
Section 3 Exploring and celebrating geodiversity

Education and research

Geological literature and studies

The scientific study of the materials of the Earth's crust began in Europe towards the close of the eighteenth century. In Northumberland studies in the new science of 'geology' commenced early in the nineteenth century. In 1817 the naturalist John Winch published a paper Observations on the geology of Northumberland and Durham which discussed the Cheviot 'porphyrites', the early Carboniferous rocks of the Tweed valley, even the Roddam Dene Conglomerate. He also traced the Great Whin Sill from Bamburgh and the Farne Islands in the north, to the Roman Wall country in the south. Like many of the early observers, Winch was a naturalist whose interests ranged widely and who established links between geology and other sciences. His paper Remarks on the distribution of the indigeneous plants of Northumberland and Durham, as connected with the geological structure of these counties (1831) was extremely influential in the field of botany. In 1822 John Hodgson, noted local historian, included a systematic study of the quarries in the area of Hadrian's Wall with an account of the central sector, and in 1867 George Tate, postmaster in Alnwick, produced a geological appendix to the enlarged third edition of The Roman Wall by J H Collingwood Bruce. It was George Tate who established the main divisions of the Carboniferous in Northumberland.

Recognition of an intrusive igneous origin for the Whin Sills during the 19th century was based largely on studies within the present district, notably on sections exposed at Ward's Hill Quarry. Subsequently, the term sill became adopted by geological science for all sub- horizontal and, within stratified sequences, broadly concordant intrusive igneous bodies. Since then, many studies of the Whin Sills and their associated dykes have drawn upon evidence gathered from its exposures in Northumberland and much of the large volume of earth science literature derived from these studies has significance well beyond the district.

Much of our understanding of subsurface geology and regional geological evolution stems from the application of techniques and principles from other branches of earth science. Of these, perhaps the most significant are the disciplines of geophysics and geochemistry. Significant advances in both the development of techniques in these disciplines, and the understanding of the regional geology of the United Kingdom have come from their application to geological problems within the district. Therefore, aspects of these disciplines can be considered an important facet of the district's geodiversity.

Geophysics

Geophysics is the study of the physical properties of geological materials and structures. The modern science embraces a very wide range of extremely sophisticated techniques derived from the principles of physics and designed to measure parameters of the Earth such as gravity variations, magnetic and acoustic properties, and natural radiation. The principle aim of these studies is to aid interpretation of the geometric form and nature of geological structures, often at considerable depths beneath the surface, and to aid understanding of the processes which may have created them.

Geophysical interpretation first made a significant impact on understanding the district's geology in the 1950s when a study of gravity anomaly data for the Northern Pennines and adjoining areas led to the postulation (subsequently proved), of the Weardale Granite and its role in the evolution of the Alston Block and adjoining Northumberland Trough. Following this seminal work, a variety of other geophysical techniques, including magnetic, seismic and magnetotelluric studies, have been applied to the investigation of the deep structure of the region.

Of particular significance have been a number of seismic profiling studies, in which the response of rocks to sound waves is used to image structures below the surface. Although detailed summaries of these investigations are not appropriate here, it is important to recall that these investigations have contributed greatly to our knowledge of the form and geological evolution of the Northumberland Trough.

The single most significant contribution from seismic survey techniques within the district is to our understanding of the Iapetus Suture (p. 18). In the early 1980s, geophysical seismic surveys were conducted across the suture, both onshore in Northumberland and offshore in the Irish Sea, in an attempt to define the geometry of the Suture at depth below northern England. The LISPB (Lithospheric Seismic Profile of Britain) passes Northumberland National Park Geodiversity Audit and Action Plan through the district and images the Suture as a northerly dipping discontinuity in the rocks that passes right through the crust and close to, and possibly into, the underlying mantle. Similarly, in the mid 1980s electromagnetic techniques were used to image the structure of the Suture, and the combination of these results with those of the seismic survey has significantly increased our geological understanding of both the geometry of this structure and its effects on the subsequent geological evolution of the Alston Block and Northumberland Trough.

Seismic techniques have also been employed to investigate structures within the Carboniferous rocks of the Northumberland Trough which may have potential as hydrocarbon reservoirs (p. 83).

Regional magnetic anomalies, resulting from iron-rich basic rocks such as the dolerite of the Whin Sills and Palaeogene dykes, have contributed much to our understanding of these rocks at depth and to the inference of their presence beneath superficial deposits within the district. An unusual pattern of circular magnetic anomalies in the Ryal area, apparently related to the Whin Sills, may result from a circumstantial intersection of a number of linear anomalies, though the pattern is also consistent with its origin as a meteorite impact feature.

Similarly, regional gravity anomalies, resulting from the presence of the significantly less dense granitic pluton of the Cheviot in the north of the district, and the significant differences in thickness of the sedimentary successions between the Northumberland Trough and Alston Block, have contributed greatly to research of the subsurface geology in both these areas.

Investigations of palaeomagnetism, recorded in the iron oxide minerals of the Whin Sills as they crystallised, have yielded evidence of the global position of the Whin Sill and therefore northern England at the time of its formation.

Geochemistry

Geochemistry is the study of the chemical composition of geological materials. It is an important tool for investigating the processes which have formed, and continue to influence, rocks and their by-products.

A range of analytical and sampling techniques aid investigations into the distribution of chemical elements within the environment and therefore contribute towards our understanding of the geological evolution, of the dispersal of natural and manmade pollutants, and the geological development of economic resources. Modern techniques of isotopic geochemical analysis provide a range of methods for dating rocks, and processes that have affected rocks, and contribute significantly to our understanding of their geological evolution.

The distribution of a wide range of chemical elements in stream sediments and stream water across the district, as determined by the British Geological Survey, is depicted in three geochemical atlases. As well as informing understanding of the local and regional geology, these provide valuable insights into patterns of man-made dispersion. Studies of stream water and sediment geochemistry from the Cheviot area have revealed a hitherto unrecognised zonation of the granite that has contributed much to the understanding of its geological evolution, and studies of metalliferous mineral concentrates within stream water from the area have detected previously unrecognised small-scale vein mineralization of copper, zinc, barium and lead.

Future earth science research potential in the district

Although much of the southern part of the district has been surveyed by BGS within the last forty years, there are significant areas farther north that have received very little systematic attention since shortly after the First World War. Selected areas have been the focus of academic study, but it is probably true to say that, in general, the district has not benefited from modern geological research. Consequently there is considerable potential to encourage and develop opportunities for earth science research and to extend the understanding of geodiversity in the district.

A number of research opportunities have been identified in the 'Wider Significance' sections earlier in the publication to which reference should be made – the list below merely highlights a few possibilities, in particular, the Quaternary landscape of the district is one that has increasing significance for the earth science community. It is recommended that a further study of possible topics should be conducted in conjunction with universities and other interested parties.

- There are few modern studies of the Cheviot igneous rocks; these rocks contribute to our wider understanding of this important phase of igneous activity in the evolution of the British Isles. The granitic rocks contain some pyroxene, a rare feature of rocks of this composition in Great Britain.
- The Cheviot massif appears to be very unusual in Britain. It is an upland area that has undergone glaciation during the Quaternary Period, but still preserves features relating to the action of longer term, less physically dynamic processes. The preservation of these normally sensitive features in a landscape that has undergone glaciation is extremely unusual. Research into the ice-sheet evolution; diversion and dynamic of ice streams and cold-based ice preservation of summit forms, such as tors and weathered bedrock would enhance understanding on a national scale
- The Wooler-Cornhill area, with its extensive lake, fan and glaciofluvial deposits may provide significant opportunities for Earth Scientists to add vital pieces of information to our fragmentary record of the period during and immediately after the decline of the last great ice-sheet in Britain (e.g. long term palaeoenvironmental reconstruction from high resolution core sampling)
- The Hadrian's Wall district exhibits the classical landscape of a palaeo-ice-stream track, now recognised as being highly significant in the regulation of the mass balance of ice-sheet systems.

Geological and other societies

Geological societies perform an important role in communicating relevant knowledge and expertise both to their members and, in many instances, the wider public. The following geological societies and organisations are active within northern England and take an interest in the district:

- Cumberland Geological Society
- North East Geological Society
- Northumbria RIGS
- Natural History Society of Northumbria (Geology Section)
- Open University Geological Society
- Russell Society (Northern Branch)
- Yorkshire Geological Society

Although not a geological society, the Haydon Bridge Nature Club organises events which involve aspects of the district's geology and Tasset Archive Group are mapping geological features, associated buildings and quarries in their area.

All of these arrange programmes of lectures and field meetings and several societies publish journals and newsletters in which original observations, or reviews, of local geology are reported. Especially noteworthy are the many original papers which have appeared over many years in the Proceedings of the Yorkshire Geological Society and The Transactions of the Natural History Society of Northumbria. There is a future need to ensure the continued monitoring and review of the full range of varied geodiversity issues covered in this audit. Local geological societies may have a useful role in this process.

There is much that can be done to support opportunities outside the formal education curriculum, either through support for children's activities such as 'Rockwatch' clubs, or through an encouragement of evening courses and community-led study.

Archives and materials collections

In a country like Great Britain, many years of geological observation, recording and research have created an enormous archive of information, published and unpublished, and collections of geological materials. Although these collections and archives may now reside at locations remote from the source area, they are, nonetheless vital parts of that area's geodiversity. In particular, such collections may include information on, or specimens from, locations or features which are no longer accessible and for which they now offer the only means of study and research.

The most significant geological archives relevant to the district are considered below:

Documentary sources

The British Geological Survey

As the national geological survey, BGS has an incomparable archive of information and materials collections relating to the district, dating back to the earliest years of geological mapping and research in northern England in the final quarter of the 19th century and continuing to the present day. Information sources held by BGS include original field maps (field slips), published maps, memoirs, reports, open-file maps and reports, borehole records, mine plans, fossils, rock samples, thin sections, hydrogeological, geochemical, geophysical and geotechnical data and photographs.

Further information on BGS publications, data sources and information available from the British Geological Survey can be accessed on the BGS Web Home Page. <https://www.bgs.ac.uk/>

Soil survey

Specialised information on soil character, properties and classification may be obtained from the publications of the Soil Survey of England and Wales, now the Soil Survey and Land Research Centre. www.silsoe.cranfield.ac.uk/nsri

Other documentary sources

Information on geological Sites of Special Scientific Interest (SSSIs) within the district is held by Natural England. Information on other geologically significant sites within the district is held by the Northumberland Wildlife Trust and Hancock Museum, Newcastle upon Tyne, which also has an extensive library of material relating to the geology of the district.

Beamish, The North of England Open Air Museum, Beamish, County Durham, holds documents relating to the rural and industrial history of northern England and has an extensive photographic collection including images of mining and quarrying.

Mine plans

Many years of mining for coal and vein minerals have produced a legacy of mine plans and related records. These documents, which contain huge amounts of often unique geological information, are an important element in the district's geodiversity. At present there is no central repository of mining information, for minerals other than coal, in the UK. Large and important collections of such records are known to be cared for by a number of organisations, though many original, and thus unique, mine plans and associated documents are known to be in private hands. These are often difficult or impossible to trace.

The County Record Offices of Cumbria, Durham, Northumberland and North Yorkshire have the most significant collections of mining information relating to the north of England. Other bodies holding mine records are the North of England Institute of Mining and Mechanical Engineers, based in Newcastle, the Edinburgh office of the British Geological Survey, The Coal Authority and Beamish Museum.

Materials collections

Many specimens of rocks, minerals and fossils collected within the district are held in the collections of Britain's national museums and university departments; important material is also held by BGS. These specimens, and their accompanying locality and other data, comprise an extremely important aspect of the district's geodiversity. Significant private collections of geological materials, mainly minerals, also exist.

The Natural History Museum, Department of Mineralogy, London collection includes mineral specimens from the mines of the Haydon Bridge area. Especially notable are specimens from Settlingstones and Fallowfield mines, including fine examples of witherite, alstonite, baryte, harmotome and niccolite. Specimens in the Russell Collection are of particular importance. The Tullie House Museum, Carlisle, and Killhope, The North of England Lead Mining Museum collections also include minerals from the Haydon Bridge area.

The geological collections of the following museums include fine minerals from Settlingstones and Fallowfield mines: National Museum of Wales, Cardiff; Hancock Museum, Newcastle upon Tyne; Hunterian Museum, University of Glasgow; Manchester University Museum; Oxford University Museum; Sedgwick Museum, University of Cambridge; Royal Museum of Scotland, Edinburgh; and Sunderland Museum and Art Gallery.

The palaeontology collections of many of these museums include significant specimens from Northumberland.

The British Geological Survey Collections hold rock and fossil specimens taken from surface exposures and boreholes within the district. Thin sections of rocks from the district are registered in the BGS sliced rock collection.

Interpreting the geodiversity of Northumberland National Park and the surrounding area

The purpose of 'Interpretation' is to broaden visitors' and residents' awareness of the rich geological heritage in Northumberland National Park. Interpretation translates the technical language of the expert to the everyday language of all age groups. With that in mind, interpretation should be creative and enjoyable. Interpretation can be accomplished using a variety of media including on-site panels and signs, exhibits in a Visitor Centre, audio/visual productions, publications and events ranging from guided-walks to hands-on activities, living history re-enactments, and lectures. Geological interpretation embraces all methods of communicating earth science information to specialist and non-specialist audiences alike. Interpretation of the National Park's geological heritage should foster an appreciation of the area, and stewardship messages such as "tread lightly" on the natural environment can and should be interwoven.

Well-planned earth science interpretation not only highlights the importance and relevance of geological interest, but also has enormous potential to contribute to, and enhance, the understanding of features and sites of parallel interest including the district's ecology and archaeology. Thus, the understanding of, for example, a limestone grassland, a population of metallophyte plants, features visible on Hadrian's Wall, or the siting of a limekiln can be greatly enhanced if the geological factors responsible for these are explained in an appropriate context.

Delivery of earth heritage interpretation

The interpretive master plan

It is recommended that in the first instance an 'Interpretive Master Plan' for interpreting the National Park's geological heritage be produced. An Interpretive Master Plan provides ideas and an approach for communicating the stories that are associated with each geological site in a way where "the whole" becomes greater than "the sum of its parts". The whole story must be coordinated and take people on a journey of discovery throughout the National Park and surrounding areas.

To inspire a wider interest in the relevance of the geological heritage of the area, natural, scenic, historical, cultural, archaeological and recreational qualities need also to be woven into the interpretive themes for each site as well as key messages and related stories. The BGS/NNPA publication Ancient Frontiers produced in 2006 explored some aspects of the geology and landscape of the Hadrian's Wall area and has started the interpretation of the district. This has been welcomed locally and similar publications might be considered for other areas.

Sites and features to be considered for interpretation

The following sites and areas are recommended because of their potential to tell a story or stories relating to the geological heritage of the National Park and surrounding area. The list does not imply any landowner agreement or support for siting interpretation material in any specific location, nor does it imply any right of access. Wherever possible, routes should be selected to utilise Public Rights of Way and/or to cross Open Access land.

The sites are arranged in alphabetical order for ease of reference. Localities within Northumberland National Park are indicated with an asterisk.

Sites to be considered for 'on-site' interpretation

Akenshaw Burn and Lewis Burn, Kielder Forest [NY 622 892]

The sedimentary sequence exposed in the cliff face and visible from the trackside is worth interpreting as it is representative of much of the geology in the area and includes a series of fold structures. The track is already part of an existing marked cycle/horse route and the site could form part of a geological trail within Kielder forest. Liaison with the Forestry Commission is advised to make use of this resource.

Barrasford Quarry [NY 915 745]

Assuming agreement can be reached on the end-use of selected abandoned faces, appropriate interpretation could be erected adjacent to key features in the event of public access being possible (e.g. limestone raft in Whin Sill in upper part of quarry face). Liaison with the quarry operators is essential at this site.

Beltingham River Shingle [NY 786 642]

This site supports unusual metallophyte flora. Its relationship to mineral deposits and their former exploitation upstream could be interpreted in some way. A particularly fine opportunity exists here to reinforce the close relationship between earth science and ecology.

Barrow Scar [NT 900 061]*

The striking exposures of the Ballagan Formation seen in the river cliff from the Coquetdale road are excellent features to interpret. Close-up the strata contain many structures and fossils which can be used to explain how the bedrock informs us about the environment millions of years ago. This would be an ideal place for group-based interpretation. Located at the edge of the Cheviot massif, this would also be a good location to show the link between geology and the landscape, and as such could be part of any guided trail or information about the Upper Coquet valley.

Black Pasture Quarry [NY 930 698]

This site exhibits fine exposures of ripple marks, which could be interpreted together with explanations of the quarrying and use of the stone from this site. Some restoration by appropriate vegetation clearance would be needed before this could take place. An opportunity also exists to comment on the vegetation that has developed over the abandoned workings and the link between the quarrying, geology and ecology.

Blakehope Nick [NY 713 983]

The lay-by located at the highest point on the Kielder 'Forest Drive' has interpretation boards describing the flora and fauna of the SSSI but nothing about geology. Adding information about the geology and the landscape on which the wildlife thrives would greatly add to the visitors' understanding of the area. The small quarry on the other side of the road in deeply weathered sandstone has revealed some large, well-preserved fossil plants. Geological interpretation could be incorporated into information given by the Forestry Commission about the Forest Drive either at this location or off-site.

Blindburn [NT 8307 1087]*

This location is ideal to explain some of the rocks and features visible within the Cheviot volcanic rocks and explore the processes that formed them. Andesite lava flows and pyroclastic breccia are visible at this site with a view point across stream; pull-offs are present. The site, within the Otterburn Training Area, could form part of a guided trail along the Upper Coquet valley.

Briarwood Banks [NY 797 640]

Existing on-site interpretation makes no reference to the spectacular gorge of the River Allen and its origins. The site offers a superb opportunity to make the connection between the Carboniferous rocks, glacial processes and the landscape we see today, including the woodland ecology and land-use.

Crag Lough/Steel Rigg [NY 752 675]*

Any review of the current interpretation panel and other information should explain the significance of ice and geology in forming the dramatic landscape seen here and how the builders of Hadrian's Wall have exploited it, in addition to interpretation of the Whin Sill itself.

Crindledykes Limekiln [NY 780 670]*

The restored limekilns are described in an existing panel, though there is no interpretation of the limestone or the quarry which supplied it. More information about the nature and working of the key raw materials would provide a complete and integrated interpretation of this once important local industry.

Deadwater Quarries and Kilns [NY 604 969]

Located on the English-Scottish border are a number of geologically related features, including limestone and sandstone quarries, limekilns and old railway buildings. The importance of the geology in this area could be explained in various ways including a geological trail within Kielder Forest. Liaison with the Forestry Commission is suggested.

Doddington [NU 0080 3260]

One of the best panoramas of glacial features in the district can be seen from here, interpretation of the view to the east over Milfield Plain would enhance any visit to the district. Features include the River Glen which occupies a former glacial meltwater channel, a glaciofluvial fan complex and Milfield Plain, the site of a glacial lake.

Fallowfield Mine [NY 937 674]

This site is internationally important as the type locality for the very rare mineral alstonite as well as being of significance as a major Northumberland lead and witherite mine. Interpretation could include information about this economically important industry.

Fourstones [NY 887 678]

The recently re-erected winding wheel from Ellen Shaft of Settlingstones Mine deserves more interpretation. Witherite mining was a unique feature of Northumberland's extractive industry history and merits recognition and interpretation.

Glanton Pike Quarry [NU 062 146]

Interpretation describing the suitability of the sandstone as a building material, which was used throughout the village and exported to Scotland, could cover the quarry and the village. The panoramic views from the quarry could demonstrate clearly the links between the landscape and the underlying geology.

Greenchesters Quarry and Limekiln [NY 872 942] Visible from the A68, these limekilns are in good condition and worthy of interpretation either at the site or off-site, for example at the car park where Percy's Cross is located, or in locally provided literature. Apart from the usual social and agricultural information, the links between these man-made

structures and the underlying geology could be highlighted drawing attention to the key raw materials and the adjacent limestone quarry which supplied it. This would provide an integrated interpretation of this once important local industry.

Haltwhistle Burn [NY 710 658] – [NY 708 645]

Much information could be provided about this site to aid understanding of key geological, mining and quarrying features. It lends itself to geological interpretation, perhaps in a self-guided walks leaflet or within the Haltwhistle walking festival walks programme.

Harbottle Crags [NT 920 044]*

Information illustrating the links between geology, agriculture and the landscape could be provided, including how millstones were chiselled out of the sandstone. Consultation with the NWT and FC should take place regarding this interpretation and how geodiversity could be integrated into their information about the site.

Limestone Corner [NY 877 715]*

Evidence can be seen at this location of how attempts by Roman engineers to excavate the Vallum were thwarted by the hard nature of the stone of the Whin Sill. In addition, the site is an excellent viewpoint giving wide vistas across central Northumberland to the distant Cheviots and Border Hills. A fine opportunity exists here to interpret the foundations of this landscape.

Housesteads [NY 780 687]*

This site would be a good one to explain the significance of the dramatic landscape seen here and how the builders of Hadrian's Wall have exploited it. Attention could be drawn to the nature and use of stone in the monument, and interpretations of the stone buildings.

In addition, landscape and land-use features encountered between the main car park and the Wall could also be explained. Liaison with the National Trust about interpreting the geology and landform of this and other sites along the Wall should be undertaken.

Makendon [NT 811 099]*

The base of the Cheviot volcanic sequence, which unconformably overlies deformed Silurian rocks here is one of the most important boundaries in the geological history of Northumberland and is rarely visible in the district. Geological structures in Northumberland's oldest rocks are clearly visible in the river cliff from bridge over the River Coquet [NT 806 096]. Information should be provided in some form to explain these geological features, the formation of the landscape of the valley and links with the local flora. There are suitable pull-offs at several places. The site is within the Otterburn Training Area. This could be part of a guided trail along the Upper Coquet valley.

Milecastle 33 [NY 831 707]*

The view westward from here is one of the finest, easily accessible viewpoints in the Hadrian's Wall area. This is an excellent place to explain the nature of the highly distinctive scarp and dip landscape so characteristic of the area.

Parkhead Quarry, West Woodburn [NY 899 858]

Parkhead Quarry was worked for building material.

The stone was used locally and exported to Newcastle by railway, and the quarry still contains many original features. It has potential for various methods of interpretation including boards or a short heritage and nature trail following the central trackway leading through the former sandstone excavations. Access is good as the site is adjacent to the A69 and a small area currently exists near the old quarry entrance which could be used for parking.

Pondicherry [NU 045 018]

At a site already popular for woodland walks, more information could be provided about the quarry face describing how the sandstone has been used as a building material throughout much of Rothbury, and linking geology to the economic and social history of the area. Other interpretation about this site could be included in information about Rothbury itself.

Redesdale Ironstone Quarry [NY 887 842]

This is one of the best fossil localities in the district.

This, combined with its historical economic importance, makes it an ideal site for interpretation. Interpretation of the varied geology exposed in the quarry face and associated fallen blocks with descriptions of how and why ironstone was worked here would greatly increase the experience. This would be a good place for group visits.

Rothley Craggs [NZ 043 886]

This location, popular for walking and climbing, would benefit from interpretation of the glacial overflow channel, the craggs, and the folly made of local cross-bedded sandstones.

Settlingstones Mine [NY 849 687]

The site of this world famous and unique witherite mine deserves interpretation.

Simonside Hills and Lordenshaws [NZ 024 987]* Interpretation illustrating the links between geology and archaeology, geology and the landscape and geology and flora of the area should be produced for this site. This may be most appropriate in Rothbury and in off-site literature as the area is a popular destination but a relatively wild upland area.

Thirlwall Castle [NY 659 662]*

Information about the castle and the use of stone has general and educational interest and should be included in interpretation about the site.

Tipalt Burn [NY 659 661 to NY 687 683]*

An exposure of the 'reef-like' Low Tipalt Limestone is located on Open Access land [NY 6799 6795] and has considerable potential for inclusion in various interpretation mediums and walks. It must be emphasised that this is not a locality from which fossils can be collected, but is an excellent example of where fossils can be observed in situ.

Tossen Quarry and Limekilns [NU 027 010]*

The restored limekilns are described in two existing panels, although there is no interpretation of the limestone or the quarry which supplied it. The nature and working of the key raw materials should be considered when the panels are renewed to provide a complete and integrated interpretation of this once important industry.

Vindolanda [NY 771 663]*

Some comment on the sourcing and use of local building materials in the Roman structures would enhance the interpretation of this site, as would an explanation of the varied use of geological materials in the archaeological remains.

Walltown Quarry and Walltown Craggs [NY 668 658] More detailed geological interpretation could augment the existing 'Hard Rock Trail'. In addition, the site is an excellent viewpoint giving wide vistas across central

Northumberland to the distant Cheviots and Border hills. From above the quarry [NY 6753 6639], the view north across Thirlwall Common, reveals streamlined features of the Tyne Gap Ice Stream. Interpretation to explain these features could help visitors appreciate how the landscape in the southern part of the district has been modified by ice and the links with glacial processes, the underlying hardrock geology, and flora of the area.

Whitelee Bridge [NT 715 049]*

From the lay-by on the A68 the links between the geology and the landscape in the Upper Redesdale valley can be seen. This includes Northumberland's oldest rocks visible in the road cutting opposite, the intrusion in Lumsdon Law which was worked economically, the siting of Catcleugh Reservoir, the limestone workings on the remote fells to the south and the sandstone quarry at Echo Crag. Many of these features could be incorporated into a geological trail. This could be integrated with information about the nearby NWT Whitelee Reserve and local accommodation providers in the area.

The following places at the southern margin of the district were highlighted for interpretation in the North Pennines AONB Geodiversity Audit and Action Plan:

Cupola Bridge [NY 800 591]

Langley Chimney [NY 840 610]

Stublick Colliery [NY 833 604].

Suggestions for non site-specific areas to be interpreted

As above, no specific styles of interpretation are suggested for the areas described below, but the information may be suitable for guided trails, walks and inclusion in literature about the localities.

Colt Crag and Throckrington area

Information could be devised for this area to include landscape interpretation and use of materials such as whinstone and limestone.

Cragside

Although there is already much information written about Cragside, more information could be provided linking the geology to the landscape of the area and the building stone used for the house, which came from a number of known quarries within the grounds.

Gunnerton and Swinburne area

This locality is a good one to explore and view 'Whin Sill country' including views of Barrasford Quarry.

Hadrian's Wall Footpath and Cycle Trail*

The area's principal long distance trail offers an obvious and ideal opportunity to incorporate interpretation of geological and landscape features which are crossed by, or visible from, the route. Attention could also be directed towards the nature and use of stone in the Wall. Interpretation could be delivered in a number of ways, for example as a component of a guide booklet or leaflet to the entire route, or the route could be treated as a number of carefully selected component sections. This should be investigated as interpretation is developed for the area.

Haltwhistle Burn

The attractive and popular footpath through this valley is an ideal location from which to explain the geology and former extractive industries, together with their collective impact upon the ecology and present land-use. Any route could be extended to include the area around Cawfields Quarry.

Haltwhistle Town

Even in a small town like Haltwhistle, the varied use of geological materials, and the impact and constraints of natural landscape features has much of interest to offer both visitors and residents alike including substantial educational value for local schools.

Harbottle Castle, Harbottle Crag and the Drake Stone*

Information about the area around the castle and crags could explore the links between geology and landscape, geology and the built heritage, and working of the sandstone for millstones.

Harthope Burn to Housey Crag and Hedgehope Hill*

Information about this area could include localities to explore the granite, andesites, metamorphic aureole and tors, and investigate links between the geology and flora on the Cheviot massif. Peat formation and Quaternary habitat development could also be included in the area of Broad Moss below Hedgehope.

Kielder Forest Drive

This scenic drive crosses areas of Northumberland which have few visitors. Visits could be enhanced by providing information about the formation of the landscape in this area and how materials were exploited in the past.

Nether Hindhope to Gaisty Law

Information for a walk between these two locations could include visits to Silurian basement rocks, volcanics, and descriptions of the topography related to lava flows, deep- weathering of volcanics and perched Quaternary gravels.

Otterburn to Cottonshope Range Road*

Although cutting through the MOD training area this road is often open to the public and would make an excellent geological trail. A whole variety of geological features can be explored within tens of metres of the road between Cottonshopeburnfoot and Alwinton.

Pennine Way*

Proposals to interpret the geological and landscape features of the Pennine Way have been made in the Geodiversity Audit and Action Plan for the adjoining North Pennines AONB (NPAONB). Collaboration between NNPA and NPAONB could be a useful means of delivering appropriate interpretation of the route through the Hadrian's Wall area and on through Redesdale and the Cheviots. Any other future information about the route should be encouraged to include much more about the geology and landforms.

Settlingstones and Stonecroft

The mining features remaining from the lead, zinc and witherite mining industries of this area would be interesting to interpret. Such a walk offers excellent opportunities to explain the interdependence of ecology with geology, for example by highlighting metallophyte plant communities. Further afield, aspects of the formerly important sandstone quarrying industry at Prudhamstone could also be incorporated.

Simonburn

This area is a good one to illustrate the interdependence of geology, ecology and land-use. Access and facilities are available in Simonburn village.

Simonside and Lordenshaws*

Information focussing on the geology of the area and its link to the archaeological remains could be provided for a route using the existing network of footpaths and Open Access land.

Thorngrafton Common

The varied landscape and land-use in the immediate vicinity could be interpreted including explanations of aspects of the excellent distant views available from the area.

Upper Redesdale valley*

Information could be developed for this area taking in the varied geology of the valley, including the riverbank exposures of Northumberland's oldest (Silurian) rocks, the sandstone quarry with sedimentary structures at Echo Crag, the igneous intrusion with columnar jointing worked at Lumsdon Law; the latter two have great views across Catcleugh Reservoir. The geological and geographical reasons for the siting of the dam could be explored together with the surviving workers' hut.

Wall, Fallowfield and Acomb

This area could be used to demonstrate landscape, use of rocks and local lead, barium and coal mining. There are plenty of existing public footpaths that could be utilised.

Wooler/Cornhill Quaternary Deposits Information about the formation, deposits and potential records of the proglacial lakes in this area could be provided.

General landscape around the National Park

Views of the landscape could be interpreted including description of views seen within, and from edges of, the Park e.g. from the A697 and the different geology seen at local villages, such as Powburn, Wooler and Longhorsely.

General Quaternary landforms of the Cheviots*

Interpretation linking various Quaternary features found within and around the Cheviots could be produced. This would explore the effect of the underlying bedrock geology on the ice-streams, the glacial processes which would have been active in the area, the resulting landforms and how various aspects of this modified landscape have been exploited by humans and plants.

Geology and landscape seen around Kielder

The geology at Plashetts and Kielder Column, the geology of sculptures and railway bridges, Kielder Castle and Border Mires could all be included in interpretation, including via the Kielder boat trips.

Geology of the Alwinton-Byrness Road

Potential for interpretation of Barrow Scar, Cheviot lavas, Silurian basement rocks and landslides.

Langley and Stublick

These two sites, at the southern margin of the district, were at the southern margin of the district were highlighted for interpretation in the North Pennines AONB Audit and Action Plan.

District wide geological interpretation

These are some basic themes and ideas that could be explored when developing the Interpretive Master Plan for the National Park and surrounding area.

Building stones

Northumberland is uniquely characterised by its sandstone built heritage, with a continuity of stone quarrying from pre-Roman times to the present day. The geodiversity is directly reflected in the diversity of building materials used historically throughout the district. More information should be made available to illustrate the variety of stone buildings in the district and explore the links between geology, our built heritage and our industrial heritage (i.e. quarrying industry).

Rocks and rock climbing

Numerous crags and former quarries have spectacular vertical rock faces and are well-known to local rock climbers. Liaison with local climbing groups and clubs should take place to produce geological and ecological information or guides for climbers to well-visited climbing sites. This would help climbers appreciate what rocks and features their finger and toes are gripping onto and why some are more fragile than others.

Drystone walls

Drystone walls are found throughout the district and have an intimate relationship with the underlying geology. Information could be made available to help explain the variety of stone types and construction styles, explore how the style is dependant on the rock type which limits its geographical extent and describe different features (and their purpose) that are observed in some walls.

Eminent geologists and naturalists in Northumberland

Information about the story of geological investigation in the district should be made available. This could include details from the early days, when Victorian 'gentleman geologists' explored, described, painted and interpreted the area to more recent times where even with the help of modern technology we still don't know all the answers!

Geology and archaeology

More should be made to illustrate the links between the geology and archaeology of the district. This could explore how the geology underlying the landscape and the availability of various geological materials has influenced the development of human settlement and exploitation of the environment through the ages.

Geology and flora

Observing geology and flora in tandem is interesting and informative. Links between the bedrock geology, the shape of the landscape and the plants that thrive in various areas could enhance any visit in the district. This should be explored in the National Park Biodiversity Action Plan review and incorporated into various interpretation products for the area.

Geology and landscape of the Cheviots

Following the success of the Hadrian's Wall book, 'Ancient Frontiers', material exploring the geology and landscape of the Cheviot massif could be produced to help interpret the dramatic scenery in the northern part of the district. This would provide an understanding of the evolution of the Devonian Cheviot volcanoes and their influence on the development of the Northumberland Trough, on Quaternary events and landscape evolution. This has the potential to be as successful as the Hadrian's Wall book because of the overwhelming popular interest in volcanoes and ice.

Iconic views of the National Park

Through its varied geology, the district displays a varied landscape. More could be done to interpret the best views in the district with information or diagrams explaining why the landscape is shaped the way it is. This could be aimed at visitors and local people.

Many locals will know the landscape visible around them and interpretation can help them to imagine what lies beneath that landscape and what has created the views they know so well.

Limekilns

Dozens of historic limekilns are scattered throughout the district. Some kilns have been restored, others are ruinous. It may be useful to collate information about the function of kilns, the raw materials used (and where they were sourced), and the different architectural styles. This could be augmented with pictures showing the variety of attractive kilns throughout the district.

Links with similar geological areas

Making links or even 'twinning' with another place in the world which has modern day equivalents to the districts Devonian volcanoes, Quaternary ice-streams or Carboniferous environments could be instructive as well as positive for tourism providers.

Millstones

Following on from some research already carried out on millstone quarries in Northumberland, information exploring the links between geology and our cultural heritage, and industrial and agricultural past could be made available. For example the rock types appropriate for millstones, quarries in which suitable stone was found, how millstones were extracted and where they can still be seen (e.g. Harbottle, Prudham).

Northumberland landscape for younger audiences

Information aimed at encouraging the younger generation to look at the scenery and buildings they pass whilst travelling through the district could be produced. Features that could be used include: stone-built castles and towers, meandering rivers, dry-stone walls, limekilns, lakes, rocky escarpments and quarries. There are lots of potential mediums for this including photos or images of a range of geologically-related features that could be spotted and 'ticked-off'. This should include some additional information about the features for a more in-depth educational product to use with school or other visiting groups. This approach could be applied equally to any geological walks and trails at specific sites.

Northumberland's landscapes and textures

Images of different landscapes and geological features visible in Northumberland could be collated to explain the links between geology, Earth processes, ecology, archaeology and our social and economic heritage. These images could be augmented with close-up pictures of rocks showing appropriate colours and textures for the location. For example, a picture of the Simonside landscape with a close up image of cross-bedding, ripple features or attractive oxidation fronts in sandstone; for the Whin Sills, a detail of vesicles or columnar jointing, or a microscope image.

Northumberland passport

To encourage people to visit new places, a number of geological sites could be chosen across the district with a linking theme (e.g. 'useful' rocks, rocky features, or 'rocks and art') and as each one is visited the passport holder would collect a unique 'stamp' in their passport from a local amenity (this could be, for example, a stamp from the local shop or a brass rubbing placed at the site).

Once all the sites have been visited the passport holder would collect a NNP badge or certificate. This idea could also be devised to create a journey through time, 'the geological story unfolding', by visiting different ages of rock across the district and recording in their passport something appropriate to rocks of that age.

Northumberland's rocks and fossils

Information about the variety of rocks, fossils and structures visible in the geology of Northumberland could be provided. This could include where to see them, how to recognise them and what they tell us about the district's geological history.

Patterns and markings in the Fell Sandstone

The Fell Sandstone which often underlies the characteristic escarpments and crags seen within the north of the district usually forms flat topped surfaces in relatively soft rock which are ideal for carving. This is where most of Northumberland's cup and ring marks are found, but it is also a rock unit which weathers to form natural pits, hollows and depressions. More information could be produced exploring the links between geology and the natural and man-made patterns/textures observed in the rock and adding a different angle to a subject which already has many publications.

The value of our rocks

The wide range of extractive industries in the district, both past and present, link geology to industrial and cultural development of the region and deserve interpretation. This could include interpretive information on a wide range of resources and products including coal, ironstone, limestone, building stones, clay roof tiles, millstones, sand and gravel and water.

Figures

(Figure 79) Volcanic rocks exposed in the River Coquet near Shillmoor Farm © Graeme Peacock www.graeme-peacock.com.

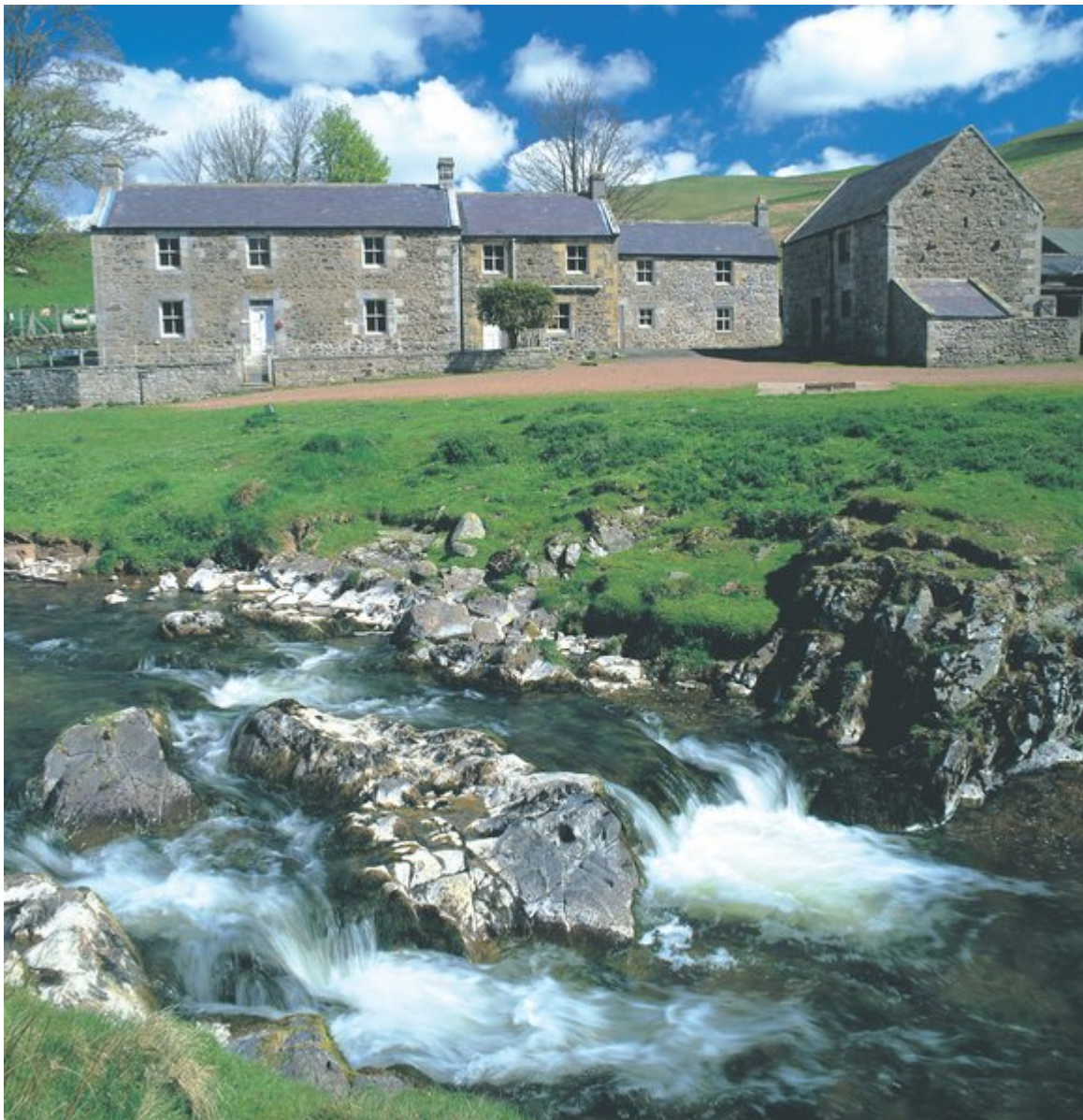
(Figure 80) Vibrator vehicles operating in Northumberland during a seismic survey in the late 1980s. Large pads are lowered onto the road surface and a radio signal is sent which induces a vibration into the ground from each pad.

(Figure 81) Guided walk exploring the landscape above Walltown © NNPA.

(Figure 82) Walltown. The hard rock trail booklet.

(Figure 83) The Lordenshaw rock, a panel of rock art cut into the Fell Sandstone; looking north-west towards the Cheviots © Graeme Peacock www.graeme-peacock.com.

(Figure 84) The opening into the pot at Great Tosson Limekiln.



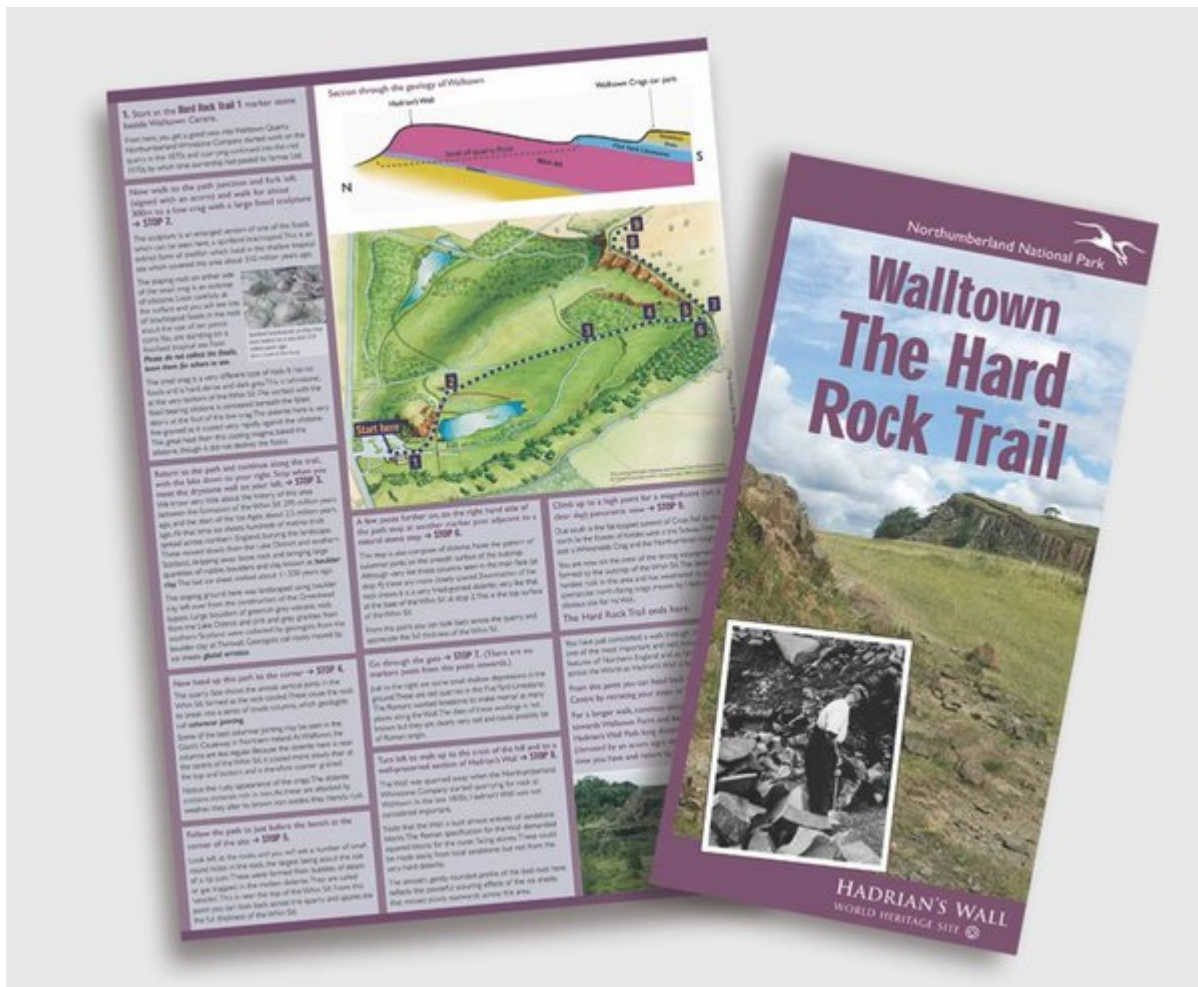
*(Figure 79) Volcanic rocks exposed in the River Coquet near Shillmoor Farm © Graeme Peacock
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