Rocks and landscapes on The Chevin

THE GEOLOGY TRAIL

Welcome to the Otley Chevin Geology Trail. The trail will take you about one and a half hours to complete, walking from East Chevin Quarry Car Park and back. Allow time for resting and enjoying the views across Wharfedale.

There is a free leaflet describing the geology trail which is available at the White House café which is accessed on foot only from Otley town or the car parks at Surprise View and East Chevin Quarry which involves a 20 minute walk, and at the Tourist Information Office in Otley library. It can be downloaded from the Friends of Chevin Forest website www.chevinforest.co.uk or the West Yorkshire Geology Trust website at www.wyorksgeologytrust.org.
There is also an audio trail which can be downloaded from the two websites.

MARKER STONES

There are 8 places on the trail where you should stop to see features of interest. They are marked by carved stones.

Marker stone 1 Here you can find out about tidal laminites. The carving on the marker stone shows waves with a moon above, to indicate that the laminates were deposited as a result of tidal activity.

Marker stone 2 shows a river delta. The rocks in the crags here are the result of mud and sand that was deposited in a tropical river delta when the Chevin was part of a land mass located near the equator.

Marker stone 3 is above Great Dib landslip. The marker stone carving shows a goniatite. These were animals that lived in the shallow seas in the Carboniferous period and their fossils are occasionally found in mudstones dating from this time, about 315 million years ago.

Marker stone 4 has an image of some tree branches. You can see short lengths of fossilised tree branches on a fallen block next to some crags.

Marker stone 5 has a carving which demonstrates the process of cross-bedding. The crags here have cross bedding in Doubler Stones Sandstone. This is highlighted by the moss.

Marker stone 6 shows the dimpling caused by fossilised tree roots.
There are some fossilised tree roots and a small coal seam at this place.

Marker stone 7 shows a stone mason's hammer and chisel. On the audio trail, Shane Green tells you about how he carved the marker stones for this geological trail.

Marker stone 8 is at Surprise View at the top of the Chevin. The carving on the marker stone shows the swirling currents that would have moved quartz pebbles along the bottom of a fast flowing river.

CARBONIFEROUS ROCKS

The rocks of the Otley Chevin area are **Upper Carboniferous** in age so they are about 315 million years old. These rocks were laid down in deltas on the edge of a large continent, with mountains to the north and south. Sands and muds were deposited in shallow water by rivers. After the sediments were formed close to sea-level, they were buried by hundreds of metres of sediment, and compressed so that the water was squeezed out. This water moving through the sediments carried minerals which cemented the sand and mud grains together to make **sandstones** and **mudstones**.

Cross-bedding is commonly formed in a river channel in which sand grains are being rolled along the bottom by fast flowing water. The grains avalanche down the front face of sand banks and settle at an angle of about $15^{o} – 20^{o}$. Each cross bedded set has been eroded by another flood of water, so the top of each sand bank has been washed away, truncating the cross-bedding. You can see cross-bedding in many of the crags on the Chevin.

Walking up the track from East Chevin Quarry car park you can see in the track that there are thin beds of sandstone called **laminites**. These thin beds were deposited in a coastal area of the Carboniferous delta. Tides were probably higher than they are today so the water would have come in fast over sand flats, as in present-day Morecambe Bay. Probably each fine lamination represents a single tide, so you can count how many days it took to deposit the layers. It is uncommon anywhere in the world, to see rocks that represent tidal sediments.

THE FOSSILS ON THE CHEVIN

There are several places on the Chevin where you can see **fossil plants**. At marker stone 4 you can see excellent branch fossils in the fallen blocks. The largest fallen block has tilted through 90^{o}. We can see this because the bedding planes seen on the side of the block are vertical. Walk behind the largest block to see the bottom surface, which is covered with fossils of tree branches. These would have been deposited on a sand bank in the river, when a flood washed tree trunks and branches downstream. The branches were then covered by another layer of sand which has preserved them as **impressions**.

At Marker Stone 6 there is a sloping sandstone bed which has very faint impressions of plant roots. The sandstone bed is overlain by a thin, black, crumbly **coal seam**, seen to the right in the low bank next to the path. This is the Morton Banks Coal. It is very thin here, but becomes thicker further south, where it has been mined.

Because this part of the Carboniferous continent was close to the equator, the climate was warm and wet, so tropical rain forest flourished. Dead plant material became trapped in stagnant swamps between river sands when the rivers in the delta changed position during floods. The water, oxygen and hydrogen were driven out of the plant remains, leaving only the carbon in coal seams.

There is grey clay above and below the coal. This is called **fireclay**, which is the remains of the soil layers in which grew the trees and ground vegetation that formed the coal.

EARTH MOVEMENTS AND WHY OTLEY CHEVIN IS A RIDGE

The rocks of northern England were tilted at the end of the Carboniferous period, when there was a major collision between two **tectonic plates**. This mountain-building period is called the **Variscan orogeny** and culminated in the uplift of a high mountain range across Europe. This affected south-west England more than the rest of Britain. However, northern England was uplifted into the Pennine **anticline**, which is an upfold. So the present Pennines were a range of hills trending north-south from the Midlands to southern Scotland after the end of the Carboniferous period.

At the same time, the brittle crust underneath northern England was under tension, so Variscan plate movements caused it to fault and fold. The Wharfedale area was affected by crustal pressure so the rocks were tilted southwards towards Airedale. The bedding planes of sandstone at Marker Stones 6 and 7 dip at 24^{o} to the south as a result of this tilting.

GLACIATION

During the last 30 million years global climate has been cooling down, culminating in the development of huge **ice-sheets** in the last 1.8 million years.

Global temperature has fluctuated since then, resulting in many advances and retreats of ice sheets over Northern Europe. Ice sheets grew in cold times in high mountain areas and advanced into the lowlands. However, most of the evidence of early ice advances has been obliterated by later events.

The last glacial stage, called the **Devensian**, was at a maximum about 17,000 years ago and ice covered the high ground in the Otley area. As temperatures rose, ice melted and ice sheets became thinner. In the final stages of the glacial period, the thickest ice was confined to the valleys. It would have been possible to stand on Otley Chevin and look over a valley, with glaciers moving down Wharfedale and Airedale and meltwater streams filling the valley floors with sands and gravels. The picture on the interpretation board at Surprise View at Marker Stone 8 shows how the landscape of Wharfedale would have looked then.

When the ice melted completely, it left behind extensive deposits of **glacial till**, also known as boulder clay, which was sometimes washed away or modified by melt water. Looking into Wharfedale from the top of the Chevin, you can see four large lakes, now used for recreation and wildlife. They give evidence for the last glaciation of Wharfedale, when the valley floor was filled with sands and gravels from glacial melt water. These have since have been extracted for building, leaving lakes.

The steep slope which drops down to Otley has been caused by **landslipping** at a time when the climate was still very cold but after the ice sheet had melted from the top of the Chevin about 14,000 to 12,000 years ago. There was probably still ice in Wharfedale, so there was very little vegetation to stabilise the slope. During the winters, water in the rocks and subsoil would have frozen, but in the summers it melted and the sandstones at the top of the slope would have been able to slide down a weakness in the lubricated mudstones below.

In places along the Chevin, large boulders have moved downslope and sometimes uneven ground is visible under the trees. The large blocks probably became detached when Otley Chevin lay under ice during the last glacial maximum about 17,000 years ago. Water beneath the ice sheet soaked the joints in the rock and widened them as it froze. Then, as the ice finally melted, about 12,000 years ago, the unsupported blocks were let down onto the slope.

Trees reduce the likelihood of further landslipping, because they take water from the ground so reducing the lubrication in the soil. Their roots stabilise the subsoil and find their way into joints in the solid rock.

STONE QUARRYING ON THE CHEVIN

East Chevin Quarry is found at on East Chevin Road and is the start of the Geology Trail. The rock was quarried for crushed grit for use as sand and gravel, although it is also suitable for building stone and setts. Imagine the quarry as a noisy, bustling place with large blocks of rock being taken off the quarry faces with cranes and crowbars. The stone would have been split into manageable sizes using mallets and wedges and then shaped into building stones by stone masons with hammers and chisels. Any irregular stones would have been used for building field walls and any waste left over was probably used for making tracks and roads. It was last quarried by local people in 1920.

Maps from 1800 show many small scale quarries across much of the scarp slope of The Chevin. Most of the stone from the Chevin was described by stone-masons as Bramley Fall Stone, although it is not as good as the gritstones that came from Bramley, Horsforth or Guiseley, which were favoured for finer-quality masonry work. The main use of Chevin stone was railway embankments, bridge footings, defensive sea walls, local houses and civic buildings, roofing slates and millstones.

Yorkgate Quarry is the large quarry to the west of Surprise View. It ceased to be used in 1969 after a public campaign against further extraction. The quarry company hoped to excavate further north beyond the ridge, which would have meant the quarry cutting into the scarp slope. The quarry would then have been visible from Otley and would have spoiled the skyline view from the town. It has been restored since then and has a pond and some mature trees. It is hard to see the original quarry faces, but the cliff at Marker Stone 7 shows you what the rock was like and why it was so excellent for building purposes.

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