Edexcel IGCSE Geography

Your notes

Coastal Processes & Landforms

Contents

- Coastal Processes
- Coastal Landforms
- Coastal Environmental Change

Your notes

Wave action & erosion

- Coasts are the meeting point of land and sea
- They are an **open system** with inputs (sediment), transfers (longshore drift), stores (beach) and outputs (water)
- Coastal processes are divided into two parts:
  - **Marine** processes: **offshore** (water-based)
  - **Terrestrial** processes: **onshore** (land-based)
- These processes are then sub-divided into:
  - Wave action
  - Erosion
  - Transportation
  - Weathering
  - Mass movement
- It is these activities that are responsible for producing distinctive landforms found on the coast

Wave action

- Waves are **marine processes**
  - They erode, transport and deposit material
- Waves are formed by winds blowing over the surface of the sea
- The height and strength of a wave is dependent on 3 factors:
  - the **fetch**
  - the amount of time the wind blows
  - the strength of the wind
- The greater the strength, time and fetch of the wind, the larger the wave
- As a wave approaches the coast it enters shallower water; friction from the sea bed causes the wave to lean forward and eventually crest and break onto the beach
- The movement of water up the beach is called the **swash**, and the return movement is the **backwash**

Types of waves

- There are two types of waves:

- **Destructive** waves erode the beach
- **Constructive** waves are beach builders

Your notes

Constructive waves

- Strong swash
- Weak backwash
- Long wavelength
- Low wave height
- Low frequency (6–8 waves a minute)
- Gently sloping beaches

Destructive waves

- Weak swash
- Strong backwash
- Short wavelength
- High wave height
- High frequency (10–12 a minute)
- Steep beaches

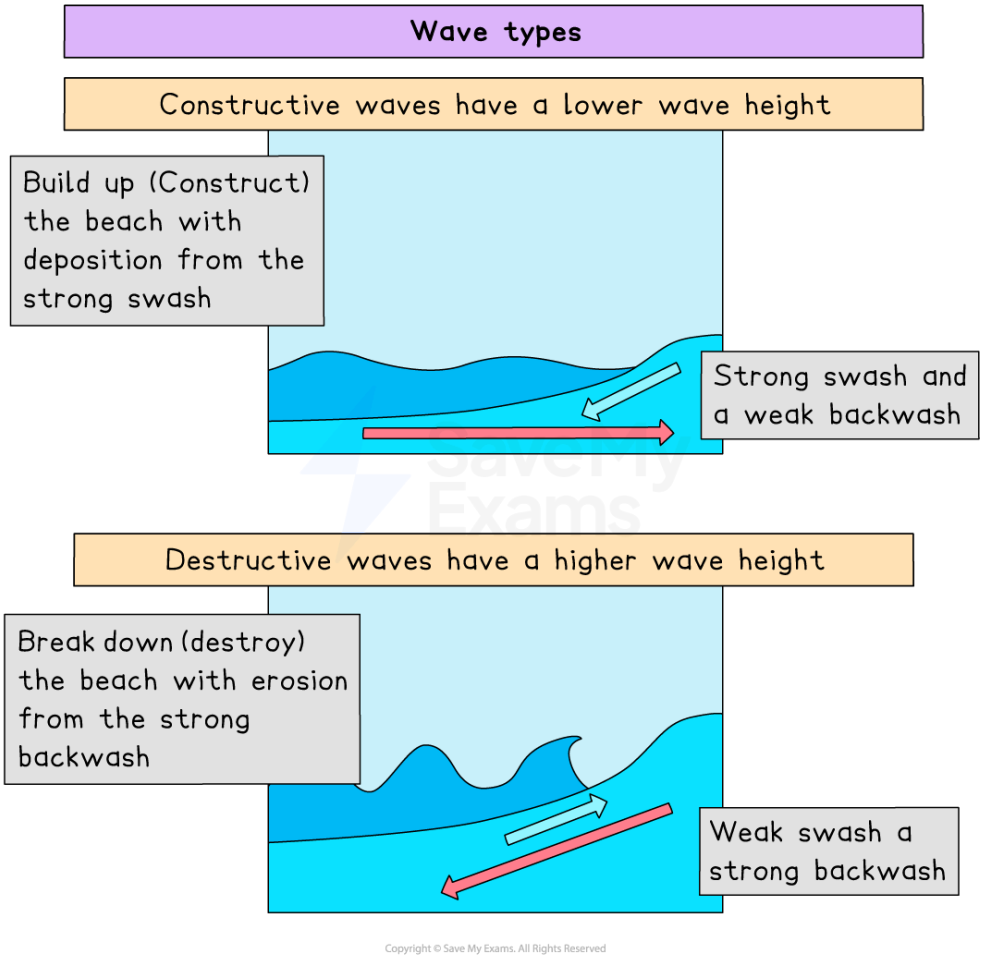


Diagram showing constructive and destructive waves

Your notes

Examiner Tips and Tricks

Make sure you are familiar with how waves form and their different characteristics. You may be asked to identify the type of wave from a list of characteristics referring to wave length, height and strength of swash and backwash.

Worked Example

Which statement below, best describes the characteristics of a destructive wave? (1)

A. Long wavelength & weak backwash

B. Short wavelength & weak backwash

C. Short wavelength & strong backwash

D. long wavelength & strong backwash

Answer

- The answer is C **(1)**:
  - A destructive wave has a short wavelength, high-frequency rate, steep wave gradient & a strong backwash
- The alternative answers are incorrect because:
  - A is a constructive wave
  - B and D are neither constructive nor destructive

Your notes

Erosion

- Destructive waves erode the coastline in four ways:
  - **Hydraulic action** is the sheer force of the waves hitting the coast
  - **Attrition** occurs when material carried in the waves bumps against each other and becomes smaller and smoother. This does not erode the coast but forms the sand and shingle
  - **Corrosion** is when seawater is slightly acidic and gradually dissolves some types of coastal rock (e.g. limestone)
  - **Abrasion** occurs when waves pick up material and hurl it at the coast

Examiner Tips and Tricks

Make sure you know the difference between the four types of erosion, particularly between **abrasion (corrosion)** and **attrition**. Many students confuse these two terms.

A tip for you is to think of abrasion as rubbing with sandpaper or maybe you have grazed your knees or elbows when you fell off your bike/skateboard. Those grazes were abrasions on your knees/elbows etc.

Rates of erosion

- The rates of erosion on the coast are affected by three factors:
  - Energy
  - Materials
  - Shore geometry

Energy

- The greater the **energy** available the **more erosion** takes place
- More energy is available when:
  - waves are steep, destructive waves

- waves breaking onshore
- there are strong tidal currents
- rip currents occur
- there are higher winds

Your notes

Materials

- The type and amount of materials at the coast affect the rate of erosion
  - Large amounts of material increase abrasion
  - When more material comes into the system than leaves the system this leads to the formation of larger beaches
  - Large beaches absorb wave energy reducing erosion
  - More resistant rocks erode more slowly than less resistant rocks

Shore geometry

- Higher, steeper waves are created by a steep seabed, these lead to more erosion
- Bars offshore lead to waves breaking reducing their energy when they reach the shore

Transportation & deposition

Transportation

- Material at the coast arrives from:
  - Eroded cliffs
  - Longshore drift
  - Constructive waves
  - River discharge
- In the water, material is moved through:
  - **Traction** is when large heavy material is dragged along the sea floor
  - **Saltation** occurs when smaller material bounces along the sea floor
  - **Suspension** is the fine material held in the water
  - **Solution** is dissolved material carried in the water

Longshore drift

- Longshore drift is the **main process** of **deposition** and **transportation** along the coast
- The **prevailing wind** pushes the waves at an angle to the beach
- As the waves break, the swash carries material up the beach at the same angle
- The **backwash** then carries the material down the beach at right angles (90°)

- The process repeats, transporting material along the beach in a **zig-zag movement**

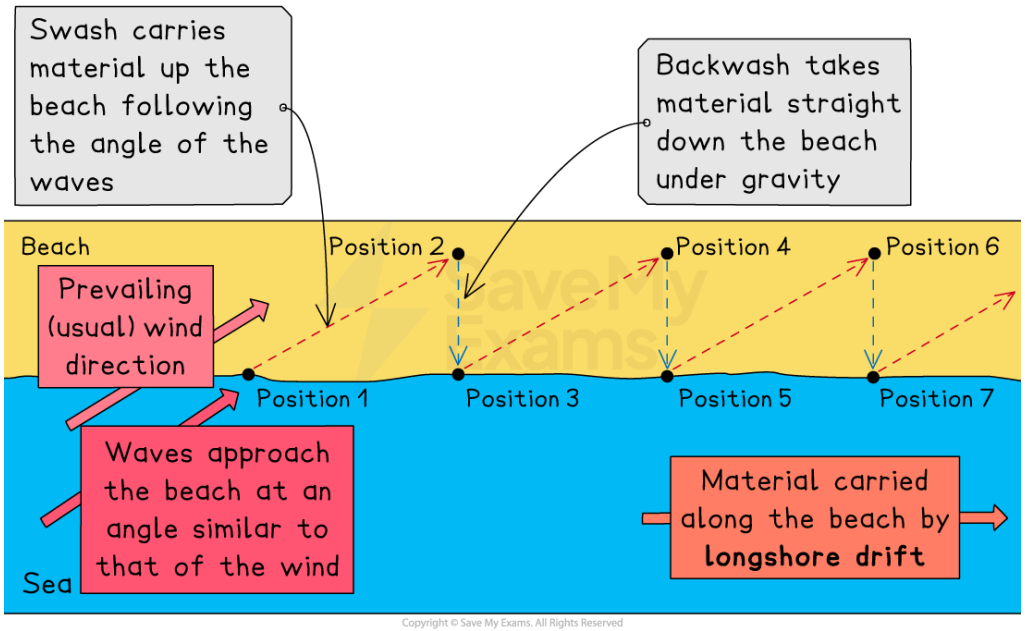


Diagram showing the process of longshore drift

Deposition

- Deposition occurs when:
  - wave energy decreases
  - there is increased friction between the water and the seabed
  - large amounts of sediment are being carried by the water
  - the water encounters obstacles causing the waves to break

Worked Example

Describe and explain the process of longshore drift

(4 Marks)

- Identify the *command words* and *link* to the key term
- Command words are '*describe and explain*' - say what you see and why
- Your focus is on '*longshore drift*' - what is it?
- **Answer:**

Longshore drift is the process where the waves transport material **(1)**, such as sand along the beach in the direction of the prevailing wind **(1)**. The swash moves material up the beach at an angle **(1)**, as the waves approach in a similar direction to the wind. The material then moves back down the beach at 90° due to gravity **(1)**, this is the

Your notes

backwash. This movement continues along the beach in a zig-zag motion **(1)** in the direction of the prevailing wind

Your notes

Examiner Tips and Tricks

You can gain full marks using well-annotated diagrams to support your answer. Just as you like having a visual prompt, it helps the examiner to see that you do know the answer. Sometimes a diagram is easier than actually writing it all out. After all, a picture paints a thousand words!

Weathering

Weathering

- Weathering is the breakdown of rock **in-situ**
  - It does not involve the movement of material, making it different from **erosion**
- **Sub-aerial weathering** describes coastal processes that are not linked to the action of the sea
- Weathering weakens cliffs and makes them more vulnerable to erosion

Types of weathering

- There are three types of sub-aerial weathering:
  - Mechanical
  - Chemical
  - Biological
- **Mechanical** weathering physically breaks up rock:
  - **Freeze-thaw or frost-shattering**
    - Water gets into cracks and joints in the rock
    - When the water freezes it expands and the cracks open a little wider
    - Over time, pieces of rock split off the rock face, whilst big boulders are broken into smaller rocks and gravel
  - **Salt weathering**
    - Water in cracks evaporates leaving salt crystals
    - The salt crystals expand and the cracks become larger
    - Over time, pieces of rock split off the rock face, whilst big boulders are broken into smaller rocks and gravel
- **Chemical** weathering occurs when rocks are broken down by a chemical process:

- Rainwater is slightly acidic through absorbing carbon dioxide from the atmosphere
- This reacts with minerals in the rock, creating new material
- Rock type affects the rate of weathering; e.g. limestone chemically weathers faster than granite
- The warmer the temperature, the faster the chemical reaction

- **Biological** weathering takes place when rocks are worn away by living organisms:
  - Trees and other plants can grow within the cracks in a rock formation
    - As the roots grow bigger, they push open cracks in the rocks, making them wider and deeper
    - Over time, the growing tree eventually forces the rock apart
  - Tiny organisms like bacteria, algae and moss can grow on rocks
    - These produce chemicals that break down the surface layer of the rock
  - Burrowing animals, such as rabbits, disturb the ground
    - This destabilises the rock above the burrow
    - Increasing pressure on any cracks
    - Eventually, pieces fall off the rock

Your notes

Mass movement

Mass movement

- The **downhill movement** of material under the influence of gravity
- **Throughflow** and **overland flow** caused by heavy rain can also make cliffs more unstable and increase the likelihood of mass movement
- It includes landslides, slumping and rockfalls

What influences the type of movement?

- The angle of slope (steeper is faster)
- Nature of **regolith**
- Amount and type of vegetation
- Water
- Type and structure of rock
- Human activity
- Climate

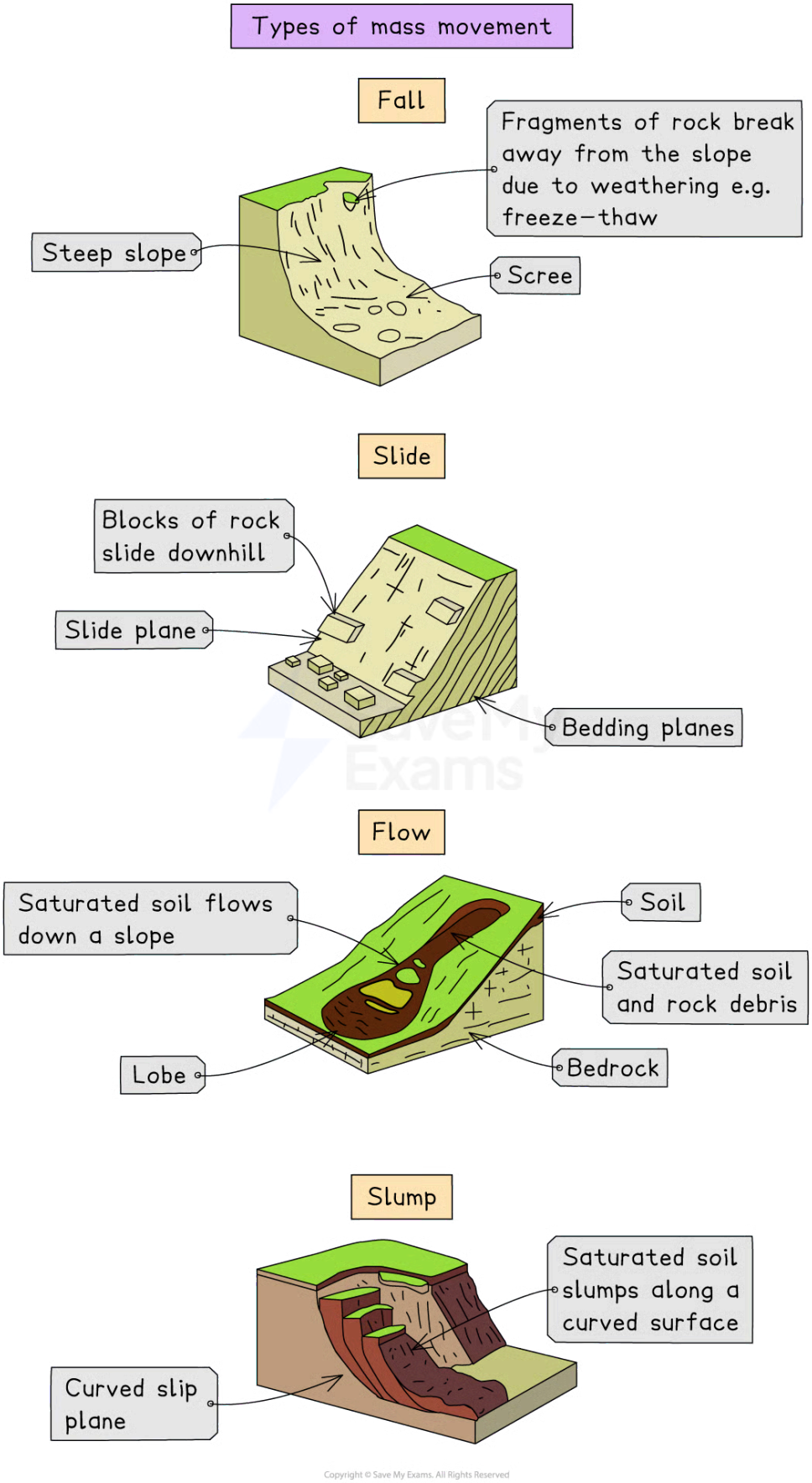
Types of movement

- **Soil Creep:**

- Speed is below 1cm per year
- Common in humid climates
- When soil expands, individual particles are lifted up at right angles to the slope
- Soil also expands when it freezes, gets wet or is heated up in the sun
- When the soil shrinks again, the particles fall straight back down
- Soil creep takes a long time because the soil moves only a millimetre to a few centimetres at a time

- **Flow:**
  - It occurs on slopes between 5° and 15°
  - Usually after the soil has become saturated with a flow of water across the surface
  - Vegetation can be flattened and carried away with the soil
  - Speeds range from 1 to 15km per year
- **Slide:**
  - A movement of material '**en masse**' which remains together until hitting the bottom of a slope
- **Fall:**
  - Slopes are steep and movement is rapid
  - Caused by a number of reasons:
    - Extreme weathering—freeze-thaw action—can loosen rocks that become unstable and collapse
    - Rainfall: too much rain will soften the surface, leading to the collapse of the slope
    - Earthquakes can dislodge unstable rocks
    - Hot weather can dry out soil, causing it to shrink and allowing rocks to fall
- **Slump:**
  - Usually found on weaker rock types (i.e. clay) that become saturated and heavy
  - This is common at the coast and is also known as **rotational slip**
  - It involves a large area of land moving down the slope in one piece
  - Due to the nature of the slip, it leaves behind a curved surface

Your notes



Types of mass movement

Your notes

Your notes

Worked Example

Outline two ways that sub-aerial processes can affect the shape of a cliff

(4 Marks)

- There will be 2 marks available for each point
- 1 mark for the processes
- 1 mark for the explanation
- **Answer:**

1. One sub-aerial process is freeze-thaw weathering (1), where temperatures need to go above and below freezing 0° C. Any water trapped in cracks of a rock, freezes and expands, exerting pressure on the crack. When temperatures rise, water melts, pressure is released and the crack contracts. Repeated cycles eventually break the rock apart. Therefore, there will be more freeze-thaw occurring in winter than in summer, resulting in more weathering of the cliff face (1). This means that the cliff is weakened and can then be eroded more easily by the waves (1)
2. Chemical weathering (1) is another sub-aerial process and the rock type will decide on how quickly the rock will dissolve. Rainwater and seawater are both slightly acidic. Less resistant rock, such as limestone, will react with the acid in the water faster than granite. Therefore, a cliff made of softer less resistant rock will weather faster than a cliff made of harder more resistant rock (1)

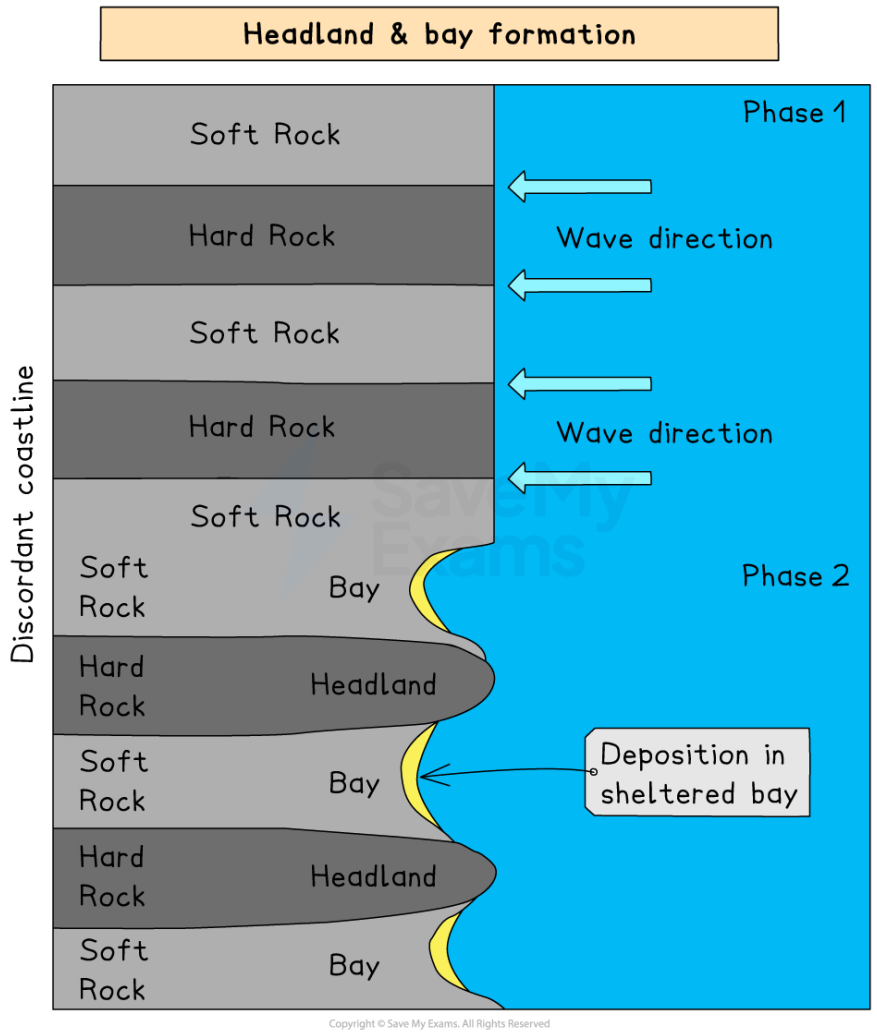
- Remember that there are three sub-aerial processes that you can use to answer this question
  - Freeze-thaw, chemical and biological
- You need to explain how each process works and then link that to how it would change the shape of a cliff

Your notes

Erosional landforms

Headland and bay

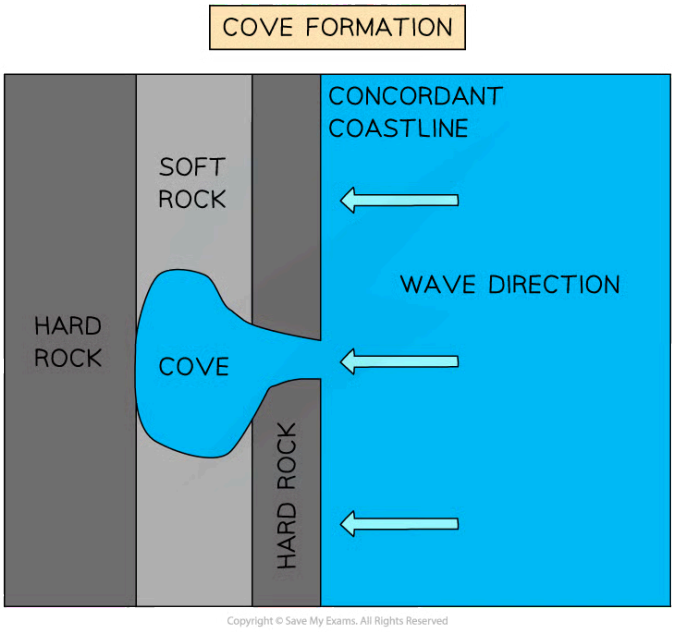
- Found in areas of alternating bands of **resistant** (hard) and **less resistant** (soft) rocks running **perpendicular** to oncoming waves (**discordant** coastline)
- Initially, less resistant rock (e.g. clay) is eroded back, forming a **bay**
  - A bay is an inlet of the sea where the land curves inwards, usually with a beach
- The more resistant rock (e.g. limestone) is left protruding out to sea as a **headland**



The formation of headlands and bays

Cove

- A cove forms where the coastline has bands of resistant and less resistant rock running **parallel** to the oncoming waves (**concordant** coastline)
  - There is usually a band of resistant rock facing the oncoming waves, with a band of softer rock behind
- Wave processes of abrasion, **corrosion** and **hydraulic action** will exploit **faults** in the resistant rock and erode through to the softer rock
- Further wave action will erode the softer rock quickly, which will leave behind a circular cove with a narrow entrance to the sea
- Wave refraction within the cove spreads out the erosion in all directions, creating the typical horseshoe shape
  - **Lulworth Cove** in Dorset, UK, is a good example of a cove



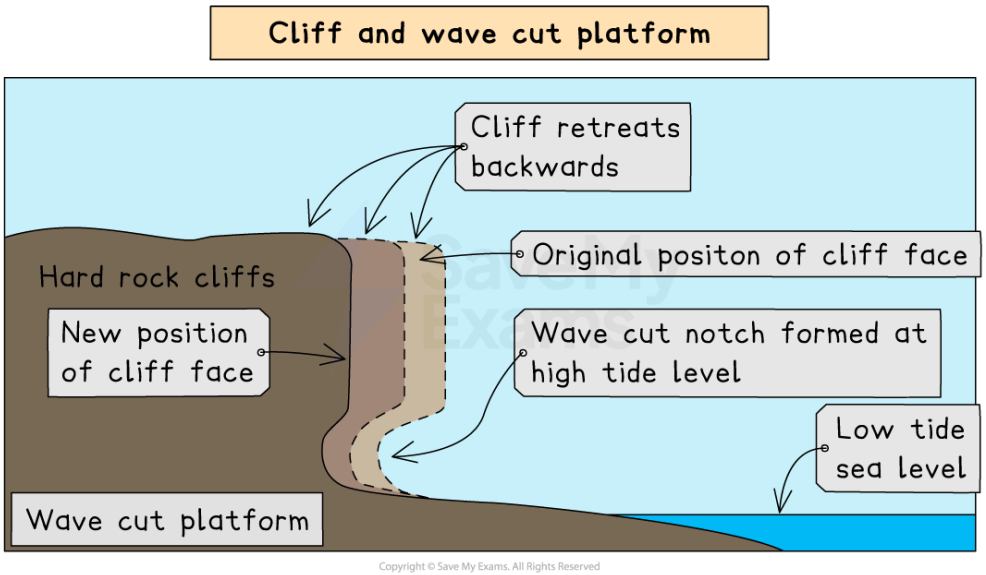
The formation of coves

Cliffs and wave-cut platforms

- Cliffs are steep rock faces
- They are shaped through **erosion** and **weathering** processes
- Less resistant rock erodes quickly and will form sloping cliff faces
- Steeper cliffs are formed where there is harder rock faces the sea
- A **wave-cut platform** is a wide, gently sloped surface found at the foot of a cliff:
  - As the sea attacks the base of a cliff between the high and low water mark, a **wave-cut notch** is formed
  - **Abrasion, corrosion** and **hydraulic action** further extend the notch back into the cliff

Your notes

- The **undercutting** of the cliff leads to instability and collapse of the cliff
- The backwash of the waves, carries away the eroded material, leaving behind a **wave-cut platform**
- The process repeats and the cliff continues to retreat, leading to a coastal retreat



The formation of cliffs and wave-cut platforms

Cave, arch, stack and stump

- Stack formation occurs on a headland due to **wave action** and **sub-aerial weathering**
- Any weaknesses/cracks in the headland are exploited by erosional processes of **hydraulic action**, **abrasion** and **corrosion**
  - As the **crack** begins to widen, abrasion will begin to wear away at the forming **cave**
  - The cave will become larger and eventually break through the headland to form an **arch**
  - The base of the arch continually becomes wider and thinner through erosion below and weathering from above
  - Eventually, the roof of the arch collapses, leaving behind an isolated column of rock called a **stack**
  - The stack is **undercut** at the base by wave action and sub-aerial weathering above until it collapses to form a **stump**

Your notes

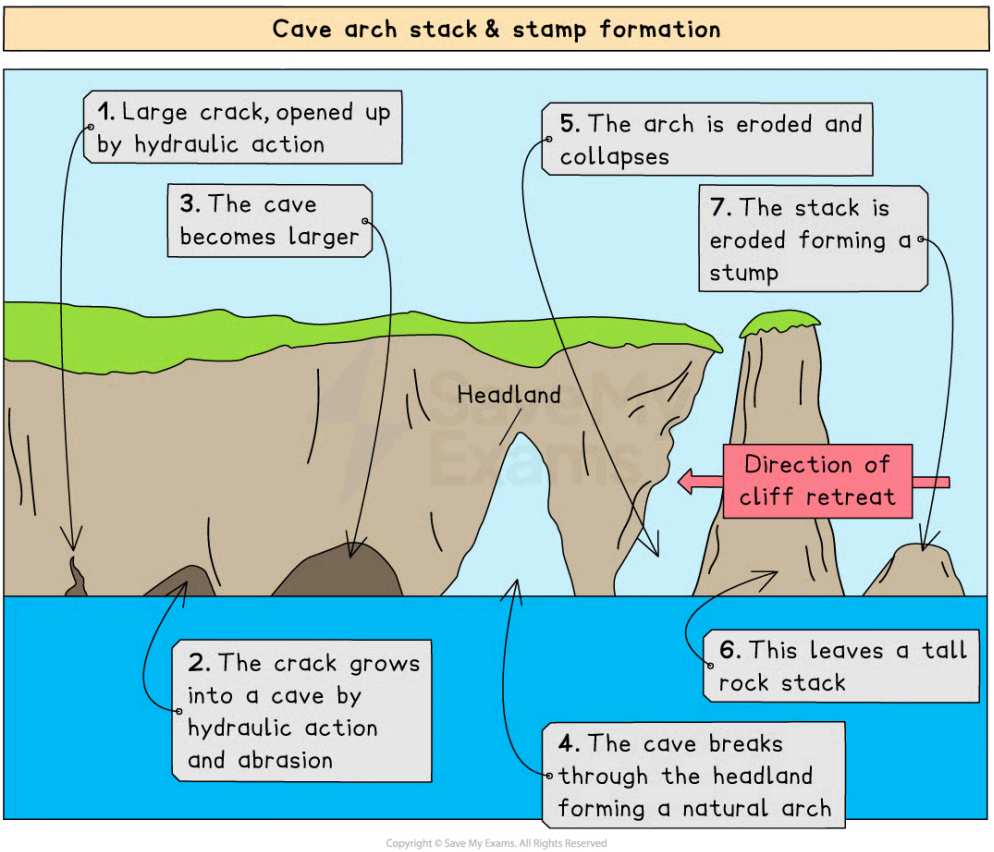


Illustration showing the stages of stack formation

Your notes

Depositional landforms

Beach

- Beaches form in **sheltered areas** such as bays
- Deposition occurs through constructive wave movement, where the **swash** is stronger than the **backwash**
- Beach formation usually occurs in the summer months when the weather is calmer
- Sometimes sand from offshore bars can blow onto the shore by strong winds
- Blown sand can create **sand dunes** at the **backshore** of a beach

Spit

- A spit is an extended stretch of sand or shingle that extends out to sea from the shore
- Spits occur:
  - when there is a change in the shape of the coastline
  - **OR**
  - when the mouth of a river prevents a spit from forming across the **estuary**

- A spit may or may not have a 'hooked' end, depending on opposing winds and currents
- A good example is **Spurn Point**, which stretches for three and a half miles across the **Humber Estuary** in the northeast of England

Your notes

Stages of spit formation

- Sediment is transported by **longshore drift**
- Where the coastline changes direction, a shallow, sheltered area allows for **deposition of sediment**
- Due to **increased friction**, more deposition occurs
- Eventually, a spit slowly builds up to sea level and extends in length
- If the wind changes direction, then the wave pattern alters and results in a hooked end
- The area behind the spit becomes sheltered
- **Silts** are deposited here to form **salt marshes** or **mud flats**

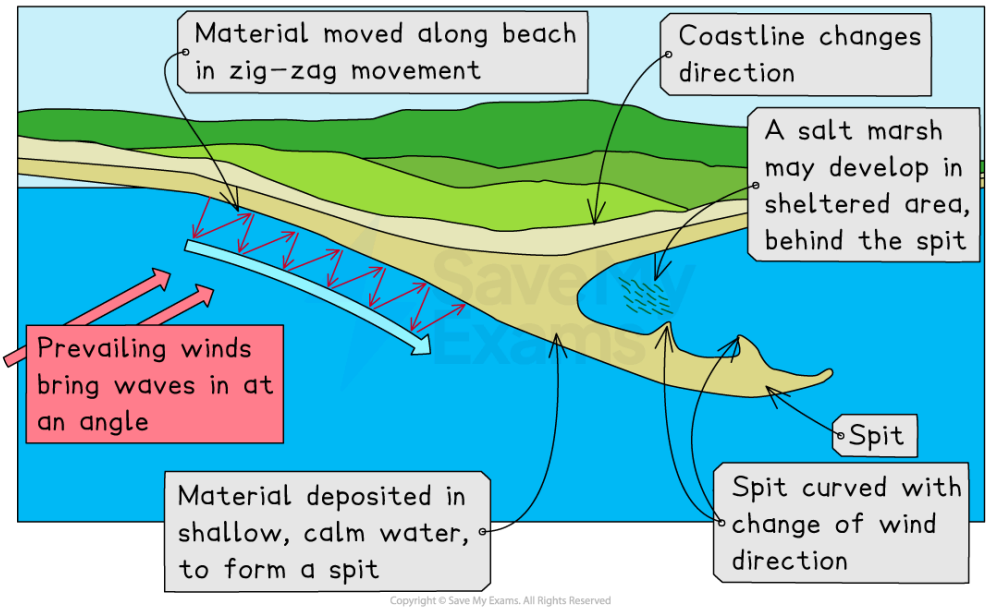


Illustration showing spit formation

Bar

- A **bar** of sand is formed (**sandbar**) when longshore drift continues to grow a spit across a bay, and joins two headlands together
- Sandbars can also form **offshore** due to the action of breaking waves from a beach

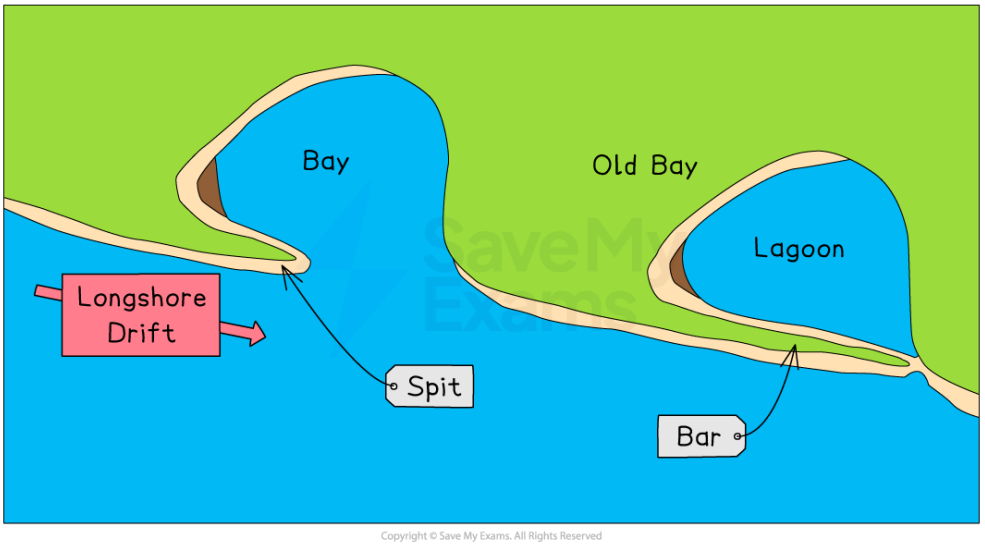


Illustration showing bar formation

Your notes

Lagoon

- A **lagoon** is where a small body of water is cut off from the sea
- They may form behind a bar or tombolo
- Lagoons do not last forever and may fill with sediment and form new land

Tombolo

- A **tombolo** is formed when longshore drift continues to grow a spit that joins the mainland to an island
- Chesil Beach in Dorset is a tombolo, as the mainland is joined to the Isle of Portland

Barrier Island

- **Barrier islands** form **parallel** to the coast
- The main difference between a bar and a barrier island is that a bar joins two headlands, whereas a barrier island is open at one or both ends

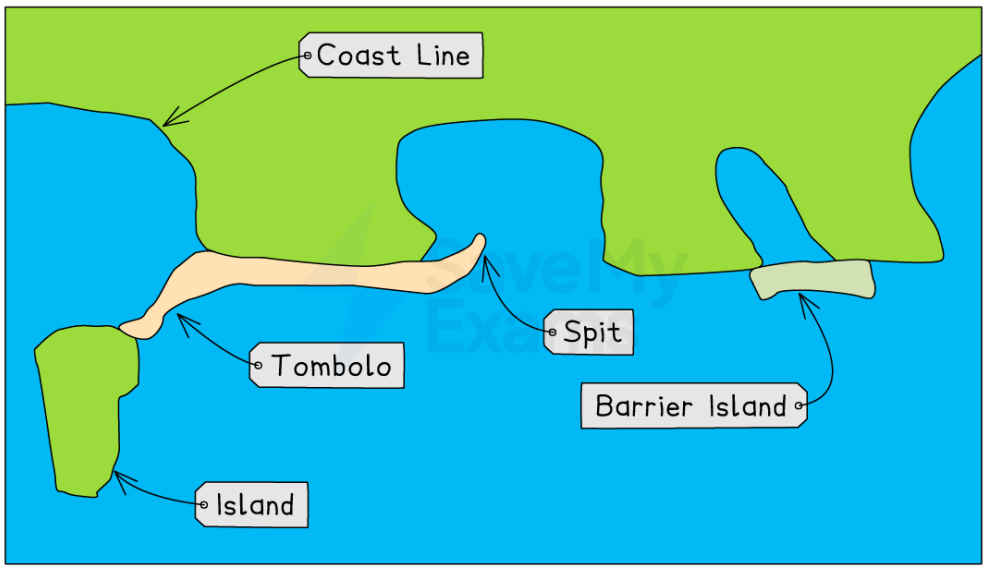


Illustration showing the formation of a tombolo and barrier island

Your notes

Examiner Tips and Tricks

You may be asked to draw and label a diagram showing how depositional landforms (beaches, spits, etc.) are formed. You need to be able to show how sediment is transported along the coast by waves. Practise drawing and labelling these diagrams so you can reproduce any of them for the exam. Marks will be awarded for the accuracy and completeness of your labelling and drawing.

Your notes

Influence of geology

- **Geology** shapes the coastline over time, place and space
  - A coastline made up of **softer rocks** such as sands and clays will be easily eroded by **destructive waves**
    - They will form low, flat landscapes such as bays and beaches
  - Coastlines of more resistant, harder rock will take longer to erode
    - This will produce rugged landscapes such as headlands
- The differences between hard and soft rocks will also impact the shape and characteristics of cliffs
- Geology, therefore, shapes the coastline vertically through the height and profile of a cliff and horizontally with bays and headlands

Hard rock

- Hard rocks will lead to the formation of:
  - high, steep cliff shapes
  - bare and rugged cliff faces
  - boulders and rocks at the foot of the cliff

Soft rock

- Soft rocks lead to:
  - lower and more gently sloped cliffs
  - smoother cliff faces with evidence of slumping
  - few rocks at the foot of the cliff

Influence of vegetation

- The longer a coastal landform has existed, the more likely it will be colonised by vegetation
- Over time, vegetation will 'fix' a feature (e.g. a sand dune)
- Vegetation **adaptation** is important to survive coastal conditions
  - Vegetation has to cope with high levels of salt in both air and soil
- The largest influence of vegetation is to assist in protecting and preserving coastal landforms such as **sand dunes, salt marshes** and **mangroves**

Influence of sea-level changes & people

Your notes

- Sea levels have risen and fallen many times in the past
  - **Rising sea levels** produce **submergent coastlines**, with **rias** and **fjords**
  - **Falling sea levels** produce **emergent coastlines**, with relic features such as **raised beaches**, **cliffs with caves, arches** etc.
- During the last **Ice Age**, sea levels fell as the water was locked up in glaciers and ice sheets, rising again as the ice melted
- Sea levels are linked to global warming and will have a significant effect on many low-lying coasts and islands
  - Many Pacific Ocean islands, such as Kiribati and Tuvalu are at risk of being completely submerged by rising sea levels
  - This issue is made worse as many of the world's densely populated areas are located on coastal lowlands
  - New York and Miami in the US are major cities vulnerable to sea-level rise as the cities are built at sea level

Influence of people

Human Activity

- Human activities, either intentionally or not, transform the features and landscape of a coastline:
  - **Settlement –** coasts have always been a place of attraction and residence for people
  - **Economic Development –** exploitation through fishing, farming, trade, tourism and energy production
  - **Coastal Management –** controlling the coastline to protect human interests
- Through any or all of the above, the natural landscapes and features of the coast can be changed, thereby changing the coastline over time, space and place

Worked Example

Study Figure 2a in the Resource Booklet. Suggest two ways changes in sea level have created coastal landforms

(4 Marks)

- This question tells you to use the figure to show how changes in sea level have created coastal landforms
- You must identify features and then develop your answer to suggest how it was formed due to changes in sea levels

- If you do not refer to the figure, you will not gain full marks

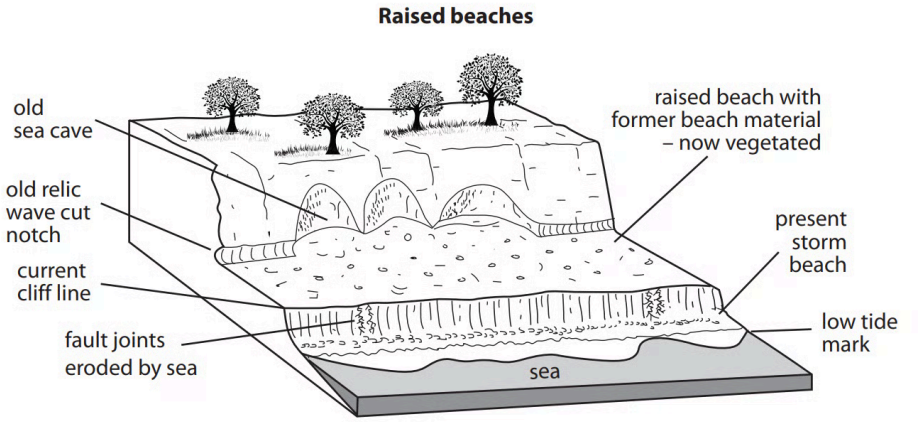


Figure 2a

An example of a coastal landscape in south west England

- **Answer:**
- From the figure we can see where the sea level has decreased (1). This has created an emergent coastline (1) with a relic cliff and raised beach (1). Over time, the raised beach has become vegetated, supporting the observation of changing sea levels (1)
- Wave action (1) from previous sea levels has eroded the relic cliff to expose a wave cut-notch (1), showing that sea levels used to be higher than the present (1). This has led to the relic cliff and sea caves further back than the current cliff face in the figure (1)

Your notes