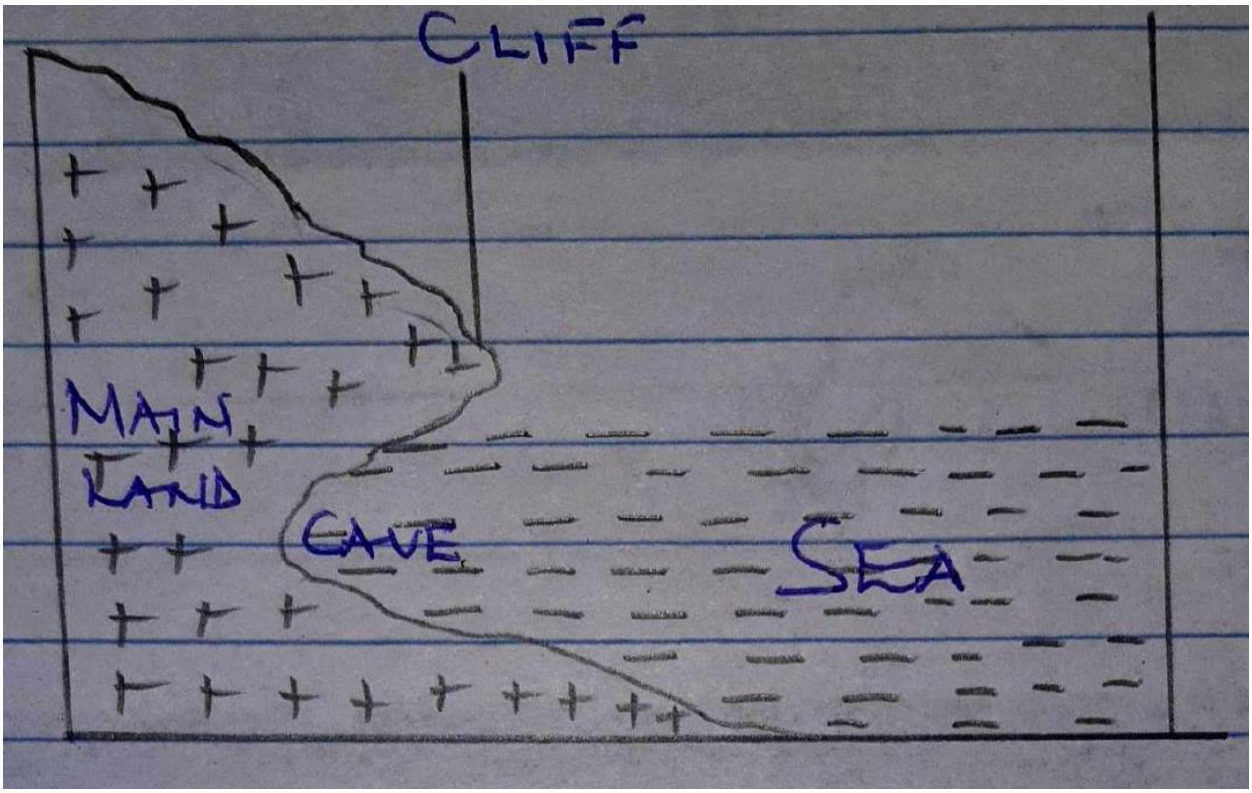
iii) Solution/corrosion
This is the solvent action of water where soluble rocks are dissolved away in solution form i.e limestone rock.

iv) Attrition
The boulders and pebbles are dragged against each other and they are (themselves) broken down into small particles.

WAVE EROSIONAL LANDFORMS

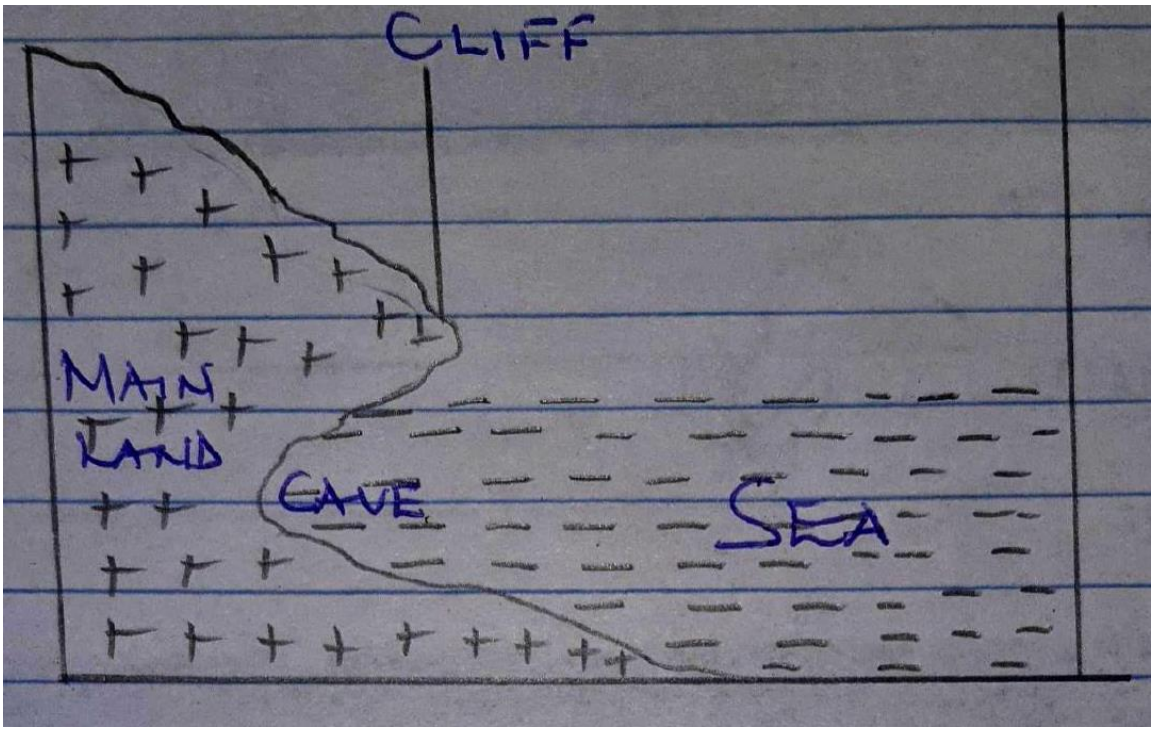
The main coastal erosion land forms (marine erosion land forms) include; Cliff, cave, headland, geo, bay, sea arch, stump, stack blow holes, wave cut platform.

a) Cliff
This is a steep rock face along the coast above high tide level. It is formed when waves through abrasion and hydraulic action attack the coastal rocks, excavating a cave in the base of the rock face. Further wave action, combined with weathering and mass wasting cause the collapse and retreat of the coast to form a cliff. Examples can be seen at Kasenyi, Lutembe beach on L. Victoria, Fort Jesus in Mombasa, Fort Gaza near Kilwa in Tanzania.



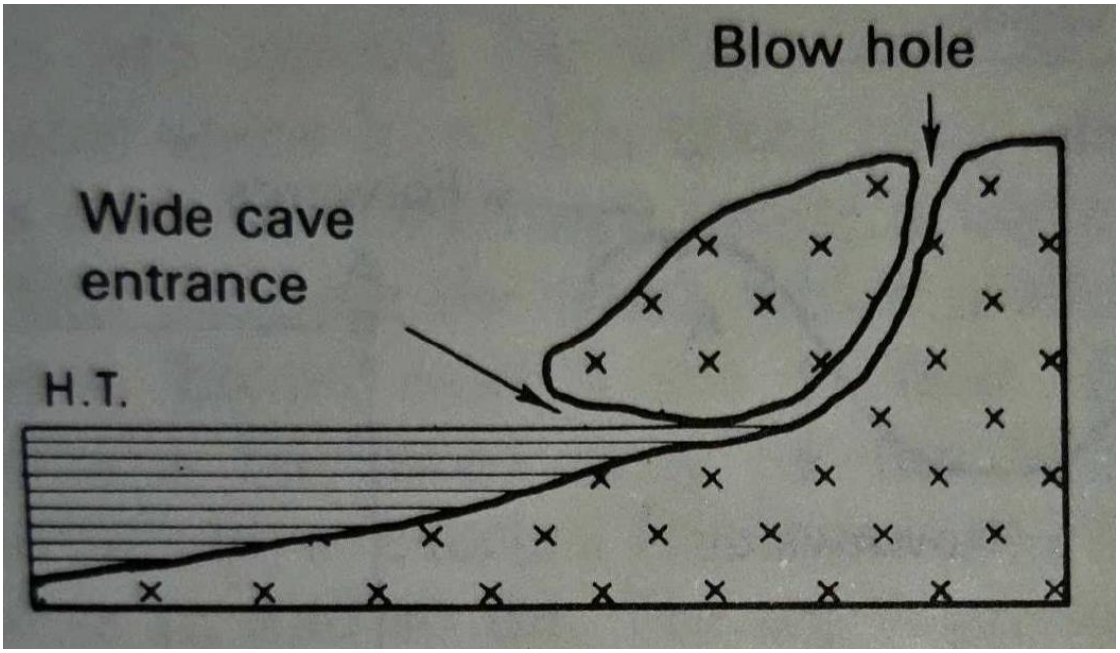
b) Cave

This is a cylindrical tunnel like opening drilled through the coastal rocks mainly by abrasion and hydraulic action. It is formed when cracks/joint at the base of the cliff are widened by wave erosion. The breaking waves compress air in the cracks. As waves retreat, the air expands and exerts pressure in the cracks. Alternating compression and expansion enlarges the cracks into holes and finally to **caves.** Examples are seen at Kasenyi landing site, Lutembe and Botanical beach on the shores of L. Victoria.



c) Blow hole/gloup

This is a vertical shaft connecting the cave with a cliff top. Wave hydraulic action in the cave, causes compression and expansion of air , further opening up the crack towards the roof of the cave, creating an opening on top of the cliff called a **blow hole**. Examples are seen at Kasenyi landing site on L. Victoria, Lesouffer blow hole along the East African coast.



d) Geo

This is a deep, narrow, steep sided inlet running inland from the cliff edge. It's formed when the cliff top or cave roof collapses due to continued hydraulic action. Examples can be seen at Kasenyi landing side on L. Victoria
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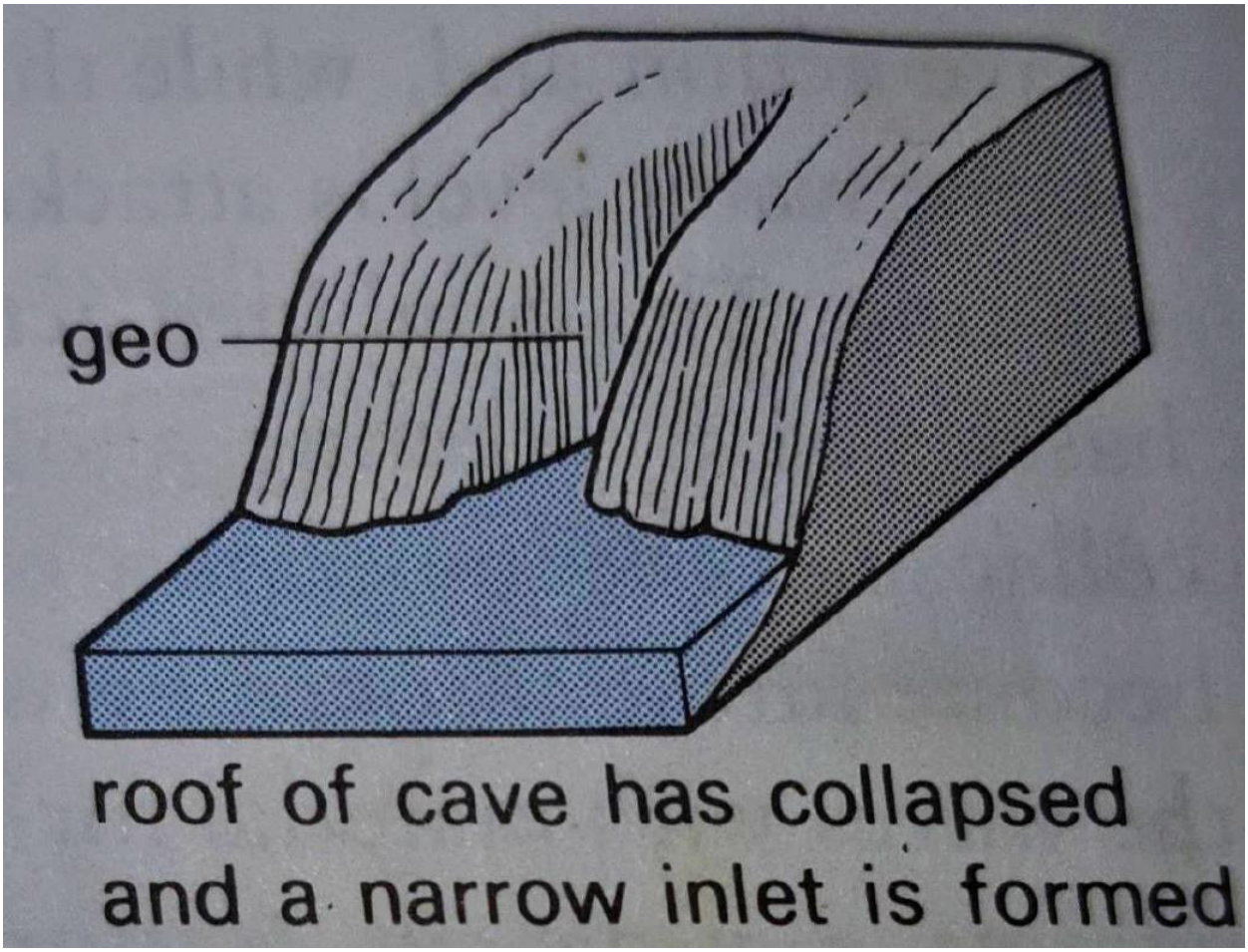
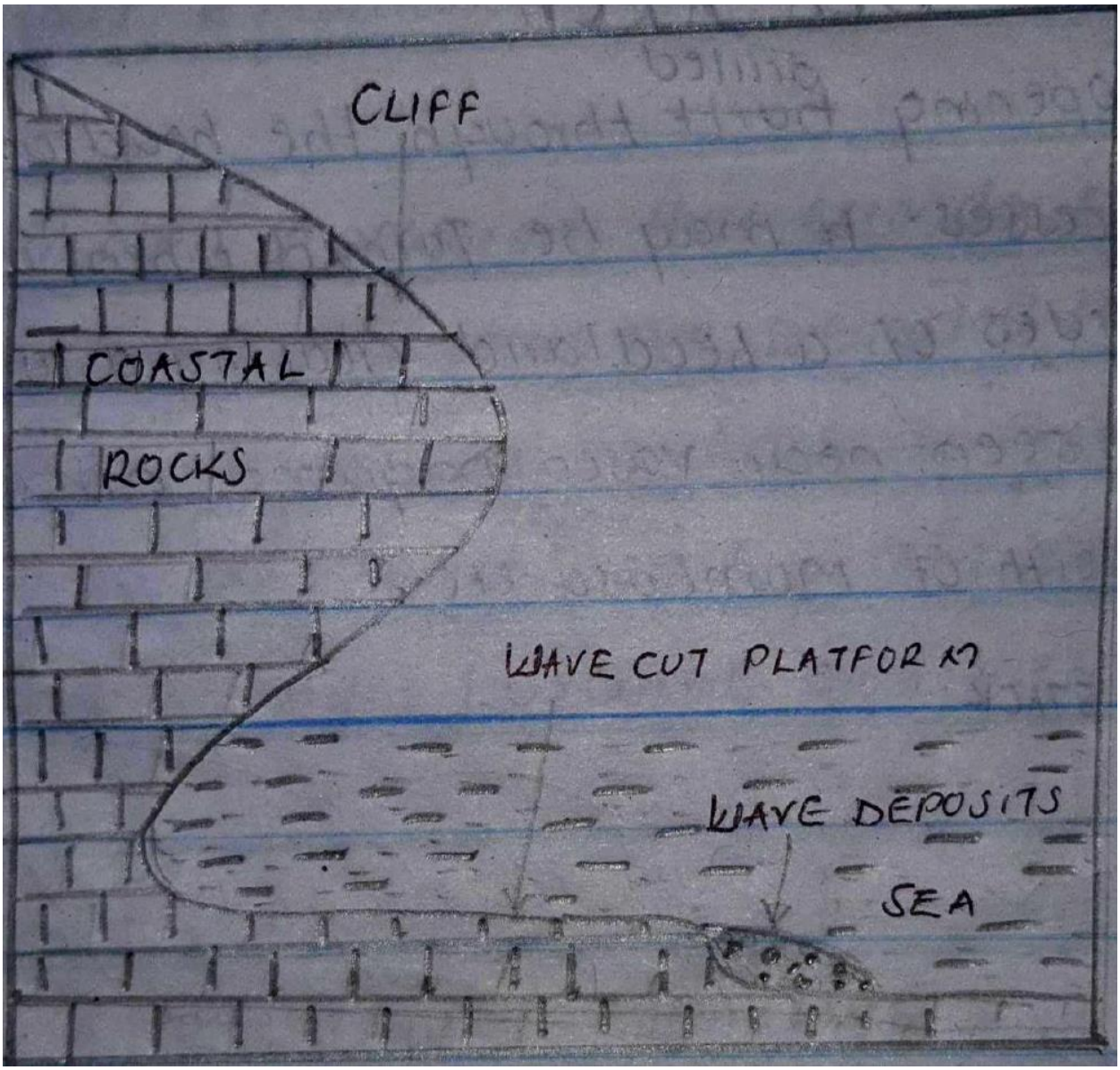


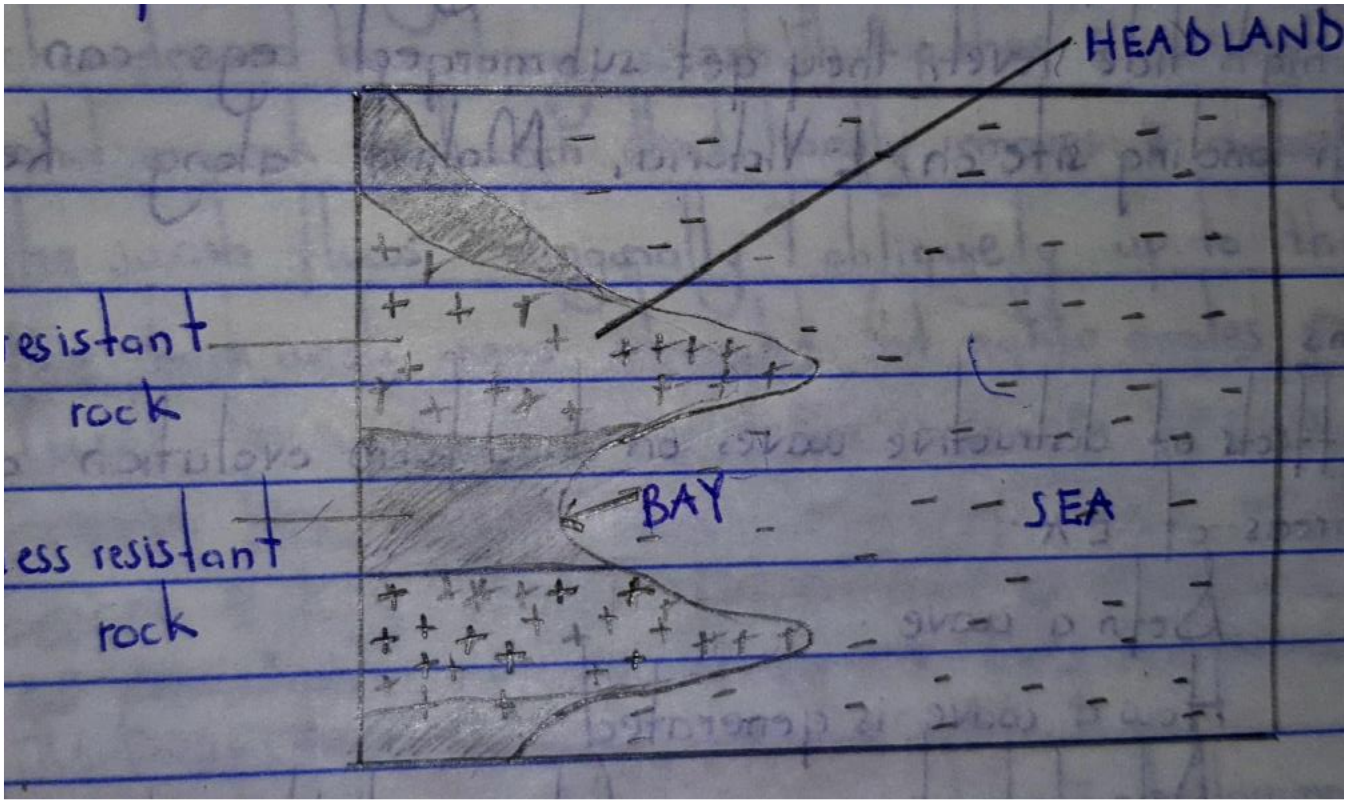
e) Wave cut platform.

These are bench like surfaces, gently sloping sea-wards at the base of the cliff. They are formed when the cliff retreats towards the mainland through abrasion and hydraulic action. The eroded materials are deposited in the water creating a levelled surface at the base of the cliff. Examples can be seen at the Gulf of Mombasa port near Fort Jesus.


CLIFF
COASTAL
ROCKS
WAVE CUT PLATFORM
WAVE DEPOSITS
SEA

f) Headland and bays

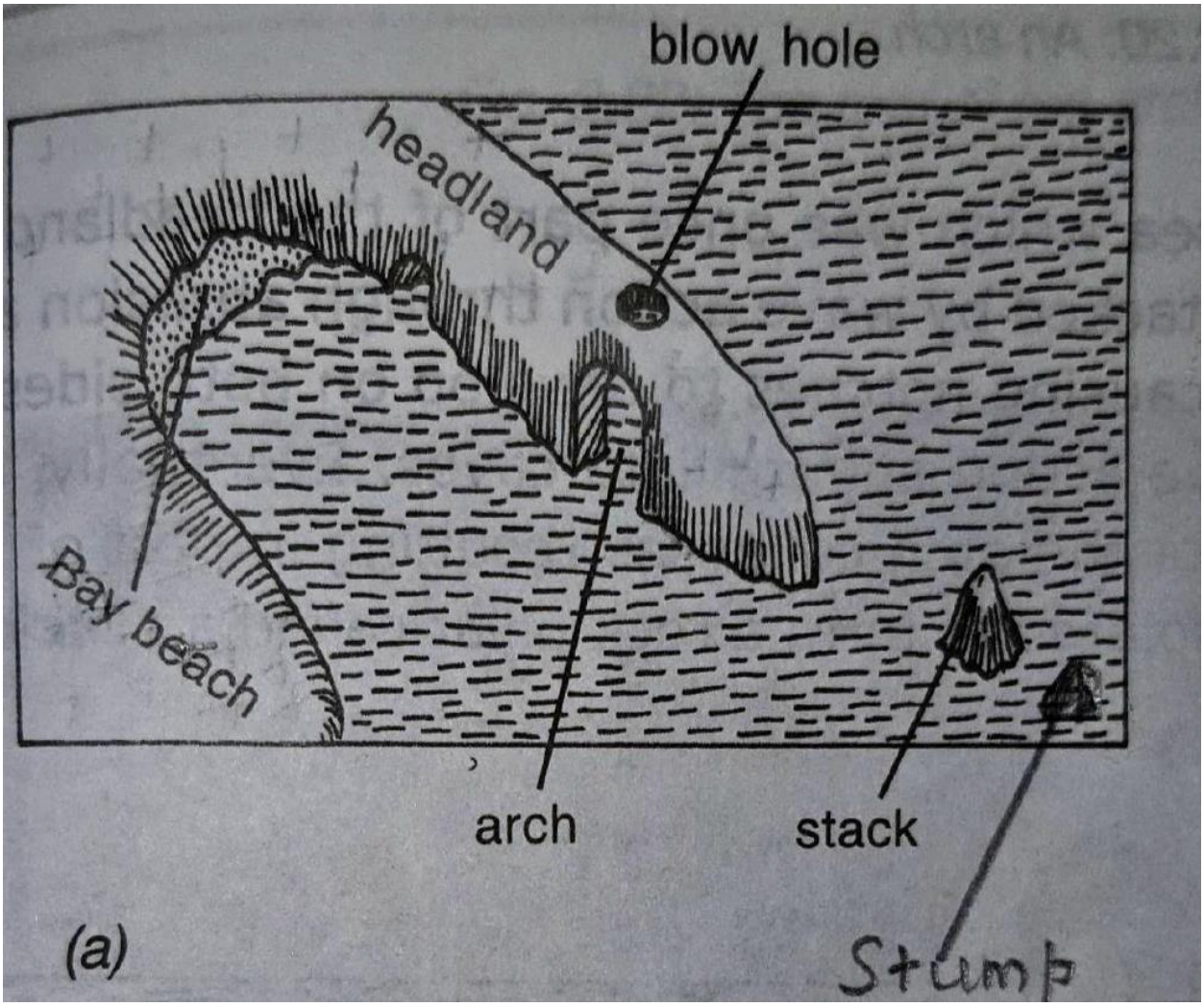
These are formed in areas of alternating hard and soft rocks along the coast. A headland is a projection of a hard rock into the sea or water body. A bay is an open wide curved depression that extends towards the mainland formed when the softer rocks are subjected to abrasion, solution, and hydraulic action leaving a hard rock to extend towards the sea example include Sango bay, Murchision bay, Kibanga bay, Kasenyi, Lutembe on L. Victoria.



g) Sea arch

This is an opening or tunnel drilled through the head land by hydraulic and abrasion processes. It may be formed when waves attack from one side or both sides of the headland creating a tunnel like passage. Example can be

seen near Vasco Da Gama pillar at Malindi, Watamu to the north of Mombasa etc.



h) Stack

These are steep sided isolated pillars formed off- shore after the collapse of the sea arch roof. It usually remains standing above the water level and thus appears at a high tide level. Examples can be seen at Kasenyi landing site and Rock pillar stack near Entebbe Airport on L. Victoria, Mombasa, Malindi along the Indian coast.

Illustrated as in the above diagram.

i) Stump

These are remains of eroded stacks that only appear at low tides. At a high tide level, they get submerged examples can be seen at Kasenyi landing site on L. Victoria, Malindi along Kenyan coast.

Illustrated in the above diagram

Questions

1. Describe the effects of destructive waves on land form evolution along coastal areas of East Africa.
2. Describe the processes responsible for the formation of erosional coastal land forms in East Africa.
3. Explain the processes of wave erosion and clearly illustrate resultant land forms in East Africa.
4. Describe the coastal land forms resulting from marine erosion in East Africa.

WAVE DEPOSITION

Deposition along the coast is as a result of **constructive waves** which are characterized by **a strong swash** that pushes the materials towards the coast and **a weak backwash** that hardly removes the deposited materials.

The swash flows diagonally/obliquely up to the coast and the back wash runs straight/ at right angles from the coast. Thus, the swash and backwash move materials to and from the coast respectively. This repeated forth and back (zig – zag) movement of materials along the shore is the **long shore drift** and it's responsible for the deposition along the coast.

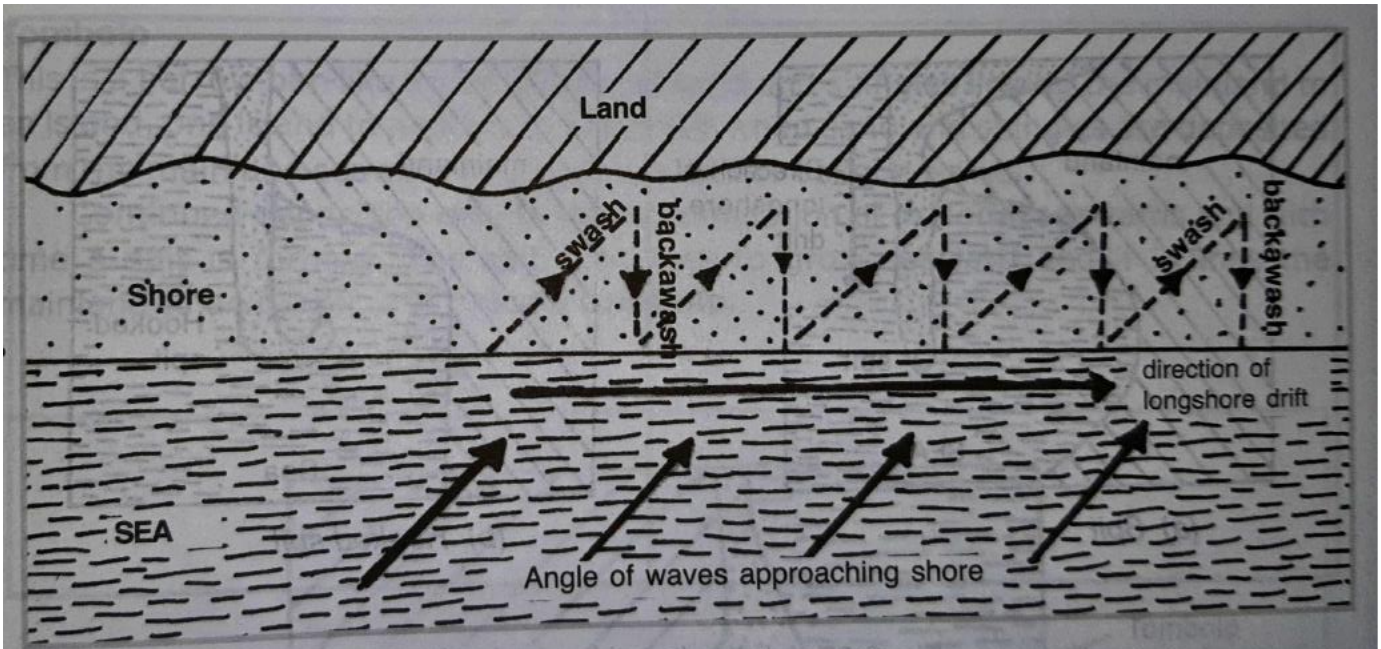


Fig. 8.25: Longshore drift.

Condition influencing wave deposition.

Wave deposition land forms occur under the following conditions;

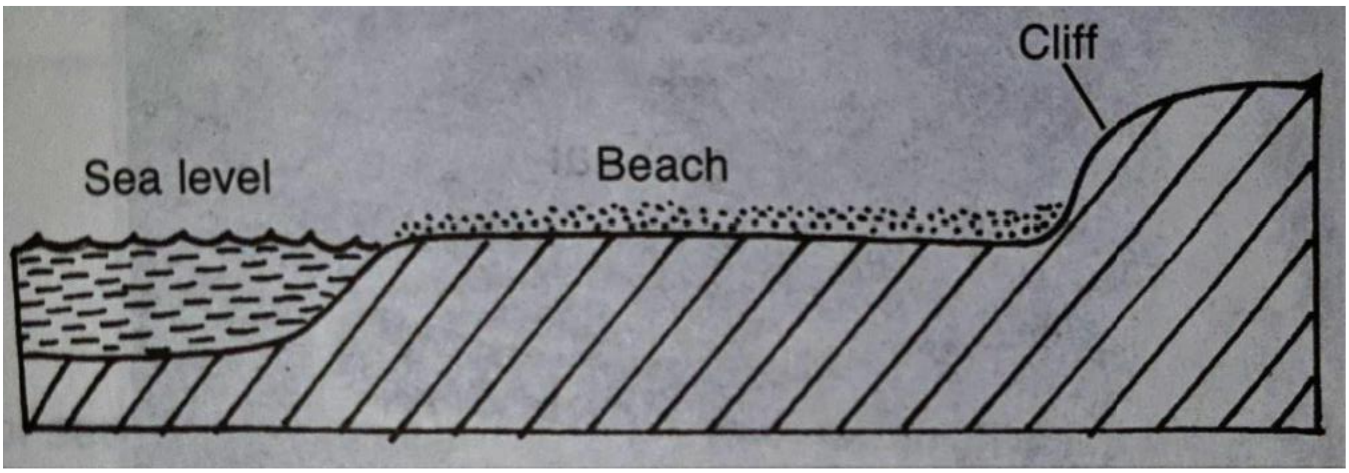
- ✓ A shallow continental shelf that favour breaking of waves before reaching the coast and also favouring the accumulation of deposits forming depositional land forms.
- ✓ Gentle relief/relatively flat areas that reduce on the strength of the backwash that allows deposition and accumulation of materials.
- ✓ Wind direction which should be onshore such that the material is carried and deposited along the shore line.
- ✓ When waves or water is loaded by large quantities of sediments that are deposited along the coast.
- ✓ Stronger swash compared to backwash to enable accumulation of the deposited material.

WAVE DEPOSITIONAL LANDFORMS

Wave deposition land forms include;-

1. **Beach**

   This is a gently sloping platform of accumulated sand, shingles or pebbles deposited between the high and low tide levels along the coast. Beaches are formed when **long shore drift** through constructive waves deposit materials on the shore. Due to a stronger swash than the backwash, the deposited material accumulates to form a beach.



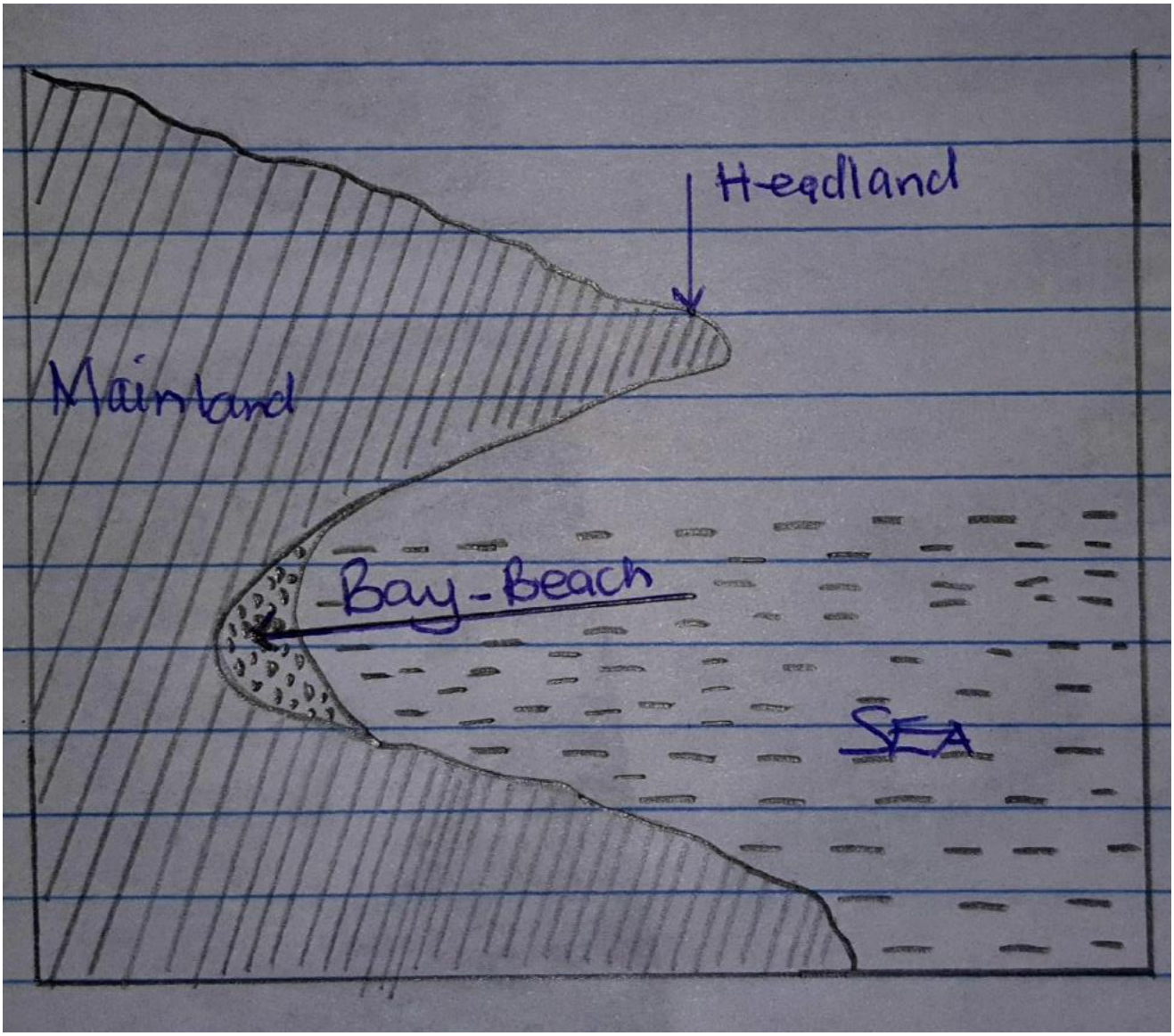
Types of beaches include;

a) **Storm Beach**

   These are formed when strong waves along the coast throw pebbles, stones and sand beyond the high tide water level during times of storms.

b) **Bay – beach.**

   This is a crescent of accumulated sand, pebbles and shingles deposited between two head lands (at the head of the bay) by longshore drift through the constructive waves. Examples include Lido beach at Entebbe , Kasenyi beach, Lutembe beach on L. Victoria, Nyali beach at Mombasa.



c) Barrier beach .

This is a long sandy ridge, parallel to the coast and separated from it by a lagoon. It is formed where longshore drift waves break at a distance before the shore, depositing material that creates the off- shore bar. Further wave action gradually moves the deposited material (off-shore bar) towards the main land as a **barrier beach** with typical features of a

beach on the seaward side. Examples can be seen at Madagascar along the East African coast.

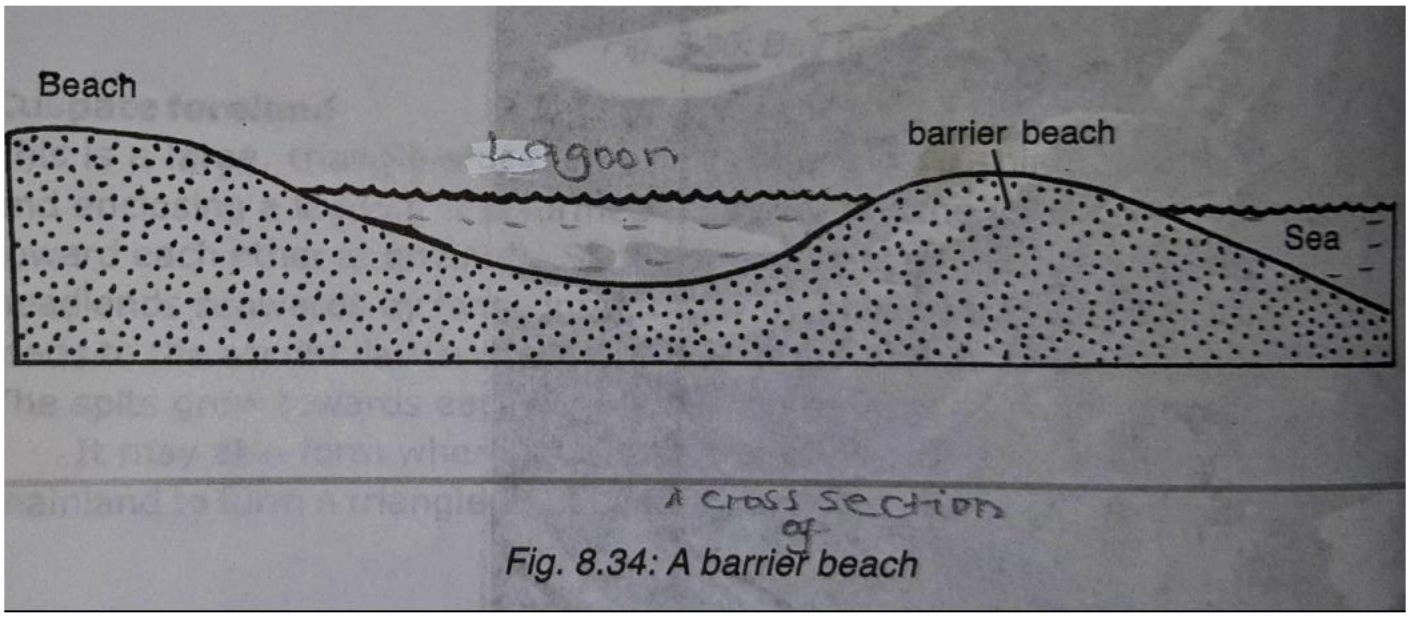


Fig. 8.34: A barrier beach

d) Beach cusps

These are horn shaped projections of sand and shingles pointing sea wards, separated by shallow and narrow indentations. They are formed by a powerful swash scouring coarse materials to the coast.

e) Beach berm

This is a ridge like feature with a steep front found on the upper parts of some beaches. It's formed due to larger accumulation of materials at the furthest limits of swash action. It develops on beaches when swash is stronger than the backwash. Examples can be seen at Mwachi in Tanzania , along the East Coast of L. Albert in Uganda, Lido beach and Lutembe beach on L. Victoria.

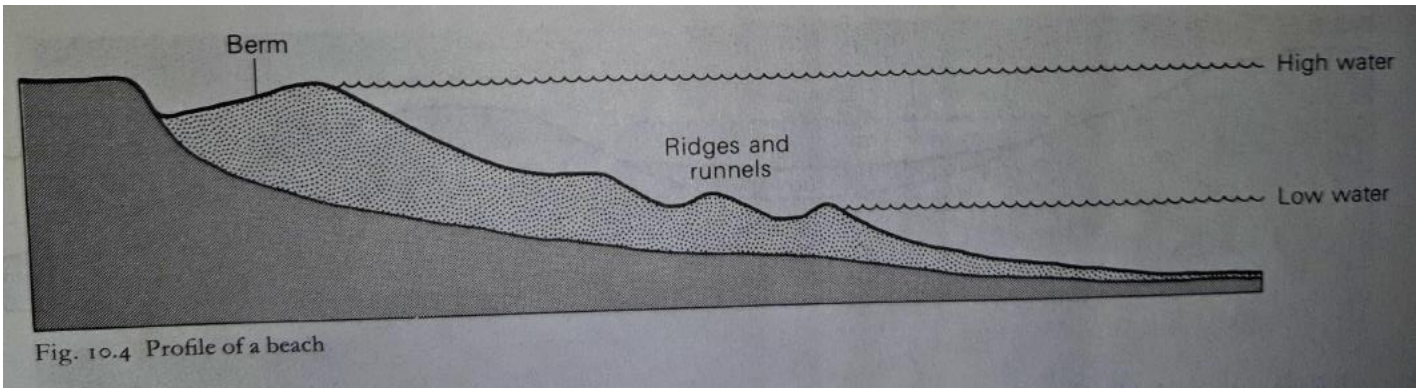


Fig. 10.4 Profile of a beach

f) Beach rocks

These are hard crust – like deposits projecting above the beach sand, composed of sand, shells , pebbles and shingles cemented together by calcium carbonate.

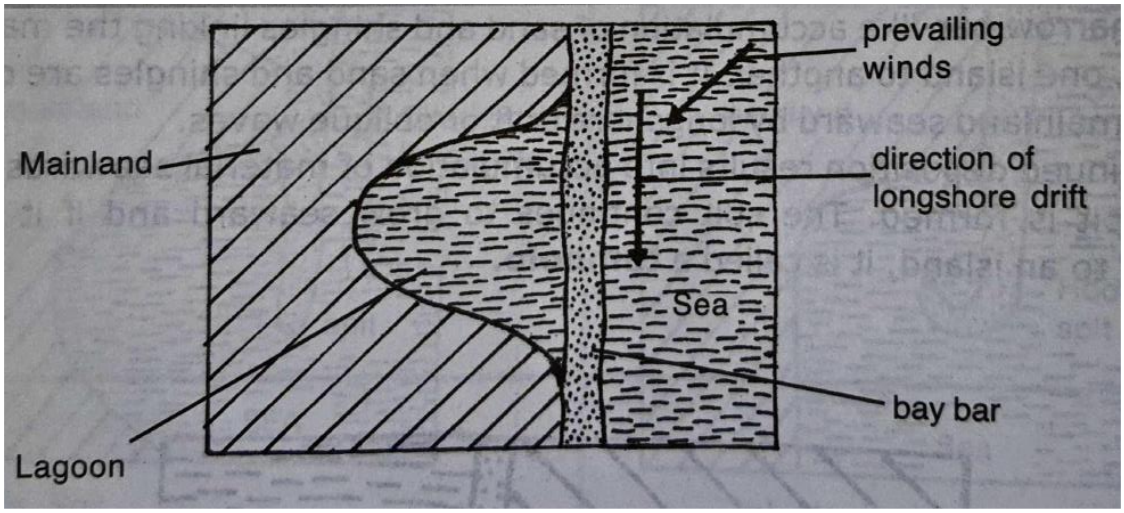
2. Bars

This is a narrow ridge of deposited sand, mud and shingle in shallow waters, lying parallel to the coast and not attached to the main land . It develops in areas of gently sloping coast and irregular shorelines. Bars are formed through the process of longshore drift when the breaking waves deposit material off shore and parallel to the coast. Lagoons usually develop behind these bars. An example of a bar is Ras Ngomeni near Malindi.

Types of bars include;

a) Bay – bar

This is an elongated ridge of sand, mud and shingle cutting across the mouth of a bay linking two headlands and enclosing a lagoon on the landward side. They are formed by long shore drift depositing material across the bay mouth which accumulates seawards as a bay – bar. An example can be seen at Nabugabo bay on L. Victoria.



b) Off – shore bar

This is a submerged narrow ridge of deposited sand, pebbles and shingles lying parallel to the coast. It develops on a gently sloping sea bed and separated from the coast by a lagoon. Off – shore bar is formed by longshore drift repeatedly depositing materials before reaching the coast. An example is at Lamu in Kenya.

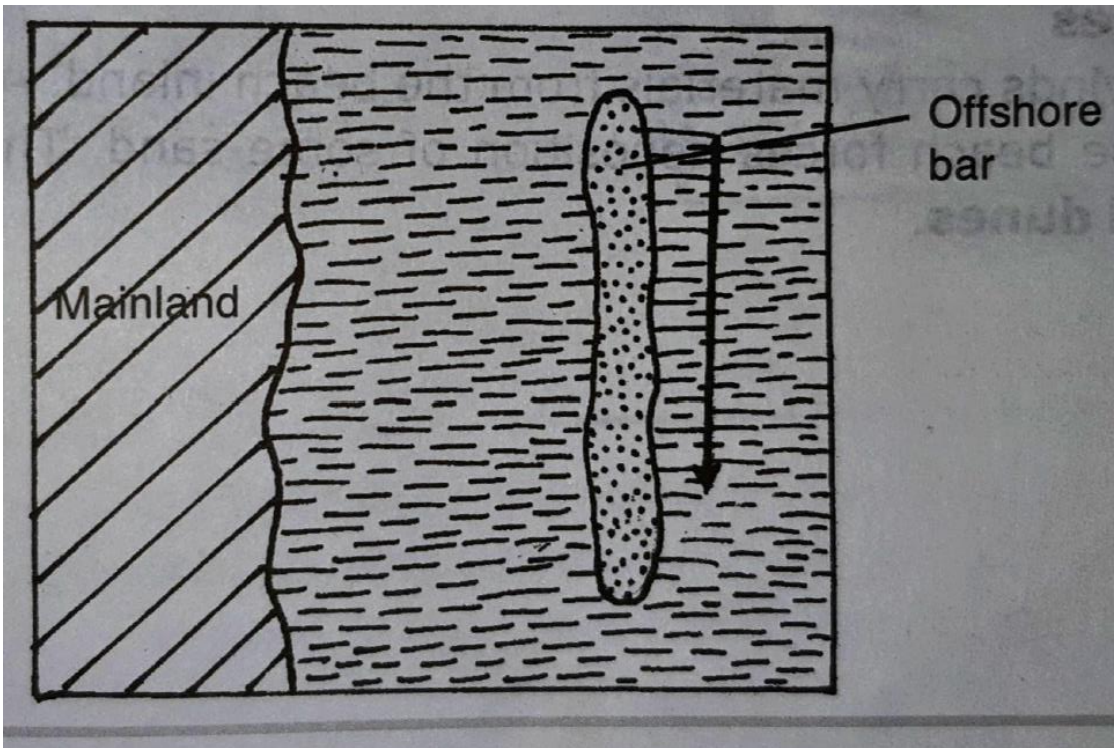


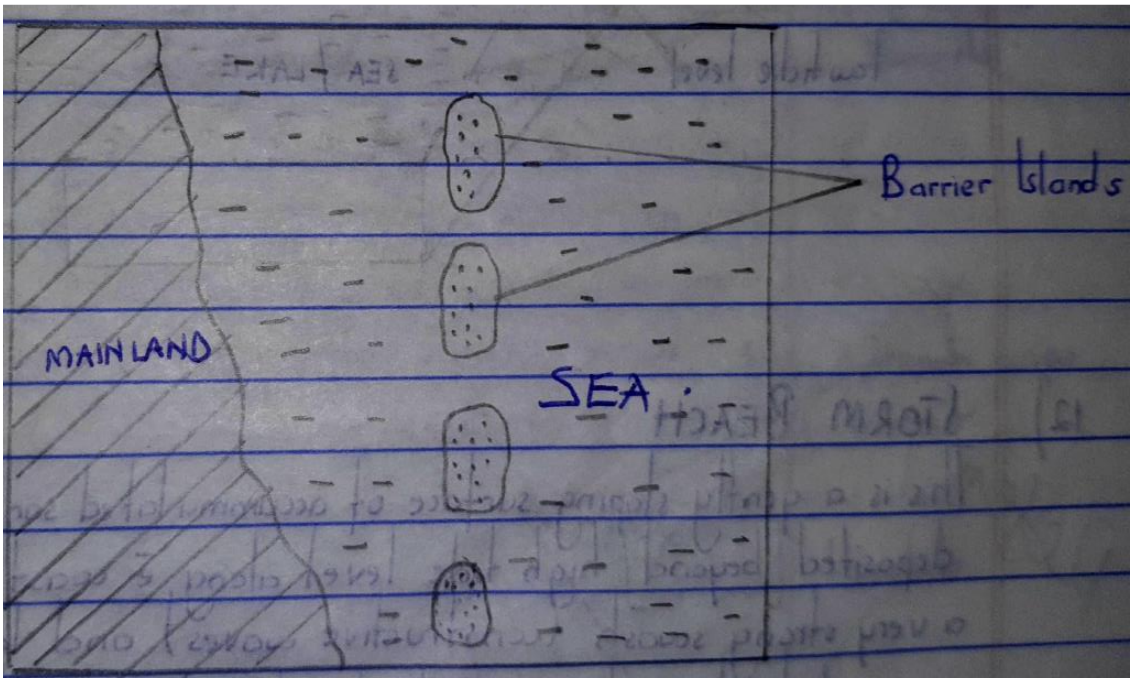
Fig. 8.33: Offshore bar.

c) Fore- shore bar

This is a bar formed by constant accumulation of sand, causing the off-shore bar to rise above the water surface. The materials are deposited by the long shore drift .

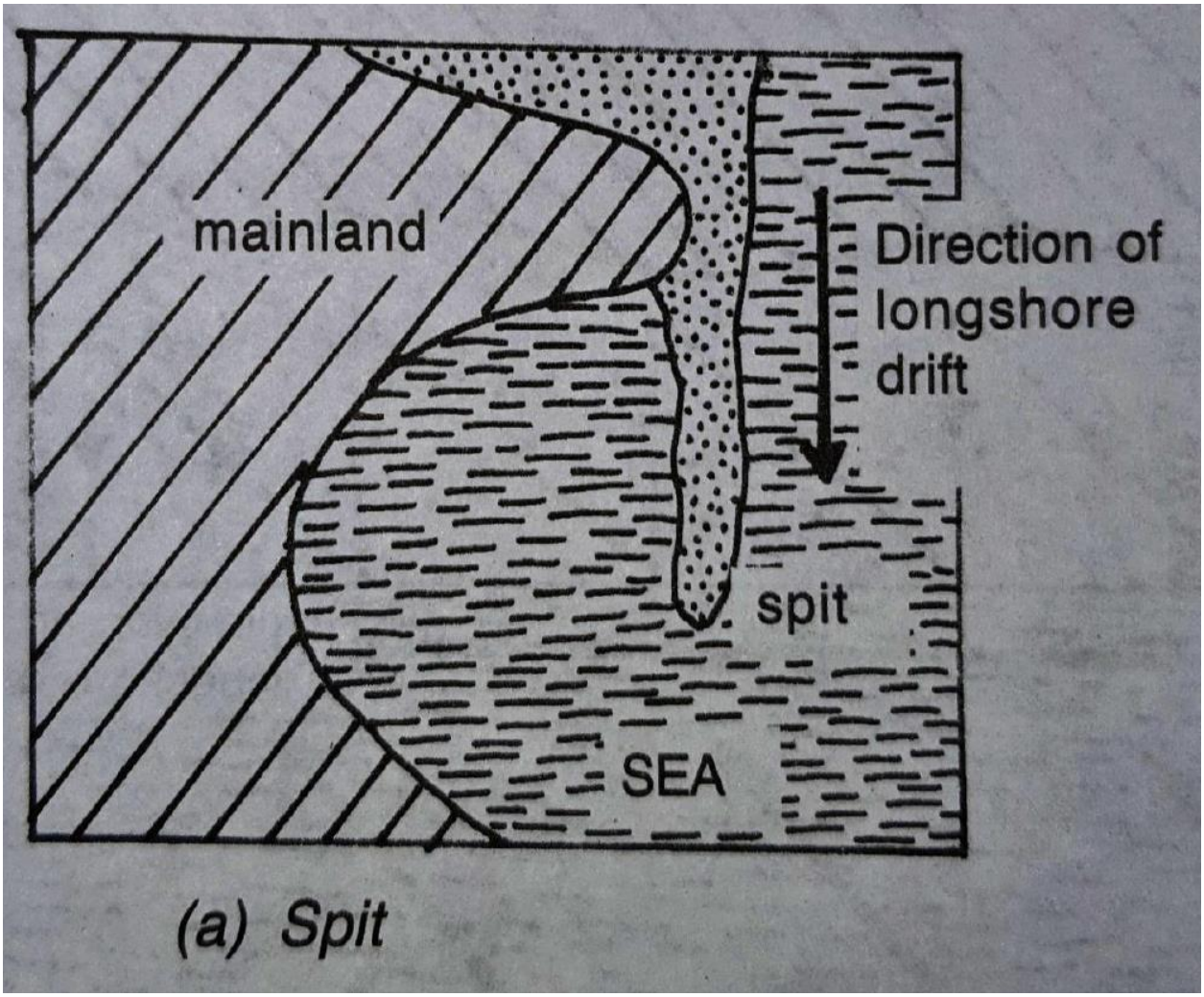
d) Barrier islands

These are a series of sand islands or bars running parallel to the coast. Barrier island are not joined to the coast and are separated from it by shallow lagoons or sounds. They are formed when long shore drift waves gradually move the sand bars towards the main land.



3. Spit

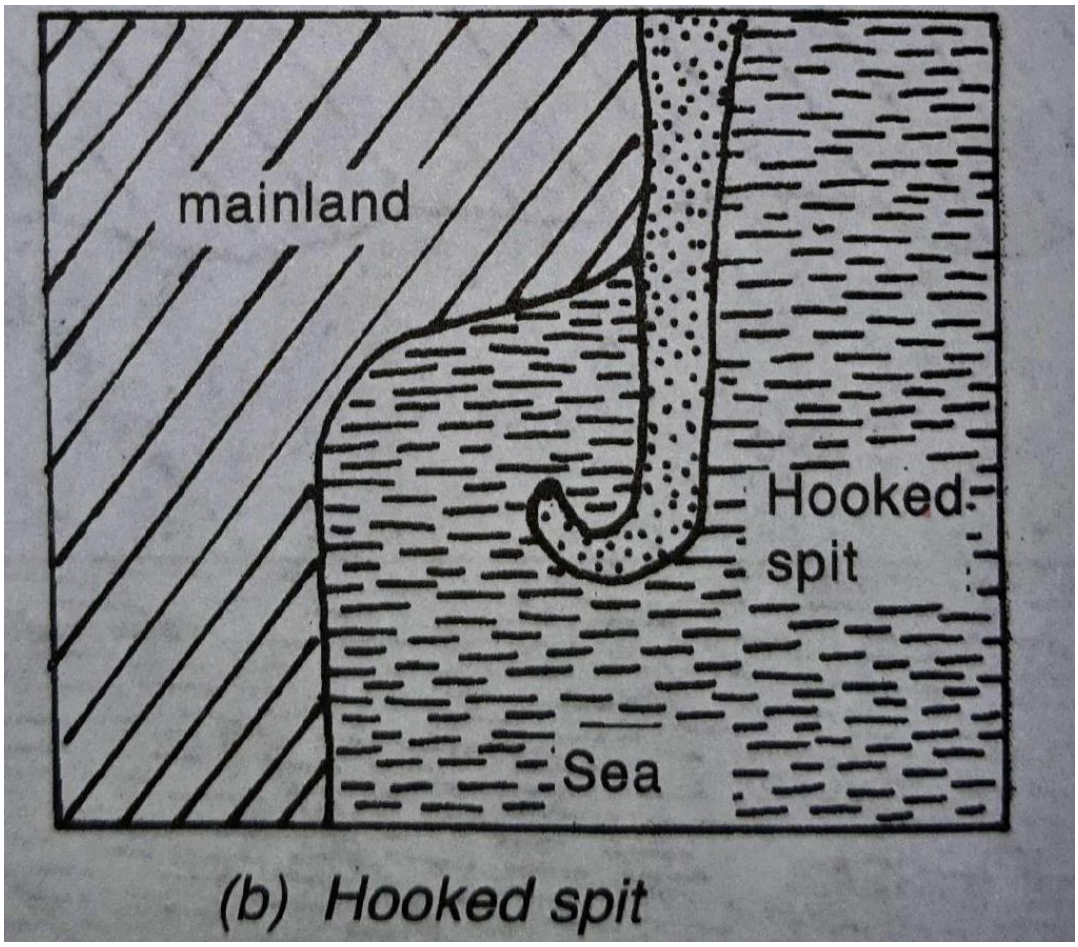
This is a long , narrow ridge of pebbles , sand or shingles linear in form joined to the land at one end, with the other end projecting into the sea. A spit is formed by the process of longshore drift in areas with indented coastlines , where materials are deposited and it grows out from a headland into the sea.



Types of spits include;

a) Hooked spit

This is a type of spit with its open seaward end hooked or curved. The formed due to waves advancing obliguely to the shore tending to swing round the end of the spit, causing it to curve. Example can be seen at Kibanga on L. Victoria, at Butiaba on L. Albert.

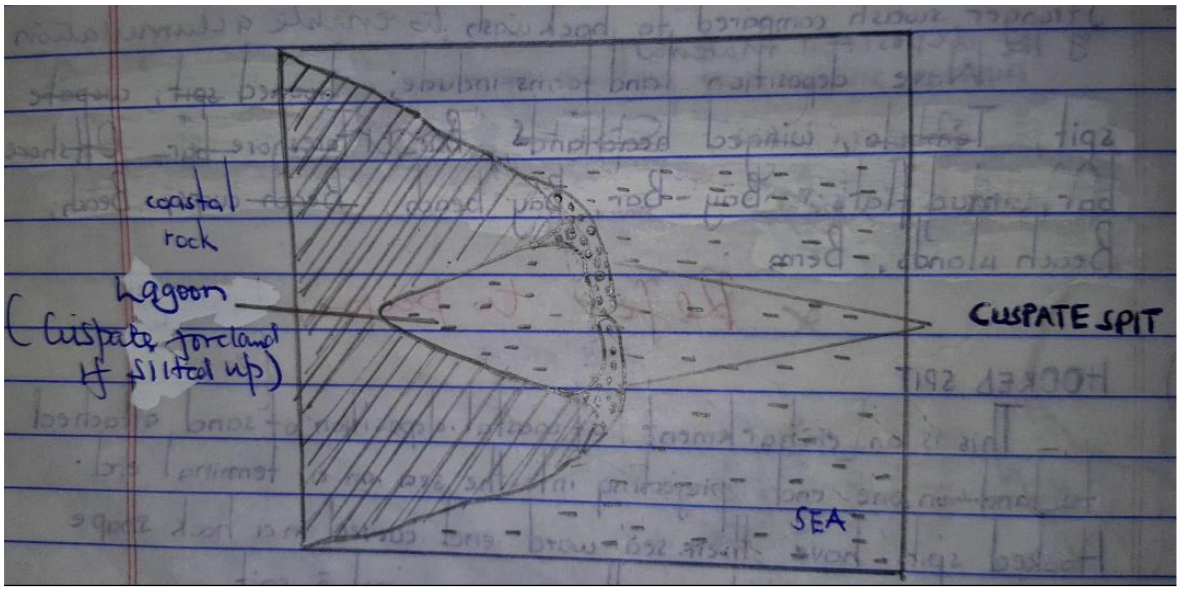


b) Cuspate spit

This is a large triangular shaped deposit of sand projecting sea- ward formed as a result of converging of two spits growing towards each other enclosing a lagoon. Further deposition enlarges the cuspate and a lagoon may get silted up and then colonized by vegetation leading to formation of **cuspate foreland.**

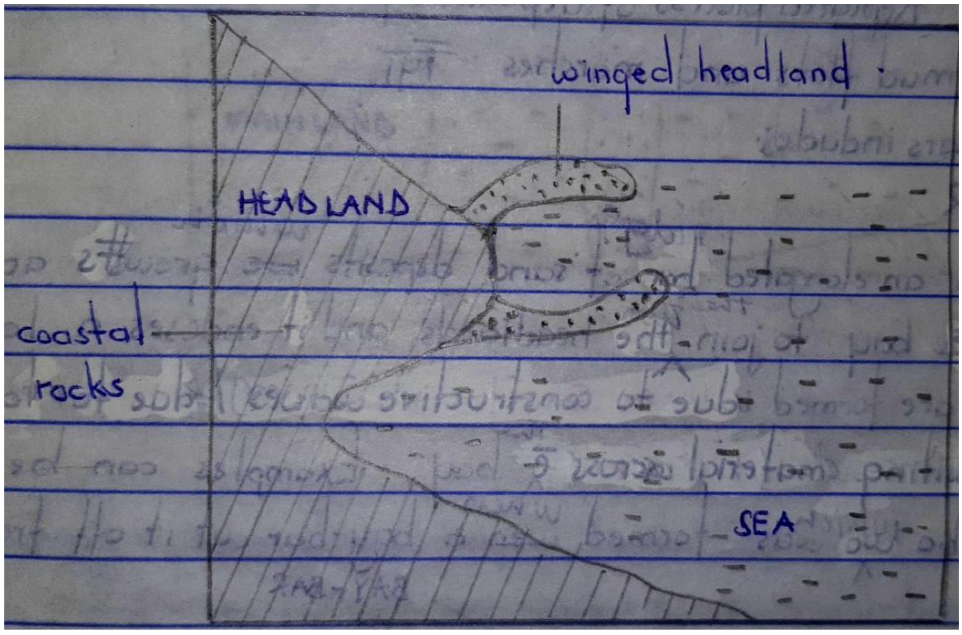
Cuspate spits are formed due to long shore drift. These can be seen at Lagodo , Tonya point on L. Albert.

NB: Cuspate spits can also form due to curving of a single spit until it becomes attached to the shore again.



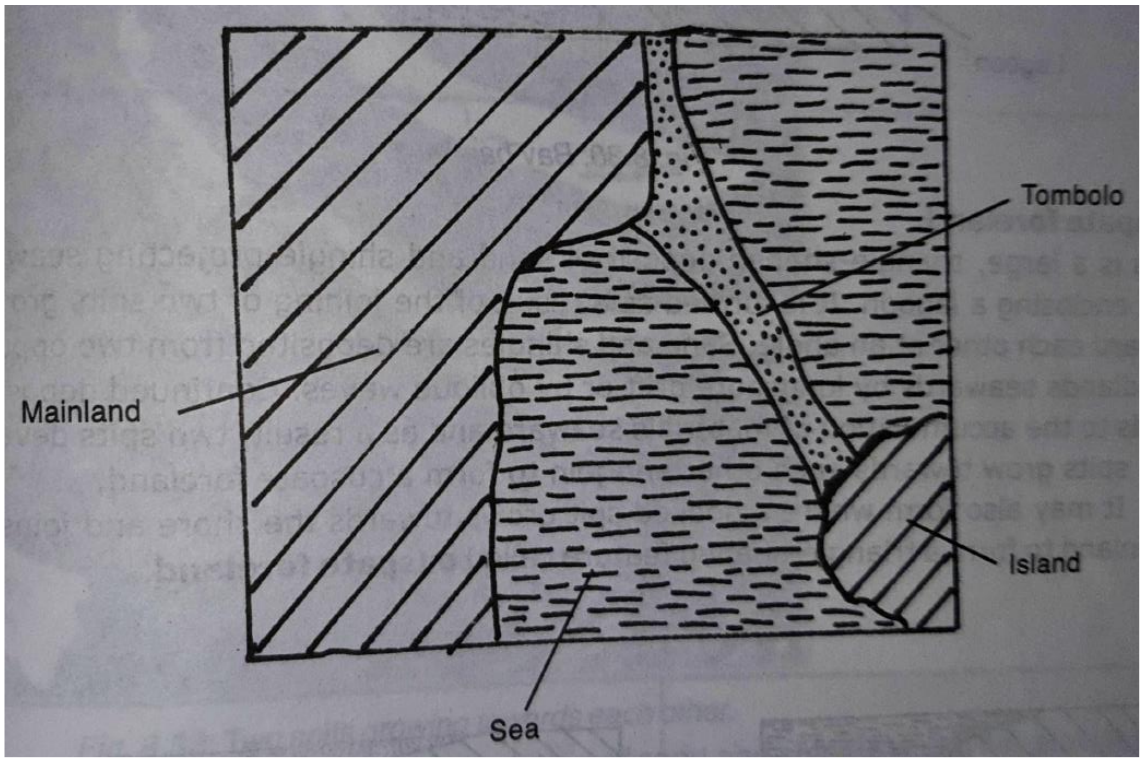
c) Winged headland

These are spits attached on both sides of the head land projecting into the sea. They form through deposition of sand and pebbles by the longshore drift.



d) Tombolo

This is a linear accumulation of sand, pebbles and shingles joining the mainland to an island or linking an island to an island. It is formed when sand and shingles are deposited from the mainland seaward by long shore drift. Deposited material gradually extends towards the island linking the two. Examples include Lunkulu island to Namazina landing site at Kibanga on L. Victoria, Bukakata – Lambu island on L. Victoria.



4. Mudflats

These are platforms of mud, silt and other forms of alluvium deposited along the gently sloping coasts especially in bays and estuaries. They develop when rivers and waves deposit materials along the gently sloping coast between high and low tide levels. Examples can be seen at mouth of R. Rufigi near Tanga.

Questions.

1. Examine the effect of constructive waves on the coastal areas of East Africa.
2. Describe the coastal land forms which have resulted from wave deposition in East Africa.
3. Examine the influence of long shore drift on land form development along the coastal areas of East Africa.
4. To what extent has long shore drift influenced the development of depositional coastal features in East Africa.

Importance of coastal wave features

- These features have unique and beautiful sceneries that attract tourists bringing revenue and foreign exchange to the economy.
- Sand mining along the sandy beaches earns income and revenue to the local community and governments respectively for example at Kasenyi landing site on Lake Victoria.
- Bays, lagoons are good fishing grounds as they are protected from strong waves and winds by cliffs and headlands for example at Kasenyi on lake Victoria
- Some wave features such as beaches are used for leisure and recreational activities for example Nyali beach along the East African coast, Lido, Nabugabo, Lutembe and Kasenyi beaches on L. Victoria.
- Some features such as mudflats have fertile soils suitable for agriculture.
- Mud flats have fine silt suitable for mangrove swamps growth. Mangrove vegetation is a source of raw material for the craft industry, fishing industry by providing the " floaters" etc. For example at the mouth of R. Rufigi on the East African coast.
- Cliffs once crossed by rivers into the sea , form water falls which are utilized for hydro electric power generation for example along R. Pangani in Tanzania.
- Cliffs shelter the mainland from strong winds and wave attack making them safe for settlement.
- Coastal wave features are used for research and study purposes for example bays, cliffs, beaches at kasenyi on Lake Victoria.

- ❖ Sheltered bays along the water bodies are used as water vessels landing and anchoring sites for example Nabugabo bay, Kasenyi bay on L. Victoria.

SEA LEVEL CHANGES (EUSTATISM) AND THE RESULTANT FEATURES.

Sea level change refers to the rise and fall of the sea level worldwide relative to the adjacent land. Sea level change can also be defined as the vertical movement of the land relative to the sea that results into a fall or rise in the water levels world wide.

Sea level changes are also referred to as **Eustatic changes**. Sea level changes are grouped into two;

a) A **positive** sea level change which implies to a rise in sea level. It is also termed as **Marine transgression**. It results into the **sub mergence** of coastal area.
b) A **negative** sea level change which implies to a **fall** in sealevel and it is also known as **marine regression**. It results into **emergence** of coastal areas/features.

On the other hand, **isostatic changes** refer to a rise or fall of sea level relative to the land on a **local** or **minor scale.**

The changes are due to **local earth movments** and they affect **particular coasts**. The changes may also result from isostatic adjustments due to **unloading or loading** of the crust.

Isostatic changes also involve **positive** movements leading to **submergence** and **negative** movements that result in **emergence.**

Causes of sea level changes

1. **Tectonic movements**

   Upwarping of the coastal areas results into a fall in the sea level while down warping of the coastal lands results into a rise in the sea level. For example the local sinking at Kilindini along the Kenya coast in Mombasa led to arise in the sea level relative to that of the land.

   Upwarping within the ocean basin will result into arise in the sea level while down warping in the ocean basin results into a fall in the sea level.

   Expansion of the ocean basin due to plate divergence causes a fall in the sea level while the contraction of the same basin due to plate convergence produces a rise in the sea level.

   A regional uplift of the coastal areas due to faulting results in a fall in sea level while sinking of the coastal areas due to faulting results in a rise in sea level.

   Volcanic activities with in the ocean where magma is poured at the ocean floor and accumulates to higher levels forming mountains displacing water upwards, results into a rise in the sea level. For example at the Mid-Atlantic Ridge in the Atlantic Ocean.

2. **Sedimentation**

   Rivers erode, transport and deposit sediments in ocean basins which displace water upwards resulting into a rise in sea level. Water run off along the adjacent areas also erodes and deposits material within the ocean basins displacing water upwards leading to sea level rise.

3. **Climatic factor.**
   - **(i) Pluviation**
     Increase in rainfall contributes to an increase in water entering the ocean basins either directly from the sky or indirectly from streams. The added water causes a rise in sea level relative to the adjacent land for example Eilnino in the late 1990's and prolonged rainfall in 2019/2020 has contributed to a rise in water levels in L. Victoria.
   - **(ii) Dessication**
     Abnormal shortage of rainfall results into a fall in sea level due to excessive evaporation of water from the sea during the prolonged dry season.
   - **(iii) Temperature changes**
     High temperature warm up the water body making the water molecules to expand and thus an increase in sea level. Low temperatures result into contraction of water molecules leading to a fall in sea level.
4. **Isostatic changes**
   Addition of material on continental areas increase weight on those areas causing continents to sink slowly hence a rise in sea level for example ice accumulation during the ice age . After the melting of the ice sheets, isostatic uplift of land masses occurred leading to a fall in sea level.

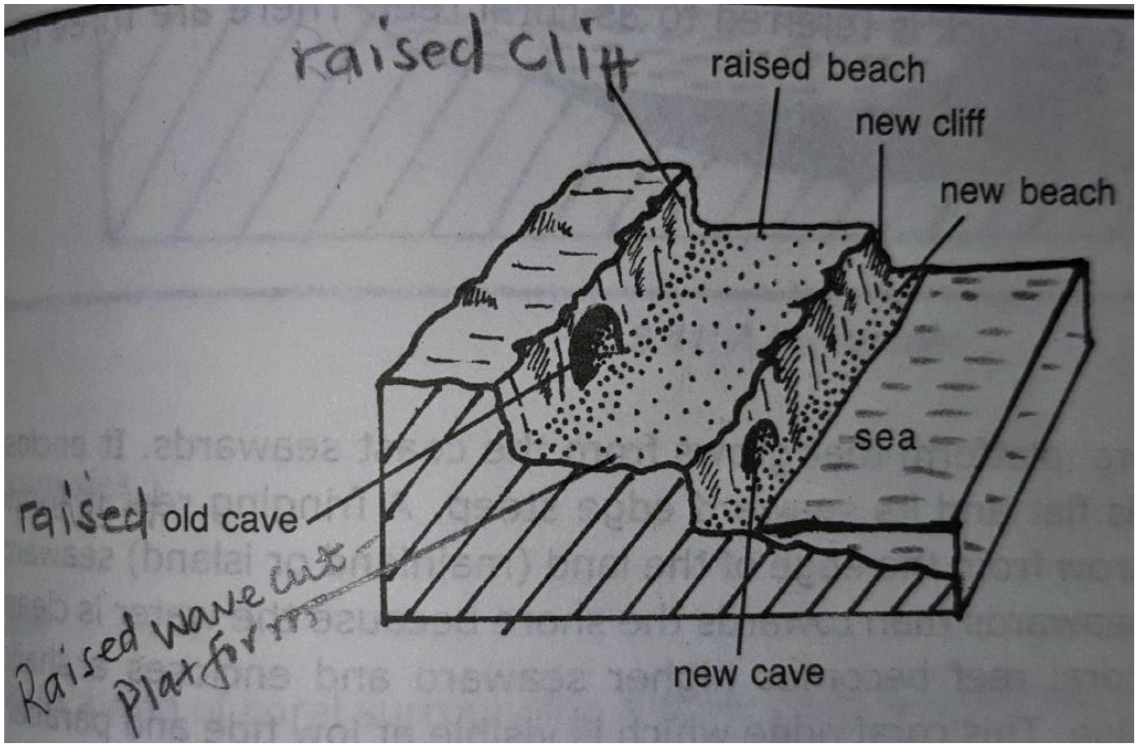
5. **Deglaciation**
   It refers to melting of ice/snow due to global warming . The melt water finds its way into the sea causing a rise in sea level.

6. **Glaciation**
   During the ice age, freezing of large volumes of water on high mountains and polar regions into large masses of ice caused a fall in sea level relative to the land.

LAND FORMS OF EMERGENCE (MARINE REGRESSION FEATURES)

These are caused by a fall in the sea level leading to emergence or exposure of the former continental shelf as dry land. The new coast takes a form of a wide gently sloping plain. Features of emergence include;
A raised beach, a raised cliff, a raised cave, raised terrace, raised wave cut platform, raised coral reefs etc

1. **The raised beach**
   This is a gently sloping surface with accumulation of sand shingles, pebbles deposited by constructive waves that now appears above the current zone of wave action due to a fall in a sea level. For example Tanga , Diani, Mama Ngina Drive at Mombasa , Shimoni along the East African coast , Kasenyi beach, Resort Beach, Lido beach on L. Victoria shores.



2. **Raised cliff**
   This is a steep rock face along the coast left hanging above the present zone of wave erosion. Raised cliffs were formed due to the under cutting

of the coastal rocks by hydraulic action and abrasion processes during the period of high tide levels. Examples can be seen at Kasenyi on the shores of L. Victoria, Mombasa, Malindi, Tanga , Bagamoyo along the East African coast.

3. **A Raised cave**
   This is an exposed cylindrical tunnel like opening at the base of the raised cliff formed due to wave erosion by hydraulic action and a abrasion processes during the period of contact with the sea water. It now appears above the present zone of wave erosion . examples can be seen at Kasenyi on the shores of L. Victoria.

4. **Raised terrace/Raised wave cut platform**
   This is a gently sloping surface at the base of a raised cliff that is no longer in contact with the water. It was formed due to the undercutting action ofwaves at the cliff base during the contact with sea water. It is now above the zone of wave action . It can be seen at Kilifi, Malindi on the East African coast.

5. **Raised coral reefs**
   When the sea level falls, the coral reefs are exposed on the surface and they are no longer in contact with water. Such coral reefs are refered to as raised coral reefs. For example at Bamburi, Mombasa along the East African coast.

Questions

1. Account for the marine regression features along the East African coast.
2. Examine the effect of marine regression on land form evolution along the coast.

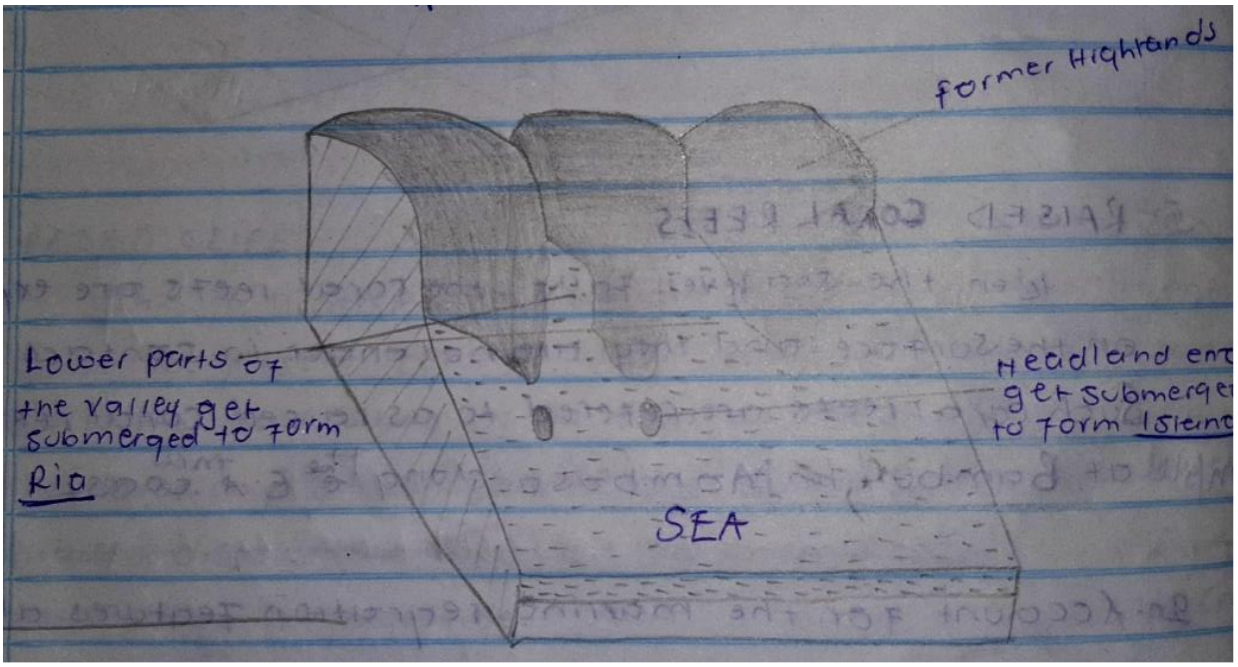
LAND FORMS OF SUBMERGENCE (Marine transgression landforms)

When the level of the sea rises, the coast adjacent to it gets submerged resulting into formation of submergence features. Land forms of submergence are grouped into tow; Submerged upland coasts and submerged lowland coast features.

Submerged upland coast features

1. **Ria**

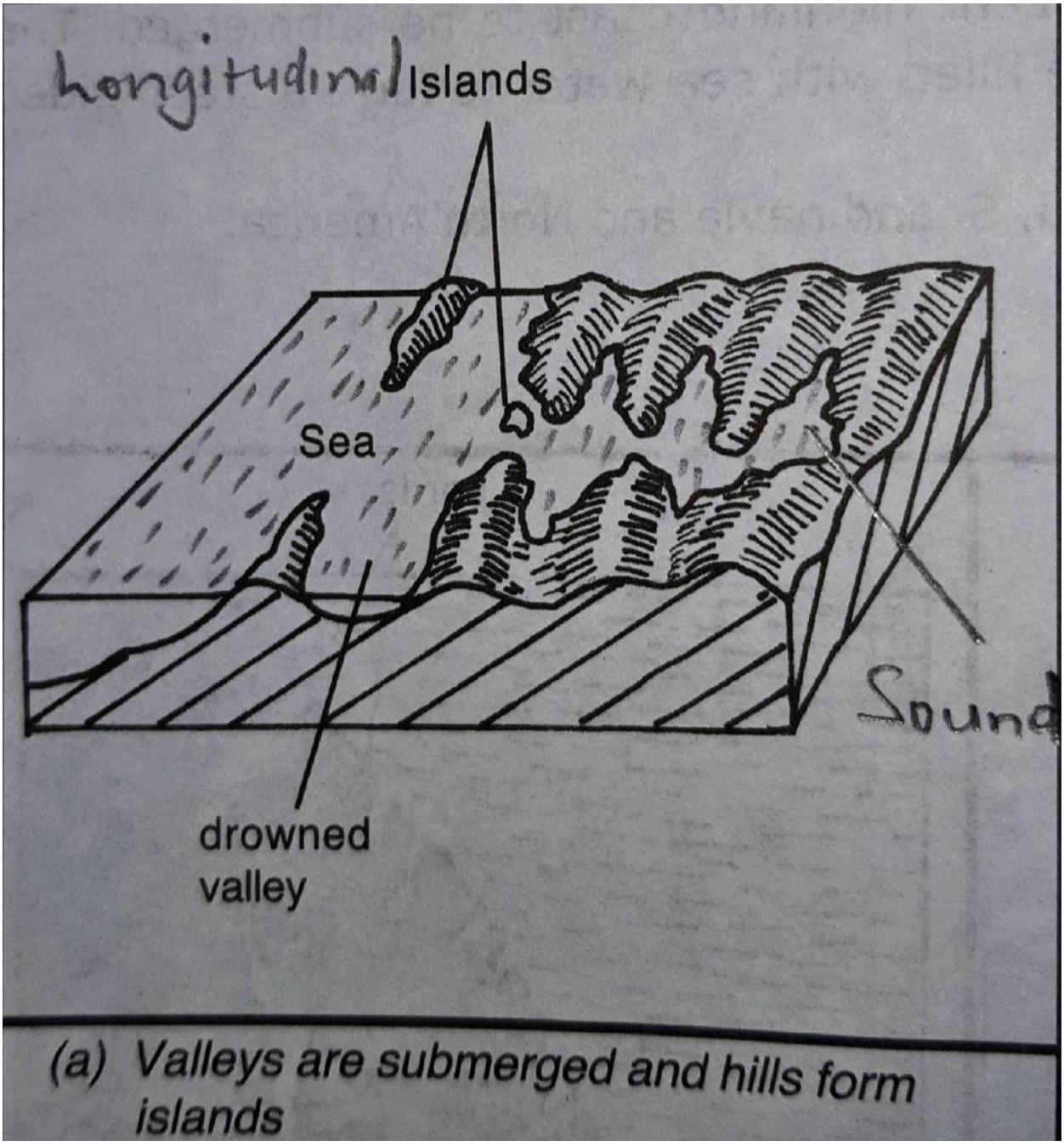
   This is a funnel shaped drowned river valley which is wider and deeper seawards than landwards i.e It is formed when river valleys and highlands meeting the coast at approximately right angles get flooded/submerged. Examples can be seen at Mtwapa , along R. Mwachi near Mombasa, at Kilindini along the Kenyan coast , Dar-es-salaam, Pemba in Tanzania, Southern shores of L. Victoria etc.



2. **Dalmation coast/longitudinal coast/island coasts**

   These form on coasts where ridges/highlands and valleys originally running parallel to the sea are submerged due to arise in sea level and the tops of the ridges or highlands now appear as chains of islands.

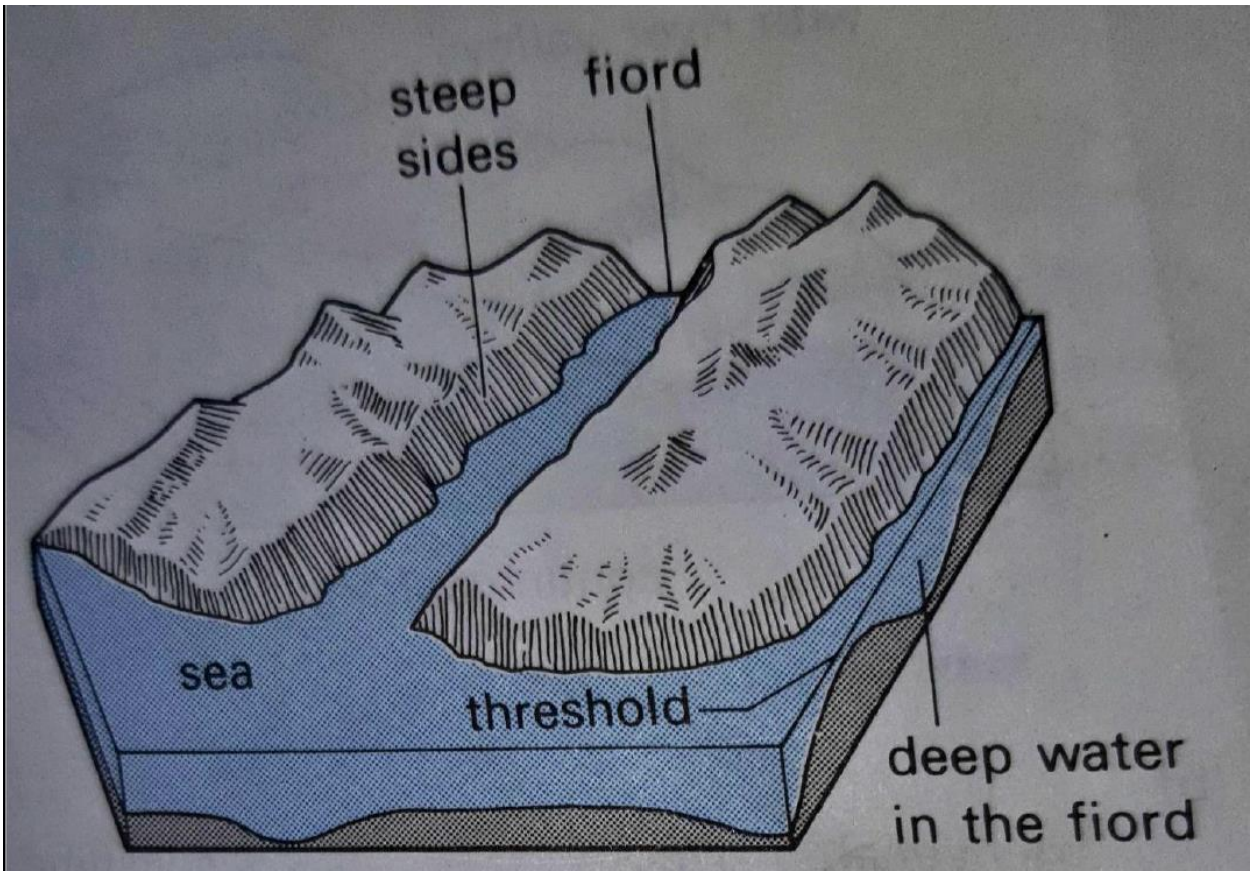
The islands are referred to as **Dalmation or longitudinal coast** example Bambuli hills, South of Bukoba on L.Victoria , Pemba and Zanzibar coast. The drowned valley (water body) that now separates the main land from the island is termed as the **sound** for example Smith sound on Southern shores at L. Victoria of Mwanza, Bambuli hills south of Bukoba on L. Victoria.



(a) Valleys are submerged and hills form islands

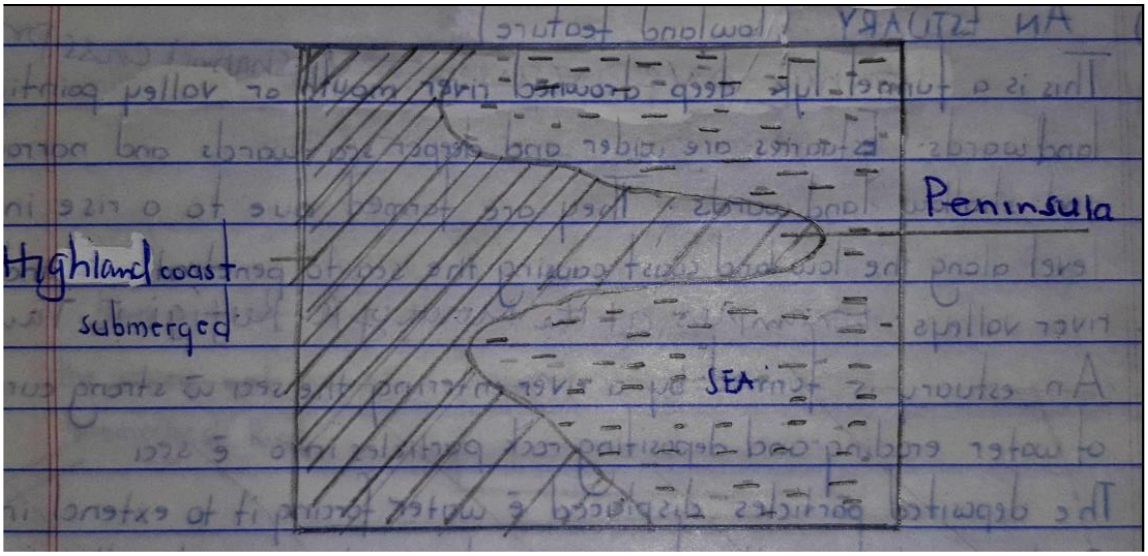
3. **Fiords**

These are submerged glacial troughs found in glaciated upland coastal areas. They are deeper landwards and shallow seawards. Fiords form when highland coastal areas are affected by glacial erosion, through abrasion and plucking processes that creat deep and steep sided U – shaped valleys which are later drowned when sea level rises. Examples include along the coasts of Norway, Sweden , Canada, New Zealand etc.



4. **Peninsula**

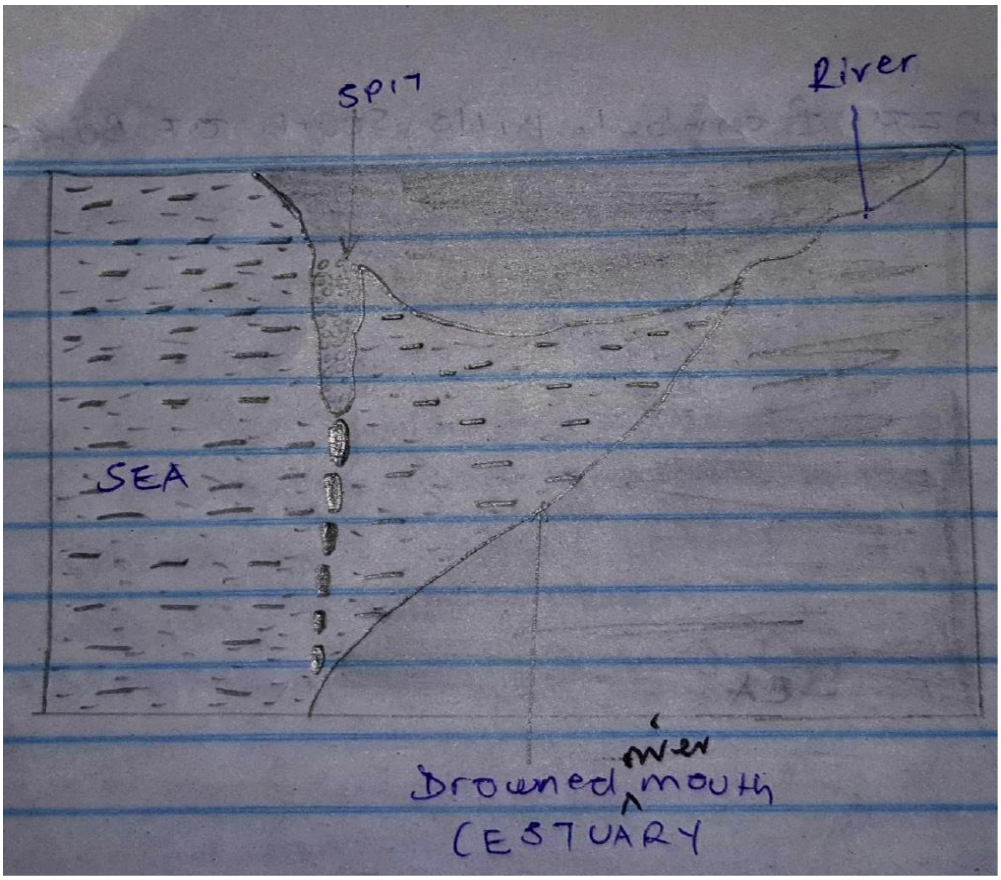
This is an elongated piece of land projecting sea- wards between bays . Its formed when a highland lying at right angle to the coast and its valleys get drowned leaving the highland projecting sea- wards as a Paninsula eg Entebbe peninsular on L. Victoria, Mweya peninsular on L. Edward.



Features in submerged lowland coasts

1. **An estuary**

   This is a drowned river valley with a V – shaped cross profile pointing landwards. Estuaries are wider and deeper sea- wards and narrow and shallow land wards. They are formed due to a rise in sea level along the low land coast causing the sea to penetrate inland along the river valleys. Examples at the mouth of R. Rufigi in Tanzania.



2. **Mudflats and lagoons**

   Mudflats are platforms of mud formed due to deposition of fine silt and alluvium from rivers or waves that accumulate in the shallow water. Sediments are deposited in water either behind bars, sand spits or sheltered parts of estuaries and bays. At the coast, such deposits enclose water and separate it from the rest of the sea to form a lagoon for example at the mouth of river Rufigi, Mombasa, Tanga , Lamu etc

3. **Creeks**

   These are narrow in- lets formed by submergence of small streams due to a rise in sea level for example Mtwapa in Tanzania, Kilifi, Makupa ,Chake chake, at Mombasa along the Kenyan coast.

Effects of sea level changes on human activities

Positive

Rias have deep sheltered waters which make them suitable for the establishment of harbours and ports for example at Kilindini, Mombasa, Dar es salaam along the East African coast.

The beautiful and unique features such as raised beaches, raised caves, rias attract tourists, earning foreign exchange, revenue and income to the region.

Mudflats have been drained and utilized for cultivation of crops such as rice along the East African coast.

Mud flats have supported the growth of mangrove swamps which are important sources of fuel wood and timber to the region for example along the Tanzanian and Kenyan coasts.

They are sites for sand extraction used for building and construction purposes for example along the raised beaches such as Kasenyi on the shores of L. Victoria, from mudflats and estuaries on the East African coast. The sand is also a potential raw material for the glass manufacturing industries.

The sheltered waters of the rias and fiords provide suitable breeding grounds for fish for example the rias at Mtwapa, Kilindini Kalifi along the Kenyan coast, Dar es salaam on the Tanzanian coast, Fiords of Norway and British Columbia in Canada.

Raised beaches, raised cliffs promote recreational activities and the film production industries for example at Kasenyi raised beach on the shores of L. Victoria.

Features resulting from sea level changes are used for research and study purposes by various institutions for example raised beaches, rias, raised cliffs etc.

Extensive raised coastal plains provide suitable sites for human settlement for example along the East African coast, along the shores of L. Victoria.

Negatives

Steep raised cliffs are susceptible to mass movements that are destructive to lives and property.

The steep sides of fiords hinder settlement and navigation along the glaciated coastal areas.

Mudflats at the mouth of drowned river valleys hinder smooth navigation along the rivers for example along river Rufiji.

Submerged lowland features are more susceptible to flooding discouraging settlement and agriculture.

Submerged coast areas provide suitable conditions for mosquito breeding, snails which transmit diseases to man.

Questions

1. Describe the causes of sea- level changes in the coastal areas of East Africa.
2. Describe the landforms resulting from a rise in sea level.
3. Examine the processes of formation of the emerged coastal landforms in East Africa.
4. Account for the transgression land forms in East Africa.
5. Differentiate between emergence and submergence of coastal land forms in East Africa.
6. Describe the land forms resulting from submergence of the coastal areas in East Africa.
7. With reference to East Africa, examine the processes of sea level changes and their effect on coastal lands.

CORAL REEFS

(CORAL LANDFORMS)

Coral reef is a lime stone rock type formed by continued deposition accumulation and cementation of skeletons of dead marine organisms known as coral polyps.

Processes of formation of coral reefs.

Coral landforms are formed when coral polyps die and the shells or skeletons made of calicium carbonate accumulate on the continental shelf. With time, the

coral deposits increase in weight, become compressed, compacted and cemented to form a consolidated mass of rock known as coral reef.

The process of consolidation of reefs is facilitated by other organisms such as algae, sea archins etc.

Conditions necessary for coral reef formation.

Coral reefs develop under warm temperatures of tropical climate between 20^0 – 30^0 c . This temperature is ideal for the growth of coral polyps. It applies to areas between 30^0 North and South of the equator for example the Indian ocean. Coral polyps also grow where there are warm ocean currents bringing in warm conditions for example at Durban due to Mozambique warm currents.

Salty well oxygenated sea water of about 27 – 40 parts per 1000cm of salinity that encourages the coral growth since coral Polyps take up calcium carbonate from sea water to build their skeletons.

Existence of clear silt free water, away from the river mouth that allows penetration of sunlight required for plankton growth on which polyps feed.

A shallow continental shelf with a depth of less than 60 m which allows sunlight to reach the sea bottom. This enables photosynthesis by the phytoplanktons to take place providing food for the coral polyps.

Presence of solid rock bed along the coast or volcanic island upon which coral reefs grow. A continuous continental shelf along the coast is also ideal for the growth of coral reefs.

Variation in the water levels i.e high and low water levels which allow death and accumulation of coral shells to form fringing barriers and finally atoll reefs.

Water must be relatively stable to allow accumulation and compaction of the coral shells.

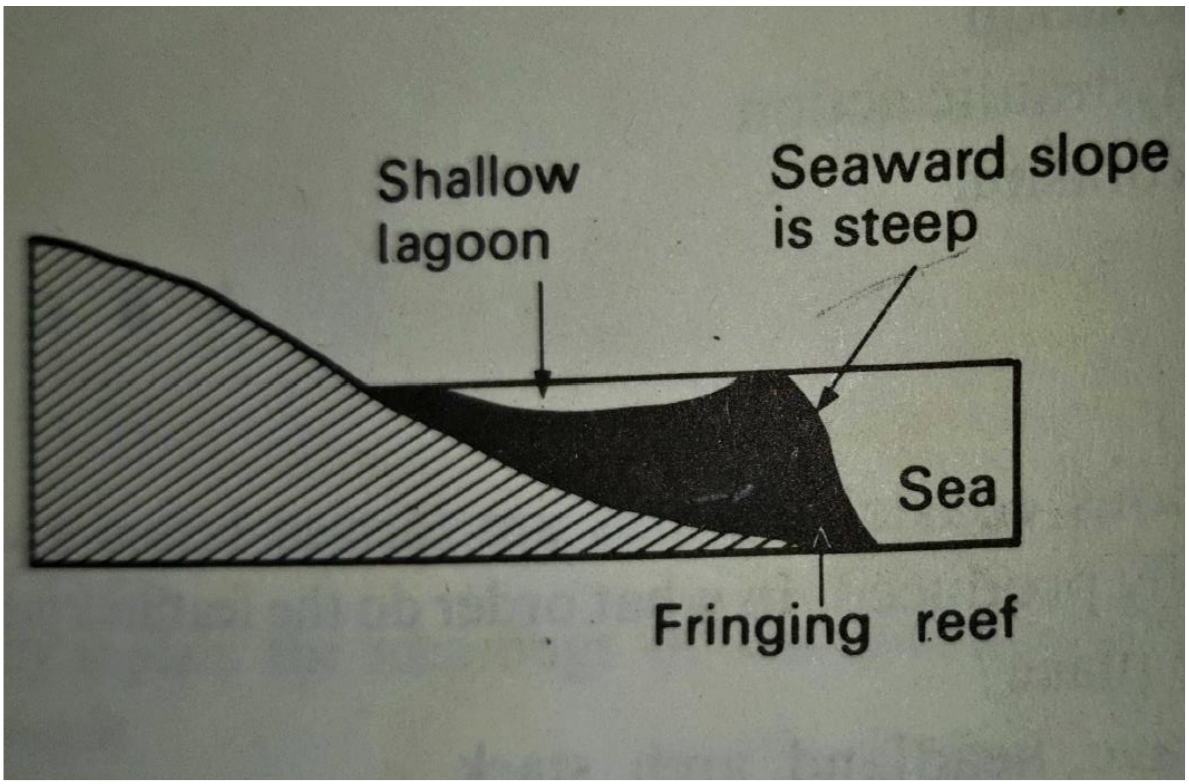
A bundant supply of planktons which is food for the coral polyps.

Types of Coral reefs

There are three types of coral reefs and these are;

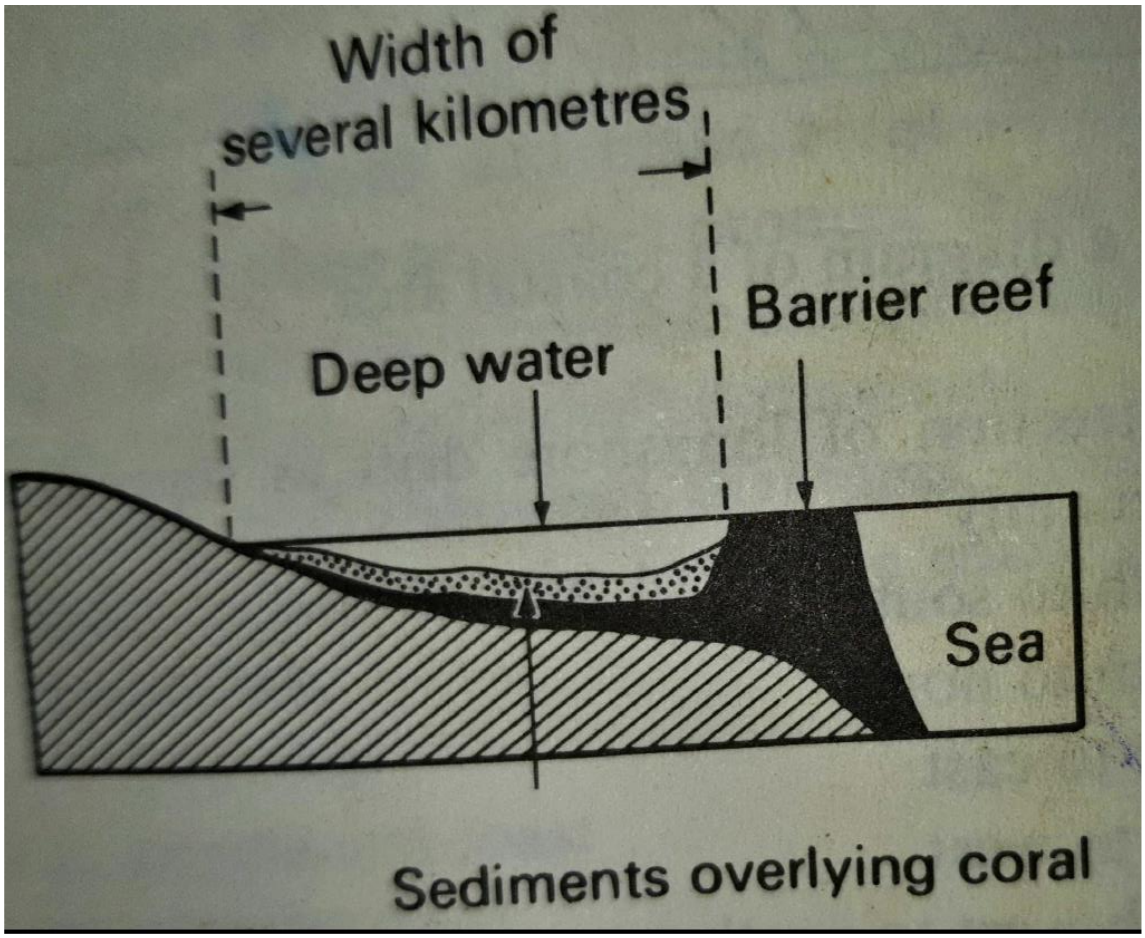
1. **Fringing reef**

   These are coral platforms of about one kilometer wide, that are joined to the coast or separated from the coast by a narrow and shallow lagoon. A fringing reef is formed very close to the coast with its seaward edge sloping steeply into the sea floor. Fringing reef is visible during low tide levels. Examples can be seen at Mombasa, Kilifi, Tanga , Dar – es – salaam along the East African coast.



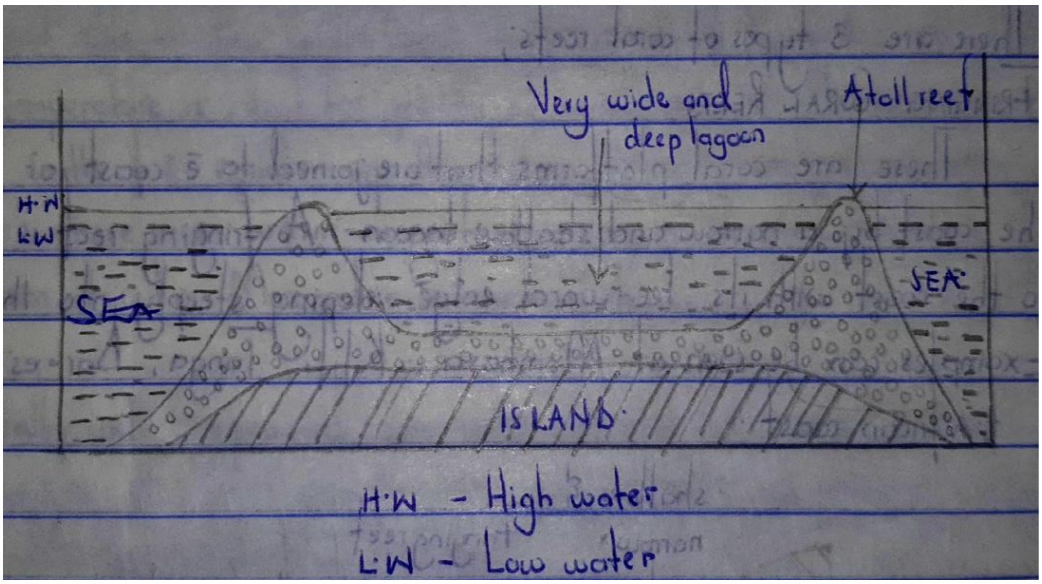
2. **Barrier reefs**

   These are coral platforms that are separated from the coast by a wide and deep lagoon. They are located several kilometers away from the coast . Barriers are not visible at lowtide levels. Examples can be seen at Mayotte island between Madagascar and Mozambique.



3. Atolls

These are circular or ring shaped coral reefs usually broken in several places by narrow channels, surrounding a fairly deep lagoon and have flat shaped floors. Examples can be seen at Aldabra between Zanzibar and Malagasy, about 700 km from the East African coast.



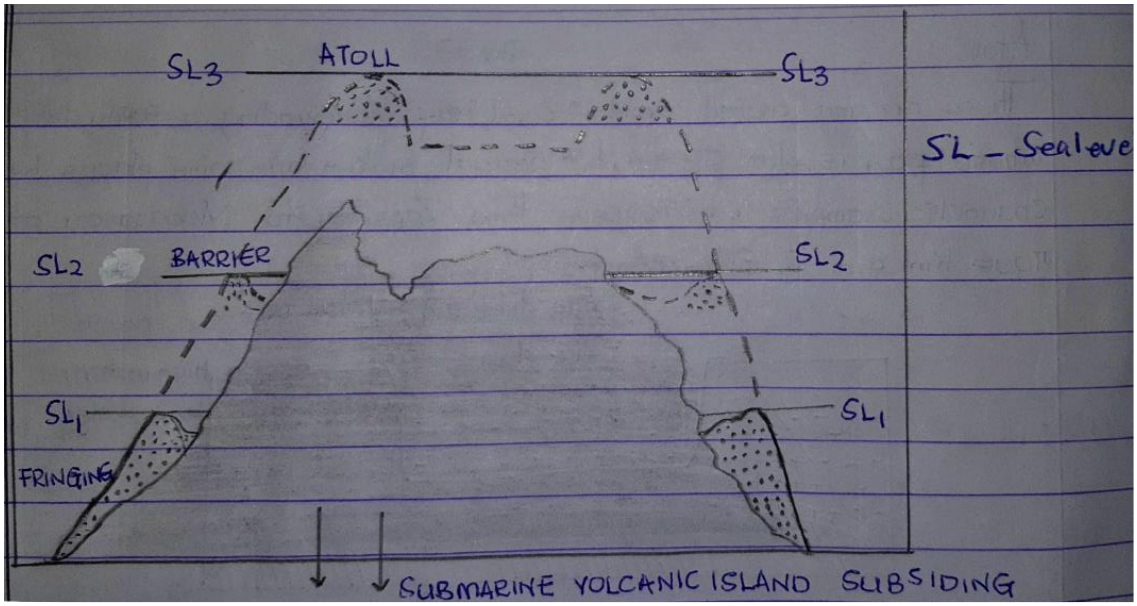
Theories for coral reef formation

Fringing reefs and some barrier reefs are formed by gradual building up from the floor of the continental shelf till they reach sea level. However, this does not apply to atolls and some barrier reefs. Theories have been put forward to explain their formation and these include;

1. **Subsidence/Darwin's theory**

   According to Darwin, coral reefs start forming on the flanks of a volcanic island as fringing reefs. As the island slowly subsides due to isostatic re-adjustments or down warping of oceanic parts, the coral reefs grow upwards and outwards keeping pace with the rate of subsidence and maintain themselves at the water surface.

   The fringing reefs at the flanks of the volcanic island grow upwards and outwards into barrier reefs and eventually into atolls when the island gets wholly submerged.



Relevance of the theory

The theory is relevant in that;

a) There was actual submergence of the East African coast evidenced by the presence of rias at Mombasa, mudflats, dalmation coast along the coastal areas of East Africa.
b) The presence of volcanic islands off the East African coast in the Indian ocean with coral reefs example at Aldabra.
c) The presence of coral shorelines all at different stages of developments along the East African coast is a proof for Darwin's theory.
d) Coral reef thickness increases downwards supporting the view of coral reef formation along the subsiding base of submarine plat form.
e) Coral reefs form on a solid sea bed especially where volcanic platforms exist as suggested by Darwin's theory.
f) The existence of lagoons partly indicates subsidence of a coral base if the base was stable, it would get filled up by deposition of sediments.

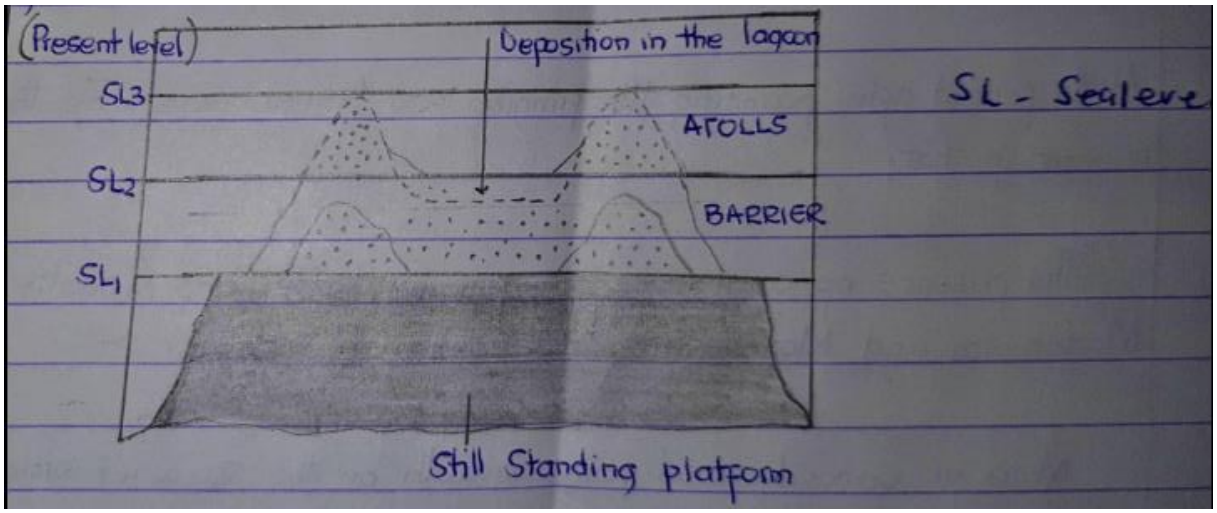
Question

Examine the relevance of Darwin's theory of coral reef formation along the East African coast.

2. Daly's /Deglaciation/Glacial control theory

According to Daly, there existed submarine still platforms from which peri – glacial coral reefs were eroded to the level of the sea.

During the deglaciation age, large volumes of glacial melt water were released into the sea causing a rise in sea level.
As sea level rose, plus a return to warmer conditions , the coral reefs started growing again on the submarine still platforms as fringing reefs. The fringing reefs continued to grow upwards and outwards keeping pace with the rate of sea level rise maintaining themselves at the water surface, gradually transforming into barrier reefs and finally into atolls when the platform got wholly submerged.



Relevance of the theory.

- ❖ Existence of coral reefs on continental shelves with fairly deep lagoons (atolls) is a proof for the upward and outward growth for coral reefs during the sea level rise.
- ❖ Most old coral reefs along the East African coast were eroded by wave action to the level of the sea during a fall in the water level.
- ❖ Most coral reefs along the East African coast were formed during the post – glacial period as explained by Daly's theory.

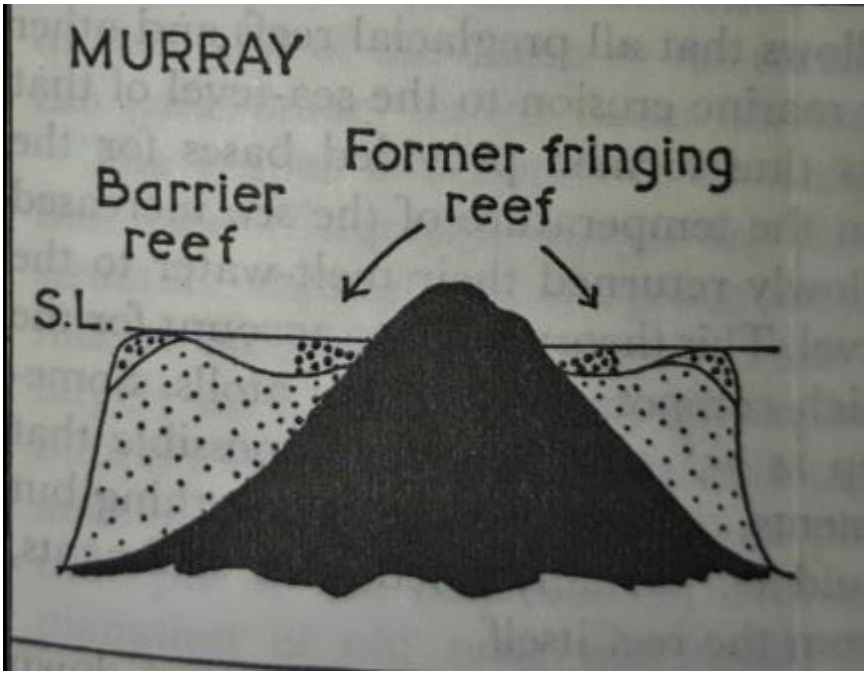
3. Murray's theory/Antecedent theory

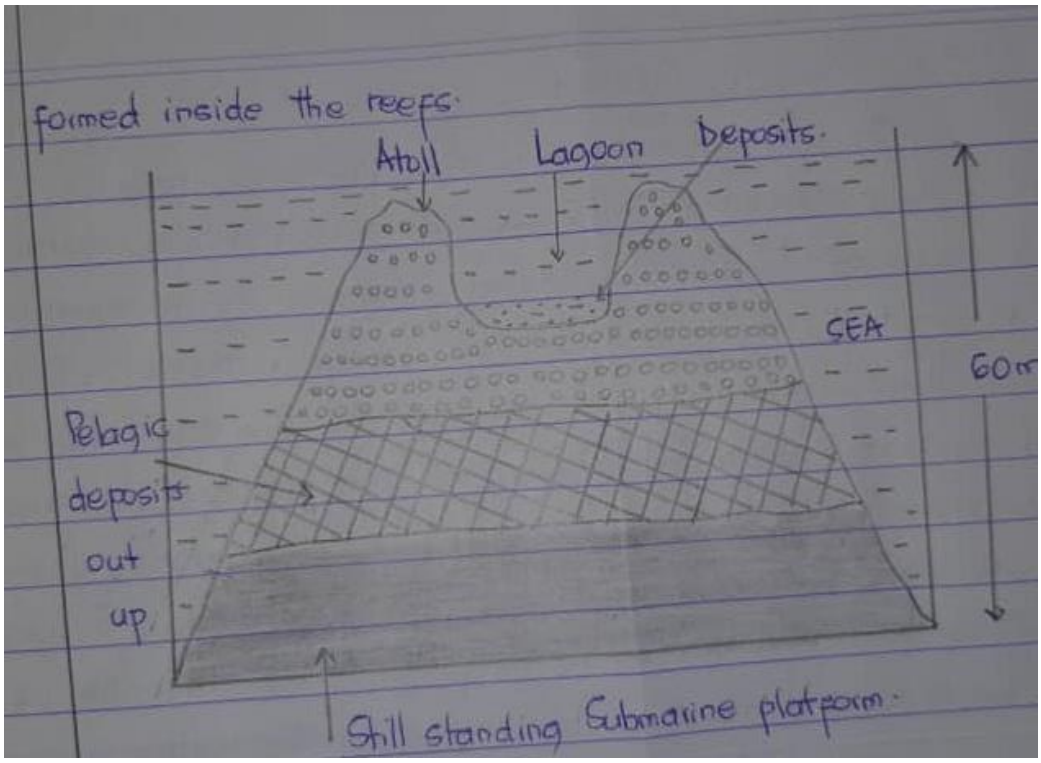
According to Murray , coral reefs developed on a stable submarine platform of pelagic deposits lying at a depth of about 60 metres. Coral reefs started growing on this stable platform as fringing reefs and later pounded by wave action into debris that accumulated on the seaward side of the reef where they got cemented into a hard rock.

Coral reefs further grew upwards and outwards upon the bases of their own debris. There was more rapid growth on the seaward than on the landward side.

As the corals on the inner side got deprived of food, they died and their skeletons got dissolved creating a deep lagoon between the land and the reef hence the formation of a barrier reef.

The lagoon deepened and widened further while barrier reefs continued to grow upwards and outwards in all directions transforming into atolls , with a ring shaped pattern around the lagoon.





Relevance of Murray's theory

- ❖ Presence of more pronounced coral polyps growth on the sea ward side than the land ward side .
- ❖ Existence of coral fragments in lagoons between reefs.
- ❖ The steepness of the coral reef is greater on the seaward side than on the landward side.
- ❖ Existence of coral reefs along the East African coast for example fringing reefs at Kilifi, barrier reefs at Mayotte between Madagascar and Mozambique and atolls around Aldabra.

Criticism to Murray's theory.

1. The theory involves two contradictory views of marine erosion and deposition at the same time over different submarine platforms.

2. Lagoons form due to solution of dead corals meaning that even pelagic deposits laid down on the submarine platforms would also be dissolved.
3. Existence of stable platforms means that the lagoons would be completely filled up with the marine sediments and then disappear.

IMPORTANCE OF CORAL REEFS

Positive

1. Coral limestone is a source of building material for example at Bamburi cement works, Mombasa in Kenya .
2. Coral rocks are directly used as building materials and for interior designs and decorations.
3. Fringing coral reefs like the ones of Mombasa contribute to the development of sheltered harbours as the reefs protect the coast against strong winds and waves.
4. Coral reefs because of their unique and beautiful nature attract tourists and this earns foreign exchange to the region for example at Mombasa in Kenya.
5. Enclosed lagoons along the East African coast form good recreational sites for swimming and bathing since they are sheltered from the attack by animals from the sea.
6. Corals are major indicators of oil wells because oil forms from accumulation of dead organisms.
7. When weathered, coral reefs break down to provide suitable soils for growing crops particularly coconuts and cloves for example at Zanzibar and Pemba.
8. It's a source of medicine for treating various diseases such as cancer.
9. They act as sites for research and study purposes.
10. Offer strong foundations for the construction of buildings.
11. The enclosed lagoons can be used as fishing grounds as the lagoons are sheltered from predators.

Negative

1. Massive coral growth on the sea floor interrupts the sea fishing activities as the sharp coral rocks tear the nets.

2. Barrier reefs and fringing reefs may hinder navigation as the water vessels may run into them resulting into breakage.
3. Coral rocks weather down to form limestone soils that are largely porous and unsuitable for the growth of deep rooted plants.
4. Quarrying of limestone leads to land degradation.
5. Fringing reefs occupy breeding places for fish hence leading to a reduction in fish numbers.
6. Lagoon enclosed by fringing coral reefs are at times transformed into swamps which are suitable breeding places for mosquitoes and snails which transmit diseases to man.
7. Mining and processing coral produce dust which pollutes the air/ environment.

Questions

1. Examine the relevance of Murray's theory of coral reef formation along the East African coast.
2. Account for coral landform formation in East Africa.
3. (a). Distinguish between fringing reefs and barrier reefs.
   (b). Describe the conditions that have favoured coral landform development along the East African coast.