Erosional Landforms

Cliffs, Wave Cut Platforms and Offshore Terraces

**Cliffs**
Waves erode the base of cliffs by hydraulic action, abrasion and solution. Erosion is greatest when waves break at the foot of a cliff. This causes erosion at the base of the cliff.

This produces a notch, at the high tide line, which undercuts the base of the cliff, as this notch increases in size the cliff above becomes unstable and reaches a stage where the weight of the material above the notch is too much to hold. The cliff therefore collapses. This material will provide temporary protection for the cliff behind. As this process is repeated the rock fall and material which falls on to the beach is carried away by longshore drift and the cliff retreats. As cliffs become eroded down to beach level they appear to migrate inland.

The remains of the former cliffs form a flat rock platform. This is known as a wave cut platform. As the cliff retreats, the rock debris is swept by the backwash creating a wave-cut platform. Some of the debris collects along the seaward edge of the wave-cut platform forming and off-shore terrace.

**Wave Cut Platforms**
The platform cuts across no matter what type or structure the cliffs have. Some pools may form where solution occurs on dissolvable and if there’s a crack in the rock. The wave cut platform is covered in debris. As the platform widens the waves break further out to sea so they have to travel over a wider area and so the energy is dissipated therefore erosion at the headland is reduced.
Headlands and Bays, Caves, Geos, Arches and Stacks

Headlands and Bays
These are alternating bands of more and less resistant rock and are exaggerated and destroyed by wave action (may not be a large difference but will show after a long period of time). Erosion/wave action acts less on the more resistant rock which sticks out into the sea creating headlands and more on the less resistant rock creating bays either side of the headland.
- Hard Rock erodes slowly = headland.
- Soft Rock erodes faster = bay.

As the headland becomes more exposed to the wind and waves the rate of its erosion increases. When headlands erode they create distinct features such as caves, arches, stacks and stumps.

Due to wave refraction energy will be less concentrated on the hard rock (headlands) and this will slow down the erosion of the bay.

Headland
Areas of harder rocks tend to resist the erosive powers of the sea. The resulting area of land, jutting out into the sea, is a headland. Bays are to be found between headlands.

Bay
A wide indentation into the land by the sea, protected on each side by a headland. The water in a bay is usually relatively shallow; the wave action less strong than at the headlands.

Blow hole
A blow hole is formed when a joint between a sea cave and the land surface above the cave becomes enlarged and air can pass through it. As water flows into the cave, air is expelled through the pipe like joint, sometimes producing an impressive blast of air or spray which appears to emanate from the ground.

Cave
A weakness, such as a joint, is enlarged by wave action, finally creating a cylindrical tunnel which follows the line of weakness. Caves developing back to back may give rise to arches and stacks.

A cave is formed by a wave cut notch eroded backwards and side wards to form a cave by hydraulic action and abrasion.
Arch

When caves, which have developed on either side of a headland, join together they form a natural arch. The beach will cause waves at high tide to channel through the arch, increasing erosion and its eventual collapse.

Arches are formed as the cave wears backwards along a fault by hydraulic action and abrasion right through the headland. When a natural arch collapses, the remaining upright sections form stacks, isolated rocks sticking up out of the sea.

These continue to erode at the arch and weathering at the top, it cracks and falls into the sea and this leaves the tip of the headland.

The diagram below shows the sequence in the erosion of a headland.

Stage 1
Waves attack a weakness in the headland. Holes in a cliff face are enlarged by wave action.

Stage 2
A tunnel like structure called a cave is formed. The cave may develop further forming a long narrow inlet known as a geo.

Stage 3
Eventually the cave erodes through the headland to form an arch.

Stage 4
The roof of the arch collapses leaving a column of rock called a stack.

Stage 5
The stack collapses leaving a stump.
The following different diagrams give an overall summary of the erosional landforms that can be found in different coastal areas.
Depositional Landforms

Coastal Deposition is when the sea drops or deposits material. This can include sand, sediment and shingle.

Bay-head beach
Bay head beaches develop at the head, or inner most part, of a bay. In this area wave action is usually not very strong and deposition occurs. The beach will not extend to the headlands since erosion from waves increases strongly towards the headlands and deeper water.

Spit
A spit is a long narrow accumulation of sand with one end jointed to mainland and the other projecting out to sea or across an estuary. Longshore drift moves material along a coastline. Where there is an obstruction or the power of the waves is reduced the material is deposited. Where rivers or estuaries meet the sea deposition often occurs. The deposition begins where the coast changes direction and extends down coast in the direction of longshore drift. The result is a narrow ridge of material (sand or pebbles) attached to the mainland at one end and terminating in the sea. The spit may extend sufficiently to form a lagoon. The sediment which is deposited usually builds up over the years to form a long ridge of material (usually sand or shingle). Such a ridge is called a spit. There are different types of spits:
- Sandy Spits - formed by constructive waves.
- Shingle Spits - formed by destructive waves.
- Composite Spits - shingle deposited before the finer sand (made of both).

Hooked or Re-curved Spits
As spits built out into deep water they require increasing volumes of sediment to build above the high mark. The tip or distal turns towards the land where it’s shallower. If it built out in deep water it would be eroded. Once formed hooks are sheltered from the dominant waves by the spit and become permanent curves also formed by the second dominant wind.
Double Spits
Are spits, which extend from an embayment this may be due to two dominant winds. Due to a spit extending across a bay (bar) and it gets breached.

Forelands
A cuspate foreland is a complex depositional feature formed when longshore drift is from two directions, which meet to produce a series of ridges at right angles to each other. This forms a low-lying triangle area.

Bay Bars
If a spit extends across a bay it links two headlands and straightens the coastline.

Tombolo
This is when a spit joins an island to the mainland.

Barrier Beaches and Islands
The beaches form as offshore bars of sand, which accumulate below the low tide mark and move inland. The shallow water generates constructive waves, which transport material landwards creating a long smooth coastal feature topped by sand dunes and separated by a lagoon. Barrier islands are long, narrow islands that form parallel to the coastline between 3 and 30 kilometers offshore. They are a natural form of protection from sea storms for the water and shore inland.

Lagoon
When a spit extends across the mouth of a river, to the extent that it causes the river to become diverted along the coast, an area of water is created separated from the sea by a narrow strip of land.
Other Coastal Landforms

Salt marshes

Where there is shelter in river estuaries or behind spits, silt and mud are deposited by the rising and falling tide or the river. Plants like algae can tolerate the submergence and the high levels of salinity. They trap more mud around them allowing the slope zone to remain exposed for longer periods between tides.

Mud Flats

Gently sloping coasts where fine sediments can settle, perhaps together with river sediments, can allow the build up of mud as a sheet known as a mudflat. Plants able to withstand salt water will often colonise the area. In tropical areas this may lead to the formation of mangrove swamps.
Managing coastal hazards

Hard coastal defences
These are rigid 'engineering' solutions, made principally of concrete. Examples include sea walls, breakwaters, groynes and jetties (See Fig 1). The principle objective of hard engineering is to resist the energy of waves and tides by a fixed structure. At present, such structures protect approximately 10% of the British coastline. The widespread use of hard coastal defences in coastal protection has both advantages and disadvantages.

Methods of Preventing Coastal Erosion

Groins or jetties
Groins or Jetties are large linear structures that are built at right angles to the shoreline. They are built to stop the movement of sediment due to long shore drift. They do this by creating a build-up of sediment on the upcurrent side. A common problem with these structures is that they often accelerate erosion on the down-drift side.
Seawalls

Seawalls are barriers that are built along the shore at the back edge of the beach. Incoming waves hit the wall and are reflected back into the ocean, scouring the beach sand. Eventually the turbulent reflection of waves can cause the beach to erode. During high tides the sea wall might take the full force of the waves and collapses. Waves will often refract around the sides of a sea wall and erode the sand behind it. Steel walls are sunk vertically into the beach to stop the sand moving. Rock walls stop waves removing sands and gravel from the beach.
**Breakwaters**

Breakwaters are structures that are erected off the coast and parallel to it. They are designed to reduce the energy of pounding waves. These features usually manage to slow the erosion down, but don’t really stop it altogether. Their efficiency frequently depends on the type of material used in their construction. Recently, decommissioned New York City subway cars have been placed off the New Jersey and Delaware coast. Engineers use these stripped-down cars to build artificial reefs as a barrier for eroding sand.

**Embankments.**

These are high walls that are situated where a beach meets the land or cliff. They are usually made of concrete or stone and bounce back storm waves.

**Soft coastal defences**

This is the use of natural systems in coastal defence, for example, salt marshes and beaches, which can absorb and adjust to wave and tide energy. Soft coastal defence involves manipulating and maintaining these systems, without changing their fundamental structure.

**Dune Re-vegetation**

By increasing the amount of vegetation on the dunes you are able to keep them more stable and keep more of the sand on the beach. Without the dunes being moved further back from the beach there is more protection for the areas behind the beach. Keeping the shapes on the beach more natural allows the coastal processes to take place as well as allowing access for other people. Some of the problems include managing the number of people accessing the area.
Beach Nourishment
Beach nourishment involves pumping large amounts of sand from off shore to increase the width of the beach. Nourishment is a common tactic where communities on submergent coastlines are dependent on tourism, and usually works at least temporarily. There are two problems with beach nourishment, the cost and the environmental impact.

- Ocean City, New Jersey frequently spends more than $5 million to nourish their beach, and most of that sand is gone within 2.5 months.
- The ecological impact of beach nourishment pertains mostly to the differences in mineralogy. These differences can adversely affect the ecosystems along a beach. For example, coral reefs can starve and die if the mineralogy is vastly different.

Government Regulations
Setting up a storm tide early warning system which provides information about extra high tides. Preventing building on high flood risk areas. This would minimise the loss of life and damage to property.

Federal Disaster Relief Funds
All taxpayers pay for the damage suffered by those who live in regions of high geologic risk. Some see this as inequitable, and several legislative acts have been sponsored to rectify this. Since 1973 it has not been possible to get federally insured mortgages in these regions without buying (federally subsidized) flood insurance. For communities to be eligible for this insurance, they must adhere to a building code. All new flood-prone region construction must meet this code to minimize potential flood damage. An ongoing problem is that people tend to simply rebuild their homes after a severe flood. As a result of this, costs to the taxpayers can far exceed the flood insurance premiums collected. One possible solution for this problem is to remove some of the most severely threatened areas from the program. However, this requires the construction of very detailed maps of flood prone areas. The Department of Housing and Urban Development makes detailed maps of flood hazard regions to guide the new construction, but these maps are notoriously slow in production.