A-Level Geography Resource Package

Welcome to Coastal Systems & Landscapes!

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Your Ultimate Guide To Geomorphological Processes On The Coast

Key Term:

Geomorphology is the study of natural landforms, their processes, form, and sediments at the surface of the Earth. This study can also include looking at landscapes to work out how movement of air, water and ice can mould the landscape around them.

1.0 Introduction:

Think about the different overarching geomorphological processes you may be familiar with from GCSE or your own knowledge – these are laid out below:

- **'Marine' Erosion**

"The action of surface processes wearing away and removing soil and rock particles by gravity, water, wind or ice."

- **Transportation**

"The movement of sediment or sand from one location to another, in coastal system driven by the movement of water through currents and tides."

- **Deposition**

"The act of transported sediment or sand being dropped onto the seabed or coastline owing to a loss in wave energy to carry it further."

- **'Sub-Aerial' Weathering**

"The disintegration or alteration of rock in its natural or original position in situ at or near the Earth's surface through physical, chemical and biological processes."

- **Mass Movement**

"This refers to the movement of ground material downhill through the influence of gravity after being eroded or broken down through weathering"

Remember! *The distinction between Erosion and Weathering – many students regularly get confused or begin to merge the two together…*

Weathering you can think of as the breaking down of rock occurring at a specified place, to then be transported (usually by mass movement) whilst processes of erosion in a coastal environment involve water and removal of eroded sediment.

Coastal Landscapes can look awesome!! For each of the pictures above, consider the landform which is being shown – answers below! ©Britannica, Countryfile, Wikipedia Commons

Wave Cut Platform, Stack/Stump/Arch, Beach, Double-Tombolo

2.0 Understanding Coastal Systems

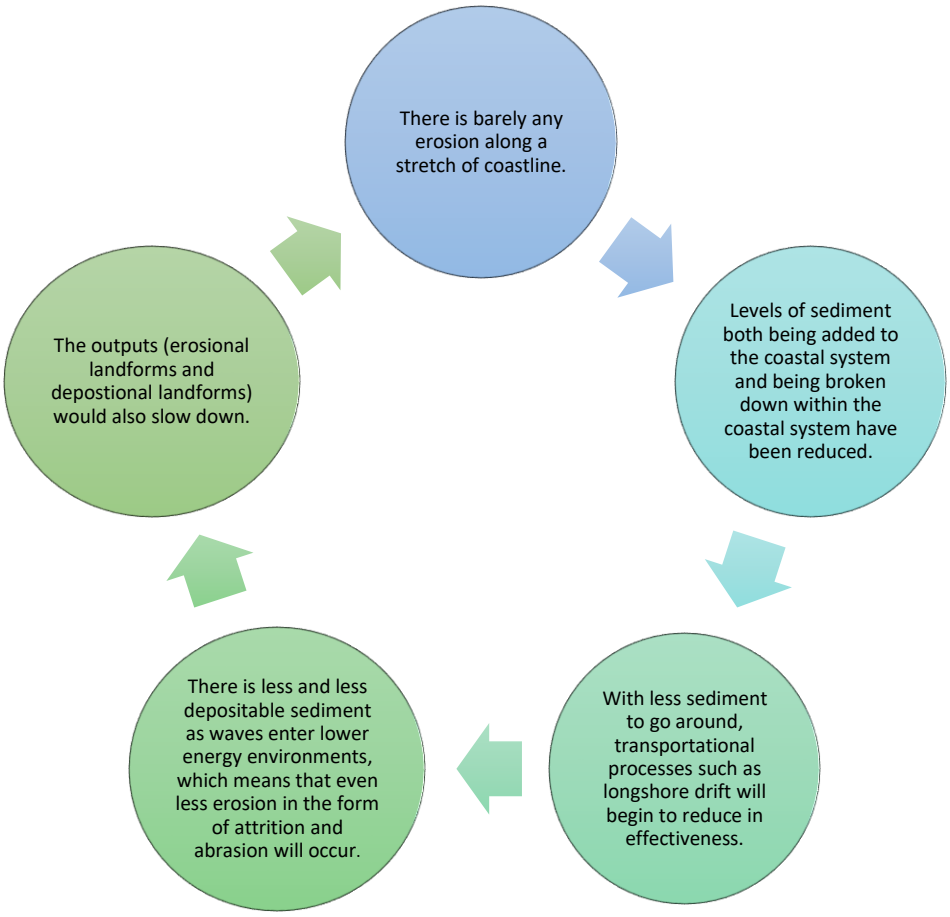
Coasts can broadly be thought of as closed and open systems on a variety of scales to help understand how inputs, processes and outputs interact with one another to strive for a global 'dynamic equilibrium.'

On most scales, coastal landscapes can be considered open systems, as the movement of energy and matter is consistent and flowing in and out, however, there are examples of closed systems within the broader coastal environment, such as sediment cells, of which there are 11 in the United Kingdom, which are areas of the coastline (typically protected by a protrusion in the land or outflow of a river) through which the overall movement of sediment is self-contained, i.e. not travelling from sediment cell to cell, which are therefore in a constant state of equilibrium.

Within these coastal subsystems, there are inputs and outputs (broadly waves, tides, currents and wind and landforms of erosion and deposition, respectively), which are mediated by the geomorphological processes in this document and are therefore highly interdependent and often fragile.

TL;DR: The reason it is important to appreciate interactions is that they give us a good idea of the context behind coastal processes, importantly that they are constantly trying to act in balance, and that without one process, the others are so interdependent they would not be able to properly function and hence this delicate equilibrium would be destroyed.

Take the removal of most erosion from a coastal system as an example of what could occur:



This would result in a vicious cycle, or a positive feedback loop, through which the balance of the system is essentially being constantly worsened.

3.0 Marine Erosion:

Marine Erosion is… "*The action of surface processes wearing away and removing soil and rock particles by gravity, water, wind or ice."*

What you need to know:

- At A-Level, the specification covers 5 different forms of erosion, some of which are fairly similar.
- Erosional processes are usually some of the most powerful, medium to longer term processes acting within coastal systems, whose impacts are constantly being felt.
- There are plenty of different factors affecting erosion and erosional landforms:

3.1.1 Physical Factors Affecting Erosion:

Lithology:

Harder rocks such as Scotland's igneous and metamorphic highlands are harder to erode and will typically form more jagged, harsh coastlines than softer or weaker rock such as clays and silts.

Coastal Conditions:

Wind speed and wave conditions both are heavily influential, driven by a larger fetch or unprotected, high-energy coastline, whereby more destructive waves erode at a higher rate.

Geological Structure:

Cracks, joints, faults, and bedding planes all can create structural weaknesses along the coast on the smaller scale, and on a larger scale, discordant and concordant coastlines erode at different rates, forming different coastal features such as headlands and bays.

The Coastal Relief:

Large, prominent cliff faces are often harder to erode by oceanic processes, but once enough undercutting has been performed, they are far more likely to shear vertically (horizontal dip) and fall down, than lower or sloped coastlines.

3.1.2 Human Factors Affecting Erosion:

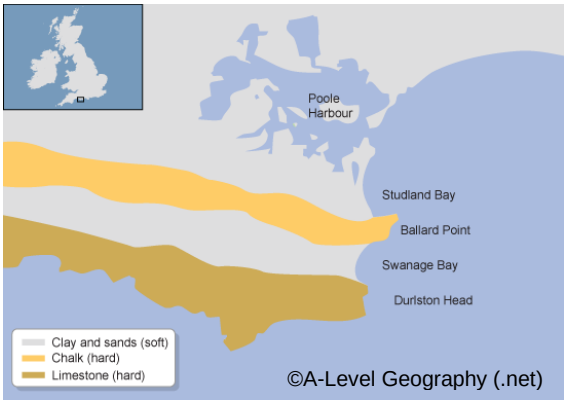
Coastal Management:

Both hard and soft management strategies have an impact on wave energy, sediment transfer and the build-up of beaches. A good example of what dangers are posed to a coastal ecosystem is on the circular figure on page 2. A sea wall almost eliminates all coastal erosion in a similar way to this, thus damaging the entire coastal system. Some of these areas have experienced the degradation and gradual removal of beaches as a result.

Recap! Key distinction – Concordant vs. Discordant Coastlines.

Concordant Coastlines have the same type of rock along its length – usually landforms here are primarily erosional.

Discordant Coastlines have different layers of strata (or bands) of hard and soft rock, leading to headlands and bays, respectively.



3.2 Distinct Forms Of Erosion:

3.2.1 Hydraulic Action & Wave Quarrying

The Process Of Hydraulic Action acts as follows:

On high energy coastlines, powerful waves interact with a cliff face directly.

Air becomes trapped within crevices of the rock.

Over repeated impacts, this can begin to dislodge and fragment the rock, which is then pulled back to sea.

Wave Quarrying is simply this, shortened – where high energy, tall waves hit a cliff face and have power to remove large chunks of rock in one go through sheer force.

	Hydraulic Action	Wave Quarrying
Strength	High	Very High
Timeframe	Medium Term	Short Term

3.2.2 Abrasion / Corrasion:

Abrasion (also known as Corrasion) is where rocks and other materials carried by the sea are picked up by strong waves and thrown against the coastline which causes further small chunks to be broken off and carried away.

	Abrasion / Corrasion:
Strength	Medium
Timeframe	Medium Term

3.2.3 Cavitation:

Somewhat similar to hydraulic action, compression of air in sea-facing joints as waves crash against cliffs can cause sea water to be severely compressed. As the wave recedes the pressure reduces and air comes out of solution in violent 'fizzing', growing cracks and speeding up rock erosion – this often leads to the formation of geos and blowholes.

	Cavitation:
Strength	High
Timeframe	Medium Term

3.2.4 Solution:

Carbonic acid within the seawater helps to dissolve rock at the coastline and break it down. This is particularly effective on rocks which have calcium carbonate within them such as limestone and chalk.

	Solution:
Strength	Medium
Timeframe	Long Term

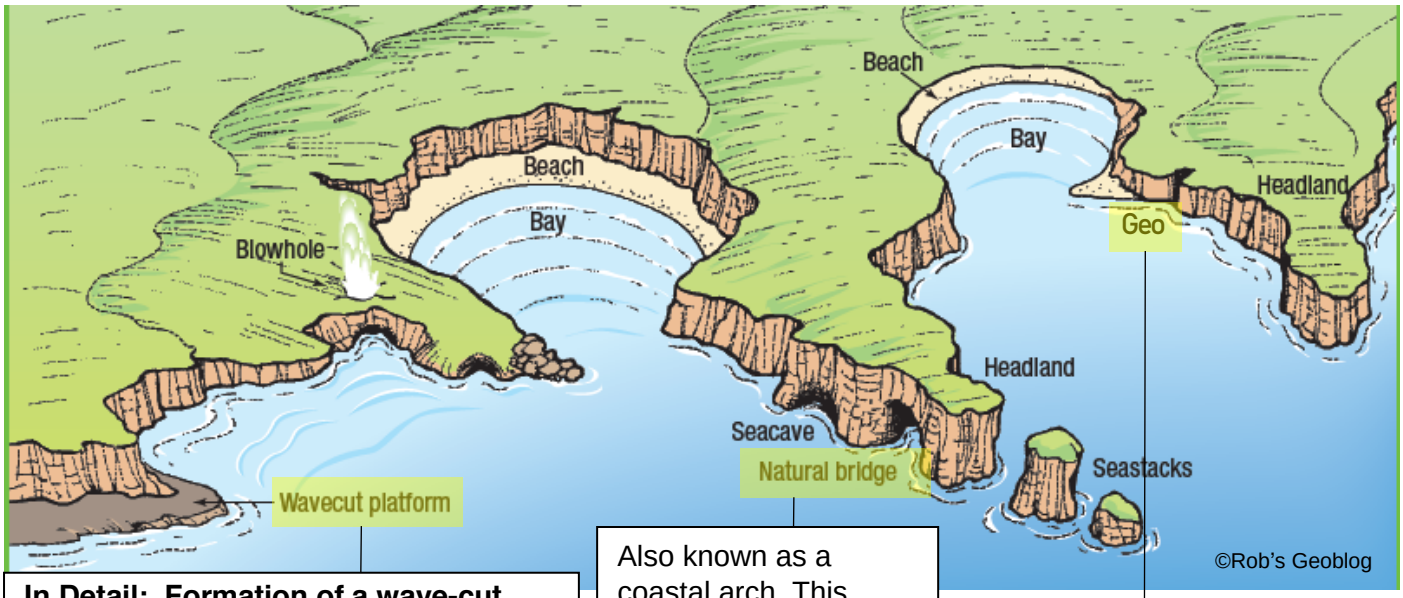
2.2.5 Attrition:

Rocks and boulders are ground over each other in the water – repeated swash and backwash -and over time become smoothed. Boulders/fragments become pebbles, pebbles become shingle, and shingle may become sand on a beach.

	Attrition:
Strength	Low
Timeframe	Very Long Term

3.3 Erosional Landforms:

Processes of erosion can lead to the formation of numerous landforms, which you need to know from the figure below. Particular aspects of interest are explained in detail below:



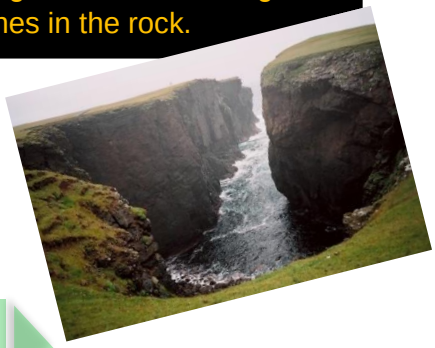
In Detail: Formation of a wave-cut platform.

Wave cut platforms are usually a result of both coastal erosion and weathering acting on a cliff face. Over time, a wave cut notch in a cliff face will be created, within the wave attack zone, which will undercut the unsupported cliff above (often freeze-thaw weathering acts as a catalyst.) This cliff face will collapse onto the seabed below and slowly retreat, leading to a build-up of sediment along the base – a wave cut platform.

Also known as a coastal arch. This succession model shows how when sufficiently heavily eroded, an arch may collapse into a sea stack, which reduces over time into a stump.

A-Level A* New Content

Geos are crevices within the coastal landscape, caused by localised high rates of erosion along faults and bedding planes in the rock.



Exam Practice 4 Mark Question: Explain how different processes of erosion can influence the coastal landscape in unique ways.

This kind of question may appear in your exam, so be prepared to use knowledge from both sections 2.2.x and 2.3 together to pick out key processes and details from both.

4.0 Transportation:

Transportation is… *"The movement of sediment or sand from one location to another, in coastal system driven by the movement of water through currents and tides."*

What you need to know:

- At A-Level, the specification covers 3 distinct types of transportation, of varying strength and scale.
- Transportation broadly is the process acting in between the erosion or weathering of landscapes and deposition in coastal landscapes.
- Therefore, we don't need to know any associated landforms, but it is important to recognise that there are factors affecting it, in brief.

A* Extra Reading Taster

4.1.1 Factors Affecting Transportation:

Transportation is the important intermediate process within coastal systems, so importantly the most crucial element in dictating the amount of transportation occurring is the energy of the coastline.

Take a high energy example, such as that on the main figure on page 5 as an example. High energy Coastlines tend to have greater inputs (wind, waves, tides, currents) into the coastal system, and henceforth higher rates of erosion. This means there will be much more sediment entering a system and being transported along by currents. Opposingly, lower energy coastlines usually are coastlines of deposition, and hence will rely on the transportation of smaller sediment and sand within environments such as bays and marshes.

In addition, factors such as landforms of erosion and deposition inhibit the transportation of sediment between areas. As an example, islands, headlands and seastacks often block the wind, thus reducing wave energy such that material cannot longer be transported and is deposited (this is often how Tombolos can be formed!)

Anthropogenic activity along coastlines has particularly affected the flows of longshore (littoral drift.) Most notably, groynes along a beach actively prevent the natural transportation of sediment, leading to unusual undulations and heigh discrepancies along a beach. Offshore artificial barriers and rock armour also can have a similar impact.

4.2 Distinct Forms Of Transportation:

4.2.1 Traction / Saltation

Traction is a form of transportation by which pebbles, and larger sediment are rolled along the seabed. Saltation just involves the bouncing of larger rocks.

4.2.2 Suspension

Suspension involves the material transportation of small particles within water, such as silts and clays, which produce a 'clouding' effect.

Make sure you are aware of the distinction between these processes – many students get confused!

4.2.3 Longshore (Littoral) Drift

When waves approach the coastline at an angle as a result of the wind driving them onwards at the same angle. Waves push material at an angle up the beach via the swash and it is then deposited on the beach. The backwash will then collect the material and pull it down the beach in a vertical direction back out to sea. Another wave will then collect that material and carry it obliquely towards shore again.

The best way to understand this concept is visually!

Exam Tip: Learn this concept super-thoroughly! That definition is perfect for a four-mark question

Resource Package Recap Exercises #1

Consider the exam question, *"Physical factors are more important in determining coastal erosion and hence coastal landforms that human factors. To what extent do you agree with this statement?"*

[20 marks]

How would you answer this question?

Here are some thoughts to help along the way:

- Following the PEEL structure, you want to begin with a brief introduction possibly explaining the concept and processes of coastal erosion (3.0 & 3.2) – acknowledging that both physical and human factors can have a large impact together and independently.
- (3.1) For a for argument, you could use historical information and context about how the coastlines of countries have been mirrored by the levels and prevalence of erosion. Scotland is a good small example you could mention here – as it has been 'defined' by its slowly eroding monolithic igneous and metamorphic rocks – leaving unique landforms such as
- (3.1) For an against argument, you could reference the coastal management strategies being implemented at an ever-increasing rate in order to counter coastal erosion in recent years. You could use the fantastic example of the Netherlands as a case study for how coastal erosion has been successfully (and most importantly sustainably so as not to cause the positive feedback loop on page 2 (2.0)) managed through a multi-billion euro investment in sea defences, dykes, dams and more, protecting the up to 30% of their land that it below sea level.
- Concluding a question like this is very important, so make sure you spend at least ¼ of your time on this. The highest-scoring students often link concepts of time and space into theses, such as by saying what may happen in the future with increasing populations living near the coast who are susceptible to coastal erosion, the impacts of sea-level rise and how that is a human factor (through climate change) which is inextricably linked with the natural world, or the scale of global erosion – is human activity a small part only locally or a large part of this?

www.geographyportal.co.uk/trialalevelmaps

Geography Portal Advice > Don't forget to check out our A-Level Interactive Map for Coastal Case Studies and A* Examples (marked in purple) such as the Netherlands and Coastal Management in Lyme Regis - many of which have detailed information or case study fact files with all the best facts included!!

5.0 Deposition:

Deposition is… *"The act of transported sediment or sand being dropped onto the seabed or coastline owing to a loss in wave energy to carry it further."*

What you need to know:

- At A-Level, you need to know about 6 different distinct landforms of coastal deposition.
- Coastal deposition takes place broadly at a similar rate to coastal erosion, meaning they are typically medium-term events, although are not usually as powerful.
- Rather, at lower energy regions along a coastline, such as secluded bay, estuary or sheltered area, wave energy reduces and hence sediment being transported is deposited, initially heavier rocks and pebbles which are carried by traction, then at event lower energies, suspended material.
- Another reason coastal deposition more generally occurs is due to the increasing friction on waves as they approach the shallower coastline, thus lose energy in a similar manner.
- You do not need to learn any additional information about factors affecting deposition.

5.1 Distinct Landforms Of Deposition:

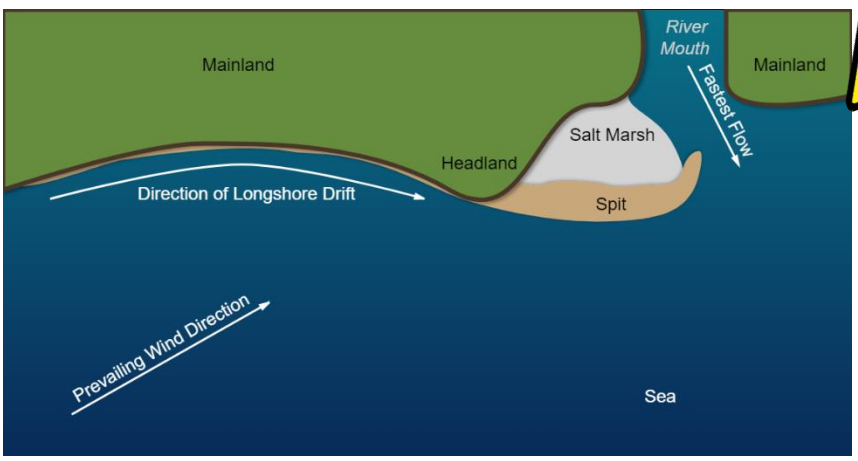
5.1.1 Beaches

These are probably the simplest concept to understand. Small sediment such as sand or pebbles (usually depending on the strength of wave energy on that stretch of coastline and the rate of erosion) will be deposited during swash either within a bay or along a coastline (swash aligned) and then sometimes moved along by longshore drift. (drift aligned)

5.1.2 Simple & Compound Spits

Consider the beach from 5.1.1 meets a point at which the coastline bends slightly. It will continue to be deposited horizontally owing to the movement of longshore drift until it is far enough away from land that the coastal energy is high enough to not deposit material anymore or there is an outflow, for example of water from a river.

If out at sea there is a change in wind direction, this sediment will 'curve' around, in what is known as a lateral recurve, forming a compound spit.



If you get a four-mark question on the formation of a spit, or depositional landforms, be sure to say that often an incredibly low energy salt marsh or mudflat may be formed behind the protection of a spit for the perfect 4!

5.1.3 Barrier Beaches & Islands

Continuing onwards if we take the simple spit from 5.1.2, if it manages to connect over a long period of time with another segment of the mainland, it will form what is known as a barrier beach, where there will usually be a stagnant body of water or lagoon behind it.

Sometimes there may be a small 'inlet' within the barrier beach, allowing a seaward flow of water, hence forming a barrier 'island.'

Did you know? These are very common landforms which you can see along the Northeast Coast of America from space?!

5.1.4 Offshore Bars:

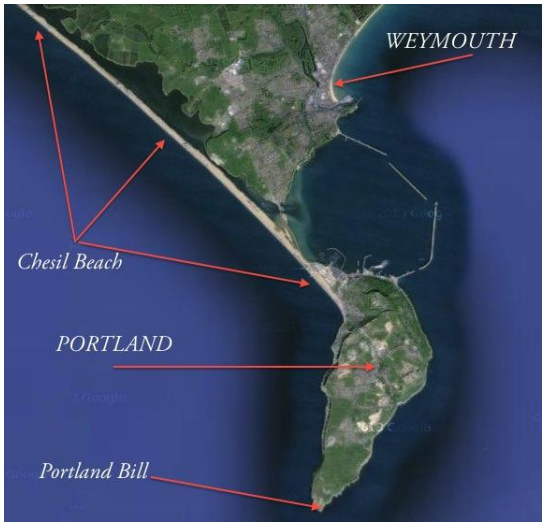
If the barrier beach from 5.1.3 isn't constantly above the tidal range, at certain times of day water will breach the beach!!, submerging it below water. This is what is known as an offshore bar, as it is usually a ridge of deposited sediment between

5.1.5 Tombolos:

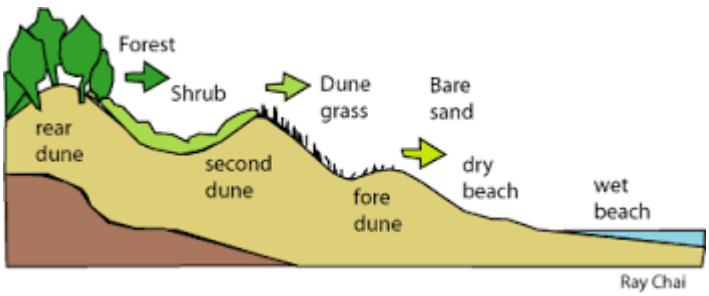
Like a barrier beach, Tombolos occur where an extended 'spit' of deposited sediment connects to a landmass, but instead an island.

This can occur either as a result of wave shadow (where the island shields the coast behind it thus forming a low energy zone where most sediment is deposited) or through traditional longshore drift.

A good example of a Tombolo for this reason is the Isle of Portland near Weymouth on the UK South Coast, where the barrier beach Chesil beach connected to the Island.



5.1.6 Sand Dune Succession:



Sand Dune succession has a slightly different formation to the others, as it involves the wind blowing sand from a beach inland, thus forming progressively higher hillocks, or dunes, which are older the farther back you travel. Over time, vegetation, and shrubs (such as Marram Grass) begins to grow on these fragile ecosystems.

6.0 Sub-Aerial Weathering:

Sub-Aerial Weathering is… *"The disintegration or alteration of rock in its natural or original position in situ at or near the Earth's surface through physical, chemical and biological processes."*

What you need to know:

- Sub-Aerial weathering is distinctly different from erosion, so don't get them mixed up! The key difference in coastal environments is that they are taking place in situ through external influences.
- There are three aforementioned sub-categories of Sub-Aerial weathering – physical (sometimes referred to as mechanical), chemical and biological.
- This is a fairly strong process, like erosion, operating with slightly longer timeframes.
- You do not need to know sub-aerial weathering in as much detail as previous coastal processes.

6.1 Physical / Mechanical Weathering:

The most notable type of mechanical weathering is **Freeze-Thaw**. This occurs when ice gets into cracks in rocks and freezes. This expands in volume by around 10%, thus over repeated cycles exerting a significant pressure on rocks which slowly crack and break. **Salt Crystallisation** involves the small fragments of salt left behind after drying which collect in cracks, acting as a catalyst of Freeze-Thaw weathering. **Wetting and Drying** involves the expansion and contraction of usually clay-rich rocks when they are wetted and dried, respectively. This also leads to further cracking within rock.

6.2 Chemical Weathering:

This type of weathering involves decomposition of rocks through chemical reactions between water and the rock itself. Rainwater with carbon dioxide in the atmosphere forms a weak carbonic acid in a process known as **Solution**. This weakens limestone particularly. Sometimes, acidic water may also break down rock through **Hydrolysis** in a similar way. Finally, **Oxidation** simply involves oxygen and water causing a 'rusting' effect on ferrous (iron rich) rocks.

6.3 Biological Weathering:

Some lump this within physical weathering as it technically involves mechanical forces acting, but for simplicity's sake, biological weathering involves **plant roots** splitting rocks or causing joints or cracks, as well as **bacteria like algae** producing chemicals which break down the rock on which they live for nutrients.

A* Extension Thoughts

Check out this website from The Geological Society for more information on weathering, if that's your cup of tea! Also consider the potential human impacts on rates of weathering, particularly chemical – as our emissions and atmospheric carbon dioxide rise.

Don't forget: The term 'Sub-Aerial' (6.0), (7.0) is used to describe processes which are occurring on or near earth's surface!

7.0 (Sub-Aerial) Mass Movement:

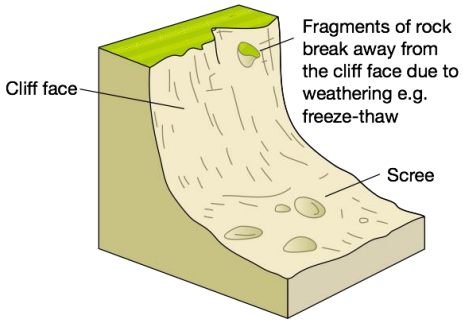
Mass Movement is… *"the movement of ground material downhill through the influence of gravity after being eroded or broken down through weathering."*

What you need to know:

- The final process we will be looking into is mass movement. This can almost be seen as a partial 'second stage' of weathering, through which sediment and rock material is moved together.
- Mass movement does not need to be studied in as much detail as the previous coastal processes.
- It can occur on a wide variety of scales, from small to very large and damaging, and is often a large focus of coastal management strategies.

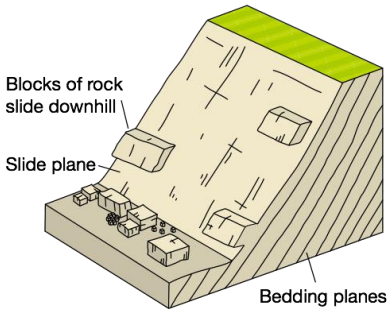
7.1 Examples Of Mass Movement:

Rock fall

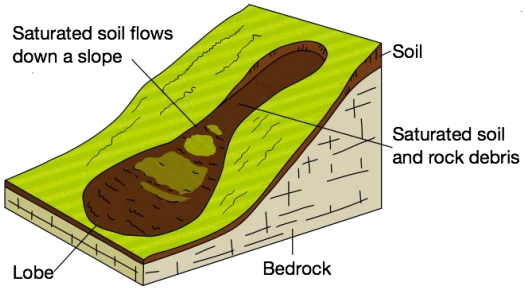


Landslide

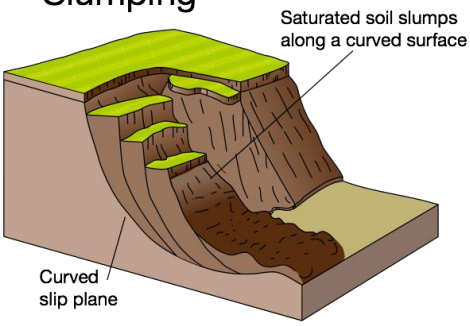
Also referred to as a landslip – usually involving rotational movement down a less steep hill than a slide.



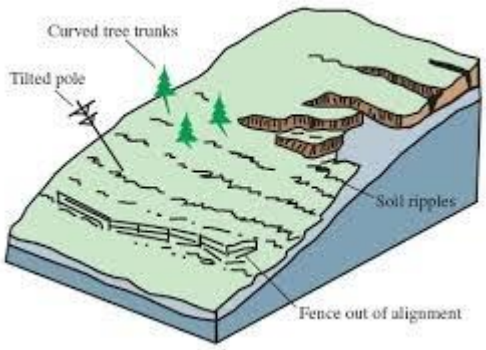
Mud slide



Slumping



Soil creep (slowest form)



Geography Portal Advice > Check out our A* Example – Coastal Management In Lyme Regis by following this link!

8.0 Relating Geographical Concepts:

It's all well and good to learn huge amounts of factual information which will only directly assist you in lower marking questions – but how do you successfully integrate knowledge like this together into a potential Coastal Systems & Landscapes 20 Marker? This is where being 'synoptic' or able to connect topics is incredibly valuable.

Resource Package Recap Exercises #2

Before, on Page 7 'Resource Package Recap Exercises #1', I stated that some of the absolute best answers focus on the notion of 'spatial' and 'temporal' changes. This, in layman's terms, means that by considering this over time and scale in your answer you can make your essay stand out!

It may sound complicated, but in practice, once you get used to it, incorporating this when writing PEEL 20 Markers can become a second nature.

Consider the exam question, *"How far do you agree with the statement 'Erosion is the most influential process acting on the coastal environment.'"*

[20 Marks]

This is a very interesting question, because it requires on a large amount of contextual geographic knowledge, as highlighted in sections 2.0 – 7.0 of this document, and you can use a plethora of points or arguments to make a case for or against this statement.

Starting with section 2.0 as a basis for my introduction, I could explain broadly how coastal systems operate, including briefly definitions for processes, interconnectedness and erosion including my viewpoint (which is elaborated further - that there cannot be an overarching influential process.)

You can, however, argue that in terms of physical strength and landforms created, erosion can (on a local scale) be highly influential in some high energy coasts – giving us some of our most recognisable coastlines (again, the monolithic Scottish highlands and Islands springs to mind here) – and also typically causing some of the greatest challenges for society in terms of the need to 'fortify' our coastlines from mainly erosion.

In low energy environments on a local scale, depositional landforms from section 5.x, such as Chesil Beach or the Isle Of Purbeck, are far more visible, becoming regional landmarks in their own right. Furthermore, in terms of potential impact, weathering (which is also often confused with erosion, but they are different concepts) can have a similarly large effect on how our coastal environments appear and act, from leading to mass movement to adding significant amounts of sediment to transport through massive landslides and rockfalls.

When we are considering wider context, realistically none of these processes in their own right is particularly overimportant. Consider the changing coastal environments of the Sundarbans Delta in India/Bangladesh, or the aforementioned barrier islands of the North East United States. Coastal environments shift and morph – and where once erosion was occurring significantly could now be more importantly under the influence of another process, for whatever reason.

In conclusion, I could state that in theory there is no ultimate 'influential process' because all need to be acting together as interconnected to balance the system in a state of dynamic equilibrium – using the example from page two about how reducing greatly the rate of erosion can affect all the other processes and hence outputs of a system, leading it to into a vicious feedback loop – which is dangerous to the whole coastal system.

Furthermore, over a longer time period and on a global scale it could be said the most crucial influence is climate and sea level change, isostatic, eustatic and tectonic – which has resulted (and will in the future with rising sea levels due to climate change) in the most radical changes to the composition of our coasts – such as the postglacial Fjords of Norway, or spectacular Croatian Dalmatian Coastline.

Many thanks for reading and using this resource – good luck!

Last Updated: 15/11/20

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