Geomorphological & Coastal Processes

What you need to know
How weathering and mass movement affects the coastline
How erosion, transportation and deposition affect the coastline

Introduction:

Coastlines differ according to their orientation and geology. Coastlines which protrude out into the sea and are formed from less resistant sedimentary deposits are more likely to be modified by a range of coastal processes than a less exposed hard rock cliff face.

Where wave energy is strong, erosion and transportation is more likely to take place and conversely, where wave energy is weaker, deposition will occur. As well as wave energy, other geomorphological processes can modify the coastline. **Chemical, mechanical** and **biological weathering** loosen rocks, in advance of their removal by waves and mass movement also provides loose material.

Geomorphological processes: These include marine, atmospheric and terrestrial processes.

Subaerial weathering:

Mechanical weathering:

- **Freeze-thaw weathering** occurs when the daytime temperature is different than the night-time temperature either side of freezing point on rock faces. During the day, water enters cracks in the rock and at night when the temperature drops the water expands as it freezes. The increase in the volume of ice exerts pressure on fissures in the rock and weakens it internally. During the day, when the temperature rises again, the ice melts. The process reoccurs repeatedly until the rock breaks apart.

- The other type of mechanical weathering is **exfoliation**. This occurs when the daytime and night-time temperatures are distinctively different on dry rock. During the day, the sun heats up the surface of the rock and at night the outer layers cool down. This repeated expansion and contraction of the surface layers results in the gradual disintegration of the top layers.

Biological weathering:

This type of weathering occurs when plants or animals break down the rock.

- On cliff faces, both animal and plant action can loosen large amounts of rock material. Trees and plant roots can prise apart rocks by growing in between the bedding planes and joints enlarging them as they increase in size. Equally damaging is when small animals burrow underground and loosen rocks such as sand martins. Microorganisms in the soil are also able to break down the rocks; particularly carbonate rocks.

- Below high tide level, seaweed will often attach itself to rocks and when waves crash on the shore, seaweed will be subject to powerful currents and forces that will pull pieces of the rock away with it.

Chemical weathering:
The chemistry that makes up coastal rocks can be affected by rain and sea water leading to the gradual disintegration of solid rocks.

- **Hydrolysis** occurs in certain rocks with minerals that are reactive to water or chemicals in the water. This is where particular minerals break down due to their contact with water leading to loss of rock coherence and structure.
- **Oxidation** can also occur on cliff faces and shoreline rocks where iron elements are present within rocks. The 'rusting' of the iron content may cause rocks to disintegrate.

Mass movement:

There are several types of mass movement that occur along a coastline and involve significant quantities of material being released and falling under gravity, usually onto the shore.

- **Rockfall:** when rocks are broken down by freeze-thaw weathering, this loosened material is vulnerable to the elements. If the rock is at the top of a steep cliff face, it can fall directly to the shore. This can occur more so when a wave cut notch is created at the foot of the cliff by wave action, causing the overhanging rock to be unsupported and more likely to fall.

- **Soil creep:** this is a process operating at the granular scale. It happens on gentle slopes and is noticeable from the wavy surface it produces. Damp soil moves very slowly down the slope as the weight of water pushes it forwards. Rain splash may release soil grains that fall further downslope.

- **Landslide**: rocks and unconsolidated material on the cliff face are saturated with water (rain or wave-splash). Eventually the material slips down the slope. Landslides occur more often on soft rock coastlines where there are natural joints in the rock, into which water can get. They occur on steep gradient slopes and are very similar to slumps, although slumps occur on shallower, concave slopes.

- **Rotational slumping**: heavy rain is absorbed by unconsolidated material making up the cliff (often glacial till, or boulder clay). The cliff face becomes heavier and eventually it separates from the material behind. Slumping occurs on a concave cliff face and contributes to this shape as successive slumps accumulate. Material at the slump foot (toe) has to be removed by wave action before more slumping can replace it.

- **Mudflows**: these occur on very steep slopes along the coastline. Where there is limited vegetation to bind the soil together and the ground is very saturated

heavy rain can produce sheet flow over the upper cliff surface. The soil continues to be lubricated and it eventually flows over the cliff face and down onto the shore at a fast speed.

Marine coastal processes:

The processes of erosion, transportation and deposition occur as a result of differing wave and current energy. Where marine energy is high, erosion, removal and transportation is more likely to take place. Where energy is reduced, deposition of transported material is more of a feature. It is important to recognise that the wave type affects the process that occur.

Erosion:

- **Hydraulic action** – this process occurs where the power of the waves hits the cliff face directly and loosens the interior of joints and bedding planes. Cavitation is a similar process. As the wave smashes into a crevice, it compresses air bubbles that effervesce (fizz) powerfully as the wave (and pressure) begins to recede, and creates a mini explosion. Rock within the crack will be loosened and over time this process will widen the opening further.

- **Wave quarrying** – when high energy, tall waves hit the cliff face they have the power to enlarge joints and remove large chunks of rock in one go through vibration. This occurs due to the intense force of these waves.

- **Corrasion / abrasion** – this process occurs when high energy waves have the energy to be able to carry pebbles with force. As the wave breaks at the foot of the cliff, material is thrown at the cliff face and wears it away by chipping fragments off.

- **Solution** – this process occurs when weak carbonic acid in seawater dissolves rock at the coastline and breaks it down (particularly that containing calcium carbonate such as limestone and chalk).

- **Attrition** – this is when rocks and boulders which have already been loosened from the coastline are ground over each other in the water – usually by repeated swash and backwash - and over time the angular edges become smoothed and rounded and boulders/fragments become pebbles, pebbles become shingle, and shingle may become sand.

- **Run-off** – this is when rivers & streams erode away their channel as they approach the mouth. Increased erosion of coastal landscapes can occur because of this. However, runoff can interfere with other process. Often, at river estuaries there is an increase in coastal deposition as the river current entering the sea increases turbulence and friction with marine currents, reduces the energy of both, resulting in deposition of fluvial and marine sediment.

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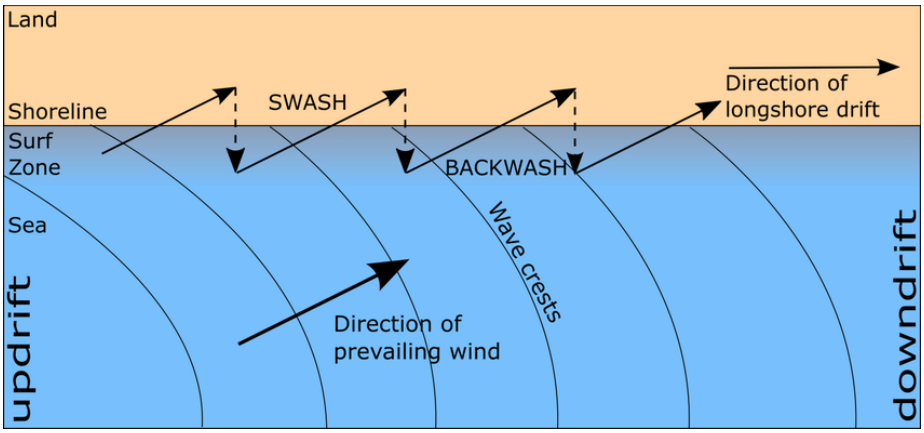
Transportation:



Most material is moved along the coastline by a process called **longshore drift (littoral drift).** This occurs when the waves approach the coastline at an oblique angle. The waves push material at an angle up the beach via the swash and it is then deposited on the beach. The backwash will then pull it down the beach in a vertical direction back out to sea. Another wave will then carry it obliquely towards shore again. The process continues until material is moved along the coastline in a zig-zag movement.

Some of this material is held within the water itself as **suspension**. When waves are predominantly constructive it is this process that creates and enlarges beaches. Larger material which has not been reduced down by attrition is unlikely to be picked up and carried by the waves, unless there are storm conditions and the waves are high energy. This material will be moved along the sea bed by the power of the current. This is called **traction**.

Deposition:

This process occurs when wave energy is reduced and friction overcomes the available energy. The wave has to drop material at this point. During the process of longshore drift, where the coastline changes and longshore drift continues to move material, energy will reduce and the transportation will stop, depositing material offshore as a **spit**. Sometimes when the coastline changes, there is a **river estuary**. The flow of water from the river into the sea can further reduce the energy of the waves; hence deposition may occur – *requiring constant dredging to keep port routes open.*

At a headland, wave energy is intensified at the promontory due to refraction and low energy waves then splay out into the bays either side. Material is then deposited in the bays due to reduced wave energy.

The formation of constructive waves also leads to deposition. **Constructive waves have a low frequency, a long wavelength and a low amplitude**. When they break on a beach, they have a **strong swash** and a **weak backwash**. This means they deposit more material on a beach as the strength in the swash allows the wave to travel far up the beach before deposition takes place. When they have deposited material on the beach, the energy in the wave is lost and much of the water percolates into the beach material and therefore the backwash is weak.