EXCURSION

Fountains Abbey / Brimham Rocks

Leader: Neil Aitkenhead

Sunday 30th September 2001

Fountains Abbey

Having travelled to North Yorkshire by coach, the party disembarked at the Fountains Abbey Visitors Centre where the leader outlined the day's programme. The abbey was built by the Cistercian Order between c.1130 and 1526 and made wealthy by its extensive sheep-rearing lands extending right across the Pennines. The carefully preserved ruins and surrounding land are owned by the National Trust and maintained by English Heritage, and are now a World Heritage Site.

The abbey lies in the incised meandering valley of the River Skell, part of which was landscaped in the 18th Century with lakes and follies as well as 'artfully contrived views'. However, it was the scattered rock exposures in the valley that were to be our main objectives and required a walk of about 2.5 km to the first exposure.

Generally the river has eroded down to 30-40 m below the adjacent terrain to expose bedrock in cliffs formed by the meander scars. However, the present flow seems too weak to erode such a deep valley. It seems likely that most of this erosion was by glacial meltwaters, perhaps initially sub-glacially and then pro-glacially. This occurred mainly during the melting of the Pennine ice-sheet towards the end of the last (Devensian) glaciation some 14 000 years ago. However, since this area was near the margins of both this ice-sheet and that of the Vale of York, meltwater erosion may have taken place over an extended time interval.

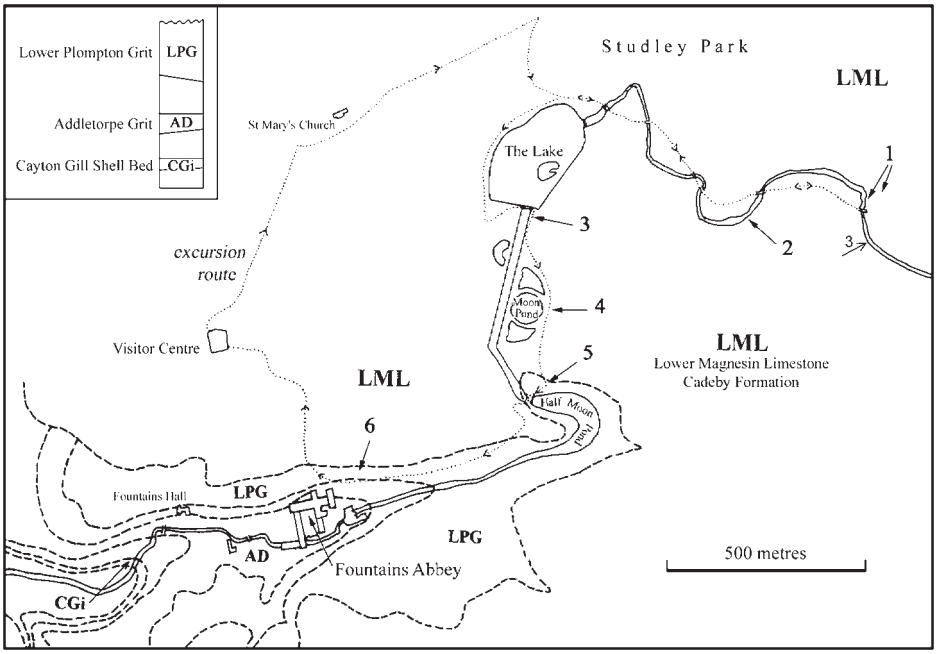
High relief moraines to the south of Fountains Abbey (e.g. How Hill with a relief of about 30 m at SE 276670) are thought to be marginal to the Vale of York ice-sheet, and the extensive cover of glacial till on the ground adjacent to the Skell valley was probably deposited by that ice.

Around Fountains Abbey, rocks of the Cadeby Formation (Lower Magnesian Limestone) of Late Permian age rest unconformably on rocks of the Upper Carboniferous Millstone Grit Group. Most of this area lies in a lower sub-division of the formation characterized by deeper water facies in contrast to "patchily-developed littoral or sub-littoral dolomites" with abundant bivalves (notably *Bakevellia*) in places (Smith, 1974). This deeper-water facies generally comprises "slightly fetid, thinly bedded to flaggy calcitic fine-grained dolomites and dolomitic limestones with knobbly bedding planes that are commonly coated with black stylolitic residues". Carbonate-lined cavities are abundant. Mottling similar to that in Durham is widespread, and much of the rock has a tendency to autobrecciation and a chunky fracture.

Our walk took us down into part of the Skell valley known as The Valley of the Seven Bridges, where seven meanders are each crossed by little hump-backed bridges. Locality 1 was next to the farthest downstream of these bridges.

Locality 1

Rubbly thin-bedded dolomitic limestones with fairly constant bed thickness occur at river level. There was some discussion about the origin of the rubbly bedding, which is sometimes attributed to burrowing or bioturbation. However, there seemed to be no evidence of the former presence of burrowing organisms such as bivalves and it was pointed out that similar rubbly beds in Durham were thought by Smith and Francis (1967) to be the result of pressure solution.



Geological map of the Fountains Abbey area, showing the route followed and localities visited. All the ground outside the Skell valley is covered with several metres of glacial till. The stratigraphic column shows only members of the Kinderscoutian within the Namurian Millstone Grit Group (based on BGS maps).

A precipitous face of apparently massive thick-bedded dolomitic limestone is present with its base about 10 m above river level showing marked contrast with the underlying thin-bedded facies. Access was not attempted due to its steepness but it was noted that the base was sharp, undulating and possibly disconformable, with a suggestion of cross bedding just above the base. A sample obtained from just above the base on a previous visit appeared under the hand lens to be a partially dolomitised grainstone in which a relict oolitic texture could just be discerned.

Walking upstream to Locality 2, it was noted that glacial till had slumped down almost to river level on the north bank and there were numerous erratics of Carboniferous sandstone on the bed of the river.

Locality 2

A meander scar extends for over 100 m, exposing some 12 m of a similar facies to the lower beds at Locality 1, at a slightly lower stratigraphic level. Bed thicknesses range from 5 to 20 cm, varying only slightly along the strike. At one point a spring seeping from the rock face has produced a large protuberance of moss-covered tufa.

Locality 3

After walking round The Lake, we arrived at a small exposure by the path below the Octagon Tower. This comprises blocky grey fine-grained dolomitic limestone (calcisiltite), and loose blocks contained tiny, white, coiled foraminifera.

Locality 4

The geological map (BGS, 1987) indicates that at some point along the path we were following, we would cross the unconformity where the Cadeby Formation rests on the Carboniferous Lower Plompton Grit. However, fragments of dolomitic limestone in the bank behind the folly known as the 'Temple of Piety', indicated that we were still on the outcrop of the Cadeby Formation.

Locality 5

A rubbly bank next to the junction of paths heading east and west of Half Moon Pond was found to have small exposures of medium- to coarse-grained sandstone. These are Millstone Grit just below the basal Permain unconformity, the actual plane of which was not exposed. However, its line can be fairly easily traced as it descends into the valley at this point.

It was pointed out that this unconformity is of great geological significance. It represents a time when some 2000 m of late Namurian and Westphalian strata may have been removed during an interval of folding, faulting, uplift and erosion lasting perhaps 30 million years. This Variscan orogeny resulted from the final collision of the continents of Gondwana and Laurasia to form the supercontinent of Pangea. From late Carboniferous to early Permian times, the region moved northwards from the equatorial forest belt to the tropical desert belt. Then, rifting in what is now the North Sea, possibly combined with a rise in sea level caused by melting of the southern polar ice-caps, created the Zechstein Sea. The carbonate rocks of the Cadeby Formation were then deposited on the western margin of that sea.

Locality 6

The Lower Plompton Grit is one of several distinct sandstone units of Kinderscoutian (R1) age in north and west Yorkshire that amalgamate southwards to form the extensive outcrop of the Kinderscout Grit. Generally, "it is medium- to very coarse-grained, locally pebbly, cross-bedded, feldspathic sandstone" (Cooper & Burgess, 1993). It was deposited in the great river system that formed an extensive delta prograding intermittantly southwards across the Pennine Basin in Namurian and early Westphalian times.

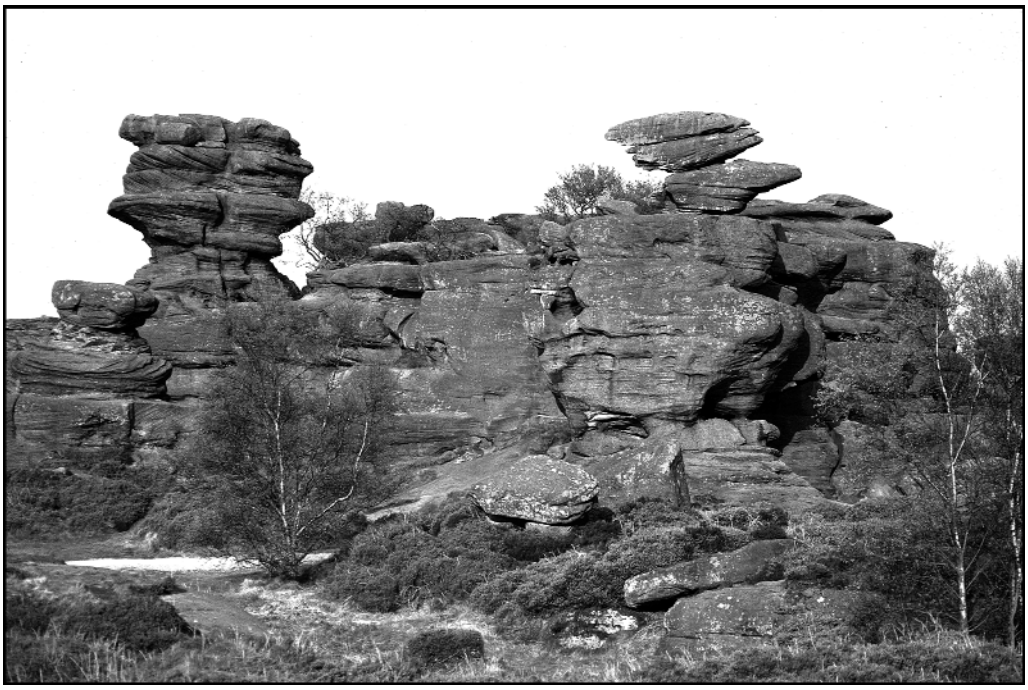
The Grit is well exposed in a quarried cliff that extends discontinuously for about 400 m beside the footpath immediately north of Fountains Abbey. The advantage of siting the abbey so near to this excellent source of building stone becomes obvious to the visitor. The sandstone in the cliff is medium- to coarse-grained and well weathered to emphasize the cross-bedding and reveal large ferruginous concretions in places. The attractive colours of the stone – pale to yellow brown with a pinkish tinge in places – probably indicates its proximity to the overlying plane of unconformity.

Before boarding the coach for Brimham Rocks, some members enjoyed their packed lunches among the abbey ruins, noting the rare examples of crinoidal Nidderdale Marble (Blacker & Mitchell, 1998) in some of the buildings.

Brimham Rocks

Owned and managed by the National Trust, Brimham Rocks lie on a broad hilltop reaching a height of 301 m on the north side of Nidderdale. This extraordinary landscape of sandstone tors is formed by the deep weathering of the Lower Brimham Grit - which is probably the lateral equivalent of the Lower Plompton Grit at Fountains Abbey, 7.5km away to the north-east. Wilson and Thompson (1965) note that in the Kirkby Malzeard area immediately to the north, the Lower Brimham Grit ranges up to about 30 m thick. The medium- to coarse-grained sandstone at Brimham displays a variety of cross-bedding sets. These can be interpreted as having formed as shifting sand bars, sandbanks and dunes migrating downstream on the bed of a powerful river that deposited huge spreads of sand in delta distributaries extending south to what is now the Peak District. Tree ferns fell from the eroding banks of this river and became buried in the sand. We saw the remains of one of these in the form of a sub-horizontal tube, 3.5 m long and 0.5 m in diameter in the side of a tor.

A few of the tors are surmounted by blocks of sandstone that have been tilted to a near vertical



The tors of Brimham Rocks.

position with respect to their bedding structures. In discussion, two explanations were put forward, the first being that the blocks had been let down by ice as it melted during a waning phase of the last glaciation. The second explanation was that at some point in the erosion process, the uppermost part of the tor had become undermined and unstable, and the perched block had simply tilted or toppled into its present position. No concensus was reached!

The main discussion, however, was about how the tors had formed in the first place. In general, it is commonly believed that tors remain after the intervening rock has been removed following softening by chemical weathering particularly along and adjacent to strong joint planes. Such planes are clearly present at Brimham and may have been widened by incipient cambering in this elevated hilltop position, especially near the flanking western and northern edges of the escarpment. About 20% of the sandstone consists of feldspar, a mineral prone to chemical weathering especially in the warm climate that prevailed during Neogene times when the area was probably uplifted to its present position.

Although it is generally accepted that almost the whole region was ice-covered during the last glacial maximum, there is little evidence of ice erosion at Brimham. The ice here may have only formed a thin, semi-static cover with the main local ice stream flowing down Nidderdale. Once melting and retreat had started, the Brimham escarpments would have been amongst the first areas to be uncovered, exposing them to the full force of katabatic winds descending from the main Pennine Ice Cap to the north-west. These winds, armed with ice crystals and (increasingly as melting progressed) with sand and rock particles, would have been the main agent for the erosion and removal of the softened rock and the abrasive etching of the tors. Disaggregation of the sandstone would have been greatly enhanced by the effects of repeated freezing and thawing. Other planes of weakness in the sandstone, such as bedding planes and poorly cemented beds, would have been more susceptible to erosion - giving rise to the strange shapes and features, including scattered small potholes, that add to the attractiveness of the tors.

Although the day had started rather cloudy and damp, it became clear and dry by the afternoon, and the party felt that their long journey from Nottingham had been well worth the effort.

Acknowledgements

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