Coastal Areas

Ocean Explorer

Module 4

Bayworld Centre for Research & Education

BCRE

Overview

Coasts are shaped through the three following processes : erosion, transportation and deposition.

Info +

If water is muddy, it is a sign that erosion is taking place. The brown colour indicates that bits of rock and soil are suspended in the water and being transported from one place to another. This transported material is called sediment.

Erosion

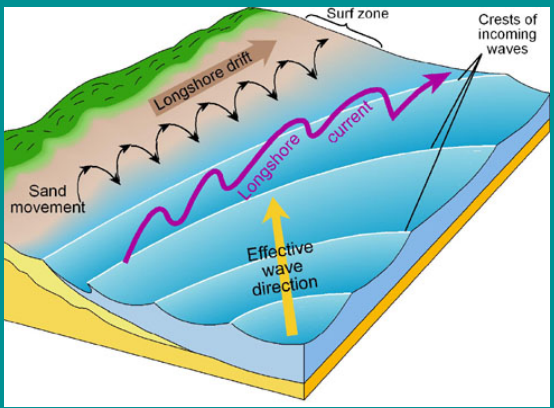
Erosion is the mechanical process by which land surface materials (e.g. rocks and soils) are gradually worn away by the action of water, wind or ice. In a coastal situation, erosion removes sand and pebbles from the coastal zone.

Transportation

Sand is moved along the coastline thanks to a process called longshore drift. When the waves wash back towards the ocean, they carry with them any eroded material present where they washed up.

Deposition

Deposition is the natural laying down of weathered or eroded sediment. In a coastal zone the deposition of sand results in the formation of beaches.



Longshore drift

When waves break on a beach at an angle (usually due to wind direction), the swash pushes material up the beach at an angle. The backwash pulls the material back down the beach at ninety degrees to the coast. In this way material is slowly moved along the coast, in the direction of the waves. This is called longshore drift. The movement of materials results in the beach migrating.

How waves shape the coastline

- **Hydraulic action :** The force of the water on the rocks or cliff forces air into cracks in the rocks. This air compresses and the resulting pressure causes the rock to break up.
- **Abrasion :** The rocks are worn away by the material carried by the water as it scratches against the rock.
- **Attrition :** As the rock fragments carried by the water knock against each other, so they wear each other down and become smaller, rounder and smoother.
- **Corrosion and solution :** Sea water corrodes some materials in rocks, which are then dissolved in the water.
- **Undermining :** The base of a cliff is eroded by waves and eventually the top part of the cliff falls into the sea due to gravity.

Info +

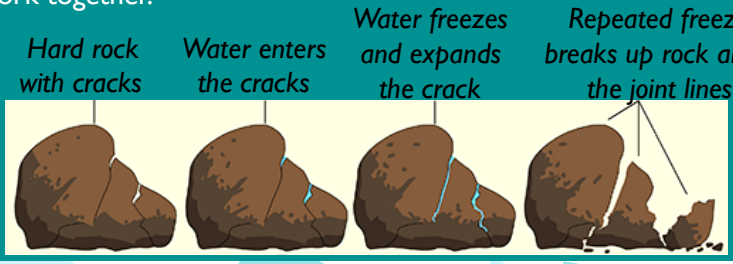
Human activities can speed up the weathering process. Air pollution increases the rate of weathering. Burning coal, natural gas, and oil releases chemicals such as nitrogen oxide and sulphur dioxide. When these chemicals combine with sunlight and moisture, they change into acid rain.

Weathering

Weathering is the breaking down or dissolving of rocks and minerals. Water, ice, acids, salt, plants, animals, and changes in temperature are all agents of weathering. Once the rock has been broken down, the **erosion process** transports the bits of rock and minerals away. No rock is hard enough to resist weathering !

Weathering and erosion constantly change the Earth. Weathering wears away exposed surfaces over time. It smoothes sharp, rough areas on rocks. Weathering also helps create soil as tiny bits of weathered rock mix with plant and animal remains.

Weathering can be a mechanical or a chemical process. Often, these two types of weathering work together.



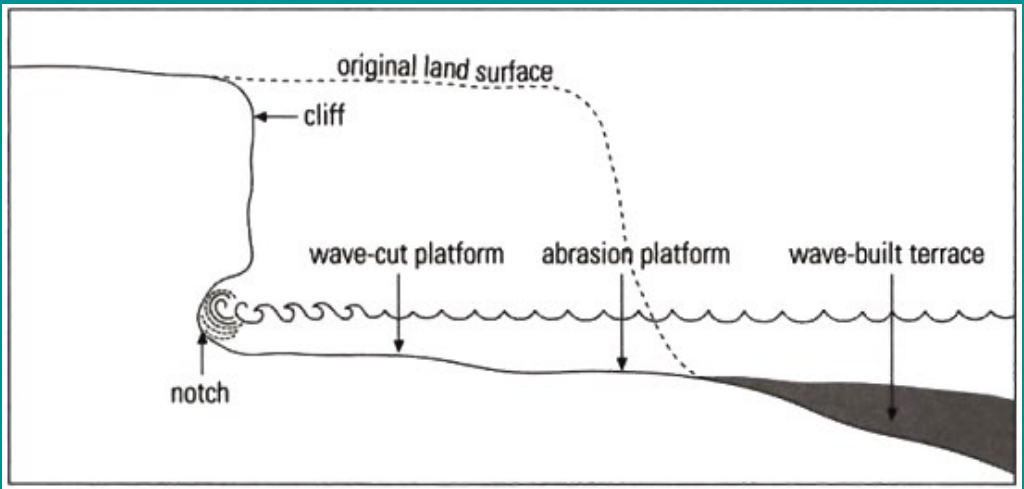
Info +

Erosion and deposition combine to produce constantly changing landforms. Coastal zones are very unstable habitats !

The area between the open sea and the land is called the coastal zone. This zone is made up of the beach and cliff or dune line. The beach consists of three sections, the backshore, the foreshore and the nearshore. Erosion and deposition combine to produce constantly changing landforms. Coastal zones are very unstable habitats.

Cliff and associated zones

- **Coast :** Narrow zone where land, sea and atmosphere meet.
- **Wave-cut platform :** Gently sloping rock surface created as the cliff retreats inland due to erosion.
- **Abrasion platform :** Area where the seabed is being worn away by the backward and forward motion of the water and sediment.
- **Wave-built terrace :** Area where the eroded material is deposited on the seaward side of the abrasion platform.



Info +

Erosion can also be done by living beings, and especially micro-organisms ! This is called ***bio-erosion****.*

Tidal currents and ocean currents influence the shape of the coast, but waves have more impact. The waves will strike the coast at different heights depending on the sea level. High and low tides are responsible for the changes in sea level. This means that the level at which erosion or deposition occurs depends on the sea level.

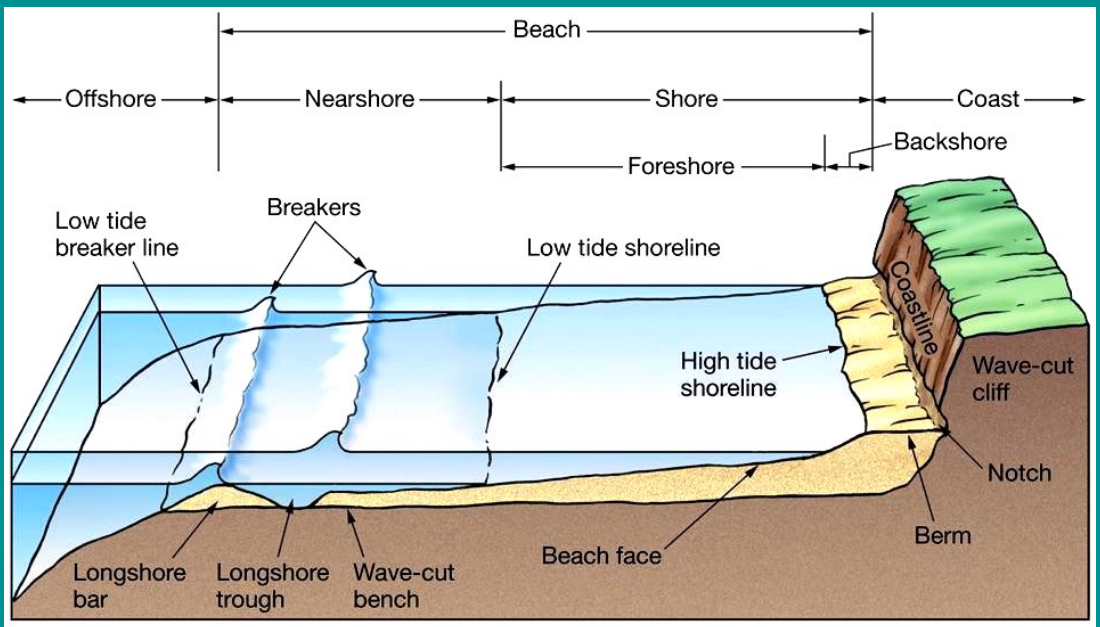
Info +

Offshore

Not part of the beach, refers to anything that is away at sea.

Parts of a Beach

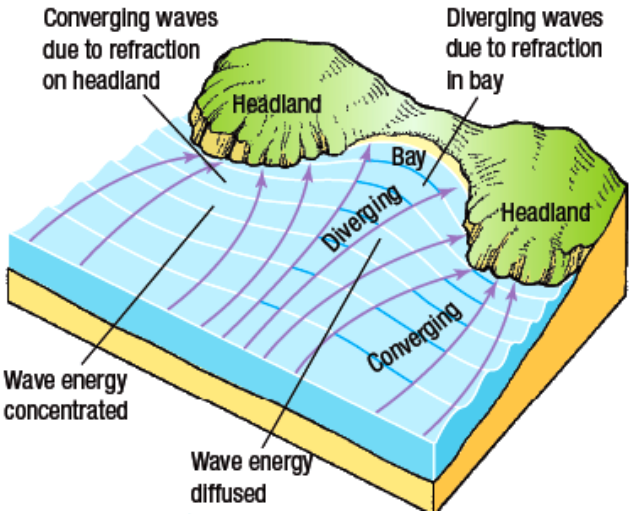
- **Backshore** : The storm beach that is usually steeper than a tidal beach. Consists of coarser beach material such as gravel and pebbles.
- **Foreshore** : Surf or intertidal zone where the high-tide mark occurs.
- **Nearshore** : A zone of breaking waves where the low-tide mark occurs.



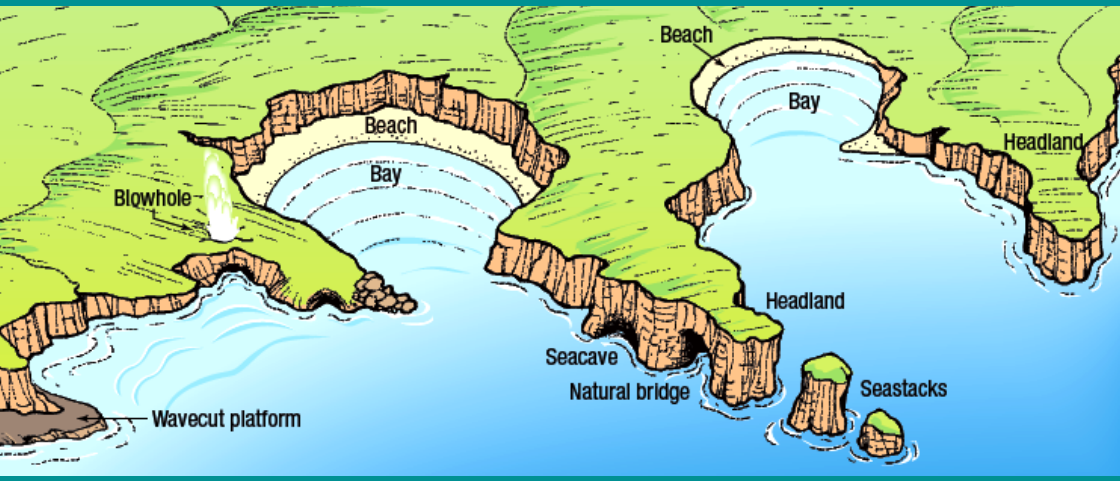
In the coastal zone, wave action results in irregular coastlines. Waves with lots of energy result in erosion, while those with less energy result in deposition. More resistant rock will form headlands or capes, while less resistant rocks form bays.

Formation of coastal landforms

Waves approach a straight coastline. Areas of less resistant rock are eroded first, leaving behind headlands. The coastline between the headlands forms bays. Material eroded from the headlands is deposited in the bays to form beaches. The waves have the most energy when they reach the headland and erode material from the headland. The waves are refracted as the section of wave that strikes the headland is slowed down, and the wave's energy is passed on to other parts of the wave, causing them to speed up and change direction. The waves that enter the bay have less energy and thus deposit the materials they are transporting there. As a result of this erosion and deposition, various coastal landforms are created.

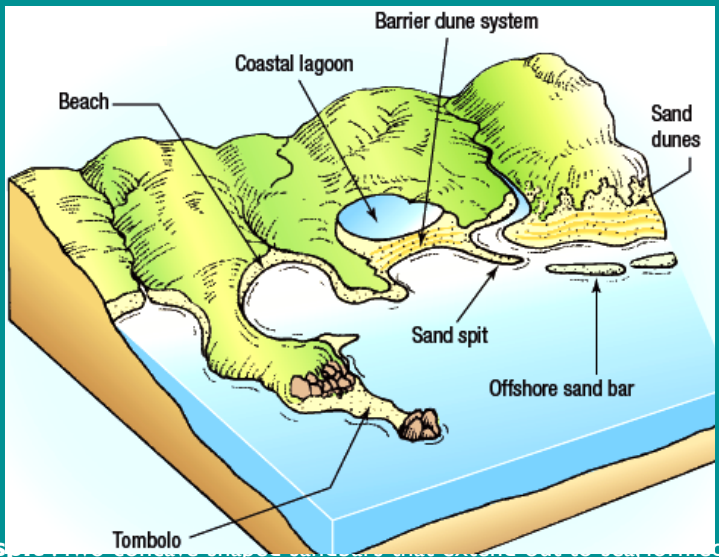


Landforms caused by marine erosion



- **Wave-cut platform** : Gently sloping rock surface created as the cliff retreats inland due to erosion.
- **Abrasion platform** : Area where the seabed is being worn away by the backward and forward motion of the water and sediment.
- **Wave-built terrace** : Area where the eroded material is deposited on the seaward side of the abrasion platform.
- **Headland (Cape)** : An area of resistant rock where waves strike first with lots of energy causing erosion.
- **Notch** : The indentation formed on a sea cliff at water level caused by wave action. The waves continue to undercut the cliff until the cliff collapses. This process continues repeatedly and the cliff retreats inland.
- **Caves** : Formed when waves undercut the base of a cliff. Usually occurs along weaknesses in the resistant rock (joints, cracks or faults).
- **Blowhole** : A hole formed in the roof of a cave by vertical erosion from waves pounding into the cave. The hole extends through to the surface of the headland, and when waves push water into the cave it is pushed out the top of the hole.
- **Arch** : Result of a cave on a headland being eroded all the way through.
- **Stack** : A piece of headland separated from the main structure when the roof of an arch eventually collapses.
- **Bay** : These form where less resistant rock is eroded away. The waves in bays have less energy and mainly deposit materials which can form beaches.
- **Spit** : A spit is formed from a sand bar when longshore drift causes a tongue of sand to form which extends from the land out to the open water or across a river estuary.

Landforms caused by marine deposition

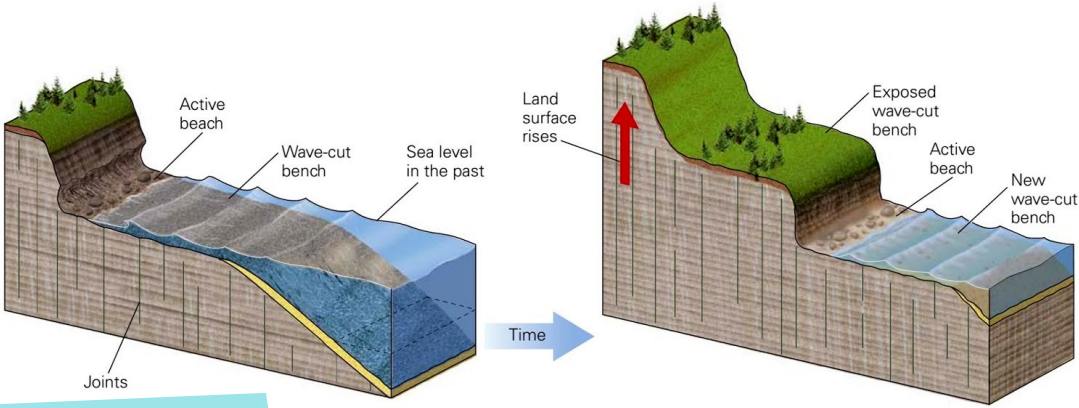


- **Sand spit**
- **Cuspate s** when sandbars are built up from opposite sides.
- **Recurved or hooked spit** : When a spit curves round towards the land due to waves approaching the shore from a different angle.
- **Tombolo** : A sand bar that joins an island to the mainland.
- **Baymouth bar (Barrier dune system)** : A sand bar that extends across a bay.
- **Lagoon** : Body of ocean water that has been cut off from the sea by a sand bar.
- **Tidal inlet** : A narrow gap in a sandbar through which water flows into a lagoon at high tide and out of the lagoon at low tide.
- **Sand dunes** : Sand from a beach is blown by the wind inland and deposited where it comes into contact with vegetation. Over time this will build up into coastal dunes.
- **Beach bar (Offshore sand bar)** : A sand bar that has developed parallel to the coastline.

Over time (millions of years) tectonic activity and changes in ice sheets have resulted in sea level changes. The freezing of ice or the rising of land (tectonic uplift) results in a sea level drop, so coastlines emerge that were previously covered with sea water. When the ice sheets melt or the land subsides, the sea level rises and the coastline can be submerged.

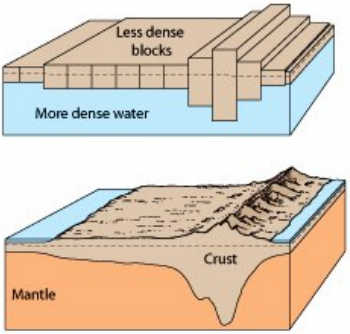
Coasts of emergence

When the sea level decreases (or a coastline is raised) by isostasy or eustasy, the adjacent sea-bed is exposed. Wave erosion produces a wave-cut bench along an emergent coast. As the land rises, the bench becomes a terrace, and a new wave-cut bench forms.



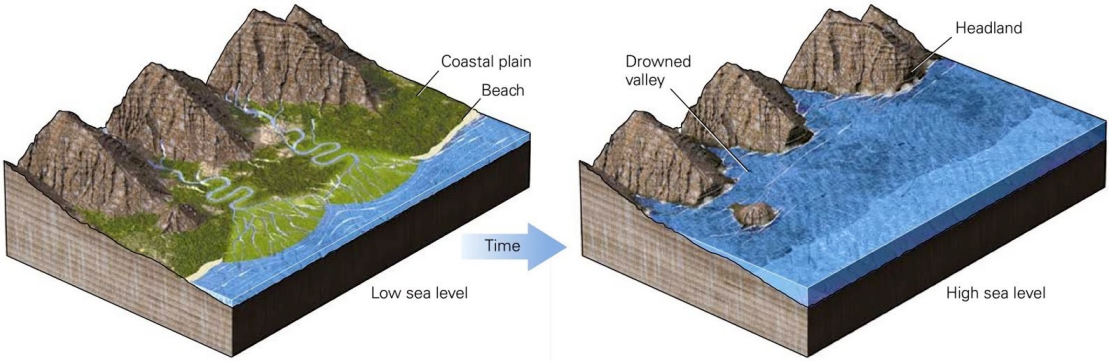
Info +

Isostasy *is the idea that the lighter crust must be floating on the denser underlying mantle. Just as a boat sinks or rises with changes in weight, so does the crust sink or rises. Plate tectonics build mountains and the extra weight causes the crust to sink. As erosion occurs, the weight of the mountains decreases and the crust rises again. This process is called isostasy.*



Coasts of submergence

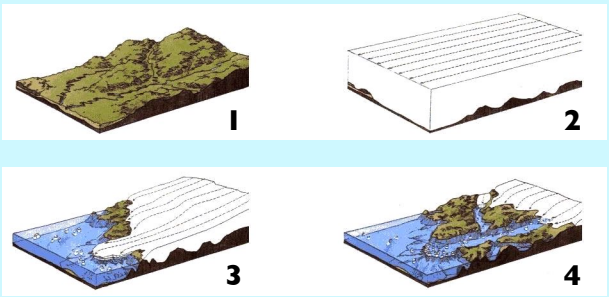
Rivers drain valleys and deposit sediment on a coastal plain. When the sea level rises or the land subsides, the sea is pushed further inland and floods areas that were previously above sea level.



- **Ria** : Also referred to as *drowned river valley*, results when the sea level rises relative to the land and the valley that was previously at sea level is submerged. The ria often forms an estuary.
- **Fjord** : Created when a long, narrow valley is carved by glacial activity and a steep sided inlet is formed.
- **Dalmation Peninsula** : Consists of a number of long, narrow islands and peninsulas parallel to the land. These are mountain ridges parallel to the coast that have been submerged in water.

Info +

Fjord formation



1 - Valley before glaciation
2 - Glaciation. The valley is covered by a glacier.
3 - The climate is warming up, the ice is melting.
4 - The sea level rose due to the climate change. The valley is now covered by sea water mixed with fresh water running from the glacier melting. It is a Fjord.

5 - The colour of water

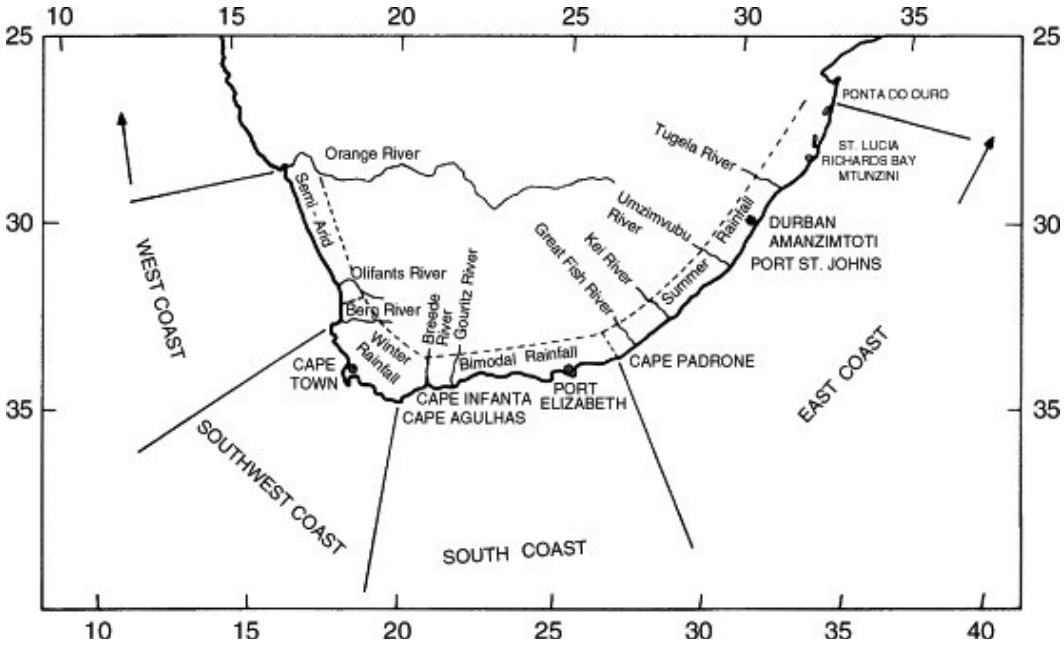
Water is blue. It may not come as a surprise, but experts until recently believed the blue colour was simply the reflection of the sky above. While there is some truth to that statement (water is indeed blue, and its colour is somewhat affected by that of the sky), that also means the oceans should be white on a cloudy day, which they are not.

Just like any other thing on earth, the colour of water has to do with light. When sunlight hits water, the red end of its spectrum is absorbed, resulting in a blue coloration being reflected back. Water itself is only very slightly blue, which is why this phenomenon is not as easily observable at home with a glass of water as it is in oceans and lakes.

But perfectly pure water does not occur naturally. In lakes, rivers, and oceans, water always contains minerals and living organisms in varying quantities, which alter its colour. For example, algae can turn it a murky green and, in some instances, red, while large amounts of mud will make it yellow, like the Yellow River in China. In some mountain lakes, fine sedimentary particles, produced when a glacier grinds over rocks in its path, reflect sunlight before much of it is absorbed by the water, giving it a bright aquamarine colour. Because of this, testing the colour of water is a quick and easy way to detect the amount of organic matter, particles, or even metals, present in a sample.

Testing the water also allows for the assessment of its healthiness. Highly-coloured water can have a negative impact on ecosystems since very little light can get through it, making life underwater virtually impossible. However, coloured water, despite not being very appetising, can sometimes be perfectly drinkable.

South African coasts can be roughly divided into six regions as per the following map.



The **west coast** is made of low rounded cliffs and rocky shores which have been subjected to substantial wave erosion, fronted by narrow beaches of sand and gravel. The west coast is exposed to the continuous pounding of heavy southwesterly swells, which produce a strong longshore drift. This coastline finishes with the entrance of the Berg river, forming a lagoon.

The **southwest coast** is very different, with widely spaced rocky headlands separated by long sandy beaches backed by dunes. Table Bay is bordered by a promontory (headland) which marks the northern limit of the Cape peninsula.

The relief gradually diminishes towards Cape Agulhas, within the **south coast**. This part is made of a succession of half-heart bays opening to the southeast. From the Gouritz river, the coast is dominated by a raised coastal platform at a height of 150 to 250m. Some coastal dunes occupy the gaps between bedrock ridges.

The **east coast** is characterised by impressive near-vertical coastal cliffs in which open into fluvially incised gorges, waterfalls and lagoons. This coast shows a range of typical erosion landforms, such as cliffs, arches and shore platforms but also depositional landforms such as sand dunes. These deposits describe the history of the coast as openly as a book.

Info +

Although rocky coasts are often seen as relatively insensitive to ongoing environmental changes, South African coasts are affected by several environmental issues. Development of tourism and infrastructure has potential to affect coastal morphodynamics, such as longshore sediment transport, sand dune stability and ecosystems. Pollution and waste water dispersal also play a role in damaging the coastal regions. But the most dramatic changes are due to climate change : the sea level rises and erodes more and more the coastal landforms, destroying the coast and its ecosystem.

To prevent erosion of sand beaches and protect the infrastructure, concrete tetrapods are often used and installed where the stronger waves hit the coast. As a result, the only erosion taking place is the erosion of these concrete blocks !

Material needed

Hammer

Plaster of Paris

Water

1 small balloon

2 empty one litter milk cartons (bottom halves only)

Freezer

2 effervescent antacid tablets

Method - Mechanical weathering

Fill the balloon with water until it is the size of a ping-pong ball, and then tie a knot at the end. Mix water with plaster of Paris; once the mixture is as thick as yogurt, pour half of the plaster in one milk carton and the other half in the other. Push the balloon down into the plaster in one carton until the balloon is about 1cm under the surface. Hold the balloon there until the plaster sets enough so that the balloon doesn't rise to the surface. Let the plaster harden for about 1 hour. Put both milk cartons in the freezer overnight.

Questions

What are your predictions about what would have happened when they froze ?

Remove the plaster-filled milk containers from the freezer.

What happened to the plaster that contained the balloon ?

What happened to the plaster that had no balloon ?

Why the difference?

Info +

*This experiment describes a process called **frost wedging**. It occurs when water seeps into cracks in rocks and freezes, expanding and cracking the rocks around.*

Method - Chemical weathering

Drop an effervescent antacid tablet into a beaker of water.

Pull out another antacid tablet and crush it with a hammer. Drop the crushed bits into water : they will dissolve almost instantly.

Drip a few drops of water on antacid tablets, just enough to start its fizzing reaction. After a few seconds, rub the dissolving tablet between your fingers.

Info +

Effervescent tablets contain sodium bicarbonate which dissolves in water in much the same way that carbonate rocks dissolve in carbonic acid.

Questions

Why are effervescent tablets dissolving into water ?

What else might accelerate the chemical weathering process you just modelled ?

Why crushed bits of tablets dissolve quicker than a full tablet ? Give the name of the 2 processes in action.

Can the opposite be true ?

Info +

When wetting and then rubbing the tablets between your fingers, the residue coming off shows how chemical weathering (i.e. the water dissolving the tablet) can facilitate mechanical weathering (i.e. the fingers rubbing or abrading the tablet). This process is the same for rocks within a longer time period !

8 - Activity : Name the landforms

In the following pictures, name as many landforms as possible, then categorise them into 2 groups : the landforms caused by marine erosion and the landforms caused by marine deposition.

1

2