Geology

foundations of natural beauty

Set in Stone

The geology that the Yorkshire Dales National Park is renowned for, is mostly made up of sedimentary rocks, such as layers of limestone and gritstone; these were formed around 360 to 300 million years ago. Below this, lie ancient and more strongly folded rocks, known as the basement rocks - formed between 541 million and 419 million years ago. Since these foundations were set, the whole of the area has been lifted above sea level and the sedimentary rocks have been worn away by natural processes, shaping the landscape over millions of years into one that is familiar to us today.



Layers of the Yoredale Series forming the summit pyramid of Inglebrough. (©S.Willis)

The Geological Structure

A large area of the National Park is dominated by the Askrigg Block, which originated from molten rock bubbling around the basement rocks around 400 million years ago. This activity left a raised section of the earth's crust; a great mass of granite invisible to the naked eye, deep underground; bounded by the Dent Fault to the west and the Craven Faults to the south. The block tilts downwards from the south-west of the National Park, to the north-east; this has influenced the rocks that have formed above and also contrast with the geology that sits beyond the edge of the block.

The visible geology varies significantly across the National Park, giving the landscape a distinctive appearance in different areas. For example, the south of the National Park is covered in Carboniferous limestone; the rock of carved limestone features, such as cliffs, caves and limestone pavement. This contrasts with the more ancient slates, sandstones and siltstones, that form the characteristically rounded Howgill Fells, in the west of the National Park.

Visit here to view a map of the Geology of the Yorkshire Dales.

Geological Timeline

For an overview of the geological eons, eras and periods, see this Geological Timechart

541 to 419 million years ago – Cambrian, Ordovician and Silurian Periods

The very oldest rocks in the Yorkshire Dales are believed to have been formed during the Cambrian and Ordovician Periods - starting from around 540 million years ago. During this time, what was to become Yorkshire was an ocean bed lying on a land mass south of the Equator. Rivers flowing into this ocean deposited mud and sand onto the ocean floor and during alternating calm and turbulent periods, distinct layers built up. These sedimentary layers were compressed to become sandstones and shales; collectively known as the basement rocks, or the Ingletonian Series.

Massive tectonic plate movements over a long period of time (490 – 390 million years ago), caused the land masses that would eventually become Europe and North America to collide, which folded and raised these layers, creating the enormous Caledonian Mountains. The friction generated by this collision produced great heat and extreme pressure transforming the shales into slate.



Folded basement slates exposed during the last Ice Age at Thornton Force, contrasting with the younger, horizontal Carboniferous Limestone. (©YDNPA)

In the west of the National Park, the visible geology is still made up of these ancient rocks that were raised during the Caledonian Orogeny. For example, the Howgill Fells, Barbon Fell and Middleton Fell are formed of very hard and compact sandstone (Coniston Grit) of Silurian age (444 – 419 million years ago). The lowlands around the town of Sedbergh sit on top of a layer of red conglomerate of Silurian-aged sandstone pebbles, cemented together with weathered granite. There are also areas of slate, such as at Cautley Spout that are older; formed in the Upper Ordovician period from around 485 million years ago.



The distinctively-shaped Howgill Fells made up of ancient, hard sandstone (©YDNPA

419 to 358 million years ago – Devonian Period

During the Devonian period, in a hot dry desert climate, the raised layers of rocks were eroded to a much lower level. Faulting along the Mid-Craven Fault around 400 million years ago began the formation of the invisible Askrigg Block. Molten rock bubbling around the folded basement rocks cooled to form a rigid granite platform across a large area of today's National Park. This raised section of the earth's crust, is bounded by the Dent Fault to the west and the Craven Faults to the south, from which it tilts downwards to the north and north-east of the National Park. Its presence was first discovered in 1973, when granite was recorded at a depth of 495m in a bore hole at Semer Water. It was this platform, which sank beneath the surface of the sea, to form the base upon which the Carboniferous rocks were laid.

358 – 298 million years ago – Carboniferous Period

Early Carboniferous Period

Under a shallow warm tropical sea, rich in corals, a succession of horizontal layers or beds of limestone were laid down around 340 million years ago. Layers of Carboniferous limestone form a wide plateau, known as Great Scar Limestone, across the south of the National Park, roughly between Grassington and Ingleton. It is effectively wedged between the North and South Craven Faults

For information on the Early Carboniferous visit, here



A horizontal layer of Limestone, more recently carved into Limestone Pavement, as it became exposed to weathering (©YDNPA)

Mid-Carboniferous

By the Mid-Carboniferous period, movements deep within the Earth's crust created hundreds of fractures on the edge of the Askrigg Block, along beds of rock that caused some of these layers to be uplifted under the immense pressure. The largest fault lines such as the North, Mid and South Craven Faults, running across the south of the National Park, created many of the renowned limestone features of the Yorkshire Dales, such as Malham Cove. The Dent Fault marks the western edge of the Askrigg Block, Carboniferous limestone lies above this to the east, whilst older sandstones, slates and gritstones remain to the west of the fault line, such as those forming the Howgill Fells. The Orton Fells in the west of the National Park, are also made up of a block of Carboniferous limestone separate from the Askrigg Block.

Above the top layer of Great Scar Limestone is the Yoredale Series rocks, which are cyclical layers of limestone, shale and sandstone formed by repeated rising and lowering of sea levels from around 320 million years ago. The resistant limestone and the weaker sandstone and shale have produced the stepped landform that are typical of present day Wensleydale and Upper Wharfedale. Wensleydale was once known as Yoredale, which gives these layers of rock their distinctive name. They also make the iconic stepped appearance of the Yorkshire Three Peaks.

Late Carboniferous Period

The Upper Carboniferous rocks containing massive layers of sandstone and gritstone are known collectively as the Millstone Grit. These rocks were formed from the sand and gravel deposits left by a huge river delta during the Late Carboniferous Period. They cover most of Yorkshire and form the main building blocks of the Pennines. As erosion to the mountains north of the National Park released the weight of the land, the land mass moved upwards supplying more material to be eroded. At the same time the weight of materials deposited on the sea bed caused this part of the land mass to sink. These rocks, (that in places are 240m deep), form many of the high moorland areas in the north of the National Park (such as the moors surrounding Swaledale) and also the tops of the peaks of the Yorkshire Dales.

298 to 252 million years ago - Permian Period

During the Permian Period the Earth's climate gradually warmed, sea levels lowered and the end of the period saw the Permian-Triassic mass extinction of land and marine species. The South Craven and Dent Faults were active at this time and the Askrigg Half Dome was formed, a process which created many faults and fissures in the rocks. Hot saline liquids forced their way through these cracks to form mineral veins as they cooled and their contents crystallised. The mineral deposits (mainly of galena, calcite and fluorite) vary a great deal in their make up and distribution, making them difficult to locate and unreliable to exploit. Since these times the area has again been flooded by seas, and covered by more sedimentary deposits. These younger rocks have been uplifted and eroded away leaving behind no trace of their existence.

66 to 23 million years ago – Palaeogene Period

Around 66 million years ago, the land masses that were to become Europe and North America began to move away from each other, causing rifting in the Earth's crust and producing faults and folds. Many of the old lines of weakness became active again. This rising of the land is the foundation from which erosion carved the current landform.

2 million – 10,000 years ago – Quaternary Period

The present landform of the Yorkshire Dales has been widely influenced by glaciation. During the last two million years ice sheets thought to have been 1000m deep in places have covered the area. There have been three glacial periods in the last half a million years, the first two began 460,000 and 190,000 years ago respectively. The effects of each glaciation tended to add to and obscure those of previous periods.



The limestone ‘Obelisk’ at Twistleton Scar: one of the many erratic boulders moved and then dumped during glaciation (©YDNPA)

The most widespread effects of glaciation visible in the landscape of today result from the most recent glacial period (Devensian). This period is thought to have begun about 80,000 years ago and is thought to have ended 10-11,000 years ago. The glaciation was not constant, the extreme cold was broken by milder periods (interstadials) during which the ice cover was reduced. The whole of the Yorkshire Dales was covered with ice at times, apart from the highest peaks which stood out as "islands". Prior to these periods of glaciation, it is thought that the modern dales were already in existence as winding v-shaped river valleys. The movement of ice spreading from the north and west and the erosive material it carried, both widened and straightened out the existing valleys to produce the glacial troughs of today's dales. The movement of ice also removed rocks above the Great Limestone Scar, which then exposed it to weathering, as glaciers retreated from around 16,000 years ago; this resulted in the relatively recent formation of limestone pavement.

Follow the links for more information about the impact of glaciation specifically in Ribblesdale and Chapel-le-Dale.

Examples of glaciation carving the landscape

- Semer Water and Malham Tarn: the last remaining examples of glacial lakes. When the ice retreated at the end of the last Ice Age, melt waters were dammed by glacial deposits, called terminal moraines.
- Norber Erratics (Crummackdale): ancient slate boulders moved by ice during the last glaciation, now stand on limestone blocks as much as 30cm above the surrounding surface, where they have protected the underlying rock from the dissolving action of rain water. Read more about Erratics here, plus see a diagram explaining the deposition of Norber Erratics here.
- Kilnsey Crag (Wharfedale): created by the action of ice freezing on to rock and then as the ice moved the rock was plucked away creating the massive vertical limestone cliff face.
- Limestone pavement, such as at Scales Moor (on the western flank of Chapel-le-Dale): created by rain water passing through soil and vegetation, whilst absorbing carbon dioxide to form carbonic acid, which dissolved the soluble limestone along weak points in the rock.

Find out more about the impact of glaciation on the landscape, including meltwater, moraines and drumlins, here.

The landscape of today

The foundations of the scenery of today owe a great deal to the nature of the rocks from which the ground is made. The details of the present day landscape have been influenced immensely by glaciation. For the last 11,000 years or so since the Devensian period of glaciation, the rivers of the Dales have continued to re-work the bedrock and the glacial deposits in the valley bottoms. The process of washing out and re-depositing further downstream continues the landscape evolution, which has been going on since these rivers began. If people were present in the area during the Ice Age, then it is most likely that any evidence will have been erased by ice. The earliest evidence of people in the area is an antler harpoon point found in Victoria Cave near Settle, dated to about 11,000 years old. The evolution of the landscape since that time is very much the story of the developing relationship between people and the land.

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