Coastal erosion

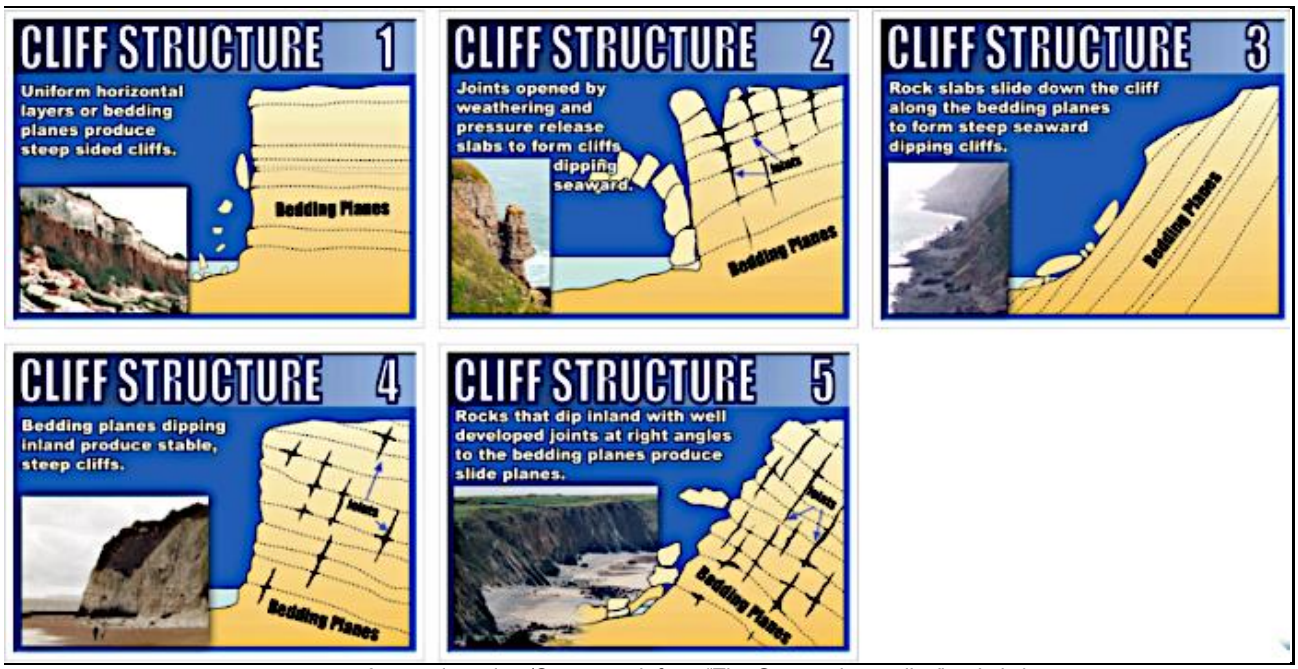
What controls the form of a coastline and the steepness of its cliffs?

Show pupils a photograph of a stretch of coastline, featuring sedimentary rocks, e.g. the coastline in Dorset below:

Coastline at West Lulworth, Dorset, England

Ask them what factors they think might control the form of the coastline and the steepness of the cliffs. (S*uggestions might include: strength of the rocks; spacing of bedding planes, joints or faults; dip and strike of strata; rates of weathering of different rocks; wave energy; tidal range; adjacent water depth; aspect of the coast in relation to prevailing winds and currents, whether the coastline is developed parallel to the strike of the rocks {as here} or at right angles; past climate changes; past sea level changes).*

Show pupils the five cartoons of cliff formation from the screen grab taken from the website “The Geographer Online” (The website shows an animated version of the cartoons). Then ask them to study the following photographs of coasts and ask them to relate the cliff form to one or more of the cartoons. Some answers may be debateable! Note that some pictures show people going dangerously close to cliffs and pupils should be warned never to do so themselves.



Cartoons of coastal erosion (Screen grab from “The Geographer Online” website)

Photographs of coastal features for comparison with the cartoons

Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

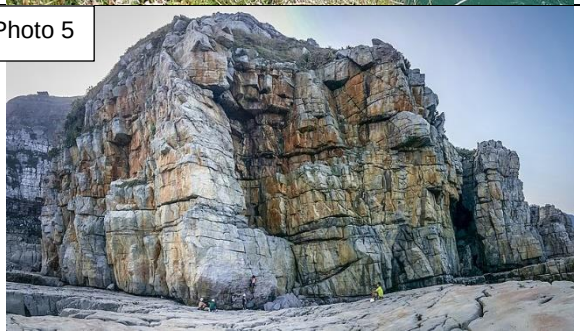


Photo 6

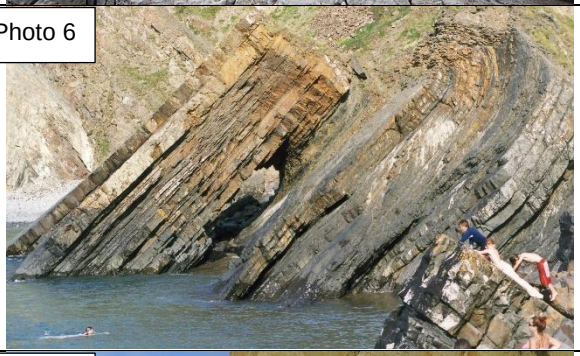


Photo 7

Photo 8

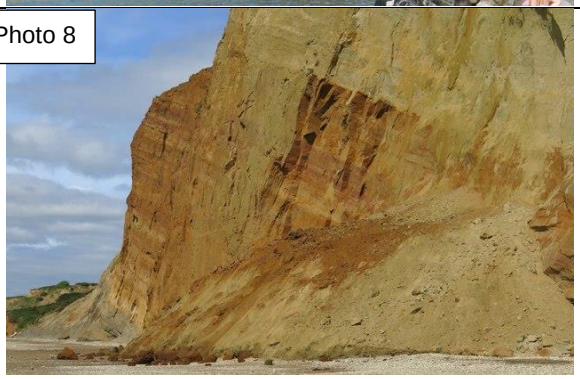


Photo 9

Photo 10

The back up

Title: Coastal erosion

Subtitle: What controls the form of a coastline and the steepness of its cliffs?

Topic: Examining how cliff structure and other factors impact cliff retreat and coastal landforms

Age range of pupils: 14 + years

Time needed to complete activity: 20 minutes, depending on discussion

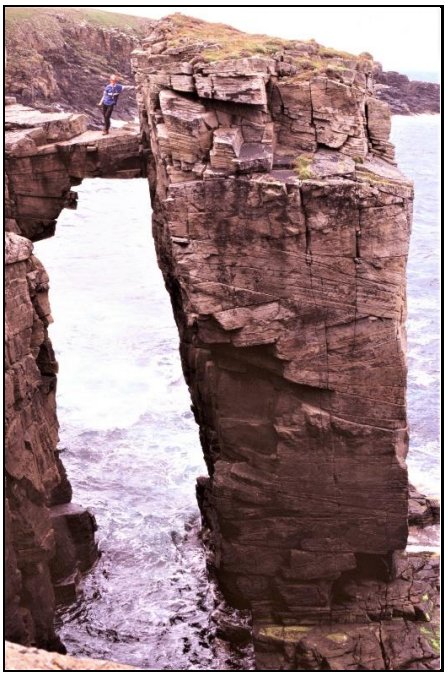
Pupil learning outcomes: Pupils can:

- list the main factors involved in coastal erosion;
- relate photographs of real coastlines to idealised situations;
- explain that there may be several explanations for any one cliff form.

Context: The activity involves a careful consideration of many possible factors involved in creating and maintaining coastal landforms, and could be used in geography or science classes.
Suggested answers to the matching exercise are:
Photo 1 - West Bay, Bridport, Dorset, England. Vertical cliffs in horizontal strata, where cliff collapse is common along vertical joints. The debris is soon washed away by the sea leaving a vertical face and enabling the sea to undercut the cliff again. Matches Cartoon 1.
Photo 2 - Clarach, near Aberystwyth, Wales. Cliffs sloping towards the sea, controlled by the seaward dip of the strata. When blocks of rock are loosened along the joints, they slide down into the sea and are eventually washed away. Matches Cartoon 3.
Photo 3 - Coast south of Kilbaha, Ireland. Strata dip inland and there are few joints, resulting in a steep, stable cliff face, although a bed of weaker rock in the middle has resulted in a step in the cliff at that level. Matches cartoon 4.
Photo 4 - Longdong, Taiwan. Strata dip towards the sea and the rock appears to be well-jointed, resulting in blocks peeling away into the sea from time to time. Some of the party are wearing hard hats, but these are unlikely to save them from serious injury if a cliff fall were to occur whilst they were so close to the face! Matches Cartoon 2.
Photo 5 - Also Longdong, Taiwan. Here the dip appears to be towards the land, but the rock is still well-jointed and could fail along the joints, so the party should keep clear of the cliffs. Matches Cartoon 5.
Photo 6 - Hartland, Devon, England. The dip of the beds in the middle ground is steep and towards the sea. If failure occurs it is likely to be along weathered joints, which occur at right angles to the bedding, so slabs of rock could slide off into the sea. There is also variation in rock type and some beds appear more easily eroded then others. Matches Cartoon 3.
Photo 7- Worms Head, South Wales. A very stable cliff, where the beds dip gently inland. In this case, there has been a relative change in sea level, resulting in the development of a raised beach at the foot of the cliffs. This has protected the cliff face from active marine erosion, which would otherwise have eaten away at its base and encouraged rock fall to occur. Matches Cartoon 4 (with allowance for the raised beach).
Photo 8 - Yaverland Cliff, Isle of Wight, England. A large cliff fall has recently occurred here. Although the bedding dips inland, the rocks are relatively weak and well jointed, and collapse is probably quite frequent.
Matches Cartoon 5.
Photo 9 - East of Loop Head, Clare, Ireland. A vertical cliff seen in a stack adjacent to the main coast. The dip is nearly horizontal and the beds are of resistant uniform rock, with quite widely-spaced joints, producing a very stable cliff. However, at some time in the past, a major collapse has occurred, resulting in the free-standing stack. Matches Cartoon 1.
Photo 10 - Stag Rock, Freshwater Bay, Isle of Wight, England. The strata dip steeply inland and most of the cliff appears to be made of uniform, rather thinly bedded rock, with closely-spaced joints, with some evidence of a section of the face about to fall away. The cliff should be regarded as rather unstable, especially when storm action can reach the base to undercut it.
Matches Cartoon 5.

Following up the activity:

- Investigate the influence of igneous or metamorphic rocks on cliff formation.
- Encourage pupils to take photographs of cliffs seen on seaside holidays and to analyse them as above. (Emphasise the need for adult permission and supervision).
- Show pupils the photograph of the student standing on a rather thin arch and ask, “What advice would you give this young man?”



Arch at Yesnaby, Orkney Islands, Scotland

- For older pupils, look at some of the examples of Scottish coasts and the ways in which they might respond to climate change on the very detailed website - http://www.dynamiccoast.com/

Underlying principles: The form of a coastline and the nature of its cliffs are dependent on many factors including:-

- rock type and strength;
- the spacing of potential planes of weakness such as bedding planes, joints and faults;
- differences in weathering rates of the rocks;
- the direction of dip and strike in relation to the overall line of the coast. When the coastline is parallel to the strike the coastline is referred to as concordant: when at right angles to the strike it is discordant;
- the "fetch" of waves impinging on the coast, i.e. the extent of open ocean over which winds can blow;
- the tidal range in the area;
- the local water depth near to the coast;
- the influence of past changes in climate and in sea level.

Thinking skill development:
A pattern is established of the influence of rock type and the dip of strata to rates of erosion.
A cognitive conflict occurs when pupils realise that many other factors may be involved in controlling the erosion of a coast, and discussion involves metacognition. Bridging skills may be needed when other examples of coasts are encountered on photographs or in pupils' own seaside experiences.

Resource list:
https://www.thegeographeronline.net/oceans-and-their-coastal-margins.html
https://www.earthlearningidea.com/PDF/345_Storms_erosion_rates.pdf

Source: Written by Peter Kennett of the Earthlearningidea Team, based on a presentation at ESTA Conference 2021 by Dr. Chris Spencer of the University of the West of England.