Rocks and Landscapes of Baildon Hill

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View of Baildon Hill from the east.

Baildon Hill is located due north of the village of Baildon and is approximately 8km north of Bradford in West Yorkshire. The summit is about 280m above sea level (SE 142 401). It rises above Baildon village which stands on a scarp of hard Rough Rock sandstone. The flat top is formed by the 80 Yard Rock sandstone-capping layer and about 20m below is an extensive plateau, which is formed by the 48 Yard Rock sandstone. Coal-bearing rocks of the Lower Coal Measures are sandwiched between this lower plateau and the scarp above Baildon village. The cross-sections on page 5 show the geological sequence on BaildonHill.

The village of Baildon had thriving coal mining and quarrying industries. Coal was extracted from mines on Baildon Hill and supplied industries and houses in the surrounding area. The first documented evidence of mining dates back to 1387 and in 1863 the last coal pit on Baildon Hill, the Lobley Gate pit, was closed. There were also a number of stone quarries exploiting sandstone around the edges of the village.

There are several roads over Baildon Moor. Two large car parks give access to the many footpaths and tracks which cross the moor and climb to the summit of Baildon Hill.

Rocks found in the Baildon area

The sediments which form the rocks in the Baildon area were deposited in Carboniferous times in river channels or in shallow lakes or mires. **Sandstone** is a sedimentary rock which is made up of sand grains. The sand grains are formed by the breakdown of pre-existing rocks by weathering. The composition of sandstone can vary, as a large number of different minerals may occur within the sediment which makes up the rock. The most common mineral is grey **quartz** which is very resistant to weathering. **Feldspar** is a cream or white mineral and **muscovite mica** is white and reflects light like a mirror. Both minerals are hard to see in sandstone without using a hand lens or a magnifying glass.

For the sediment to develop into sandstone, it must be **compacted** to drive out water and the sand grains must be **cemented** together by other minerals. Quartz, calcite and iron oxides are the most common cementing minerals for sandstone. They are deposited in the spaces between the sand grains by water, and over time, these minerals fill up the spaces by crystal growth. Iron is usually present in the cement, so that sandstones take on a reddish, yellow or brown colour, as found at Baildon Hill.

Rough Rock sandstone is made of angular quartz grains, stained by orange or yellow iron oxides.

Siltstone is very similar to sandstone in appearance but has a finer texture. Grains of silt are just visible to the naked eye or with a hand lens. Only the most resistant minerals are found in siltstone as other minerals will have been broken down chemically before they could be physically broken down to silt size. Therefore quartz is the most abundant mineral found in silt deposits, along with more minor quantities of feldspar and mica. As with sandstone, once the sediment has been deposited, it is compressed and is cemented together by one, or a combination of, quartz, calcite or iron oxides.

Mudstone (often called **shale**) is a sedimentary rock which is made of clay particles. **Clay** is defined as the finest grade of sedimentary particles and can only be observed through a high powered microscope. Clay particles commonly form as breakdown products of feldspars and other silicate minerals.

The small size and plate-like shape of clay particles means they remain in suspension in water currents in lakes, rivers or seas and are only deposited when water flow is extremely slow-moving or stationary. Once clay particles come into contact with each other, they tend to stick together because they are cohesive. Over time, clay builds up and is compressed into beds less than 1cm thick, called **laminations**. Clay forms a solid rock which can be grey or black (if the rock has a high carbon content).

Regular bedding and cross bedding

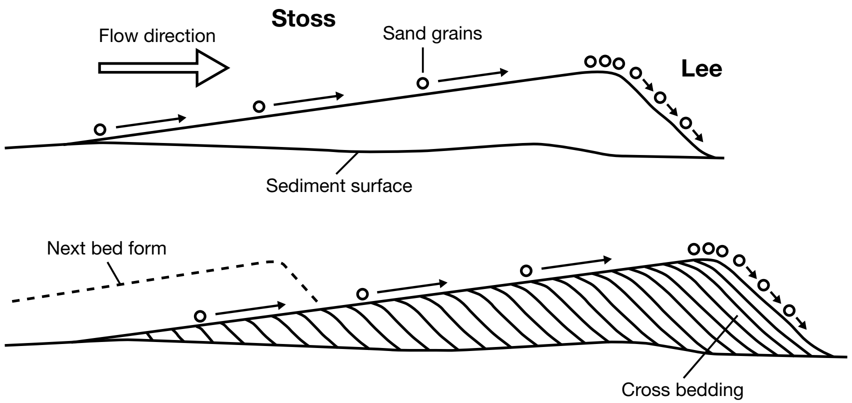
Sedimentary rocks are made up of layers or beds. If the bedding of the rocks is horizontal, or very nearly so, and the upper and lower surfaces of the bed are parallel, the bedding is said to be regular. **Regular bedding** forms when sediment settles out of a slow, steady water current.

Sometimes bedding appears to run at a gentle angle to regular bedding and this is called **cross bedding**. It occurs on various scales in medium to coarse-grained sediments and forms in currents of water or wind as shown in the diagrams below.

Sand grains are transported along a sediment surface and begin to form a gentle slope. Sand grains are continually forced up the “stoss” side of the mound.

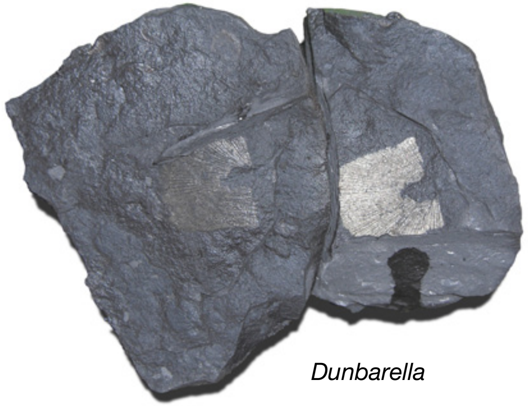
Eventually so many sand grains build up that they avalanche down the steep “lee” side of the mound. This process occurs repeatedly and cross-bedded sandstone layers are created as the current continues to move downstream.

Mudstone exposed in a gully at SE 1405 4014 on the west slope of Baildon Hill.



Formation of cross bedding in a water flow with sand sediment.

Cross-bedding runs at an angle (green line) to the regular bedding-planes (yellow arrow). Eaves Crag SE 1498 4045

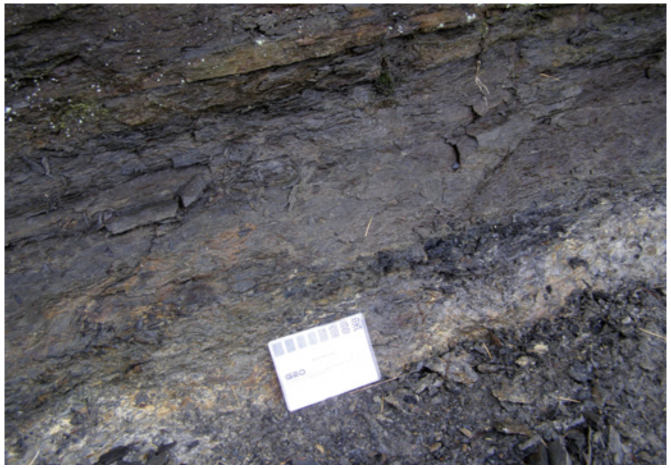


Dunbarella

Gastrioceras

A **marine band** refers to a bed of rock which contains an abundance of fossils of marine organisms and is commonly a dark grey or black mudstone (shale). These beds represent episodes of flooding by seawater. There are marine bands in the Baildon area which yield fossils of shells and goniatites. *Dunbarella* is a shell a bit like a present-day scallop and *Gastrioceras* is a **goniatite**, which was an ancestor of the ammonites and is now extinct.

Fireclays are sedimentary mudstones that occur as "seat-earths" which underlie almost all coal seams. **Seat-earths** represent the fossil soils on which coal-forming vegetation once grew and are distinguished from other associated sediments by the presence of rootlets and the absence of bedding.



Thin coal seam (black) underlain by grey fireclay. Scale is 8cm long. Photo taken in Dimples Quarry, Haworth.

Fireclays are typically thin beds, normally less than 1m but sometimes up to 3m thick. They are composed of clay minerals, mica and fine-grained quartz in various proportions. The term "fireclay" was derived from its ability to resist heat. Its original use in manufacture was for lining furnaces and for brick making. Fireclay is shown in the photo, as a pale bed in line with the scale card.

Ganister is also a seat-earth and is a hard, fine-grained, quartz-rich sandstone. It used to be crushed and mixed with fireclay to create the manufacturing material for lining furnaces. Ganister was formed when a soil developed in sandy sediments and therefore is much harder and coarser-grained than fireclay. Ganister is called "galliard" or "calliard" in some of the older references. It often contains fossil plant rootlets, preserved by black carbon, as shown in the photo.

Ironstone is a sedimentary rock comprised of a high percentage of iron minerals. It is often found as **nodules** within bands of mudstone but it is not regularly distributed at Baildon Hill. It was extracted by picking the nodules out of the shale. Smelting took place in this area in medieval times. A bloomery or smelting works has been located at Glovershaw, to the west of Baildon Hill. Local mudstones could have provided the ironstone nodules that were exploited here.

Sample of Ganister.

Ironstone nodule in a path on the east side of Baildon Hill.

Baildon Hill geology

There are three main sandstones underlying Baildon Hill, with mudstones and coal seams lying between each of them. As the rocks are nearly horizontal, the geology of this area is very straightforward and is shown in the cross-sections below. An account of each rock type is given.

Rough Rock Flags and Rough Rock

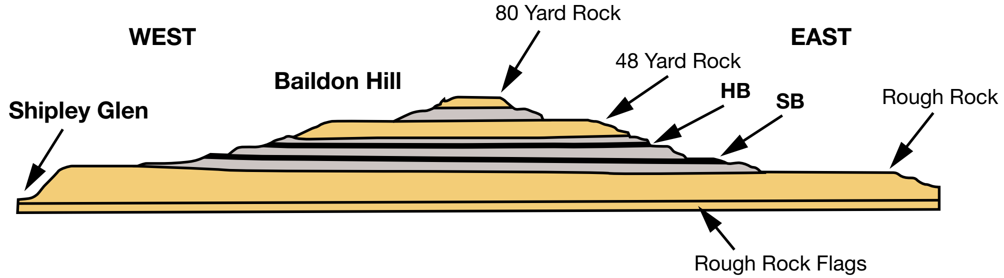
The Rough Rock Flags and the Rough Rock are up to 50m thick in this area, as seen in the quarries on Baildon Bank and on Eaves Crag. The name implies that the Rough Rock Flags have flaggy bedding, with the bedding-planes close enough for flags to be produced. However, both divisions of the Rough Rock are very similar in composition and bedding structures. They cannot be easily told apart, unless the marker band between them can be seen. This marker band takes the form of a bed of mudstone or broken rocks, which can be seen at High Eaves Delph, where the junction between the two is a discontinuous band of broken rock near the base of the quarry face as shown in the photo.

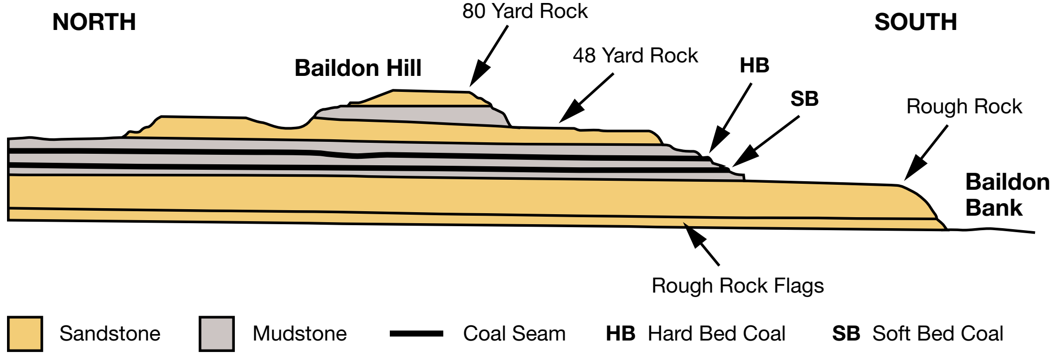
When the quarries were working, the Rough Rock Flags were exposed below the Rough Rock at Baildon Green and in the Baildon Bank Quarries. At Baildon Green, grey shale is the marker band which separates the two rocks. However, this shale thins out eastwards and is absent from other exposures of the rocks.

Rough Rock and Rough Rock Flags are well-cemented, tough, resistant rocks and therefore have many uses. A photo of Rough Rock is shown on page 2. The best stone with well-spaced bedding planes was used for construction stone, particularly in the lower walls of large buildings. Stone with bedding-planes which were spaced more closely together was used for flagstones or roofing slates. Kerbstones, setts and building stone would have been masoned to the right size by stone-masons working in the quarries. Any rocks which had weaknesses, such as plant fossils, would have been used for field walls. Waste stone was sometimes crushed and used for tracks and paths, if there was a demand. However, much waste stone was left in spoil tips close to the quarries.

Beds between the Rough Rock and Soft Bed Coal

In other areas of Bradford, a sandstone called the Soft Bed Flags occurs above the Rough Rock, but it is not found on Baildon Hill. 15m of shale lie between





Junction between Rough Rock and Rough Rock Flags in High Eaves Delph SE 1527 4053.

Eaves Crag SE 1498 4045 showing different uses of stone.

Northern entrance to the fireclay mine on the east slope of Baildon Hill SE 1450 3847.

the Rough Rock and the Soft Bed Coal. It is reported that there is ganister lying below the coal seam, which would have been of interest to early miners.

Soft Bed Coal

The Soft Bed Coal is reported as being 0.4-0.5m thick on Baildon Hill. The coal has been worked at Baildon and was described as being of a fair quality. The roof of the coal bed is hard black shale which contains fossilised fish scales and other fish remains. Overlying the coal is a thick fireclay which was worked locally for the manufacture of fire-bricks.

Middle Band Rock and Middle Band Coal

The Middle Band Rock is a sandstone of variable thickness in the Baildon area, but does not form a significant feature on Baildon Hill and is not included on the cross-sections on page 5. The sandstone is often ganister-like at its top. The Middle Band Coal which lies above it is reported to be too thin to be workable in this area.

Seat-earth below the Hard Bed Coal

Above the Middle Band Rock is about 6m of what was described in 1878 as clay, but is possibly mudstone rather than fireclay. Above that is a bed of seat-earth 8m thick, which was of economic importance. White fireclay and ganister are found, both of which are of variable thickness and both have been worked extensively. It was recorded in 1878 that the seat-earths were used for making tiles and chimney pots. The fireclay was worked at the mine on the east side of Baildon Hill at SE 1450 3847. The mine abandonment plan from 1904 records that 1.4m of fireclay was worked. Above it was 0.45m of coal, which is the Hard Bed Coal.

Hard Bed Coal

The Hard Bed Coal is recorded on Baildon Hill as being 0.45m thick. It has been worked along its whole outcrop and has also been extracted by shaft-mining on the higher parts of Baildon Common. The Hard Bed Coal was the most important source of coal in the area despite its poor quality and high sulphur content. The coal was mainly used as engine coal but also used domestically in some areas.

Stanningley Rock and 36 Yard Coal

In the Bradford area, the Stanningley Rock is a sandstone which varies considerably in thickness and is not seen on Baildon Hill. The 36 Yard Coal which lies above it is also not present at Baildon Hill. However, the Stanningley Rock has been worked for ganister at the Hawksworth Quarry, which is approximately 2km north-east of Baildon Hill.

48 Yard Rock and 48 Yard Coal

The 48 Yard Rock is a sandstone which varies in thickness in the Bradford area. It is so called because its base lies 48 yards above the Hard Bed Coal. The sandstone forms a large escarpment on the flanks of the hill, as shown in the photo on page 1, and a prominent shelf on Baildon Common. It has been quarried on the south side of Baildon Hill, as shown in the photo below. In a quarry west of Hope Hill Farm (SE 138 395), it is a flaggy sandstone more than 7m thick. It was clearly worth exploiting and probably was used for the same purposes as the Rough Rock. The 48 Yard Coal seam, which lies above this sandstone in some parts of Bradford, is not found here.

80 Yard Rock and 80 Yard Coal

The 80 Yard Rock lies 80 yards above the Hard Bed Coal. It caps Baildon Hill and is probably only 8-10m thick. It is likely that the 80 Yard Coal, which occurs above it in some parts of Bradford, has been removed by erosion. The sandstone is a thin rubbly bed but may have been used for construction purposes, particularly for any buildings near the summit of Baildon Hill. The uneven ground and pools of water on the summit of Baildon Hill show that shallow quarrying took place.

Landslips at Baildon Hill

Landslipping has occurred on steep slopes at Baildon Hill in past times. The south-facing slope which drops down to Baildon Bank was modified by landslipping at a time when the climate was still very cold but after local ice sheets had melted, about 14,000 to 12,000 years ago. Ice still lay in Airedale, so temperatures were too cold to support sufficient vegetation to stabilise the slope. During winters, water in the rocks and subsoil would have frozen, but in the summers melt water permitted sandstones at the top of the slope (the 48 Yard Rock) to slide down weaknesses in the lubricated mudstones below.

The landslips have covered the coal seams between the 48 Yard Rock and the Rough Rock with a layer of clay and sandstone, which perhaps explains why there is little evidence that the coal seams were exploited on the south side of Baildon Hill.

Escarpment formed by the 48 Yard Rock, looking north east from Bracken Hall. There are quarries in the 48 Yard Rock along the slope to the right of the Crook Farm caravan park.

Mining Activities

The two main coal seams on Baildon Hill are the Hard Bed and Soft Bed Coals. By the 17th century, mining was a well established industry on Baildon Hill and coal was being extracted from open workings, bell pits and deep mine shafts. During the 19th century, the level of coal extraction increased to meet the requirements of the industry, with the mills of Baildon and nearby Eldwick receiving coal from Baildon Hill. During the 19th century, there was also a great demand for stone as a building material. The 1852 Ordnance Survey map shows a number of sandstone quarries in the vicinity of Baildon village, including one at the bottom of Baildon Bank.

The mining activity has affected the landscape at Baildon Hill in several different ways. At the time when areas of Baildon Hill were being exploited, there was no particular legislation to enforce mine restoration. In the 19th century there was early legislation which was created to provide a safer working environment for miners and, as the industry grew, mine abandonment plans were eventually introduced. However, this meant that the environmental impact of the mines once they were closed was usually overlooked.

Over much of the area, depressions in the ground can be observed. These represent places where some of the bells pits and shafts once were, but they are now flooded and covered in vegetation. They are usually a circular shape, with some being deeper and more obvious than others. There are also two large, steep faces where the ground has been dug out, which indicate the entrances to the fireclay mines.

Spoil heaps are common in mining areas and are comprised of waste material from the mining activities. Landslips are also frequent around mines where loose ground moves downwards either due to gravity or to high water content, which reduces the friction within the material. Both spoil heaps and landslips create undulating ground, which can be seen over most of Baildon Hill.

Fireclay spoil to the north of the fireclay mine.

Sandstone quarry waste at Acrehow Hill Delph.

Geological history of the rocks of Baildon Hill

The geology of Baildon Hill dates from the Upper Carboniferous period, approximately 327 million years before present (Ma) to 299 Ma, as shown in the stratigraphic table.

During the Carboniferous period, the British Isles had an equatorial location and therefore experienced a hot and rainy climate. The area was a lowland plain with mountains lying to north and south. Large rivers flowed from the north-east into the lowlands, which were periodically flooded by shallow seas. Sea level altered frequently because of glacial fluctuations in the ice-sheet which lay over the South Pole.

Sediment brought down from the mountains by rivers was deposited in estuaries or on the tops of deltas, in an environment similar to the present-day Mississippi or Ganges deltas. Wide, shallow river channels flowed between sandbanks, surrounded by flat plains which were occasionally flooded when rainfall was very high or snow melted in the mountains to the north. The sands that form the Upper Carboniferous sandstones were typically deposited in these large channels.

ERA	AGE MILLIONS OF YEARS BEFORE PRESENT	PERIOD
CENOZOIC	2.6	QUATERNARY
	23	NEOGENE
	65	PALAEOGENE
MESOZOIC	145	CRETACEOUS
	199	JURASSIC
	251	TRIASSIC
UPPER PALAEOZOIC	299	PERMIAN
	359	CARBONIFEROUS
	416	DEVONIAN
LOWER PALAEOZOIC	443	SILURIAN
	488	ORDOVICIAN
	542	CAMBRIAN
PRECAMBRIAN		

Because the climate was warm and wet, forests grew on the surrounding lowlands, so sometimes tree branches drifted onto sandbanks, carried by rivers in flood. You can often see plant fossils in field wall stones, as quarrymen regarded them as waste rock which reduced the strength of the stone for building.

Coal Measures Rocks

Later in the Carboniferous period, the continent was above sea-level for longer. Equatorial forests thrived, so that rocks now contain thicker coal seams. Rocks formed during these times, from 310-300 million years ago, are often called the **Coal Measures**. Sandstones, siltstones and mudstones are still found at this time, interbedded with thick coal seams which have been worth exploiting.

Large forests grew on the low-lying deltas and it is this vegetation which became buried and over time formed coal seams which can be found at Baildon Hill. However, the species of plants found in the Carboniferous forests are very different from the trees and shrubs of today's vegetation.

The sediments which were deposited by the deltas, which included mud, sand and silt, were also buried and compressed and ultimately made up the sedimentary rocks at Baildon Hill.

Plant fossils on a large boulder at High Eaves Delph, Baildon Hill.

Acknowledgements

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Photos © Alison Tymon

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Waters, C N, 2000, *Geology of the Bradford District*, Sheet Description of the British Geological Survey 1:50,000 Series Sheet 69 Bradford

Useful maps

OS SHEET 1:50,000 Landranger 104 Leeds and Bradford

OS SHEET: 1:25,000 Explorer 288 Bradford and Huddersfield

British Geological Survey 1:50,000 Geological Sheet 69 Bradford

Further reading

Minerva Heritage Ltd, 2013, *Riches of the Earth: Over and Under the South Pennine Moors*, Pennine Prospects

www.wyorksgeologytrust.org

West Yorkshire Geology Trust (WYGT) is part of a national network of voluntary 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) and there are about 80 in the county. The Baildon area has several LGS sites at Baildon Moor, Baildon Green and Baildon Bank Quarries. West Yorkshire Geology Trust aims to encourage public enjoyment of rocks, fossils and landscapes and link geological features with the local industrial heritage.

This leaflet has been produced with support from the Watershed Landscape Project, a three year Heritage Lottery Funded project managed by Pennine Prospects to enhance and conserve the South Pennine upland landscape and its heritage, whilst improving access for all.

The aims of the project are to protect the internationally important natural and historic features of this special landscape and to encourage greater understanding and enjoyment of the area so that it is further valued and protected. The project has been telling the fascinating stories of the moors by offering opportunities to get involved in local heritage projects, delivering moorland conservation initiatives, developing resources to help people explore the landscape, hosting exciting events and activities, and working with artists and writers on an original creative arts programme.

For more information about the Watershed Landscape Project please visit **www.watershedlandscape.co.uk**

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