
Article:
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Karstification of the Permian limestones and dolostones of north eastern England

A sequence of carbonate and mudstone dominated late Permian aged strata crops out as a 5 - 10 km wide continuous north south aligned strip from Nottinghamshire in the south to the north east coast at Hartlepool. The lowest carbonate unit, the Cadeby Formation (the Ford and Raisby Formations in the north), is overlain by the mudstone dominated Edlington Formation. This is in turn overlain by the carbonate Brotherton Formation (the Seaham Formation in the north) which is overlain by the mudstones of the Roxby Formation. The carbonate units have been dolomitised which, in addition to lowering the overall solubility, results in a volume loss giving a 'vugy' appearance to many outcrops. The geology and geomorphology of the outcrop area were reviewed as part of the Geological Conservation Review programme (Smith 1994). Both the Edlington and Roxby Formations contain significant thicknesses of gypsiferous strata towards their bases and the subsidence geohazards posed by the rapid dissolution of the gypsum and resulting spectacular collapse dolines has received significant attention in both the popular and scientific press (e.g. Cooper 2020 & 1996, Cooper *at al*. 2013 and references therein). The distribution of the gypsum extends from outcrop, where it is partially dissolved, to a depth of around 40–120 m, where it passes into anhydrite. This gypsum zone defines a belt about 2–3 km wide where gypsum can dissolve in the subsurface, causing subsidence. To the south the gypsum horizons become thinner so that there is only a very minor presence south of Doncaster. Both the Cadeby and Brotherton Formations are significant aquifers being exploited for both drinking water and, in Tadcaster, for brewing. Groundwater flow is dominated by fissure flow and as such they are prone to rapid transit of pollutants, for example in the Bramham 1980 drinking water contamination incident (Short 1988).

Karstification of the carbonate strata has received much less attention than the far more spectacular evaporite karst but both surface and underground karst features are known in and on both the Cadeby and Brotherton Formations (e.g. Murphy 2000, Brook *et al*. 1988). The exception being the excavations of Pleistocene interior deposits in the Cresswell Crags gorge caves during the 19th century including the discovery of Neanderthal remains. The discovery of the most northerly occurrence of Franco-Cantabrian cave art at the site once again brought it to both archaeology and the public attention (Bahn and Pettitt 2009, Pike *et al*. 2005). The purpose of this paper is to summarise the present knowledge of the karstification of the carbonate strata of the Permian sequence and thus hopefully ensure it included in future geological and hydrological studies, as for example a recent hydrogeological study where a karstic element has been included in the modelling of groundwater flow (Medici *et al*. 2019).

The two carbonate formations outcrop as north-south orientated ridges. The dip slopes act as rainfall catchment and water is fed down dip into the gypsiferous sequences where it returns to the surface along buried valleys associated with the present day river valleys. The ridges therefore provided high well drained ground along which the Romans built the main arterial road between London and York (Ermine Street) and part of its northerly continuation to Hadrian's Wall (Dere Street). This major transport corridor is still utilised today by the A1 major trunk road. The lack of surface water is reflected on the historical low density of settlements over the outcrop, towns and villages being sited either around a spring or adjacent to a stream crossing the outcrop. The presence of a series of engorged river valleys cutting west-east across the narrow outcrop enable the viewing of vertical sections through the sequence. The dip slopes are often incised by dendritic dry valley systems which presumably date to a time when infiltration was prevented by permafrost conditions.

During the last glaciation ice reached as far south as the Wetherby area in west Yorkshire and both the River Nidd and the River Wharfe have been subject to glacial diversions (Kendall & Wroot 1924 p445, Bridgland *et al*. 2011). South of this line the outcrop is partially covered by heavily dissected older glacial and fluvioglacial deposits.

Caves

The most recent overview of the entire outcrop (Brook *et al.* 1988) lists 53 sites in total of which 6 are believed to be of mass movement origin (Houghton le Springs Rifts, Farnham Cave, Nearcliff Wood Rift, Smeaton Pot, Went Edge Rift, Pleasley Valley Railway Cutting Pot) and others may be at least part a result of mass movement. One site is a flooded collapse feature with no cave passage leading off (Hall Garth Ponds - Murphy pers. obs.). The 46 potential karst cave sites listed cover 56 separate caves. The previous review listed 42 cave sites of which four are of mass movement origin (Brook *et al*. 1977). In the first edition of the Northern Cave guides 9 sites were listed in the 'other areas' chapter (Brook *et al.* 1974) and the caves of Cresswell Gorge were listed and described in The Caves of Derbyshire guide (Ford 1974). These caves and others between Mansfield and Maltby have been covered in the more recent caving guides to the Derbyshire region (Barker & Beck 2010 - 17 sites listed). A detailed study of cave and other karst sites the whole of the outcrop was undertaken by Tony Gibbs during the early 1990s (Gibbs 1994 a & b, 1995 a-e).

The known caves are generally not very extensive with the longest karstic cave recorded being Robin Hoods Cave in Cresswell gorge at 290m long, though a significant portion of the passage has been accessed due to extensive archaeological excavations. Herne Hill Cave No.1 is the second longest so far explored at 170m (Ryder 1974, 1979, 1981, 2008) and is one of three caves exposed by quarrying. Herne Hill Cave 2 is over 70 m long and is in part floored by concrete injected through a borehole in a failed attempt at ground stabilisation (Ryder 1980). Herne Hill Cave 3 (Gateways Cave) is 25 m long (Gibbs 1995d,e). Assuming all three caves are part of a system dissected by quarrying this gives a minimum length of around 270 m. Of the 56 possible karstic caves 34 are less than 20 m long. The majority of the caves occur in disused quarries or are found in the deeply incised river valleys cutting across the outcrop including the valleys of the Nidd at Knaresborough, the Went at Wentbridge , the Don at Conisborough and Cresswell Gorge. A number of caves are known as a result of railway cuttings having been engineered through the relatively high ground formed by the Permian outcrop including Ryhope Caves near Sunderland and in the extensive railway cutting complex around Conisborough near Doncaster (Ryder 1983, Mellors 1991). The presence of disused quarries and railway cuttings have proved attractive sites for landfill and a number of caves are no longer accessible including those in railway cuttings around Ryhope in the north and South Elmsall quarry in West Yorkshire. The caves show features typical of phreatic cave development such as roof domes and tubular passage cross sections but so far little or no evidence has been recorded which indicates vadose development has taken place. A number of cave sites show evidence of modification by human activity such as at Anston Stones near Sheffield (Brown 1968).

Age of the caves

The only dating undertaken on speleothem deposits is a study undertaken in the1980s (Rowe *et al*. 1989). The ages obtained for the speleothems, and particularly the absence of any samples that are beyond the range of the U-series dating technique at the time (350 Ka), strongly suggest that the caves are no older than mid-Pleistocene and Creswell Crags Gorge itself is a mid - late Pleistocene feature and not of possible Tertiary age or even an exhumed product of the Permian paleogeography.

Mass Movement Caves

There are a number of mass movement caves along the outcrop and these are the longest caves so far explored in the Magnesian Limestone. The systems associated with the valley of the River Went have been interpreted as being a result of valley side cambering (Shooter 1994, Speight 1987) but sites such as Farnham cave near Knaresborough are not as simply aligned with the topography and may have formed as a result of small scale localised folding (Lowe 1978 & 1974). The last known communication about this interesting cave unfortunately reported the landowner had blocked the entrance (Shennan & Shennan 1991).

Sinking Streams

The lack of impermeable cover to concentrate recharge means sinking streams are rare, so much so that Cooper (1986) comments on the lack of springs and sinking streams on the Cadeby Formation outcrop. There are however some notable exceptions such as the sinking of the River Skell near Ripon (Murphy 1999, Lowe 1978) to emerge 2 kilometres to the east and 40 m lower at Hell Wath. A number of active steam sinks are known in the Wadsworth Woods area adjacent to the M18 motorway in South Yorkshire (Higgins 2018, Smith 1971). No attempt at water tracing is known to have taken place though Smith speculated on a possible connection with the wet workings of the then active Edlington Colliery.

Springs

While the area has many springs and often settlements historically grew up around them finding any which appear associated with enterable or potentially enterable cave passage has so far proved fruitless. Promising sites such as the Jewisons Wood Springs (SE379447) and associated sites between the villages of Bardsey and Collingham to the east of Leeds situated at the base of the Cadeby Formation on investigation turn out to be either be heavily culverted due to agricultural activity or arise from areas of diffuse seepage. Many large potentially artesian springs occur along the river valleys appear manly associated with gypsum karst and the water rises through unconsolidated Quaternary deposits.

Dolines

In an overview of karst engineering hazards Farrant and Cooper (2008) report few sinkholes are found on the Permian outcrop, possibly due to agricultural infilling. A more localised study in the Yorkshire area however identified a number of such features on the carbonate strata in addition to those resulting from gypsum dissolution (Murphy 2000,2003, Lowe 1974). With the availability of detailed lidar data over much of the area and an increased pressure for development the identification of such features will become more common.

Comparison with other British karst areas

The outcrop has many similarities with the chalk karst lands of south east England, having little in the way of impermeable cap to focus recharge, porosity being dominated by the presence of fissure networks and being heavily developed for agriculture. The high fissure density and porosity mean conduit development which progresses to the scale of enterable caves only occurs under exceptional conditions (Farrant *et al*. 2021). The presence of deeply incised valleys (gorges) cutting across the Permian outcrop is a major contrast with the chalk karst of southern England which lacks

such features and may account for the comparative abundance of caves known in the Permian strata (Reeve 2021).

Future prospects

The outcrop has lacked systematic and sustained research and searches by cavers with the exception of the work of the Yorkshire Subterranean Society around Castleford, the Moldywarp Speleological Group and the extensive works of Tony Gibbs and others published by the Derbyshire Caving Association.

Of the river valleys crossing of the outcrop which do not have caves associated with them the valley of the River Aire is a broad gap as a result of its Pleistocene history and lacks steep valley sides. However the valley of the River Wharfe is heavily incised between Wetherby and Tadcaster and appears to lack caves compared to other similarly incised river valleys. Generally close observation of active quarrying across the outcrop may be worthwhile.

Conclusions

The carbonate strata of the Permian succession of northern eastern England are karstified, though explored cave development is of limited extent and no active conduits have so far been entered. The relict caves so far explored are mainly accessed through either natural or man-made vertical sections through the strata and appear to be entirely phreatic and only formed under exception circumstances. Evidence of active karstification have been identified so searches should not be limited to seeking just further examples of relict caves

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Other areas section 136-141 includes some caves in the Permian – 9 sites listed two of which are mass movement features

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Magnesian Limestone caves 141-152 from County Durham to Nottinghamshire. 42 sites listed 4 mass movement

Brook D Davies GM Long M H & Ryder P F 1988. Northern Caves Volume 1 Wharfedale and the North-East. Dalesman Books

Magnesian Limestone caves 262-275 from County Durham to Nottinghamshire. 53 sites 6 mass movement

Covers the Cresswell Crags caves.

Yorkshire Rocks and landscape

At the start of the last glacial advance (Devensian) the topography of the Knaresborough district was different to that seen today. The proto River Nidd ran to the north and east of the present town. It deviated from its present course at Nidd [SE 302 608] and ran through Brearton and past Farnham [SE 345 605] to the northern outskirts of Knaresborough [SE 363 580], before heading eastwards. During the advance of the Devensian ice-sheet a thick fan of sand and gravel was deposited in this valley, emanating from the front of the ice-sheet via glacial channels around Farnham [SE 352 606] and Occaney [SE 352 619]; this deposit was worked in the gravel pits north of Knaresborough [SE 356 587]. If Knaresborough is approached from the north via the B6166 from Boroughbridge the extent of this buried valley, and its associated sand and gravel deposits, can be appreciated from the road. As the ice advanced further to the south and west it over-rode the sand and gravel, completely blocking the proto-Nidd drainage and diverting the river westwards. Here the river exploited the lowest, softest rocks and incised the present Nidd Gorge. West of the Nidd Gorge the glacial deposits are generally thin and probably pre-

Devensian in age; east of the gorge the Devensian deposits comprise thick hummocky glacial **till** with **moraines**, **eskers** and late glacial lake deposits.

http://nora.nerc.ac.uk/id/eprint/7489/1/CR07025N.pdf

(print a copy)

Dog rescue from a cave near Knaresborough

https://www.harrogate-news.co.uk/2012/11/18/dog-rescued-from-cave-near-knaresborough/