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The Black Country Geological Society
www.bcgs.info

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Copy date for the next Newsletter is Saturday 1 April

Contents:

To find out more about this photo - read on!

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For enquiries about field and geoconservation meetings please contact the Field Secretary.
To submit items for the Newsletter please contact the Newsletter Editor.
For all other business and enquiries please contact the Honorary Secretary.
For more information see our website: bcgs.info, YouTube, Twitter: @BCGeoSoc and Facebook.

Future Programme

Indoor meetings are normally held in the Abbey Room at the Dudley Archives, Tipton Road, Dudley, DY1 4SQ, 7.30 for 8.00 o'clock start unless stated otherwise.

Visitors are welcome to attend BCGS events but there will be a charge of £1.00.

Monday 20 February *(Indoor Meeting):* Please note change of talk. 'The early Anthropocene: our lifetimes'. Speaker: Ian Fairchild (Emeritus Professor, University of Birmingham and Chair, H&W EHT). Ian is a member of the Working Group on the Anthropocene, a sub-group of the Subcommission on Quaternary Stratigraphy (part of the International Commission on Stratigraphy). We are grateful to Prof. Fairchild for stepping in at short notice.

Saturday 4 March *(Geoconservation Day):* Sedgley Beacon. Meet at the Sedgley Beacon car park entrance (GR: SO 923943), off Beacon Lane for 10.00. Note: this is a change from the previously advertised day at Hay Head Quarry. Wear old clothes, waterproofs and strong footwear. Bring gloves and tools (loppers, secateurs, forks, rakes and spades if you have them). Also bring lunch. Finish at 2.30.

Monday 20 March *(Indoor Meeting, 7.00 for 7.30 start):* AGM followed by: 'Celebrating the Origins of Animal Life: Building a UNESCO Global Geopark in Charnwood Forest, UK'. Speaker: Jack Matthews (Geoheritage Conservation and Interpretation Officer for the Charnwood Forest Geopark, UK). Charnwood Forest in Leicestershire is host to some of the oldest animal fossils in the world. This presentation will outline the internationally significant geodiversity of Charnwood Forest - including the outstanding ancient fossils - and the ways it has shaped the landscape, communities, and people of Britain's 'unexpected upland'.

Video recording of meetings

We have started recording meetings by video and members will receive links by email when the recording is available. Initially they will be available to members only but will be added to our YouTube public channel in due course. Please note that not all talks will be recorded as we need to have the agreement of the speaker who may want to use unpublished or copyright material.

Saturday 1 April *(Field Visit):* Wroxeter Roman City. Led by David Pannett (Shropshire Geological Society). Meet in the car park at Wroxeter Roman City, near Shrewsbury, Shropshire, SY5 6PJ, (GR: SJ 565087, from the Black Country, follow the old A5 Watling Street), for 10.30. We will look at the building stones used within the city, where they came from and what happened to them after the city was abandoned. Lunch break in Atcham, followed by afternoon visits to local churches and Acton Burnell. There is an entrance fee for Wroxeter Roman City (an English Heritage site). Bring a packed lunch and comfortable footwear. Aim to finish around 4.30.

Monday 17 April *(Indoor Meeting):* 'The origins of starfish and their relatives'. Speaker: Dr Aaron Hunter.

Saturday 20 May *(Field Visit):* Little Doward and Arthur's Cave. Led by Jim Handley (EHT Champion for the Dowards and Arthur's Cave). Details TBC.

Other Societies and Events

Woolhope Naturalists' Field Club - Geology Section

Friday 24 February: 'Malvern Rocks: Geology in a Victorian Resort'. Speaker: Dr JT Carter.

Friday 24 March: 'Strange Plankton of the Past'. Speaker: Dr Denis Bates (Aberystwyth University, Department of Geography & Earth Sciences).

Non-members of the Club pay £2. Visit: https://www.woolhopeclub.org.uk/meetings All meetings will be held in Hereford Town Hall. Friday evening meetings start at 6.00, unless otherwise notified. Non-members are welcome.

Shropshire Geological Society

Wednesday 8 February: 'The geology and geomorphology of West Cumbria and the geological disposal of high level wastes'. Speakers: Dr James Lawrence and Sinead Birks (Imperial College).

Wednesday 8 March: 'HS2 and the engineering properties of the Charmouth Mudstone Formation (Lias Group)'. Speaker: Dr Kevin Briggs (University of Bath).

Some Lectures are now being held in person at the University Centre, Shrewsbury and some are by Zoom. Further info: http://www.shropshiregeology.org.uk/SGS/SGSEvents.htm

Lapworth Lectures

There were no lectures advertised on the Lapworth Museum's website at the time of publication. Please keep checking their website for details: Lapworth Lectures & Events

Teme Valley Geological Society

Monday 27 February: 'Sand Grains on Speed – radioactive particles in the sea off the north coast of Scotland'. Speaker: Tim Atkinson (University College London).

Monday 27 March: 'An update on the Anthropocene'. Speaker: Prof. Ian Fairchild (University of Birmingham).

Talks take place in Martley Memorial Hall at 7.30. Non-members £3. For field trip details and further information contact John Nicklin, email: martleypfo@gmail.com or phone on 01886 888318 or visit: https://geo-village.eu/

Open University Geological Society, West Midlands

Saturday 11 February: Thin Section Microscopy Laboratory Workshop. Led by Alan Richardson at Lickey Hills Visitor Centre Schoolroom, Lickey, Birmingham.

Saturday 11 March: Geology Field Skills Workshop. Led by Alan Richardson, near Bridgnorth, Shropshire.

See website for further details and joining instructions: https://ougs.org/westmidlands/

East Midlands Geological Society

Saturday 11 February at 6.00: The Presidential Address - 'Civil engineering meets geology at the Panama Canal'. Speaker: Dr Tony Waltham.

Saturday 11 March at 6.00: 'A Recipe for Disaster'. Speaker: Ekbal Hussain.

Non-members are welcome and should register with the secretary. Meetings will be held in the Geography Department of Nottingham University, which is in the Sir Clive Granger Building. Further info: www.emgs.org.uk or email: secretary@emgs.org.uk

Mid Wales Geology Club

Wednesday 15 February: 'What triggered the Cambrian Explosion'. Speaker: Prof. Rachel Wood.

Wednesday 15 March: 'The Geology of the Canary Islands'. Speaker: Chris Darmon.

Further information: Tony Thorp tel. 01686 624820 and 622517 tonydolfor@gmail.com
Web: http://midwalesgeology.org.uk lectures start at 7.15 via Zoom.

Warwickshire Geological Conservation Group

Thursday 16 February at 7.30: 'Birmingham Erratics Project'. Speaker: Zoe Jackson. NB. The venue has had to be changed for this month only - the talk will be given at Kenilworth Senior Citizens' Club.

Thursday 16 March at 7.30: 'The Voyage of the Beagle'. Speaker: Peter Worsley.

There is a charge of £2.00 for non-members. These meetings are both live at St Francis, Kenilworth and by Zoom. For more details visit: http://www.wgcg.co.uk/ or email: WarwickshireGCG@gmail.com.

Manchester Geological Association

Wednesday 8 March at 7.00 (Zoom only): 'The UK's nuclear legacy - opportunities and challenges'. Speaker: Prof. Katherine Morris (University of Manchester).

Events are likely to take place via Zoom. Visitors are always welcome. For more information: http://www.mangeolassoc.org.uk/ or contact lectures@mangeolassoc.org.uk

Editorial

Once again we are in the satisfying position of having more than enough material to include in this issue of the Newsletter, so this editorial will be deliberately brief. We have a full programme of talks, geoconservation sessions and field meetings for all of us to enjoy. If transport is a problem for you please contact Andy.

The year started with a flurry of activity and a hastily planned clearance session for those involved in the Erratics Project *(full report in the April issue).* This was followed the next day (15 January) by Liam Herringshaw's excellent talk on the Yorkshire Jurassic coast, and a rewarding clearance session on 4th February at the southern end of the Wren's Nest. This is shaping up to be a very successful year for BCGS thanks to your support, but we would love to see more of you on our geoconservation sessions and field trips. Enjoy the Newsletter and please get involved! ■

Julie Schroder

Field Meeting Reports

Wednesday 4 August: Himley Estate and Baggeridge Country Park. Led by Graham Worton.

Regional Location

Himley Hall sits on relatively flat, low-lying ground forming the eastern valley floor of the River Smestow, which flows southwards from Wolverhampton to the River Stour at Stourton. The Hall itself is situated approximately 2.6km east of the river, between 90-95m Above Ordnance Datum (AOD) with the ground rising sharply northwards to Himley Park at roughly 135m. It is a U-shaped, Grade II listed structure that today is owned by Dudley Metropolitan Borough Council. The ground rises more gently eastwards towards Baggeridge Country Park, The Straits and Lower Gornal. To the south and west the landscape remains relatively flat and low-lying with a gentle dip to around 85m at the Dudley Road (B4176). ►

Extending north-east from the Hall is a wooded valley that leads past Lydiates Hill and into Baggeridge Country Park approximately 980m away. Within the valley bottom there are several connected pools that include Rock Pool, Island Pool, Spring Pool and Lower and Upper Wishing Pools. Dominating the flat landscaped estate to the west of Himley Hall is a large pool called the Great Pool.

Members of the BCGS and the West Midlands Regional Group of the Geological Society met Graham at 7.00 in the main car park to Himley Country Park. The weather was warm and sunny for our evening walk, taking in the Hall, the valley to the north-east and up to Baggeridge Country Park. Along the way Graham spoke about how the underlying geology has controlled human decisions in shaping the existing landscape, drainage and the biodiversity that covers it today. Our first stop was Himley Hall for an introduction to its history and the local area.

History of the Himley Estate

Human occupation within the Himley estate has been recorded back to the Bronze Age (c. 750 BC) and the Hall started life as a moated farmhouse, which dates back to the 1300s. A small stream leading from the valley to the north-east provided water to fill the moat that would have provided protection from wild animals at the time. In the 17th century, Baron Dudley took the property over from the tenant farmers. The Baron replaced the original farmhouse with a larger structure that included a northern and southern wing, used as a library and ballroom.

Himley Hall

When the Earl of Dudley (John Ward) later took over the Hall in the 18th century, he had the previous structure demolished and a new one built and extended. His son later employed the well-known landscape architect, Capability Brown in 1779, to change the pre-existing farmland into the existing landscaped gardens. This included constructing the Great Pool. By the 1830s, having decided that the Hall was too small and close to the Black Country, the Earl of Dudley sold the property and moved to Witley Court in Worcestershire. The Hall was sold to the National Coal Board in 1948, then Dudley and Wolverhampton County Borough Councils acquired it in 1966. In 1988 Dudley Council bought Wolverhampton Council's share of the property, gaining outright ownership. Today the Hall is used for wedding ceremonies, other special occasions, exhibitions, conferences and guided tours. It is also the current home for the Dudley collection of rocks, minerals and fossils that have long been associated with the Black Country Geological Society. The Hall's design was well planned with the central structure and two wings creating a sheltered courtyard from the prevailing westerly weather. The high ground to the north and east also provided shelter from the weather coming from that direction.

Geology

Superficial deposits are only present along the Himley Estate's southern periphery and continue southwards beyond Himley Road. These deposits include glacio-fluvial sheet deposits (sand and gravel) and head deposits (poorly sorted and stratified rock debris resulting from hill wash and soil creep). ►

The underlying bedrock increases in age from Baggeridge Country Park, in the north-east, to the Great Pool, in the south-west. The youngest stratum is orange and red-brown fine to medium micaceous and feldspathic sandstone, with rare mudstone and siltstone bands, belonging to the Wildmoor Sandstone Formation. Early Triassic in age, this stratum underlies the Great Pool and forms the low-lying flat ground beneath the estate's south-west corner and the A449 before continuing westwards.

Underlying Himley Hall and the parkland immediately to the south, are weak medium-grained and cross-bedded red-brown sandstone strata belonging to the Bridgnorth Sandstone Formation. Permian in age, these strata were formed under arid desert conditions where rounded wind-blown grains were piled into dunes like those seen in the present Sahara Desert.

Forming the tree covered hill and Himley Park immediately to the north of Himley Hall are harder red-brown sandstone strata belonging to the Chester Formation (formerly the Kidderminster Formation). Unlike the Chester Formation beds seen at Barr Beacon during July's field visit, these beds contain far fewer pebbles and are poorly cemented and porous, making them free draining. Triassic in age, and older than the Wildmoor Sandstone, these beds were deposited within a much quieter extension to the Budleighensis River system, hence the lack of pebbles.


The 'Rock Pool', Himley

Continuing up the valley to the north-east, the geology changes to red-brown mudstone strata with interbedded sandstone and thin 'Spirorbis' limestone layers. These beds belong to the Alveley Member, the lower part of the Salop Formation, (formerly the Keele Formation). This stratum is Upper Carboniferous in age and formed under fluctuating intertidal conditions with some fluvial input.

Underlying the high ground forming Baggeridge Wood and Lydiates Hill to the north-east and east, are red and yellowish-brown pebbly sandstone strata with interbedded mudstone and conglomerate horizons belonging to the Enville Member. Forming the upper parts of the Salop Formation, this stratum also dates to the Upper Carboniferous. It is poorly sorted and was deposited under rapidly flowing fluvial conditions with occasional storm surges. It is also very porous, and carbonate cemented, which means it strongly influences the quality of groundwater percolating through it.

Structurally, these various strata show a general dip towards the east, at around 18° to 22° in the case of the Bridgnorth Sandstone and Chester Formations. The tilting resulted from compressional forces and deformation during the Caledonian and Variscan/Hercynian Orogenic events at the end of the Silurian and Carboniferous periods. Permo-Triassic extensional forces during the opening of the North Atlantic resulted in creating numerous major faults, trending roughly north to south, that include the Western Boundary and Lloyd House Faults. The Western Boundary Fault delineates the western edge of the Black Country (South Staffordshire) Coalfield and lies to the east of Baggeridge Country Park. The Lloyd House Fault lies between Himley and Wombourne. Numerous smaller north-east to south-west trending faults also break up the landscape between the more major ones. Together these faults have created various downthrown blocks that have shaped the landscape into steps from Gornal in the east to the River Severn in the west. One such north-east to south-west trending fault has created the wooded valley leading from Himley Hall to Baggeridge Country Park. ►

Hydrogeology and Hydrology

Permeable geology at higher elevations results in most groundwater percolating directly into the ground and occurring at depth. Around Himley Hall less permeable strata cause the stream that historically fed the moated farmhouse to flow at the surface. Such strata along with engineering have formed the Great Pool in the south-west. The small stream flowing from the north-east has used the fault to create the small valley that cuts into the landscape. Historically, in order to supply Himley Hall with a guaranteed water source, the valley was filled, and the stream dammed in places to create the large, picturesque pools seen today. Dolerite was used to line interconnecting channels between the pools.

Historic quarrying of the Chester Formation, immediately north-east of the Hall has created high exposures, into which brick structures have been constructed. One such structure was an ice house, historically used to freeze food for the Hall and ideally located in an area with the least sunlight and warmth. The porous nature of the Chester Formation meant that should the ice thaw, the meltwater would drain away freely.

Himley 'Spring Pool' Cress Beds

Up the valley, at Spring Pool a tributary flows westwards off Lydiates Hill with relatively clear and slightly alkaline surface water that is in contrast to the silty and fairly acidic water in the main stream. The difference in groundwater quality is due to different stratigraphic sources. Where the water in the main stream originates from the Coal Measures strata to the east, the water in the tributary filters through the granular strata belonging to the Enville Member. The tributary's water quality made it ideal historically, for growing watercress. Before entering Spring Pool, the tributary flows through a series of open brick-lined chambers that formerly acted as a watercress garden for the Himley Hall residents.

Baggeridge Country Park and Colliery

On entering Baggeridge Country Park towards the north-eastern end of the valley, the landscape changes to more wooded deep valleys and hills interspersed with open, flat grassy areas. Three faults merge towards the Country Park's entrance, each creating its own small valley and stream that feed into the one leading back to Himley Hall. The visible landscape is one created from industry and the exploitation of the underlying geology through mining.

Baggeridge Colliery opened in 1902 and included two deep shafts (the Big and Little Pits) sunk into the valley bottom. The shafts had to be at depths of around 525 yards (480m) to reach the productive coal seams (24 foot thick 'Thick Coal') that occurred deep beneath the Enville Member strata. When the colliery opened, coal mining in the Black Country had been ongoing for over 800 years, with the more accessible and shallow beds being worked to the east of the Western Boundary Fault. Baggeridge Colliery was very productive, and the Coal Board estimated that there was over 16.9 million tonnes of coal present when it took over the site in 1948. ►

A double (later triple) decker cage transported miners, resources and coal up and down the Big Pit. Waste from the pit was stockpiled on the valley slopes, gradually infilling it and forming the hills and depressions that shape the landscape today. Some spoil heaps were flattened to prevent them becoming unstable and today form the open grassy areas, ideal for grasses and wildflowers.

A dismantled mineral railway runs along the western edge of Lydiates Hill from Himley Wood in the south to Gospel End in the north on an embankment that still runs through the Country Park. Built between 1902 and 1905, the mineral railway carried heavy steam trains and wagons to and from the colliery. To carry the railway over existing roadways, arched bridges were constructed from Staffordshire Blue Brick, which is strong and hardwearing.

With the coal industry in decline, the Baggeridge Colliery only lasted around 46 years before closing in March 1968 with over 2,500 miners losing their jobs. This dealt a big blow to the local community, which, like many mining communities across the UK, lost its local pride and identity. Following a miners' reunion in 1998, the Baggeridge Country Park was born. The landscape was re-profiled and a visitor centre constructed. Over time plant species have moved in to create the woodlands seen today. Around Baggeridge and the valley to the south-west, many species that love freely draining soils, low in nutrients can be found. Back towards Himley Hall, poorly draining soils and slightly boggier conditions prevail that are ideal for a host of other plant species. Today, the Himley and Baggeridge Country Parks provide many varied habitats that are home to many faunal species.

As the sun set and the moon rose, the skies started turning to dusk and a tawny owl began calling. This was our cue to head back to Himley from Baggeridge after what, had yet again, been another very informative trip to an area that represents an interesting and great example of how geology controls the landscape.

I would like to thank Graham for his time, and we look forward to more such trips around the Black Country to come. ■

Andy Harrison

Wednesday 7 September: Visit to Portway Hill, Rowley. Led by Graham Worton.

Members of BCGS and Friends of Rowley Hills met at 6.30 in the lay-by on Darby's Hill Road. Graham explained how the visit would follow the recently published Geopark trail for The Rowley Hills, which is 2 miles long with 15 points of interest, taking in great views, geoart, geological exposures and providing an insight into how human activity has helped to shape today's landscape.

Starting on Darby's Hill Road, the trail heads west onto Darby's Hill for an initial view over the surrounding Black Country landscape. From the hill summit the trail follows a grassy path, formerly a mineral railway, eastwards to St Andrew's Road and on to Lye Cross Road and the site of the former Lye Cross Colliery. Continuing eastwards a short way down Portway Hill, the trail heads on to the southern slopes of Portway Hill and over grassy fields separated by trees, scrub and dry stone walls. Relatively flat and undulating landscapes contrast with more hummocky rough ground and an old coach road that reflect historical human activity. Towards the eastern end of Portway Hill, the trail encounters rock exposures at the former Blue Rock Quarry, Bob's Canyon and Mike's Quarry which hint at the hill's mining legacy. Returning westwards and crossing Tower Road, the trail continues to Massey Bank Viewpoint (No.14), and ends with a view over the restored Darby's Hill Quarry with good views northwards. ►

Regional Location and Topographic Setting

Situated between Dudley and Oldbury on the border between Dudley and Sandwell boroughs, the Rowley Hills form the highest point in the West Midlands, (271m) at Turner's Hill. The range also includes Bury Hill (~235m), Portway Hill (248m) and Darby's Hill (270m).

To the north-west, the high ground continues as an undulating ridge between roughly 170m AOD and 230m, forming several hills, including Tansley Hill, Cawney Hill, Kate's Hill, Castle Hill, Wren's Nest Hill, Hurst Hill, Cinder Hill, Sedgley Beacon, Park Hill and finally Goldthorn Hill. To the north and east, ground elevations fall away towards Sandwell Country Park, West Bromwich and Smethwick at just over 130m. To the south-east, ground elevations fall towards Blackheath, Woodgate Valley Country Park and Northfield at around 150m to 200m. To the south-west and west they fall to around 80m towards Stourbridge, Wombourne and Kinver. This undulating landscape reflects various hard and softer bedrock strata. The ridge which includes the Rowley Hills, forms an important topographic feature in the regional landscape. During prehistoric times, it acted as a transport link between the north and south parts of the country and represented a major obstacle to the local canal network during the Industrial Revolution. It sits on the edge of the River Trent and Severn drainage basins and consequently forms the Severn-Trent watershed for central England.

Rowley Hills Geology

Hard dolerite, known as Rowley Rag, forms the elevated Rowley Hills, with softer Coal Measures and later strata forming the lower lying ground surrounding them. Dark bluish-grey in colour, the dolerite is fine-grained and comprises interlocking plagioclase feldspar, olivine and pyroxene crystals. The dolerite formed from molten magma, injected into the Coal Measures country rock around 307 Ma during the late Carboniferous (Hercynian/ Variscan) tectonic mountain building events.

View towards Birmingham from Portway Hill

Historically, this dolerite intrusion was believed to be a volcano with a feeder pipe beneath. However, early mine workings and the British Geological Survey thematic mapping revealed this not to be the case. No collieries sunk in the area ever recorded a feeder pipe. Instead, it was discovered that the hills comprise a thick central intrusion (Turner's Hill and Darby's Hill) that thins out towards the edges forming what looks like an upside down bowler hat. Bounding the thicker, central mass are two large steeply dipping normal faults that are believed to have subsided during intrusion to form this large sagging structure known as a lopolith - or the Rowley Lopolith.

The lower-lying surrounding landscape generally comprises faulted softer mudstone strata belonging to the Pennine Coal Measures that form the South Staffordshire (Black Country) Coalfield. Beyond, towards Birmingham in the east is a broad plateau covered with glacial deposits – glacial till and glacio-fluvial sands and gravels. Underlying these deposits and beyond the Black Country Coalfield in the west, are later Permo-Triassic sandstone and mudstone strata. ►

Society members will be familiar with the high-wall exposures at Blue Rock Quarry on Portway Hill, where we have been involved with many geo-conservation days in recent years. The exposure shows well, how cooling and weathering impacts the dolerite. As the molten magma cooled it began to shrink, allowing shrinkage fractures and cooling joints to open up in the rock mass. The cooling and shrinking create polygonal columns like those seen at the Giant's Causeway.

'Onion skin' weathering in Blue Rock Quarry

Hot water and steam escaping through the fractures attack the dolerite and slowly erode into the centre of the polygonal block causing it to 'exfoliate' in thin layers. This is known as 'onion skin' weathering. The resulting weathered features are known locally as 'giants eyes'. The hot water and steam also allow minerals to form on the fracture walls causing them to fur up. Common to the dolerite bodies forming the Rowley hills and other Black Country intrusions is calcite infill, which has formed in just such a way. The calcite comes from carbonate rich fluids that have been in contact with more alkaline rocks. *(See also Matt's Maps on our website for this area here.)*

Human Legacy

As elsewhere in the Black Country, the Rowley Hills landscape tells more than just a geological story, but also one of economics and human exploitation. Historically the Rowley Rag dolerite was worked to provide road and paving stone and eventually hardcore.

The earliest recorded industrial workings on the hills is Lye Cross Colliery, off Portway Hill Road, that operated in the 1800s and closed shortly before 1900. The colliery was the first attempt to sink a pit shaft through the dolerite to the underlying coal measures. Rather than hitting the dolerite at shallow surface, the shaft encountered a 58 yard thick sliver at around 100 yards depth. This provided the initial insights into the intrusive mechanism for the dolerite into the Coal Measures strata.

Today, looking around the local landscape on Portway Hill, there is a distinct lack of spoil heaps from the Lye Cross Colliery. The mine is long gone and the landscape smooth and rounded, due to the later quarrying activities that the area was subjected to.

Quarrying the dolerite lasted for around 200 years with the last blast, within the Hailstone Quarry, being heard in 1997. After their closure, the quarries were generally filled in with waste from the collieries to create the existing landscape. Some features such as the screening bund and quarry high wall at Blue Rock Quarry can still be seen today. The quarry high wall forms Geopark Geosite No. 23, which is otherwise known as the Blue Rock Geosite.

South of Portway Hill, the Rowley Regis golf course sits on another infilled quarry. BCGS members visited Allsops Hill Quarry in 1975 during their first field trips, after the Society reincarnated for the third time. On a similar note, Lye Cross Quarry also holds resonance with the BCGS. In 1868, a party of around 60 participants from the then 'Dudley and Midland Geological and Scientific Society Field Club' visited the site on a Sunday afternoon. They went down the active mine and the visit was followed with a cold buffet at a local hostelry. Unfortunately all we see today are smooth fields and a golf course at these sites. ►

Point No.14 on the Rowley Hills Geology Trail is the Massey Bank Viewpoint, situated at the top of a dramatic wooden staircase. Developed as a local project, 'Tales of Rowley' in 2008, the viewpoint pays homage to the key industries that thrived in the area. An iron brazier atop a wooden pole acts as a beacon for lighting on special occasions and is reference to how these hills form the highest point in the Black Country. According to Graham, a beacon was lit in the same spot in the 1500s when the Spanish Armada threatened our shores. Carvings on large blocks from Edwin Richards Quarry and placed about the viewpoint, depict the key industries including ragstone quarrying, coal mining, nail and chain making. A seat and toposcope, formed from hand-crafted cobblestones and ceramic tiles commemorate the quarry owners who supplied the stone for this site. The toposcope points to various features in the surrounding landscape, although trees block the view today.

Biodiversity

Blue Rock Quarry on Portway Hill

The geology and infill used to backfill the quarries provide unique and fairly acid, nutrient poor soils which give rise to special botanical conditions. Bramble, gorse and hawthorn are amongst the larger plant species to be seen across the hills, whilst during the spring and summer months, ox-eye daisy, bush and common vetch, meadow buttercups, mouse-ear hawkweed, red clover and ribwort plantain are just some of the wildflowers to be seen. Good King Henry, an old-fashioned spinach variety, is amongst one of several rare plant species to be found on Portway Hill.

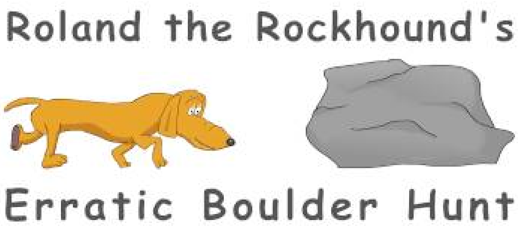
Around 28 species of butterfly and moth are attracted to the habitats that the Rowley Hills have to offer and these include the rare green hairstreak butterfly. In turn, the habitats and insects found on the Rowley Hills attract many bird species, many of which stop for a rest on their migrations north and south.

Once again, I would like to thank Graham for a very interesting visit, exploring another part of the Black Country landscape, and look forward to further such visits in the future. ■

Andy Harrison

Birmingham's Erratic Boulders: Heritage of the Ice Age

The Origins of the Birmingham Glacial Erratics Project



Our regular up-date on the progress of this project is interrupted in this issue for some reflection on its origins by the original 'Rockhound', Roland Kedge. The first of the erratic trails: 'The Great Stone Northfield to the University of Birmingham' is dedicated to Roland, and he kindly lent his name to the cheeky 'rockhound' logo! We hope you will enjoy reading Roland's tale of how it all came about. Ed. ►

Roland Kedge

This article about the Glacial Boulder Project has been written for two reasons: firstly to record the significant contribution made by various people during the earlier development of the Project, and secondly to provide a short history of the Project for volunteers and others who wonder how it all got started. Inevitably the article is also a personal story.

The formal beginning of the Project was the formation of a steering group in 2019 with four partners: the Herefordshire and Worcestershire Earth Heritage Trust (H&WEHT, lead partner), the Lapworth Museum, the Black Country Geological Society, and Birmingham Open Spaces Forum. Then came a bid by the H&WEHT for funding from the National Lottery Heritage Fund early in 2020. The successful bid was led by Professor Ian Fairchild (H&WEHT Chair) and a part time Project Manager and Volunteer Coordinator were appointed. The Project envisaged the creation of several walking or cycling trails across South Birmingham and North Worcestershire. The first Trail for walking was launched on 23rd April 2022. It led from the Great Stone in Northfield to the boulder on the campus of the University of Birmingham. So far as we know the Trail is the first designated glacial boulder trail in the country.

However, the Project had its antecedents in the late 19th and early 20th centuries when professional and amateur geologists began to draw public attention to the glacial landscape beneath the urban and rural landscape of the area. They often recorded the exact location of boulders and this greatly facilitated my own searches a hundred and fifty years later! It seems some of the boulders I discovered have not been previously recorded: hence my Project nickname 'Roland the Rockhound'. Julie Schroder and others have recently described in the Project literature the public excitement over the boulders all those years ago. Since then, apart from some academic papers about the glacial geology of the area, there has been a loss of connection between the boulders and the residents of Birmingham and North Worcestershire.

I have long had an interest and feeling for the natural landscape and when I retired twenty years ago I turned my attention to it locally, and quickly gathered that it was a glaciated landscape containing large boulders. I gave myself the pleasure of seeing how many I could find. The more I found the more puzzled I became that public awareness of the boulders did not seem to exist. I observed people in a public park walk past a conspicuous boulder without a second glance. I considered that people might pay attention to the boulders if they knew about their dramatic journey by ice from North Wales. I decided to try to raise public awareness of them. I produced two pamphlets to be distributed from a stall run by The Rea Valley Conservation Group at local carnivals and open days. The pamphlets were named 'The Rea Valley Mystery Boulders' and 'The South Birmingham Glacial Boulder Trail'. I also led a number of walks along this trail which finally became Project Trail number one. I wrote articles for local publications and developed a power point presentation for various local Group meetings. Perhaps, fortuitously, I provided the Friends of Cotteridge Park with copies of the early 20th century Bournville Works Magazine which described the discovery of large boulders on Cadbury land and their preservation in Cotteridge Park by the then Chief Engineer, Louis Barrow. ►

Rob Ixer at the 2016 unveiling of the descriptive plaque at the 'Great Stone'

Years went until in 2014 I realized that something else needed to happen if the boulders were to be given the recognition they deserved. I had long thought that if some of the more conspicuous boulders could be signed in some way then passers-by might stop to read. I chose the Great Stone in Northfield, set safely in the pound owned by the Great Stone Inn. Janet Ward, the manager of the Inn readily and helpfully gave her consent to my placing a plaque in front of the boulder. The next person was Dr Rob Ixer whom I approached at a meeting of the Black Country Geological Society. He was giving a lecture on the Welsh origins of the blue stones of Stonehenge. I needed a professional geologist to approve the wording of the plaque, and he readily agreed to do this and later assisted the Project by doing chemical analysis of boulder rock samples. When I needed advice about the making and form of the plaque itself I received this from John Gale of The Birmingham Civic Society. He provided the unveiling apparatus and, crucially, the local media coverage. Someone estimated that a hundred or so people crammed in and around the pound on that day in October 2016, including Julie Schroder and other Black Country Geological Society members.

What happened next? There is a gap in my knowledge, but I understand there was a connection made between the well-publicised unveiling event in Northfield and the boulders in Cotteridge Park. Emma Woolf, MBE, of the Friends of Cotteridge Park led on a Lottery Project to explore the history of the park and she made contact with the Earth Heritage Trust via the Lapworth Museum to develop a theme about the boulders in the Park. As a result of this contact, Professor Ian Fairchild became involved and he asked me to show him the boulders I had been finding. Together with Julie Schroder we traversed the country between Barr Beacon, Rowley Hill and Bromsgrove. Ian and Julie examined, measured and employed GPS as we moved from boulder to boulder. Only about that time did it dawn on me that a major project was being considered for the boulders and that it would be in the safe hands of the Herefordshire and Worcestershire Earth Heritage Trust, led by Emeritus Professor Ian Fairchild. It gives me pleasure to think that others have continued to find new boulders during the project and that this heritage is being safeguarded for the future. ■

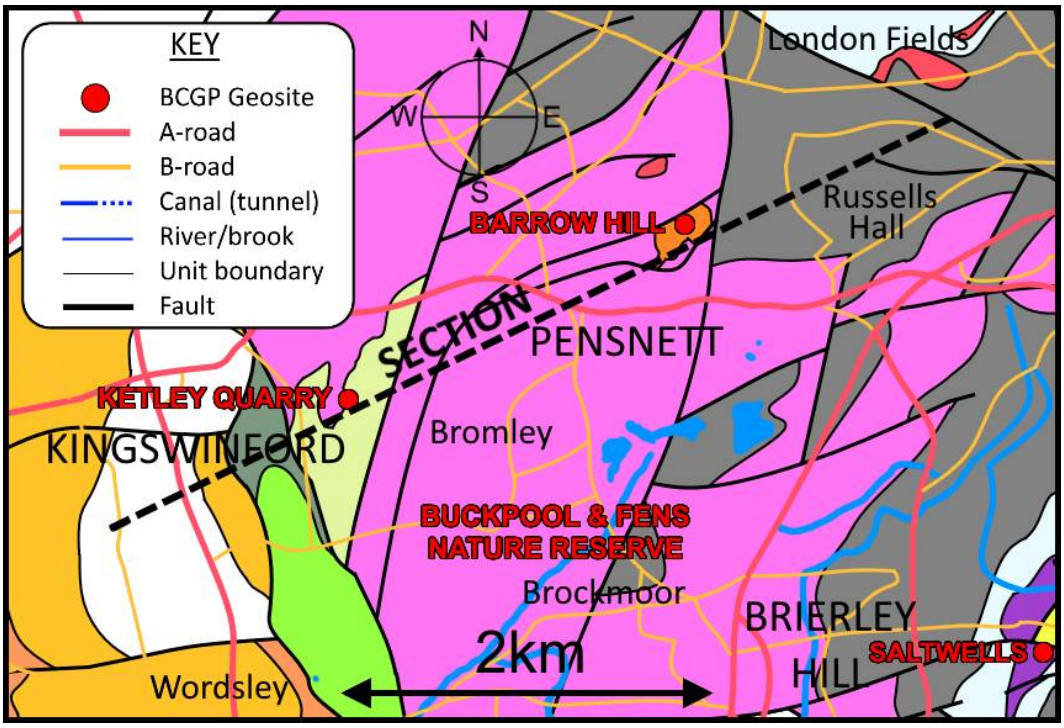
Roland L. Kedge

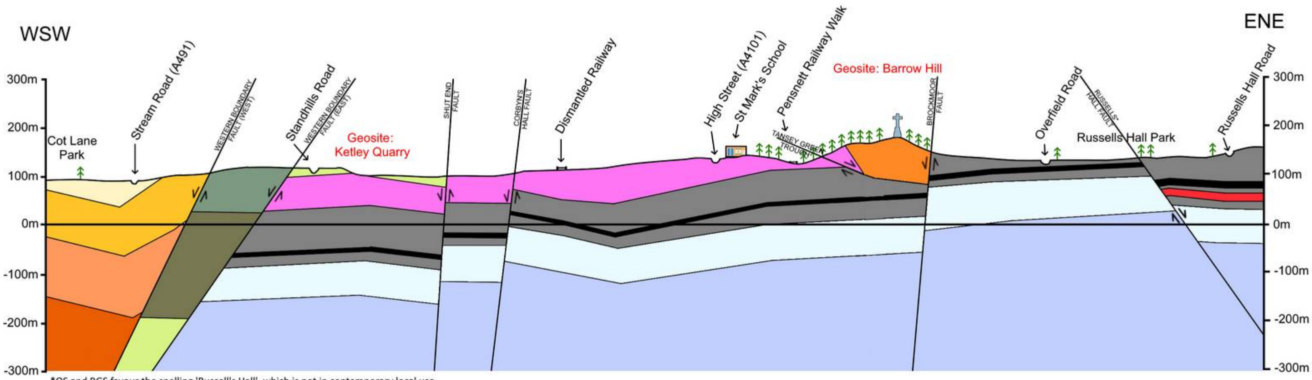
Matt's Maps No. 10

Barrow Hill, Tansey Green & Ketley Quarry

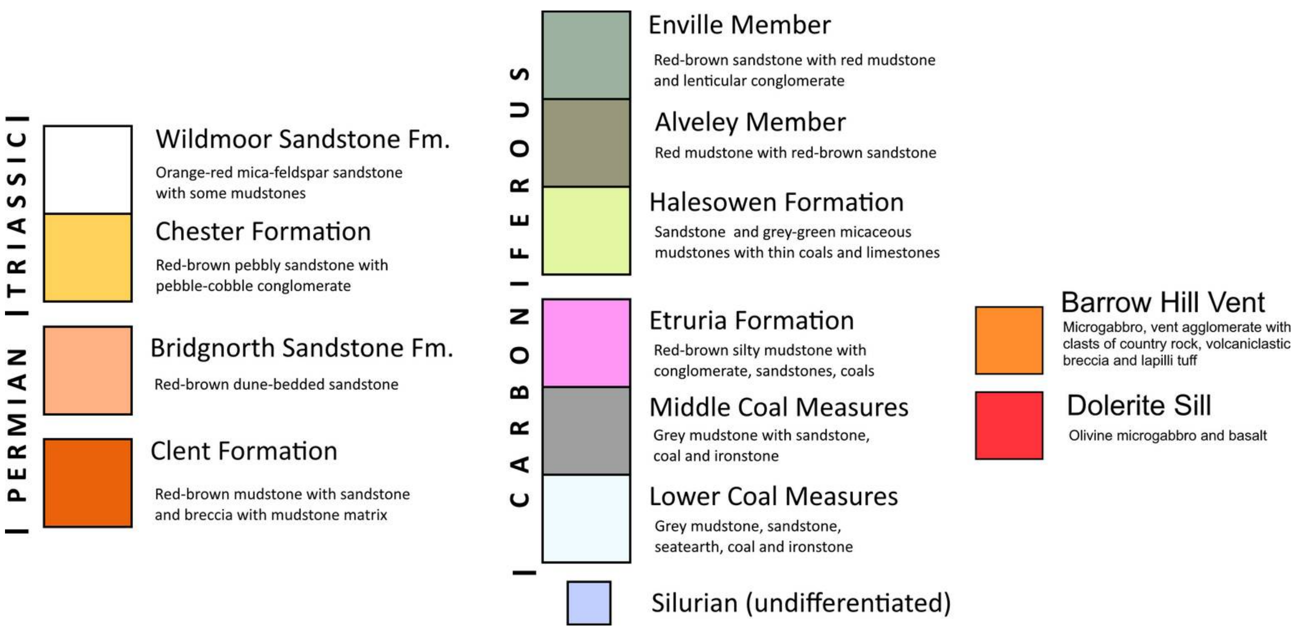
In a broad Carboniferous floodplain a giant predator weaves between conifer saplings. *Meganeura* - a close relative of modern dragonflies - is about as large as a border collie and seeks out small vertebrates and insects to eat. But frequent Earth tremors have startled any potential prey into the undergrowth. The nearby hills are beginning to swell and in just a few hours this entire landscape will be suffocated by smoke, soot, and ash. Welcome to Barrow Hill, otherwise known as 'The Dudley Volcano'.

Barrow Hill is one of the better-known geosites of the Black Country Geopark, partly due to the uniqueness of its geology but also due to the relative abundance of outcrop exposed here compared to most other local sites. Barrow Hill's summit is marked by a striking metal cross, and from here you gain a great overview of the western Black Country, the Rowley Hills and all the way over the Severn valley to the distant peaks of Shropshire. Downhill to the north of the cross is where you'll find the real highlight of this geosite: two adjacent quarries that permit a 3-dimensional view of this cooled dolerite mass. During the late Carboniferous, and likely in association with the major igneous intrusion in the Rowley Hills just a few miles east of here, a magma body was injected into the sedimentary sequence of the coal measures. In Rowley, there is no indication that this magmatic body broke out into the surface environment. However, at Barrow Hill an array of evidence points towards a direct role for lava and volcanism in shaping the landscape and the organisms that once inhabited it. ►



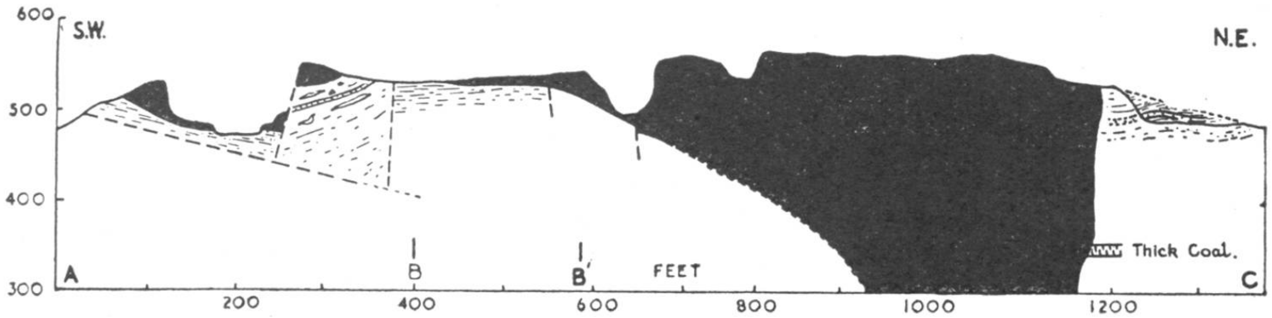


*OS and BGS favour the spelling 'Russell's Hall', which is not in contemporary local use



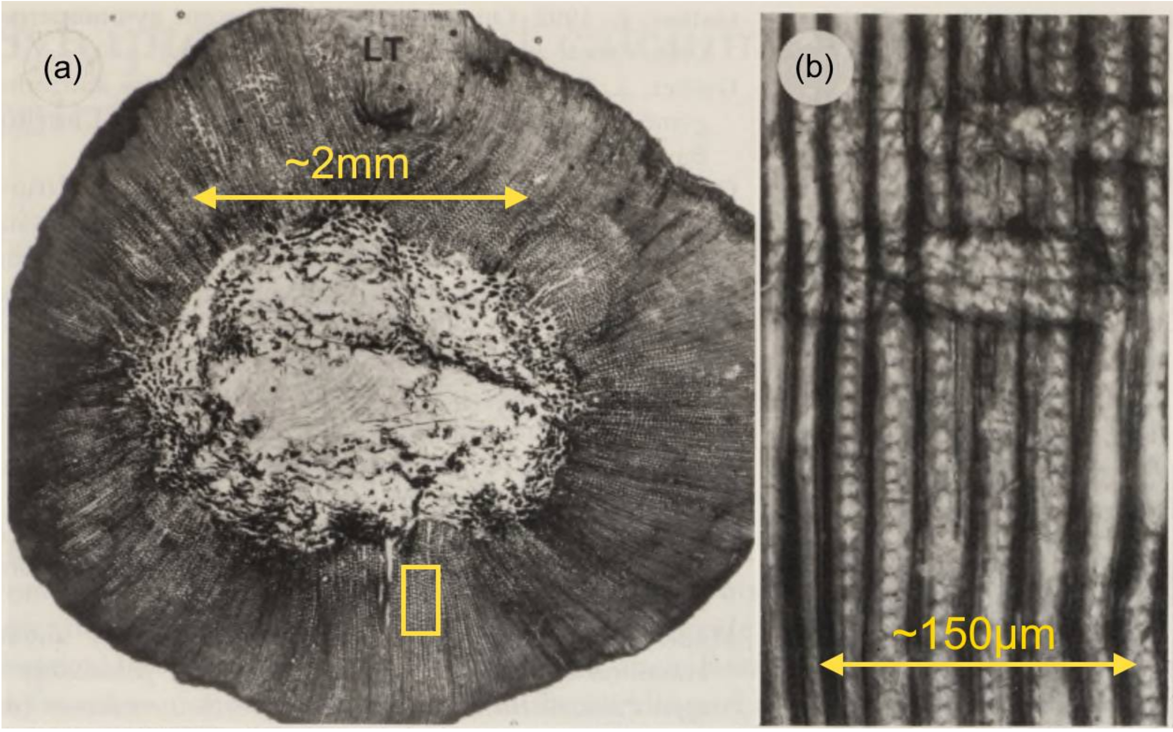
The amount of academic literature discussing this site is testament to its complexity and the headaches it seems to have caused numerous early 20th century geologists. I can't hope to do justice to the full extent of those arguments in the space available here, but please refer to some of the 'Further Reading' below for extra information. The 1945 article by Charles Edward Marshall is probably the most comprehensive paper available on the subject.

So back to the quarry itself - this was a sporadically used site where dolerite was removed for use as a roadstone. An 1886 Ordnance Survey map already marks it as 'Old Quarry', implying it had fallen into temporary disuse even 140 years ago. Columnar jointing akin to that of the Giant's Causeway can be seen in the eastern quarry, evidence of the natural shrinkage of a subterranean magma mass as it turned from liquid to rock. We can also see evidence of the interaction between that volcanic mass and the country rock present at the time when it was rising through the Earth's surface. This local sediment (Etruria Marl Formation, more on that below) has in places undergone thermal metamorphism, changing its physical and chemical characteristics in response to the intense heat of the magma. In places we can see metre-scale xenoliths of country rocks within the magmatic mass, implying that either the magma was cool enough or the Marl robust enough to prevent the total melting of the sedimentary host.



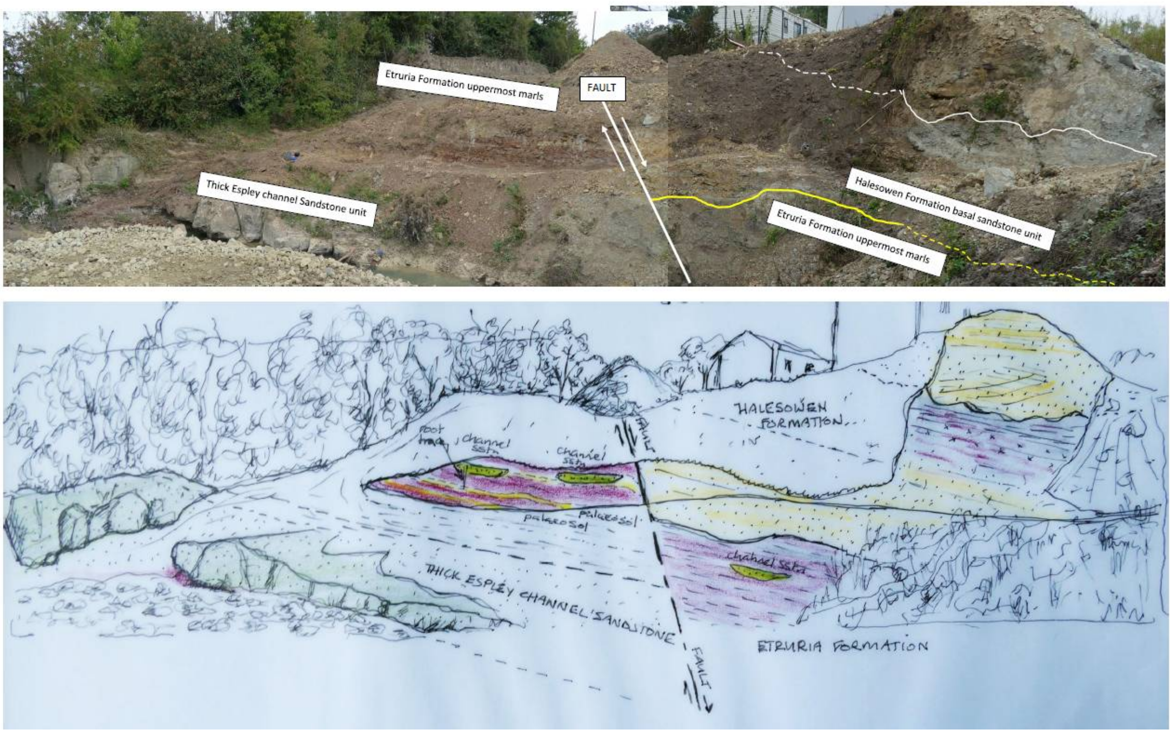
SW-NE cross section through the Barrow Hill intrusion, distances are in feet.
Image reproduced from Marshall (1945).

To the west of Barrow Hill, the other side of the former Pensnett Railway (now part of the muddy Kingswinford Railway Walk) is Tansey Green. Quarries here removed clay from the Etruria Marl and thus supported the local brick industry, evidence of which can be seen in the warehouses lining the road from Pensnett to Kingswinford. Etruria Marl typically consists of interbedded layers of sand, silt and mudstone representative of a warm environment where rivers and streams moved fairly rapidly across a vegetated landscape. Tansey Green is locally unique in also hosting volcaniclastic sediments. These take a few different forms including: debris flows where volcanic material barrelled downhill; volcanic breccias containing angular clasts of sedimentary and igneous material; and volcanic tuff, essentially lithified volcanic ash ejected from local volcanic eruptions. This last facies is of particular interest to a palaeontologist like myself due to the Pompeii-style preservation of cm-sized stems of conifer plants. Despite being a ubiquitous plant group today and for most of the last 300 million years, conifers are thought to have first evolved at some point in the Carboniferous, not long before the deposition of the Tansey Green sediments. These are therefore some of the earliest known conifers, and the oldest conifer fossils that preserve woody stems, found anywhere in the world. They met an unfortunate end after being buried in volcanic ash 307 million years ago, further evidenced by the loss and charring of their outermost bark layer under the intense heating of the ash. But this chance preservation has, not for the first time, enabled a Black Country quarry to inform a chapter in the history of life on Earth. ►



(a) Cross section of Tansey Green conifer stem showing excellent preservation of pith (central white structure), primary and secondary xylem (dark central blobs and outer radial structure).
(b) Higher magnification image of radial structures of the secondary xylem.
Images are modified from Galtier et al. (1992).

Ketley Quarry SSSI, Kingswinford.
(Images Taken 10/9/2020 - G J Worton, Keeper of Geology Dudley Museum)



Composite photograph of faulted Etruria-Halesowen unconformity as seen at Ketley Quarry (top). Bottom image is a geological sketch interpretation by Graham Worton.

Just a mile to the west of Tansey Green is Ketley Quarry, the second geosite covered in this cross-section. As with Tansey Green, this was a site primarily used for extracting the clays of the Etruria Marl for supplying the once-numerous local brickworks. This was the last major Etruria quarry in the region and ceased operating less than a decade ago. It recently received renewed interest in local newspapers as its current owners submitted a proposal to build 650 new houses on the site in December 2022. This article series falls outside the remit of urban development, but it is worth highlighting the invaluable work of the BCGS's own Graham Worton in preserving the geological integrity of this site during its backfilling.

Ketley is significant for hosting the best exposure between the Etruria Marls and their overlying unit, the Halesowen Formation. This is a significant unconformity representing a sedimentation gap of up to 10 million years (though likely less than that at this site). The younger rocks demonstrate a gradual move away from the swampy lowlands of the earlier Carboniferous into increasing dry upland conditions.

This article covers only a 1-mile stretch of road either side of Pensnett High Street, but once again it goes to illustrate what a unique density of important urban geological features are present in the Black Country, and the invaluable role they have played in sculpting our views of the ancient Earth. ■

Matthew Sutton

References/Extra reading

If any newsletter readers have an interest in delving into the literature around Barrow Hill, Tansey Green and Ketley Quarry but can't access the below articles due to paywalls, please send me an email (matthew.sutton@st-annes.ox.ac.uk) and I'll see what I can do.

Comprehensive description and interpretation of the geology of Barrow Hill:
Marshall, Charles Edward. "The Barrow Hill Intrusion, South Staffordshire." Quarterly Journal of the Geological Society 101, no. 1-4 (1945): 177-205. (For link click here.)

A brief summary description of the anatomy and significance of the conifer finds at Tansey Green:
Galtier, J., A. C. Scott, J. H. Powell, B. W. Glover, and C. N. Waters. "Anatomically preserved conifer-like stems from the Upper Carboniferous of England." Proceedings of the Royal Society of London. Series B: Biological Sciences 247, no. 1320 (1992): 211-214.
https://royalsocietypublishing.org/doi/abs/10.1098/rspb.1992.0031

Excellent, detailed description of the geology of Tansey Green and its relationship to the adjacent Barrow Hill sediments:
Glover, B. W., J. H. Powell, and C. N. Waters. "Etruria Formation (Westphalian C) palaeoenvironments and volcanicity on the southern margins of the Pennine Basin, South Staffordshire, England." Journal of the Geological Society 150, no. 4 (1993): 737-750. (For link click here.)

Site-by-site description of significant sites where Etruria Marl and Halesowen Formation outcrops in the Midlands region, including Ketley Quarry:
Cleal, Christopher J., and Barry A. Thomas. British Upper Carboniferous Stratigraphy. Chapter 7: English Midlands. Springer Science & Business Media, 2013. (For link click here.) ►

Chris Baker's article discussing the economic development of this area through industrial times, which I didn't have time to delve into for this article:
Baker, Chris, 2020. Coal mining in the Shut End and Corbyn's Hall area.
https://profchrisbaker.com/2020/04/18/coal-mining-in-the-shut-end-and-corbyns-hall-area/

Industry leaflet about the mineralogy and history of the Etruria Marl. Including the curious story of why it is called a 'Marl' despite lacking any resemblance to the marine rocks we would call marls in modern geological parlance:
X-Ray Mineral Services - Question: When is a 'Marl' not a Marl?
https://www.xrayminerals.co.uk/wp-content/uploads/2021/06/EtruriaMarl.pdf

Mike's Musings No. 43

Sedimentary Rocks: Chips off the old block?

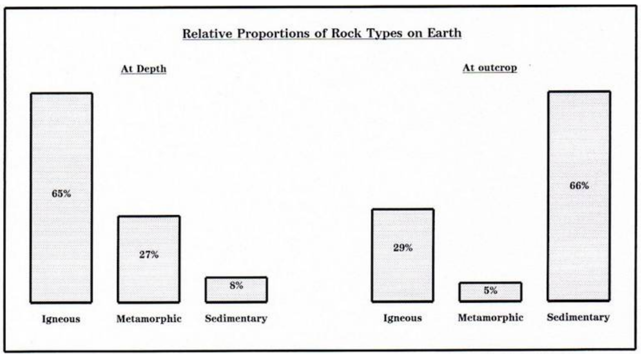


Figure 1

Having engaged your attention with both igneous and metamorphic rocks in recent 'Musings', I commence my piece on the sedimentary world by pointing out the enormous difference between their relative occurrences both at depth and at outcrop. The Earth's crust as a whole consists of 65% igneous, 27% metamorphic and only 8% sedimentary rocks. So why bother even discussing the sedimentary contribution? The simple answer is that we humans mostly live on, and interact with, the surface of the planet. And there, at outcrop, we find 66% of the surface to be sedimentary, 29% to be igneous and only 5% metamorphic. What a turnaround! (Fig. 1).

But we shouldn't really be that surprised by this: metamorphic rocks are formed only at depth, igneous rocks at either, while sedimentary rocks are formed only at the surface. Both 'only's' do have their exceptions - meteorite impacts produce metamorphic effects at the surface, while cave formations could be regarded as sedimentary rock formed underground (but not really 'at depth') and, of course, it is the deposition of sediments that occurs at the surface; their transformation into rock occurs mostly with burial to significant depth. They are brought back to the surface by the removal of overburden.

Sedimentary, like metamorphic, rocks, are secondary by definition: they are derived from a pre-existing 'parent', which may be igneous, metamorphic or sedimentary. The first sedimentary rock was presumably derived from an igneous, primary, 'parent'. They are widespread on Earth because our world has an active atmosphere which promotes the weathering and breakdown of pre-existing material. This process results in particles of sediment which vary greatly in both composition and size. These particles are known as **clasts**, and most sedimentary rocks are therefore **clastic** in origin. Part of their transformation into rock involves their being bound together by a cementing agent: so a typical clastic rock has two components: particles and binding matrix. It is also easy to see that rock material can be re-cycled many times over, with the more chemically inert material surviving best from generation to generation. The mineral quartz is pre-eminent in this respect, hence all the world's sandy beaches! ►

Fig. 2. A colourful sequence of ash beds (weakly lithified) from young volcanics in the Eifel region of Germany

In my Musing (No. 38, Newsletter 272, April 2022) on igneous rocks I referred to the **volcaniclastic** fraternity which have both igneous and sedimentary characteristics, and therefore acknowledge them again in the present context. They may alternatively be referred to as **pyroclastic**, many of which have their own specialised terminology, but are fundamentally sediments that include a significant proportion of volcanic material. Such particles of **ash** become lithified into **tuffs** (Fig. 2).

Fig. 3. Fossils weathering out from a Devonian bioclastic limestone

Another important part of the sedimentary world are **chemical** precipitates. These rocks are formed from aqueous solution – in some respects not dissimilar to minerals being 'deposited' from magmas as in the igneous world. Some texts recognise further categories: **biochemical** (Fig. 3) and **organic**, but these might equally be subsumed within the clastic or chemical headings. All are typically deposited layer upon layer, building up a series of stratified beds in which the oldest are at the bottom and youngest at the top. This provides the basis for the geological sub-discipline of **stratigraphy**.

As usual, it is part of the study of these rocks to classify their variety of forms. The two obvious lines of attack for doing so are based on their **composition** (or mineralogy) and their **grade** (or particle size and shape). Since the Earth's crust is largely composed of oxygen and silicon, most rocks consist of silicate minerals, notably olivine, pyroxene, amphibole, feldspar, mica and quartz - the so-called 'rock formers' (see Musings 20 and 21 in Newsletters 254 and 255, April and June 2019). Some of these decompose into minerals of the clay family. Calcite, dolomite, coal, various 'salts' and various 'ironstones' (Fig. 4) are also important, especially as matrix or chemical / biochemical rocks, or in the way they impact the human world. ►

CONSTITUENT MINERALS OF SEDIMENTARY ROCK

	ABUNDANT	COMMON	"ACCESSORY"
CLASTIC	quartz clays and allied minerals micas calcite (or other "carbonates")	orthoclase (K feldspar) plagioclase (Na/Ca feldspar) pyroxenes amphiboles (less common) olivine (sometimes) serpentine (sometimes)	"assorted ironstone minerals" "heavy minerals" e.g. spinel, rutile, ilmenite, zircon, apatite, sphene, tourmaline, topaz, monazite, corundum "metamorphic minerals" e.g. garnet, chloritoid, cordierite, andalusite, sillimanite, kyanite, epidote, staurolite, glaucophane
CHEMICAL	calcite / aragonite (limestone) dolomite (limestone) siderite, chamosite (ironstones)	silica ("non crystalline" forms) gypsum / anhydrite halite (common salt) etc.	carbonaceous material phosphates hematite, ankerite, limonite

Figure 4

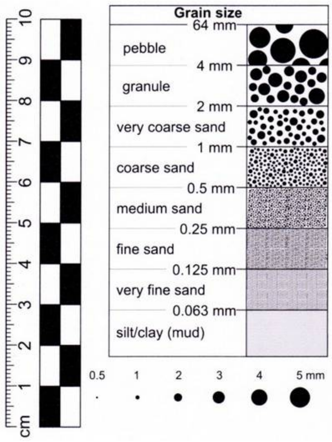


Fig. 5. NB not to scale

PARTICLE SIZE (and SHAPE)		
PARTICLE TYPE	**PARTICLE DIAMETER**	**NAME OF ROCK TYPE**
Boulders	>256mm	Boulder Bed, ("Melange")
Cobbles	64-256mm	) Breccia (angular particles)
Pebbles	4-64mm	) Conglomerate (rounded particles)
Granules	2-4mm	) Breccio-conglomerate (all particle shapes)
Sand very coarse	1-2mm	)
Sand coarse	1/2 - 1mm	) Sandstones (rounded particles)
Sand medium	1/4 - 1/2mm	) "Flagstone" (with partings)
Sand fine	1/8 - 1/4mm	) "Gritstones" (angular particles) **
Sand very fine	1/16 - 1/8mm	)
Silt coarse	1/64 - 1/16mm	Siltstone
Silt fine	1/256 - 1/64mm	("Muddy Siltstone" or "Silty Mudstone")
Mud / Clay	<1/256mm	Mudstone, Claystone, ("Shale")

** The term "grit" (and hence "gritstone") is one of those much maligned words used in many different meanings, so this usage is generally not recommended. It is one of my personal hobby-horses that a better defined usage could be helpful and appropriate.

Figure 6

As far as clast, or particle, size is concerned, both imperial and metric systems have been proposed and field geologists are wont to carry around a 'grain-size comparator' (Fig. 5) that allows a simple 'on the spot' comparison to be made by eye alone. Ironically, a fusion of metric and imperial seems to be quite a common choice for more rigorous determinations according to the following scheme (Fig. 6).

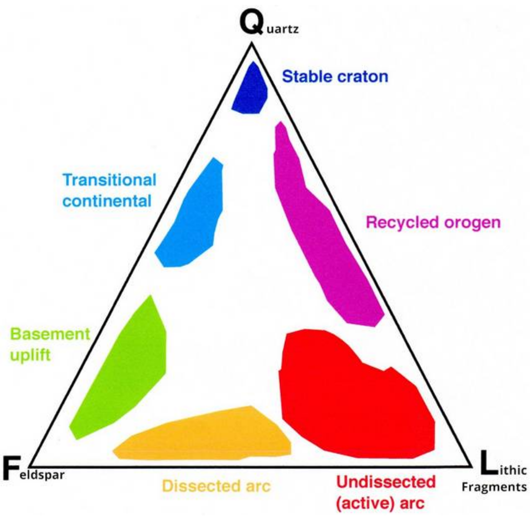


Fig. 7. A 'Q-F-L' ternary diagram

Compositional analysis has been used to indicate deposition in different plate-tectonic situations using a so-called 'QFL ternary diagram' in which the relative proportions of quartz, feldspar and lithic (rock) fragments are plotted against each other (Fig. 7). Empirical observations based on samples of known provenance reveal differences in the relative proportions of 'QF and L' in sediments deposited in various tectonic settings. For instance, arc-related sands plot along the F-L base of the triangle, while craton sands plot close to the Q pole.

Particle size analysis can also be useful in discriminating between sediments of different origin. One example plots the relative proportions of gravel, sand and silt/mud against each other on a ternary diagram, as shown in Fig. 8, which shows up the difference in composition between screes, debris flows and glacial tills.

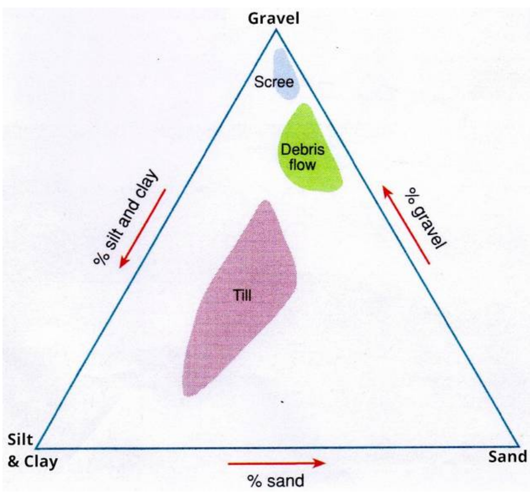


Fig. 8. A 'Particle-size' ternary diagram

Particle shape can be another significant factor in how sedimentary rocks behave, and in some cases different nomenclature discriminates between rocks with rounded or angular fragments. The most common example is the distinction between conglomerates and breccias. The term agglomerate is applied to their volcaniclastic equivalents, while the particular case of an aerodynamically shaped boulder-grade 'volcanic bomb' reflects its passage through the air prior to deposition (Fig. 9). The term grit has been used in so many ways as to have become rather vague and best avoided. This seems a pity as in my opinion it could ►

Fig. 9. Eifel Region, volcanic bomb, aerodynamically shaped (the small cobble on top is 10cm in diameter)

usefully be reserved for a sandstone grade rock in which particles are mostly angular.

Perhaps the greatest importance of sedimentary rocks is the fact that they can convey a great deal of information about the environments in which they were deposited, partly from their own inherent characteristics, but also from the fossils they contain, sometimes in great abundance, unlike igneous rocks in which they are virtually absent and metamorphic rocks in which they are rare (and often 'strained', although this can be very useful in tectonic analysis). The most basic inference which may be drawn from a sedimentary rock is whether it was deposited in a marine, terrestrial or marginal environment.

Marine rocks may convey information about water depth. Limestones, especially in combination with evidence of reef structures, generally indicate shallow deposition on shelf margins within the photic zone (that part of the water column penetrated by sunlight). Evidence of wave action such as ripple marks implies shallow water. Cross stratification may indicate slightly deeper water while different burrowing traces have also been used to imply varying water depths. Deposition on deeper submarine slopes may show signs of mass movement and slumping. Sediments laid down in deep ocean basins are often very finely laminated 'oozes' accumulated very slowly from a background 'rain' of organic debris derived from dead micro-organisms and other decaying life forms.

Fig. 10. Neoproterozoic tillite, Finnmark (note variety of angular lithic fragments set in a fine-grained silty matrix)

Terrestrial (or continental) rocks may include those that reveal evidence of hot or cold conditions. Desert sandstones will show evidence of aeolian transport (i.e. windblown) in the form of various cross-stratification structures indicative of dunes and significant rounding of grains ('millet-seed' sandstones). Glacial landscapes produce poorly sorted 'tills or tillites', also known as 'boulder clays' or, more technically by the rather ugly word 'diamictite' (Fig. 10). Evidence of freeze-thaw in the form of frost-wedges (Fig. 11) are commonly associated with periglacial environments. Recognisable characteristics such as various current structures (rivers), rhythmic couplets indicative of annual deposition known as varves (lakes) and accumulations of organic material (marshes or swamps), are further pointers to non-marine but aqueous deposition. Desiccation cracks suggest both terrestrial and warm, arid conditions.

Fig. 11. Frost wedges in cliff section at South Ferriby

Marginal or **coastal** environments such as deltas, estuaries and tidal zones may often be subject to freshwater or brackish conditions that are indicated by particular fossils. An abundance of evaporite ►

minerals such as gypsum or halite are indicative of hot, arid, tropical environments such as marginal mudflats (sabkhas) or perhaps playa-lakes set in a more continental location.

These examples usually need to be evaluated in conjunction with other features which may be more subtle, or less specific, but a trained eye can often 'read the rocks' like pages from a history book. Some rock types that convey a wealth of information will be quite familiar, others perhaps less so, which a few examples help to illustrate:

Arkose: A coarse sandstone containing much fragmented feldspar, a mineral which decomposes rapidly in oxygenated environments. Its presence therefore suggests rapid burial, implying little transport from source, and so having continental tectonic associations (cf. Fig. 7). Such a rock is considered to be 'immature'.


Fig. 12. Seven Sisters Chalk Cliffs, Sussex

Bentonite: A useful rock with many applications, largely composed of certain highly absorbent clay minerals (montmorillonite in particular), formed by the devitrification of volcanic glass or chemical weathering of related volcanic rocks. It lends itself to radiometric dating techniques and often forms 'marker' bands in sedimentary sequences.

Chalk: (Fig. 12). A distinctive and generally very pure variety of limestone familiar to all. Largely composed of coccoliths, the skeletal plates of tiny calcareous algae living in warm, shallow seas. The remains of larger marine fossils and flint may often also be present.

Cornstone: A silt-grade rock containing small nodules of carbonate material (lime), formed during soil-making processes by capillary action of limy groundwaters, indicative of hot, arid conditions.


Fig. 13. A cobble of Morvern Greensand with scattered shells, Carsaig, Mull

Greensand: (Fig. 13). A sandstone containing a significant amount of the green mineral glauconite (green due to iron in a reduced ferrous state). It is only present nowadays in slowly accumulating, shallow marine reducing environments, which is taken to imply similar conditions in the past.

Laterite: By contrast, this variety of mud-rich rock contains much iron in an oxidised ferric state. It is commonly derived from volcanic rocks which undergo deep and extensive decomposition in tropical environments, and produce highly fertile soils.

Loess: A distinctive, yellowish fine-grained calcareous 'dust' (mostly silt-grade) in which particles are angular and only loosely packed. It is thought to ►

accumulate mainly in windswept, periglacial conditions. Its open structure absorbs fluids and readily collapses under just mild compression, making it a civil engineering nightmare foundation rock! Despite this, it has been widely used to make bricks, hence the alternative name of **brickearth**.

Oolite: Another familiar and specific type of limestone consisting of small rounded grains (**ooliths**) of lime with a concentric internal structure. It resembles the roe of a fish (Greek 'ōión' = egg), and indicates an inter-tidal environment in which particles of lime are constantly rolled back and forth in shallow marginal waters. Occasionally the grains grow larger and are called **pisoliths**.

One final thought: with the recent recognition of all the plastic particles that end up in our present-day oceans, it is plausible that this will become a familiar constituent in some sedimentary rocks of the future and reflect one aspect of the 'Anthropocene' Age some would have us recognise within the stratigraphic record. ■

Mike Allen

A Visit To The Outdoor Geological Display In Tromsø, Northern Norway

Situated above the Botanical Gardens and adjacent to the Planetarium and University of the Arctic this outdoor geological display has excellent interpretive boards and specimens illustrating the varied geology of Northern Norway *(see front cover photo).* In addition there is also a thrust plane to examine, which must be a first for any outdoor geological display. Here are a few examples of the display and information boards to whet your appetites. ■

Mike Williams