GEOFILE 830

The diversity of the UK coastline

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Synopsis

- The United Kingdom, comprising the mainland of Great Britain and the north-east coast of Ireland plus its many smaller islands, is located on the western edge of the Eurasian plate. It has a coastline over 7,730 miles in length.
- The UK's geology is complex, because of its location on the western edge of the Eurasian Plate. Its coast is affected by weather systems from both the Atlantic Ocean and North Sea. The resultant waves directly modify coastal features through erosion, transportation and deposition.
- Today's rising sea levels associated with the inter-glacial period of ice melt and global warming associated with human activity also affect the diverse nature of the UK coastline.

Key terms

Fjord: a glacial trough/U-shaped valley, drowned by a post-glacial rise in sea level

Ria: a river valley drowned by a post-glacial rise in sea level

Concordant coastlines: a coastline where the geological beds run parallel to the line of the coast, causing a relatively smooth profile – only weaknesses like faults allow the penetration of wave power inland

Discordant coastline: a coastline where the rock beds are perpendicular or angled to the coast – this usually leads to a bay and headland coastline

Hausdorff dimension: a measure of the variation of the shape of the coastline

Amphidromic points: points at which there is zero tidal amplitude

Longshore drift: the lateral migration of beach material by oblique waves

Jurassic Coast: the coastline of Dorset (mainly) in which rocks and fossils of the Jurassic period are found

Ridges and runnels: ridges and troughs parallel to the coast found on shallow beaches.

Learning objectives

By the end of this **Geofile** you will have learnt about:

- the significance of geology in determining coastal features
- the effects of the 'trend' and length of fetch on a coastline
- the effects of waves, tidal range and currents and longshore drift
- the effects of sea level rise on coastal features
- the UK coastline as a composite of all these features.

Links to specifications

Exam board	Link to specification
AQA AS	3.1.2 Coastal systems and landscapes pdf p10 Click here
A2	3.1.3 Coastal systems and landscapes pdf p13 3.1.3.1 Coasts as natural systems pdf p13 3.1.3.2 Systems and processes pdf p13 3.1.3.3 Coastal landscape development pdf p13 3.1.3.4 Coastal management pdf p14 Click here
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OCR AS	1.1.1 Coastal landscapes pdf p13 Click here
A2	1.1.1A Coastal landscapes pdf p13 Click here
Eduqas	1.1 Coastal landscapes pdf p14 Eduqas/WJEC links Click here
WJEC AS	1.1 Coastal landscapes pdf p16 Click here

The diversity of the UK coastline

The creation of the set of islands that now form the UK occurred when the land bridge to mainland Europe was broken 8,000 years ago. The rising sea level associated with the retreat of the last ice age and a tsunami off the coast of Norway has created a very uneven and fractured coastline.

The Hausdorff dimension is the degree of straightness of a coastline. If the coastline of South Africa is compared to that of the UK, for instance, a fractal dimension of 1.02 compared to 1.25 is calculated. This indicates that, compared with South Africa, the UK coastline is less smooth and more 'wiggly'. This is evident from the greater number of estuaries, headlands, bays and peninsulas characteristic of the UK coastline compared to that of South Africa.

The landscape of the UK

The coastal landscape seen today is the result of many factors.

- Geology: in general terms, north and west of the Rivers Tees-Exe axis (Figure 1), the coastline is more mountainous and rugged. This is due to the more resistant nature of the igneous and metamorphic rocks found in these areas. In contrast, the eastern and southern areas are composed of sedimentary rock of varying degrees of resistance and producing a less rugged landscape.
- Location on the western edge of the Eurasian plate. The shallow waters are exposed to the energy generated by weather systems which travel from the west to south-west across the North Atlantic and southwards down the North Sea. Wind direction controls wave direction (Figure 2).
- Past and present climatic activity, including ice ages and current dynamic activity.
- The landscape of the UK with its 16 distinct river basin districts that drain the landscape and create estuaries on all coastlines.

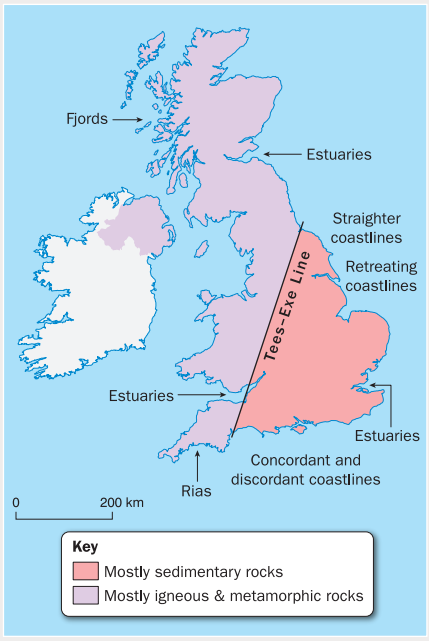

Figure 1 The Tees-Exe divide

Consequently, a diverse range of landscapes exist, including features such as:

- **The Giant's Causeway of Northern Ireland:** the result of volcanic activity from fissures or cracks in the Earth's crust 50–60 million years ago. The basalt cooled rapidly on contact with the air, producing a unique structure of 40,000 hexagonal blocks. This resistant material is now exposed to the action of the sea and its erosive power.
- **The White Cliffs of Dover:** deposition of calcium carbonate from the shells of sea creatures such as ammonites in deep clear seas produced the resistant chalk sediment. This was later exposed and produced the white cliffs dominating the south-east coast of England.
- **Skipsea, in the East Riding of Yorkshire:** the retreating cliff line at Skipsea, recently deposited glacial till which lies above soft clay deposits is being eroded by wave action. A retreat of 12 miles (17 km) in the last 10,000 years, averaging over 6 ft (2 m) a year, has been measured.

Figure 2 Dominant wave directions and longshore drift directions around the UK coastline

The UK experiences a cool temperate western margin climate; high rainfall figures create much surface flow and a dense pattern of rivers which flow across the UK's diverse geological foundation. The many river basins flow to estuaries surrounding the country carrying eroded material which becomes beach material, transported along the coast by longshore drift.

Dominant winds

The western coastline, especially in Scotland and the south-west of England, is open to storm force winds which are generated over the North Atlantic. These produce waves with considerable erosive power capable of eroding the resistant cliff lines. Ireland shelters the remainder of the west coast, especially Wales, from the full strength of these waves as a reduced fetch restricts the power they generate. The north and east coasts are affected by northerly winds originating in the Arctic. Although less frequent, their effects on the coastline are important.

Waves

- A wave is a surface disturbance of the sea normally caused by friction between wind and the sea surface. The stronger the wind, the greater the disturbance and the greater the wave height and frequency.
- Waves transfer energy and transport eroded sediment along the coast which will later be deposited at a new location in a process called longshore drift.

Tides

- Tides are produced by the gravitational pull of the moon and sun and the rotation of the Earth.
- Tidal range, the difference between high and low tide, depends on distance from an amphidromic point, the pivot point where sea level does not change.
- The further from this point, the greater the tidal range.

Location determines the tidal range a stretch of coastline receives (Figure 3).

Figure 3 Tidal ranges in the UK

All of these factors play a role and add to the diversity of the UK coastline, affecting rates of erosion, transport and deposition.

The UK is currently in an inter-glacial period, and sea levels have been rising for at least the last 10,000 years. This has produced two contrasting features on the west coast of the UK.

1. Rias

When water was locked in as ice, the oceans and seas were smaller. River systems that were unaffected by ice continued to flow, and cut down to the lower base (or sea) level. When ice melt began and sea levels began to rise, the lower parts of these systems were flooded. This produces a ria, or drowned river valley.

Rias are surrounded by undulating higher land, and their waters can stretch inland for many miles, altering the length and shape of the coastline. The broad inlet is deepest in the middle of the mouth of the flooded estuary, narrowing inland.

Kingsbridge estuary in Devon and the Milford Haven estuary in South Wales are examples of ria coastlines. Milford Haven has lent itself to significant dock development (Figure 4).

Rias are only found in south-west England and Wales.

2. Fjords

Flooded U-shaped glacial valleys which reach the sea are found on the north-west coast of Scotland. These are called fjords, or in Scotland, sea lochs. There are over 100 lochs on the western coastline of the country. They are characterised by steep valley sides, deep water and a shallow entrance called a strandflat.

When glaciation dominated the northern landscapes, sea level was lower, and so the ice had to cut down to sea level. The retreat of the ice and the end of the ice age saw ice melt, sea level rise and the flooding of these low-lying areas. Fjords are only found on the western sides of continents, due to dominant weather systems producing the snow to form the ice, and drainage patterns that developed in mountainous regions. The shallower lip at the entrance to the loch or fjord can be explained by the ice spreading out onto the plains once free of the restricted glacial valley, and lower rates of erosion and down-cutting.

Fyne (56°N 5.1°W) and Loch Broom (57°N 5.1W°) are two examples located on the west coast of Scotland.

The Jurassic coast

In contrast, the 96-mile stretch of coastline between Exmouth in East Devon and Studland Bay in Dorset is the result of plate movement and the folding of sedimentary strata exposing five

Figure 4 The ria estuary at Milford Haven (note the tanker docked in the deepest part of the estuary)
Source: Shutterstock/Phillip Roberts

Figure 5 View of Lulworth Cove with the chalk cliff (left)
Source: Shutterstock/Daniel Spence

rock types of different resistances. Known as the Jurassic coast, it is a world heritage site, displaying a diversity of coastal features due to its geology and location.

The sandstone cliffs lining the Devon coastline are replaced by chalk and then Portland limestone cliffs further east in Dorset. Both materials are exposed at the surface as a result of plate movement and folding. The resistance of the material has produced steep cliffs, with bays forming where softer sedimentary material lines the coast. Longshore drift is evident as seen with Chesil Beach, a tombolo joining the mainland to the Isle of Portland.

At Lulworth Cove, part of a concordant coastline is found with the Portland Stone running parallel to the coast. However, faulting has led to lines of weakness in the rock being exploited by wave activity generated by strong winds from the south-west. This has broken through the outer layer of Portland stone and led to the erosion of the softer Purbeck beds and even softer Wealden beds and Greensand. Wave refraction has created the cove in the softer beds. Coastal retreat has been reduced as waves now break against the more resistant chalk which marks the back of the cove.

Adjacent to Lulworth Cove lies Stair Hole. This displays the same processes that created Lulworth Cove but is at an earlier stage in its development. The Portland stone and Purbeck beds have been broken through, displaying an anticline in its rock strata. Softer Wealden and greensand beds are retreating, eroded more easily by the waves. It is another Lulworth Cove 'in the making'.

Further east, at Swanage, in east Dorset in the Isle of Purbeck, discordant coastline is found. The same bands of rock as seen at Lulworth Cove are exposed at the coast and produce a series of headlands and bays. Continuing east, the Jurassic Coastline continues to the sea stacks of the Old Harry Rocks marking the former cliff line. North lies Studland Bay where the Jurassic coastline ends.

Kent coast

Chalk cliffs dominate much of the remainder of the south coast of England, with boulder-strewn wave-cut platforms marking their retreat. However, at Dungeness in Kent the largest **cuspate** foreland in Europe can be found. Occupying 12 sq miles, this extension into the English Channel is the result of sediment accumulation. Waves generated by south-westerly winds transport sediment eastwards along the English Channel, while easterlies transport sediment westwards through the narrow Straits of Dover. The merging wave actions have created at

Figure 6 Concordant and discordant coastline by Swanage, Dorset

Dungeness a triangular-shaped foreland containing stable shingle beaches and Romney Marsh. It is now a stable feature and a Site of Special Scientific Interest (SSSI).

The transportation of sediment by wave action is called longshore drift. Along most coastlines, it operates in one direction and transports material creating a dynamic 'river' of sand and shingle, constantly altering the shape and profile of beaches bordering the coastline.

Suffolk coast

At Orford Ness in Suffolk, East Anglia, the UK's longest vegetated spit runs parallel to and is separated from the mainland by the River Alde. Flowing over the flat landscape, the River Alde lacks sufficient energy to move the sediment transported by the waves. Sediment accumulation has diverted the mouth of the river southwards. The resultant spit now runs parallel to the coast for approximately 10 miles and covers 2,230 acres. Its stability derives from storm waves which have thrown this flint beyond the range of the normal wave action and tidal activity. The size and shape of the spit change constantly.

Coastal bars

Where a river mouth is completely blocked by the actions of longshore drift, a bar is formed.

- Slapton Ley, in south Devon is such an example and the lagoon which lies behind the bar is tidal, with water percolating through the shingle making the bar.

Where an island is joined to the mainland by such action, a tombolo is formed.

- At Chesil Beach in Dorset, stretching from Abbotsbury to the Isle of Portland, pebbles are graded on the beach, gaining in size closer to Portland – a mystery. Longshore drift would indicate that the smallest pebbles would be transported the furthest, and yet the opposite is seen. Glacial deposition may be an answer to this anomaly.

Conclusion

The UK's origins and location adjacent to the North Atlantic Ocean and the Eurasian landmass have created a coastline varying from steep resistant to shallow non-resistant cliffs to lowland areas subject to the actions of longshore drift. It is a dynamic coastline which will continually alter, especially with climate change and predicted rises in sea level.

Focus questions

1 Examine the reasons for the UK having such a diverse coastline.

2 Describe and explain the differences between ria and fjord coastlines.

3 Using the map extract of Swanage, Figure 6, explain how geology has created both concordant and discordant coastlines, with examples.

4 Essay question: Location is key to determining how coastal features in the UK have evolved. Discuss this statement.

5 Critically consider the statement that 'the east coast is more liable to coastal erosion than the west coast of the UK'.

Learning checkpoint

After working through this unit:

1 On an outline map of the UK, mark and name all places mentioned.

2 Discuss the importance of rock type in determining coastal features. What other factors are important in producing coastal diversity?

3 What causes a location's tidal range, and what effects can this range have upon the coastline?

4 To what extent is longshore drift of more significance on the south and east coasts compared to the north and west?

Selected websites

The Jurassic coast

click here

Spurn Point

click here

The diversity of the UK coastline

The UK land mass varies from the old red sandstone cliffs at Rackwick Bay on the west coast of Hoy in Orkney, Scotland, to the coastal spit at Spurn Head in Lincolnshire. From the 139m (449 ft) sea stack, the 'Old Man of Hoy', to the saltmarsh and mudflats which shelter from the North Sea to the lee of Spurn Head, a varied landscape of erosion, transportation and deposition can be found.

All of the UK coastline is subject to hydraulic action, abrasion, corrosion and attrition by the action of the sea. Location affects the effectiveness of each. The erosive forces act between high and low tide mark, with the amounts of beach exposed depending upon the gradient of the beach. Geology determines what is eroded and what can be transported by wave action.

Beaches are dynamic environments and are the buffer between land and sea. The three components are

- nearshore
- foreshore (surf zone)
- backshore above the high tide mark

In the UK, tidal range varies between 0.5 and 15 m. Where a large tidal range exists and beach slope is less than 4°, greater widths of beach are exposed. At Saltdean in Sussex, a wave-cut platform in the chalk cliffs is exposed. The beach is strewn with boulders from undercutting which dislodges the chalk, causing cliff collapse. As the wave-cut platform widens, wave energy decreases and further erosion is reduced.

Harlech beach in North Wales has a shallow gradient and large expanses of beach are exposed at low tide. The breaking waves have a weak backwash, enabling the returning water to percolates downwards. This deposits sand which stronger winter swash waves cannot remove, and ridges develop which run parallel to the shoreline. In between, runnels form to drain water that flows up the beach at high tide. Further landward is the storm ridge, reached only by the stronger spring tides which deposit larger material that weaker tides cannot reach or remove.

The future of such beaches is under threat from global warming and predicted sea level rises. The UK has already experienced changes as a result of isostatic uplift in Scotland, as the weight of the ice which compressed the landscape has been released. Meanwhile the south of England, with its different geology, is sinking. Both have an effect on the coastline and the zone of wave activity. The UK coastline consequently maintains its diversity due the dynamic nature of all the forces acting on it.

Challenge yourself

1 What effect does the tidal range have upon an area of coastline that you have studied?

2 Draw a field sketch based on Figure 7 to represent Harlech Beach and annotate it to show the features associated with the tidal activity on the beach.

3 With examples drawn from either the text or your own knowledge, explain why the UK has such a diverse coastline.

Ready for more?

- Research predicted sea level rises as forecast for the end of the 21st century.
- What effects will these changes have on the shape of the UK coastline?

Figure 7 Harlech Beach
Source: Shutterstock/Iolo ap Gwynn