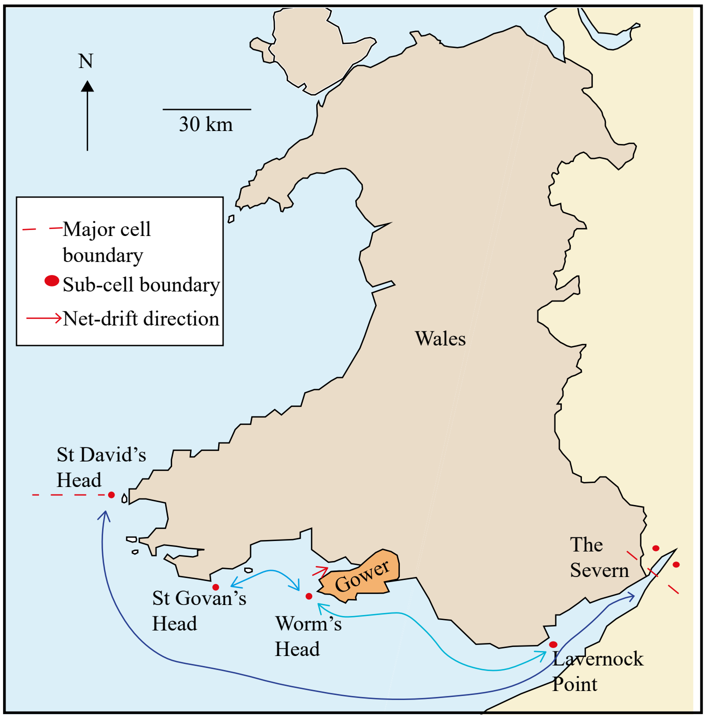
Geo Factsheet

www.curriculum-press.co.uk Number 352

The Gower: Waves, Tides, and Coastal Deposition

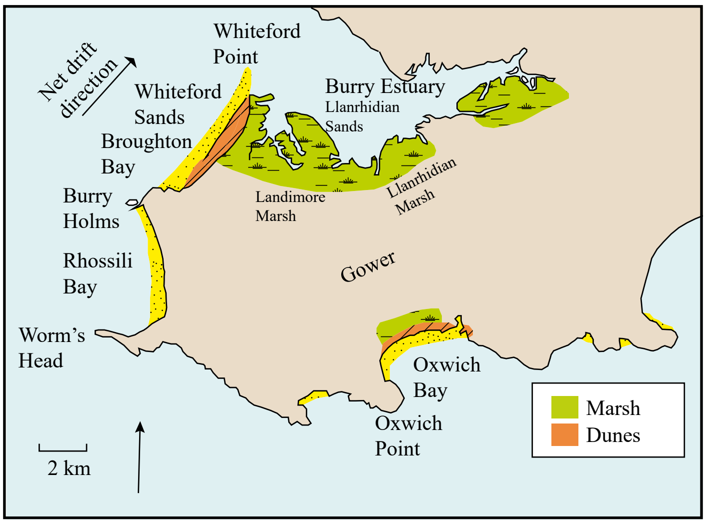
The Gower in South Wales is a peninsula of approximately 180 km^2 in size which was designated as an Area of Outstanding Natural Beauty in 1956. This Factsheet will use examples from the Gower coastline to examine the role of **waves** and **tides** in the creation and modification of **depositional** landforms including beaches and spits, as well as sand dune and salt marsh ecosystems.

Figure 1a. The Gower in Wales



This map also shows the sediment cell and sub-cells in which material is transported around the Gower coast.

Figure 1b. The Gower Peninsula



This map shows the location of areas and landforms mentioned throughout this Factsheet.

Coastal deposition

Coastal **deposition** takes place when the accumulation of coastal material such as sand and shingle is greater than its depletion. That is, the coast acts as a **store** of material as inputs exceed outputs. Depositional coastal landforms include beaches and spits and coastal ecosystems such as sand dunes and salt marshes. The material from which depositional landforms are comprised can range in size from large boulders and cobbles to fine silts and clays. The sediment which accumulates may come from a number of sources:

- The breakdown of rock faces such as cliffs and headlands.
- The breakdown of existing larger calibre material on beaches or material moved from beaches elsewhere by currents.
- Material brought to the coast from inland by rivers.
- Deep-water offshore sediments carried and deposited onshore as sea levels rose after the last Ice Age ended.

The Gower is situated within a **storm-wave** environment and depositional landforms are fed by material which has been eroded by wave action largely from the sedimentary rock outcrops of Carboniferous Limestone, Old Red Sandstone, and boulder clay which make up the coastline of the peninsula. The valley of the **River Loughor** was occupied by ice during the last Ice Age and has provided a source of glacial deposits which have been transported from inland to the shoreline over time. During the Flandrian Transgression much material was carried onshore by the rising seas as temperatures rose, bringing offshore material landwards towards the Gower coastline.

Transportation and sediment cells

The **transportation** of sediment around coastlines tends to take place in **sediment cells** (or ***littoral cells***) which are discrete areas of coastline where sediment is moved. Cell boundaries are often delimited by where the coastline's orientation shows a marked change, for example, at large headlands (**littoral drift divides**), or in **sediment sinks**, which are commonly tidal inlets or estuaries. Cells are defined based on the idea that the movement of most sediment within one cell does not influence adjacent cells. A number of sediment cells have been identified around the coastline of Great Britain. **Figure 1a** shows the major sediment cell for the Gower, which runs from the **River Severn estuary** in the east to **St David's Head** in the west. Sediment cells can be divided into **sub-cells**, marked by smaller, yet still significant changes in the coastline. The Gower peninsula itself provides a sub-cell boundary within the larger cell. **Worm's Head** (see **Figure 1b**) marks this drift divide. The sub-cell to the east extends to **Lavernock Point**. The adjacent sub-cell extends from Worm's Head to **St Govan's Head** in Pembrokeshire. The littoral drift in both sub-cells is mainly eastwards, but drift is not a significant process overall and is variable in direction within more sheltered embayments. There is, however, a clear net drift towards the northeast along the coast from Burry Holms to Whiteford Point in the north-western part of the peninsula which has helped to form a spit (see **Figure 1a** and **Figure 6**).

Waves and tides

Waves, generated by wind blowing over the sea's surface, provide a mechanism by which material can be eroded, transported, and deposited within sediment cells. They play an important part in the formation and ongoing modification of depositional landforms.

Constructive waves are associated with deposition. These waves have a stronger swash than backwash thus encouraging a net shoreward movement of material. Once established, depositional landforms can be shaped and modified by both constructive and destructive waves.

Tides are the result of the gravitational pull of the Sun and Moon on the Earth's water surface and cause the mean sea level to oscillate. The British Isles experiences two high and two low tides per day and the tides reach different levels at different points throughout the lunar cycle.

- **High tide:** when the coastal waters reach the highest level of the day, we often say 'the tide is in'. As the water advances to submerge the intertidal zone, this can be termed **lood tide**.
- **Low tide:** the lowest coastal water level of the day, we often say 'the tide is out'. **Ebb tide** is the period when the tide 'goes out' to reveal the intertidal zone again. At the point between high and low tide, we may say 'the tide is **turning**', the water becomes quite motionless at this time and this phenomenon can be termed **slack tide**.
- **Tidal range:** this is the difference between high and low tide levels. It differs throughout the lunar cycle with spring tides giving the largest tidal ranges and neap tides the smallest. Tidal ranges can be classified as *macrotidal* (>4m between high and low tide), *mesotidal* (4-2m), and *microtidal* (<2m).
- **Spring tide:** this occurs when the Sun and Moon exert pull in the same direction during full and new moon phases, resulting in the highest high tides and the lowest low tides of the cycle.
- **Neap tide:** this shows the lowest high tides and highest low tides of the cycle during half-moon phases, as the influence of the gravitational pull is lessened as the sun and moon pull in different directions.

The coastline of the Gower is **macrotidal**, as is most of the rest of the British Isles.

Beaches

Beaches are depositional landforms created by the accumulation of both unconsolidated inorganic and organic material – that is, the products of broken down rocks and biological material (most commonly fragments of shells). Beaches form in the intertidal zone between the lowest spring tide level and the highest level reached by the waves, usually a storm beach (see below). The factors that influence beach **profiles**, which consist of a series of undulating troughs and ridges, can be summarised as follows:

1. **Waves** - wave **energy**, which becomes greater as wind strength, duration and fetch increase, and whether the waves are **constructive** or **destructive**.
2. **Tidal range** – this influences where waves will break on the shore and the expanse of beach over which the waves may break.
3. The type of **beach material** – its size, shape and composition, which affects the beach gradient and extent to which the dissipation of wave energy takes place. This is largely linked to percolation, which is greater on coarser shingle beaches compared to sand.

Material size is significant as it influences the steepness and width of a beach. If a beach is made of shingle, the larger material piles up creating steep, narrow beaches; the smaller particle sizes on sand beaches result in them being wide and flat. Cobbles and pebbles (the large calibre beach material), therefore, form the steepest beaches, and very fine sand the most gently sloping (almost entirely horizontal) beaches. **Rhossili Bay** in the western part of the Gower is a wide embayment formed by the differential erosion of less resistant Old Red Sandstone and boulder clay flanked by the more resistant limestone forming Worm's Head to the south and Burry Holms to the north. The bay has a 3-mile long sandy beach made up of small-sized sand particles which help to give rise to its wide expanse and low-gradient (**Figure 2**).

Figure 2. Rhossili Bay at low tide

Figure 2 Shows Rhossili Bay at low tide and also shows evidence of the influence of tides on beaches:

- **Strand line:** a non-permanent marker which shows the position of the last high tide for a current portion of the lunar cycle. It is usually comprised of material such as driftwood, seaweed and non-natural materials washed onshore and deposited by the waves. **Figure 3a** below clearly shows the strandline on **Whiteford Sands** and **3b** the waves meeting the strandline at high tide under non-stormy conditions on Rhossili Bay.
- **Storm beach:** This is a distinctive raised mound of large calibre beach material which has been deposited by high energy storm waves during the highest spring tides. A storm beach can remain in situ until altered by the next point in time at which the waves reach a similar magnitude.

Another common beach feature whose positioning is determined by tide is a berm.

- **Berms** are seaward-sloping ridges of sand, shingle or pebbles, which lie parallel to the storm beach, formed by deposition of coarse material at the furthest limit reached by the swash during previous high tides.

Figure 3a. The strandline at Whiteford Sands
Figure 3b. High tide at Rhossili Bay

Sorting of sediment on beaches

If beach material has been **sorted** this means that it has been organised and graded, largely according to its size. This happens as particles of different sizes have different velocities at which they will 'settle' and be deposited by the waves. As well as storm beaches being evident on beaches in storm-wave environments such as the Gower, particles may be sorted so that the coarser material tends to be found at the furthest limit reached by the waves and the finest sediments are found on the seaward portion of the beach. This is because if the material is carried up the beach by the strong swash of a constructive wave, its strength enables it to transport the larger, heavier sediments to its furthest limit. The water will then percolate down through the deposited coarser material, which will have large spaces between the particles, and will provide a rough surface which will dissipate the wave's energy. The strength of the backwash is therefore reduced, only enabling it to return the smaller particles seawards. The upper parts of beaches therefore are covered by larger calibre material and the smaller material will be situated further seawards. This sorting can be seen in the photograph of **Whiteford Sands** below (**Figure 4**). Particles may also be sorted by the process of **longshore drift** (see later), with material becoming progressively smaller, smoother, and more rounded along the length of a beach, or spit as the waves carry it further downdrift.

Figure 4. Sorting of coarser and finer grained sediments on Whiteford Sands

Note that the more seaward sandy portion of the beach to the left of the photograph has a gentle gradient compared to the more landward pebble-covered portion of the beach.

Spits

Spits are long, narrow accumulations of sand and/or shingle which are attached to the mainland at one end and extend seawards, usually into an estuary or bay. **Longshore drift** (also called *littoral drift*) is the key process involved in the formation of spits and it occurs when the prevailing wind approaches the shore at an oblique angle and material is moved along the coastline. Driven in the direction of the prevailing wind, swash carries sediment such as sand, shingle, and pebbles, up the beach at an angle, and then backwash moves sediment back down the beach at right angles to the shoreline along the steepest path, under the influence of gravity. Repetition of this process means that material will gradually be transported along the coast in a zig-zag fashion, leading to a net movement of material downdrift. Spits are created when the coastline changes direction relatively abruptly, for example at a river estuary or when differential erosion of the coastline has created an indentation or bay, but the longshore drift continues in the same direction as it did before. The material carried by the longshore drift will be presented with more tranquil waters in the lee of the point at which the coastline has changed direction and deposition by constructive waves is encouraged, creating the spit as material continues to be moved along the coast and eventually builds up above sea level in the relatively shallow waters close to the shoreline. Spits may have a recurved end, owing to changes in the dominant wind direction to the second-most-dominant, forcing the waves to move and deposit the material in a slightly different direction. They are unlikely to extend fully across estuaries as the current will carry the material out to sea, meaning that it will not deposit and also, as the water deepens, the material is less likely to be able to build up to the point where it is raised above sea level.

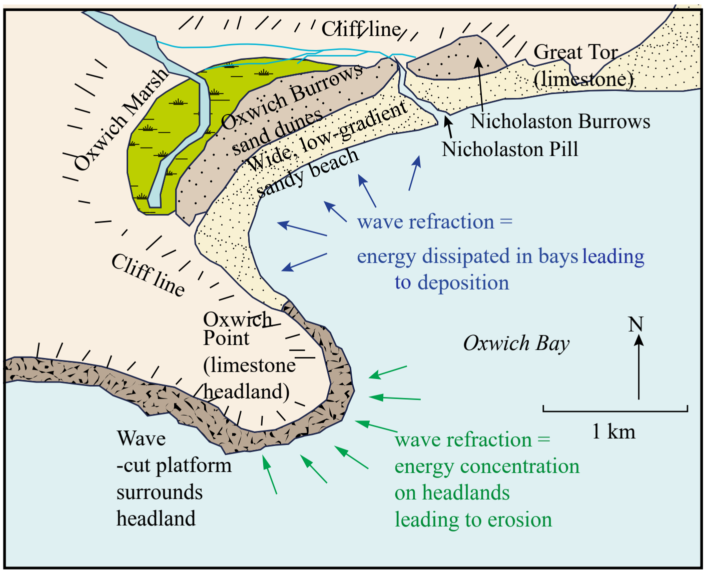
Coastal sand dunes may form to the rear of sand spits, especially in macro-tidal environments, as onshore winds blow dry sands, revealed at low tide, to the back of the sand spit. Mudflats and saltmarshes can develop behind spits as mud and fine silt are deposited in the low-energy, sheltered environment, protected from the full force of the sea. See **Figure 6** below for an example of a spit, **Whiteford Point**, and its associated sand dunes and salt marsh.

Sand dunes and salt marshes

Sand dunes

Dune formation requires relatively persistent and strong onshore winds and a plentiful sediment supply. Sand deposited by longshore drift is moved up the beach by wind via the processes of saltation, creep, or sometimes suspension, to create coastal sand dunes. Sand is trapped by an obstacle of some sort – perhaps a berm or driftwood - and is then colonised by vegetation. Vegetation stabilises the sand and encourages more sand to build up. This initial build-up of sand creates **embryo dunes**. Dunes migrate inland over time as newer embryo dunes are formed at the shore. The **mature dunes** further inland can reach heights of 10 metres or more, interspersed by **dune slacks** which dip down towards the water table. **Oxwich Bay,** in south Gower, is an extensive sandy beach backed by sand dunes (see **Figure 5**).

Figure 5. Oxwich Bay (see Figure 1b. for location)



Deposits forming Oxwich Bay were carried shoreward by the rising sea level of the Flandrian Transgression. They were trapped by the enclosure created by a synclinal dip flanked by the limestone outcrops at Great Tor promontory to the east and Oxwich Point to the west. Oxwich Bay beach, like Rhossili beach, is comprised largely of small-grained, sandy material which helps to create the wide, low-gradient profile. Combined with the large tidal range influencing the Gower, this means that there is potential for a very large expanse of sand to be revealed at low tide, especially low spring tide and this provides a sustained sediment source for the Oxwich and Nicholaston dunes that have developed to the rear of the bay.

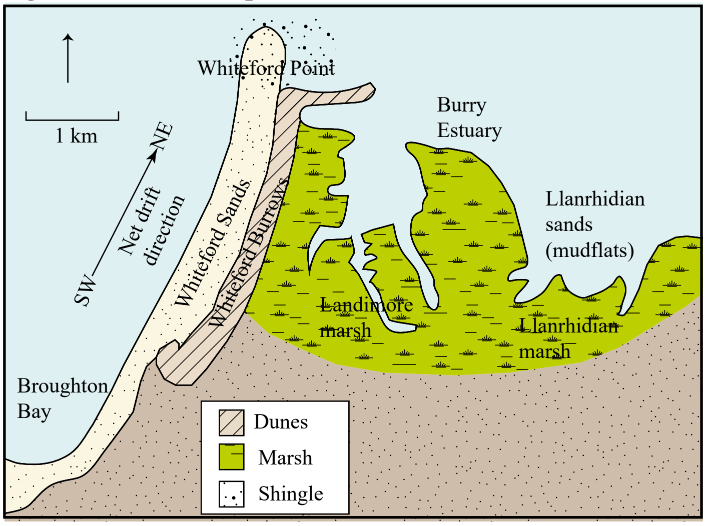
Oxwich Bay – a wide, flat beach backed with sand dunes

The Oxwich dune complex to the rear of Oxwich Bay

Salt marshes

Salt marshes are commonly found in river estuaries or behind spits, in sheltered water (a low energy environment). Mudflats develop in the sheltered zone as fine particles of silt and mud are deposited. These mudflats can be colonised by salt-tolerant (*halophytic*) vegetation, including species such as Salicornia and spartina, which are able to cope with regular submergence by the fluctuating tidal levels. The plants trap more mud and silt over time and eventually create an area that will remain exposed for increasingly longer periods between tides. Established saltmarshes can be split into two zones: **mudflats**, covered at ordinary high tides, are found on the seaward side of the marsh, and the **sward zone**, which is only covered periodically during high **spring** tide. When the sward zone is flooded by the tide, the salty seawater collects in hollows, which may enlarge and become increasingly saline, forming **saltpans**. A network of creeks which allow the seawater to drain away cut across the zone.

Figure 6. Whiteford point



Whiteford Point, located in north-west Gower, exhibits the typical properties of a spit. Whiteford Sands beach, attached to Broughton Sands to the south, extends northwards for over three kilometres, eventually extending into the mouth of the River Loughor (the Burry Estuary), thus creating the spit. The spit is oriented from southwest to northeast, showing that the dominant wind is coming from the south-west and thus driving the net littoral drift in a north-easterly direction. The spit has a recurved shingle and sand bank at its distal end and its furthest extent is marked by Whiteford Lighthouse, which is surrounded by a mussel bed and quicksand. The spit was able to build up above sea level using its foundation of glacial till deposits left by ice that extended through the Loughor Valley during the last Ice Age. The beach and dunes are composed of material driven landwards by the rising seas of the Flandrian Transgression. The beach is backed by Whiteford Burrows sand dunes; around 3 km long and between 400m and 600m wide, reaching heights of up to 24m.

The spit provides shelter in its lee for the extensive Landimore Marsh, Llanrhidian Salt Marsh and the Llanrhidian Sands mudflats. The fine sands and silty clays of the mudflats are made up of glacial outwash material and glacial drift which has been broken down by fluvial and marine processes.

Whiteford Point – this image shows the distal end of the spit, largely covered in dunes

Note the low-gradient wide beach to the left of the photograph, which would provide, at low spring tide especially, a plentiful source of sediment for the Whiteford Burrows dunes.

Llanrhidian Salt Marsh with salt pans and a network of creeks

Summary

The Gower peninsula provides examples of depositional landforms and ecosystems including Rhossili Bay, Oxwich Bay and its dunes, and Whiteford Point and its associated dunes and saltmarsh. These examples illustrate how waves and tides are important influences on coastlines regarding the creation and modification of depositional landforms and ecosystems.

Bibliography and further reading

- Bird, E. (2008) Coastal Geomorphology: An Introduction Wiley
- Bridges, E. M. (1997) Classic Landforms of the Gower Coast The Geographical Association
- Davies, A. (2012) Walking on Gower Cicerone
- Hill, M. (2004) Coasts and Coastal Management Hodder and Stoughton
- Masselink, G. Hughes, M. G. & Knight, J. (2011) Introduction to Coastal Processes and Geomorphology (2nd Edition) Routledge
- Motyka, J.M. & Brampton, A.H. (1993) Coastal Management: mapping of littoral cells H.R. Wallingford (A report for MAFF) *http://eprints.hrwallingford.co.uk/748/1/SR328.pdf*

Acknowledgements: *This* ***Geo Factsheet*** *was researched and written by* ***Kate Cowan,*** *a teacher of Geography at King Edward VI High School for Girls, Birmingham, and published in* ***September 2016*** *by* ***Curriculum Press****. All photographs by K. Cowan.* ***ISSN 1351-5136***