Coastal landform and landscape development: The East Riding of Yorkshire coastline

Coastal landscape development 3.1.3.3

The coast of the East Riding of Yorkshire (including the Holderness coast)

The East Riding of Yorkshire coast provides some of the most variable coastal features in a 70km stretch of contrasting landscapes and coastal processes. Features of erosion dominate the northern sections while the most rapidly eroding coast in Europe occupies the central plain of Holderness, with the southern end given a distinctive profile with the growing spit of Spurn Point extending into the Humber estuary and sheltering the mudflats and saltmarshes of the Humber Estuary behind. The factors responsible for the contrasting coastal landscapes extend over space (spatial factors) and time (temporal factors).

Spatial factors

Lithology and rock structure

At the northern end of East Yorkshire there are thick layers (over 300m) of Upper Cretaceous chalk that originated in warm tropical seas around 75 million years ago. These are gently dipping on a north west/south east axis, outcropping at their highest at Bempton cliffs 4 km north of Flamborough Head and gently shelving until they disappear under glacial deposits at Bridlington on the south side of the headland. The layers of chalk are largely undisturbed for the most part, exposed at right angles to the cliff face and, consequently, forming vertical cliffs over 100m. high (the highest sea cliffs on the east coast of Britain).

At Flamborough Head the chalk has been subject to tectonic movement with extensive faulting and folding at Selwick's Bay that have fractured the chalk more fully, allowing agents of weathering and marine erosion to erode bays into the promontory. Weaknesses in the chalk have enabled distinctive features of erosion to develop around Flamborough Head in contrast with the relatively massive beds of more undisturbed, resistant chalk just north at Bempton. Caves, arches, stacks and blow-holes are common and lateral erosion of chalk promontories by wave refraction have indented the coast at this point even further. There are extensive wave cut platforms in the small coves and bays of Flamborough Head denoting cliff retreat over thousands of years.

Sediment transfer

The prevailing north easterly winds drive onshore waves that generate longshore movement of sediment from north to south along the coast. Chalk debris from Flamborough Head is deposited all along the coast as far as Spurn Point in the south. From a zone of net erosion and sediment loss in the north, the sediment budget changes to net deposition and sediment gain in the south in the form of the spit Spurn Head.

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At the southern end of the county the River Humber, one of Britain's largest drainage systems capturing over 20% of British river water, enters the North Sea. Not only has it prevented the spit of Spurn Point becoming a bar, but it deposits far more sediment into the sub-cell than is provided just from coastline mass movement and marine erosion. The combination of this river sediment encountering the southward littoral movement of marine sediment has enabled a larger spit to form than otherwise would have been the case. The turbulence between the two currents meeting at right angles deposits river and marine sediment at the end of the 4.8km. long spit, continuously extending its length. Behind (to the west) of the spit the calm tidal waters of the Humber estuary have created large mudflats that develop into saltmarsh successions closer to the shore.

Temporal factors

Ancient processes

The deposition of the shells and skeletons of marine sea creatures 75m. years ago and subsequent uplift of the lithified sedimentary rock 15m. years later are responsible for the basic structure of the northern part of the East Yorkshire coast. The chalk has been subject to erosion at various phases since then.

Quaternary processes

The last major advance of ice during the Pleistocene era (began 2.5m years ago) came to an end 18 000 years ago. The rapidly melting ice sheets left a layer of glacial till over the entire region, plastering the exposed chalk and depositing boulder clay to such an extent that it became the Holderness Plain as ice sheets retreated. As sea levels rose rapidly around 10 000 years ago this unconsolidated material became the new coastline of the region. Rapid coastal retreat has occurred ever since and continues today. With an average retreat of 1.6m of coast each year, over 2km have been lost since Roman times and the constant slumping and removal by littoral drift is the key characteristic of the mid-section of the East Yorkshire coast.

Century cycles

It is thought the development of the Spurn spit operates on a 350-year cycle of development, growth, extension, breaching at the neck and washing away, before a new cycle of growth begins at the new position of the retreated coastline. The current spit is thought to be reaching the end of the cycle: the neck is regularly breached and the lifeboat families that lived at Spurn Head have now been permanently moved off the spit.

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Short term cycles

The tidal range of the Humber estuary varies from 2.8m at average neap tide to 5.7m at average spring tide. This contributes to the extensive development of mudflats on the north bank of the Humber estuary. Sea level rise is expected to inhibit the development of saltmarsh successions that would otherwise be expected to take place. One result is managed retreat developments taking place near Paull to the east of Hull which are creating human-induced saltmarsh habitats in an effort to contain rising sea levels and absorb periodic flooding.

Exam style questions:

1. **For one feature of coastal erosion examine the role played by subaerial weathering in its development (9 marks)**

2. **'The development of distinctive coastal landscapes is largely to do with the type of rock that is found at the coast in particular sections of coastline.' Assess the validity of this statement. (20 marks)**

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1. **For one feature of coastal erosion examine the role played by subaerial weathering in its development (9 marks)**

Nearly all features of coastal erosion are formed as a result of both subaerial weathering and marine erosional processes. This question is asking for both an explanation of the weathering processes in how they contribute to the development of an erosional feature but at the top end of marks also expects a comment on the relative importance of the them compared with erosional processes.

Level 1 (1-3 marks)

Simple description of the processes that result in a feature of coastal erosion. Weathering and erosion processes are outlined but not distinguished.

Level 2 (4-6 marks)

Fuller description and explanation of clearly defined weathering processes and how they have contributed to a feature of erosion. Lack of comment on the significance of these processes in the overall formation sequence.

Level 3 (7-9)

Detailed description and explanation of clearly defined weathering processes and the role they have in the development of a feature of erosion and how they will continue to act on the feature. Comment assesses the degree of significance of these, compared with marine erosion processes.

Example: Formation of a stack

Cave develops from marine erosion in the intertidal zone and just above (storm wave height). To enlarge the cave roof higher, weathering processes are responsible (chemical action – solution, oxidation, mineralisation). Once an arch develops the arch roof is often above direct wave action but is reduced by subaerial weathering from above (mechanical freeze-thaw, chemical solution, biological weathering) and below (chemical action). Once the roof collapses the stack will be eroded at its base by marine erosion process and lowered from the top by subaerial weathering processes. The relative balance may be determined by the rock lithology and structure. Many 'stumps' suggest subaerial weathering is more potent than marine erosion processes in reducing the stack.

2. **'The development of distinctive coastal landscapes is largely to do with the type of rock that is found at the coast in particular sections of coastline.' Assess the validity of this statement. (20 marks)**

This question tests a students' understanding of the difference between a coastal feature and a coastal landscape. While individual coastal features may depend on the nature of rock for their form and characteristics, a coastal landscape is an accumulation of features as a result of processes occurring at different scales of space (spatial) and time (temporal). The student should use their answer to show their understanding of a coastal landscape arising from different coastal systems operating at different scales from the small and regular (beach ripples from varying tides) to the large and over extended periods of time (eustatic sea level change).

Coastal landscapes may vary according to:

- High degree of coastal uniformity or significant complexity due to lithological variability not only in the type of rock but also the structure of the rock (highly jointed/massively bedded) geological angle (dip) and orientation (concordant/discordant coastline).

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- High energy coasts v low energy coasts: there may be net deposition that dominates the nature of coastal features, irrespective of the nature of the rock forming the coast. In extensive deltaic, estuarine, saltmarsh, sand dune and mangrove coasts the natural 'rock' may be far from the actual coastline. It is the features of deposition that give the coastline its landscape characteristics.
- System dimension: relatively small sub-cells of larger sediment cells may be in a state of equilibrium with little change, but the input of a major inland drainage system to a coastal environment can bring significant change if flood waters introduce periodic sediment dumps, affecting coastal currents and developing barrier islands, building up beaches and extending depositional features.
- Time dimension: some coastlines are relatively 'new' (volcanic island of Surtsey off Iceland) with relatively few coastal features and those that exist at an embryonic stage of development. Others are an accumulation of past processes and relict features, such as parts of the west coast of Scotland where isostatic recovery has left relict cliffs, arches, caves and wave cut platforms high above current sea level, where early-stage formation of new caves and associated features are taking place at a lower level. Fjord landscapes of Norway and New Zealand owe their origins to glacial processes occurring repeatedly over tens of thousands of years and that present coastal processes are relatively modest in generating significant modification.

In conclusion the student should 'assess the validity' of the original statement to justify whether it is applicable to any coastal context and note the factors, systems and scales that render it inaccurate for the majority of coastal landscapes.