The factors influencing the rate and location of coastal processes, to include marine (including refraction), atmospheric, geological and human factors.

You need to appreciate the spatial and temporal variations in the influences of a range of factors.

Wave Influences

Breaking point of waves. Maximum erosion is caused if a wave breaks at the base of a cliff, releasing most of its energy. This will happen at high tide, under storm conditions at Hartland Quay. Waves that break further offshore will have their energy dissipated. This will happen on gently sloping beaches such as Saunton Sands or where there are wide wave-cut platforms or reefs. The wave-cut platforms at Warren Bay and Well Beach at Hartland Quay dissipate wave energy, but only at low tide. At high tide waves can cross the platform to the base of the cliffs. In tropical islands like Barbados, coral reefs help to dissipate wave energy.

Wave steepness. Locally produced storm waves are often steeply sloping. Large swell waves also become steeper as refraction takes place as they approach the shore. Steeper waves are more likely to be **destructive** and less steep, waves are more likely to be **constructive**.

Wave construction & destruction.swf

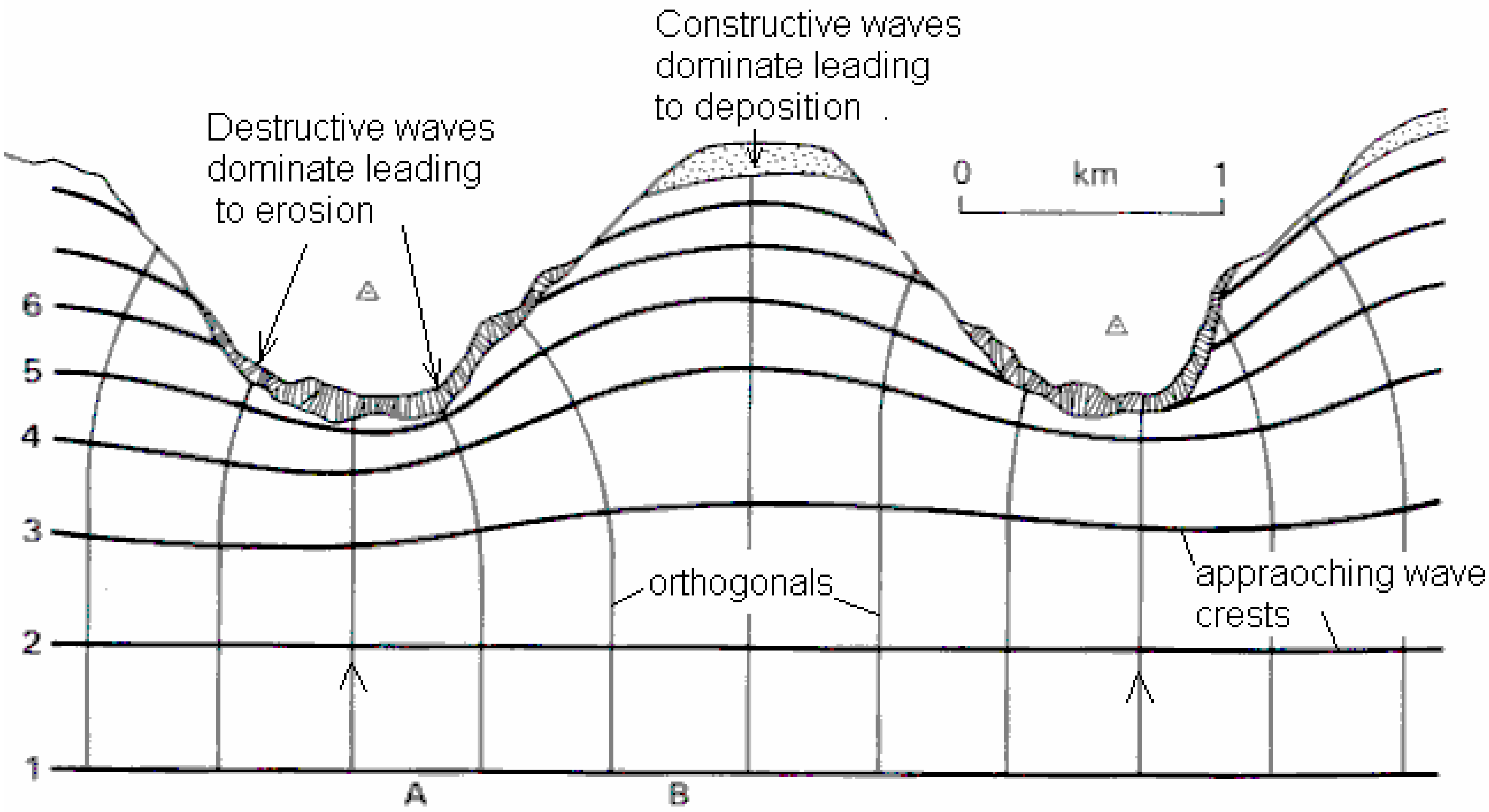
Length of Fetch. Coastlines with a large fetch, such as at Hartland Quay, are more likely to receive high energy waves and therefore erosional processes will be more dominant.

Tidal currents.

In estuaries, and in narrow straits between the coast and offshore islands, with a macro-tidal range, tidal currents can have a scouring effect leading to erosion. Tidal currents are important in the mouth of Poole Harbour and in the Taw/Torridge estuary for removing sediments. In more sheltered locations, such as the inner part of Poole Harbour or the shores of the Taw/Torridge estuary, tides supply fine sediments for the accumulation of salt marshes. Tides are also important for exposing large areas of sand on Saunton Sands which, when it dries, forms the raw material for sand dune building at Braunton Burrows.

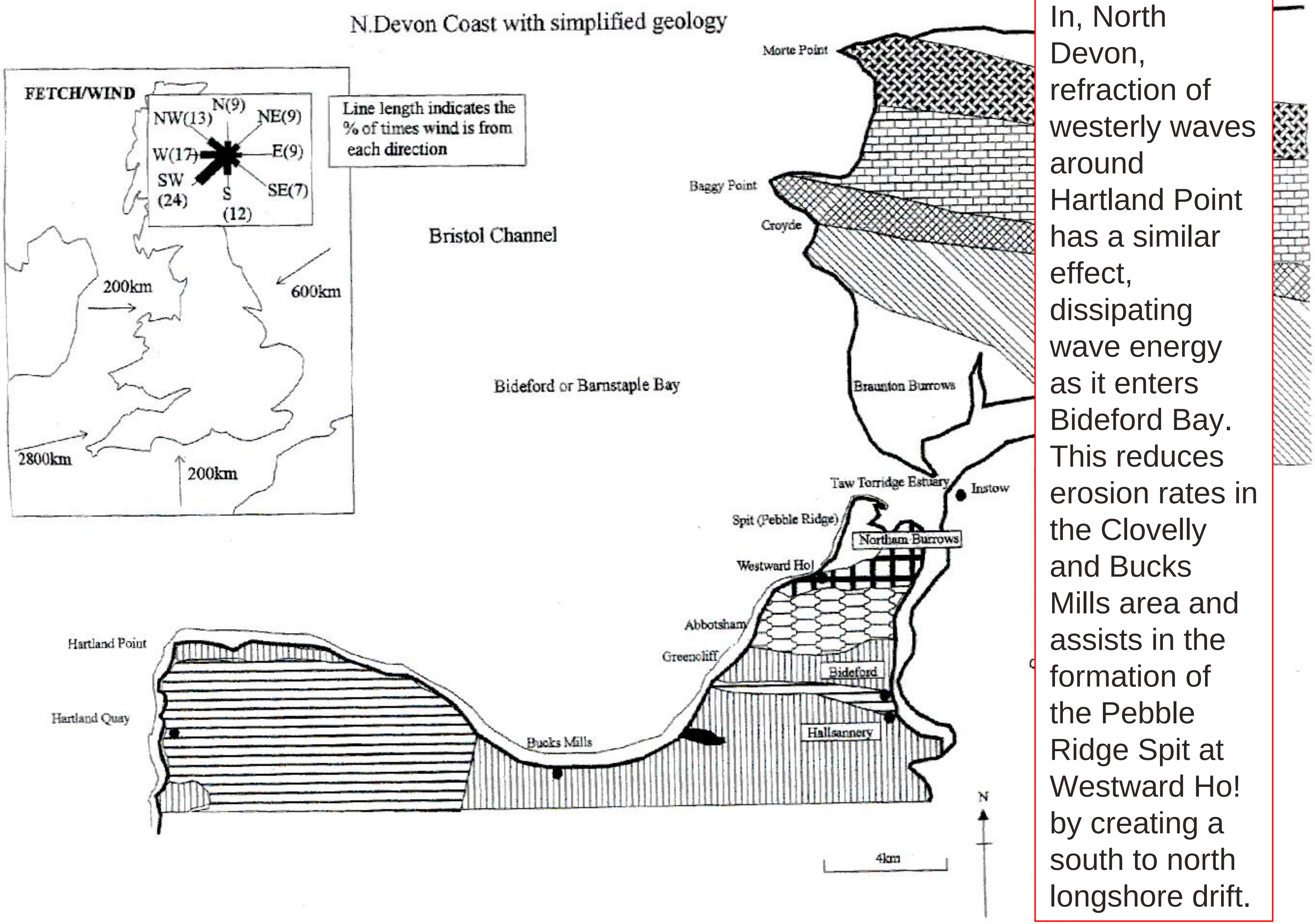
The impact of tidal currents between Sandbanks and Brownsea Island at the entrance to Poole Harbour

Wave Refraction



Wave refraction focuses wave energy at headlands and dissipates energy in bays.

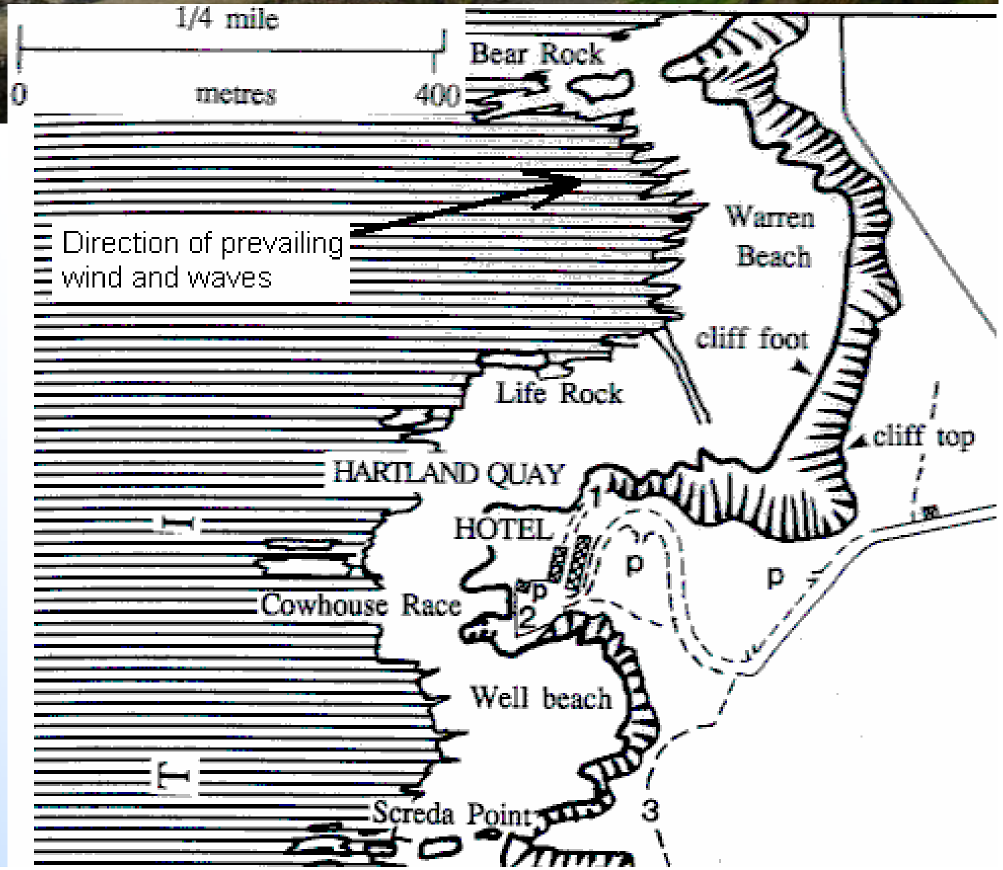
Waves refract into Swanage Bay around Durlston Head. *(Notice the groynes designed to reduce longshore drift.)*



In, North Devon, refraction of westerly waves around Hartland Point has a similar effect, dissipating wave energy as it enters Bideford Bay. This reduces erosion rates in the Clovelly and Bucks Mills area and assists in the formation of the Pebble Ridge Spit at Westward Ho! by creating a south to north longshore drift.

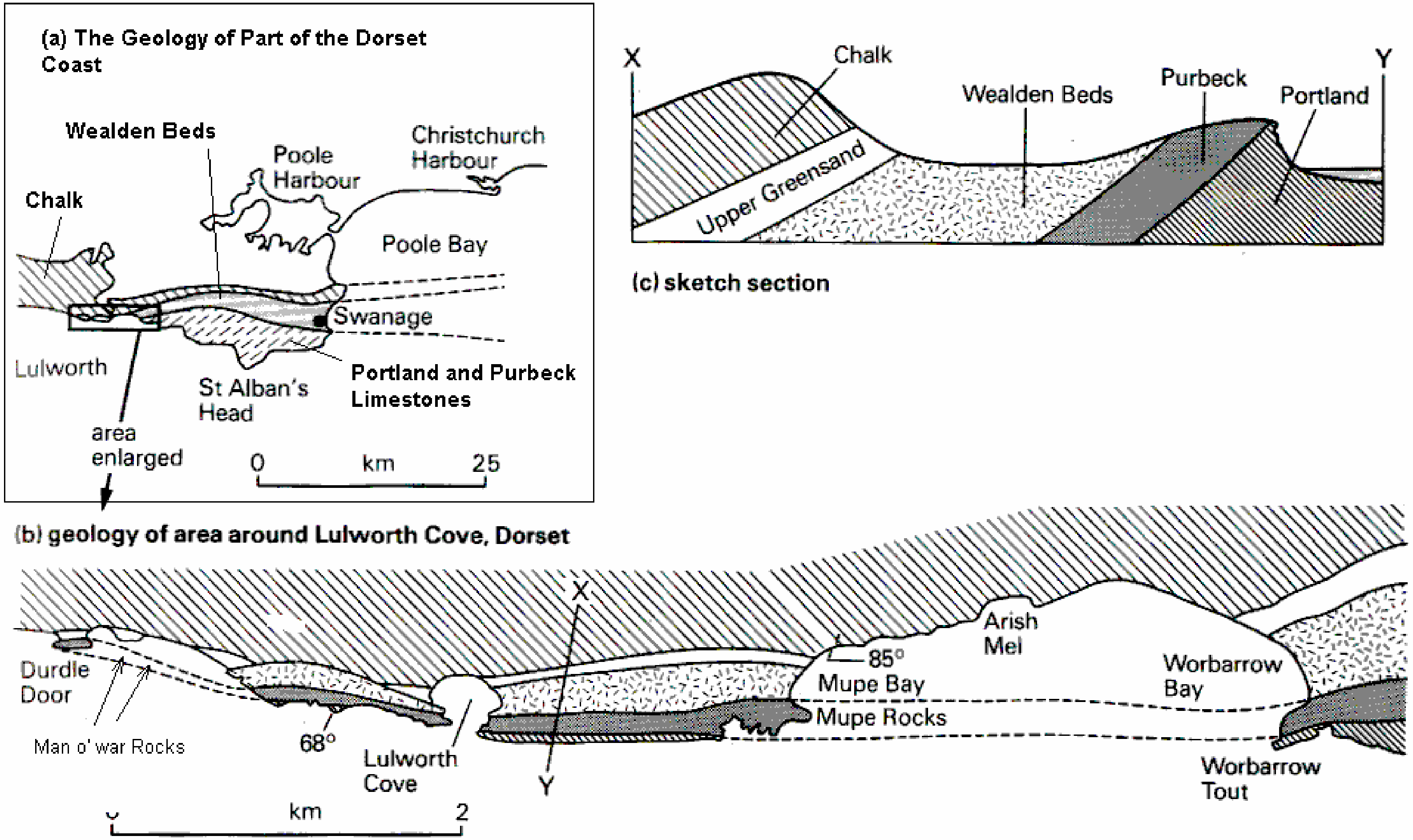
Warren Bay, Hartland Quay

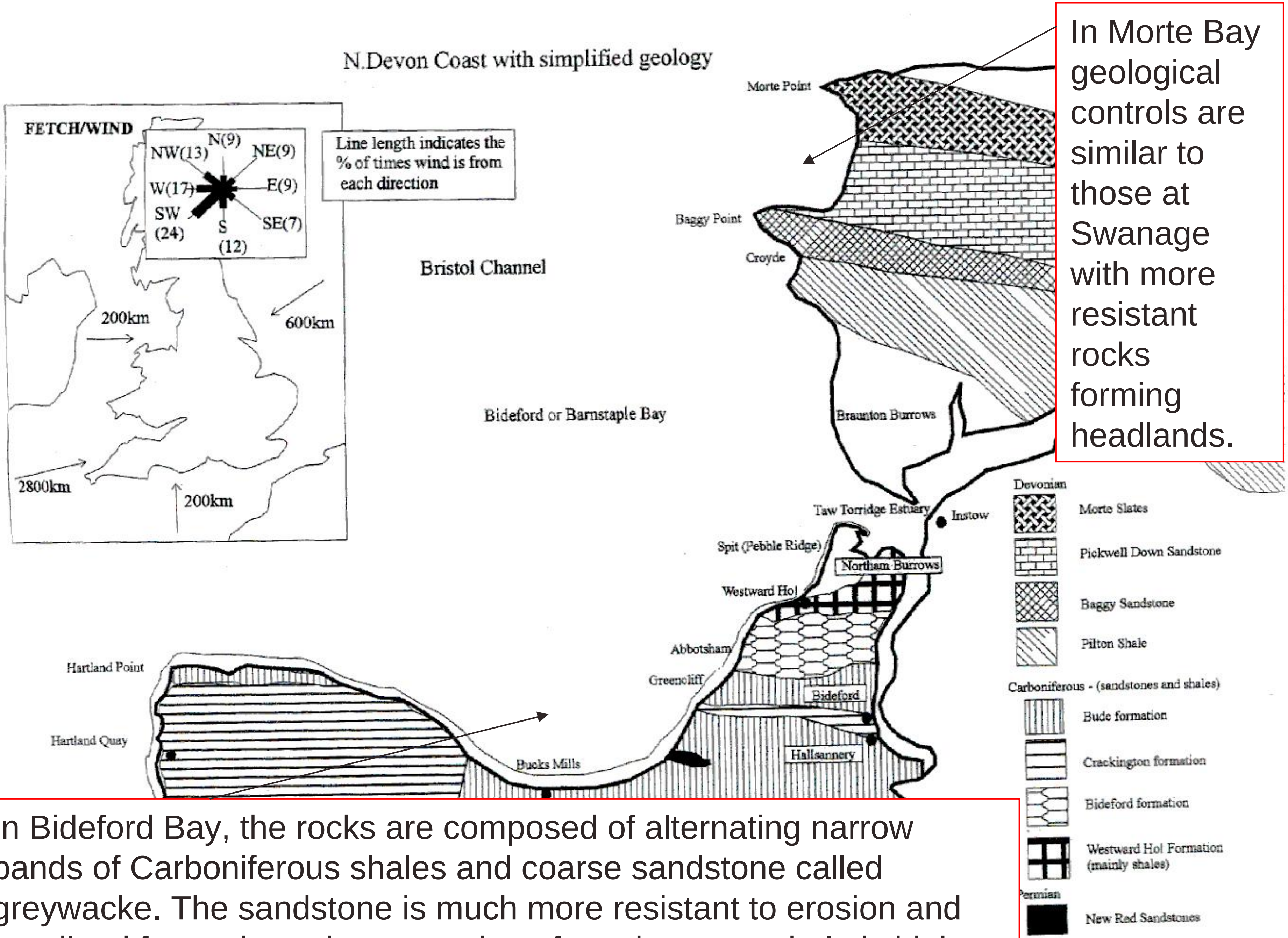
In Warren Bay, the **refraction** of waves around Life Rock leads to lower wave energy in the southern part of the bay where sandy beaches can accumulate in the summer months (many beaches are temporary features). The Northern part of the bay is **swash aligned** and receives the brunt of the Atlantic Storm Waves. The Headland, on which the Hartland Quay Hotel stands, is also prone to concentrated wave attack.



Geological factors

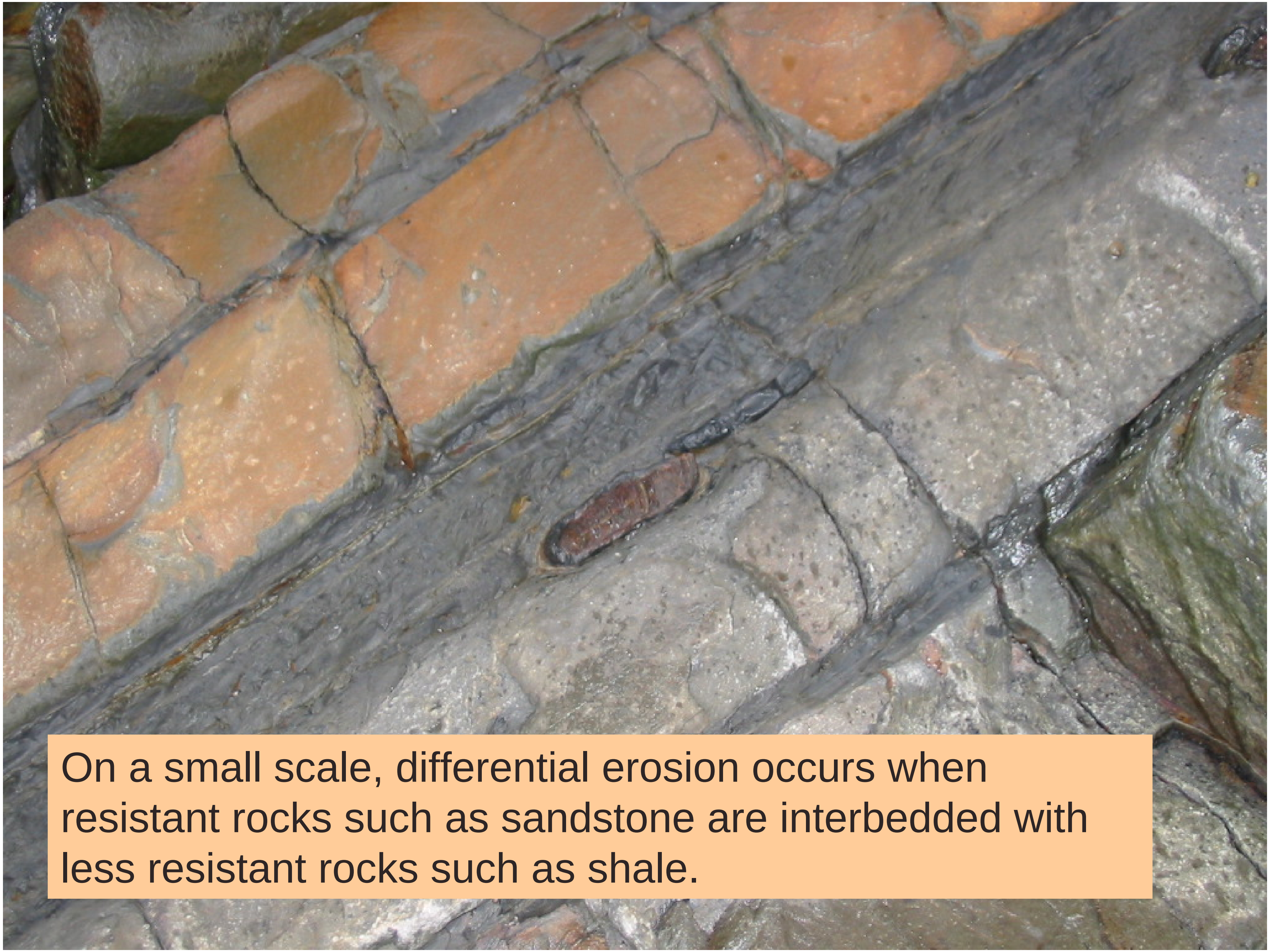
Rock lithology. Some rock types resist erosion more than others. In Dorset, the weaker rocks are the clays and soft sands of the Wealden Beds, whereas the relatively harder Portland Limestones and chalk resist erosion more effectively



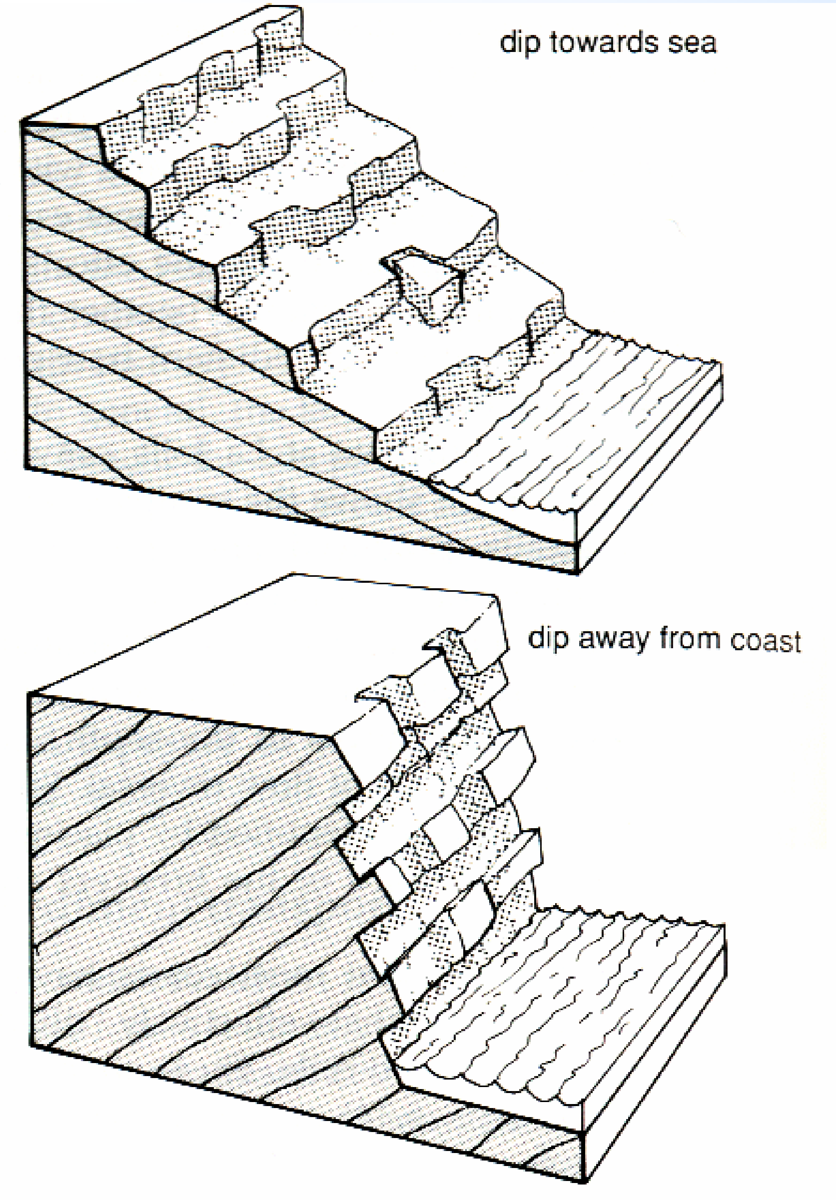


In Morte Bay geological controls are similar to those at Swanage with more resistant rocks forming headlands.

In Bideford Bay, the rocks are composed of alternating narrow bands of Carboniferous shales and coarse sandstone called greywacke. The sandstone is much more resistant to erosion and headland form where the proportion of sandstone to shale is higher.



On a small scale, differential erosion occurs when resistant rocks such as sandstone are interbedded with less resistant rocks such as shale.

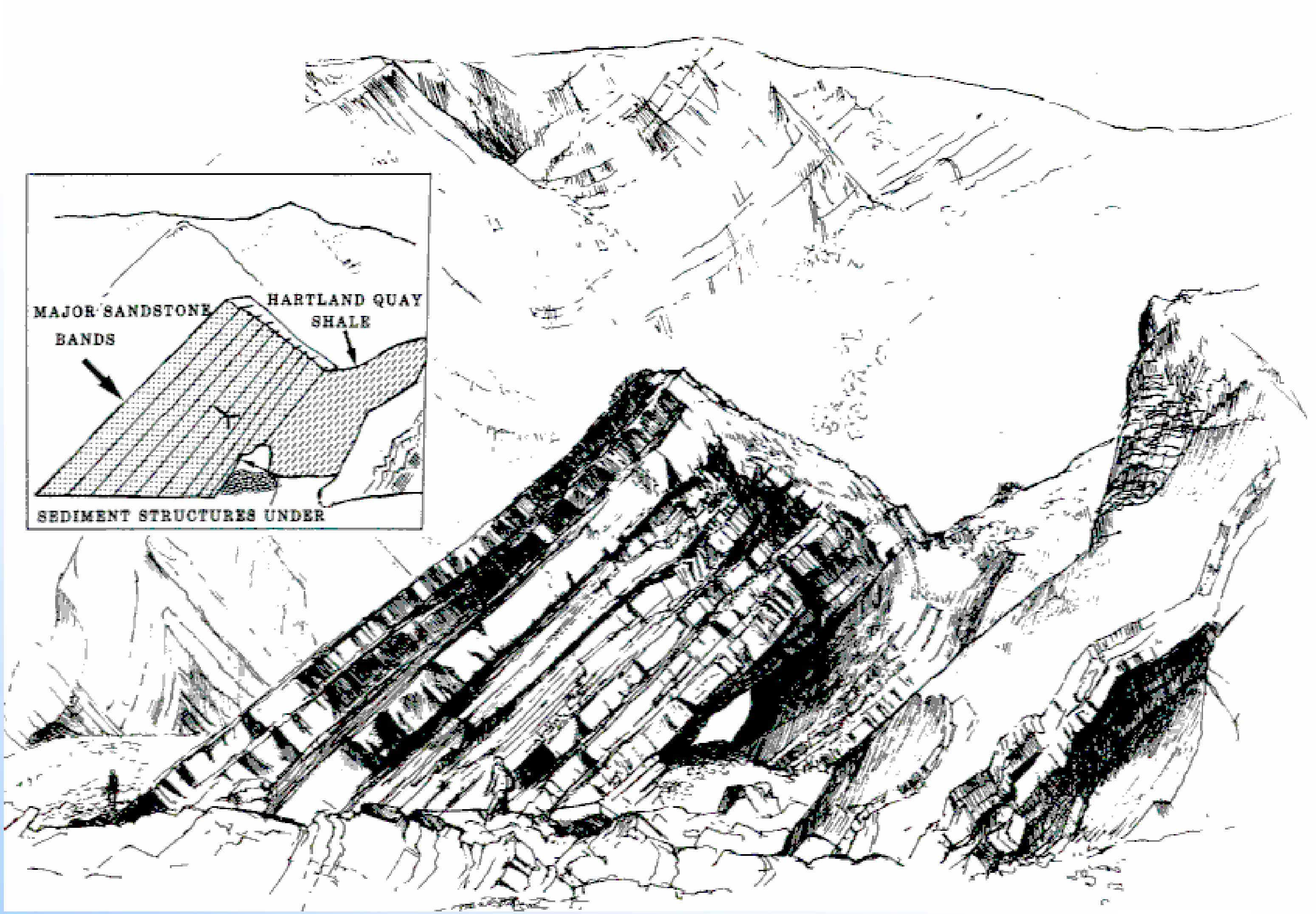


Rock dip and geological structures

Most rocks have internal structures. These include bedding planes (found in most sedimentary rocks), cracks or joints, folds and faults. These structures provide weaknesses in the rocks that can be exploited by processes such as hydraulic action and abrasion. Very often, tectonic processes in the past will have compressed or distorted the rocks, causing the structures.

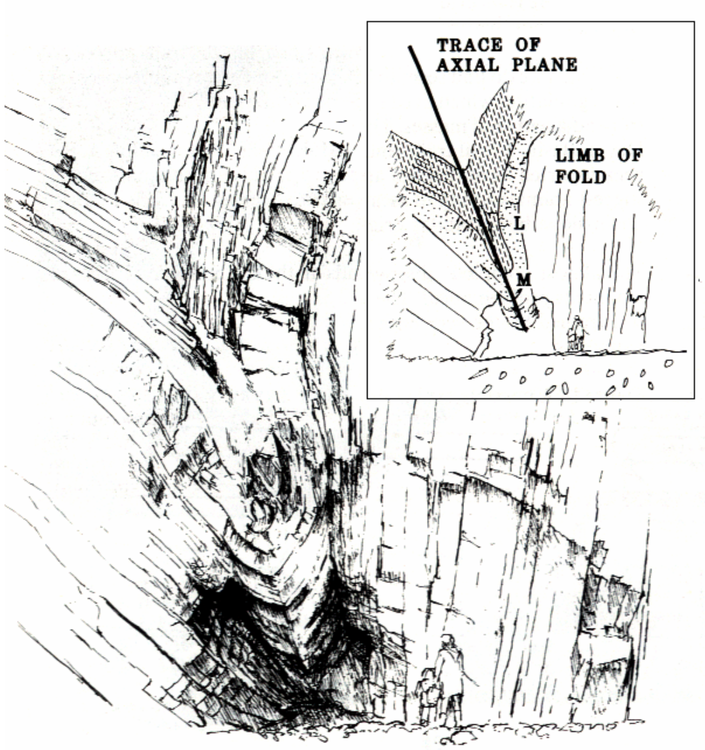
Dip towards the sea at Tunnel Slab

Dip away from the sea at Hartland Quay Hotel



The rocks at Hartland Quay also demonstrate the impact of other geological structures on the shape of a cliff face. At tunnel slab, the erosion of a thicker band of Shale (the Hartland Quay Shale) has produced an arch-like like formation. Notice the differential erosion in the rocks along bedding planes and joints.

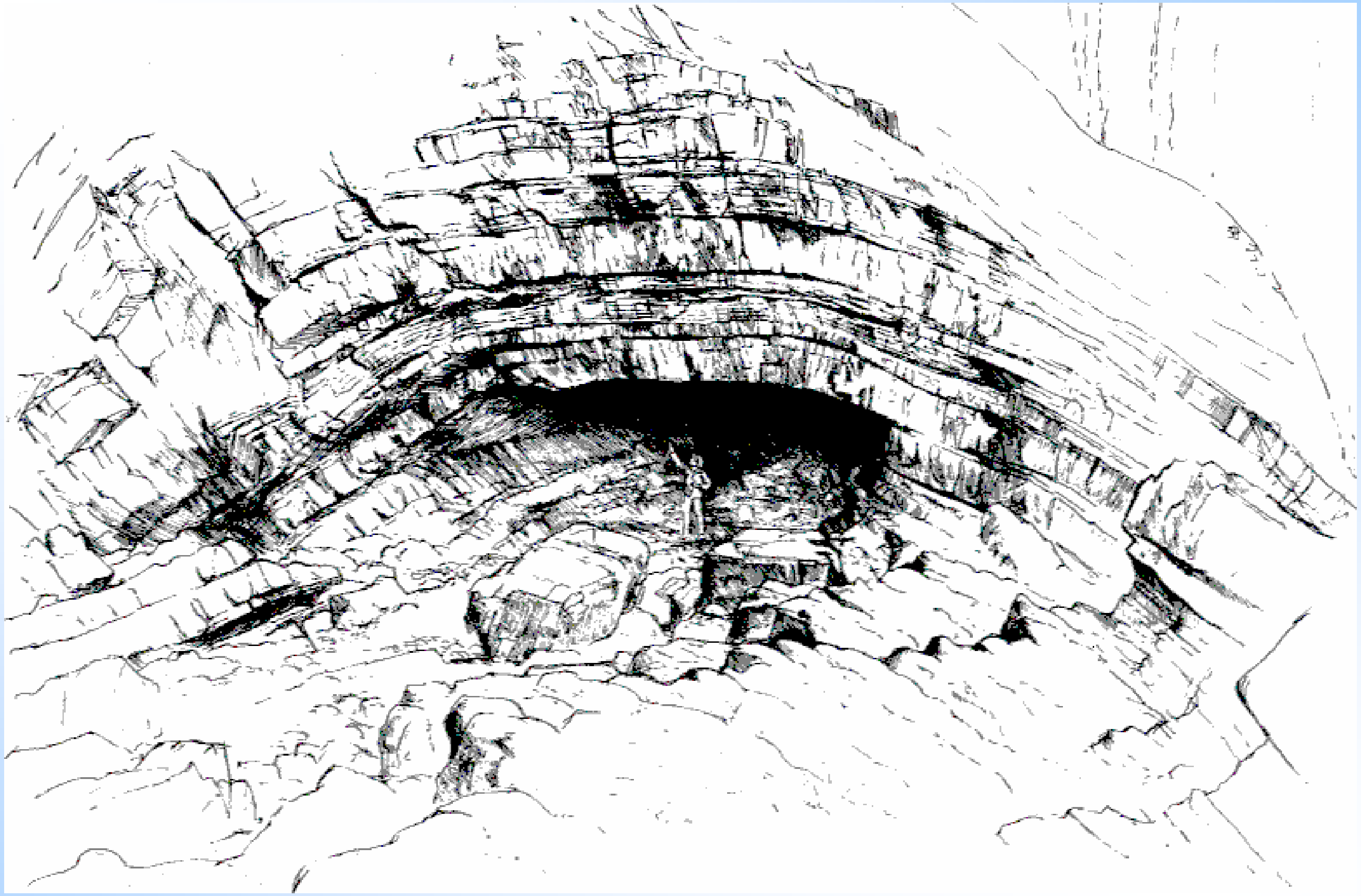
The influence of folding



The impact of tight **chevron folding** at Warren Bay is to weaken the rocks along the **axis** of the fold. Whether the fold is a **syncline** of an **anticline**, the weakening of the rock has enabled the processes of erosion to deepen the **wave-cut-notch** into a **sea cave**.

An eroded anticline in the wave-cut platform at Hartland Quay

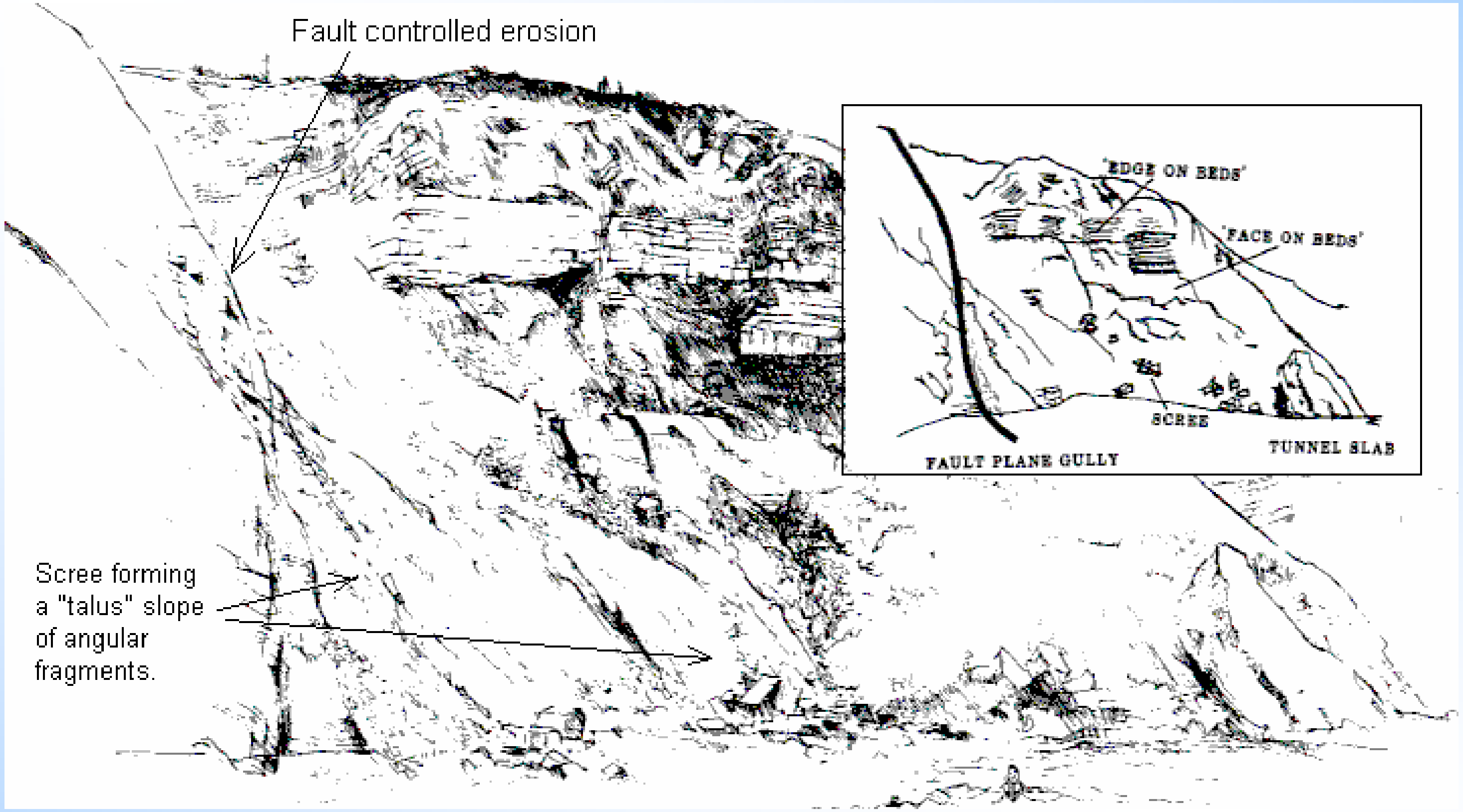
Here an anticline leads to differential erosion both in the cliff face and on the wave-cut platform.



Here an open anticline provides a point of weakness for marine erosion along the line of its axis.

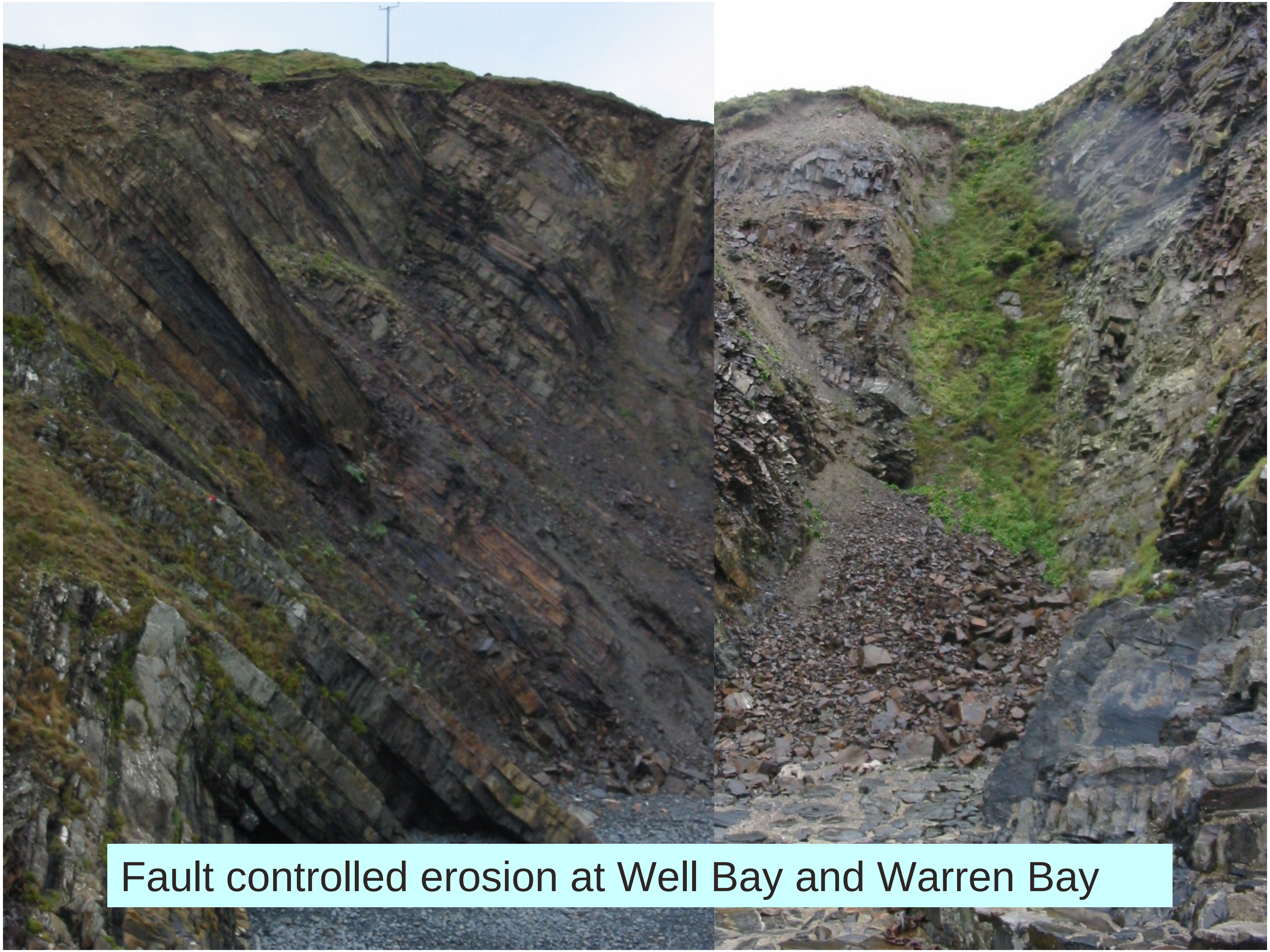
Folded sandstones and shales of the Upper Carboniferous Crackington Formation at Warren Bay . This section is the “**type locality**” for chevron folds. Note the contrasting difference in the style of folding across the section.

The Influence of Faulting



Geological **faults** in Warren Bay also provide a line of weakness as the rock will have been crushed and fragmented at the time of faulting. Notice the fallen rock "**scree**" at the base of the cliff called a "**talus**" slope. This may be removed by later wave activity.

Fault control at Well Bay at Hartland Quay



Fault controlled erosion at Well Bay and Warren Bay


Fault controlled erosion in the wave-cut platform in Warren Bay

Coastal Orientation (Concordant or Discordant)

In both North Devon and Dorset it is possible to see the impact of the **orientation of the coast** in relation to the geological strata. Where the rocks run parallel to the coast, it is said to be **concordant** and when the strata intersect the coast they are said to be **discordant**.

With both types of coast waves will try to exploit and attack the weaker rocks. These may be weak because they are physically soft, or if they have structures such as faults and folds which can be exploited by hydraulic action, abrasion and other marine processes.

On the Dorset coast, the impact of the **discordant coastline** in the Swanage area of the Isle of Purbuck is clear. **Headlands** form where the harder chalk and limestone and **bays** form where the rocks resist erosion less. These sheltered bays will also be the sites of sediment deposition in sheltered water where waves are refracted.

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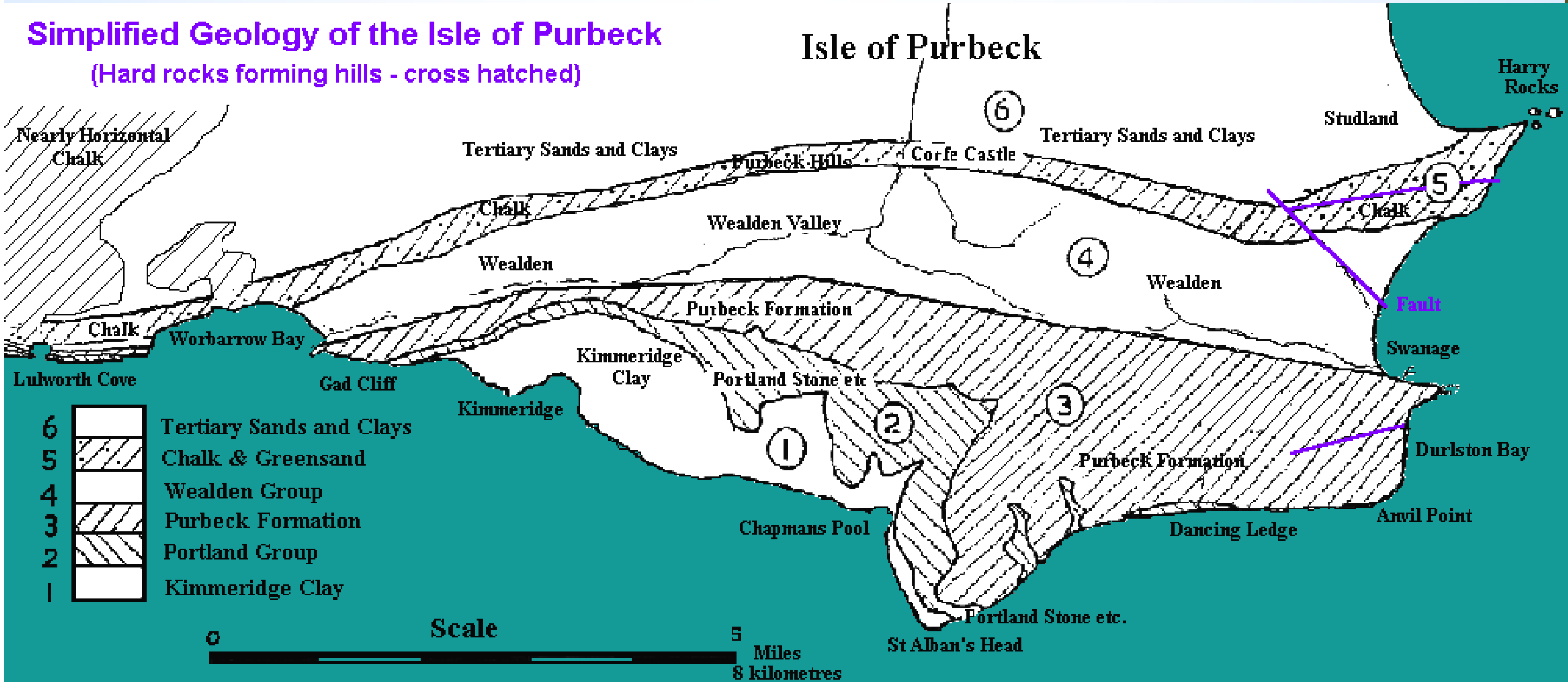
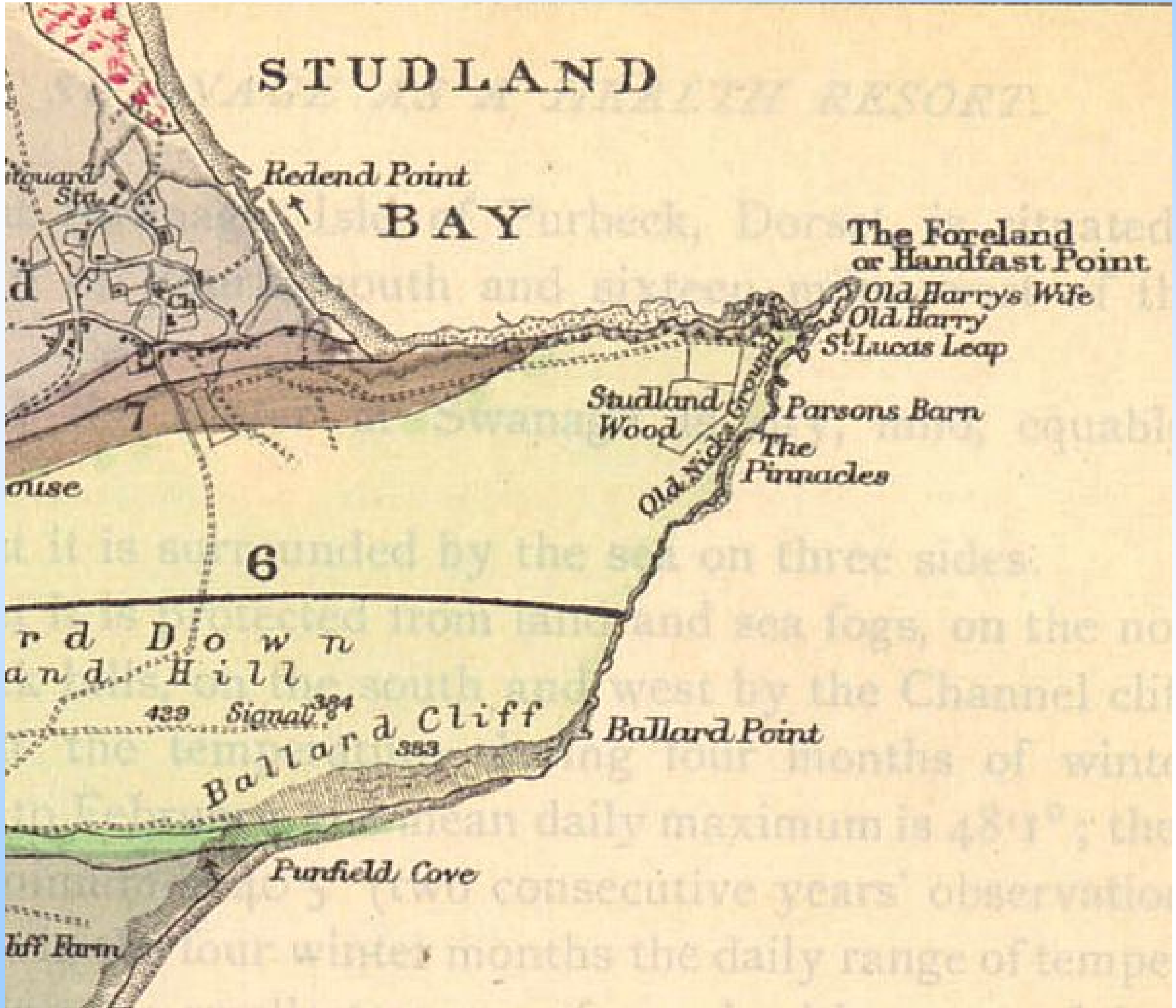
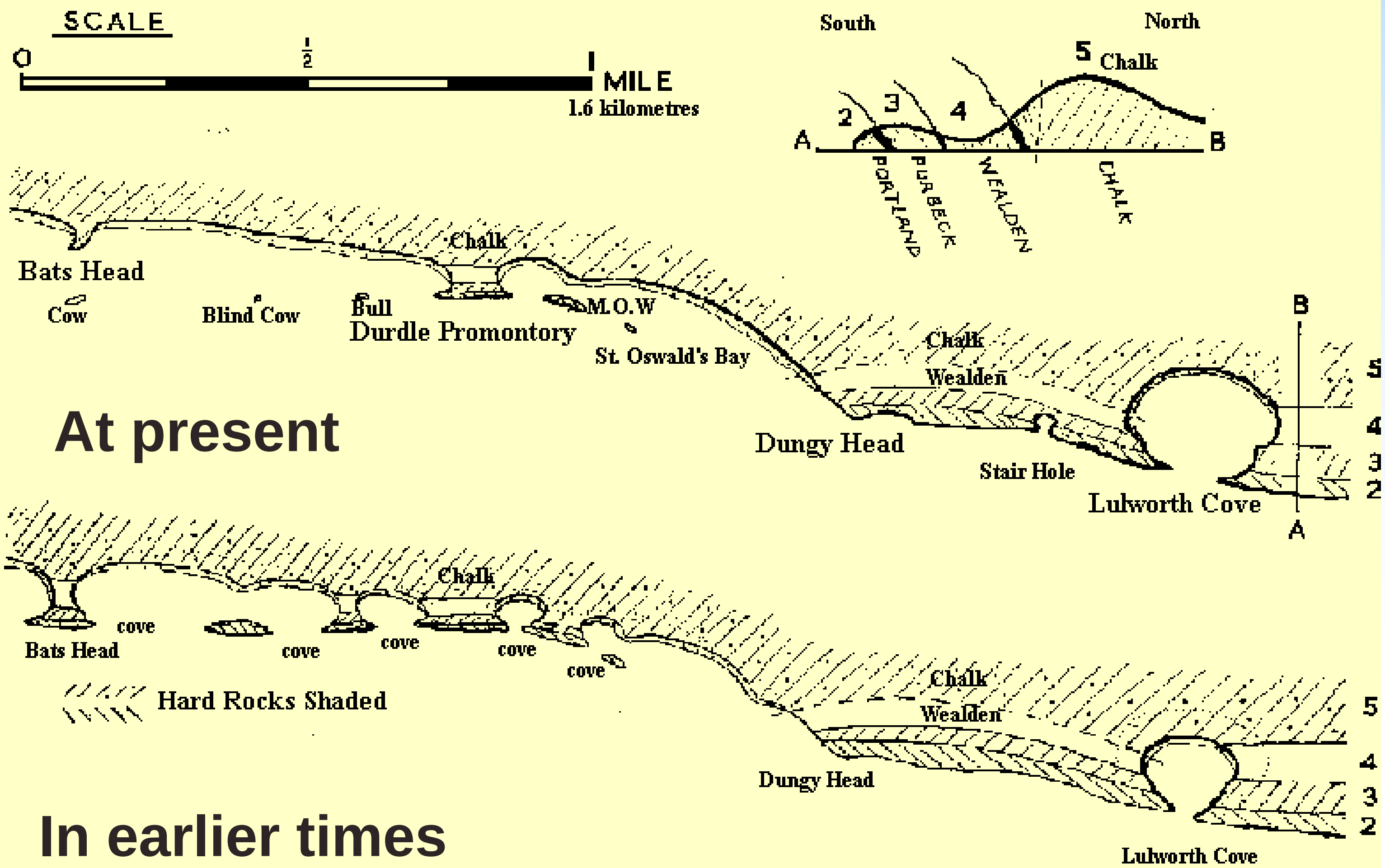



STUDLAND BAY
Studland
Ballard Down
Ballard Point
Corfe Castle
Corfe Common
Nine Barrow Down
Godlingston Heath
SWANAGE BAY
SWANAGE
Peveril Point
DURLSTON BAY
Durlston Head
Tilly Whim
Anvil Point
LANGTON MATRAVERS
WORTH MATRAVERS
Kingston
Seacombe Cliff
St. Aldhelm's Chapel
Aldhelm's Head
INDEX OF COLOURS.
BLOWN SAND.
TERTIARY ... EOCENE.
LO. BAGSHOT BEDS. 9
LONDON CLAY. 8
READING BEDS. 7
SECONDARY.
UPPER CRETACEOUS
CHALK. 6
UPPER GREENSAND, GAULT. 5
LO. CRETACEOUS OR NEOCOMIAN.
LOWER GREENSAND, WEALDEN BEDS. 4
UP. OOLITIC OR JURASSIC.
PURBECK BEDS. 3
PORTLAND BEDS. 2
KIMERIDGE CLAY. 1
DIPS. THICK LINES FAULTS.
Scale of English Miles
0 1 2 3
1½ Inches - 1 Mile
London: W. H. Everett & Son, 13a Salisbury Square E.C.
F. S. Weller, 34 Red Lion Square W.C.


STUDLAND
BAY
Redend Point
The Foreland
or Handfast Point
Old Harrys Wife
Old Harry
St Lucas Leap
Studland
Wood
Old Nick's Ground
Parsons Barn
The
Pinnacles
7
6
Signal
429
384
383
Ballard Cliff
Ballard Point
Punfield Cove

Rocks running parallel to the coastline typify the concordant coast of south Dorset.




The concordant coast of Dorset from Lulworth Cove to Mupe Bay

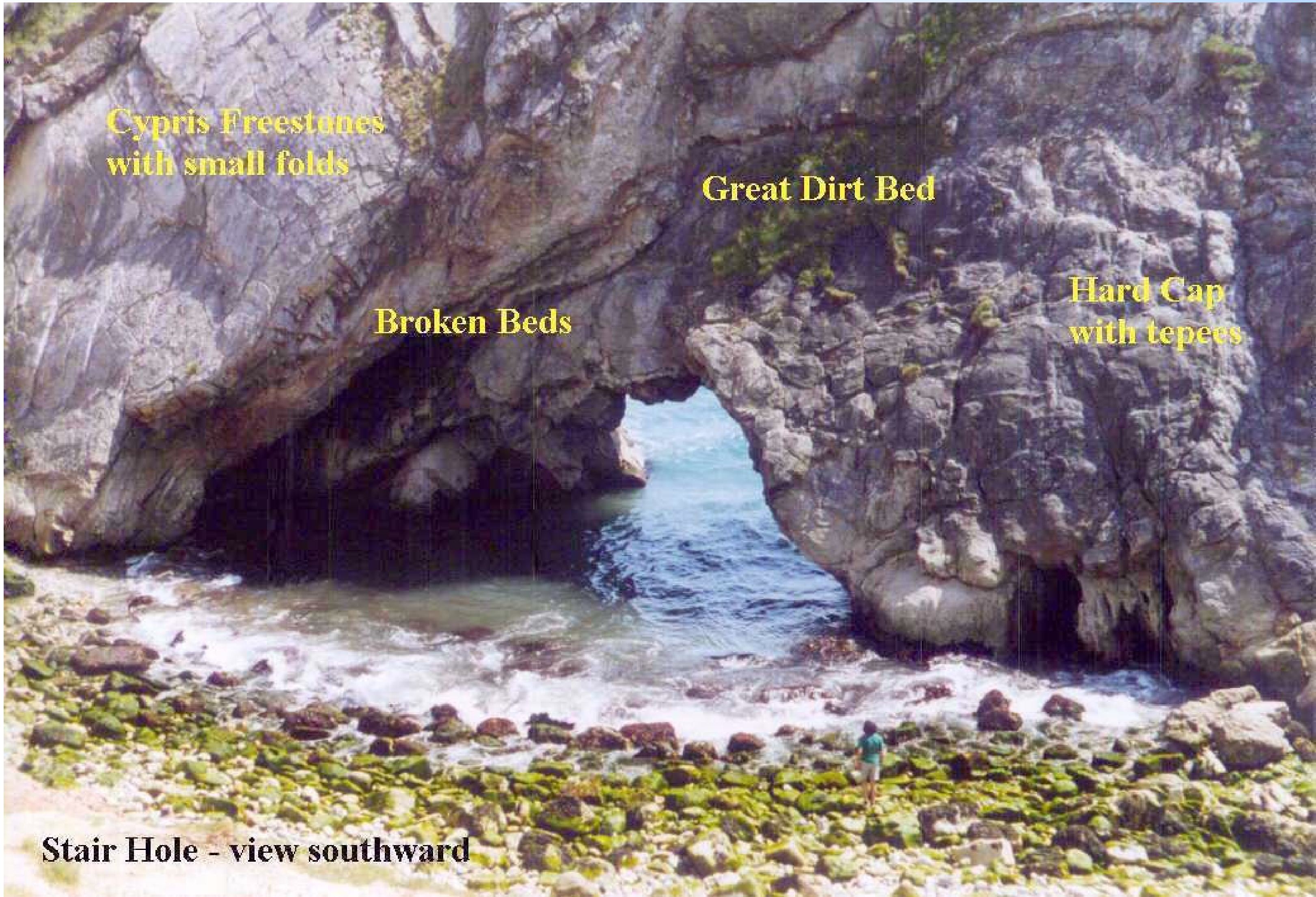
The erosion of the coastline can be traced as a sequence of events. This is reflected in current coastal landforms that are various stages of development.

The Portland Limestone (and to a lesser extent, the weaker Purbeck limestone) acts as a barrier to erosion. It is folded, faulted and fractured in places, having been subject to tectonic pressures in the past.

The processes of marine erosion exploit weaknesses in the limestone, forming wave cut notches, and in places caves. In places such as **Stair Hole,** these caves have reached the much softer Wealden Clays and sandstones. This material, when undercut by marine erosion, is very easily removed. It is washed by rainwater and winter mudflows towards the sea where it is removed by marine processes. This can be clearly seen in Stair Hole.

Stair Hole, near Lulworth Cove, Dorset

The sea forms sea caves in the Limestone barrier



The sea caves collapse allowing sea access to the softer Wealden clays and sandstones.

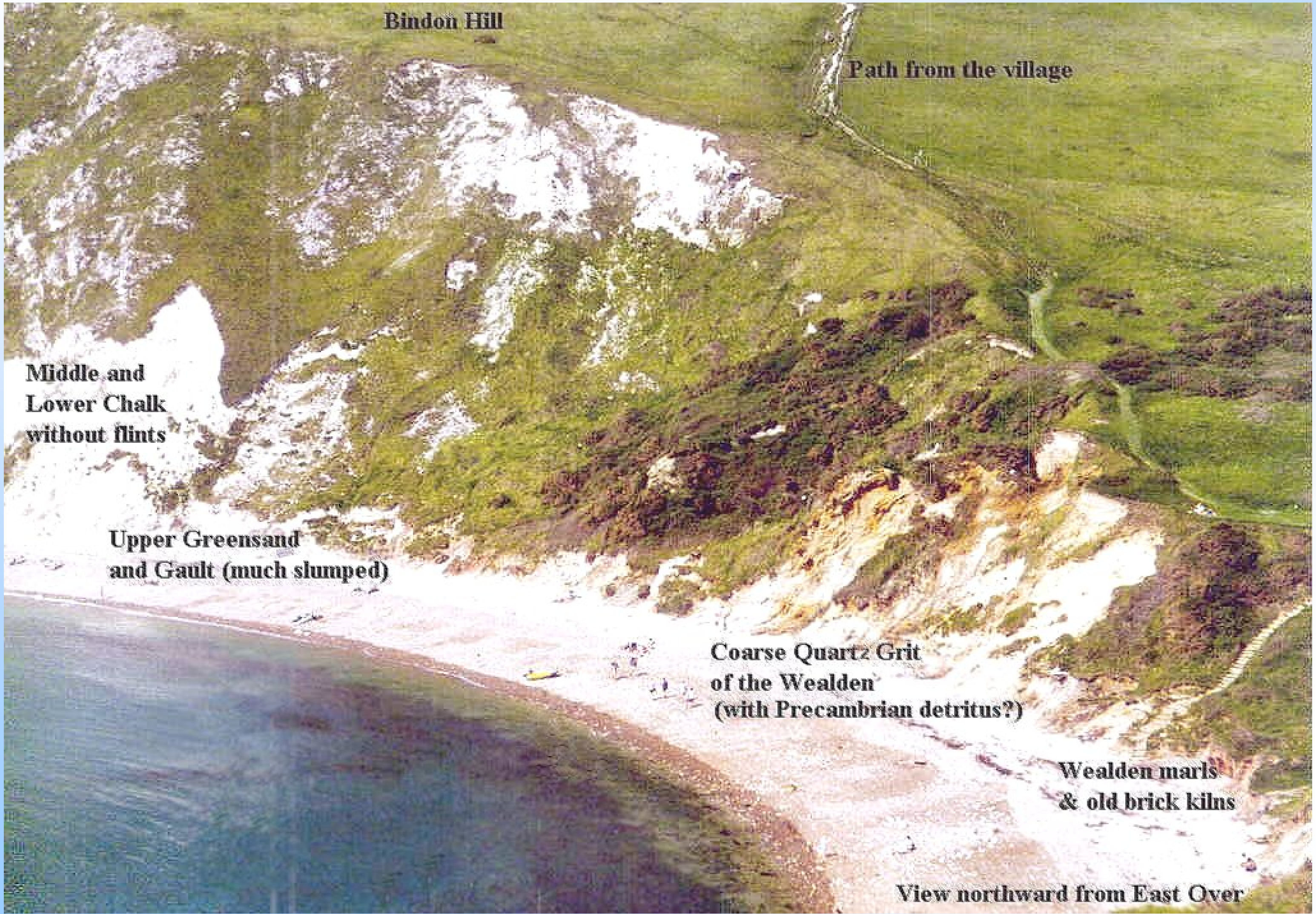
The Wealden clays and sanstones are subject to a range of subaerial processes leading to mudslides.

A fine example of “Alpine folding” at Stair Hole

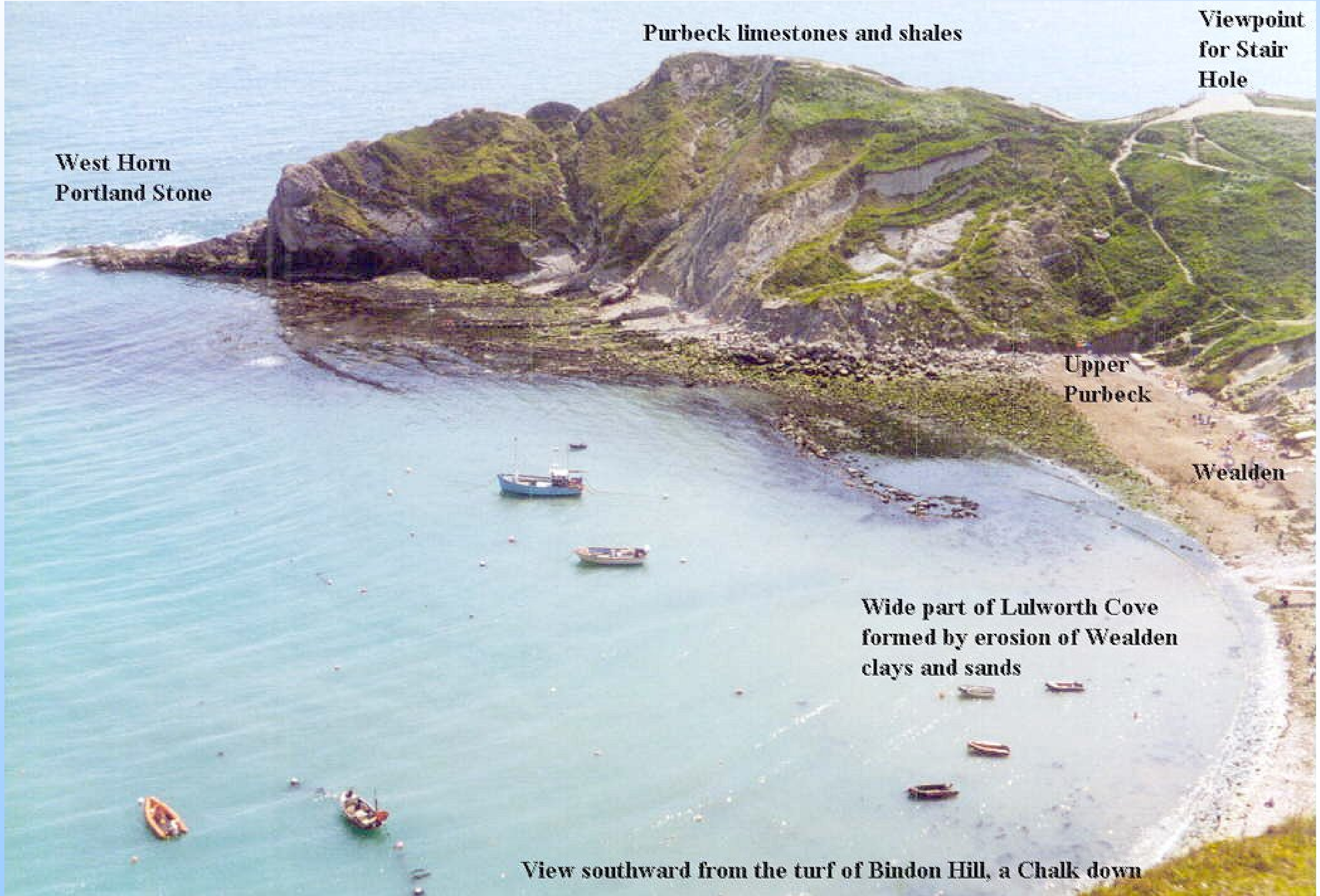
At **Lulworth Cove** and the gap in the limestone has also been enlarged. Waves entering the Cove refract so they have dispersed energy by the time they reach the chalk wall. The chalk erodes slowly through gentle wave-trimming and occasional rockfalls and cliff face collapses.

The Chalk Cliff in Lulworth Cove

Meanwhile, mudflows, streams and rainwater help to remove the soft clay and sand into the Cove, which is removed by the tides



Wave refraction in Lulworth Cove dissipates the wave energy.



Further along the coast in St. Oswald's Bay, close to Durdle Door, the clay and sand have been completely removed and the chalk cliff now marks the main line of the coast. However remnant of resistant limestone still exist for example the Man-o'-War rocks (stacks and stumps) in St.Oswald's Bay.

The Arch at Durdle Door

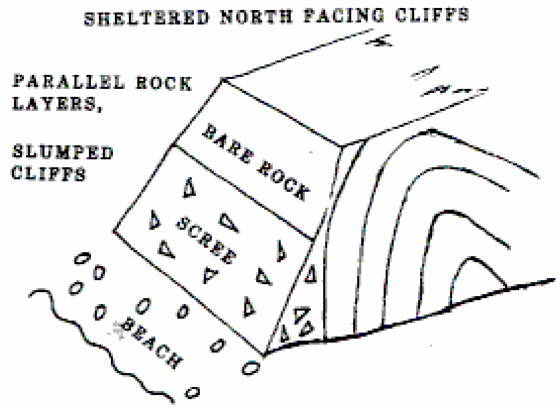
Some more resistant bands of limestone still remain. The Arch at Durdle door is in one of them. The arch is a remnant of a former cave that probably started life in a similar way to the new caves back at Stair Hole

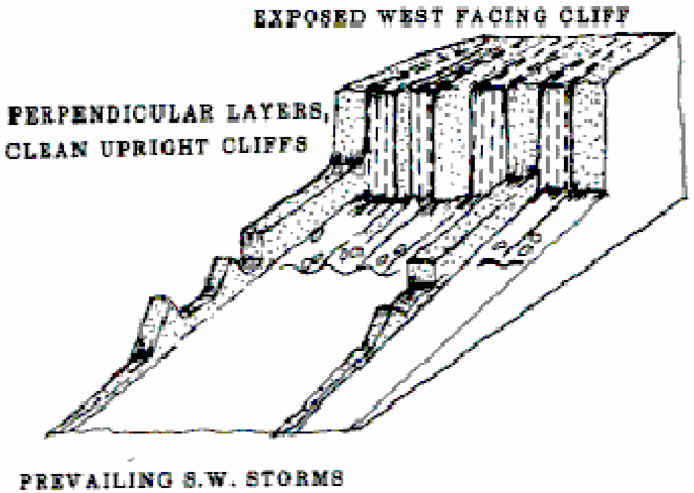
The chalk cliff looking from Durdle Door towards Scratchy Bottom and Bats Head

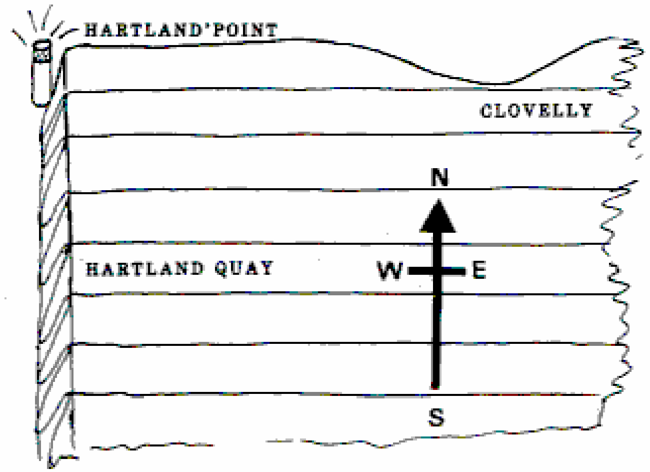
In North Devon, the impact of rock structure is more important that the rock type as the shales and sandstones form relatively thin bands. On the west facing rocks at Hartland Quay, the beds and folds face straight out to sea and this encourages the formation of upright cliffs. On the northern coast of the Hartland Headland, the rock structures (or strike) run parallel to the coast. Where the beds dip seawards, this encourages the cliffs to slump (landslides) creating a more gently sloping but untidy cliff face. This difference is exaggerated by the relative exposure of each coast to destructive waves. The west facing Hartland Quay coast is much more exposed and therefore there is more **wave-trimming** at the base of the cliff.

The impact of coastal orientation in North Devon

The impact of coastal orientation and exposure on the coast of the Hartland area of North Devon







On the west facing rocks at Hartland Quay, the beds and folds face straight out to sea and this encourages the formation of upright cliffs

By contrast with the cliffs at Hartland Quay, those on the north coast of the Hartland Headland have more gentle slopes. *Note the well developed storm beach*

Plate Tectonics, Earthquake and Volcanic activity.

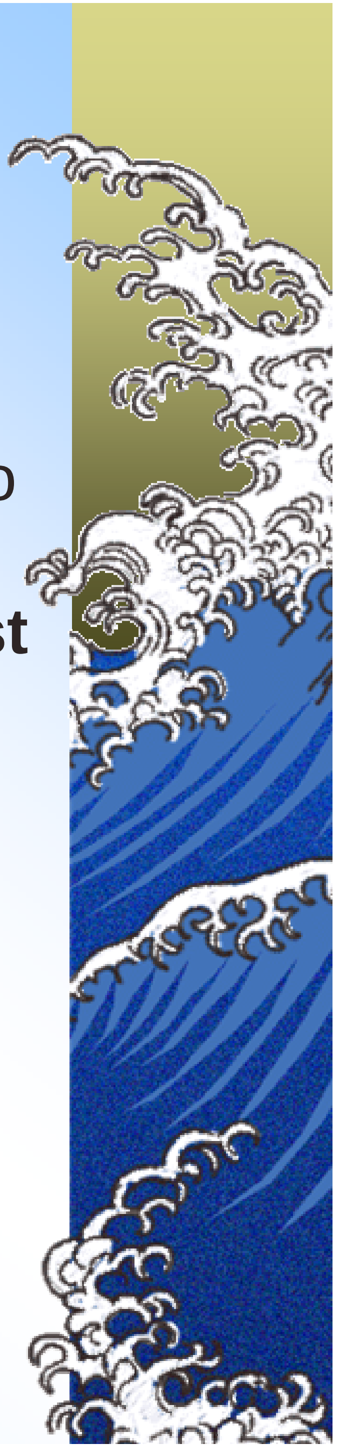
In the long term, plate tectonic movements in the earth's crust are responsible for most of the folding and faulting that can be found on the coastline. It is also responsible for the long term shaping of the coastlines of whole continents.

In the short term, volcanic and earthquake activity have local influence. Volcanic eruptions on Hawaii regularly extend the coast outwards creating new land. The 1964 Alaskan Earthquake caused major changes to the coastline; some areas experienced a fall in sea level while others experienced a rise as the crust readjusted to the reduction in pressure between tectonic plates (see later notes on sea level changes).

Atmospheric Factors.

Variations in weather. Variations in **wind speed** and **wind direction** are the most important influences of the weather as these effect the direction and strength of wave energy. Heavy or continuous **rainfall** can also induce landslides and mudflows in coastal environments, accelerating erosional processes. **Frost action** on cliff faces can accelerate weathering rates leading to rockfalls and **chemical weathering** processes which weaken rocks, will usually be more effective in warm, moist locations.

Variations in climate. In the long term, climatic deterioration in the past has lead to glacial erosion on many parts of the coastline of North West Scotland and it is also closely linked to sea level change (see later notes).



Fluvial Influences. Rivers supply much of the coastal sediments in some areas, such as in the Taw/Torridge estuary. Where there are strong river currents, bars can be prevented from forming across bays.

Biological factors. We will examine the role of vegetation later when looking at salt marshes and sand dune systems and the erosive impact of some burrowing molluscs has already been mentioned. In tropical seas, coral reefs and mangrove swamps are both important environments in discouraging coastal erosion and encouraging deposition. Both types of environment are under threat in many parts of the world, which may lead to an increase in coastal erosion.

Rivers Supply Sediments to the Coast

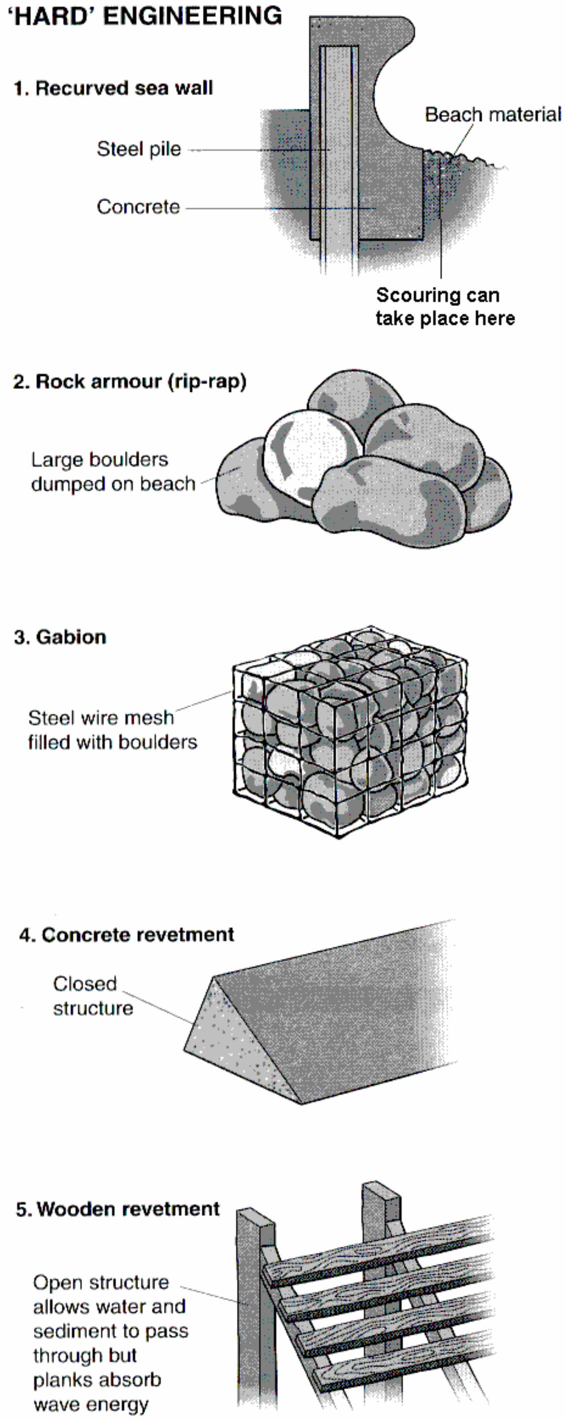

Salt Marsh Vegetation


Sand Dune Vegetation

Human factors

- The construction of dams on rivers.
- Pollution of sea water affecting marine organisms.
- Development in sensitive coastal environments such as mangrove swamps.
- Trampling of plants in ecosystems.
- The impact of global warming.
- Unintentional barriers to longshore drift.
- Coastal management.

A widely used alternative to **hard engineering** is to use **beach replenishment.** The beach is fed artificially with material from another locality or dredged from the seabed, or from down drift where sediments are accumulating.




A simple vertical sea wall built across an eroding geological fault line below the Hartland Quay Hotel in Warren Bay


A vertical sea wall


A curved sea wall

Rip-rap used on Hurst castle Spit

Groynes.

Wooden groynes are probably the most familiar way in which people try to manage coastal processes. These reduce longshore drift and help to accumulate beach sediments. This can protect cliffs from erosion. At West Bay, larger groynes called bastions are used. These are more robust, but serve much the same purpose. In Christchurch Bay in Hampshire, they are called strong-points. More conventional wooden groynes are used at Milford-on-Sea.

Coastal Groynes at Bournemouth

Groynes at Westward Ho! failed a because the beach material contains large cobbles which destroyed them during winter storms. Only a few remnants survive.

Dredging.

Dredging is used, either to maintain **deep water channels** for shipping or to obtain **aggregate** for the construction industry. Dredging can upset the balance of sediment within a littoral cell. This was demonstrated in 1917 when the South Devon village of Hallsands was largely destroyed by a storm. Contractors building the Devonport Naval Dockyard removed the shingle beach that had previously protected the village. The beach was lowered by 65m when 660,000 tonnes of gravel were removed. The beach was probably a relict feature, deposited as sea levels rose about 6000 years ago. Up to 6m of cliff erosion took place at Hallsands between 1907 and 1957.