Welcome to **The Chevin Forest Park Geology Trail**. With its distinctive topography and geology, The Chevin is a wonderful and safe place from which to explore and understand the underlying geology and subsequent erosion (by ice and water) of what is today known as **Lower Wharfedale**.

In the centre of this leaflet is a geology trail which includes a number of **marker stones** at which you can stop and read the relevant information about the geological features. The trail is designed to explain how the rocks and fossils of The Chevin were formed and to show how the landscape of the area is related to the rock types and geological processes that have taken place in the last 300 million years. There is more geological information to be found on the **interpretation board** at **Surprise View**.

There is also an **audio trail** available on the **Friends of Chevin Forest** website **www.chevinforest.co.uk**. This will take you around the trail and give you additional information on the rocks and the landscapes, with a fuller description of the views you can see on the trail.

Marker stones for each location were provided by **Blackhill Quarry** in Bramhope and carved by the local artist **Shane Green**. Each carving is related to the geological feature found at that location.

This Geology Trail has been set up by a partnership between **Leeds City Council**, **The Friends of Chevin Forest**, the **West Yorkshire Geology Trust** and the **Leeds Geological Association**. It has been funded by the **National Lottery** through the **Heritage Lottery Fund** as part of a larger history project called **"Chevin Through Time"**. There is also a **Heritage Time Trail** with leaflet and audio trail on another part of The Chevin. To find out more about **"Chevin Through Time"** go to **www.chevinforest.co.uk**

Toilets, **light refreshments**, leaflets and other information is available from the **White House Café** which is open most **weekdays 10am to 2pm** *(check the noticeboards for seasonal changes in opening)*. For information about access for less mobile people and the use of **mobility scooters**, please contact the **Chevin Estate Officer** on 0113 395 7400.

West Yorkshire Geology Trust is part of a national network of groups which are actively conserving important geological features. These sites include rocky crags, active or disused quarries, railway cuttings and stream beds. Important sites are called Local Geological Sites (LGS), of which The Chevin is one of about 70 in the county.

West Yorkshire Geology Trust aims to encourage public enjoyment of rocks, fossils and landscapes and link geological features with the local industrial heritage. We also maintain a database of Local Geological Sites and encourage land-owners and managers to participate in good site practice and management, as well as make information on Local Geological Sites available to local authorities.

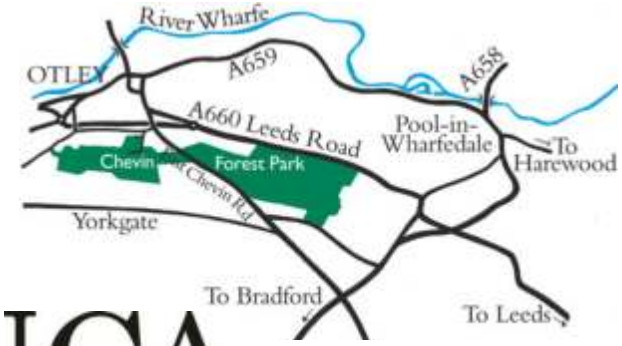
Carboniferous goniatite *Reticuloceras bilingue*. Illustration, trail map and leaflet design by **Richard Bell**

www.wyorksgeologytrust.org

HOW TO FIND CHEVIN FOREST PARK

BY CAR: Follow the signs from Otley town to car parks on East Chevin Road

BY BUS: Travelling from Leeds City bus station, Ilkley, Skipton, Chevin Forest Park can be reached by the X84 service. Telephone 0113 245 7676 for details or go to www.wymetro.com



This leaflet is available in braille and large print, telephone 0113 395 7400.

Supported by The National Lottery® through the Heritage Lottery Fund

heritage lottery fund

Chevin Forest Park Otley

Geology Trail

CARBONIFEROUS TIMES

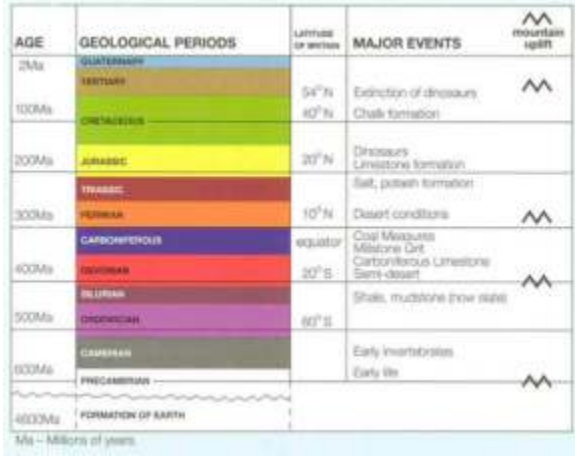
The rocks of The Chevin area are **Upper Carboniferous** (about 315 million years old). The sands and muds that now form the rocks were deposited by rivers on the edge of a large continent, with mountains to north and south.

Because the area 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 water channels. Rivers changed position during floods and built up more sand and mud on top. Water, oxygen and hydrogen were driven out of the plant remains, leaving only the carbon which was eventually compressed into **coal**. At least a kilometre of sand and mud was deposited above the sediments, slowly **cementing** and **compressing** them into solid rock. Water was squeezed out and minerals cemented the sand and mud grains together to make **sandstones** and **mudstones**.

The mudstone beds include **fossils** of marine creatures, such as **brachiopods, bivalves** and **trilobites.** This shows that sea-level must have risen from time to time about 315 million years ago and flooded the low lying land.

Sea-level changes occurred because the land at the South Pole at that time had a large ice-cap which fluctuated in size. When there was a cold period, snow remained on the ice-cap and was compacted into ice, making the ice-cap thicker. Because there was less melting, water did not return to the oceans so sea levels fell. In warmer times, the ice-cap melted so sea levels rose again.

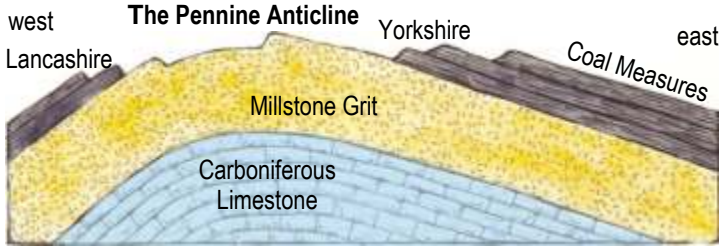
When sea-levels rose, water flooded back between the Carboniferous mountains and covered the delta, bringing marine creatures with it. When they died they were buried in muds on the sea-bed, where some of them have been preserved as fossils.



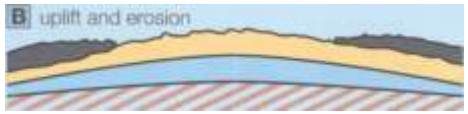
FOLDING AT THE END OF CARBONIFEROUS TIMES

At the end of the Carboniferous period, a major collision between two tectonic plates culminated in the uplift of a high mountain range across southern Europe in a series of events called the **Variscan orogeny**. This affected south-west England more than the rest of Britain. However, northern England was uplifted into the **Pennine anticline** (an upfold), which trended north-south from the Midlands to southern Scotland.

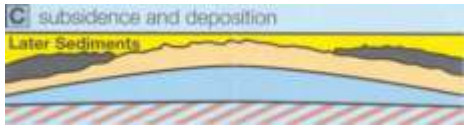
In addition, the Lower Wharfedale area was folded into an anticline which runs east-west along the Wharfe valley. Otley Chevin lies on the south side of the fold so the rocks slope southwards towards Airedale, as shown in the cross-section on the other side of the leaflet. You will see the angle of slope of the rocks in Yorkgate Quarry.



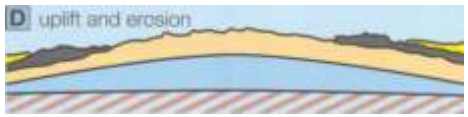
A. At the end of the Carboniferous period, sediments were being compressed into solid rock by the weight of deposits above them.



B. During the late Carboniferous and early Permian periods, a plate collision further south led to the uplift of the area and the subsequent weathering and erosion.



C. In the Triassic to Cretaceous periods vast quantities of river and airborne sediments were deposited, but only those from the Triassic period have been found here.



D. Further uplift in early Tertiary times led to renewed erosion. During the last 20 million years erosion has removed at least 1 km of overlying sediment and dug deep into the Carboniferous rocks below, to produce the present Pennine landscape.

THE MISSING 280 MILLION YEARS

For the last 280 million years northern England has been an upland area on a continent which has drifted very slowly northwards. Vegetation flourished in warm times and animal life developed, as reptiles, birds and mammals evolved. However, because any sediments and rocks have been eroded away, there is very little evidence in this area to show what happened since the late Carboniferous period until the onset of the ice ages 1.8 million years ago.

GLACIAL TIMES

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. The thickest ice was confined to valleys in the final stages of the glacial period. It would have been possible to stand on The Chevin and look over glacial valleys, with ice moving down Wharfedale and Airedale and meltwater streams filling the valley floors with glacial sands and gravels. The picture on the interpretation board at Surprise View shows how the landscape of Wharfedale would have looked then.

By about 12,000 years ago, when the ice had melted completely, it left behind deposits of **glacial till** (boulder clay)**,** which was sometimes washed away or modified by meltwater.

Chevin Forest Park Geology Trail

PLEASE NOTE that the terrain of The Chevin is steeply sloping and paths are uneven in places. The route is about 3 km long and will take most people about 2 hours to complete.

Hand lenses are useful so that you can look closely at the geological features, but there should not be any damage caused to the rocks.

Eight figure grid references for each location have been provided for those who want to use GPS to follow the trail.

***Start at* East Chevin Quarry car park**
SE 2121 4448

East Chevin Quarry (also known as Pelstone Quarry) was excavated in sandstone called the **Addingham Edge Grit,** which was formed 315 million years ago during the **Carboniferous** period.

***Walk up the footpath for about 100m to* Marker Stone 1**

1 Tidal Laminations, SE 2109 4447. In the track are thin beds called tidal **laminites**. These were deposited in very shallow water in a single tide. So, with two tides each day, you might even count how many days it took to deposit the layers. The structure of these thin beds can be seen in a small rock face 5 metres to your left *(see photograph)*. It is extremely rare to see deposits which are clearly tidal.

***Continue up the path for about 250m until you reach* Marker Stone 2**

2 Cross-bedding on crags of Addingham Edge Grit, SE 2087 4439. Here you can take a short detour up a steep and narrow path along the base of the cliff *(below, left)*. In about 50m this path rejoins the main route.

The Addingham Edge Grit is made of **sand grains**. With a hand lens you will see **quartz** grains which are a grey colour, while **feldspars** are pink, white or cream. All rocks are composed of minerals such as quartz and feldspar, with a particular composition and structure.

These rocks are made from sands deposited in a **river delta**. The lines on the rock face run in two directions. The horizontal lines are called **bedding planes** and show that there were times when the river flow slackened and sand deposition temporarily ceased. Between some of the bedding planes are other lines which slope at a gentle angle and these represent sandbanks in the river channel. This is called **cross bedding.**

After the river sands had been turned into a rock by being deeply buried, compressed and cemented, earth movements fractured the brittle rock and caused the vertical cracks, called **joints,** to develop. The rusty red colour comes from iron which has been washed through the rock later.

The base of the cliff shows the cross bedding and a few layers of coarse grit with rounded quartz pebbles deposited when the river was in flood.

The crags along the path are old quarry faces. The Addingham Edge Grit is an excellent building stone because it has regular joints and bedding planes which made it easier for the quarrymen to break the stone into blocks that could be transported.

Walk along this level path for 100m. On your right you will see down across the Wharfe valley, where there are four large lakes, now used for recreation and wildlife. They give evidence for the last glaciation of the Wharfe valley, when the valley floor was filled with glacial melt water sands and gravels. These have since been extracted for building.

Continue past a picnic bench until you reach a path junction. Turn sharply left and continue steeply up the track. After 100m turn sharply right onto a level path. Walk along this level path for about 700m.

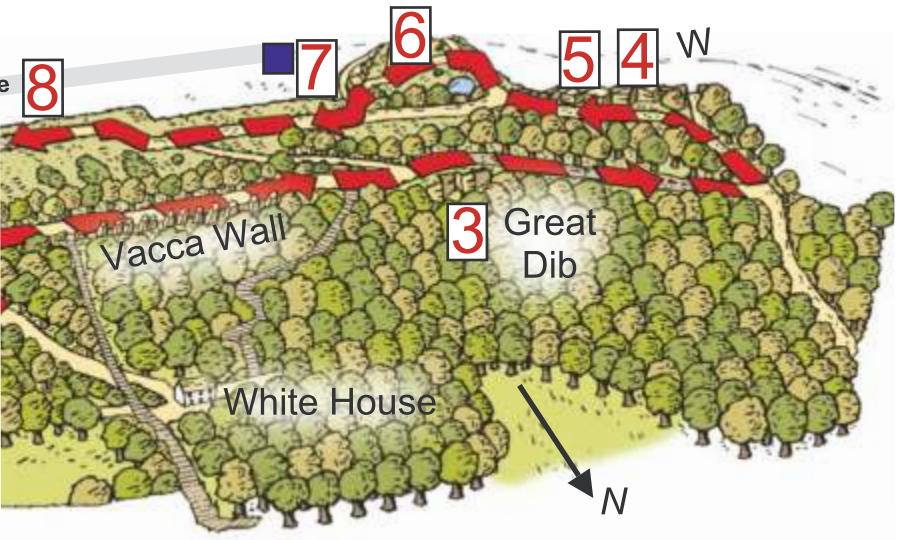
You will go past the standing stones of the **Vacca Wall** which is built from large blocks of sandstone from local quarries and was used to keep cattle from straying.

***Continue straight along this path, going through a derelict dry stone wall, then follow the path as it bends to the right and reach* Marker Stone 3.**

3 Great Dibb Landslip, SE 1991 4435. You are standing on the **Long Ridge Sandstone**. The steep slope which drops down to Otley has been caused by landslipping 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.

The whole length of The Chevin was prone to landslipping because of the steep slope. In places along The Chevin, large boulders have moved downslope and sometimes uneven ground is visible under the trees. 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.

***Follow the path, with a remnant stone wall on your right hand side. After 150m pass through another old stone wall into woodland. Keep going for another 200m with the edge of the slope on your right. At a path junction with a timber marker post turn sharply left, going steeply uphill through the wood following timber marker posts, to* Marker Stone 4**



4 Fossilised tree branches on fallen block of crags, SE 1953 4416. The crags here are made of the **Doubler Stones Sandstone** which lies above the mudstones. The main face of the crag shows **slump bedding** with interesting contortions of the cross bedding surfaces. As the wet sand of the delta was being covered by more sediment, the water in it was able to escape upwards, distorting the bedding surfaces if it happened suddenly, perhaps due to an earth tremor. These features are called **soft-sediment deformation structures** which are due to **dewatering**.

The largest fallen block has tilted through 90°. We can see this because the cross 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** *(above)*. 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.

***Walk amongst or around these crags east along the path for 100m to* Marker Stone 5**

5 Cross-bedding in Doubler Stones Sandstone, SE 1959 4417. Here the Doubler Stones Sandstone shows excellent cross-bedding highlighted by the moss which thrives under the trees *(left)*.

Cross-bedding is 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° – 20°. 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.

There are many fallen blocks of sandstone below the crags. The large blocks probably became detached when The 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, the unsupported blocks were let down onto the underlying slope.

Follow the path and walk uphill following timber marker posts, keeping close to the stone wall on your right. At a path junction turn right to follow a path near a pond into the disused Yorkgate Quarry. Follow timber marker posts through an open grassy area for 200m and then look for* Marker Stone 6 *on your left.

6 Fossilised tree roots and Morton Banks Coal seam, SE 1990 4412. Walk from the marker stone across the grass for a few metres towards the east, where you can see some exposed rock. Be careful if you walk onto the sandstone bed as it is slippery. This exposure shows a thick bed of Doubler Stones Sandstone dipping at 24° to the south. The surface (bedding plane) is dimpled with the fossils of tree roots. The sandstone is made of fine to medium size quartz grains, with a few pink grains of feldspar and was formed in a river.

The sandstone bed is overlain by a thin, black, crumbly **coal seam** to the right of the bedding plane. This is the **Morton Banks Coal** *(right)*. It is very thin here, but becomes thicker further south, where it has been mined. There is grey clay above and below the coal. This is **fireclay**, which is the remains of the soil in which grew the trees and ground vegetation that formed the coal.

Return to the marker stone and go back the way you came for a short distance, and at the second path junction, bear right, following a timber marker post and then right again towards the bottom of a sandstone crag and Marker Stone 7.

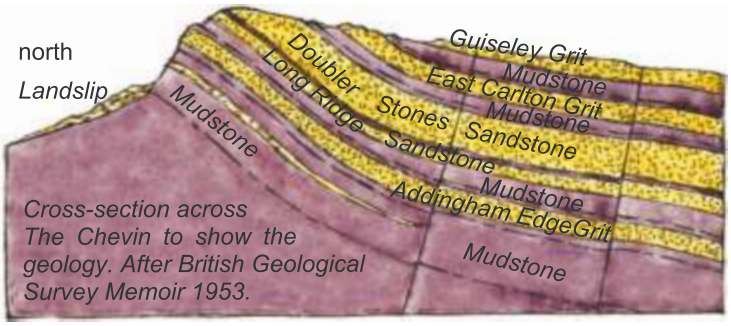
7 Variscan Orogeny - Plate Collision, SE 1993 4420. The sandstone face is about 4 metres high and the rocks dip at 24° to the south. The rocks were tilted at the end of the Carboniferous period, when there was a major plate collision across southern Europe.

***Walk up the narrow steep path to the top of the quarry face and across to the main path running along The Chevin ridge. Turn right and continue for 300m until you see a timber marker post that leads you to the crags of* Surprise View *and* Marker Stone 8.**

8 Surprise View, SE 2043 4419. You are now on the crest of The Chevin **escarpment** formed by the Doubler Stones Sandstone. The steep slope below you, which faces north towards Wharfedale, is a **scarp face** which cuts across the rock beds which dip to the south. If you turn around and look to the south you can see the gentle slope down towards the towns of Guiseley and Yeadon. This slope is called the **dip slope** and is shown in the cross-section below.

The rocks exposed in the footpath nearby are coarse sandstones, with rounded quartz pebbles. The rivers which deposited these sandstones were probably moving fast, as their velocity was great enough to drag pebbles along the bottom of the channel.

To return to East Chevin Quarry car park, follow the ridge path eastwards, then take a flagstone path downhill. At the end of the flagstone path, turn left down a steep track which joins the path you came up earlier. Keep going down and turn right at the wooden sculpture to retrace your footsteps to the car park.



Cross-section across The Chevin to show the geology. After British Geological Survey Memoir 1953.