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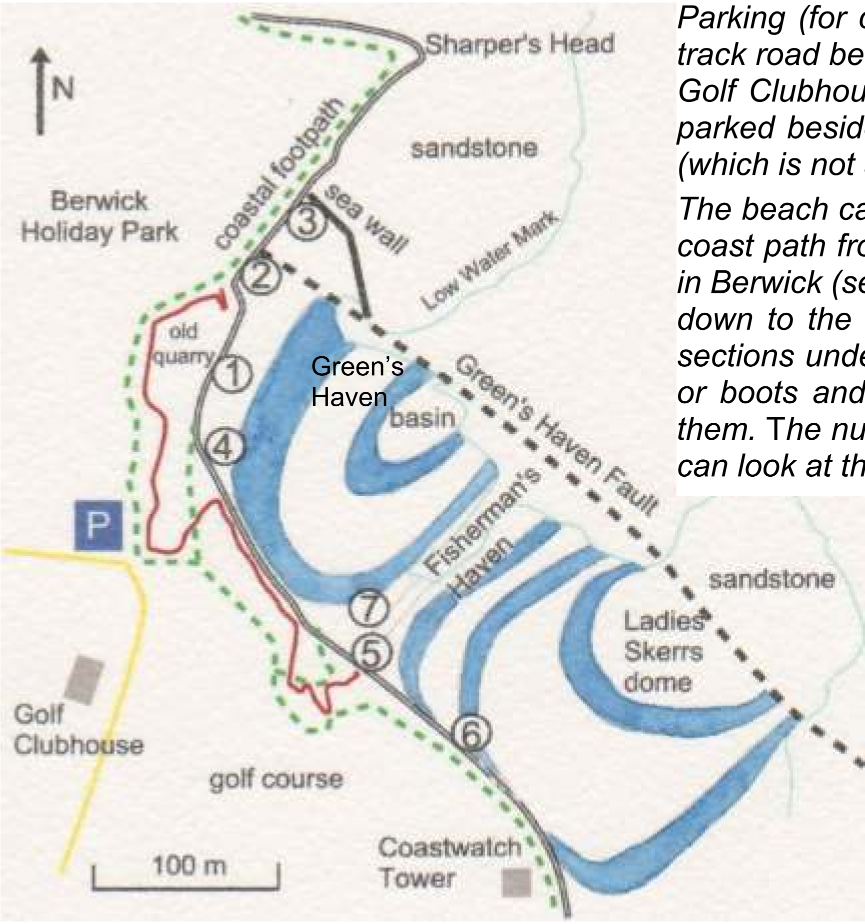
BERWICK BEACH

Berwick Beach would have been an industrial scene 150 years ago, busy with fishing, limestone quarrying and lime kilns. Now you can see rocks folded gently into domes and basins, rarely seen around the coast of Britain, as well as a variety of fossils in the limestone beds.

Berwick beach is also known as Green's Haven, perhaps a derivation of Greenses Haven named after the nearby part of Berwick. Old maps show an inlet for small fishing boats between the rocky skerrs at Fisherman's Haven on the south side of the bay. Green's Haven on the north side of the bay was used by boats after the sea wall was built in the early 20th century. The limestones and siltstones exposed on the beach contain good examples of fossils, although they are rarely found in pebbles or loose rock .



Parking (for cars only) is available at the end of a single-track road between Berwick Holiday Park entrance and the Golf Clubhouse (NU 003 536). An ice-cream van is often parked beside the parking area and there is a toilet block (which is not always open during the week and in winter).

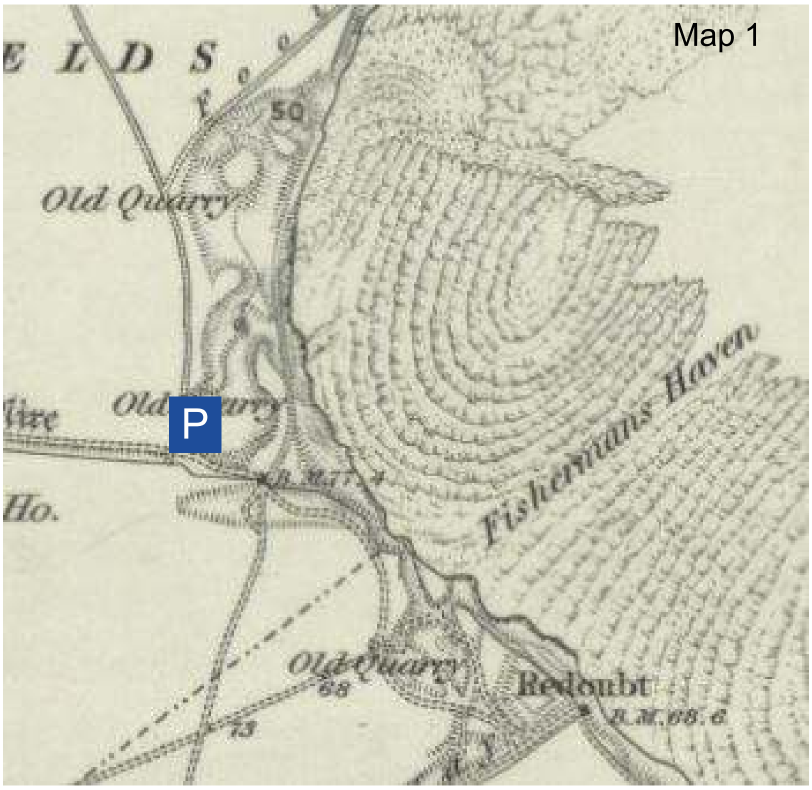
The beach can also be reached by walking north along the coast path from the large car park at the end of Pier Road in Berwick (see Berwick Monocline leaflet). There are steps down to the beach at locations 4 and 5 and some rocky sections under cliffs to reach location 6. Wear good shoes or boots and take walking poles for balance if you need them. The numbers on the map are at locations where you can look at the rocks and features of geological interest.

Photo A shows the well known view from the coastal footpath. The best time to see the features is just before or after low tide.

From the top of the cliff the view to the beach shows that the bay has a variety of different rock features. The noticeable **basin** formed by the **siltstones** and the Eelwell and the Thin Limestones (Photo A) is a continuation of the **dome** and **basin** pattern between the Meadow Haven Fault and the Green's Haven Fault (see Berwick Monocline leaflet).

The Green's Haven Fault cuts across the basin from the cliff under the holiday park and is marked by a **landslip** on the beach. The far side of the fault has **sandstone** cliffs which form Sharper's Point and the rocky foreshore. *Walk down the steps past the old quarry onto the beach to see more.*

As you walk down the steps from the parking area (Photo B), try to imagine how the **limestone** quarry might have looked when it was actively working. There would have been steep quarry faces, piles of stone, sheds for the stone masons, horses and carts waiting at loading ramps to take the stone away, as well as noise and white limestone dust everywhere.



Ordnance Survey Six-inch map Berwickshire Sheet XVIII 1862
Reproduced with the permission of the National Library of Scotland

Map 1 is taken from the Ordnance Survey six-inch map of Berwick-upon-Tweed published in 1862. The main quarry is due north of the present car parking area (symbol added). The quarries were disused by 1862, but their size shows that they had been extensively worked, probably for centuries.

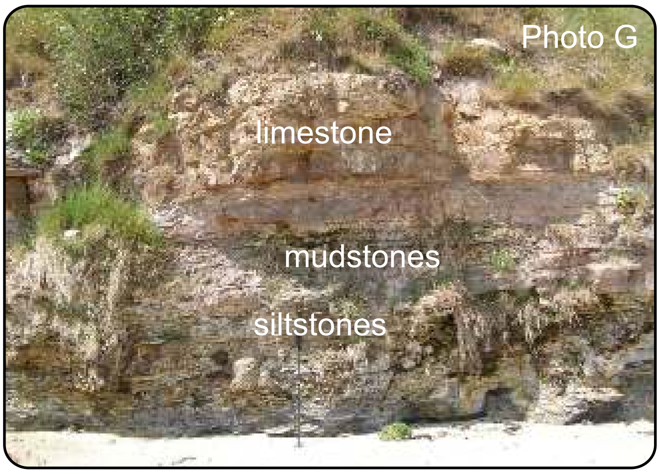
The rubble fillings of Berwick Castle, built in 1297 by Edward I, are made of random sandstone and limestone blocks, held together by **lime mortar.** The nearest source of limestone was the cliffs at Green's Haven, so perhaps lime was carried to the castle site by horse and cart. Map 2 shows that there were limekilns in the area in 1832, probably used and rebuilt over many centuries.

John Thomson's Atlas of Scotland 1832 Reproduced with the permission of the National Library of Scotland

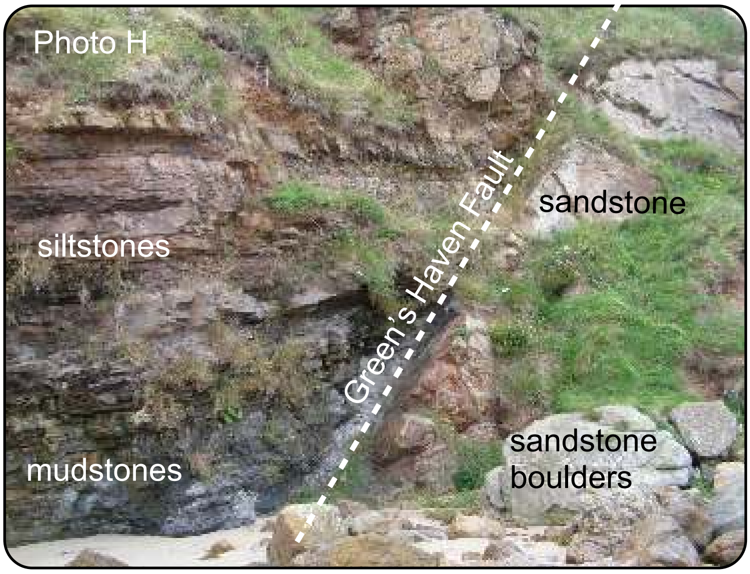
The Elizabethan fortifications of Berwick were built between 1558 and 1570 (Photo D) using some stone from the medieval walls and castle. Good quality facing stone was used to cover the rubble filling and limestone was used for most of the length of the ramparts, although the upper courses are built from **sandstone** blocks. The limestone for the ramparts was obtained locally, due to the inconvenience and cost of transporting stone. We can be sure that the limestone came from the quarries at Green's Haven by looking at the **fossils** in the limestone blocks.

The rampart walls contain typical fossils found in limestones, such as shells at Brass Bastion (Photo E) and **crinoid** stems near Flagstaff Park (Photo F). The large shells are called ***Gigantoproductus*** and are characteristic of the Eelwell Limestone, the rock exploited in the old quarries at Green's Haven.

Turn left when you reach the beach and walk along top of the beach towards the landslip of large blocks which have fallen off the cliff above to look at the cliff faces.



① The rock at the top of Photo G is a bed of limestone, with less resistant **siltstones** and **mudstones** beneath it. The mudstones formed from the muddy sediment at the bottom of a lake or marsh during **Carboniferous** times about 330 million years ago. Siltstones are formed from silt particles which are fine grains of **quartz**, probably carried into the wetlands by rivers. Limestone formed from the **calcite** shells of animals that lived in clear seas, so it is known that sea level rose and covered the wetlands.



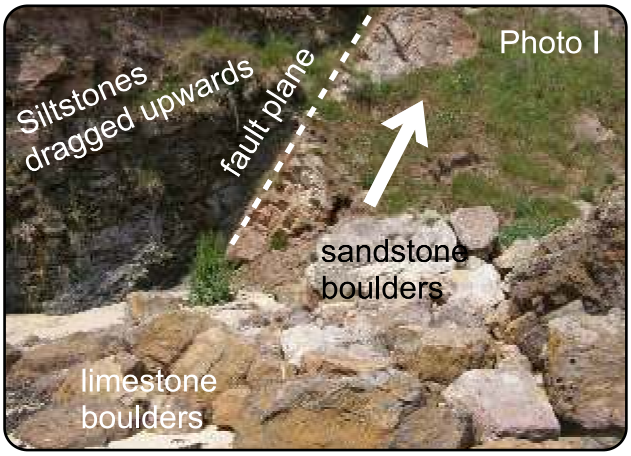
② When you reach the sandstone boulders of the **landslip** it is clear that there are changes in the rocks of the cliff face. The mudstones and siltstones can be seen at the base of the cliff (Photo H) but they change abruptly to sandstones along a **fault plane** which runs diagonally up the cliff from the beach. This is the Green's Haven Fault, part of the system of **tectonic** features formed under stress during the **Variscan mountain building** at the end of the Carboniferous period, 30 million years after these rocks were formed. As the **Berwick Monocline** developed due to pressure from the east, the stress in the earth's crust caused the rocks to break. The Green's Haven Fault and the Meadow Haven Fault are related and both have had movements on the fault planes of more than 100 m (see Berwick Monocline leaflet).

FAULTS AND EARTHQUAKES

Faults are breaks in the brittle part of the **earth's crust** due to local stress and occur no more than about 20 km below the earth's surface, except in areas under major **mountain chains**. When the stress exceeds the breaking point of the rocks, they crack and energy is given off as **earthquake waves** which could be felt by people living in the area and are recorded by **seismometers**. The rocks can break many times if the tectonic stress continues, giving a **fault zone** which is hundreds of metres wide in major faults, such as the Great Glen Fault in Scotland.

Geologists recognise faults by their characteristic features. Rocks on either side of the fault are often different, showing that there may have been movement vertically, as well as sideways. The rocks along the fault zone are sometimes shattered by pressure and **recrystallised** by frictional heat, so that new **minerals** can form and cement broken pieces of rock together to produce a new rock - a **fault breccia**. Sometimes rocks crack under pressure and in areas of limestone, **calcite veins** form, while in sandstone areas, **quartz** is the major mineral in veins. The **fault plane** is the surface along which the rocks slide and sometimes elongated scratches called **slickensides,** which show the direction of movement of the rocks on either side of the fault, are seen on the fault plane. Slickensides occur when hard rocks such as limestones or sandstones scrape past each other.

The Green's Haven Fault (Photo I) has some of the typical features of faults. The rocks on the right side of the fault have moved upwards, shown by the arrow, and have dragged the siltstones on the left side upwards. The fault plane is reddened by iron-rich water which has seeped along the fault planes. The fault plane has no slickensides, perhaps because the siltstones on one side are not resistant so there has been no scratching of the sandstones. There is no sign of fault breccia, although the siltstones close to the fault plane are broken up in places. The boulders of the more recent landslip are both limestones (the brown blocks) and sandstones (the paler blocks).



Continue walking towards the sea wall past sandstone cliffs. The sandstones were deposited during the Carboniferous period in the channels of large rivers which carried sand grains **eroded** from a range of high mountains to the north and east of this area. Photo J shows that some of the rock faces have flat surfaces, which suggests that the sandstone was worked by hand with chisels and crow-bars to extract stone to build dwellings and walls in Berwick, possibly many hundred years ago. Photo K shows deep chisel marks on the sandstones next to the steps.

Photo J

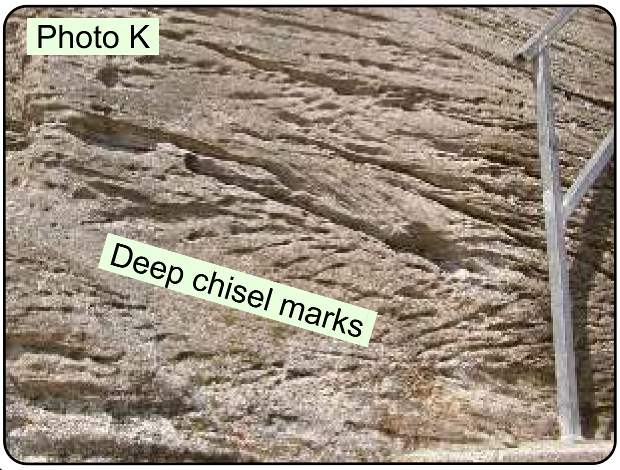


Photo K

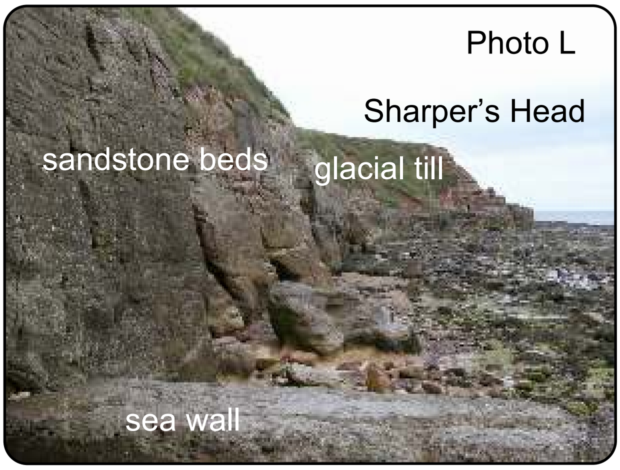


Photo L

③ *Look over the sea wall at the sandstone cliffs towards Sharper's Head (Photo L).* Some of these cliffs have been quarried for sandstone. The top of the cliff is made of a softer material called **glacial till**, which was deposited by an ice sheet which melted about 12,000 years ago. It is difficult to walk beyond the sea wall over the rocks to Sharper's Head, but the horizontal sandstones continue into Murphy's Beach, the next bay to the north.

As you turn to walk back along the beach you will be able to see many beds of the Eelwell Limestone (Photo M) which is about 8 m thick in total. However, the rocks are covered with sea weed and barnacles so it is easier to find fossils higher up the beach where the rock is cleaner.

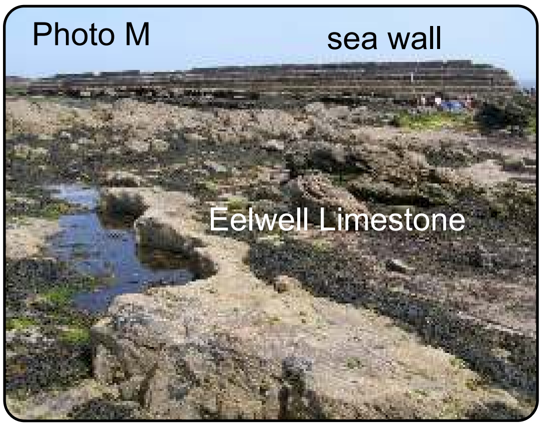


Photo M

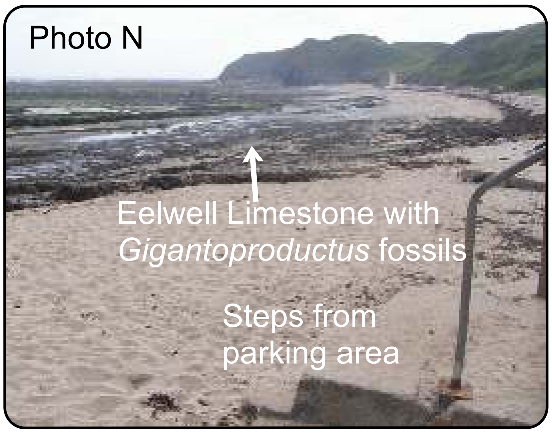


Photo N

④ *The rocks of the Eelwell Limestone at the foot of the steps may be covered by sand (Photo N). However, there are fossils on the rock surfaces if they are exposed. Take care if it is wet as limestone can be slippery.*

Photo O

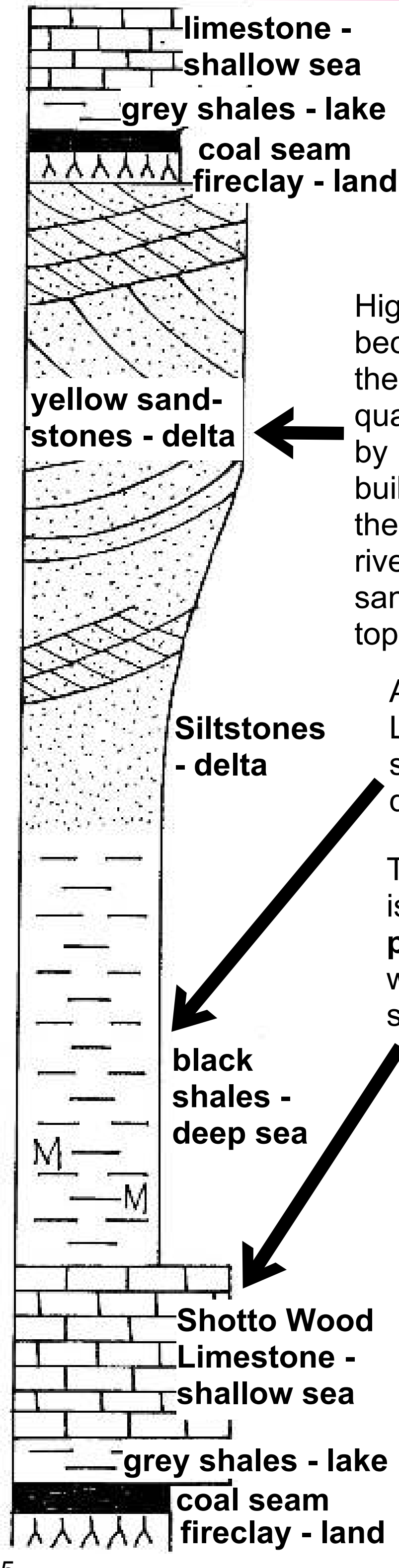
Photo P

The limestone beds are reddened in places because iron-rich water soaked through them after their formation. *Gigantoproductus* (Photos O and P) was an invertebrate with two shells, a smaller, thinner shell nesting inside the larger shell. Photo O shows the two shells. The thicker shell of the animal would have been buried in the limey sea bed and the upper shell could open to allow the animal to extract food from sea water.

Continue to walk across the beach towards the concrete wall of the old swimming pool to look for other fossils in the limestone beds at the top of the beach. These have been smoothed by the sea but the fossils often disappear under the sand (Photos Q and R).

⑤ *Walk along the beach until you reach the second set of steps. Just beyond is a cliff which may be unstable after rainfall or very high tides. Walk a few steps farther along the beach and look up at the cliff (Photo S).*

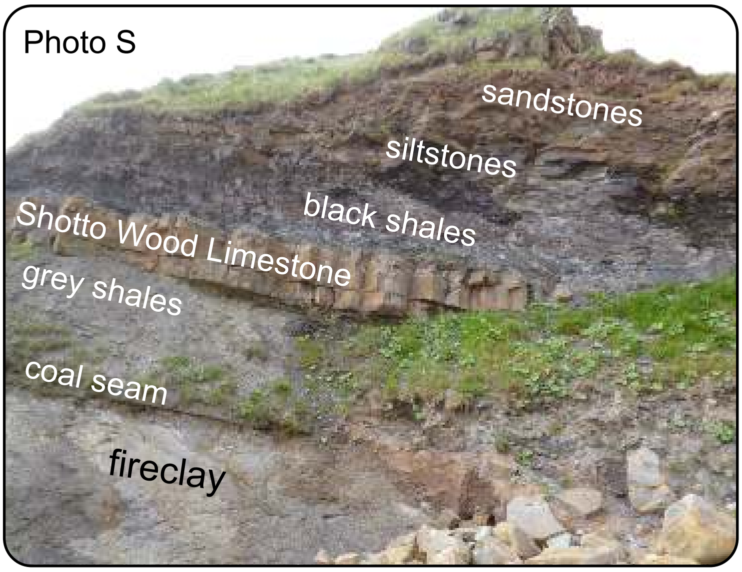
Diagram 1



THE CYCLOTHEM

This cliff illustrates the sequence of sedimentary rocks typical of the early Carboniferous rocks of north Northumberland. The rocks show a complete **cyclothem** (Diagram 1) and are described from the oldest rock at the base of the cliff (Photo T), to the youngest at the top (Photo S). Geologists prefer to work from oldest to youngest rock because that is the logical way to describe the changes in the environment over time. So you might like to start reading at the bottom of the page and work upwards!

Higher up the cliff the beds become gradually paler as the sea bed was covered by quartz sand grains carried by rivers forming deltas that built out into the sea, just like the Mississippi or the Nile rivers today. Siltstones and sandstones are found at the top of the cliff.



Above the Shotto Wood Limestone are black shales with marine fossils, deposited in deeper water.

The prominent brown rock (Photo S), which cuts across the middle of the cliff, is the Shotto Wood Limestone, which has two beds separated by a **bedding-plane**. The limestone breaks into many blocks along the near-vertical **joints,** which cut across the bedding-plane. Limestones are formed in shallow, warm seas, so we know that sea level rose and flooded the land surface.

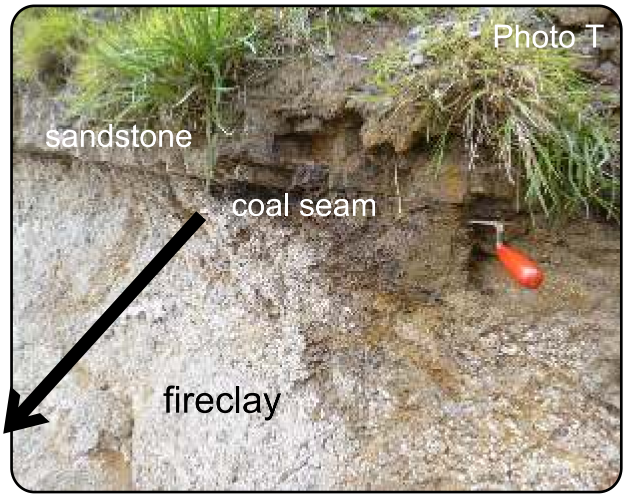
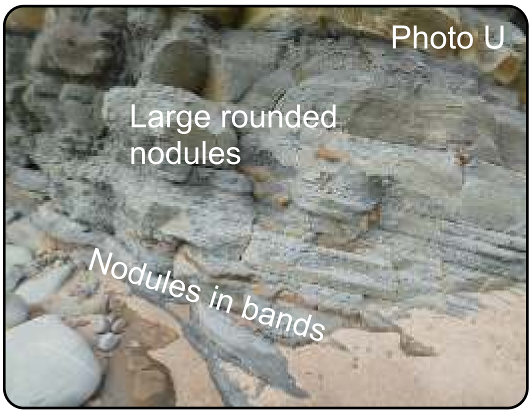


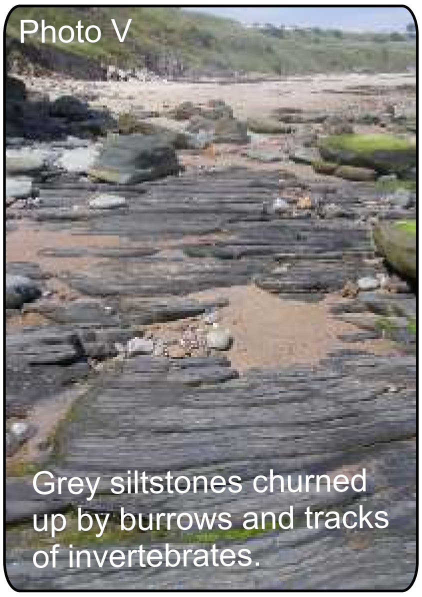
Photo T shows a pale rock called **fireclay** made of the deep soils found in warm, wet climates in conditions similar to present-day equatorial forests. At the point of the red-handled trowel is a very thin **coal seam** formed by plant material buried under layers of rock, although in this case the forest trees were quickly overwhelmed by the sand from a river channel. The grey shales above were probably formed in a lake.

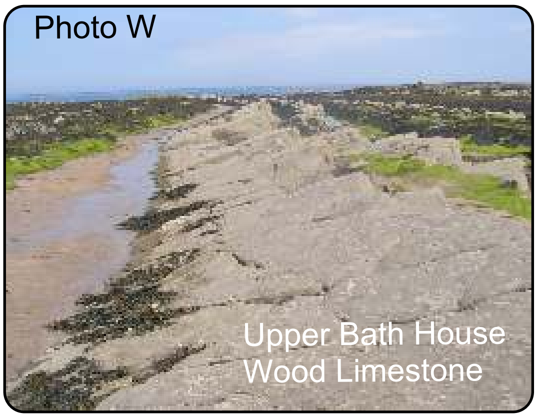
⑥ *If you want to continue to walk under the cliffs, there is an interesting fossil exposure in the Upper Bath House Wood Limestone (NU 005 534). The high cliff may be unstable so keep away if there has been recent rain. If you would prefer not to walk over the rocks, go straight to location 7 and enjoy the pebbles at Fisherman's Haven.*

At the base of the cliff is a greenish sandstone which contains large, rounded, brown **ironstone nodules** and smaller nodules in bands parallel to the bedding-planes (Photo U). Iron has accumulated and precipitated for reasons that are not thoroughly understood.



*Walk onwards over the bedded grey siltstones (Photo V) which are full of the tracks and burrows of invertebrates and were probably deposited in shallow water with rich organic life. You will reach the Upper Bath House Wood Limestone (UBHWL) (Photo W) and find that the top reddened surface (Photo X) is covered with **coral** fossils with occasional shells and single corals.*



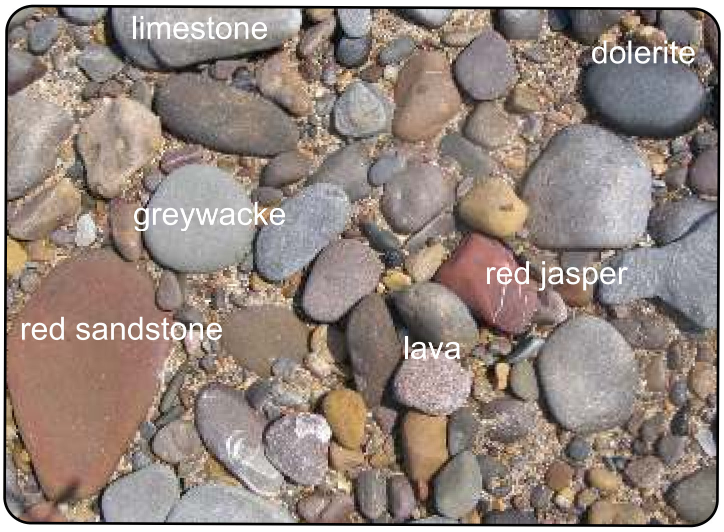


The photos will help you identify the fossils. Imagine corals covering the sea bed with many other creatures living in the clear, warm water.

At low tide you can walk around the headland and reach the relatively flat surface of the Lower Bath House Wood Limestone (LBHWL), which you can follow for several hundred metres to Meadow Haven. After crossing some boulders onto Meadow Haven beach you will be walking over the UBHWL which contains superb fossils, best seen in sunshine, on your knees with a hand-lens.

From the coastal footpath the UBHWL and the LBHWL can be seen clearly (Photo Y). Both have two 'leaves' with beds of shale between so we know that the shallow sea varied between clear water (limestones) and muddy water (shales).

7 *Fisherman's Haven is a good place to study pebbles. While it may not be illegal to take pebbles from this beach, it is best to leave them for others to study. Removal of pebbles from beaches along the Berwickshire coast is illegal, as the coastline is designated as a Site of Special Scientific Interest for its geological as well as its wildlife importance.*



HOW DO PEBBLES FORM?

Pebbles on beaches are eroded by the action of waves, so they are composed of the most resistant and toughest rocks, able to survive constant attrition at every tide. **Attrition** is the action whereby pebbles and sand grains roll over each other so that both are eroded. Angles are worn away so that the pebbles become smaller and more rounded.

Rocks are made of **minerals** of different hardness. **Quartz**, a mineral composed of **silica**, is the hardest of the common minerals, so sand grains on beaches are generally made of quartz, as other minerals are broken into their constituent molecules. Pebbles on beaches are often those which have the highest proportion of quartz, or are composed of **silicate** minerals. This includes many **igneous** rocks and sandstones. **Clay particles**, the end product of many minerals after breakdown, are washed out to sea and deposited on the sea bed.

The rocks which survive best because they are most resistant to **erosion** are those which are **crystalline**, which means that the minerals have been heated so that they weld together. This group includes the igneous rocks as well as some limestones.

WHERE DO PEBBLES COME FROM?

Most beach pebbles have not travelled far. The local rocks are limestones and sandstones. Limestones are crystalline rocks and survive wave action so are common on this beach. Sandstones are made of cemented sand grains and are easily broken down by waves into sand. On Berwick beach most sand has come from the sandstones of Sharper's Head and further north.

Glacial till, composed of clay and pebbles, was deposited by an ice sheet during the last ice event and can seen above the solid rock on the cliff tops. It contains fragments of rocks picked up by ice. As ice movement was from the west, the till contains red sandstones from Jedburgh, **greywackes** from the Lammermuirs as well as many local igneous rocks. They all form pebbles on local beaches.

USEFUL MAPS AND REFERENCES

OS 1:50,000 Landranger 75 Berwick-upon-Tweed

OS 1:25,000 Explorer 346 Berwick-upon-Tweed

British Geological Survey 1:50,000 (England) Sheets 1 & 2 Berwick-upon-Tweed and Norham (Solid)

Northumbrian Rocks and Landscapes - A Field Guide 1995 (ed. C. Scrutton) Yorkshire Geological Society