The Barnsley Local Geodiversity Action Plan

PREPARED BY SHEFFIELD AREA GEOLOGY TRUST &
BARNSLEY COUNCIL

September 2025

2030 Barnsley – the place of possibilities.

Sheffield Area Geology Trust

BARNSLEY Metropolitan Borough Council

Summary

This Local Geodiversity Action Plan (LGAP) has been written by Sheffield Area Geology Trust (SAGT) and Barnsley Local Geodiversity Sites Panel (BLGSP), part of Barnsley Council's Local Sites Partnership. SAGT is a not-for-profit body interested in good geoconservation and site management practice across South Yorkshire.

The purpose of this LGAP is to clarify the position of geodiversity in planning, development and decision-making in the borough; and to explain the importance of geodiversity assets in order to support their positive management and use. It is an approach that looks forward to the future of managing sites and landscapes in Barnsley Metropolitan Borough, and forging effective links with partners in site management, development and planning. Barnsley's rich geological history has shaped the character of its landscapes, rivers, settlements, people, industry and agriculture, but in the future it will be the wide-ranging demands from green industries to interplanetary exploration and the minerals, knowledge and people that will be needed to win them, that will become important.

Geodiversity sites also have an important role to play in providing local amenities for the health and education of young people as part of a population that appreciates and values the natural environment as well as the history and character of the area in which they live. Barnsley's geodiversity sites in recent years have also been a resource for higher education and the topics for scientific papers.

All images are by Rick Ramsdale, unless otherwise stated.

The aims of the Barnsley Local Geological Action Plan are to:

1. Explain the meaning of geoconservation and the reasons for its importance in Barnsley Metropolitan Borough (BMB);
2. Show how geodiversity fits into the planning policy frameworks at local, national and international levels;
3. Explain the local sites partnership and how geodiversity fits into it;
4 Explain the geodiversity objectives in working with developers at or close to a geodiversity site;
5. Explain the principles of enhancing geoconservation;
6. Discourage destructive use of geodiversity sites;
7. Promote constructive use of geodiversity sites by local schools, local decision-makers, communities and the wider public;
8. Establish links between different partners with an interest in the good management of geodiversity sites.

Introduction and Context:

Geodiversity is interested in valuing and conserving the non-living world around us; this means rock strata, minerals and fossils, that is, everything that isn't currently living and growing. Plants and animals, and their well-being, are the province of biodiversity.

The National Planning Policy Framework (NPPF, 2019) has provision to protect and enhance geodiversity (S174) and this Local Geological Action Plan (LGAP) is intended to assist the planning and management of sites in Barnsley Council by clarifying the structure and process of decision making about geodiversity sites for developers, builders, planners and councillors. It also provides guidance and information for individuals, local communities, local Councillors, parish councils and area assemblies about local schemes and it support individuals and groups that celebrate what is unique and valuable in their communities. It may also help with funding bids for appropriate local geodiversity site management operations.

Geological diversity underpins the variety of landscapes and habitats and includes the forces of weathering that shape them; it helps us understand and interpret the surface and deep-seated processes that have changed our planet over millennia and will continue to affect us into the future.

Fig 1. A typical upland view of a stone-built farmhouse and barns, with fields surrounded by dry stone walls.

Geodiversity is important in understanding, our landscape features and a wide range of ecosystem services of value to society. These include buffering river floods, managing aquifers and water supply. It also applies to managing agricultural land for food, as well as influencing the materials and sites for buildings. In addition, there is a role in possible green energy solutions for the future, for example, in using heat pumps to extract heat from warm mine waters.

Geodiversity needs to be taken into account in describing and managing ecosystem services and the environment more widely. This document should help towards better maintenance of geoconservation sites to avoid damage and enhance their value. The management of vegetation growth and erosional processes on sites are particularly relevant to this. In addition, the understanding of the natural environment and wildlife habitats may be enhanced.

An education in geodiversity, and all of its wide implications, will continue to provide jobs and work opportunities into the future, when we continue efforts to reduce carbon dioxide emissions, reduce energy usage and switch to green energy sources. Batteries for electricity storage will require many different mineral resources from those of the past, and it will require more of them, and more of the people to find and retrieve them for use.

This education should start at an early age with an appreciation of the local geodiversity assets in Barnsley, but it also provides opportunities for higher education, with many Barnsley Council sites being used in the past as fieldwork sites for international geological conferences and as the subject for academic papers.

In addition, Barnsley's links to scientific endeavour exceeds 100 years with the work of Walter Hemmingway. Born in 1859 on Old Mill Lane, he was a miner's son, who remains the only Barnsley-born person to have a fossil named after him. In 1901, Robert Kidston, in his two papers on "Flora of the Carboniferous Period", often cited Hemingway's valuable contributions to science, and included a plant specimen supplied by Walter and named *Equesites hemingway.*

Barnsley's geodiversity should also be valued for its aesthetic qualities from the landscapes of the upland moors in the west, to the lower farmlands and settlements of the east. Physical and mental well-being are supported by access to such places and their variety.

This Local Geological Action Plan (LGAP) has been prepared in two sections:

Sections 1 to 4 should be relevant to a range of developers, decision-makers and planners

Fig 2. View west over the Don Gap at Penistone to the treeless and peat covered, high moors. The A628 and a line of pylons mark the line where the River Don cuts through the west facing scarp of the Grenoside Rock.

who need to understand the decision-making structures which deal with geodiversity issues.

Its purpose is to clarify the significance of geodiversity in Barnsley Metropolitan Borough and its place in decision-making structure.

Section 5 has been prepared to promote wider awareness and understanding of the geodiversity assets in Barnsley Council to the wider public, local decision-makers, and educational interests at all levels. It has a role informing local decision-makers at parish level, as well as the people who will benefit from the use of local geodiversity sites in a range of ways from enhancing personal health and well-being to furthering their own, or their children's understanding of the natural world.

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The meaning of geoconservation and the reasons for its importance in Barnsley Metropolitan Borough (BMB)

1.1 The definition of geodiversity

Geodiversity is defined as the natural range or diversity of geological features, including rocks, minerals and fossils as well as geomorphological features such hill slopes, flood plains and other landforms. Geodiversity includes the inter-relationships between the rocks, soils, minerals, fossils and geological structures of the area. (Gray, 2004). This means it has a direct influence on 'where things are' in Barnsley; uplands, valleys, routeways, reservoirs, settlements, agricultural land and work opportunities are all located in places influenced by the geology of the area. Geodiversity also includes the many features arising from the exploitation by either underground or surface extraction of minerals from underground, as well as the evidence for such activities including abandoned mines, bell pits, open-cast sites, spoil heaps and other features.

A great deal about the geology can be learned from surface exposures, but the long history of mining means there has, in the past, also been a wealth of information about the sub-surface geology that is no longer available to us, making modern surface exposures even more important for future scientific work. Apart from the records from mining activities, information has also been derived from thousands of quarries, boreholes and shafts required for the planning and exploitation of minerals.

An understanding of the underlying geology also leads to a better understanding of habitats and their variation. The altitude, aspect, slope, permeability, soil chemistry and acidity of a site are all directly influenced by underlying bedrock. A similar effect will also be detectable in the river water, affecting aquatic communities: for example, the concentration of magnesium and calcium ions would be expected to increase rapidly downstream when the Dearne river water enters the River Don and flows over the limestones of the Don Gorge. Turbulence created by streams tumbling over resistant rock ledges in the stream bed also help to aerate the water and support aquatic communities. (See Fig 3).

Fig 3 Sandstone ledges eroded into stream beds help to aerate the waters and support aquatic habitats.

The recognized geodiversity sites in Barnsley include two Sites of Special Scientific Interest (SSSIs) and, currently, thirty-two Regionally Important Geodiversity Sites (RIGS), but there are also very many Local Geological Sites (LGS), which augment the understanding of the geological interpretations between the major sites.

1.2. A summary of Barnsley's geological history and landscapes.

The primary evidence for the science of geology comes directly from rocks, either underground or at surface outcrop, and this is the basis for the recognition and selection of geodiversity sites. In order to understand why sites have been selected it is necessary to summarise the geological context in which they are believed to have formed and the effect they have had on both man-made and natural landscapes.

The deposits in Barnsley Metropolitan Borough are from two very different contexts. The older is from the Carboniferous geological period (from about 359 to 290 million years ago) and the younger is the Quaternary glacial epoch and Holocene, from 1.8 million years ago to the present day.

1.2.1 The borough's Carboniferous geological history

Barnsley lies in the South Pennine Coal Measures Basin, of Upper Carboniferous times (Westphalian) age. These are the same strata which underlie the southern North Sea gas fields, and they are a valuable world-wide scientific example for study of their sedimentary characteristics at outcrop. Due to the rapid and varied lateral changes in these beds, three dimensional exposures at the surface are easier to understand than from borehole cores. These rocks also provide a continuing source of material for modern and historical stone buildings.

During the Early Carboniferous time period (called the Visean Stage) South Yorkshire lay across the Equator on the southern edge of a huge continent and had a tropical climate. During the early part of the Carboniferous warm, clear, shallow seas allowed thick limestones to be deposited, these now underpin the landscapes of the White Peak, but are at depth, and do not outcrop in South Yorkshire.

Later, in the Namurian Stage, of the Carboniferous the 'Millstone Grit' rivers flowing from the north brought vast amounts of coarse sands and mud and repeatedly built large deltas into the, now muddy, sea. This area known geologically as the Pennine Province, lay between the Southern Uplands and a topographical ridge which extended between Wales and London and into Belgium. Layers of rock were deposited on muddy sea floors, sandy delta tops or on the underwater slopes between the two. The result was a sequence of coarse gritty sandstones deposited between muds, with an occasional coal seam. Periodic flooding by the sea deposited thin Marine Bands, recognised by their marine fossils.

The upper two of the resistant 'Millstone Grit' sandstone layers (White Rock and Rough Rock) now form the, largely treeless, western uplands of Barnsley Metropolitan Borough, mainly within the Peak District National Park. The headwaters of the River Don and its tributary 'dikes' rise at 480 m above sea level. and are fed by springs from the White Rock sandstone and its cover of peat (See Fig 4.). They have cut narrow, incised valleys (cloughs) as they flow east into Winscar reservoir, itself sited there because of the high relief rainfall on the uplands, the presence of less permeable clays and also local building stone for the dam. The Don then flows east to Penistone and turns southwards into Sheffield Metropolitan Borough at the Don - Dearne watershed which divides the borough (See Fig. 4.).

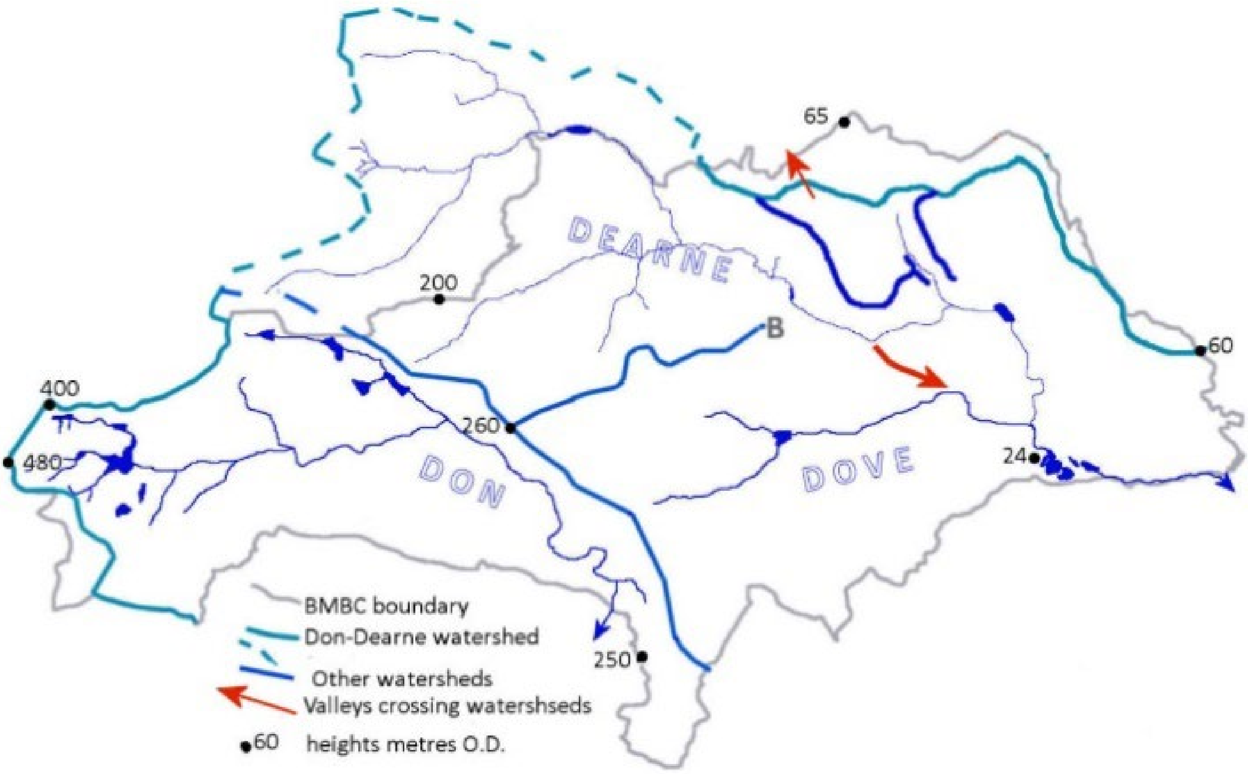


Fig 4. Map of the main drainage features of BMBC.

The acid soils on the gritstones support blanket bog and heather moorland, which, apart from storing large amounts of carbon, slow up water flowing into the rivers reducing flood hazards as well as providing the habitat for rare bird species. Humans have taken the lower slopes as 'in-bye' and used them for upland pasture in a landscape characterised by gritstone dry wall field boundaries and stone-built farms and villages (See Fig 1.).

During the later Carboniferous time period, called the Westphalian Stage, the Pennine Province became a near sea level waterlogged plain covered with lakes and large river delta distributary systems, part of a landscape which extended from Ireland across northern Germany to Poland. The rivers flowing into the Pennine Province came from a huge continental mass to the north and west and brought mud and sands to build extensive deltas. For the one and only time in Earth history, large forests of arborescent (tree-like) lycopod plants colonised the large waterlogged areas on top of the deltas where extensive peat mires developed from the fallen vegetative debris.

This material became changed, during long periods of burial, into the large number of coal seams. Although these coal seams only form about 2% of the sediment thickness, they became outstandingly important as a source of fossil fuel, as sites for industry, work and for understanding the development of settlements, as well as the road and rail links between them. In addition, pot clays, brick clays, sands and siderite ironstones supported local industrial development, along with sandstone quarrying.

The large number of sedimentary cycles and coals was caused by a repeated series of sea level changes during the Westphalian times, driven largely by changes in the volume of ice caps at the southern pole. The rising sea level flooded the peat marshes on the delta tops and 'reset' the coastline and river systems further back, causing another delta to be built over the deposits of the previous one. The most recent delta top then became re-colonised by plants and another cycle of sediments, with a possible coal seam at the top, was formed (See Fig 5.).

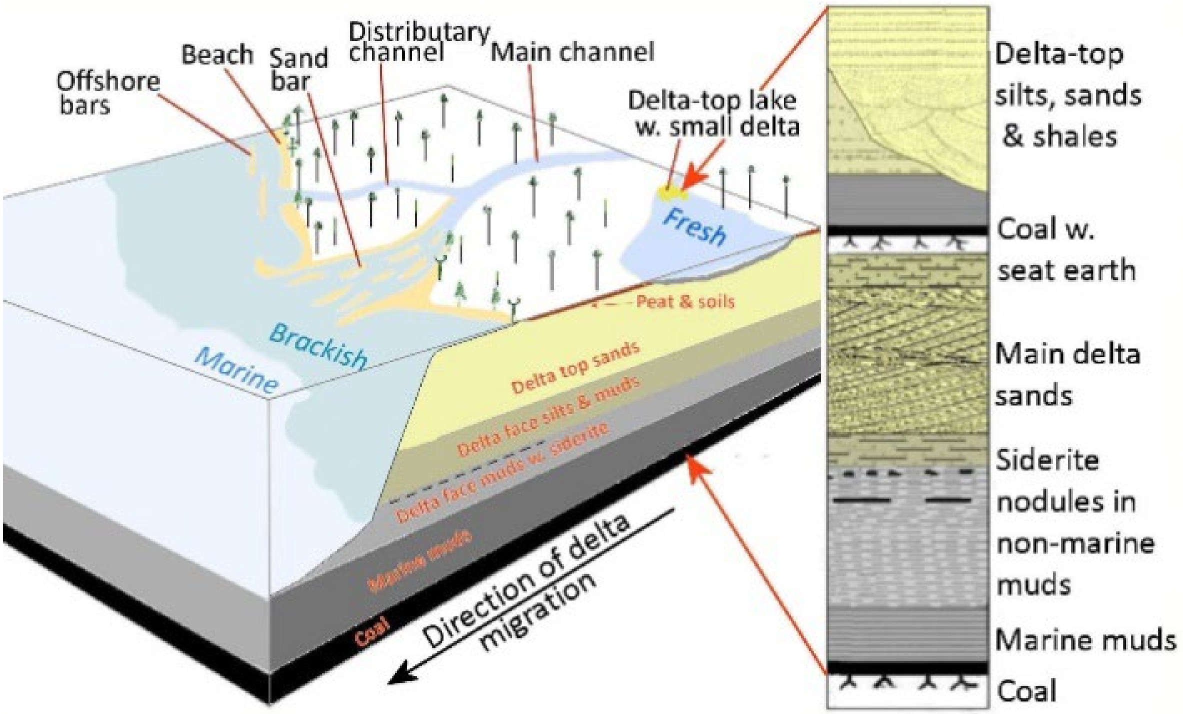


Fig 5. Diagram showing how delta migration can form repeating cycles of sedimentary layers after the area becomes re-submerged.

Towards the end of the Carboniferous Period continental collision built a fold mountain chain across southern England, and through northern Europe, causing uplift and erosion. This means the younger Coal Measures (Stephanian Stage) strata are now missing from South Yorkshire. This continental uplift caused the initial raising of the Pennine axis as well as the faulting and generally east-north-eastwards dip of rock strata across Barnsley Metropolitan Borough. This eastwards inclination is why the rock strata get younger from west to east across the borough. (See Fig. 8). Any rock deposition that might have occurred after the Carboniferous period was removed by erosion and leaves no evidence within Barnsley Metropolitan Borough.

The landscape of the eastern two thirds of Barnsley Metropolitan Borough has been largely shaped by two river systems, the Dearne and its tributary, the Dove. They both rise from springs at heights around 200 m O.D. in the sandstones and shales of the ridge of Penistone Flags that extends ENE to WSW (roughly along the line of the A629 Huddersfield Road). They flow east and southeast leaving the borough just downstream from the Old Mill wetlands at a height of 24 m above sea level. (See Fig. 4).

Fig 6. A cuesta (asymmetrical ridge) caused by the Silkstone sandstone dipping east (left) forming the gentle dip-slope, whilst the westerly facing scarp slope is much steeper and covered by Tom Royd Wood.

Today the landscape of the South Pennine fringe is characterised by western uplands of more resistant ‘gritstones’ and higher rainfall giving way eastwards to a progressively lower landscape of meandering rivers, like the Don and Dearne, in wooded valleys formed where mudstones outcrop. The faulted blocks of these sandstones (less resistant to weathering than the ‘millstone grit’) underlie the short lengths of low, faulted escarpments with steeper westerly slopes and more gentle easterly slopes. (See Fig 6). To the east more agricultural use of the land occurs in fields usually divided by hedgerows rather than drystone walls. In places the hedgerows have been replaced by wire fencing, often where the shallow coals were open-casted during the war, thereby destroying the hedges. Older settlements made use of local stone to construct houses and churches and many villages gave their name to the sandstone (and coal seams) strata on which they were built: for example, Silkstone, Haig and Barnsley.

1.2.2 The borough’s Quaternary Glacial history.

The last glacial epoch was not a single event of climate cooling with ice building up, becoming thick enough to flow from northern mountains out over lower ground and deposit its load of moraines across the landscape as it melted and receded. Science dates the beginning of the glacial epoch from 1.8 million years ago and sediment cores from ocean floors indicate that more than fifty repeated cycles of glacial or periglacial (tundra) cold followed by warmer periods have occurred. There is nothing to suggest these cycles have stopped. We are currently living in the most recent inter-glacial episode.

Since each ice sheet bulldozes the evidence of previous ones there are only traces of a few of the more recent glacial events across Northern Europe. The last U.K. glacial episode is called ‘Devensian’ and its end is dated at 11,000 years ago. In Yorkshire the ‘newer’ glacial moraine deposits from this event can be seen on the east coast cliff tops north of Bridlington, and along Holderness, but not in Barnsley Metropolitan Borough. Glacial moraines are typically made of ground up rock and clays with sand and a range of sizes of cobbles and boulders mixed in, sometimes called 'boulder clay'. Devensian moraines do not occur in Barnsley because the ice didn't reach here during the Devensian. This means that the 'older' glacial deposits that had been deposited here much earlier were not bulldozed away or buried. They occur today in small patches, generally across slopes and hilltops in South Yorkshire, having been eroded off lower slopes and are regarded as 'older' deposits from the 'Anglian' glacial episode, around 440,000 years old, or nearly half a million years ago. The absence of a Devensian glacial cover also means the rivers and landscapes in Barnsley Metropolitan Borough are very old compared with the rest of Northern England, having developed through a series of periglacial and interglacial climates over the last half a million years.

It is thought that the major river systems of northern England, like the Trent and the Don (and probably the Dearne) began as meltwater outflow channels from the Anglian ice and have become re-routed and shaped by the climate changes that have happened since. The alluvial deposits, floodplains and river terraces, built up along these valleys have been deposited during this time. The complicated post-glacial history may explain some of the strange valleys in the Dearne catchment, now used as routeways; for example, the breach in the watershed between the Dearne and the Calder near Royston, where the Barnsley canal crosses the watershed, and the short valley between Grange Bridge and Stairfoot, crossing from the Dearne to the Dove catchment and now followed by the A633.

Fig 7. Sandstone gargoyle with the detail weathered away over centuries of exposure.

1.3 Barnsley's man-made environment and geodiversity.

Not all of the Westphalian sandstones provide high quality building materials, especially where the natural cement holding the sand grains together is weak. Some of these stones have, however, been used for walls and sometimes barns and houses locally, but after more than a century have become deeply weathered. (See Fig. 7).

The better quality (and more expensive) stones were used for the keystones at edges of buildings, lintels and for ornamental designs where they could hold a sharp edge. These stones were called 'ashlar' and can be seen on many older buildings around the borough. These stones were usually brought from specialist quarries often in other parts of South Yorkshire, but recently a quarry opened up near Penistone quarrying Grenoside Rock for new housing and for repairs to older properties. Grenoside Rock was commonly used as a building stone in the west of the borough and most of older Penistone buildings and its viaduct, for example, are built of Grenoside Rock.

Later builders made use of different materials (bricks and slates) which could be brought in cheaply, initially by rail, from large producers elsewhere in the U.K. Barnsley Town Hall is an outstanding example of a Portland Limestone building in a borough that has no natural limestone at the surface.

Apart from timber and paper, the materials used for modern houses are geological in origin: components of cement, tiles, asphalt, glass, paint, plastic, ceramic and steel all originally came from a hole in the ground.

Today a walk down any shopping street will take you past shop fronts with decorative stone from other continents, chosen not for their strength and local supply, but for unusual mineral colour or geological texture.

Society's geological needs have changed in the past and will continue to change into the future. Many new products like cars, computers, mobile phones and anything with a battery require an enormous number of different chemical elements, mainly from new geological sources.

1.4 Barnsley's geodiversity heritage

The evidence to support the national interpretation of geological events comes from a wide area of Britain, but some of the sites in the borough are of international importance. There are Barnsley Regionally Important Geological Sites (RIGS) which record this evidence, as well as two Sites of Special Scientific Importance (SSSIs).

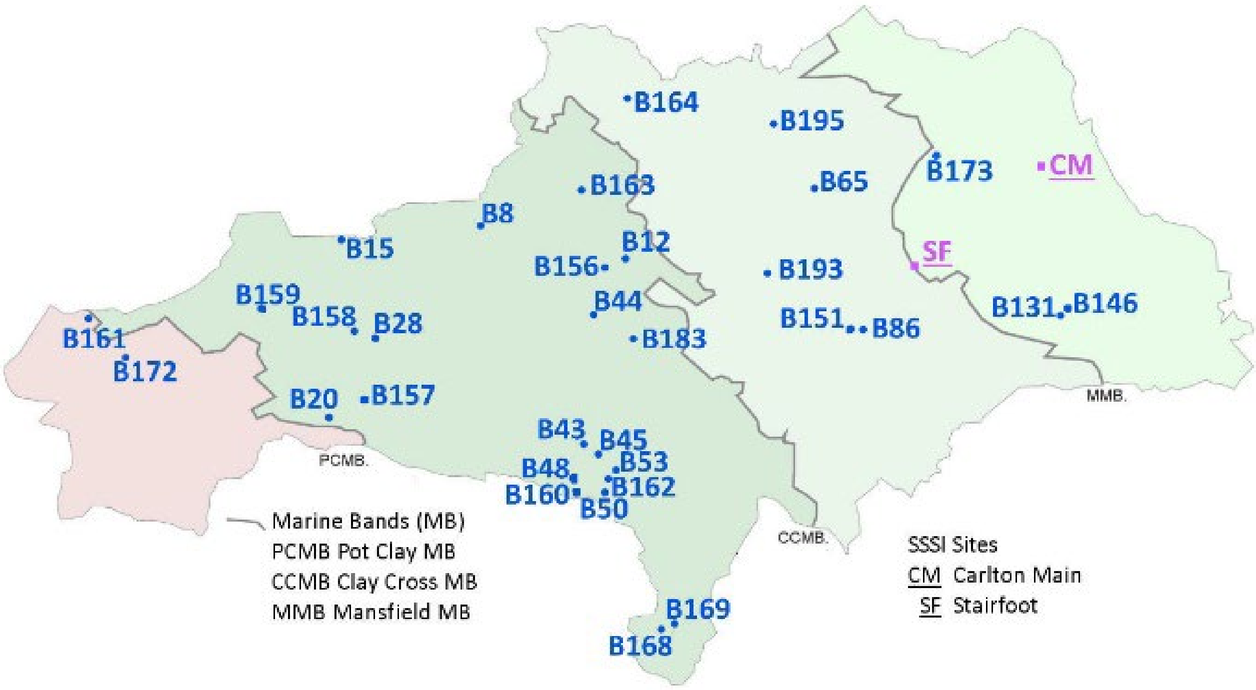


Fig 8. Map of the Marine Bands and location of RIGS sites in Barnsley MB.

The Upper Carboniferous strata are divided by important marine bands which mark marine transgressions (floods) across the coal fields. Each of these marine bands are marked by Sites of Scientific Interest (SSSIs) two of them in Barnsley Metropolitan Borough. Some marine bands can be traced across northern Europe. They are recognised by, and named after, the marine fossil goniatites they contain. The outcrops in this area are so important many features have been named after local places. (See Fig 8.).

Fig 9. Images of finds at Rabbit Ings and Yorkshire Main.
a: Palaeoxyris: (a shark's egg case) longitudinal section. Found at Rabbit Ings.
b: Palaeoxyris: showing external detail. Found on the tip for Yorkshire Main Pit, Doncaster.
c: Neuropteris leaves, found at Rabbit Ings.
d: Mick Birkinshaw at the Rabbit Ings site in 2016.

The Carboniferous deltaic strata, stacked one upon the others, have been divided up by the marine bands which mark marine transgressions, or marine flooding events, and are named after fossils they contain. The top of the Millstone Grit and the base of the Coal Measures is marked by the *Gastrioceras subcrenatum* Marine Band which lies immediately above the Pot Clay coal. (See Fig.8.) Above it lie the Langsettian strata the top of which is the G. *vanderbeckei* (Clay Cross) Marine Band. Then comes the Duckmantian strata topped off by the G. *aegiranum* (Mansfield) Marine Band), protected by the Stairfoot SSSI. The Bolsovian strata above have been eroded and the top is missing after the deposition of the Dalton, Wickersley and Ravenfield sandstones, but the last, or Top, Marine Band, named after G. *cambriense* is important, even though it wasn't used to divide up the strata, and it is legally protected by the Carlton Main SSSI.

Regionally important sites (RIGS) preserve a wide variety of evidence about the Carboniferous environments and the changes they underwent. The most prominent outcrops are the sandstones which vary in thickness and split into separate layers. They record important information about the river channels and their distributaries crossing the low vegetated, marshy area and feeding into lakes and deltas. Mud rocks and marine bands are rarely exposed today because they weather quickly to form a soil which covers the outcrops. With these rocks we need to rely on temporarily exposed sections during construction.

Not all of Barnsley's geological heritage is at outcrop. Some are disused mine dumps and pit tips which have provided rare examples of fossilised materials. Dumps from nineteenth century mines in the Ganister Coal, pits now closed and dangerous, have been the source of silicified examples of *Stigmaria ficoides* rootlets. A more recent, twentieth century tip, Rabbit Ings, once the tip for Monkton Main, has been the site for finds of *Stigmaria*, fragments of *Calamites* and *Lepidodendro*n stems as well as the leaves of the seed fern, *Neuropteris*. (See Fig.9.). The second and third Carboniferous shark egg case (*Palaeoxyris*) to be found in South Yorkshire were also found here.

The best example of a Quaternary glacial erratic (a rock with a geology not matching the area in which it is found) is now located in Locke Park Gardens, after being moved from Royston early in 1887. This was a result of co-operation between the Barnsley Naturalist and Scientific Society, the Town Council and the Wentworth Estate and reflects the considerable civic pride of the time in Barnsley's geological heritage.

How geodiversity fits into the planning policy frameworks at international, national and local levels.

2.1 Outline of the planning policy structure at international, national and local levels.

Internationally geodiversity is recognized and protected by the United Nations Educational, Scientific and Cultural Organization (UNESCO), through the Global Geoparks Network and, working with the UK National Commission for UNESCO, it advocates the importance of geodiversity along with its environmental, historical and cultural links as well as its role in sustainable economic development.

England has one UNESCO World Heritage Site, the Jurassic Coast in Dorset, and, currently, three Global Geoparks. These are The North Pennines Area of Outstanding Natural Beauty, the English Riviera in Southwest England, and the West Midlands (Black Country) area. In addition, the Peak District National Park has been proposed as a further Geopark.

In England geodiversity is currently protected by the Wildlife and Countryside Act (1981) and the Countryside and Rights of Way Act (2000) and the importance of including geodiversity in the planning system is recognised in the National Planning Policy Framework (NPPF) (2012).

The conservation status of Barnsley's RIGS is measured by the Single Data List 160 and, as a result, Barnsley's Local Plan has adopted Policy B101 'Biodiversity and Geodiversity' with the aim of conserving and enhancing the Borough's biodiversity and geodiversity features. It is measured by the SDL 160 which the local authority reports annually to Defra. SDL 160 is a simple count, expressed as a percentage, of local sites regarded as being in positive conservation management over the previous five-year accounting period.

The management of this process (described in section 3.1) is achieved through the Borough's Local Sites Partnership which comprises the Local Wildlife Panel and the Local Geodiversity Panel. It is not unusual for Local Geodiversity Sites (LGS) to include assets of interest for the Local Wildlife Panel and vice-versa.

2.2 The description of the hierarchy and significance of geodiversity sites in Barnsley M.B.

The hierarchy of geodiversity sites is based on their national, regional and local significance. At the national level the Natural Environment and Rural Communities Act (2006) stressed the importance of geology, both nationally and regionally, and it placed a duty of care on Natural England to protect geology at a regional level.

Sites of Special Scientific Interest (SSSIs). In 1977 the UK Joint Nature Conservation Committee (JNCC) began a Geological Conservation Review (GCR), whose aim was to identify and catalogue the most important geological sites in Great Britain. This programme was fundamental to the identification of geological Sites of Special Scientific Interest (SSSIs) (as well as European and Global Geoparks and World Heritage Sites) and it still underpins the geoconservation advice provided by Natural England. By 1990 over three thousand SSSI sites were listed including, in England, including more than 1200 geological and geomorphological nationally important SSSIs. This amounted to 30% of the total.

Local Geological Sites (LGS). These sites are not protected by national legislation, but have recognition within the local planning framework. The terminology used to describe LGS sites has been subject to change over recent years, but in Barnsley the following definitions of LGS sites are in use.

- *Regionally Important Geological and Geomorphological Sites (RIGS).* These are selected by reference to a series of criteria which are based on the 1996 RIGS selection guidance for sites in South Yorkshire, UKRIGS criteria and DEFRA (2006) Local Sites Guidelines. Sites are recognised for their regional significance if they cross the threshold. Candidate RIGS (cRIGS) are proposed and discussed at the Barnsley Local Geodiversity Panel, where full RIGS status may be conferred. Degraded or 'lost' sites may similarly be deselected.

- *Locally Important Geological and Geomorphological Sites (LIGS).* These sites do not reach the threshold to be recognised as RIGS sites, but may still be important in the way they augment more significant sites in the area, for example providing evidence of lateral geological changes, or the areal extent of geological phenomena.

- *Temporary Sites: S*ites in key areas may become temporarily exposed, for example during construction work, and here it is often useful to gain permission to log, perhaps collect samples, and photograph the site before it is re-covered.

- *Other Sites:* For completeness of the SAGT database of sites, information is also kept on a wide range of other sites which are not included within the LGS designation. Many are very small, difficult to access, or otherwise unsuitable, but contain useful information.

2.3 The pathways for moving geodiversity sites into positive management.

The procedures for managing geodiversity in the borough lies with the Barnsley Local Geological Sites Panel (BLGSP).

A programme of condition monitoring reviews of Local Geological Sites (LGS) is commissioned by Barnsley Council each year on a rolling five-year cycle, and these are conducted and reported on by members of the BLGSP. These, and other reports, may be the basis for a new designation of RIGS status, or the deselection of degraded or 'lost' RIGS

The role of the BLGSP.

- Agree the basis for LGS selection
- Evaluate proposed LGS against the agreed site selection criteria.
- Approve the designation of LGS to include them within the Local Plan.
- Review existing LGS and approve de-selection.
- Collect data to enable LGS to be proposed and monitored
- Provide guidance on monitoring and management of LGS and assist with identification of opportunities for conservation, enhancement and mitigation.
- Review and revise the LGS system as necessary.
- Support BMBC in SDL-160 reporting.
- Promote the importance of LGS at a strategic level.

sites. They are also the basis for the decision of whether or not the site is in positive management.

Until 2023 the DEFRA guidance suggested that a site in positive management must have a Geological Action Plan (GAP) which formally states the management guidance and advice. As such, Barnsley had one geodiversity site in positive management, as a plan of action had been agreed with a local Parish Council. Another has recently been agreed with Yorkshire Water.

However, the June 2023 DEFRA guidance on SDL 160 data, makes it clear that two other pathways are possible. In each case decisions by the BLGSP must be based on documented field evidence deriving from a field visit to the site in the form of a condition monitoring report. Now there are three pathways into positive management for geodiversity sites. These are:

1. A site where there is no plan for management intervention may still be regarded as in positive management if a field visit establishes the evidence that no action is needed over the next five years in order to conserve the features of the site. (DEFRA 2023, p 16)

2. At a geodiversity site where the primary interest is public education (e.g. it is the subject of a geo-trail or walk) and access is managed for reasons other than geodiversity, the site may be regarded as in positive management. (DEFRA 2023 p 15).

3. An agreed and documented five-year GAP negotiated between the site manager and SAGT (on behalf of BLGSP) detailing the guidance and advice for conserving the site, and listing the actions necessary and those responsible for carrying them out.

The Local Sites Partnership and how geodiversity fits into it.

3.1 Description of the structure of the Local Sites Partnership and the place of geodiversity.

The Barnsley Local Sites Partnership (BLSP) comprises Barnsley Council representatives and members of the Barnsley Local Wildlife Sites Panel (BLWSP) and the Barnsley Local Geological Sites Panel (BLGSP).

The two panels works together in the partnership arrangements for the delivery of the overall Local Sites system in Barnsley. The panel operates in accordance with the Local Sites Guidance published by Defra in 2006. The overall purpose of the local sites system according to DEFRA (2006 p.40) is as follows:

"The series of non-statutory Local Sites seek to ensure, in the public interest, the conservation, maintenance and enhancement of species, habitats, geological and geomorphological features of substantive nature conservation value. Local Site systems should select all areas of substantive value including both the most important and the most distinctive species, habitats, geological and geomorphological features within a national, regional and local context. Sites within the series may also have an important role in contributing to the public enjoyment of nature conservation."

RIGS threshold levels.

SCIENTIFIC: The features are the best in the region. The site has been cited or made a contribution to published research.

EDUCATIONAL: Basic educational ideas can be easily conveyed to primary or secondary pupils, or the general public.

HISTORICAL: A regionally important site (e.g. a building stone source). The site was first described by a generally known geologist. Evidence of extraction or processing.

AESTHETIC: A regionally important landscape feature, or a site well used for non-geological purposes e.g. hiking.

The role of the BLGSP is to maintain the geographical and geological distribution of sites and seek to designate new sites where there are spatial gaps or gaps in the coverage of parts of the geological sequence or geological features. Those which become irretrievably lost will be de-selected. The BLGSP works to promote site conservation and improvement.

3.2 Outline of the methods for identifying, describing, mapping and managing local geodiversity sites.

The process begins with the collecting of evidence, including desktop and field research, whereby a report on a site including details of its location and features of importance is compiled. This report will include relevant maps, measurements, sketches and photographs, as well as citations from previously published work. This evidence base forms the foundation for the rest of the process which will include a field visit.

Work on LGS sites has been conducted in South Yorkshire since the 1970's, but the main impetus came in the 1990's when the current RIGS method was introduced and most RIGS sites were first identified. Assessment of sites is conducted in four areas: Scientific, Educational, Historical and Aesthetic. A site need only pass the threshold for one area in order to be considered for RIGS status.

The condition of geodiversity assets at a site can be generally expected to deteriorate over time. Vegetation growth, slipping and slumping, or erosion and vandalism can affect sites. These factors should be included in the report.

In addition, the accessibility of sites is also a relevant consideration in assessing a site. The availability of parking for 2-3 cars or a minibus close to the site, the condition of footpaths, gates, stiles and wheelchair access are also considered.

Many of these sites have various limitations regarding access. Many have limited parking or are on private land making it necessary to obtain permission for access to the site. At certain times this may not be forthcoming for various operational reasons, e.g. the presence of pasturing animals, lambing time or bird nesting season.

The safety of sites is also a consideration. High, or potentially unstable faces, would require suitable precautions, for example avoiding dangerous areas and the wearing of hard hats and / or high visibility clothing.

Reports and photographic evidence are considered at a meeting of the BLGSP where, after discussion, a decision to adopt a site as a RIGS, or not, is taken. Once the BLGSP decision to accept a RIGS site has been taken, the wider Partnership is notified and any comments taken. The site is then located on the borough's mapping system and the site manager receives a copy of the site description, or, for established sites, the condition monitoring report. The site is then included within the SDL-160 monitoring system.

The issue of deselection of a RIGS site is approached in the same way. Sites which, for a variety of possible reasons, have slipped below the threshold can be removed from the system.

LIST OF BARNSLEY RIGS AS AT OCTOBER 2025 (n=32)

8 Bentcliffe Lane Q	12 Little Fall Wood Q
15 Summer Ford	20 Bradshaw Q
28 Westfield Lane Q	43 Thurgoland Cutting
44 Nabbes House Cutting	45 Huthwaite Q
48 Greenmoor Q	50 Well Hill Lane Q
53 Hey Crook Q	65 Burton Bank
86 Lewden Q	131 Quarry Hill Railway Cutting
146 Darfield Q	151 Worsborough Dale
156 Silkstone Bypass	157 Hartcliff Hill
158 Thurlstone Bank	159 Burntshaw Q
160 Greenmoor Delph	161 Harden Clough
162 Raven Rocks	163 Cawthorne Bypass
164 Brookhill Q	168 Hobb Stones Tor
169 Scarp; Wharncliffe Rock	172 Winscar Reservoir
173 Knowle Q	183 Falthwaite Wood
193 Locke Park Gardens	195 Staincross Railway Cutting

3.3 Outline of the significance of these sites to the understanding Carboniferous and Quaternary environments and modern landscapes.

Attempts are made to create a spread of geodiversity sites, but it is noticeable that the eastern side of the borough has fewer than the west (See Fig. 8.). This is due to the geological changes late in the Carboniferous period (called Westphalian) that resulted in fewer sands and more muds being deposited. Consequently, there are fewer surface exposures since the mud rocks weather and slump very easily, smoothing the slopes and covering the geology. This also means that the stratigraphical coverage of the whole sequence of strata in the borough, is likewise, slightly skewed.

The geodiversity sites that have been selected do reveal a great deal about the sedimentation in the Pennine Basin and the behaviour of the delta distributary systems. Those sites exposing a continuous upward sequence reveal changes over time, whilst a series of sites across the borough may also reveal lateral environmental changes across the delta system at a particular point in time.

One site, a working quarry, did, temporarily, expose the full coal measure cycle between the Hard Bed (Ganister) and the Lower Band coals in almost 35 metres of succession. This occurrence is extremely rare, but led to the recording of valuable information.

During the Westphalian the Pennine Basin lay just north of the Equator and received the rivers from extremely large continents to the north and west. These rivers were easily the size of any we know today and broke up into many delta distributaries as they reached the near sea-level swamps of the Pennine Basin. The behaviour of these river systems is recorded in the rocks of South Yorkshire.

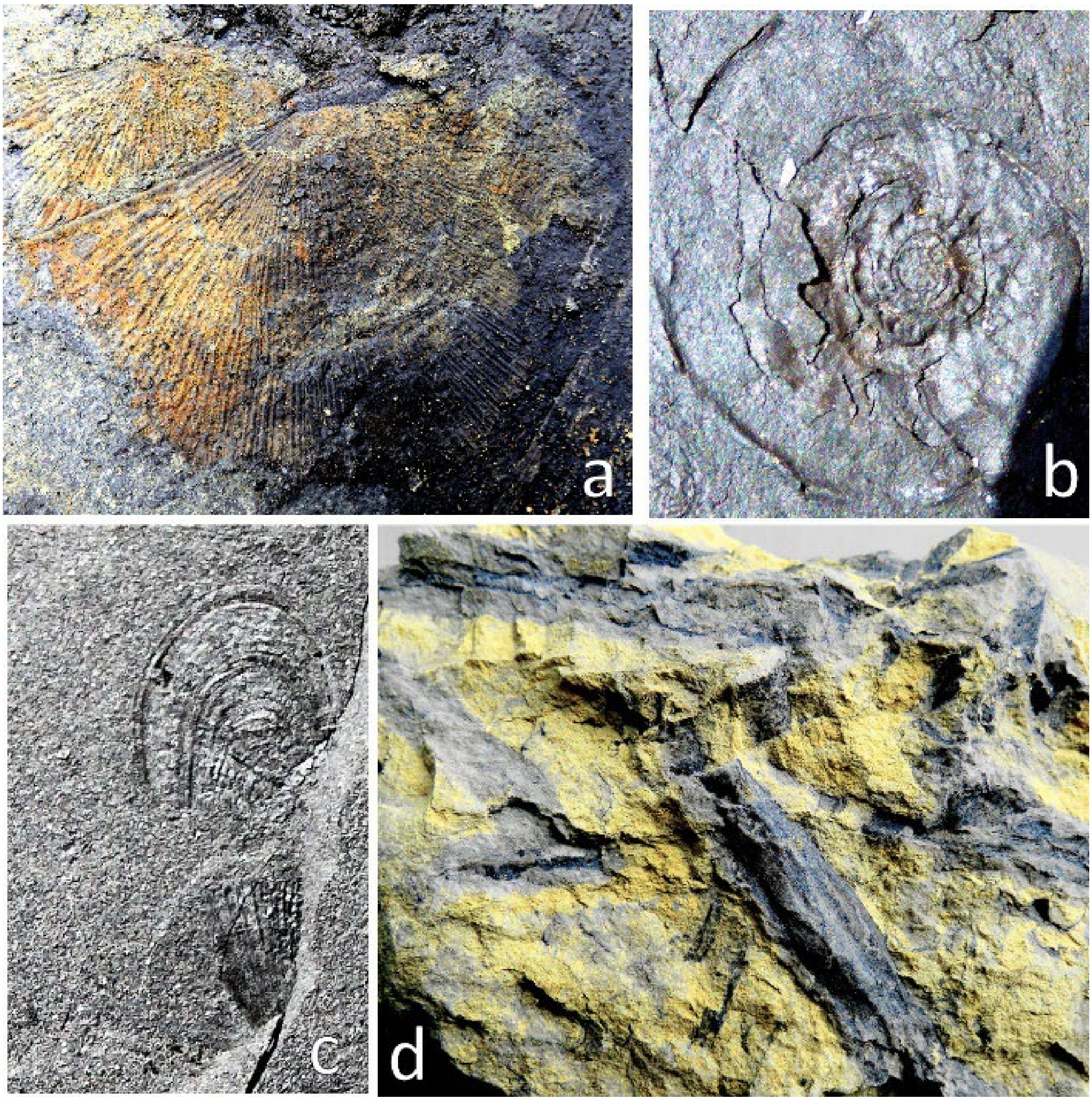


Fig. 10. Examples of fossils from the Barnsley Coal Measures.
a: *Dunbarella*, a flattened and decalcified bivalve.
b: G. listeri a flattened and decalcified goniatite from the Listeri Marine Band.
c: *Lingula*, a flattened and decalcified brachiopod.
d: a seat earth with carbonised rootlets from beneath the Hard Bed Band coal.

Sites revealing channels cutting into previously deposited rocks have been identified, representing diversion of a channel and a possible time of lowered sea levels facilitating down cutting. Overbank deposits, which are thinner than channel deposits and with different sedimentary structures, are also known at Barnsley LGS sites. Other sites reveal where the river banks were breached and a short-lived flood of water and sediment bursts across the floodplain or into a lake, forming small deltas in lakes and laying down sand beds over the thinner bedded lake deposits.

Some sites record the details of the changes after the channel becomes abandoned. Channel sides slump into the slack water in the abandoned channels helping to silt them up creating a muddy marsh land. Plants then colonise the abandoned river system, an event usually recorded as root systems, often stigmaria, indicating the formation of extensive forests of lycopods (scale trees) which formed coal marshes, and, if preserved, a coal seam above the root bed which is often called seat earth.

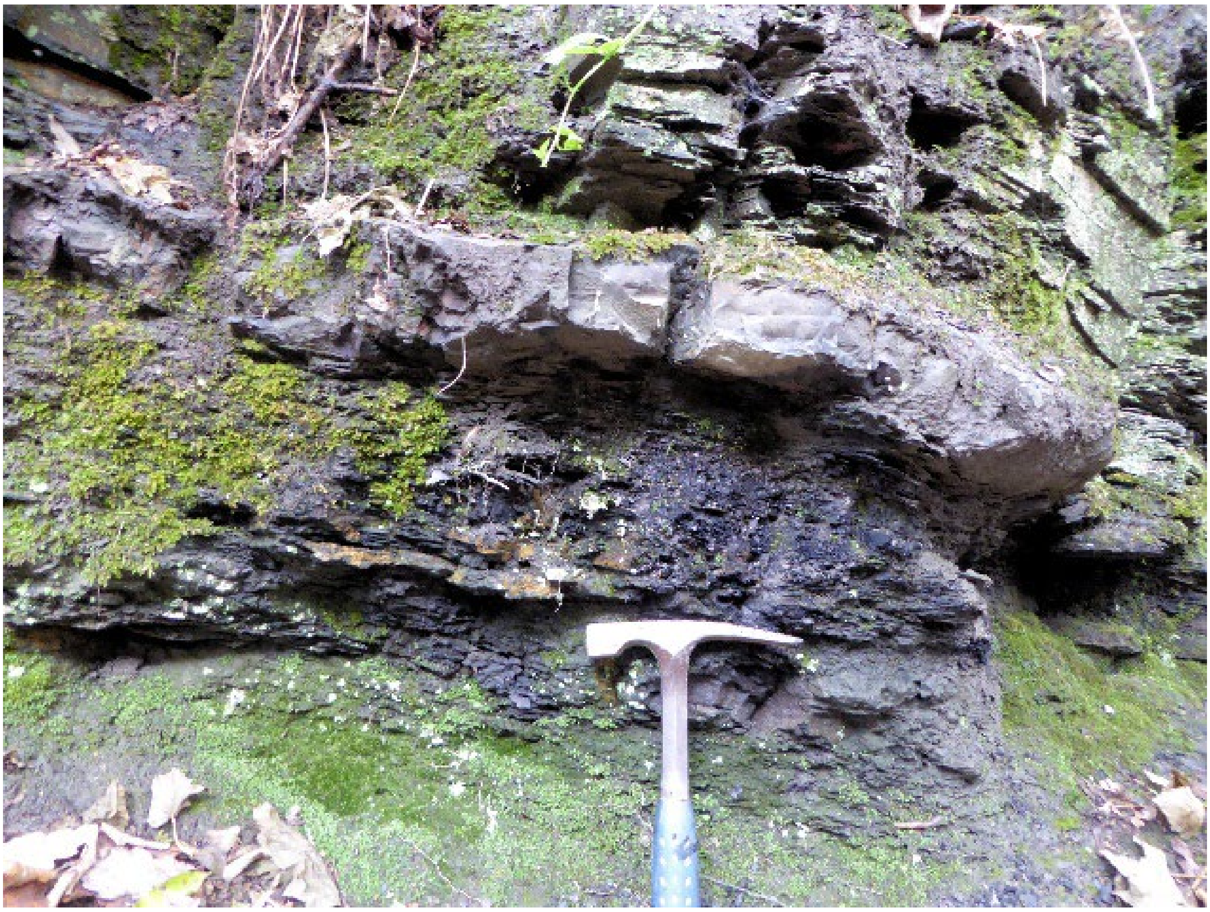


Fig. 11. The Claywood Ironstone overlying a thin coal seam. The proximity of thin, and relatively impure, sedimentary resources such as these were the basis for small scale local industries in the borough, in earlier centuries.

Other details of the vegetation cover may be recorded as flattened coalified imprints of plant stems and leaves, often in channel, or abandoned channel, sandstones.

Calcitic fossils are poorly preserved with the calcite being chemically weathered away over geological time and Coal Measures specimens are usually flattened. (See Fig.10). Trace fossils, usually in the form of burrows made by soft bodied animals that leave no other trace, are common in certain beds.

Where sands became colonised by plants any impurities were sometimes removed by organic processes and weathering, leaving relatively pure sandstones, called ganisters, which are an important material in refractory brick-making. Sometimes exposed and weathered clays had their chemistry changed and were later found to be suitable for pot clays.

Microscopic organisms also existed in the sediments. Near the surface they were aerobic, (oxygen using) but deeper, where the oxygen had been almost used up, siderophile bacteria survived and their biological activity reduced iron in the sediment to the iron carbonate called siderite. Siderite ironstone beds, with iron content up to 30%, later became the basis for small scale ironstone working. (See Fig 11.)

The polar ice cap on the southern continent waxed and waned during the Westphalian causing changes in world sea levels. These important marine flooding events are recorded by Marine Bands, marked by their fossil fauna of goniatites (shelled, nektonic (swimming) organisms). These may occur just above a coal seam, as with the Hard Bed (Ganister) coal, or interrupt the Coal Measures cycle at any point. Being fossilised in mud rocks means the state of preservation is usually poor, however, the shape of the flattened goniatites is often characteristic enough to allow identification.

The borough also has two Quaternary Pleistocene (Anglian) glacial sites; one a single glacial boulder (erratic), and the other, a section through a set of complex glacial deposits. Both have historical connotations, with the erratic being moved to a safe place in Locke Park by Barnsley Town Council in conjunction with Barnsley Naturalists and Scientific Society and the Wentworth Estate. The other site was described by Professor A.H. Green shortly after he had mapped the area in the late nineteenth century (with others) for the British Geological Survey (BGS).

Some sites also are important for their landscape value and the information they have about post glacial geomorphological processes. Sites preserving historical mining and quarrying activity are also recognised as important.

Finally, sites can be recognised for their educational significance at many levels. Sites close to schools which allow a grasp of basic science concepts are important. Several sites in the borough have been used as sites for self-guided walks focussed on public learning. In addition, higher education has used, and continues to use, Barnsley Borough sites for research. New and novel techniques for studying these strata are being developed all the time. Heavy mineral analysis of almost three dozen Barnsley sites demonstrated the presence of several different continental masses supplying sediment to the Pennine Basin during the Westphalian. Micro fossil analysis from Barnsley sites has also been useful in interpreting geological events.

3.4 Four examples of Barnsley's remarkable geodiversity.

Four examples have been selected to illustrate the wide range of geological evidence preserved at Barnsley geodiversity sites and show why sites have been selected for recognition.

The White Rock:

an example of environmental change over time

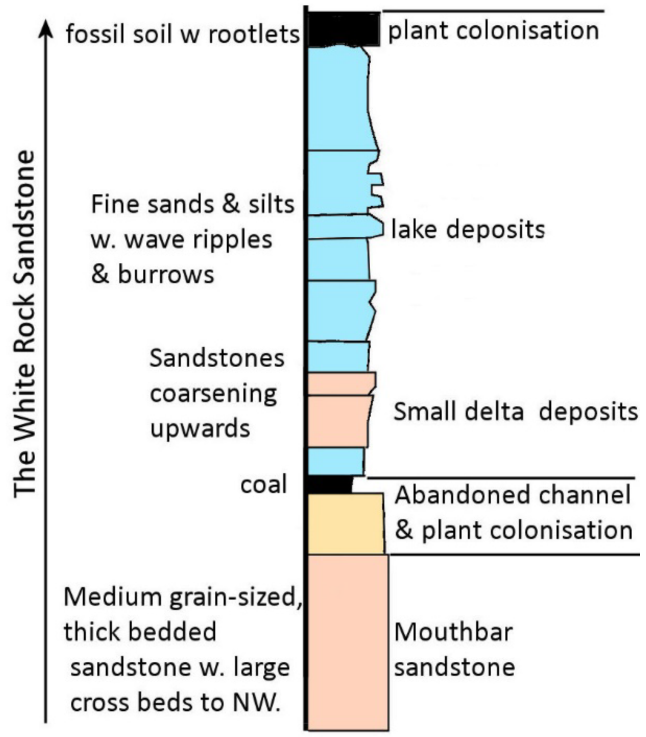
These strata outcrops in the Peak District National Park (PDNP) and are only visible when low water occurs in the very deep reservoir.

The White Rock is a Namurian sandstone with an erosive base, cutting into the rocks below to form a large channel in which a river deposited its load of coarse sand as part of a large delta extending north from Sheffield.

Above the channel sandstone are beds providing evidence of the channel becoming abandoned by the main flow and silting up, eventually becoming colonised by plants, now present as a thin coal.

Above lie fine rippled sandstones indicating quieter backwaters, with a small delta building out into a lake. Soft-bodied animals feeding on the sediment left burrows on the bedding planes.

At the top is a rootlet bed and a ganister palaeosol (a fossil soil) with coal occurring intermittently above it, suggesting re - colonisation by plants.

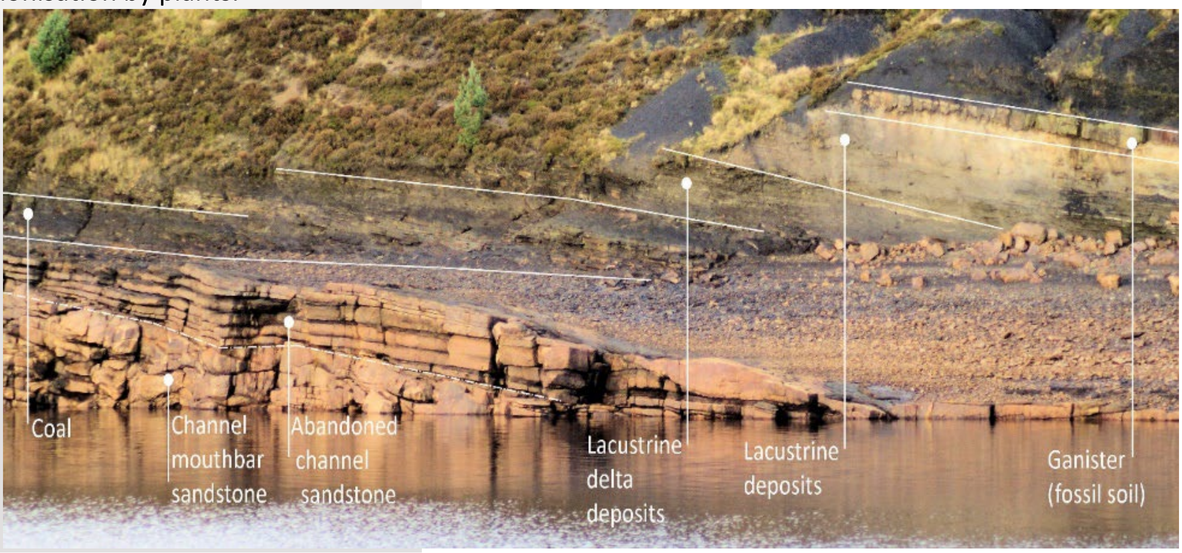


brown= channel & delta; yellow = abandoned channel;

blue= lake; black= plant colonised land

[This interpretation is simplified and taken from: Waters CN, Chisholm JI, Benfield AC et al. (2008) Regional Evolution of a fluvio deltaic cyclic succession in the Marsdenian of the Central Pennine Basin, UK. Proceedings of the Yorkshire Geological Society, v57, pp1 – 28].

Fig 3.4.1. Above is a simplified sketch section through the White Rock with the accompanying environmental interpretation.



The Green Moor Rock:

an example of transition from river to vegetated swamp.

The faces in the main channel sandstones of the Green Moor Rock are close to the village and can be visited at the Delph. However, on private land a few kilometres away the transition at the top of the sandbody from channel deposits to vegetation by lycopod vegetation has been preserved.

Towards the top the sandstone loses its clear bedding surfaces which become contorted by the sediment slumping from the banks into the channels which became silted up. This indicates that the main channel flow has switched leaving the area to become part of a waterlogged swamp.

Above the slumping the sandstone has stigmaria fossils. These are the root systems of large lycopods. Here the density of vegetation was not enough to form a coal seam, but the site is one of the few places the details of the stigmarian root system can be seen.

The circular marks along the stigmarian root are the attachment points of tubes of soft tissue radiating outwards into the sediment and long enough to reach into the water above. The function of these rootlets (called stigmarian appendages) is not clear.

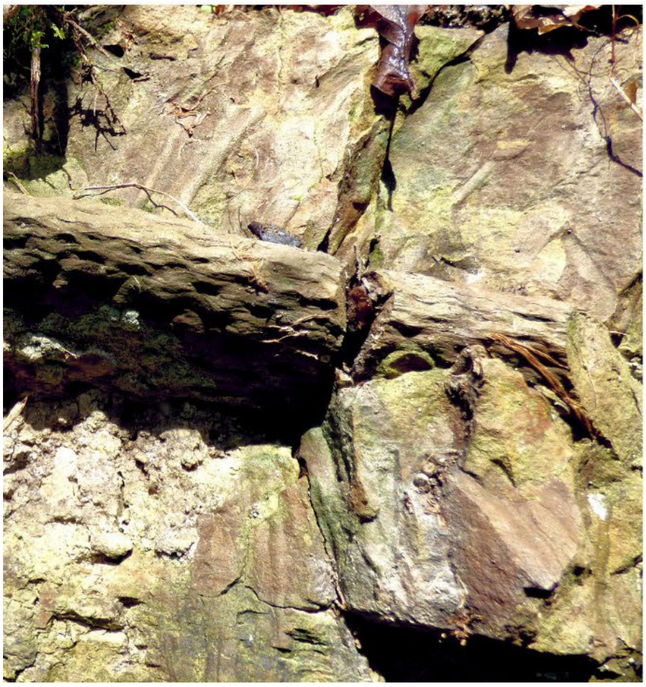


Fig 4.3.3. Above: Slumping of Green Moor Rock sediment shortly after its deposition.

Fig 4.3.4. Below: Stigmarian root system one metre above the slumping. The stigmarian appendages can be seen as linear imprints in the sandstone above and below.

The Woolley Edge Rock (WER):

an example of lateral environmental change.

The WER. outcrops across the centre of Barnsley from Burton Bank, where it is almost 40 m thick, SE towards Wombwell, where it thins away to nothing. Apart from the thickness the environments that the sandstone was deposited in also changed dramatically.

The Burton Bank outcrop is interpreted as a stacked series of channel sands, the base of each channel marked by a gravel of pebbles and mud clasts. This suggests the river had well established levees which maintained a preferred route till the river flow switched.

To the SE the WER changes character laterally. One sequence (on private land) is interpreted as a 2 m thickness of lake silts with a single, 50 cm thick sandstone bed across the middle, indicative of a bank collapse (crevasse splay) allowing a sudden flood of river water to bring a load of sand into a quiet lake.

Another sequence (also on private land) shows a stacked series of large cross-bedded sandstone, interpreted as a repeated series of river mouth bars formed as the main channel entered a large lake.

Fig 4.3.5. Above: The WER at Burton Bank

Fig 4.3.6. Centre: The WER where a crevasse splay sandstone occurs in a sequence of lake silts.

Fig 4.3.7. Bottom: The WER occurs in stacked, thick, cross bedded sandstones.

Anglian Glacial Erratic:

an example of a remote glacial event.

Located in Locke Park Gardens is a boulder, almost a metre in diameter of a rock type unknown in South Yorkshire. It was originally located in Royston and moved in the late 1800's and donated to Barnsley Town Council. The erratic is of an igneous rock type with large pink feldspar crystals and glassy quartz. It was first described by A.H. Green in 1872, who noted the similarity with the Shap Granite outcrop in the eastern Lake District. A second, much smaller example, occurs outside the Cawthorne Village Museum.

The rock is interpreted as being part of the moraine of a large Anglian ice sheet that extended across most of the UK, almost half a million years ago, and was deposited as climates warmed and the ice melted. Most of the finer part of the moraines have since been washed away.

These moraines are not the same as the moraines found along the Yorkshire east coast. Those are from the Devensian glaciation which ended only 11, 000 years ago. They also have (smaller) Shap Granite erratics, as the ice seems to have followed similar routes from the Lake District on both occasions.

Fig 3.4.8. Above: The Anglian erratic in Locke Park gardens.

Fig 3.4.9. Below: Detail of the crystal structure of the igneous rock Its of a rock type not found outcropping in South Yorkshire.

4. Working with developers at, or close to, a geodiversity site.

Barnsley Council Planning Department have the responsibility for making all planning decisions regarding development in the borough, but where there are issues close to an important geodiversity site, they consult Sheffield Area Geology Trust (SAGT) a non-profit making geoconservation body interested in good geoconservation and management practice. SAGT provides advice and information to Local Authorities in South Yorkshire who do not have such expertise and information available in-house. The participation in the process, however, is through the Barnsley Sites Partnership structure.

BMBC has published their Supplementary Planning Document (SPD) 'Biodiversity and Geodiversity (2023)' which details the context and procedures for submitting planning and development applications, and the relevance of biodiversity and geodiversity considerations in that process. It states, paragraph 2.1:

> 'This SPD sets out the council's approach to planning decisions in respect of biodiversity and geodiversity and is designed to be used by those considering and applying for planning permission in the borough, to ensure biodiversity and geodiversity is adequately protected through the planning process. This document provides practical advice and guidance on how to deliver proposals that comply with the NPPF and the Local Plan, adopted in 2019'.

The Barnsley Local Geological Sites Panel assists in the balancing process between development decisions in the borough and the need to protect the geodiversity assets during the planning process. Development sites either on, or within 250 m of a RIGS site are of particular interest. In many cases the development does not cause concerns, but where it does the position of SAGT is to strive to work with planning authorities, owners and contractors to attempt to minimise possible damage to, or loss of, geological information at individual sites. In some cases, a geodiversity input involves the developers at a very early stage, to the benefit of the process.

Each site is considered on a case-by-case basis by the BLGSP, but the geoconservation aims are the following:

1. to preserve the geological integrity of the site;

2. to preserve its visibility and availability for scientific and educational use;

3. to ensure workable, on-going access arrangements after completion, and;

4. to work to protect the geodiversity site from any subsequent challenges from the new, or adjacent, land owners, tenants, or residents.

The boundaries of every geodiversity site are drawn in accordance with good practice, i.e. along clearly mappable boundary lines. As a result, the geodiversity interest may only occupy a small part of the enclosed area.

Consequently, it is possible that a planning decision may be made, with provisos, to allow a development at a sensitive geodiversity site.

If, after planning permission has been granted and modifying a damaging development is not possible, then the BLGSP will attempt to have the information at the site recorded by a suitably qualified geologist, using the best means available, including photography and sampling, before the loss of any part of the site occurs. All information obtained in this way, by the cooperation of the developer, will be shared with the local museum service and other publicly owned stakeholders, for the benefit of the wider community with geological interests.

The majority of development types will now be subject to mandatory Biodiversity Net Gain (BNG). Developers will have to demonstrate that their proposals deliver a 10% net gain in biodiversity, based upon the value of the development site prior to works. If developers cannot achieve this on their own sites, they will have to make off-site gains by using off-site biodiversity units. Off-site means outside the red line boundary of the development that has planning permission requiring BNG. Land managers creating, or selling, off-site biodiversity units should take care not to adversely affect any nearby RIGS site. Prior to habitat creation or enhancements being carried out, land managers should refer to the BMBC Local Plan to see the boundaries of any nearby RIGS sites and, if necessary, contact the BMBC Planning Department. Advice from SAGT may then be sort to consider any potential impact upon RIGS as a result of the habitat creation/enhancement works.

Each site, and each development, is different and creates different geoconservation situations. Advice is best canvassed before planning proposals are made so it can be incorporated into the early design. Sometimes a geoconservation site might be affected during offsetting activities arising from a completely unrelated development.

The most commonly occurring problems are caused by:

1. preventing access to, or dividing site ownership of, a site (e.g. back garden fences);

2. burying or obscuring the geoconservation site either during construction or landscaping (e.g. tree planting);

3. obscuring the rock by using unsympathetic slope stabilization techniques, such as steel-mesh, shotcrete or placing a retaining structure across the face, or landscaping by re-sculpturing the surface, often after covering it with material brought from off site.

4. un-sympathetic layout (e.g. a road plan unsuitable for access to the geoconservation site.);

5. lack of adequate post-development arrangements for access to the geo-site;

6. the new owners being unaware of geo-site status due to inadequate details in the sale transaction information;

7. challenges, made after the construction, by the new owners, or new owners of properties on adjacent sites.

5.Ways of enhancing geoconservation

5.1 The processes causing loss or damage to geodiversity sites.

The decline of quarrying and mining in the region is also significant because the ending of coal mining has eliminated the possibilities of studying strata in three dimensions underground. This makes the surface exposures even more important as they are now the last remaining opportunities for direct study, using evolving new technologies and techniques.

There are many ways surface sites can become degraded or damaged. Sites can become infilled, used as a tip for farm or domestic waste, used inappropriately (e.g. burning waste against rock faces), damaged by vehicular use (quad bikes, motorbikes or off-road bikes) or built on. Often this occurs as a result of a lack of inadequate research or consultation before decisions are made. Sites can change in ownership resulting in site loss, or refusal of, access by the new owner.

Casual recreational use by members of a local community can also cause damage due to a lack of understanding about the importance of the site.

Geodiversity sites vary enormously in their character and management issues. At any one site these factors can vary with the rock type, the aspect and altitude of the site and the degree of rainfall and lingering dampness across the face.

The adjacent areas can have an influence on a site: the proximity of a treeline, or a suburban or urban area can affect the management issues at a site and the ways in which a site can be either effectively managed or damaged. Understanding how sites can become damaged is a first step in knowing how to conserve them.

- *New building developments:* These are dealt with in section 4.1

- *Existing factories or works areas:* As with many sites the biggest concern here is access to the geodiversity asset, often in the quarry walls at the back of the factory or works. This can be compromised by the building of new plant against the face or the stacking of stored materials against the face. The geoconservation efforts here are to develop constructive discussions with the operator to try to find ways of allowing the changes whilst preserving access to the geological site.

- *Active quarries:* These are commercial sites and plans for the development of the site, usually, these involve the pattern, timing and extent of extraction. In addition, there may well be a

reinstatement plan, agreed when quarrying permission was granted. This usually involves infill and landscaping, obliterating the site and establishing grassland with planted trees, or amenity areas on top. Access to a working site to study the geodiversity has to be negotiated with the site manager and will usually require Personal Protection Equipment (PPE, usually hi-viz clothing, hard hat, and possibly steel toed boots). Limitations on timing and areas of access will depend on the works programme.
Constructive relationships with the site manager are necessary to find a solution that allows change whilst conserving the geodiversity asset.

- *Disused quarries and railway cuttings:* These sites have often not been used for many decades and can be the sites of considerable biodiversity value as well as the geodiversity assets. Often overgrown with saplings, grass, nettles and brambles these sites become repurposed, either formally as a development site or footpath, or informally as a recreational amenity, graffiti venue or dumping ground by people who are unaware of the site's significance.
  In such situations the objective is to develop good communications with the landowner and agree access and discuss management practices, and to inform local communities. The Trans Pennine Trails are an exception, managed as they are for easy public access.

- *Stream sections:* Where these pass across farmland, they usually have a substrate of impermeable mud rocks and gentle slopes. Often these are sources of water for grazing animals and become trampled. Access to such sites is dependent on the management priorities of the farmer. Where streams pass through woodland there is usually less damage to the banks and the access is often along footpaths. Here the geodiversity value may be in the exposures in the stream bed or banks, or equally in the maintaining the landscape value and natural processes of the stream itself. Managing the encroachment of vegetation onto the geodiversity site is often the main issue, especially if the species is a non-native invasive one, such as Japanese knotweed.

* *Natural outcrops:* In Barnsley Metropolitan Borough these tend to be small sandstone outcrops, often containing useful information about the areas between larger sites. When located in urban areas they tend to be in small areas of greenspace and can be the target for graffiti. In more rural areas the problems of maintaining access and visibility often include development or road building, encroachment of vegetation, or plans for tree planting or forestation. Early involvement in the planning process in order to find a workable solution that protects the geodiversity interest is important.

- *Commercial woodland*: Small areas of woodland that have been planted with a dominant commercial species can extend close up to a rock face. Often the canopy can be useful in inhibiting development of an understory of vegetation encroaching onto the face, although closely spaced trunks interfere with the view of any laterally continuous features. Inevitably, when the woodland is harvested the site will become exposed and will rapidly become re colonised. If other options are not possible, then negotiating access to allow logging photographing and sampling immediately after clearance, is important.

5.2 The positive management of local geodiversity sites.

The Geodiversity Charter for England stress that positive management of sites requires good co-operation between partners and good management practices. In Barnsley Borough these partners are BMBC Planning Department, landowners and land managers and Sheffield Area Geology Trust (SAGT).

- SAGT is a not-for-profit organisation run by volunteers who specialise in geoconservation. SAGT maintains and updates a database of all local geodiversity sites in South Yorkshire and provides advice and support to LAs and other organisations and individuals in South Yorkshire. In BMBC this is through the Barnsley Local Sites Partnership. Advice to developers, and on-site consultations is available to any who want to develop areas close to geodiversity sites without causing damage to the borough's geodiversity assets (See section 4.1).

- BMBC is the coordinating partner in the Local Sites Partnership and commissions geoconservation reviews on Barnsley's sites in order to monitor and manage the process.

5.3 Constructive use of geodiversity sites by local schools, local decision-makers, communities and the wider public.

- *Local Community action:* Often a community that has taken the time to learn about the local geodiversity is interested in maintaining it and using it constructively. One way to start is by contacting BLGSP or SAGT.

One Parish Council approached the BLGSP and SAGT with a view to integrating geoconservation into their plans to develop a local woodland area. The result was a new footpath, better access to the site, with a cleared face for better viewing. An information board giving a brief description of the site's geological and quarrying background was commissioned and installed. The site became part of the well-used footpath network around the village and a focus for communal activity.

Individuals and groups interested in local geodiversity have several avenues to explore.

- Self-guided geowalks: Some of these are available on the SAGT website (https://www.sagt.org.uk/). They include the Dove Valley, the Trans Pennine Trail, Burton Bank and Rabbit Ings and provide an introduction to the geological context of the area through which people may want to walk, cycle or ride.

All of these sites are open to the public, but not all geodiversity sites are on ground which has open public access and permission to visit would be necessary from the landowner. At any site sensible health and safety precautions should be taken and the face should not be damaged or climbed on. In addition, the relevant Ordnance Survey map and, either map reading skills or a GPS device will be needed to locate the map references given in the geowalk.

- *Guided geo walks*: At various points through the year guided geowalks are available. GeoWeek is just one established national initiative and occurs each year during the last week of May. GeoWeek has the purpose of introducing geo-sciences to as many members of the general public as possible. Recent years have seen a guided Barnsley GeoWeek walk from Centenary Square to Locke Park Gardens taking frequent stops to observe the links between the town and its geology.

- Other *sources:* At many sites there are interpretation boards, leaflets, and sometimes guides, provided by those who also want to share the understanding of their area with others.

- *Educational users*: Several organisations have developed and made available ideas, materials and guides to help primary, secondary and sixth form teachers integrate geodiversity into their pupil's curriculum. A list of these providers and their contact websites can be found on the SAGT website at https://www.sagt.org.uk/education_and_geology

The Earth Science on-Site (ESO-S) materials can now be found at https://geohubliverpool.org.uk/esos/index.htm. These free-to-download materials are examples of sites from around England showing how to approach Earth Science field work with primary and secondary pupils. Although several are in the Peak District, the ideas may be applied to safe and accessible sites closer to schools.

In addition, there are opportunities to use urban and churchyard locations to develop and practice pupil's Earth Science skills locally. For videos outlining how to use such opportunities see: https://www.earthlearningidea.com/Video/V14_Gravestones1.html and

https://www.earthlearningidea.com/Video/V36_Quarry1.html

Links with higher education have been many. Several scientific papers have been written in recent years that include, or are exclusively about, sites in the borough. The local knowledge of South Yorkshire sites has also assisted work on Barnsley geology by post graduate students at Ph.D and M.Sc levels

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UK National Commission for UNESCO. https://uk-ioc.org/UKNC

7. GLOSSARY

Calcitic fossils: Fossils with a calcite shell ($CaCO_3$). Often these shells are destroyed by acid ground water during long periods of burial, leaving only an imprint in the rock.

Carboniferous time period. The time period from about 359 to 299 million years ago. It is divided into four stages. The oldest strata are **Visean** in age, the next youngest is the Namurian, followed by the **Westphalian.** The youngest stage, called the Stephanian, is not found in South Yorkshire.

Distributaries: Natural river channels that branch off from the main river channel, often occur in delta-top conditions.

Ecosystem services: The direct and indirect benefits that ecosystems provide for human wellbeing and quality of life. This can be food from the fields, water from rivers and aquifers, and includes regulating the climate, as well as being good for people (e.g. by reducing stress and anxiety).

Fold mountain chain: A linear or curving part of the crust, uplifted into mountains and folded and faulted by compression during tectonic plate collisions.

Gastrioceras: An extinct free swimming, marine organism with a coiled calcite shell. Its presence indicates an important marine bed between the otherwise deltaic beds of the Carboniferous. It is often abbreviated to G.

Geoconservation: The practice of recognising, protecting and managing sites and landscapes which have value for their geology or geomorphology

Geodiversity refers to the natural range or diversity of geological features, including rocks, minerals and fossils as well as geomorphological features such hill slopes, flood plains and other landforms. Geodiversity includes the inter-relationships between the rocks, soils, minerals, fossils and geological structures of the area.

Geomorphological processes: These are the processes of wind, rain, ice, and waves that shape our landscapes.

Glacial epoch: The last period of widespread glaciation, from around 2 million years ago to 10,000 years ago. There were many cold and glacial periods within this period, but in our region we only know more details about the last two or three.

Gritstone. A coarse-grained sandstone with angular grains 2 to 4mm across.

Lintel: A load-bearing stone slab above a door or window.

Lycopod: A largely extinct group of spore-bearing plants. Some, like the Scale Tree *(Lepidodendron*) reached 30 m in height during the Carboniferous, and, after death, formed a large contribution to coal seam formation.

Overbank (sediments): Sediments deposited outside of the river channel during a flooding event.

Periglacial: The cold tundra areas around the edge of large Ice Sheets that experienced repeated freeze-thaw conditions

Seat Earth. A fossil soil layer, recognized by rootlets, and often found just below a coal seam

Sedimentary cycles: Repeated series of sedimentary rocks, in a similar order. Coal delta cycles generally consist of a marine band at the bottom, shale, sandstone, seat earth and coal at the top. Each cycle results from marine flooding leading to retreat of the coastline and another delta building out over the top of an earlier one.

Siderite Ironstone: This is a low-grade iron ore that was important in the area during the early industrial days. It is a carbonate of iron, and forms in the sediment after its deposition.

Stigmaria: The underground roots of a large lycopod (*Lepidodendron*).

Transgression: Marine transgressions are when large areas of continents are flooded by the sea, often as the result of ice melting at polar ice caps