

Geology of coasts

The geological structure of coasts and the type of rock found there influence the erosion landscapes formed.

Soft rock (e.g. clay)

- ✓ Soft rock is easily eroded by the sea.
- ✓ Cliffs will be less rugged and less steep than hard rock coasts.
- ✓ Soft rock landscapes include bays.

Hard rock (e.g. granite)

- ✓ Hard rock is resistant to all types of erosion.
- ✓ Cliffs will be high, steep and rugged.
- ✓ Hard rock landscapes include wave-cut platforms and headlands where caves, arches and stacks are formed.

Quick notes:

- a. Rock is broken down by mechanical, chemical and biological weathering.
- b. Mass movement is when material falls down a slope.
- c. Waves wear away the coast using three processes of erosion.
- d. Transportation is the movement of material.
- e. Constructive waves deposit material.
- f. Deposited sediments forms spits and bars.
- g. Human activities have direct and indirect effects on the coast.
- h. The Holderness coast is on the East coast of England.
- i. Parts of Holderness are protected by coastal defences.
- j. The defences have caused problems further along the coast.

Concordant and discordant coasts



Concordant coasts are made up of the same rock type, parallel to the sea. On discordant coasts the rock type alternates in layers perpendicular to the sea, forming headlands and bays.

The hard rocks in this diagram are chalk and limestone; the soft rocks are mudstone, sands and clays.

Worked example

Study the photo below, which shows a chalk headland and stacks. Which point on the geological map opposite marks the location of this feature? (1 mark)

C



Now try this

Identify two landforms that are characteristic of a discordant coast. (2 marks)

Key words: Read and highlight key words.

Write key words in this space.

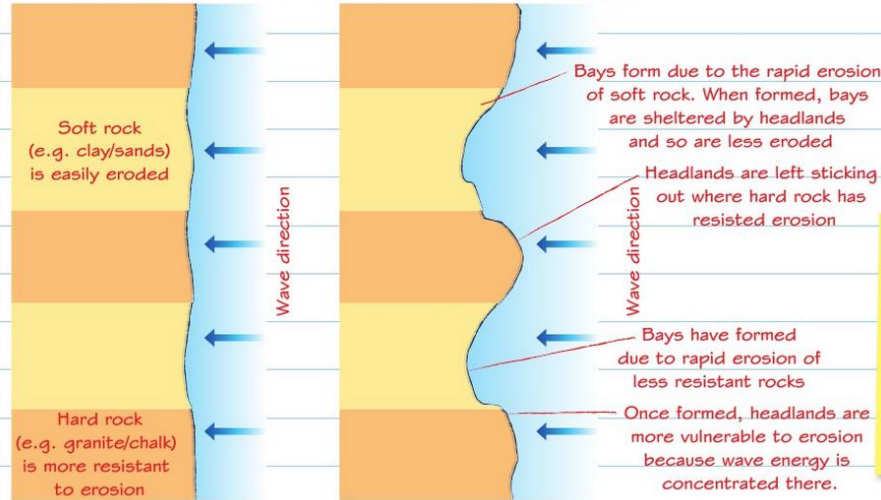
Weathering and erosion:

1. **Mechanical weathering** is the breakdown of rock without changing its chemical composition. Salt water weathering affects the coast. Sea water gets into the cracks of the rock. Salt crystals form when sea water evaporates. The crystals expand putting pressure of the rock. Overtime the cracks widen and the rock breaks up.
2. **Chemical weathering** is the breakdown of rocks by changing its chemical composition. In warm and wet conditions carbonation weathering happens. Sea water and rain water have carbon dioxide which makes them weak carbonic acids. Carbonic acid reacts with rock that contains calcium carbonate, e.g. carboniferous limestone, so rocks are dissolved by salt water.
3. **Biological weathering** is the breakdown of rock by living things, e.g. plant roots break down rocks by growing into cracks on their surface and pushing them apart.

Landscapes of erosion

You need to be able to explain how coastal landscapes are formed.

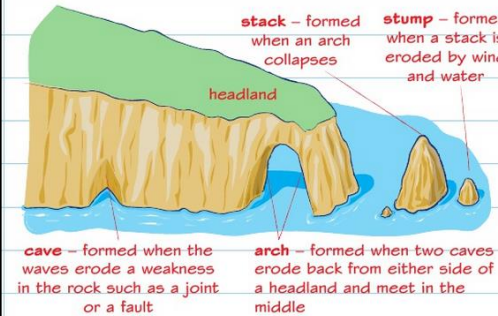
The formation of headlands and bays



'Differential rates of erosion' is the technical term for when rocks of differing resistance are eroded at different rates.

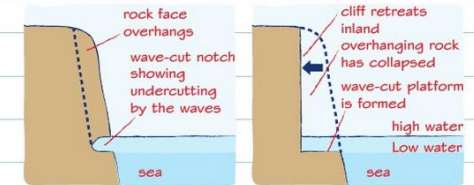
Hard rock coastal landforms created by erosion

Caves, arches and stacks



Wave-cut platforms

The erosion of cliffs can create wave-cut platforms – areas of flat rock at the base of the cliff.

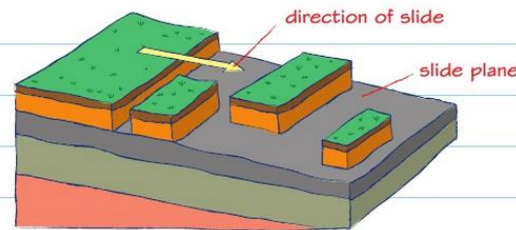


Worked example

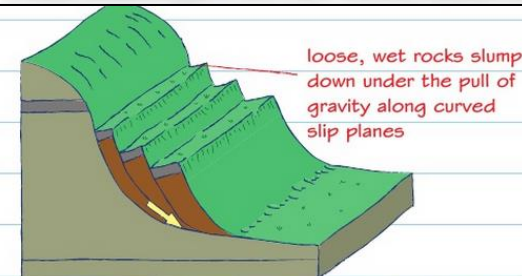
Explain how geological structure can influence the erosion of a coastal headland. (4 marks)
 Headlands are sections of resistant rock which jut out in the sea. Erosion by the sea will happen faster where there are gaps, cracks, joints, faults or other weaknesses in the rock. Caves are formed as erosion happens more quickly at this weaker section of the rock. If the weakness goes right through the rock, an arch may form as caves on either side of the headland join up.

Mass movement is when material falls down a slope.

- The shifting of rocks and material down a slope e.g. a cliff. It happens when the force of gravity acting on a slope is greater than the force supporting it.
- Mass movements cause coasts to retreat rapidly.
- Mass movement is more likely to happen when the material is full of water – It acts as a lubricant, and makes the material heavier.
- There are 3 types of mass movement – slides (straight line movement), slumps (rotation of material as it moves) and rock falls (material breaks up and falls down the slope).



Sliding happens when loosened rocks and soil suddenly tumble down the slope. Blocks of material might all slide together.

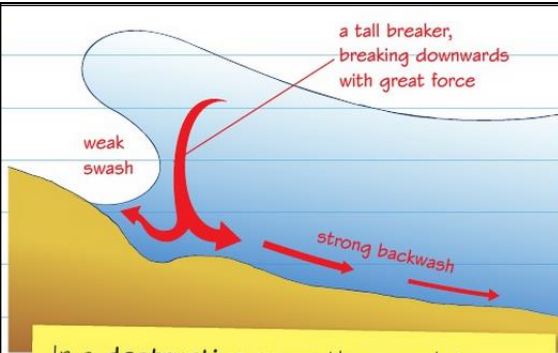


Coastal erosion leads to **coastal retreat**, when the coastline moves further inland. Another way to look at this question is to think about factors that increase the rate of erosion at the coast.

Worked example

Explain factors that lead to a fast rate of coastal retreat. (4 marks)
 Coasts exposed to frequent storms will retreat faster than other areas because strong winds increase the eroding power of the sea and heavy rainfall will contribute to mass movement. Soft rock coastlines will retreat faster than hard rock coastlines as soft rock erodes quickly. Cliffs where the rocks have a large number of joints and faults will also erode more quickly than cliffs with fewer joints and faults.

Task: Write down what you remember about concordant and discordant coastlines in this space.



In a **destructive wave** the swash is weak and the backwash is strong, which means material is dragged back down a beach into the sea.

How waves erode the coast

- **Hydraulic action:** the sheer weight and impact of water against the coastline, particularly during a storm, will erode the coast. Also waves compress air in cracks in the rock, forcing them apart and weakening the rock.
- **Abrasion:** breaking waves throw sand and pebbles (or boulders) against the coast during storms.
- **Attrition:** the rocks and pebbles carried by the waves rub together and break down into smaller pieces.
- **Solution:** chemical action by seawater on some rocks, especially limestone.

The four **seasons** have different impacts on coastal erosion. For example, cold temperatures in winter lead to **freeze-thaw** weathering in cliffs.

Prevailing winds in the UK are from the south-west, bringing warm, moist air from the Atlantic and frequent rainfall, leading to weathering and mass movement on the coast.

Impact of UK climate on coastal erosion

Storm frequency is high in many parts of the UK, so coasts are often subject to strong winds, leading to an increase in the eroding power of waves and also leading to heavy rainfall contributing to mass movement.



Worked example

This is a good answer because the points it makes are accurate and each explained in terms of contribution to coastal erosion.

Explain how the UK climate contributes to coastal erosion.

(4 marks)

The UK's climate is temperate maritime, which means winters are mild and wet and summers are warm and wet. The prevailing winds from the south-west often bring rainfall to the country. The large amount of rainfall causes coastlines to erode through weathering and can also lead to mass movement and cliff collapse. Storm frequency is high, which brings heavy rainfall and strong winds that increase the erosional power of waves. The UK winter climate frequently sees temperatures dipping below freezing at night and then rising above 0°C in the daytime. When this is repeated many times, freeze-thaw weathering results, which adds to erosion.

Quick notes:

- Coastlines can be concordant or discordant.
- The UK's climate has an impact on coastal erosion and retreat.
- Destructive waves wear away the coast.
- Waves erode cliffs to form wave-cut platforms.
- Headlands and bays form along discordant coastlines.
- Headlands are eroded to form caves, arches, stacks and stumps.
- Climate change is increasing the risk of coastal flooding.
- There are threats to people and the environment.
- Coastal defences include hard and soft engineering.
- Management strategies need to be sustainable.

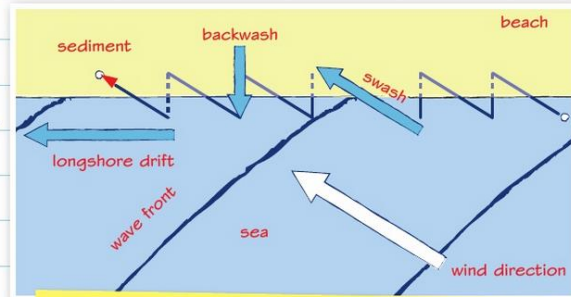
Task: Practice drawing the formation of a stack here, add labels and annotation.

Transportation and deposition

Waves transport eroded material along the coast and deposit it when they lose the energy to carry it further.

Longshore drift

- 1 Waves approach the coast at an angle.
- 2 Swash pushes sand and gravel up the beach at the same angle.
- 3 Backwash carries sand and gravel back down the beach at 90° to the coastline under the force of gravity.
- 4 Sand and gravel move along the beach in a zigzag fashion.
- 5 Sand is lighter than gravel so moves further up the beach.



Adapted diagram courtesy of Barcelona Field Studies Centre, www.geographyfieldwork.com

Landscapes of deposition

Landscapes resulting from deposition include beaches, spits and bars.

Beaches

Beaches are accumulations of sand and shingle formed by deposition and shaped by erosion, transportation and deposition.



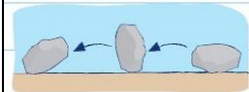
Beaches can be straight or curved. Curved beaches are formed by waves refracting, or bending, as they enter a bay.



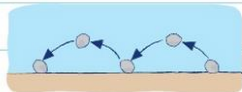
Beaches can be sandy or pebbly (shingle). Shingle beaches are usually found where cliffs are being eroded and where waves are powerful. Ridges in a beach parallel to the sea are called berms and the one highest up the beach shows where the highest tide reaches.

Transportation

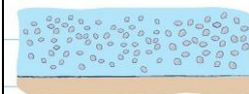
Waves transport material by:



Traction – large boulders are rolled along the seabed by waves



Saltation – smaller stones are bounced along the seabed

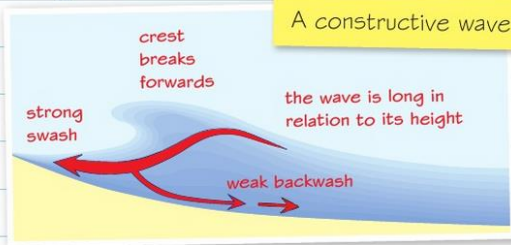


Suspension – sand and small particles are carried along in the flow



Solution – some minerals are dissolved in seawater and carried along in the flow

Deposition



The load carried by waves is deposited by constructive waves. Different factors influence deposition, for example:

- sheltered spots (e.g. bays)
- calm conditions
- gentle gradient offshore causing friction.

All reduce the wave's energy.



Spits are narrow projections of sand or shingle that are attached to the land at one end. They extend across a bay or estuary or where the coastline changes direction. They are formed by longshore drift powered by a strong prevailing wind.

Bars form in the same way as spits, with longshore drift depositing material away from the coast until a long ridge is built up. However, bars grow right across the bay, cutting off the water to form a lagoon.

Tasks:

1. Describe and explain the process of longshore drift (4)
2. Describe and explain the formation of a spit. (4)
3. Suggest ways in which waves transport material. (4)
4. Compare and contrast destructive and constructive waves with the help of a diagram (6)

Read and highlight your notes. Ensure you understand the KEY PROCESSES, LANDFORMS AND IMPACTS OF COASTAL CHANGE.

CREATE REVISION CARDS AND TEST A FRIEND

Practice your diagrams and add labels and annotations.

There are threats to people and the environment:

People:

1. Low-lying coastal areas could be permanently flooded and become impossible to inhabit.
2. Coastal industries may be shut down because of damage to equipment and buildings, e.g. fishing boats can be destroyed.
3. There's a risk of damage to infrastructure like roads and railway networks. For example railway lines in Dawlish, Devon run parallel to the sea and are badly affected by flooding. Floods in 2014 caused damage to flood defences and part of the track.
4. There's a booming tourist industry in coastal areas. Flooding and erosion can put people off visiting, fewer tourists' means businesses that rely on tourism may close, leading to loss of livelihoods.

Environment:

1. Ecosystems will be affected because sea water has a high salt content. Increased salt levels due to coastal flooding can damage or kill organisms in an ecosystem. It can also affect agricultural land by reducing soil fertility.
2. The force of floodwater can uproot trees and plants, and standing floodwater drowns some trees and plants.
3. Some conservation areas are threatened by coastal erosion. For example there are lagoons on the Holderness coast that are protected. The lagoons are separated from the sea by a bar. If this is eroded it will connect the lagoons to the sea and they would be destroyed.

Climate change

- As atmospheric temperature rises, it is likely that storm frequency and strength will increase. This can increase the height and strength of waves reaching the coast (especially when combined with high tides). An increase in heavy rainfall and wind will also increase weathering and mass movement on the coast.
- As sea temperature increases, the water expands so sea levels rise. The melting of ice on land also adds to the water in the ocean. Rising sea levels put low-lying coastal land at increased risk of flooding.

The effects of climate change on the coastal environment

- Erosion may increase, so some beaches may disappear.
- Depositional features such as spits and bars may be submerged or destroyed.
- Natural ecosystems (e.g. the Essex marshes) and habitats may be destroyed.
- Erosion may increase, adding to coastal retreat and the risk of cliff collapse.

Impacts of increased risk of flooding on people

- Flooding associated with storm surges can put people at risk of injury and death.
- Psychological impacts of losing or potentially losing homes and livelihoods.
- Settlements either need to be moved or defended, both of which will be expensive.
- Coastal tourism may diminish in some areas if beaches or other landscapes are lost.
- Flooding of roads and damage to railways will make travel more difficult.
- Loss of agricultural land will affect food production and the economy.

Now try this

Explain why climate change brings an increased risk of coastal flooding in the UK.

(4 marks)

Explain how climate change may affect coasts in the future. (4 marks)

Sea levels are predicted to rise because of climate change. This will mean that low-lying coastal areas, such as in much of East Anglia, are at increased risk of flooding or may even completely disappear into the sea. There is likely to be more frequent and stronger storms in the UK. This will mean that coastlines are eroded faster and there may be more instances of coastal flooding, which may damage people's properties and destroy depositional features such as beaches.

This answer includes an example of an area that's at risk of increased flooding. It's always a good idea to include examples in your answers where you can.



Human impact on coasts

Human activities can have direct and indirect, positive and negative, effects on coastal landscapes.

Development

- 👎 The weight of buildings increases cliff vulnerability
- 👎 Changes in drainage increase saturation
- 👎 Raises interest in protecting coastal landscapes



Industry

- 👎 Can cause/increase air, soil, water and noise pollution
- 👎 Can destroy natural habitats for birds, animals and sea life
- 👎 Brings wealth and jobs to an area



Agriculture

- 👎 Increased soil erosion
- 👎 Increased sedimentation
- 👎 Wildlife habitats may be created and preserved



Coastal management

- 👎 Can increase erosion further along the coastline
- 👎 Helps reduce risk of coastal flooding
- 👎 Some salt marshes, sand dunes, sand bars and spits are preserved and protected



Tourism

Coasts attract tourists for relaxing on beaches, swimming and water sports as well as enjoying the beautiful landscape. The effects can be diverse.

- 👎 Increased development for hotels and campsites impacts on natural processes – for example, increasing/decreasing coastal erosion, transportation and deposition and mass movement
- 👎 Increased pollution – for example, littering, noise, traffic fumes
- 👎 Increased revenue benefits people living there
- 👎 Increased desire to protect and preserve landscape so tourism continues

Worked example

Describe **two** effects of human activities on coastal landscapes. (2 marks)

Human development of coastlines by building houses and other buildings on the coast increases the risk of mass movement and cliff collapse as the weight of the buildings puts increased pressure on the cliffs and adds to run-off, which leads to soil saturation.

Humans can also decrease coastal erosion and transportation by building sea defences, which protect the coastline from the sea, reducing the risk of flooding and coastal retreat.

When a question asks for a specific number of things (in this case 'two'), show the separate points, as in this example.

Now try this

Explain **one** way in which agriculture has affected coastal landscapes.

(2 marks)

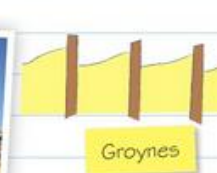
Coastal management

Managing coastal processes can be done in different ways. All have different costs and benefits.

Hard engineering



- 👎 Protects cliffs and buildings
- 👎 Expensive



- 👎 Prevents sea removing sand
- 👎 Exposes other areas of coastline

Soft engineering



- 👎 Sand reduces wave energy and maintains tourism
- 👎 Expensive



- 👎 Reduces slippage
- 👎 Foot of cliff still needs protection from the waves

Integrated Coastal Zone Management



- 👎 Do nothing
- 👎 Cheaper than taking action
- 👎 Homes and land are lost

- 👎 Hold the line
- 👎 Existing shoreline maintained
- 👎 Expensive

- 👎 Strategic realignment
- 👎 People and activities move inland
- 👎 Unpopular with local residents

Worked example

Explain conflicting views on **one** method of coastal management. (4 marks)

Groynes are a hard engineering method of coastal management. They help prevent erosion of that bit of coastline and stop longshore drift transporting beach sediments along the coast. People who have homes and businesses that would be impacted by coastal erosion if the groynes were not built are likely to approve of the scheme. However, people who live further along the coast may disapprove as their homes and businesses will be negatively impacted. People who are not affected at all may disapprove of taxpayers' money being used to fund such schemes.

With questions like this, it is always good to begin answers by naming the method the answer will discuss.

Now try this

Outline one cost and one benefit of **one** hard engineering method of coastal management.

(4 marks)

Holderness coast



You need to know how the interaction of physical and human processes is causing change on one named coastal landscape, including the significance of its location. We've used Holderness; you should use the example you did in class.

Holderness coast in East Yorkshire is one of the most vulnerable coastlines in Europe.

Significance of location

- Rock type is soft boulder clay, which is easily eroded and prone to slumping when saturated.
- Exposed to strong waves from the North Sea.
- Harder chalk rocks at Flamborough Head.

Physical processes at work

- Coastal erosion – a combination of strong waves (especially during storms) and rock type ensure the coast is eroded rapidly.
- The mean rate of erosion is around 2 m/year: one of the fastest-eroding coastlines in Europe.
- Mass movement – clay frequently slumps from the cliffs after rainfall.
- Transportation – strong waves move the eroded material away from the coastline.

Human processes at work

- Hard engineering on some parts of this coast – for example, rock armour and groynes at Mableton have protected some areas from erosion and cliff collapse.
- Hard engineering in some places has prevented transportation, making erosion worse in other places.

Changes caused

Some parts of this coastline are retreating at a rate of nearly 2 m/year. Farmland, property and settlements have been lost to the sea, changing the landscape permanently.



The Holderness coast



Sea defences at Mableton on the Holderness coast

Worked example

Using one named example, describe **two** ways in which human processes have affected physical processes in a coastal landscape. (3 marks)

On the Holderness coast in East Yorkshire, hard engineering methods including rock armour and groynes have slowed down the rate of coastal erosion and cliff collapse, which would otherwise have been fairly rapid. However, the rock armour and groynes in some places, such as Mableton, have prevented the transportation of material along the coast, leaving these other areas more exposed to erosion by the sea than they would have been and therefore speeding up the rate of coastal retreat.



Make sure you name your location in your answer.

Now try this

Explain how the location and geology of the Holderness coast contributes to its rapid rates of coastal erosion. (4 marks)

Coastal Management must be Sustainable

1. In order to protect the coast and avoid conflict, management strategies need to be sustainable. This means making sure erosion and flooding are controlled without causing more problems elsewhere (e.g. erosion further down the coast) or affecting the people who live and work at the coast (e.g. farmers and business owners). Strategies also need to be cheap to avoid conflicts about the spending of public money.
2. Integrated Coastal Zone Management (ICZM) is an approach that aims to protect the coast while taking everyone's interests into account – this makes it easier to find solutions that people can all agree on.
3. It's also a long term approach so it can be adapted to any future needs and changes along the coastline. This makes it a sustainable approach to managing the coast.

Tasks:

1. Draw a landform created by constructive waves (4)
2. Draw a landform created by destructive waves (4)
3. Describe the process of mass movement (3)
4. Explain why coastal management should be sustainable (6)
5. How is the Holderness coastline changing? (6)
6. What is ICZM? (3)
7. What's the difference between mechanical and biological weathering? (2)
8. Assess how humans have impacted on the coast (8)
9. Assess the advantages of hard engineering. (8)
10. How is climate change affecting our coastline? (6)
11. Assess the use of soft engineering along the coast (6)
12. Identify 4 types of transportation (4)
13. Identify 3 types of erosion (3)
14. Name 3 types of mass movement (3)
15. Describe and explain the process of longshore drift with the use of an annotated diagram. (6)

OS maps – Find an Ordnance Survey map and try to identify coastal features: Use the key to help you.

Caves, arches and stacks / cliffs and wave cut platforms / beaches and spits