THE MALHAM LANDSCAPE TRAIL

A GUIDE FOR GROUP LEADERS

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Introduction



In simple terms, the Yorkshire Dales rocks rest on a bed of granite called the **Askrigg Block** which is relatively bouyant on the earth's mantle and so its covering rocks protrude dramatically into the landscape. Huge cracks (faults) separate the Askrigg Block from the Lake District rocks and from the deep **Craven Basin** to the south. During the **Carbonfierous Period** (350 million – 300 million years ago) the Craven faults were continually moving the land masses in relation to one another. To the south of Malham the ocean floor was deepening all the time, while to the north of the **Craven Fault** – shelly creature remains were being laid down on a in a shallow shelf sea to form the famous limestone! Other rock layers, such as the Yoredales that form the Three Peaks – were laid down on top – along with gritstones and coal measures – but most of these have since been stripped away by glaciers. 'Craven' – by the way, probably originates from the Celtic 'Craig Vaen' – the 'land of the crags.'

1. Cawden Reef Knoll



The division between the shelf and the sudden plunge down into deep water was ideal for coral and algal formation. This hill is a remnant of an ancient 'barrier reef' that once stretched along the southern edge of the **Askrigg Block** – where the shelf met the deep sea. It is therefore rich in fossils and was popular with Victorian fossil hunters. It is made up of **'reef limestone'** which is different than the **Great Scar Limestone** of the Cove behind it. It is less 'lithified' (the process by which mud is converted into rock under pressure) so its fossils are far more abundant. The water sinking below Malham Tarn has been tested to pass through a portion of this hill as – in the heaviest floods – it bursts dramatically out of a scree slope on the hillside in a phenomenon known as 'Cawden Burst' or 'Brast.'

2. Location of Aire Head Springs



Looking south from the path, and hidden by the trees, are the well-known **Aire Head Springs**. Here most of the water sinking below Malham Tarn at **Watersinks** emerges into daylight. Although its mysterious route passes to the east of Malham village (including Cawden) – it amazingly emerges on the *west* side of Malham Cove Beck, having passed *underneath* it. This combines with the waters of **Gordale Beck** and **Malham Cove Beck** to form the **River Aire** on its trip south and then eastwards to the North Sea. The gentler landscape to the south of the path is formed, not of limestone, but of **Bowland Shales** – sediments that were washed into deep water during the Carboniferous period. The Great Scar Limestone behind was formed on a shallow water shelf caused by the Mid Craven Fault which continually deepened the basin while leaving this 'shelf' at a higher elevation.



3. Mires Barn and Mid Craven Fault



This barn fits harmoniously into the landscape. Many **stone barns** in the Dales date back to the early 18th century. Their purpose was to store feed (hay) and overwinter livestock. They were situated well away from the farm houses and the muck was spread on the adjoining hay meadows. Note the ventilation holes. Inside were usually three bays – one for up to four cows, each divided off by a wooden stall called a 'boose' – and the central one usually for the hay cart – while the third was the 'mew' where hay was stored.



Looking west from this point – the line of the **Mid Craven fault** can be clearly seen – the white limestone of Pikedaw Hill contrasting with the gritstones of Kirkby Fell on the left – the clear division between shallow and deeper water in an ancient sea.

Bowland Shales



Here we are looking out into the **Craven Basin**, south of the path. The underlying rocks are **Bowland Shales** – washed into the deep sea during the Carboniferous – in water that was generally too deep for limestone to form. Remember that large masses of shales that lay above those that remain will have been stripped away by glaciers and erosion over millions of years!

Reef Limestone Fossils



A notable pale stone on the wall top here is just one of many **'reef limestone'** examples in the wall. This one contains the fragmented stems of animals called **crinoids** – which looked rather like giant sea anemones and are sometimes called 'sea lilies'. They flourished in the warm Carboniferous seas over 300 million years ago.



Hedgerow



Hedgerows were often planted to mark parish boundaries and can date back many centuries. They are a rapidly disappearing part of the English landscape and this is a fine example. As land boundaries – they pre-date any fences or drystone walls – and they are excellent habitats for wildlife.

Gordale Beck



Here the beck turns at a sharp angle and shows a good example of erosion and deposition. The stream's velocity on the outer bank is eroding it closer and closer to the path – while deposition on the innner bank – where the water moves more slowly – is increasing the 'tongue' of land seen in the picture.

Scree Apron



As we approach Gordale, the large scree aprons either side catch the eye. Scree is largely the result of erosion, and especially the freezing and thawing of water in small cracks in the rock, causing fragments ot break off and cascade down steep slopes.



Cove and Gordale Limestone



The great mass of limestone laid down in the shelf sea is what we term **'Great Scar Limestone'** – but even this can be sub-divided according to its characteristics. When deposition of shelly remains stood at a consistent level for millions of years the limestone was uniform and largely unbroken by bedding planes. This we call **'Cove Limestone'** from its archetypal example on the great unbroken face of Malham Cove. It can be seen here as the limestone immediately below the bedding plane at top right – and forms the remaining cliffs of Gordale down to floor level. Above – the limestone is more broken and forms a characteristic series of steps – and this is termed **Gordale Limestone**. During its formation, sea levels must have fluctuated, allowing muds to form over each limestone bed, resulting in many bedding planes.



Gordale Scar



'Gore' or 'geir' is an ancient name for an angular piece of land. The huge gorge has walls of **Cove Limestone** 50 m high, topped by terraced **Gordale Limestone** for another 100 m. At its narrowest the leaning walls are only 15 m apart. The stream seems out of place in a gorge of this scale and is known as a **'misfit' stream**. Its predecessor was a different story. Great channels of glacial meltwater (from about 14 000 years ago) exploited a network of small faults in the limestone here to create the gorge – though the precise age and origin have always been debated. Less water exits than enters the gorge – as much of it finds its way into fissures in normal conditions. A 10 m high tufa waterfall (see point 15) dominates the scene – while the upper fall crashes through a window in the limestone which it first broke through in 1730. To its left – the 'dead' tufa screen that it once flowed down can be seen. The path up and out of the gorge follows a minor fault leading to the west.

Mid Craven Fault



Leaving the gorge and taking the footpath up towards the Cove – we have a fine view to the east along the line of the Mid Craven Fault, which more is more or less followed by the road (Hawthorns Lane). Swathes of **Bowland Shales** (bottom right) are overtopped by the **gritstone** hills of the Weets (top right) which represent huge amounts of gritty sands and gravels being washed into the deep sea by a huge **delta** from the north at the end of the Carboniferous. Nearly all these shales and their covering rocks have been swept away by glaciers and erosion. The Great Scar Limestone 'shelf' on the north side of the fault line is seen on the left.



Settlement and Lynchets



As we proceed up the hill there is evidence all around of Medieval settlements and field systems including terraced lynchets as described in point 19. These probably date back to the early Medieval period.



Grey Gill



Opening up on the right – this dry valley – formed on a series of faults - was again carved by meltwater but its stream has now once again found its way underground. A small cave in the gorge, Grey Gill Hole – reveals the enticing sound of underground water but its route is uncertain once it reaches Wedber. The Malham underworld is ever mysterious! Step Cave is the small passage up on the left.

Malham Cove Fields



From here we get a fine view westwards of the ancient field boundaries close to Malham Cove – which are best seen from this elevated position. Their exact age is unknown but they are believed to date at least as far back as the Romano-British period.

Shorkley Hill



Reaching the road we encounter the unusual limestone knoll of Shorkley Hill. It is said that a gallows was erected here for public executions – though there is no documentary evidence. Certainly, the hill appears to have had some significance to ancient peoples as there are many settlements and field systems just to the north.

Shorkley Hill Settlements



The ancient remains crossed by the path here are fascinating – ancient turf and stone boundaries, huts and enclosures – indicating that the proximity to Malham Cove may well have had a ritual significance to the ancients. They date back to the Romano British period – and maybe even earlier.

Sheriff Hill Burial Cairn



What a final resting place! This mound – known for years as 'Friar's Heap' as it was wrongly believed to be associated with monks – dates back to the late Bronze Age/early Iron Age. When excavated in 1845 it revealed human remains – the remains of a spearhead in iron – and a beautiful red and blue incense cup. The situation has a brilliant view to the 'mother' hill of Pendle 20 miles away. Whoever was buried here must have been of great importance.

Limestone Pavement



The large blocks are called **'clints'** and the gaps between them **'grykes'**. There are many **joints** here as the limestone is relatively close to the **Mid Craven Fault** and so has fractured extensively. Limestone pavements originated under a soil cover where the carbon dioxide rich water easily eroded and enlarged the joints. The process of formation is complex. Glaciers probably exposed the 'benches' of pure limestone by scraping away the weaker covering rocks and soils – and then glacial deposits or **'till'** were dumped behind on them, created the conditions ideal for the percolating water to enlarge the joints beneath. Also – following the retreating glacier – wind-blown silt called **'loess'** smothered much of the pavements and further improved conditions for pavement formation. In the last few thousand years erosion through wind and water has removed this covering soil and exposed the pavements – with much of the soil being washed down into the grykes. The Malham Cove pavement is so pronounced due to its exposure and the huge amount of water and ice that flowed over here at the end of the last glaciation. The clints have grooving known as **'rundkarren'** and many **pans** and **holes** (kamenitzas).



Malham Cove



The massive cliff, in a gentle horseshoe – is over 70 metres (230 feet) high in the centre. It is a remnant of the 'step' in the sea bed created by the Mid Craven Fault – and has been cut back some 600 metres from the fault's position. Erosion has been greater at the centre than the flanks, suggesting a long period when it was a spectacular waterfall – and there is little doubt that towards the end of the last glaciation the fissures beneath and to its height were frozen up, causing meltwater running above to cut out the **Watlowes** 'dry' valley. Only a small portion of the water sinking at Watersinks below the tarn now emerges here and the main flow comes from the **Smelt Mill** sink to the west of the tarn. The great **mystery** is this: if Malham Cove was formed by waterfall action – it would now be at he end of a narrow walled gorge. Instead it is a wide sweep and the current theory is that ice, rather than water – carried out the actual formation – though the actual age of the cove is hotly debated. Work in the caves beneath are suggesting the cove's origins could date back at least 50 000 years. The flooded passages in the vicinity overflowed in December 2015 causing a 230 foot waterfall to once again tumble over the edge – the first time since about 1850. The upper part of the cliff is in Gordale limestone – with Cove Limestone forming the overhang and cliff face. Black streaks are actually algae on the rock surface. Charles Kingsley commented that they appear to have been made by a chimney sweep falling down the cliff – and from this idea came the classic story of the *Water Babies*, begun when he was staying at Tarn House. Peregrines breed on the great cliff and it popular with climbers, offering a variety of routes.



Time Beater



The largest of the ice transported limestone boulders beneath the cove is sometimes called the 'Time Beater' because Hurtley, the old Malham school master – discovered it produced an amazing echo and used to beat time on it while brass bands were playing in the stunning acoustics beneath the cove!

Malham Cove Rising



This is the rising for the water that sinks near the smelt mill 2km to the north-west. As only a tiny stream sinks there – it must gather considerably more on its journey and at least some of the Watersinks water emerges here. Divers have explored flooded cave passages for at least 1.2km from here – including an 'air bell' or dry cave section known as 'Hel's Bells'. Their ambition is to find a huge chamber or further passages to tell more of the Malham story.

Clapper Bridge



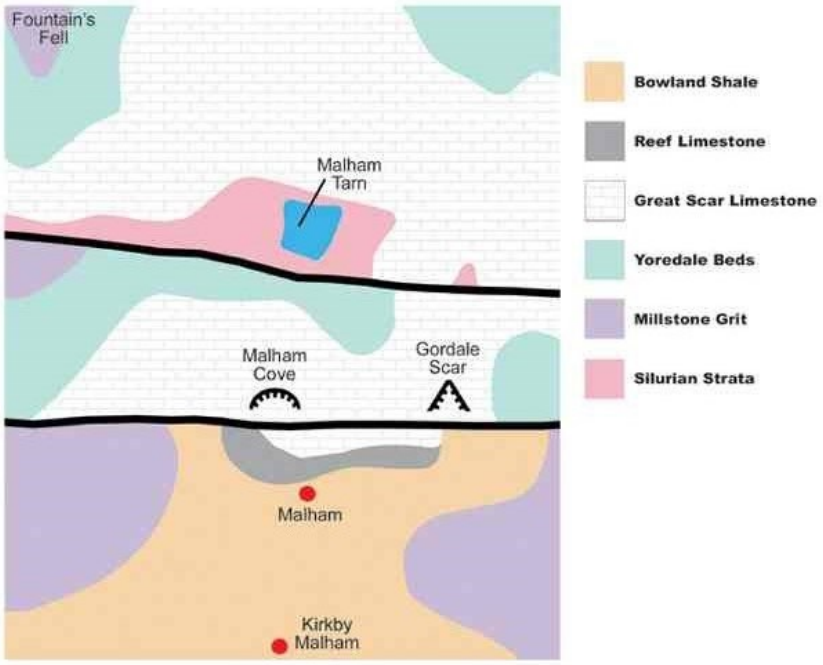
This ancient old limestone bridge- one of several 'clapper' bridges over Malham beck – is a fitting end to our adventure.

THE GEOLOGY OF MALHAM

TEACHERS NOTES

The Basement Rocks

The piece of the earth's crust on which Malham sits has changed dramatically in the last 400 million years - the time for which we have local evidence. A 1960s study showed the National Park area to be underlain by granite. A deep borehole, drilled in the 1970s near Semerwater proved its existence. All of the surface Dales rocks are of 'sedimentary' origin, deposited by water, mostly under the sea.



Geology of the Malham Locality

The oldest rocks surface in the area around Malham Tarn, where they are mostly covered by younger 'Ice Age' deposits. These siltstones were deposited about 400 million years ago during the 'Silurian Period', on a sea bottom near the southern shore of the Iapetus Ocean. We know their age from the Silurian fossils they contain - long spidery fronds called graptolites. Similar rocks are quarried around Horton in Ribblesdale, they include 'Horton Flags', used as paving stones and for lining sheep troughs.

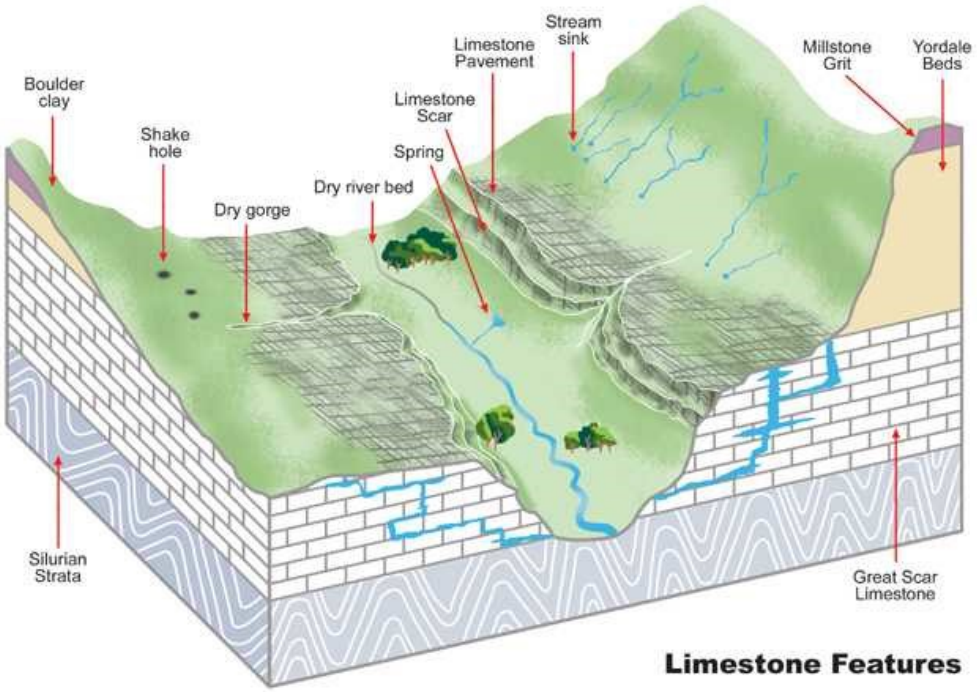
After deposition of the Horton Flags, the Iapetus Ocean, which divided land areas of what are now Scotland and England, was squeezed out of existence by the drift of these land masses towards each other. For the next 50 million years (the 'Devonian Period'), this part of the earth's crust was a desert.

Carboniferous Limestone

About 350 million years ago at the beginning of the Carboniferous Period, sea levels rose worldwide flooding many Devonian deserts. What is now northern England was flooded by warm, tropical seas. We know from magnetic orientation in the rocks, that this part of the earth's crust was then about 10 degrees south of the equator. The Malham area lay near the southern edge of the 'Askrigg Block', approximately the area of the present-day National Park. This was a stable submarine plateau, underlain by granite, overlain by shallow, clear, marine lagoons. Surrounding areas, especially to the south had deeper water and a subsiding sea-floor. The lagoons provided ideal conditions for limestone deposition (as today in the Red Sea and around the Bahamas).

On the Askrigg Block, beds of pure, pale grey 'shelf' limestone were deposited, almost as horizontal today as when first laid down. In the Malham area this limestone is generally known as the 'Great Scar Limestone' and can be seen at Malham Cove, Gordale Scar and on the plateau to the north. The distinct horizontal lines between the beds of limestone (bedding planes) indicate pauses in deposition. The bedded limestones contain many fossil corals, crinoids (sea-lilies) and shells; the latter are mostly brachiopods, a rare group of animals now, but probably more common than any other in Carboniferous seas.

The boundary between the 'block' and the deeper basin to the south was marked by reef growth. Reefs provided a habitat for many sea-shells, mostly brachiopods, and were made from a framework of calcareous algae, sponges and bryozoa (sea-mats) - rather than the later corals. Reef limestone is visible at Burns, just west of Malham village, and Cawden Hill, to the north-east. The limestone is pale grey like that of the bedded limestone to the north but without the clear horizontal bedding planes.



Limestone Features

South of the Askrigg Block in the area between Malham and Gargrave, Carboniferous rocks are very different in character. Deposited in a deeper, dirtier sea, they are mostly dark grey shales and limestones, rarely visible on the surface, except in the local dry-stone walls. Limestone deposition ended gradually with sediment brought from the north by huge rivers, deposited in a Mississippi-like delta. During early delta growth, intermittent sea-level rises brought clear water intervals and further limestone deposition, these thinner limestone beds were separated by sand and shale from the river-delta waters. The cycle of repeated limestone, shale and sandstone - seen on Fountains Fell - are called 'Yoredale Beds' (best seen along the sides of 'Yoredale', Wensleydale). South of the Askrigg Block limestone deposition had ended, rocks of the same age as the Yoredale Beds are the dark 'Bowland Shales', seen in the Bowland Fells to the south-west.

Millstone Grit

The clear seas of limestone deposition disappeared about 325 million years ago as the deltas grew. Alternating sandstones, deposited by the rivers, and shales laid down in the quiet waters between channels and during marine incursions, are characteristic of these times. The sandstones, known as grits, are made of coarse sand with quartz pebbles. Stones quarried from them and shaped circular have been used for grinding corn. In the marine shales the squashed remains of mussel-like shells and coiled shells called goniatites can be found. The latter evolved rapidly during this period and have proved invaluable in dating the strata. Hard gritstones cap all the highest hills in the area: Fountains Fell, the 'Three Peaks' to the west, Simon's Seat and Barden Moor to the east.

Millstone Grit to the Ice Age

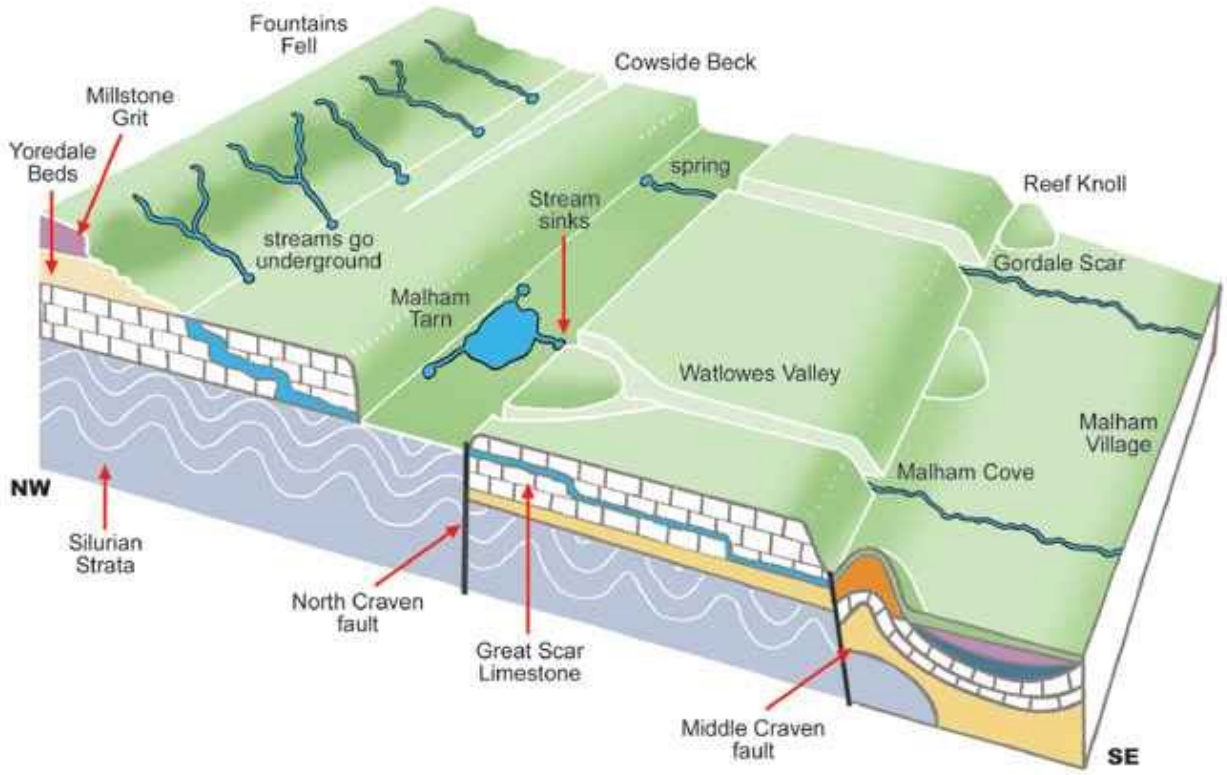
Towards the end of Carboniferous times, earth movements began producing great cracks and folds in the rocks of the area. While strata remained more or less horizontal in the Askrigg Block area, in the Craven Basin to the south, they were folded into east to west aligned domes and troughs. Close to the boundary between the two areas are several major fractures, two of which, the North and Middle Craven faults displaced the rocks to the south downwards. This helped create the great fault scarp, of which Malham Cove and Gordale Scar are two major features and helped bring to the surface the base of impervious rocks under Malham Tarn.

As sedimentary rocks dry out after deposition they develop vertical cracks or joints. Jointing and faulting created a plumbing system for the movement of hot richly mineralised fluids during the Permian period. These liquids rose, evaporated and deposited the minerals within them. Metallic and other minerals of this age occur in many parts of the Pennines: in the Malham area zinc, lead and copper ores were mined north-west of the village during the eighteenth and nineteenth centuries.

Little trace remains of events in the Malham area during the 250 million years from the end of Permian Period, up to two million years ago. Evidence suggests that the surface rose and fell several times, perhaps falling below sea-level again. About sixty million years ago, along with much of Britain, the surface rose to form the land upon which the main features of the present-day have been modelled.

The Ice Age and After

'The Ice Age,' is only the latest of several very cold periods throughout geological time. Ice-cap advances in northern Europe in the last two million years have completely re-shaped the scenery. It was the last of four ice advances within the last sixty thousand years, which had most significant effects. Eroding ice scoured the limestone plateau north of Malham to create the bare limestone pavements. Alternate freezing and thawing of rocky outcrops helped create huge limestone cliffs like Malham Cove. Moving ice scoured huge amounts of clay and boulders (glacial till) from the land, carrying it and dumping it as featureless sheets, or moulding it into egg-shaped hills, or drumlins. These indicate, by the orientation of their long axes, the glacial flow direction. Large boulders were dumped as 'glacial erratics,' miles from their origin. Rushing torrents created by thawing ice gouged out the valleys of Watlowes and Gordale Scar and spread sheets of sand around Malham Tarn. The last ice sheet in the area melted about ten thousand years ago, since



Surface Geology of the Malham Area