EXCURSION

Permo-Triassic rocks of Nottingham

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The city is blessed with many fine exposures of what for many years has been known as the Nottingham Castle Sandstone, but, following a very recent review of the Sherwood Sandstone Group by BGS, will now be known as the Chester Formation. Some 22 members of the Societ survived the road closures due to the tram works and the Robin Hood Marathon to meet at Clifton.

The Sherwood Sandstone Group has long been subdivided into three main units with different names for different regions or basins. As we can now correlate the units across the country with the aid of geophysical logs. the stratigraphy has been simplified with one name for each of the three subdivisions. A number of names have been abandoned, such as the Nottingham Castle Sandstone and Bromsgrove Sandstone, while other well-established names have become members, such as the Wildmoor Sandstone and St Bees Sandstone Members. The main aim of this rationalisation is to simplify the seamless geological map of Britain and to make the construction of 3D geological models much easier. The Mercia Mudstone Group has also recently been reviewed and its stratigraphy simplified.

Locality 1: Clifton

From the village of Clifton [NGR 539348], about half-way down the path towards the river, and on the right, there is an exposure of the Cotgrave Sandstone Member. This bed is very persistent throughout much of the East Midlands and recent work has shown that it extends across Yorkshire to Teeside. Southwards, it is not well developed. It is a greenish grey, fine-grained sandstone that commonly occurs as two leaves, separated by a thin bed of red or greenish grey mudstone. Sedimentary structures noted include cross bedding, cross lamination and parallel lamination. The Cotgrave Sandstone represents the establishment of a river system that was probably flowing northwards, but there is no palaeocurrent data to indicate the precise flow direction.

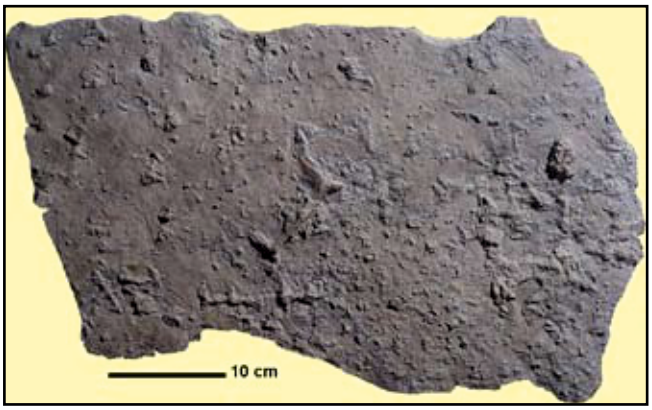
At the foot of the slope, turn left and head along the outer margin of the Trent valley. Here, forming a river cliff to the River Trent, there are excellent exposure of the Gunthorpe Member of the Sidmouth Mudstone Formation of the Mercia Mudstone Group. All show the same part of the sequence. This member generally shows blocky, structureless red mudstones, but here, the sequence unusually comprises mainly laminated mudstones with only one 0.5 m thick bed of structureless mudstone at or near the base of the exposures. Some green mottling can be seen; small green reduction spots

Typical blocky mudstones that are usually predominant in the Sidmouth Mudstone Formation.

may also be visible. These can be caused by the decay of radioactive minerals. Two beds of green siltstone occur in the face, one with interlaminations of red mudstone. Sedimentary structures in these green siltstones include salt pseudomorphs and ripple marks. Both symmetrical wave ripples and asymmetrical current ripples can be found in similar beds within the Mercia Mudstone Group. In the exposures there are two thin continuous beds of gypsum up to 10 cm thick and other beds with anastomosing veins of gypsum.

The Mercia Mudstone is thought to be the deposit of a dust desert, with dust accreting on a sediment surface kept generally damp by a high water table. Because of a high evaporation rate, the water was saline, resulting in the precipitation of gypsum very close to the ground surface, as small nodules. Much of this primary gypsum was dissolved away and re-precipitated as the veins and veinlets most commonly seen within the formation and in this exposure. At times, later during deposition of the Mercia Mudstone, gypsum was much more common with precipitation possibly aided by marine waters. These beds of gypsum have been extensively mined and quarried in Nottinghamshire, Leicestershire

Typical ripple marks seen in the Mercia Mudstone Group.



Typical salt pseudomorphs in the Mercia Mudstone Group.

and Staffordshire. There are two main seams: the lower Tutbury Gypsum is up to 6 m thick and formed the bed quarried at East Leake, Barrow on Soar and at Fauld in Staffordshire. The higher Newark Gypsum is extensively quarried around Newark and occurs as several thinner beds.

Deserts today are prone to the occasional very heavy rainfall, and this can be seen in the Triassic desert. The beds of green siltstone and fine-grained sandstone are the result of these heavy rain storms, which resulted in extensive flash floods. As these flood waters subsided, they left behind temporary playa lakes. Dust blowing into these produced thin sequences of laminated beds. They are also characterised by a number of sedimentary structures, including mud cracks and salt pseudomorphs. These both formed in the very late stages of the lake, as it dried up. The water became hyper-saline resulting in the precipitation of halite crystals on the sediment surface. Later wet episodes dissolved these away and sediment infilled the hollows made by the crystals, resulting in pseudomorphs after halite.

Borehole core with gypsum typical of that in the Mercia Mudstone Group.

Exposure of the Lenton Sandstone under the Keighton Auditorium in the University of Nottingham campus.

Locality 2: University of Nottingham

This was originally locality 2a in Excursion 9 in the East Midlands Guide, where slope stabilisation work has now spoilt the exposure. The same rocks have been recently become assessable within the main university campus west of the ring road, at a site south of the visitors car park under the cantilever of the Keighton Auditorium [54683890].

The Lenton Sandstone was originally included as part of the Sherwood Sandstone Group and thought to be of Late Permian to Early Triassic age. Recent work by BGS redefined that group with the base taken at the incoming of the fluvial facies. The Lenton Sandstone is mainly aeolian and no longer included in the Sherwood Sandstone Group.

The sandstone exposed near the Queens Medical Centre is in a former quarry face. The section shows about 4 m of deep red, fine to medium grained sandstone. It is poorly cemented, the individual well rounded quartz grains being held together weakly by films of clay minerals and iron oxide (haematite) which produces the deep red colour. The sandstone is crumbly to touch but has an almost silky feeling when rubbed between the fingers. This is due to the clay content which is one of the features of a good moulding sand. Individual beds range from a few centimetres to about 1 m thick; some cross bedding can be seen, dipping to the

north, in dune sets up to 1 m thick. Also visible are the grain-flow and grain-fall strata. These are indicated by alternating finer and coarser grained laminae. The fine laminae are the grain-fall,and the coarse laminae the grain-flow, although bedding surfaces are generally poorly defined. The Lenton Sandstone was deposited as migrating windblown sand dunes in an aeolian environment but there is the suggestion in places that parts of the sequence have been reworked by fluvial processes, probably the result of heavy rains and flash floods.

The Lenton Sandstone was formerly quarried in the Nottingham area for use as moulding sand in iron foundries. The sandstone was ideal for this purpose because of the clay and iron content, giving it natural bonding properties that prevented the sand moulds from collapsing when molten metal was poured in. It was once exported to many countries worldwide, but the demand eventually declined due to the development of cheaper, synthetic substitutes. All the quarries in the area have now closed.

The sandstone at the new exposure under the Keighton Auditorium is wind-blown sand with cross bedding showing dune movement and separation by grain size due the wind slowing when passing over the crest of the dune. The much debated location of the Permian/Triassic boundary is now thought to be closer to the base of the Roxby Formation, with the Lenton Sandstone entirely in the Triassic. The nearby Rock Garden is constructed of Bulwell Stone.

Locality 3: Park Tunnel, Nottingham

Excavation of this tunnel [5652 3996] was commissioned in the mid-19th century by the Duke of Newcastle who owned the Nottingham Park Estate and was a recluse. The tunnel was designed to provide access to the Derby Road from the estate, so was built high to allow horse-drawn coaches to pass through. It quickly became redundant when new roads were built into the estate. The Duke of Newcastle's folly is now a splendid legacy to geologists, as it allows the observer to get right inside the former river bed of the former Nottingham Castle Sandstone and observe the cross bedding and other sedimentary features in three dimensions.

The sandstone is brownish grey in colour, medium to coarse-grained and pebbly. Grains are mainly of well-rounded quartz and quartzite eroded from rocks in northern France. It was deposited by a major braided river system that flowed across most of England, originating in the Variscan mountains in France. It had numerous channels that branched, diverged and re-joined around low sand bars. The channels and sand bars were constantly shifting with sand eroded from upstream re-deposited downstream. This caused the bars to migrate downstream, producing the characteristic tabular cross bedding. Foreset dips show a predominantly northeasterly direction, indicating both the direction of the sand bar migration and the flow direction of the river. Some examples of smaller trough cross bedding records the migration of smaller sinuous bedforms along the margins of larger sand bars.

As well as downstream migration of the sand bars, the channels also tended to migrate laterally, producing the sub horizontal erosion surfaces separating the cross-bedded sets. This process also led to the erosion of muddy sediment deposited in the abandoned channels or on the tops of sand bars. Remnants of these muds are preserved as eroded, pebble-size flakes of red or green mudstone. Near the base of the section, the sandstone occurs in cross beds up to 2 m thick, bounded above and below by sub-horizontal erosion surfaces. Both tabular and trough cross bedding can be seen, indicating the different styles of dunes on the river bed. The trough cross beds are best seen at the southwest end of the tunnel and above the arched roof at the Derby Road end. Thinner sets of cross bedding predominate towards the top of the section. Basal pebbly lags occur in some of the cross sets, with pebbles lining some of the foreset laminae.

The northern end of the tunnel is lined with stone blocks. These are from one of the best building stones in the Nottingham area, known as the Bulwell Stone, or the Cadeby Formation, which was once known as the Lower Magnesian Limestone, and is of Permian age. This rock is a dolostone but looks very like a sandstone, due to the sand-sized dolomite crystals that form it, and some are visible as rhombohedra. This stone was used to build the Houses of Parliament.

Locality 4: Brewhouse Yard and Castle Rock

Castle Rock [56953938] is a magnificent, river bluff 30 m high in the former Nottingham Castle Sandstone that shows all the features seen at Park Tunnel. It was probably carved initially when the Trent valley was excavated by glacial meltwaters at the end of the Anglian ice age about 450,000 years ago, but did not acquire its present form until the valley was deepened by further meltwaters from the last (Devensian) ice age, about 13,000 years ago.

Brewhouse Yard is well known for its caves carved into the sandstone, notably Mortimer's Hole, which dates back to the 12th century and linked the yard to the former Nottingham Castle, providing a supply route for the milled corn and ale. The local sandstone is riddled with numerous man-made caves, excavated for various purposes including cellars, vaults, rock houses, access tunnels and sand mines. The weak nature of the rock made excavation easy and the general lack of jointing made the roofs more stable.

Locality 5: Eccles Way, off St Annes Well Road

A former quarry beside Eccles Way [60063974] is cut in the Tarporley Siltstone Formation, formerly known as the Sneinton Formation in the East Midlands. The face is around 10 m high. This is the lowermost

Castle Rock, with the entrance to Mortimer's Hole lower left within the central group of cave openins, and some of the buildings of Brewhouse Yard on the right. Once the type locality of the Nottingham Castle Sandstone, this rock unit should now be described as the Chester Formation.

formation of the Mercia Mudstone Group and is around 30 m thick in the Nottingham area. It is approximately equivalent to the former Waterstones, named because the shine of micaceous bedding planes resembled water. Coincidentally, it also marks the uppermost part of the Sherwood Sandstone Group aquifer. Lithologically, the formation is dominated by beds of very finely interlaminated mudstone, siltstone and sandstone. The mudstones are typically red-brown and the siltstones and sandstones are paler and commonly greenish grey or yellow-buff in colour. Mica is common as one of the main distinguishing features of the formation. Within the sequence, there are beds of sandstone up to around 0.5 m thick. These are typical of the formation but are not always present. They can be up to about 3 m thick and tend to increase in number towards the base. Mud-flake breccias can be found at the base of some sandstone beds, and there are small calcite nodules in the sandstone. Less common are beds of red-brown, blocky, structureless mudstone typical of those in the overlying formations of the Mercia Mudstone Group. Gypsum is also present.

The laminations suggest mainly subaqueous deposition on a low lying coastal flat of mud and sand. The sandstones were deposited by ephemeral river channels subject to crevassing and overbank sheet floods. Ripple marks are commonly found, together with cross lamination and cross bedding. The bedding may show disruptions and soft sediment deformation. Lakes were common and some sediment was blown in by wind. An oscillating water table and frequent drying of the substrate is indicated by common desiccation cracks. Proximity to a marine environment is shown by the rare fossil finds that include the brachiopod *Lingula*, and the crustacean *Euestheria*, as well as fish remains and reptile tracks. The formation normally represents an upward transition from the Sherwood Sandstone Group to the Mercia Mudstone Group but here it unconformably overlies the former Nottingham Castle Sandstone.

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