

# WEST YORKSHIRE GEOLOGY TRUST

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## BAILDON HILL



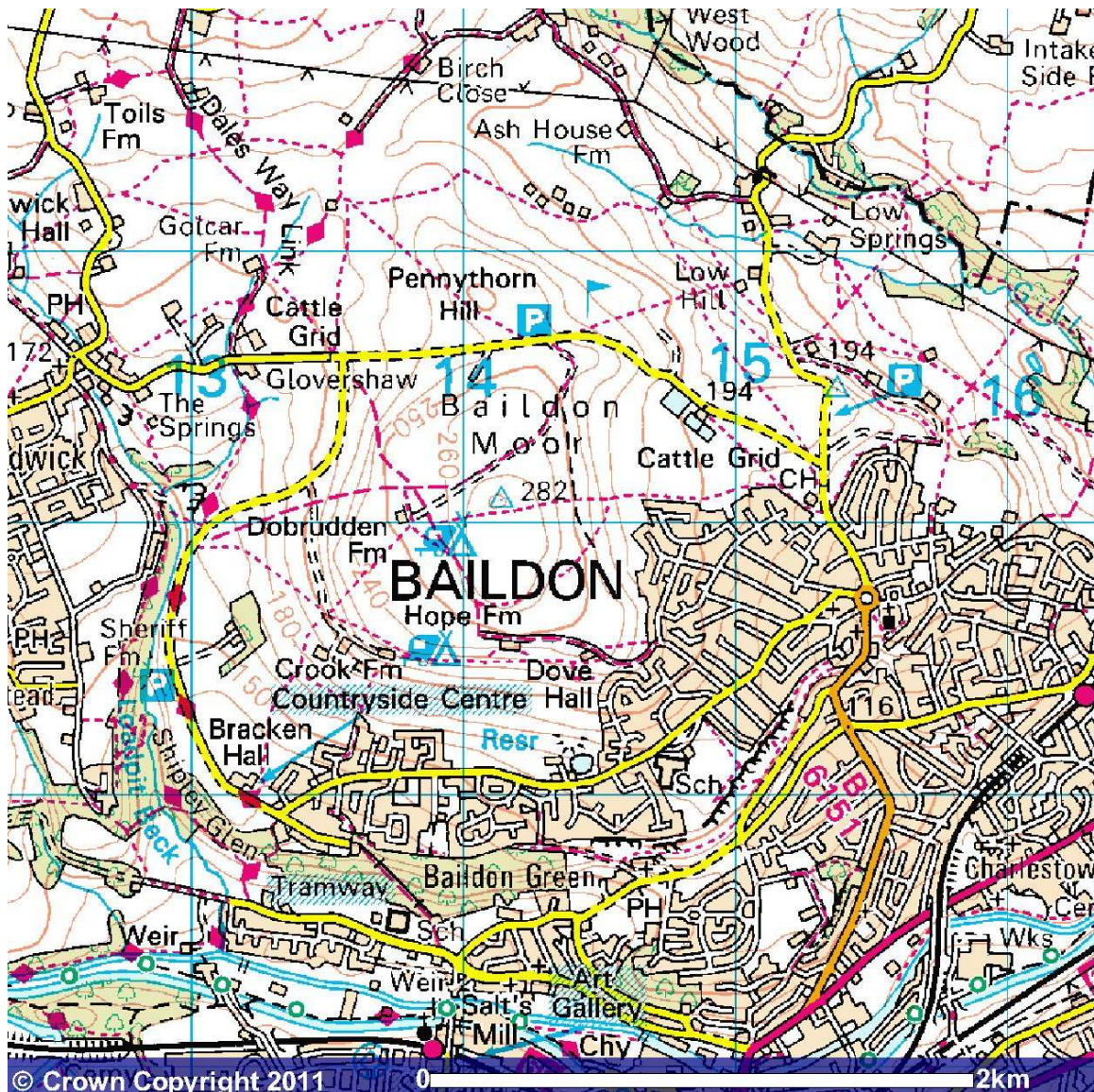
View of Baildon Hill from the east

## GEOLOGY REPORT SEPTEMBER 2011

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## Introduction



OS 1:25,000 Map of Baildon Hill

Baildon Hill is located due north of the village of Baildon and is approximately 5 miles north of Bradford in West Yorkshire.

The general 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 in Appendix 1 on page 14 .

During the Carboniferous period, the British Isles had an equatorial location and therefore experienced a tropical climate. At the start of the period, there was a major sea-level rise which covered almost all of England and Wales. These tropical seas were rich in marine life, particularly corals, brachiopods and trilobites. A gradual shallowing of the sea, along with the formation of extensive deltas originating from the north-east, allowed terrestrial conditions to become established during the Upper Carboniferous. Large, complex forests grew on these low-lying deltas and it is this vegetation which became buried and over time formed coal seams (10), which can be found at Baildon Hill.





**Thin coal seam (black) underlain by grey fireclay. Scale is 8cm long. Yorkgate Quarry, Otley Chevin**

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.

The village of Baildon had a thriving coal mining industry. Coal was extracted from Baildon Hill and supplied industries and houses in the surrounding area. The first documented evidence of this 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 around the edges of the village which particularly exploited sandstone and seemingly enjoyed a prosperous trade (3).

## **Geology**

### **Sandstone Lithology**

Sandstone is a sedimentary rock which is primarily made up of sand sediment with a grain size ranging from 63 microns ( $\mu\text{m}$ ) to 2mm. The sand grains are formed by the breakdown of pre-existing rocks by weathering and erosion and also from material that forms within the depositional environment, i.e. fragments of plants and animals found in a deltaic environment. The grain size range is divided into; very fine, fine, medium, coarse and very coarse. 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 minerals are quartz, which is very resistant to weathering, feldspar and mica (12). For the sediment to develop into sandstone it must be compacted and cemented together. 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 much time, these minerals fill up the spaces by crystal growth. When iron is present in the cement, the sandstone takes on a reddish colour (14), otherwise sandstone is generally a yellow or brown colour as found at Baildon Hill.



**Sandstone texture of Rough Rock**

## **Siltstone Lithology**

Siltstone is a sedimentary rock which is very similar to sandstone in appearance but has a finer texture, as it is silt dominated. Silt is defined as the grain size of material between  $4\mu\text{m}$  and  $62\mu\text{m}$  in diameter and the size range is divided into coarse, medium, fine and very fine. The coarser grains of silt are just visible to the naked eye or with a hand lens. Only the most resistant minerals are common 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. Silt deposition only occurs within very slow water velocities or standing water as it can easily remain in suspension due to its minute size (12). As with sandstone, once the sediment has been deposited, it is compressed and is commonly cemented together by one or a combination of, quartz, calcite or iron oxides (14).

## **Mudstone Lithology**

A mudstone is a sedimentary rock which contains both silt and clay components. If two thirds or more of the rock is made up of silt, it is termed a siltstone. However, if it comprises predominantly of clay particles then the rock is termed a claystone, which is most commonly referred to as shale.

Clay is defined as the finest grade of sedimentary particles, those less than  $4\mu\text{m}$  in diameter 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 weak fluid flows and are only deposited when the flow is extremely slow-moving or stationary. Once clay particles come into contact with each another, they tend to stick together because they are cohesive and this cohesion makes the particles resistant to being remobilised in a flow (12). Over time clay builds up and is compressed into fine layers, called laminations, and forms a solid but quite brittle rock which is of a grey colour or can be black if the rock has a high organic content.



**Mudstone in gully at SE  
1405 4014 on the west  
slope of Baildon Hill**

## **Glacial Till**

Glacial till is unsorted material which has been deposited directly by glacial ice and shows no stratification. Its content may vary from clays, to mixtures of clays, sand, gravel and boulders. The rock fragments are usually angular and sharp because they have been deposited by ice and have undergone little water transport (5). Over time, glacial till may be buried and compressed and can form a sedimentary rock called tillite. Tillite is comprised of the unsorted till material held in a rock flour which has ultimately hardened and bonded together. Rock flour acts as the cement and usually makes up a large percentage of tillite. It tends to be dark grey to greenish black in colour and consists of angular quartz, feldspar grains and rock

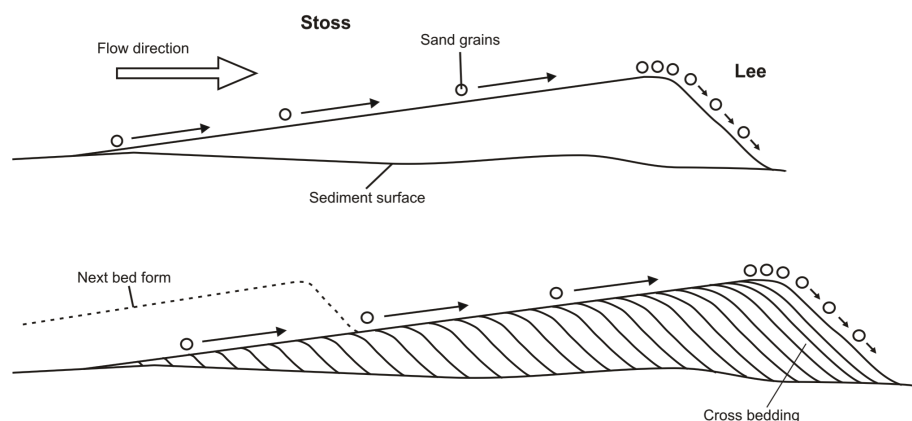
fragments in a very fine grained paste of clay particles (6). Glacial till has been deposited around the lower slopes of Baildon Hill and on Baildon Common but has not been surveyed for this report.

### 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 (photo page 9), the bedding is said to be regular. Regular bedding forms by sediment settling out of a slow and steady flow allowing lateral layers to build up.

Cross bedding occurs on various scales in medium to coarse sediments and is associated with the formation of ripples, dunes and other bed forms. The process which creates cross bedding occurs within a water flow (but can also be wind blown).

Sand grains are transported along a sediment surface and begin to form a gentle sloping accumulation of sediment. Sand grains are continually forced up the "stoss" side of the mound.



**Fig 1** Formation of cross bedding in a water flow with sand sediment.

Eventually so many sand grains build up that they avalanche down the steep, down-current "lee" side of the mound. This process occurs repeatedly and after many of these bed forms have migrated over a surface, cross bedded sandstone layers are created (Fig 1).



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

1498 4045

## **Lamination**

Lamination is a small scale sequence of fine layers, called laminae, which can sometimes be found within the beds of sedimentary rocks. Laminae are less than 1cm thick and can occur as parallel structures called parallel lamination, or they may be at an angle in which case they are termed cross lamination. They are created by regular changes in the supply of sediment and therefore consist of small differences in the type of sediment within the rock. The changes can be in grain size, clay percentage, organic material content or mineral content which often show colour change between the laminae (1).

## **Marine band**

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 shale. These beds represent episodes of flooding by seawater (4). There are marine bands in the Baildon area but they have not been surveyed for this report.

## **Fireclay**

Fireclays are sedimentary mudstones that occur as “seatearths” which underlie almost all coal seams. Seatearths 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. Fireclays are typically thin, normally less than 1m but are rarely greater than 3m. 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 and its original use in manufacture was for lining furnaces. Today it is principally used for brick making (2). Fireclay is shown in the photo on page 3, but has been darkened by wash from the coal above.

## **Ganister**

Ganister is also a seatearth and is a hard, fine-grained, quartz-rich (quartzose) sandstone. It was crushed and mixed with fireclay to create the manufacturing material for lining furnaces (9). It is thought that typical ganister is the silicified surface of a buried soil developed in sandy sediments and therefore is much harder and coarser than fireclay (13). Ganister is also called “galliard” or “calliard” in some of the references.



Ganister is usually seen in West Yorkshire as a hard white sandstone. It often contains fossil plant rootlets, preserved by black carbon as shown in the photo.



## Ironstone

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 medieval times in the area. A bloomery or smelting works has been located at Glovershaw, to the west of Baildon Hill. Local shale could have provided the ironstone nodules that were exploited here.



**Ironstone nodule in path on the east side of Baildon Hill**

## Mining Activities

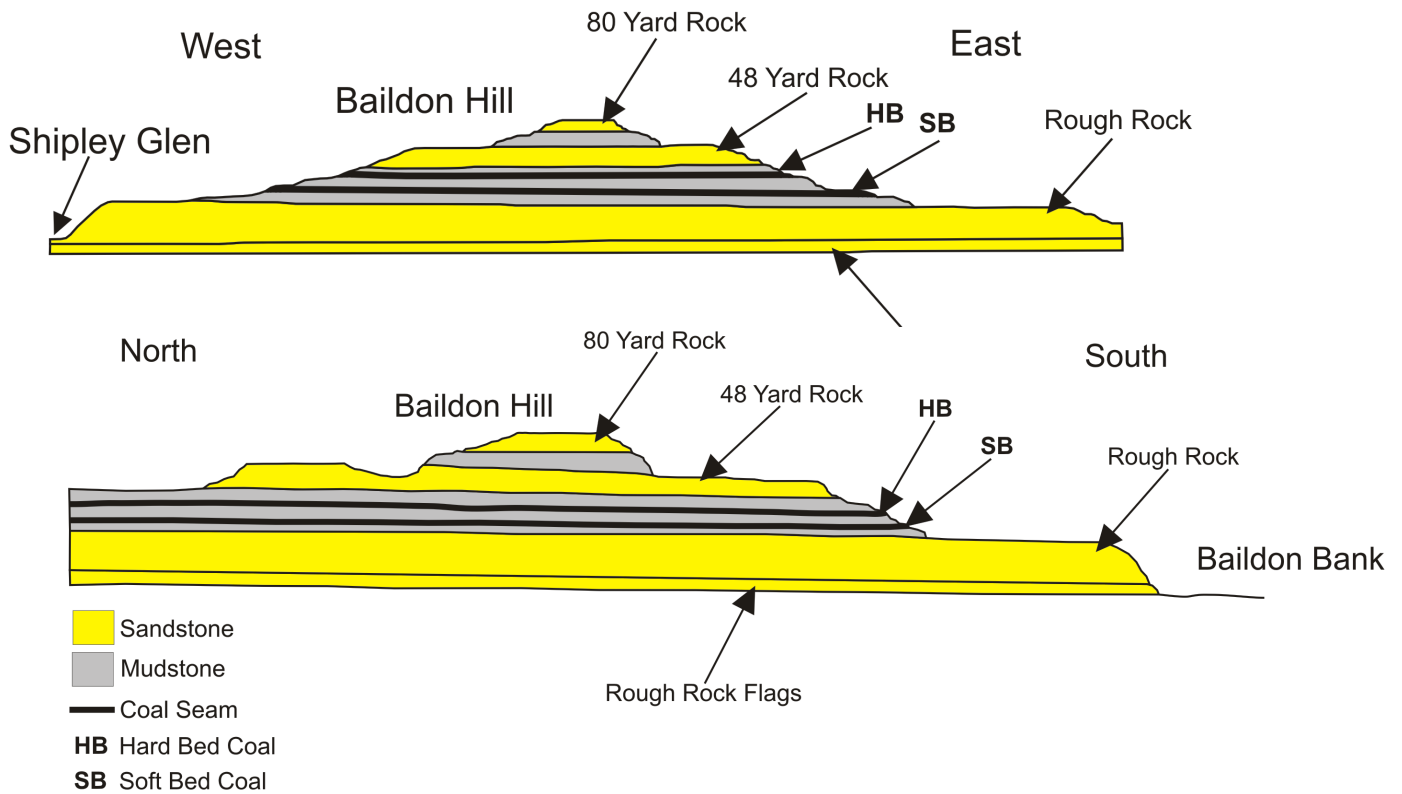
Baildon Hill covers about 20 km<sup>2</sup> and has an elevation of 280m above sea level at the summit. It rises above Baildon village on a thick scarp of the hard Rough Rock sandstone. The flat top is formed by the 80 Yard Rock sandstone-capping layer and about 20m below is an extensive plateau, which is formed in the 48 Yard Rock sandstone. Coal-bearing rocks of the Lower Coal Measures are sandwiched between this lower plateau and the thick scarp above Baildon village (8). The cross-sections on page 8 show the simplified geological sequence on Baildon Hill. The full stratigraphy is shown in the diagram in Appendix 1 page 14.

Over much of the Baildon Hill area the depth to the two main coal seams, the Hard Bed and Soft Bed Coals, is largely due to the surface topography. Shallow depth bell pits into the Coal Measures are distributed around the perimeter of the lower plateau, and larger, deeper mineshafts can be found in and above the lower plateau (8).

By the 17<sup>th</sup> 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 19<sup>th</sup> 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 19<sup>th</sup> Century, there was also a great demand for building materials. 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 (3).

## Baildon Hill geology

A simplified geology map can be seen in Appendix 2 on page 15. This description of the rock types and their economic importance is written in order of age, starting with the oldest;



### Rough Rock Flags and Rough Rock

The Rough Rock Flags range from 1-32m and the Rough Rock ranges from 12-30m in thickness in the Bradford area. They are certainly seen to be thick in the Baildon area, as seen in the quarries on Baildon Bank and on Eaves Crag. The Rough Rock Flags were exposed below the Rough Rock at Baildon Green and in the Baildon Bank Quarries when the quarries were working. At Baildon Green, grey shale separates the two rocks. However, this shale thins out eastwards and is absent from other exposures of the rocks (15). At High Eaves Quarry the junction between the two is a discontinuous band of broken rock near the base of the quarry face as shown in the photo below.

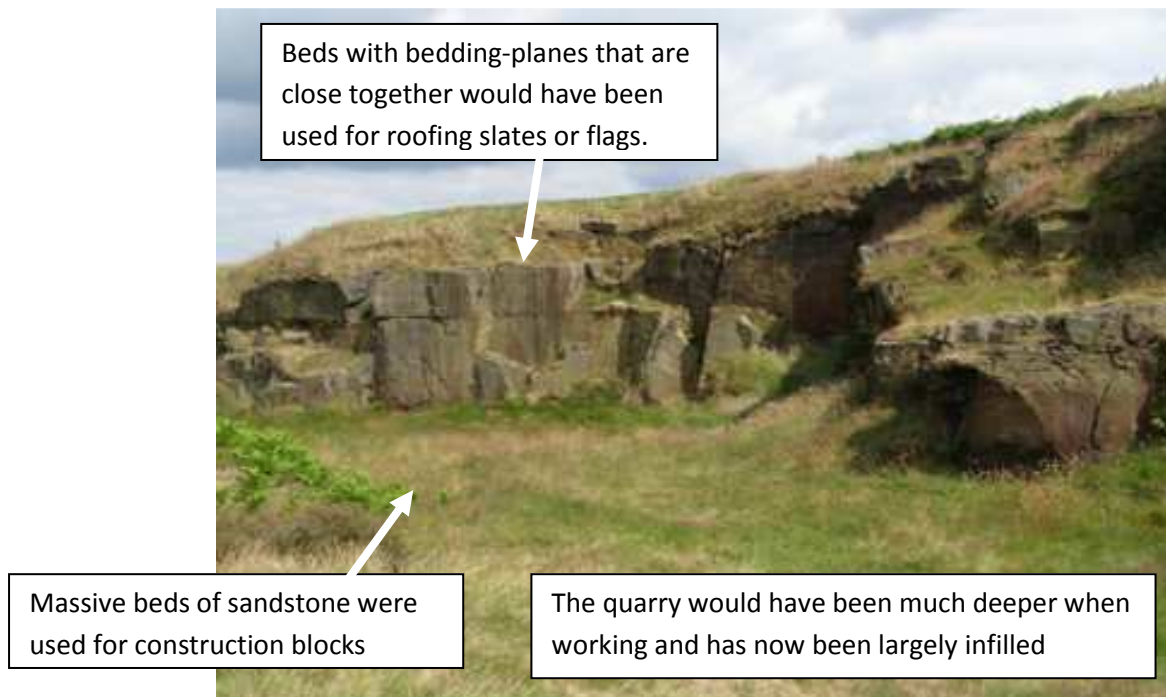


**Junction between Rough Rock and Rough Rock Flags in High Eaves Delph SE 1527 4053**



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 3. The best stone with well-spaced bedding planes is used for construction stone, particularly in the lower walls of large buildings. Stone with bedding-planes which were spaced more closely together is used for flagstones or roofing slates, depending on their thickness. 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 also left in spoil tips close to the quarries.

Rough Rock was also exploited in the quarries to the east of Baildon Hill at Eaves Crag and at High and Low Eaves Delves as well as at Baildon Green and Baildon Bank quarries.



**Eaves Crag SE 1498 4045 showing different uses of stone**

### **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 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 (7).

### **Soft Bed Coal**

The Soft Bed Coal ranges from 0.2-0.9m thick in the Bradford area but 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 scales and other fish remains. Overlying the coal is a thick fireclay which was worked locally for the manufacture of fire-bricks (15).

### **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. The sandstone is often ganister-like at its top. The Middle Band Coal which lies above it ranges from 0-0.2m thick but is reported to be too thin to be workable in this area (15).

### **Seatearth 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 seatearth 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 seatearths 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 abandonment mine plan from 1904 records that 1.4m of fireclay was worked. Above it was 0.45m of coal, which is the Hard Bed Coal.



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

### **Hard Bed Coal**

The Hard Bed Coal ranges from 0.5-1.0m thick in the Bradford area but 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 (15). The coal was mainly used as engine coal but also used domestically in some areas (7).

### **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 a mile north-east of Baildon Hill (15).

### **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 (7), as shown in the cover photo, and a prominent shelf on Baildon Common (15). It has been quarried on the south side of Baildon Hill, as shown in the photo on page 11. 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.



**Escarpment formed by 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.**

### **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 about 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 (7) but may have been used for construction, 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.

### **Was groundwater an issue?**

Groundwater can cause many problems for mining operations such as the requirement for pit drainage, a reduction in slope stability and an increase in costs (11).

At Baildon Hill, there is evidence of mine adits which are horizontal or near-horizontal passages by which the mine can be drained of water and ventilated. The most probable cause of the presence of groundwater in mines at Baildon Hill is inflow from atmospheric precipitation. Sandstones have a high permeability which means fluid can pass through the rock easily. When there is rainfall, the water moves down (percolates) through the soil and into the underlying rock. There are many sandstone beds at Baildon Hill and therefore rainwater would have easily flowed into the mines and a drainage system would have been required.

### **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 meltwater permitted sandstones at the top of the slope (the 48 Yard Rock) to slide down a weakness 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. The landslips are mapped on BGS Bradford Sheet 69 Solid and Drift and a simplified map is given in Appendix 3 on page 16.



## How has mining affected the landscape?

The mining activity has affected the landscape at Baildon Hill in several different ways. Although some land restoration has been carried out once the mining ended, there is still evidence of the past excavations.

At the time, when areas of Baildon Hill were being exploited, there was no particular legislation to enforce mine rehabilitation. In the 19<sup>th</sup> 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.

When mining is initiated, land is often cleared which removes much, if not all the original flora of the area. Therefore, once the mining had ended at Baildon Hill, the land was probably left to repair itself. This led to the vegetation which eventually grew to be quite hardy due to the lack of good soil and possible mine pollution. The main types of plants found are ferns, grasses, gorse and other shrubs.

Over much of the area, depressions in the ground can be observed. These represent where some of the bells pits and shafts once were, through which coal was extracted, 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 fireclay mines. These are also presently covered by vegetation growth, as shown in the photo on page 10.



**Fireclay spoil to the north of the fireclay mine**



**Sandstone quarry waste at Acrehow Hill Delph  
SE 1444 4059**

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 due to either gravity or 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 and often has vegetation growth on top.

Baildon Hill also has areas of “made ground” which are man-made and are usually areas which have been filled in and often flattened using natural local materials or refuse. There is a map of made ground in the area in Appendix 3 page 16.

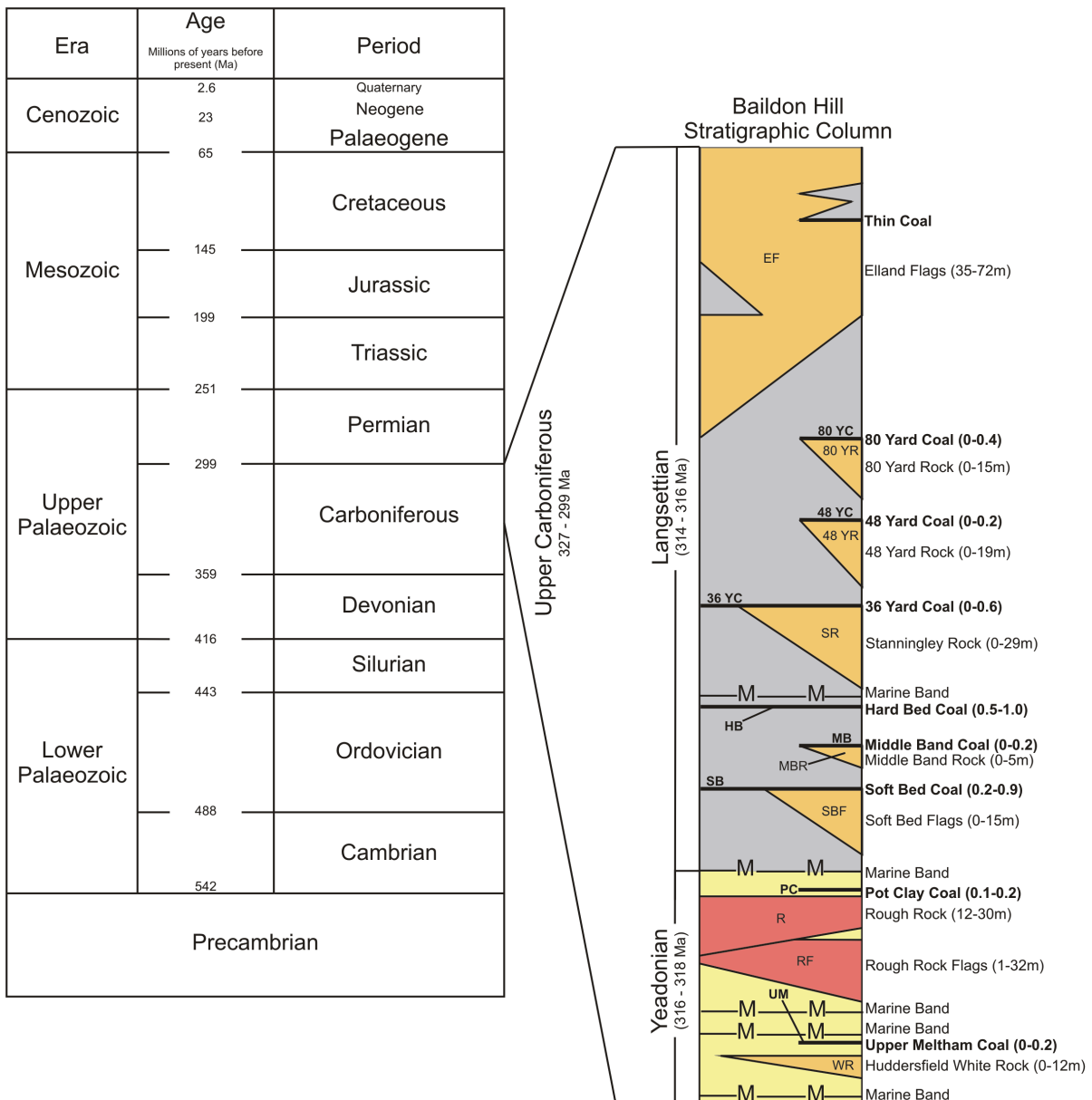
## Acknowledgements

Thanks to Gavin Edwards and Mike Short

## Reference List

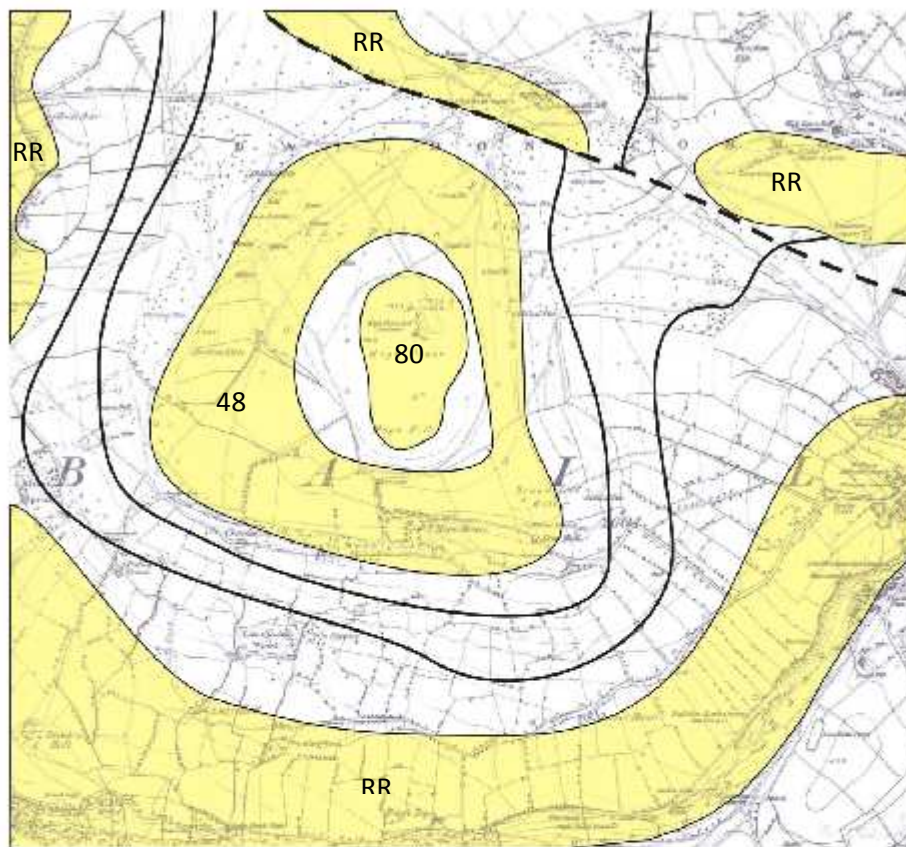
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## APPENDIX 1 Stratigraphic Column of Baildon Hill adapted from BGS Sheet 69 Bradford Solid





## APPENDIX 2 Simplified Geology Map of Baildon Hill



Sandstones are shown in yellow

RR – Rough Rock

48 – 48 Yard Rock

80 – 80 Yard Rock

Coal seams are shown as thick lines

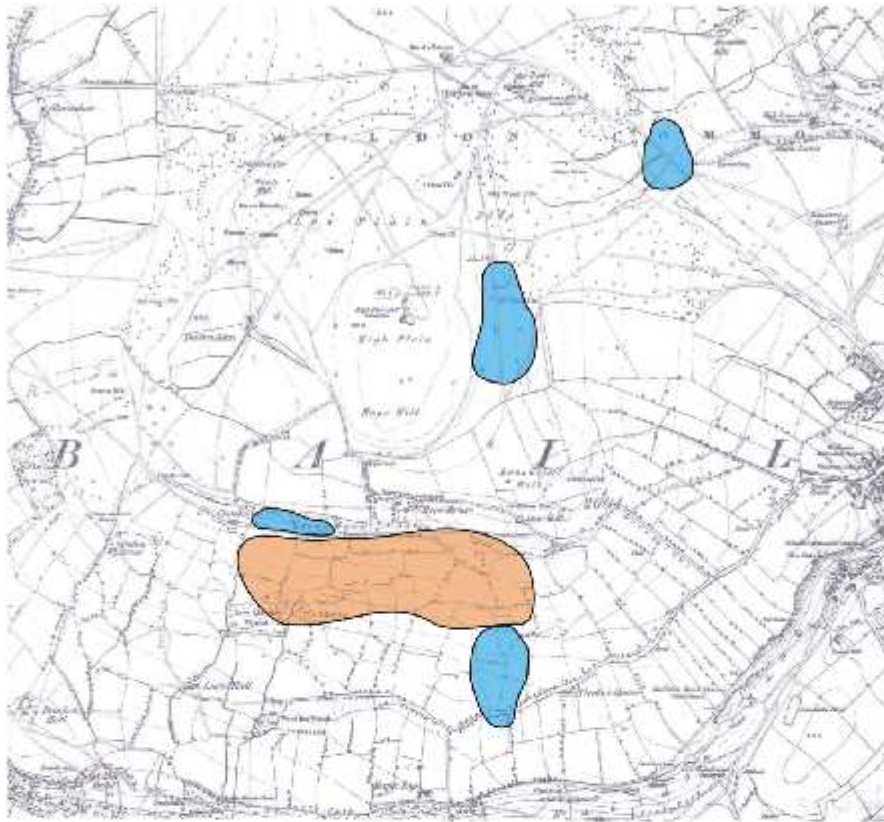
HB – Hard Bed Coal

SB – Soft Bed Coal

Mudstones and siltstones are left uncoloured

**Simplified geology map of the Baildon Hill area, with reference to BGS Sheet 69  
Bradford Solid and Drift. Base map is Ordnance Survey map c. 1852**

### APPENDIX 3 Simplified map to show landslips and made ground on Baildon Hill



The main areas of made ground resulting from mining or quarrying are shown in blue.

The landslipped area is shown in brown.

Information from BGS Sheet 69 Bradford Solid and Drift

Base map is Ordnance Survey map c. 1852