MY REVISION NOTES

HODDER EDUCATION

OCR

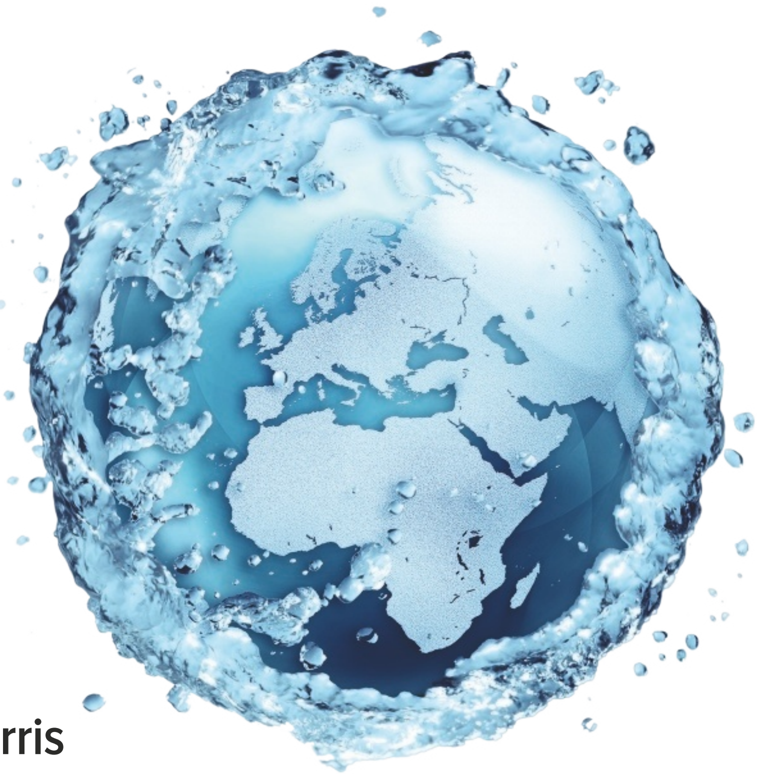
A-level

GEOGRAPHY

SECOND EDITION

- Plan and organise your revision
- Reinforce skills and understanding
- Practise exam-style questions

MY REVISION NOTES
OCR A-level
GEOGRAPHY



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Boost

HODDER EDUCATION

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My Revision Planner

Part 1 Physical systems

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Part 2 Human interactions

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1 Option A Coastal landscapes

How can coastal landscapes be viewed as systems?

Coastal landscapes can be viewed as systems

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The components of coastal landscape systems including energy flows

The system approach is a way of analysing the relationships within a unit, e.g. a coast. It consists of several components (stores) and processes (links) that are connected and represented in a flow diagram.

The coast is an **open system** (Figure 1.1), meaning that energy and matter can cross the boundary of the system to the surrounding environment. It has:

- **inputs**, which include **kinetic energy** from waves and wind, **thermal energy** from the heat of the sun, **potential energy** from material on slopes and material from **processes** of weathering, mass movement, erosion and deposition
- **outputs**, which include marine and wind erosion from beaches
- **throughputs**, or stores including beach sediment and flows (transfers) such as the movement along a beach by longshore drift.

The combination of these factors forms distinctive landscapes that are made up of a range of erosional and depositional landforms created by natural geomorphic processes and reflecting human activity.

When the inputs and outputs of a system are equal, it is in a state of **equilibrium**. However, coasts are dynamic (constantly changing) places and the equilibrium is often disturbed, resulting in **dynamic equilibrium**.

Change occurs to upset the balance of the system; for a coast this may be landslides, storms or human activity, for example. The system adjusts by a process of **feedback**, which can be either **positive** (an initial change bringing about further change in the same direction) or **negative** (the system is returned to its normal functioning).

Now test yourself

TESTED

1. Why are coasts classed as open systems?
2. Define what is meant by dynamic equilibrium.
3. What is the difference between positive feedback and negative feedback?
4. What are the main inputs of energy in a coastal system?

Answers on p. 242

Revision activity

Produce a summary diagram that includes the terms in bold in this section and a definition for each.

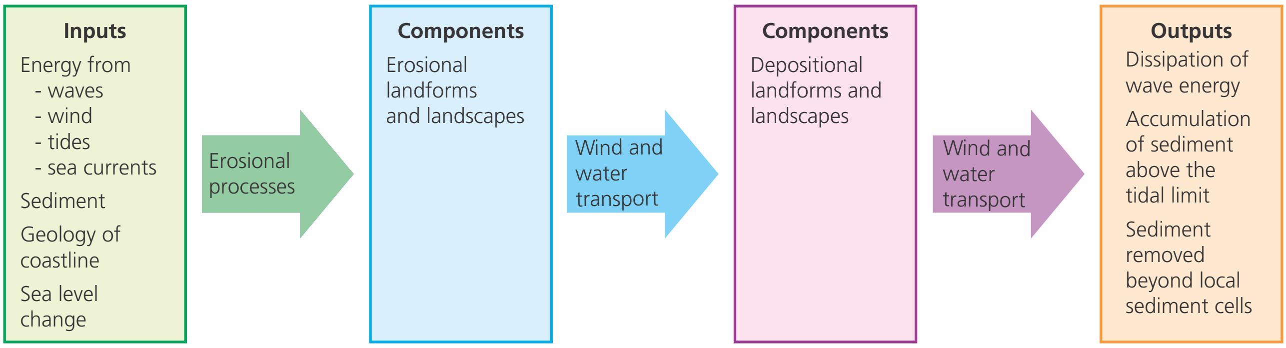

Figure 1.1 The coast as an open system

Sediment cells

- Sediment movement occurs in distinct areas called cells — a stretch of coastline within which the movement of sediment, sand and shingle is largely self-contained (Figure 1.2).
- If part of a larger cell, they are called **sub-cells**. For example, the **Flamborough Head–Humber Estuary** sub-cell is part of the larger **Flamborough Head–The Wash** cell.
- Sediment cells are an example of a closed system. While there are inputs and outputs of energy, the sediment stays largely within the cell.

Figure 1.2 Coastal sediment cells around England and Wales

Coastal landscape systems are influenced by a range of physical factors

REVISED

A range of physical factors affect the way coastal processes work and thereby the shaping of the landscape. These factors are often interrelated and vary over space and time.

Wind

Wind is the primary source of energy for a range of other processes, e.g. erosion and transportation (Figure 1.3).

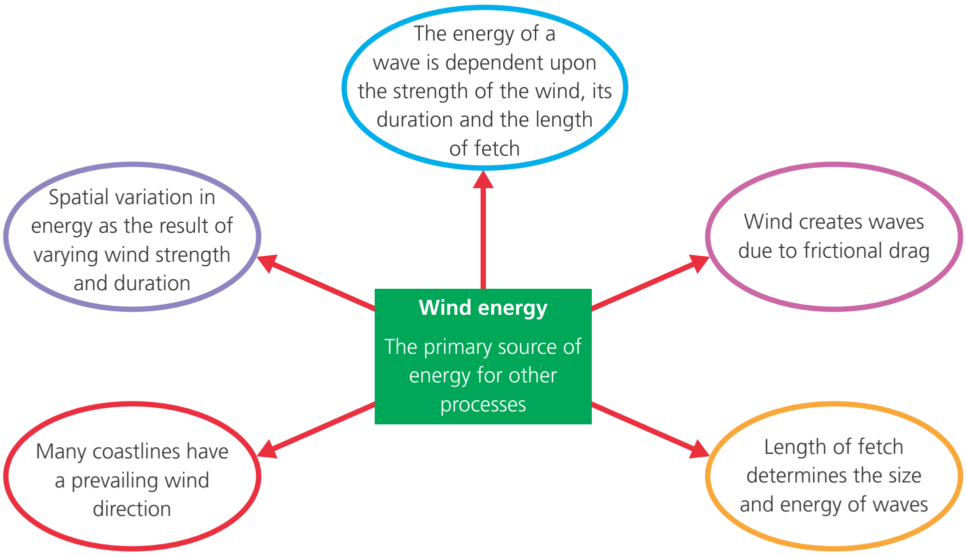

Figure 1.3 Wind energy in coastal systems

Waves

Wave formation

Waves are undulations on the surface of the sea driven by wind.

- **Fetch:** the distance a wave travels over the sea/ocean.
- **Height:** the difference between the crest (the highest part) and the trough (the lowest part) of a wave.
- **Length:** the distance between crests.
- **Frequency:** wave features lead to distinctions between swell waves — waves formed in open oceans with a wave period (time between crests) of up to 20 seconds, and storm waves — waves with a short length, greater height and wave period of up to 5 seconds.

Wave development and breaking

1. A wave enters shallow water.
2. Friction with the seabed increases, causing the wave to slow down.
3. The wavelength decreases and successive waves start to bunch up.
4. The wave increases in height…
5. and plunges or breaks on to the shoreline.

Breaking waves can be **spilling** (steep waves on gently sloping beaches), **plunging** (steep waves on steep beaches) or **surging** (low-angle waves on steep beaches).

The wash of water up the beach is the **swash**; the drag back down the beach is the **backwash**.

Constructive and destructive waves

- **Constructive:** low, long length (up to 100 m), low frequency (6–8 per minute), gentle spill on to the shore. The swash loses volume and momentum, leading to a weak backwash and low sediment movement off the beach. Swash energy exceeds backwash energy. Material is slowly and gradually moved up the beach. Forming: **berms**.
- **Destructive:** high, steep, high frequency (10–14 per minute), rapid approach to shoreline, little forward movement of the water, powerful backwash, sediment is pulled away from the beach. Swash energy is less than backwash energy. Very little material is moved up the beach. Forming: **storm beaches**.

Revision activity

Draw a simplified diagram of a constructive and a destructive wave and apply the descriptions given in this section. Use the outline provided in Figure 1.4.

Exam tip

Remember that the description of the waves refers to the transportation of sediment in the coastal zone. Although constructive waves deposit sediment and destructive waves remove it, it is not always the case that destructive waves lead to erosional features and constructive waves lead to depositional features at the shoreline.

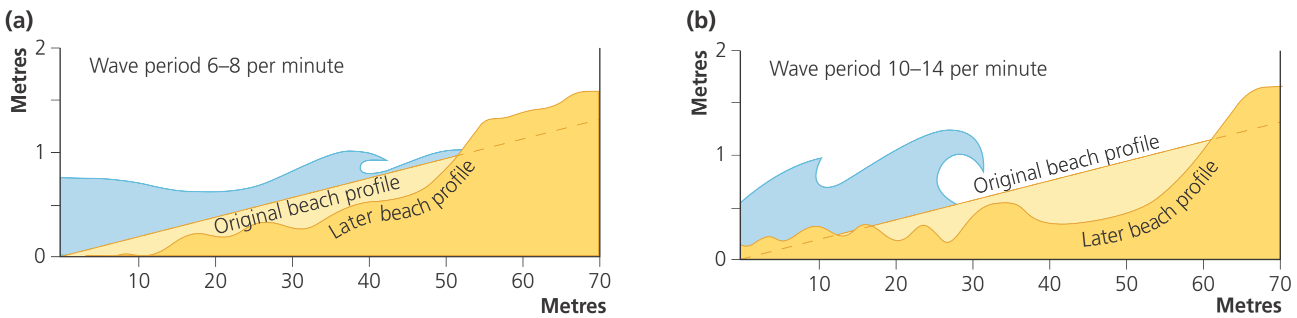

Figure 1.4 Outline diagram of (a) a constructive and (b) a destructive wave

Wave refraction

Wave refraction is the process by which waves break on to an irregularly shaped coastline, e.g. a headland separating two bays.

- Waves drag in the shallow water approaching a headland.
- Wave becomes high, steep and short.
- The part of the wave in the deeper water moves forward at a faster pace, causing the wave to bend.
- The low-energy wave spills into the bays as most of the wave energy is concentrated on the headland.

Now test yourself

5 What makes a wave increase in height?
6 Explain how and why the impacts of constructive and destructive waves differ.
7 Explain how wave refraction might have an impact on the coastline.

Answers on p. 242

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Tides

Tidal cycles

The periodic rise and fall of the sea surface is produced by the gravitational pull of the moon and (to a lesser extent) the sun.

- The moon pulls water towards it, creating a high tide.
- There is a compensating ‘bulge’ on the opposite side of the Earth.
- At locations between the two bulges, low tide occurs.
- Highest tides occur when the moon, Earth and sun are all aligned and so gravitational pull is at its strongest = **spring tides** (have a high tidal range).
- When the moon and the sun are at right angles to each other, the gravitational pull is weak = **neap tides** (low tidal range).

Tidal range

Tidal range is a significant factor in the development of coastlines as it influences where wave action occurs, the weathering processes and the impact of processes between tides, such as scouring.

Tidal range The vertical difference in height between the consecutive high and low water over a tidal cycle.

Geology

Lithology

- Lithology refers to the chemical and physical structure of rocks. This has an impact on physical processes such as weathering, mass movement and erosion.
- Weak rocks such as clay erode faster than resistant rocks such as basalt.
- Chalk and limestone are susceptible to chemical weathering because of their calcium carbonate content, which is soluble in weak acids.

Structure

Structure refers to features of jointing, faulting and bedding planes in rock and also to its **permeability**. Permeable rocks include chalk (water absorbed through tiny pores) and limestone (water absorbed through joints).

Structure also affects the shape of the coastline:

- Where rocks lie parallel to the coastline, it tends to be straight or **concordant**.
- Where rocks lie at right angles to the coast, a series of headlands and bays are formed according to the location of weak or resistant rock — this is a **discordant** coastline (Figure 1.5).

Structure also affects the 'dip' of rocks towards the coastline:

- Landward-dipping rock layers lead to steep cliffs.
- For seaward-dipping rock layers, cliffs follow the angle of the dip.

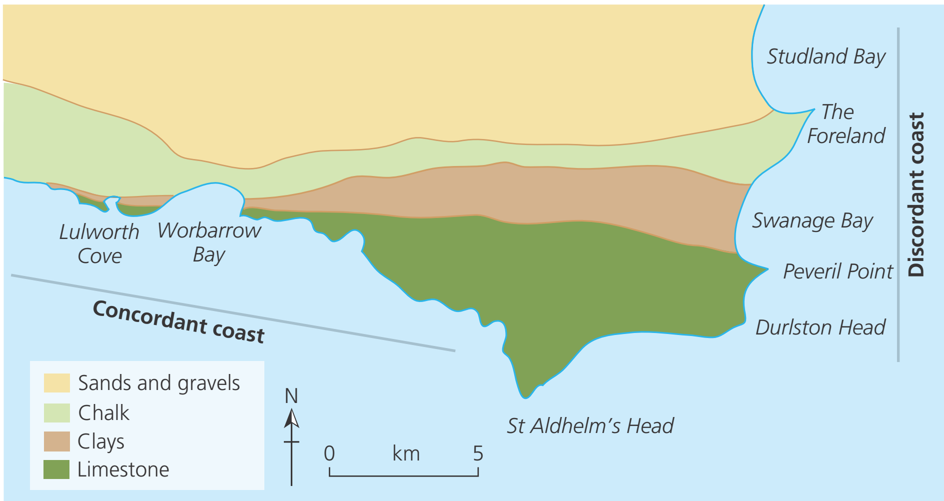

Figure 1.5 The Isle of Purbeck: east-facing discordant and south-facing concordant coastline

Ocean currents

Currents are the permanent or seasonal movement of water in the seas and oceans. There are three types (Table 1.1).

Table 1.1 Types of currents

Type	Description/effect
Longshore currents	Most waves approach the shoreline at an angle. This creates a current of water running parallel to the shoreline. Effect: transports sediment parallel to the shoreline.
Rip currents	These are strong currents moving away from the shoreline as a result of a build-up of sea water and energy along the coastline. Effect: creates beach features such as cusps.
Upwelling	The global pattern of currents circulating in the oceans can cause deep, cold water to move towards the surface, displacing the warmer surface water. Effect: a cold current rich in nutrients.

Exam tip

In physical geography, learning the correct sequence to an explanation is key to achieving accuracy.

Permeability The ability of rock to absorb water through joints and pores.

Making links

How might tectonic processes impact on coastlines?

Now test yourself

8 When do the highest tides occur?
9 Why is tidal range significant?
10 How can structure affect the shape of the coastline?

Answers on p. 242

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Global pattern of ocean currents

- The global pattern of ocean currents is generated by the Earth's rotation and the currents are set in motion by the wind.
- Warm ocean currents transfer heat from low latitudes to high latitudes, and cold ocean currents from high to low latitudes.
- This transfer of heat energy is significant to coastal development as it affects air temperature and, therefore, **sub-aerial processes**. Figure 1.6 shows the global pattern of ocean currents.

Sub-aerial processes
A collective term for weathering and mass movement processes.

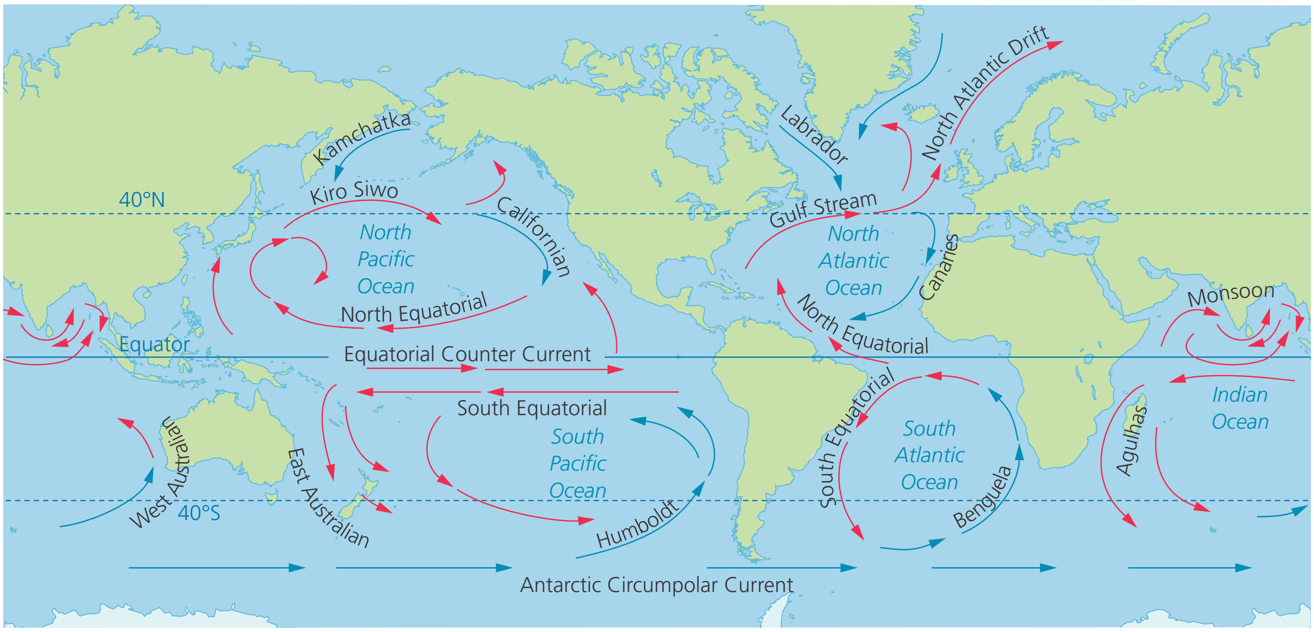

Figure 1.6 The global pattern of ocean currents

Exam tip

Be very clear on the dominant processes for different locations, e.g. tidal energy dominates in estuarine environments, wind energy in dune environments.

Coastal sediment is supplied from a variety of sources

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Coastal sediments form depositional features such as beaches and mudflats, and on coastlines there is a delicate balance between the input and removal of sediment, which is referred to as a sediment budget. In its simplest form:

- more material added than removed = a positive budget (accretion of material) ⟶ shoreline builds to the sea
- more material removed than added = a negative budget ⟶ shoreline recedes landward.

Calculating sediment budgets is complex, as all possible inputs, stores (sinks) and outputs of sediment need to be identified.

Revision activity

The revision activity in Chapter 4, p. 76, lists various methods you can use to make a revision summary. Choose one of the methods to make your own revision summary of the sources of coastal sediment.

Include the following:

- terrestrial sources (fluvial, weathering, mass movement, aeolian deposits, longshore drift)
- offshore sources (e.g. marine deposits)
- human sources (e.g. beach nourishment).

Exam tip

Remember that river and seabed sources account for the highest proportion of sediment sources, not cliff erosion.

How are coastal landforms developed?

Coastal landforms develop due to a variety of interconnected climatic and geomorphic processes

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Geomorphic processes

Figure 1.7 provides a summary of coastal processes.

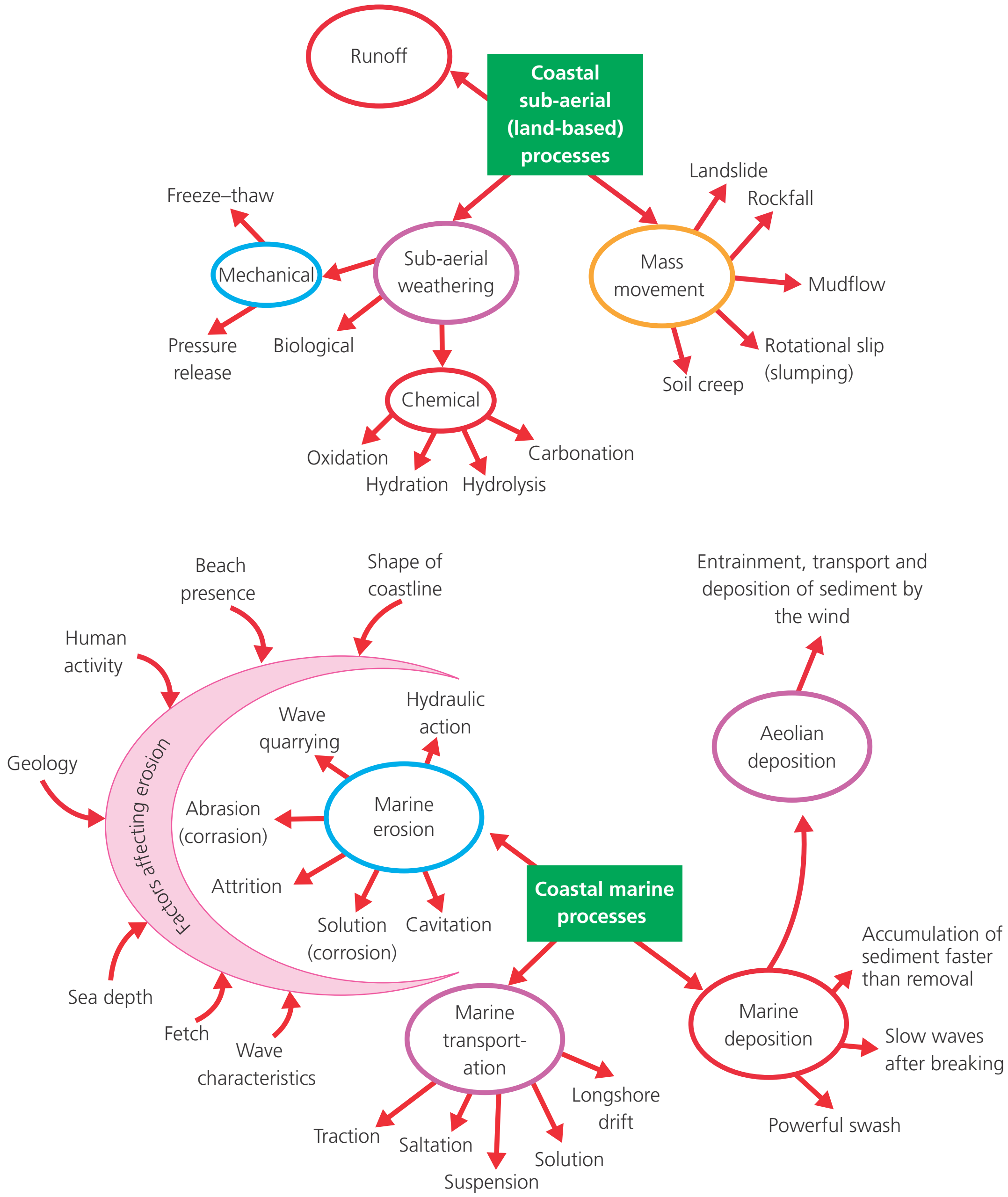

Figure 1.7 Coastal processes

Weathering processes

- Weathering uses energy to break down material from surface or near-surface rock.
- Weathering processes weaken rock and provide material that is then used in erosion.
- Weathering is a significant process in the formation of coastal landforms.
- There are three types of weathering: physical (or mechanical), chemical (involving chemical reactions) and biological (the result of plant and animal activity). They are summarised in Tables 1.2, 1.3 and 1.4.

Exam tip

When referring to coastal processes in the formation of landforms and landscapes, don't just say 'erosion processes'; be specific — state what type (e.g. hydraulic action or abrasion) and then define the terms you use.

Table 1.2 Processes of physical (mechanical) weathering in coastal environments

Process	Description
Freeze–thaw	Water enters cracks/joints and expands by nearly 10% when it freezes. In confined spaces this exerts pressure on the rock, causing it to split or pieces to break off, even in very resistant rocks.
Pressure release	When overlying rocks are removed by weathering and erosion, the underlying rock expands and fractures parallel to the surface. This is significant in the exposure of sub-surface rocks such as granite and is also known as dilatation. The parallel fractures are sometimes called pseudo-bedding planes.
Thermal expansion	Rocks expand when heated and contract when cooled. If they are subjected to frequent cycles of temperature change then the outer layers may crack and flake off. This is also known as insolation weathering, although experiments have cast doubts on its effectiveness unless water is present.
Salt crystallisation	Solutions of salt can seep into the pore spaces in porous rocks. Here the salts precipitate, forming crystals. The growth of these crystals creates stress in the rock, causing it to disintegrate. Sodium sulphate and sodium carbonate are particularly effective, expanding by about 300% in areas of temperatures fluctuating around 26–28°C.

Table 1.3 Processes of chemical weathering in coastal environments

Process	Description
Oxidation	Some minerals in rocks react with oxygen, either in the air or in water. Iron is especially susceptible to this process. It becomes soluble under extremely acidic conditions and the original structure is destroyed. Oxygen often attacks the iron-rich cements that bind sand grains together in sandstone.
Carbonation	Rainwater combines with dissolved carbon dioxide from the atmosphere to produce a weak carbonic acid. This reacts with calcium carbonate in rocks such as limestone to produce calcium bicarbonate, which is soluble. This process is reversible and precipitation of calcite happens during evaporation of calcium-rich water in caves to form stalactites and stalagmites.
Solution	Some salts are soluble in water. Other minerals, such as iron, are only soluble in very acidic water, with a pH of about 3. Any process by which a mineral dissolves in water is known as solution, although mineral-specific processes, such as carbonation, can be identified.
Hydrolysis	This is a chemical reaction between rock minerals and water. Silicates combine with water, producing secondary minerals such as clays. Feldspar in granite reacts with hydrogen in water to produce kaolin (china clay).
Hydration	Water molecules added to rock minerals create new minerals of a larger volume. This happens when anhydrite takes up water to form gypsum. Hydration causes surface flaking in many rocks, partly because some minerals also expand by about 0.5% during the chemical change because they absorb water.

Table 1.4 Processes of biological weathering in coastal environments

Process	Description
Tree roots	Tree roots grow into cracks or joints in rocks and exert outward pressure. This operates in a similar way and with similar effects to freeze–thaw. When trees topple, their roots can also exert leverage on rock and soil, bringing them to the surface and exposing them to further weathering. Burrowing animals may have a similar effect. This may be particularly significant on cliff tops and cliff faces.
Organic acids	Organic acids produced during decomposition of plant and animal litter cause soil water to become more acidic and react with some minerals in a process called chelation. Blue-green algae can have a weathering effect, producing a shiny film of iron and manganese oxides on rocks. On shore platforms, molluscs may secrete acids which produce small surface hollows in the rock.

Mass movement processes

These processes refer to the movement of material (**regolith**) down a slope. They are sub-aerial (above ground) and are dependent on slope angle, particle size, temperature and saturation. The main forms of mass movement in coastal areas are summarised in Table 1.5.

Regolith A loose layer of rocky material lying over bedrock.

Table 1.5 Processes of mass movement in coastal environments

Process	Description
Landslides	Cliffs made of softer rocks slip when lubricated by rainfall
Rockfalls	Rocks undercut by the sea or slopes affected by mechanical weathering
Mud flows	Heavy rain causes fine material to move downhill
Rotational slip/ slumping	Where soft material overlies resistant material and excessive lubrication takes place
Soil creep	Very slow movement of soil particles downslope

Wave processes

Breaking waves erode the coastline through a range of processes (Table 1.6). Waves can also supply sediment to the system which is either deposited or transported (Table 1.7).

Table 1.6 Processes of wave erosion in coastal environments

Process	Description
Hydraulic action	Wave pounding — the force of the water on the rocks
Wave quarrying/ pounding	Breaking wave exerts pressure on the rock, air is trapped in cracks in a cliff face, as the water pulls back air is released under pressure. The rock face is weakened over time
Abrasion/corrasion	Sand, shingle and boulders picked up by the sea and hurled against a cliff
Attrition	The wearing down of rocks and pebbles as they rub against each other, making them smaller and rounder
Solution/corrosion	Where fresh water mixes with salt water, acidity may increase and carbon-based rocks are broken down

Exam tip

It does not matter which term you use — abrasion/corrasion or solution/corrosion. Best practice is to pick one, learn it and stick to it.

Table 1.7 Processes of transportation by waves in coastal environments

Process	Description
Traction	Large boulders rolled along the seabed
Saltation	Small stones bounced along the seabed
Suspension	Very small particles carried in moving water
Solution	Dissolved material
Longshore drift	Waves approach the shore at an angle, swash moves material up the beach in the same direction as the wave, backwash moves the material back down the steepest gradient — usually perpendicular to where it is picked up by the next incoming wave

Longshore drift The process by which sediment deposited on the shore is moved along the shoreline.

Deposition occurs when velocity and/or volume of water decreases and energy is reduced. Deposition takes place in coastal environments when:

- sediment accumulation exceeds removal
- waves slow after breaking
- backwash water percolates into beach material
- there is a sheltered area such as an estuary.

Fluvial processes

These are significant in estuarine environments. Fluvial erosion, weathering and mass movement processes supply sediment to river channels. This is then transported downstream and deposited as rivers enter the sea.

Mudflats and **salt marshes** are landforms that form in sheltered low-energy coastlines. They are associated with large tidal ranges where powerful currents transport large quantities of fine sediment.

Aeolian processes

Coastal landscapes are significantly influenced by winds. Wind picks up sand particles and moves them, a process known as **deflation**. Attrition on land by windblown particles is also effective over long distances. When the wind speed falls, material carried by the wind will be deposited. These are **aeolian processes.**

Aeolian processes Erosion, transport and deposition by the wind.

Now test yourself TESTED

11 Explain the transfer of heat by ocean currents.

12 What is a sediment budget and how is it calculated?

13 Why are weathering processes an important factor in the development of coastal landscapes?

Answers on p. 242

Revision activity

Create flash cards for the key coastal processes, with the term on one side and the explanation on the other. You can then test yourself or get others to test you.

The formation of distinctive erosion landforms

Headlands and bays

Headlands and bays form where there are bands of different rock with different resistance to erosion.

- Where these bands of rock lie perpendicular to the coastline, the weaker rock erodes more quickly, forming a bay, and the hard rock is left as a headland. This is a **discordant** coastline.
- Where the bands of rock lie parallel to the coastline, the hard rock lies on the seaward side of the coastline and bays develop when a weakness is eroded landward. This is a **concordant** coastline.
- Figure 1.5 on p. 14 shows sections of discordant and concordant coastlines.

Exam tip

Always read the terminology in exam questions carefully. For example, landforms are small-scale features, but landscapes refer to the way features interconnect to form a landscape.

Cliffs and shore platforms

The formation of cliffs and wave-cut platforms is outlined in Figure 1.8.

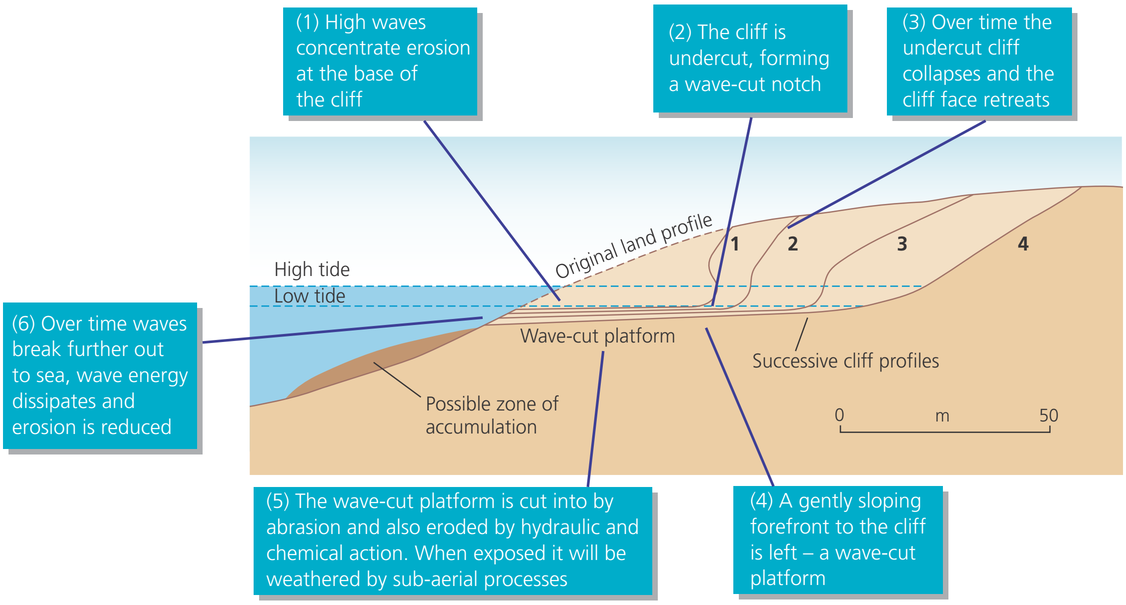

Figure 1.8 The formation of cliffs and wave-cut platforms

Geos and blowholes

Geos are narrow, steep-sided inlets formed on a coastline where there is a weakness (joint or fault) in the rock which is exposed by erosion processes such as hydraulic action. If geos become enlarged by continual erosion and the roof collapses then they become a blowhole, appearing as a vertical shaft that reaches the cliff top.

Caves, arches, stacks and stumps

The formation of caves, arches, stacks and stumps is outlined in Figure 1.9.

Exam tip

Sometimes in exam questions you might be asked to apply your knowledge to unfamiliar contexts or locations. Make sure that you can apply reasoning to explain how different factors will affect different coastlines.

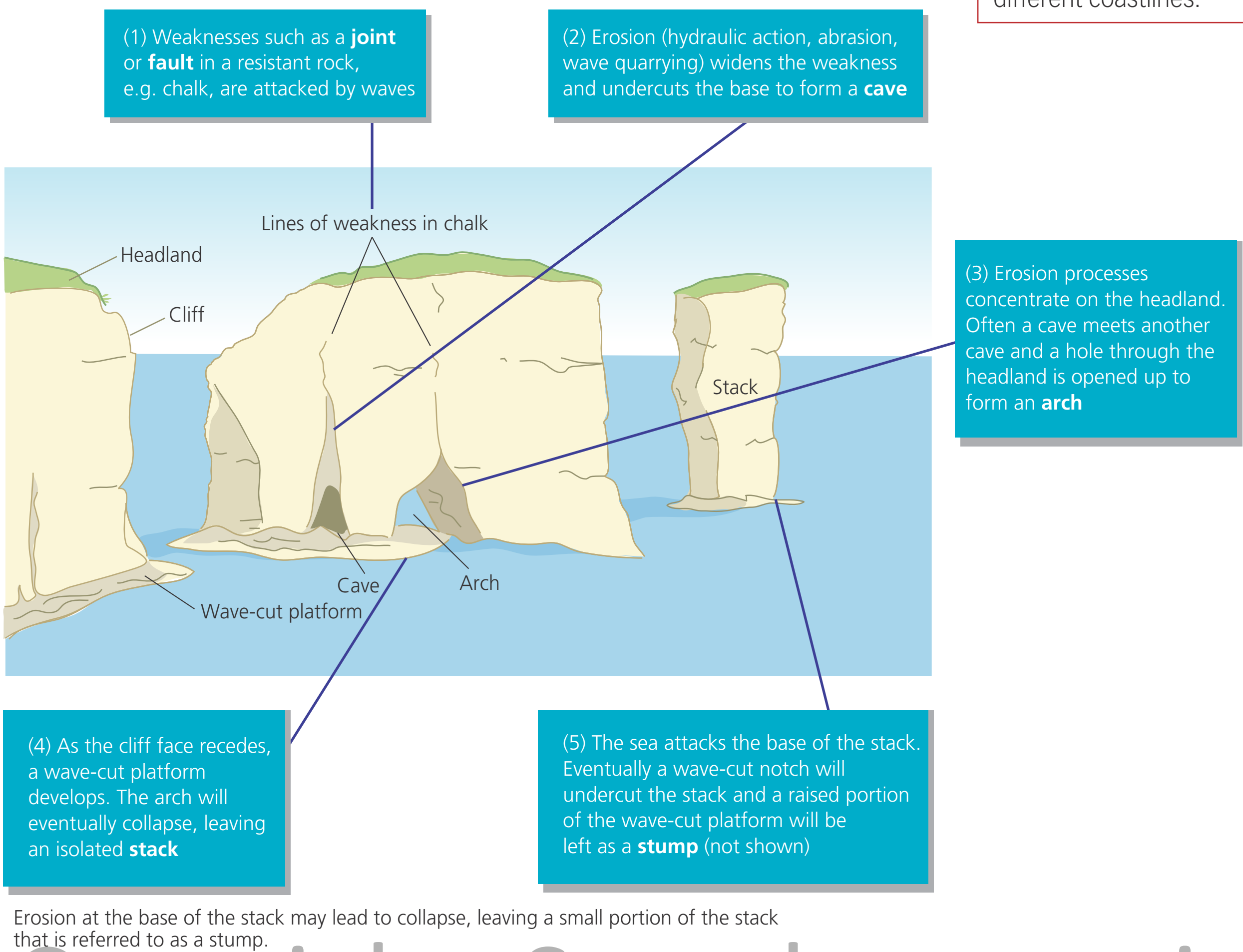

Figure 1.9 The formation of caves, arches, stacks and stumps

Revision activity

Practise drawing an annotated sketch diagram to explain the formation of cliffs and wave-cut platforms or caves, arches and stacks. Base your diagram on a located example.

Exam tip

Remember that not all cliffs develop caves, arches and stacks. Geology can have an important effect, e.g. clay may form cliffs but does not support caves, arches and stacks as chalk would.

Now test yourself TESTED

14 Assess the impact of the different factors that affect coastal landscapes and their characteristic landforms.
15 Describe the characteristics of a landscape of coastal erosion.
16 What is the difference between a concordant and a discordant coastline?
17 Explain the processes involved in the formation of caves, arches and stacks.

Answers on p. 242

The formation of distinctive depositional landforms

Beaches, spits, tombolos, onshore and offshore bars

The landforms formed by coastal deposition are summarised in Figure 1.10 which shows a coastal landscape.

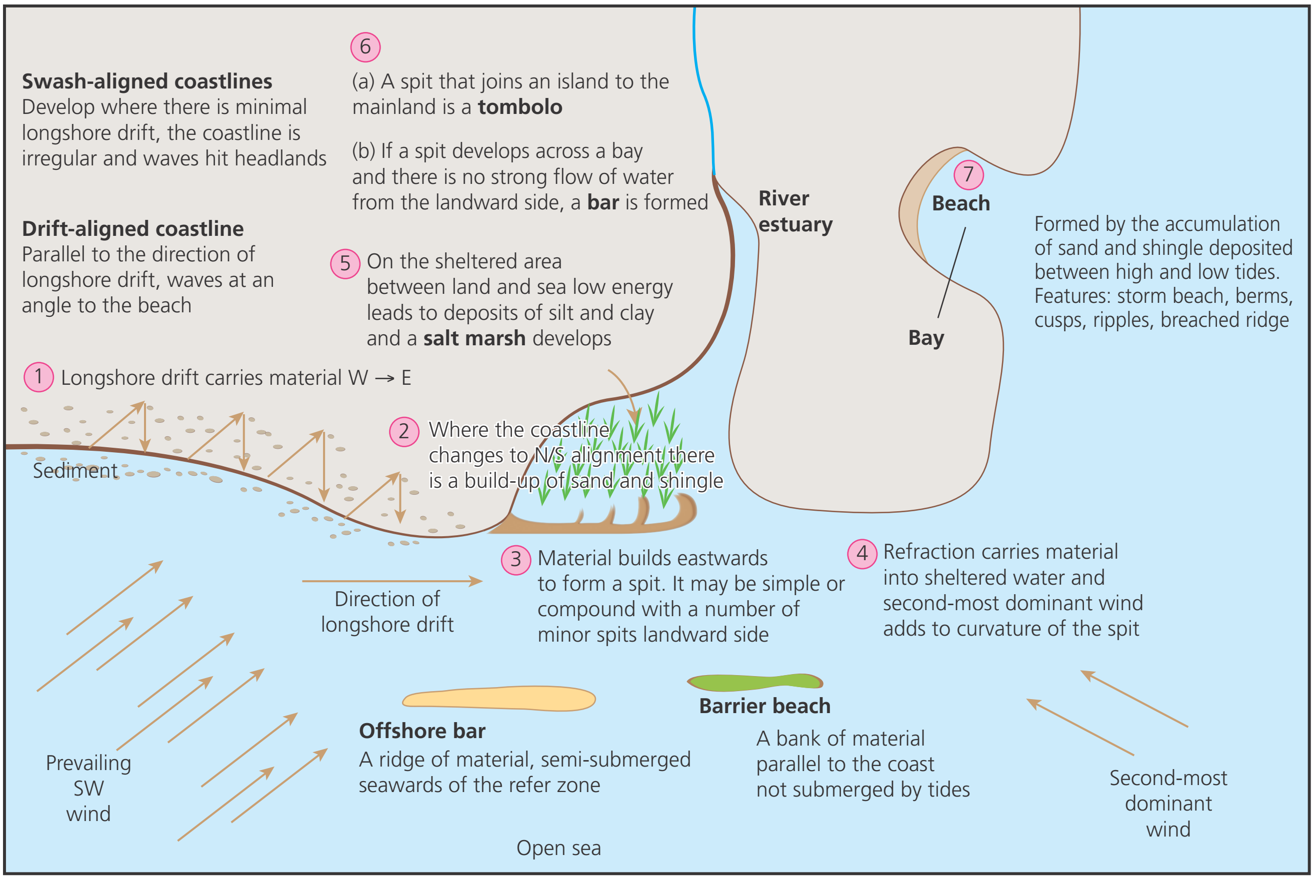

Figure 1.10 Landscapes and landforms of coastal deposition

Beaches are the most common depositional landform. Material consists of sand or shingle (a mix of pebbles and cobbles) from sources such as cliff erosion, rivers and the seabed.

Beach profile features are shown in Figure 1.11. Beaches are dynamic landforms and the profile will change over time according to wind strength. An equilibrium profile develops with a balance between erosion and deposition.

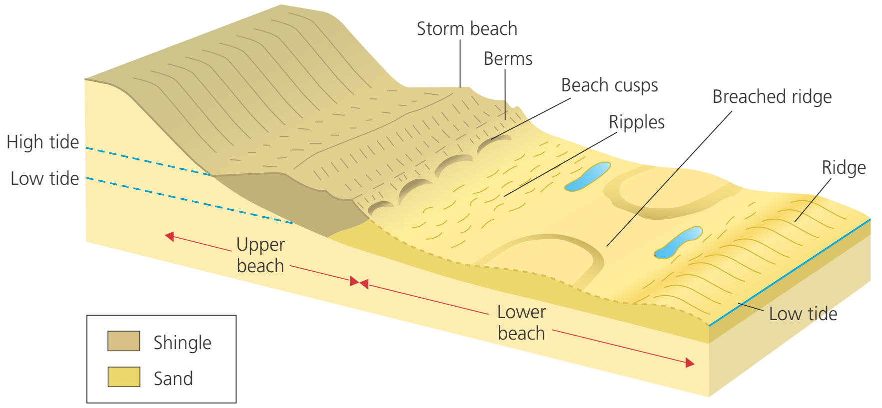

Figure 1.11 Beach profile features

Salt marshes form a flat landscape in low-lying estuarine areas. They form over time in three distinct stages, each showing a specific ecology (Table 1.8).

Table 1.8 Salt marsh formation

Stage	Description	Ecology
1	Pioneer species develop (halophytes — salt tolerant)	Glasswort (*Salicornia*), cord grass (*Spartina*). These plants slow the movement of water and encourage sedimentation. Their roots stabilise mud
2	Soil develops, lower salinity, current slows, more deposition, organic matter produced. The marsh increases in height. Biodiversity and plant cover increase	Sea aster, sea lavender, marsh grass
3	Mud level rises, land rises above sea level, rushes and reeds grow. Salinity levels fall and soil develops	Climax vegetation: ash, alder and oak

Now test yourself

18 What is the difference between the formation of flat and steep beach profiles?

19 How does vegetation change as a salt marsh develops?

20 What are cusps and how are they formed?

Answers on p. 242

TESTED

Revision activities

Referring to Figure 1.11 showing beach profile features, write a short sentence to explain the following: storm beach, berms, cusps, ripples, ridge and breached ridge.

Relate the formation of the deposition features outlined in this section to a located example, e.g. Orford Ness, Suffolk. Base your summary on a sketch map similar to Figure 1.10.

Coastal landforms are inter-related and together make up characteristic landscapes

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Low-energy and high-energy coasts

Figure 1.12 summarises the features of high- and low-energy coastlines.

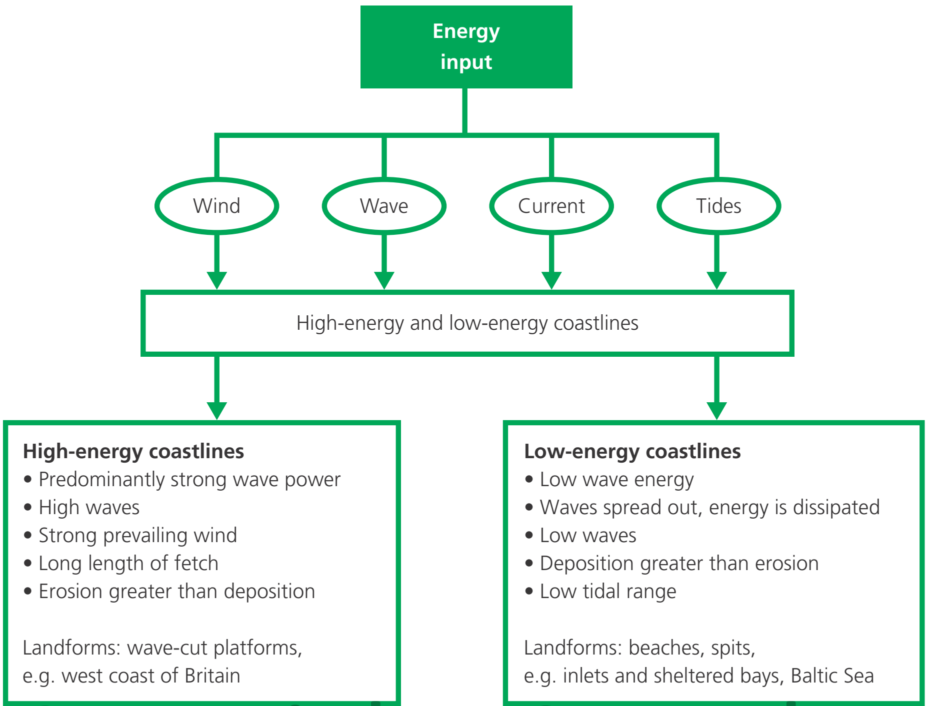


Figure 1.12 The features of high- and low-energy coastlines

Exam tip

Be very clear on the dominant processes for different locations: e.g. tidal energy dominates in an estuarine environment; dune environments tend to be dominated by wind action. Take into account the geographical context of a location/example.

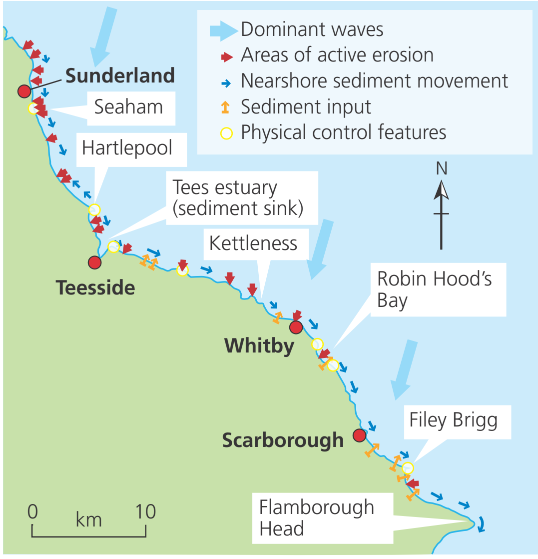
Case study

One high-energy coastline: Saltburn to Flamborough Head, Yorkshire

Rocky upland area, 60 km-long coastal environment. Characteristics reflect the influence of high wave energy.

Physical factors influencing landform formation

- Geology: differences in rock resistance responsible for varied coastal scenery.
- Energy: dominant waves from N and NE — fetch of over 1500 km leads to high-energy waves, which leads to significant longshore drift from N to S, as well as impact on erosion.
- Sediment sources: some nearshore area, driven onshore at end of last glacial. Some from cliff erosion (sandstone, chalk, boulder clay).



Landforms and landscape systems

- Cliffs — vertical faces due to horizontally bedded sedimentary rocks. Further north they have a more stepped profile due to more varied geology (sandstones, limestones, shales and clay).
- Shore platforms, e.g. Robin Hood's Bay.
- Headlands and bays, e.g. Flamborough Head formed of chalk, flanked with deep bays either side formed of clay (Filey Bay).
- Landforms on headlands as a result of wave refraction. Weaknesses in the rock are eroded leading to caves, arches and stacks.
- Very few well-developed beaches apart from in sheltered, low-energy bays, e.g. Filey Bay. High-energy waves elsewhere remove sediment before it can accumulate.

Changes over time

- During the late Cretaceous period, tectonic processes caused folding and faulting, affecting the resistance of rocks to geomorphic processes.
- Net increase of beach sediment of 9245 m^3 at Saltburn between 2008 and 2011.
- Geos and blowholes have developed in the chalk, which has then collapsed into underlying sea caves, leaving funnel-shaped depressions on cliff tops.

Figure 1.13 Saltburn to Flamborough Head: a high-energy coastline

Case study

One low-energy coastline: Rhone Delta, France

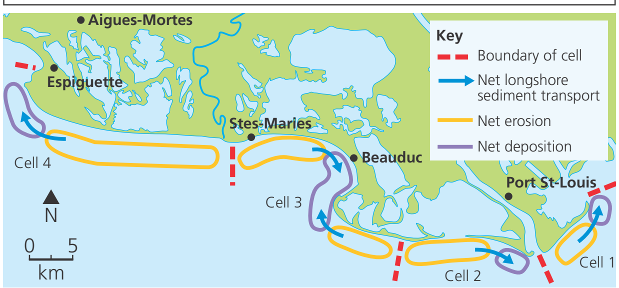
River Rhone flows into the Mediterranean Sea just west of Marseilles in southern France.

Delta lies between two major distributaries of the River Rhone — Grand Rhone and Petit Rhone, which diverge 4 km north of Arles.

From this point to the sea, the Rhone splits into many further distributaries to form a delta.

Physical factors influencing landform formation

- Delta formed over last 7000 years since sea level rise at end of the last ice age.
- Low-energy coastal environment due to:
  - short fetch due to enclosed shape of Mediterranean Sea
  - low wind speeds of dominant wind direction (NW), so waves are low in height and energy
  - high levels of sediment from river deposition creating a gently sloping coastal landscape, so waves break early.



Landforms and landscape systems

- Onshore bars form where a sediment cell has converging longshore drift currents.
- Lagoons created where longshore drift has moved sand to create lagoons trapped behind onshore bars and spits.
- Narrow coastal beaches with dunes formed behind.
- Gently sloping delta.

Changes over time

- Climate change has led to rise in sea level of 2 mm/yr since 1950.
- Increased storm activity has led to more erosion.
- Coastal protection has been introduced to combat coastal retreat.

Figure 1.14 Rhone Delta: a low-energy coastline

How do coastal landforms evolve over time as climate changes?

Emergent coastal landscapes form as sea level falls

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- **Eustatic change** is a global change in the volume of sea water resulting from a rise or fall in the level of the sea itself, e.g. caused by the retreat of ice following a glacial period. Eustatic changes are influenced by variations in mean global temperature.
- **Isostatic change** is a local change in sea level resulting from the land rising or falling relative to the sea, e.g. tectonic movements.

Exam tip

Make sure you can explain the factors that can affect global temperature change and the volume of water in oceans, e.g. variations in the Earth's orbit and tilt.

Cooling climate and emergent landscapes

Climate change and sea level fall

- Climate change can lead to sea level fall.
- Fall in global temperature → more precipitation in the form of snow → snow turns to ice → more water stored on the land as solid ice rather than liquid water, which is returned to the oceans.
- Colder water has a lower volume.

The influence of sea level fall on geomorphic processes and landforms

Landforms shaped by wave processes when the sea level was higher are exposed when sea level falls. They may be found inland from present coastlines. Such landforms include raised beaches, marine terraces and abandoned cliffs. See Figure 1.15.

Modifications by present and future climate and sea level change

- As they are now exposed and above the waterline, these emergent landforms are now affected by weathering and mass movement processes, e.g. freeze–thaw.
- In post-glacial periods when the climate is wetter and warmer, vegetation develops. Warming is predicted in the future and this could lead to chemical and biological weathering becoming more influential.
- If the rise in temperature is enough for sea level to rise, these emergent features may then become closer to the coastline and wave processes will again be an influential factor.

Submergent coastal landscapes form as sea level rises

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Warming climate and submergent landscapes

Climate change and sea level rise

Climate change can lead to sea level rise.

- Warmer water has a higher volume.
- Rise in global temperature → melting of ice stores on the land → increase in the volume of water in the oceans → sea level rise.

The 1.1°C rise in mean global temperature since pre-industrial times has resulted in a mean sea level rise of 15–25 cm since 1901.

The influence of sea level rise on geomorphic processes and landforms

The main influence of a rise of sea level is the submergence of features such as river valleys — **rias**, and glacial valleys — **fjords**. **Shingle beaches** also appear where former coastal sediment is pushed onshore by wave action.

Modifications by present and future climate and sea level change

- Rias and fjords can be modified by wave processes. The height and intensity of the waves will increase if there are more storm conditions as a result of future climate change.
- The valley sides will be modified by sub-aerial weathering processes, e.g. mechanical weathering.
- Shingle beaches will be modified by processes that transport sediment such as **longshore drift** (Figure 1.15).

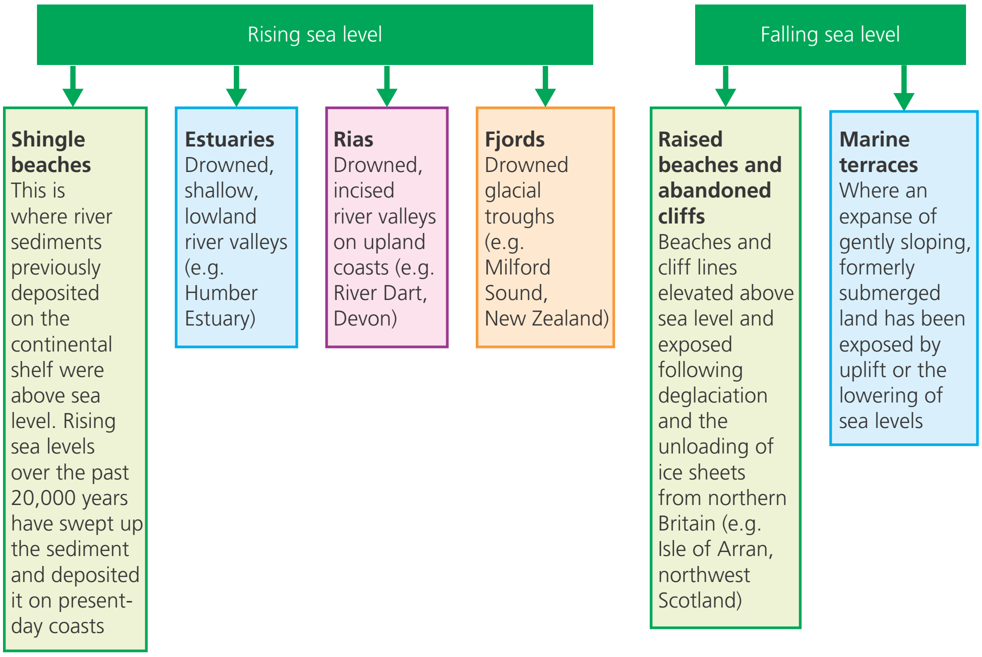

Figure 1.15 Changing sea level and coastal landforms

Now test yourself

TESTED

21 What are the main features of a high-energy coastline?

22 What landforms characterise a low-energy coastline?

23 How are abandoned cliffs formed?

24 How does sea level rise influence geomorphic processes and landforms?

Answers on p. 242

Making links

Explain how climate change can impact coastlines.

How does human activity cause change within coastal landscape systems?

Human activity intentionally causes change within coastal landscape systems

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Case study

One coastal landscape that is being managed: Sandbanks, Dorset

Need for management

- Large number of high value commercial and residential properties.
- Beach is a major tourist attraction.
- Provides protection for Poole Harbour — used for water sports, yacht clubs and marinas as well as commercial shipping.
- Climate change means sea levels predicted to rise, causing £18 million of damage to residential properties.

Management strategies and impacts

- Rock groynes to minimise movements of sediment along the beach:
  - Restricts sediment from entering the harbour entrance.
  - Sediment absorbs wave energy and reduces rates of erosion.
- Beach recharge — sand dredged from offshore sprayed on to beach, adding to its size. This is a more natural-looking management strategy.

Exam tips

Remember that any intervention in the coastal system invariably has an impact elsewhere (for example, by accelerating erosion or narrowing beaches). You may need to explain these impacts in an exam answer.

There is a range of environmental impacts on which it is impossible to place monetary value — make sure you include these in a cost–benefit analysis of coastal management.

Economic development unintentionally causes change within coastal landscape systems

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Case study

One coastal landscape that is being used by people: Mangawhai-Pakiri, New Zealand

Economic development

- High quality sand found in nearshore zone.
- Area is 50 km north of Auckland, where one-third of New Zealand's population live and 35% of its GDP is generated. Area is growing rapidly.
- Nearshore sand dredging along 20 km of this coastline for over 70 years to replenish Auckland's tourist beaches and for use in the construction industry.
- Current rate of extraction 75,000 m^3/year.

Unintentional impacts on processes, flows, landforms and landscape

- Sand here is a non-renewable resource — coastal sediment budget is essentially a closed system.
- Extraction rates exceed inputs by a factor of 5 so movements of sand between the major stores has diminished.
- Beaches are wider and flatter so higher energy waves erode beaches.
- Foredune ridges are undercut by wave action, developing steep scarps.
- Coastal retreat is partly due to sand extraction as well as climate change — long-term retreat is estimated at 35 m by the end of the century.

Making links

Consider the impact of coastlines on food security and the spread of disease.

Exam tip

Case study examples need careful revision of accurate, up-to-date facts if evaluation is to be addressed in a high-level response.

Summary

- The coastal system is an open, dynamic system driven by flows of energy.
- The sources and flows of sediment are key sub-systems (closed systems).
- Physical factors such as wind, waves, tides, geology and currents affect coastal landscapes.
- Geomorphological, marine and sub-aerial processes lead to the formation of characteristic coastal landforms, which combine and integrate to form coastal landscapes unique to location and geographical contexts.
- Rising and falling sea levels impact on coastal landscapes.
- Human activity can intentionally cause change within coastal landscape systems.
- Economic development can unintentionally cause change within coastal landscape systems.

Exam skills

- Remember that the description of the waves refers to the transportation of sediment in the coastal zone. Although constructive waves deposit sediment and destructive waves remove it, it is not always the case that destructive waves lead to erosional features and constructive waves lead to depositional features at the shoreline.
- Be very clear on the dominant processes for different locations, e.g. tidal energy dominates in estuarine environments, wind energy in dune environments.
- Remember that river and seabed sources account for the highest proportion of sediment sources, not cliff erosion.
- When referring to coastal processes in the formation of landforms and landscapes, don't just say 'erosion processes'. Be specific — state what type (e.g. hydraulic action or abrasion) and then define the terms you use.
- It does not matter which term you use — abrasion/corrasion or solution/corrosion. Best practice is to pick one, learn it and stick to it.
- Always read the terminology in exam questions carefully. For example, landforms are small-scale features, landscapes refer to the way features interconnect to form a landscape.
- Sometimes in exam questions you might be asked to apply your knowledge to unfamiliar contexts or locations. Make sure that you can apply reasoning to explain how different factors will affect different coastlines.
- Remember that not all cliffs develop caves, arches and stacks. Geology can have an important effect, e.g. clay may form cliffs but will not support caves, arches and stacks as chalk would.
- Make sure you can explain the factors that can affect global temperature change and the volume of water in oceans, e.g. variations in the Earth's orbit and tilt.
- Remember that any intervention in the coastal system invariably has an impact elsewhere (for example, by accelerating erosion or narrowing beaches). You may need to explain these impacts in an exam answer.
- There is a range of environmental impacts on which it is impossible to place monetary value — make sure you include these in a cost–benefit analysis of coastal management.
- Case study examples need careful revision of accurate, up-to-date facts if evaluation is to be addressed in a high-level response.

Exam practice

1 Using evidence from Figure 1.10, p. 21, suggest why warm ocean currents have a greater effect on coastal landscapes than cold ocean currents. [3]

2 Suggest reasons for a predominance of erosional features on the SW coast of the UK. [4]

3 Explain the formation of shore platforms. [8]

4 Explain the influence of geology in the formation of coastal landscapes. [8]

5 Using the data in Table 1.9:

  a Calculate the interquartile range (IQR). [2]

  b A fieldwork study of the relationship between pebble size and distance from the sea on beach A gave a Spearman rank correlation result of R_S −0.843 for 18 paired values. Using Table 1.10, state the null hypothesis and interpret this result. [4]

Table 1.9 Pebble sample, beach A

Sample number	1	2	3	4	5	6	7	8	9	10	11
A-axis (cm)	2.5	3.1	4.6	2.2	1.9	4.8	5.2	6.2	3.3	4.2	4.7

Table 1.10 Fieldwork study

Degrees of freedom	0.05 significance level	0.01 significance level
17	+/−0.412	+/−0.582
18	0.399	0.564
19	0.388	0.549

Answers and quick quiz available online

2 Option B Glaciated landscapes

Glaciated landscapes have been formed to a greater or lesser extent by the action of glaciers. They include areas glaciated in the past, e.g. northern Britain. Cold climates still supporting glaciers occur in locations of high latitude — Antarctica and Greenland. Mountain ranges with glaciers include the Himalayas. Landscapes are usually classified as erosional or depositional.

Exam tip

There are a range of locations and types of glaciated landscapes. Be aware of this when responding to exam questions.

How can glaciated landscapes be viewed as systems?

Glaciated landscapes can be viewed as systems

REVISED

The system approach is a way of analysing the relationships within a unit. It consists of several components (stores) and processes (links) that are connected and can be represented in a flow diagram.

Glaciated landscape systems store and transfer energy and material on timescales that can vary from a few days to millennia.

The components of glaciated landscape systems including flows of energy

Glaciated landscape systems are **open systems** (Figure 2.1), meaning that energy and matter can cross the boundary of the system to the surrounding environment. They have:

- **Inputs:** kinetic energy from wind and the movement of glaciers, thermal energy from the heat of the sun, and potential energy from material on slopes and material from processes of weathering, mass movement and deposition.
- **Outputs:** which include glacial and wind erosion from rock surfaces; evaporation, sublimation and meltwater.
- **Throughputs:** stores including ice, water and debris accumulations; and flows (transfers) such as the movement of ice, water and debris downslope under gravity.

The combination of these factors forms distinctive landscapes, which are made up of a range of erosional and depositional landforms created by natural geomorphic processes and reflecting human activity.

When the inputs and outputs of a system are equal, it is in a state of **equilibrium**. If the rate at which snow and ice is added to a glacier equals the rate at which snow and ice melts, the glacier will remain the same size.

If this equilibrium is disturbed, self-regulation will take place to restore the equilibrium, resulting in **dynamic equilibrium**.

The system adjusts through **feedback processes**, which can be either **positive** or **negative**:

- Positive feedback is an initial change bringing about further change in the same direction and away from equilibrium.
- Negative feedback is a change in the system but the system returns back to its normal functioning, back to equilibrium.

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OCR A-level

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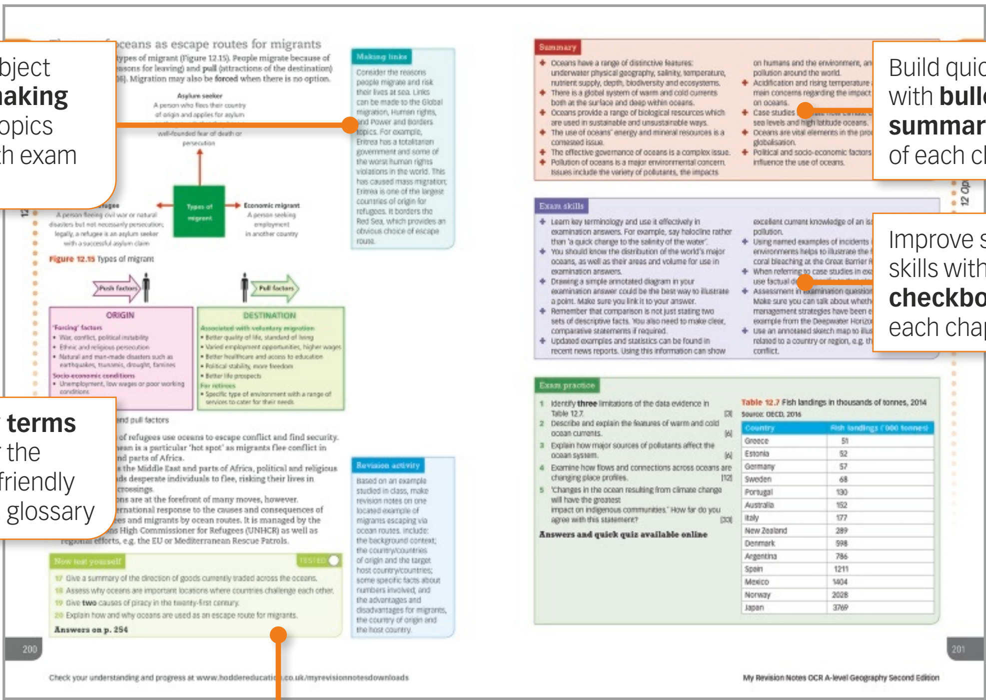

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