Chapter 16

The Geology of the Middle Gwash Valley

Clive Jones

Introduction

The Rutland landscape has an individual and distinctive character. Modestly hilly and rolling, it is dissected by long wide and deep valleys draining east towards the fenlands. The largest of these valleys is occupied by the River Gwash which rises near the highest point in east Leicestershire – Whatborough Hill at 230m OD (OD, or Ordnance Datum, is the height above the mean level of the sea at Newlyn, Cornwall. This level was established between May 1915 and April 1921). Flowing into Rutland the Gwash passes to the south of Oakham and, prior to the flooding of Rutland Water, it was joined by its northern arm just downstream of Bull Bridge. This stream drains the wide Vale of Catmose around and to the north of Oakham. The construction of the Empingham Dam in 1974 at a point where the riverbed is 48m OD led to the flooding of both valleys to a height of 84m OD at top water level, thus creating the present north and south bays which are separated by the high Hambleton interfluve.

Above: The Gwash valley looking north from Normanton in 1974 (Richard Adams)

Left: The River Gwash due north of Edith Weston, near Brake Spinney (Jim Levisohn ARPS)

Above: The River Gwash south of Nether Hambleton in 1972, looking downstream (Jim Levisohn ARPS)

Left: Building the dam for Rutland Water in 1973 (Richard Adams)

The overall geology of Rutland is fairly simple. It was first surveyed systematically by J W Judd of the Geological Survey between 1867 and 1871 (Judd 1875). Interesting new information has accrued initially from the evaluation of the iron ore resources of the area (Hollingworth *et al* 1944) and remapping by the Geological Survey (Sheet 157, 1957), and more recently from urban development, road realignment and the construction of the Empingham Dam (Horswill & Horton 1976; Horton & Coleman 1977).

Rutland's geology comprises a succession of sedimentary formations or mapable rock units of Lower and Middle Jurassic age (150-200 million years old). These bedrock strata are gently inclined to the south-east at an average

4°. They consist of soft plastic sediments, mainly clays and muddy siltstones, forming incompetent beds, alternating with harder brittle rocks, mainly sandstones and limestones, forming competent beds. Lying irregularly over this bedrock are spreads of poorly consolidated material of Quaternary (a million years ago) to Recent age. These superficial deposits consist of glacial boulder clay, landslip debris and other hillwash and, in the valley bottoms, river gravels and sands (alluvium) including older river terraces.

An aerial view of Rutland Water, looking east (John Nowell, Zodiac Publishing)

The classification of the bedrock and superficial formations is shown in the table below. The table overleaf gives the names which geologists have given to the bedrock formations and it shows their respective ages within the Lias Group of the Lower Jurassic and the Inferior Oolite Group of the Middle Jurassic. With the recent adoption of the principles of lithostratigraphic mapping by the Geological Survey (mapping based on rock type rather than fossil content), the old and familiar unit names have been replaced. The table gives both the new and former names.

Succession of Strata

The succession of bedrock strata cropping out in the middle Gwash valley ranges upwards from the oldest unit, the Dyrham Siltstone Formation of Middle Lias age, to the youngest unit, the Lincolnshire Limestone Formation of Middle Jurassic Inferior Oolite age (*see* Table). Most of the valley however is underlain by the dark-grey mudstones of the Upper Lias Whitby Mudstone Formation. Because of the regional south-east tilt of the strata the oldest (lowest) occur in the west around and immediately below Oakham (Map A). Much of Oakham is in fact underlain by Middle Lias strata – the sandy, iron-rich limestone of the Marlstone Rock Formation and the underlying grey, muddy siltstones of the Dyrham Siltstone Formation. These strata extend down-valley almost as far as the Hambleton Peninsula. The flanks of the valley here are formed of the Whitby Mudstone Formation, the top of which slowly descends to the valley floor at Empingham. The harder sandstones and limestones of the overlying Northampton Sand and Lincolnshire Limestone Formations now occur on the lower valley flanks, their outcrop having dropped eastwards from the high ground around Burley, Manton and Upper Hambleton in the west (Map B). Because of this and due also to their relative hardness the valley becomes markedly narrowed. The dam wall of Rutland Water was therefore sited at this narrow point 1km south-west of Empingham. At this position the outcrop of the Northampton Sand Formation and the lower beds of the Lincolnshire

Limestone Formation lie beneath the dam wall. Designs for the dam had therefore to deal with the problem of leaking permeable strata overlying the impervious clays along the valley bottom. The solution was to install clay-filled cut-off trenches along the outcrop of the permeable strata.

The lithologies (rock types) composing the bedrock formations are summarised in the table. Because of the widespread occurrence and engineering importance of the Whitby Mudstone Formation at the dam site these strata have received particular attention (Horton & Coleman 1977). The unit is 63m thick and comprises mainly medium to dark grey mudstone with occasional limestone lenses and bands with nodules of calcareous, phosphatic and iron-rich material. Various subdivisions (Members) have been recognised. These include the Fish Bed Member at the base followed upwards by the richly fossiliferous Cephalopod Limestones Member, the Pisolite Bed, the Ammonite Nodule Bed and the undifferentiated silty mudstones which make up the rest of the sequence.

Of the superficial deposits Boulder Clay of glacial origin (the debris dropped from melting ice sheets) is the most widespread and occurs as thin spreads of sticky mottled grey-brown clay usually carrying many rounded

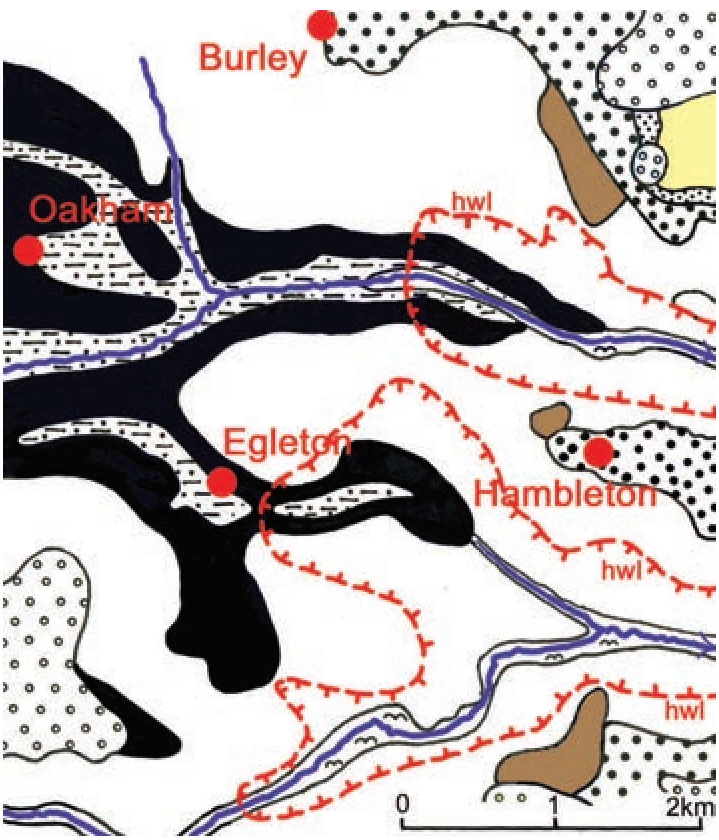
Table of bedrock strata and superficial deposits underlying the lower Gwash valley
(Clive Jones)

AGE	GROUP	FORMATION NAME AND FORMER NAME	NATURE OF DEPOSIT
QUATERNARY TO RECENT		SUPERFICIAL DEPOSITS	
		ALLUVIUM	RIVER GRAVELS, SANDS AND SILTS AND SIMILAR TERRACE DEPOSITS
		LANDSLIP	DISTURBED SOILS AND SUBSOILS
		BOULDER CLAY	PEBBLY AND NON-PEBBLY GLACIAL DRIFT
MIDDLE JURASSIC	INFERIOR OOLITE GROUP	BEDROCK FORMATIONS	
		LINCOLNSHIRE LIMESTONE FORMATION (LLF) formerly Lincolnshire Limestone	HARD CREAM-GREY OOLITIC AND NON-OOLITIC LIMESTONE
		GRANTHAM FORMATION (GF) formerly Lower Estuarine Series	LOOSE WHITE-YELLOW SANDS AND CLAYS
		NORTHAMPTON SAND FORMATION (NSF) formerly Northampton Sand	HARD BROWN IRON-RICH SANDSTONE
LOWER JURASSIC	LIAS GROUP – UPPER	WHITBY MUDSTONE FORMATION (WMF) formerly Upper Lias Clay	DARK GREY MUDSTONE AND CLAYS
	LIAS GROUP – MIDDLE	MARLSTONE ROCK FORMATION (MRF) formerly Marlstone Bed Rock	HARD GREY-BROWN IRON-RICH SANDY LIMESTONE
		DYRHAM SILTSTONE FORMATION (DSF) formerly Middle Lias Siltstone	DARK-GREY SILTY MUDSTONE AND CLAYS

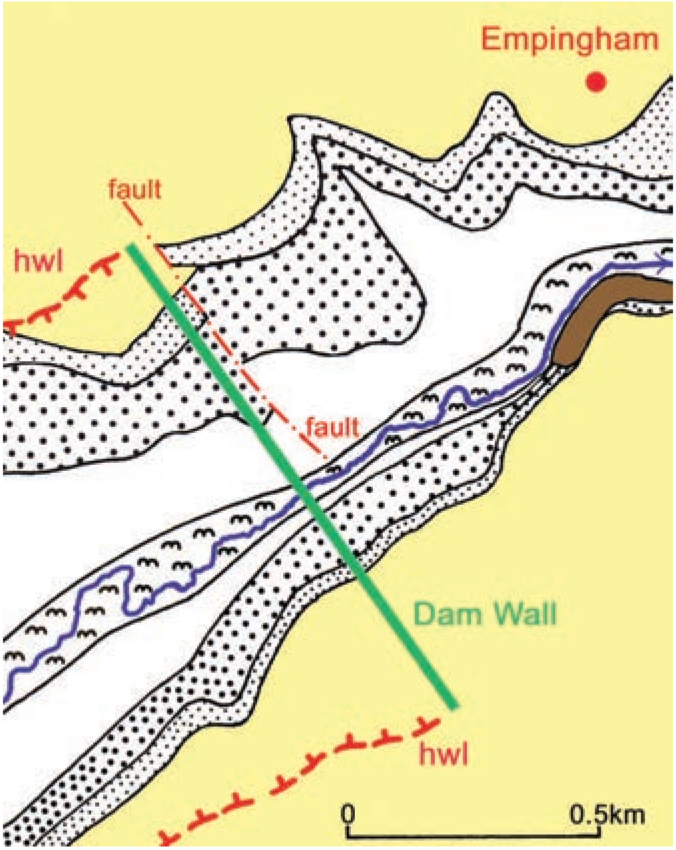
pebbles on the high ground of the interfluves. The pebbles vary greatly in size and rock type. They include Cretaceous flint and chalk, various Jurassic limestones and hard quartzite derived from Triassic conglomerates. Landslip and related hillwash material occurs commonly along the lower valley slopes where the Lias mudstones outcrop. In this disturbed clayey ground there may be some admixture of material which has slumped down the hillsides from the overlying formations. This can include blocks of sandstone and limestones, sand and pelletal iron-oxide. Along the valley bottoms the unconsolidated gravels, sands, silts and muds of the Gwash and North Tributary floodplains now mostly lie submerged beneath Rutland Water.

Structure

As described above, the structure of the bedrock formations is simply that of a conformable, alternating sequence of hard and soft formations tilted at a low angle to the south-east, disturbed only by the occasional fault. The movements which raised the sediments from the sea floor to form a land-mass took place during the mid-Tertiary, around 30 million years ago. By contrast, much more recent structural movement and deformation involving the stability of hillsides, valley bottoms and ridge crests dates only from the Quaternary, about 0.5 million years ago. The processes responsible for these structures are still operating.



Map A: The geology of the Gwash valley at the western end of Rutland Water
(Clive Jones)



Map B: The geology of the Gwash valley at the dam end of Rutland Water (Clive Jones)

The recent structures and deformation are attributable to gravity and to the extensional stress caused by the lateral squeezing of plastic clays under the weight of superincumbent competent strata. These vectors have produced a variety of structures which are illustrated in Map C. Although the weight of overlying competent strata has been mainly responsible for the squeezing out of the underlying clays onto the hillslopes, it is likely that the process was facilitated, if not initiated, by the added weight of ice caps which remained on the ridge tops towards the end of the main (Anglian) glaciation. Melt-water and the effects of permafrost would also have assisted in the extrusion process.

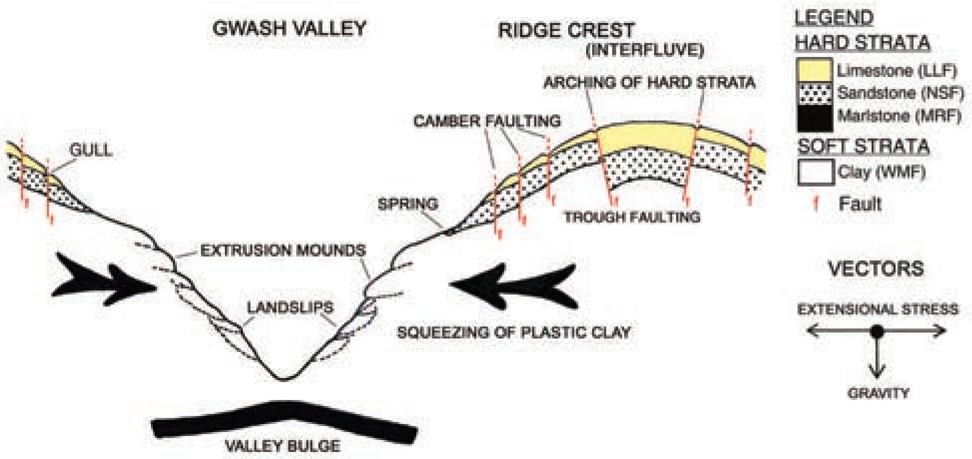
On the upper valley sides extrusion mounds are the most obvious signs of clay squeeze. Downhill creep of these mounds leads to actual slope failure and the production of landslides. Arcuate failure planes are often exposed as gaping cracks and small faults with throws of about a metre which are best seen in mature pastures. Large landslides are preserved near Barnsdale and Upper Hambleton where slippage along old interglacial erosion surfaces has been recorded (Chandler 1976).

Loss of volume below ridges and the adjacent valley shoulders caused by clay extrusion results in the arching of the competent strata capping the interfluves. Along the shoulders the beds of hard sandstone and limestone bend down and fracture in a process known as cambering. At first, cracks appear which produce surface grooves known as gulls. These develop into small faults (camber faults) and finally the blocks become detached and begin creeping valley-wards. The lowering of beds of sandstone and limestone by an estimated 10m due to cambering has contributed to the narrowing of the Gwash valley at the Empingham dam site (Horton & Coleman 1977).

Along the ridge crests gravity and extensional stress have promoted axial trough faulting in the competent strata. This has resulted in blocks of younger strata falling down into position against older strata at the top of the interfluves, a feature spectacularly exposed in the working faces at Ketton Quarry.

Gravity-induced movements have also been responsible for axial doming of the bedrock beneath the valley floor in a process described as valley bulge. Site investigations before the construction of the Empingham Dam disclosed the presence of a narrow zone of deformation and arching in the Lias strata below the valley bottom (Horton & Coleman 1977). The Marlstone Rock Formation was found to be updomed by 2m and the overlying mudstones were fractured. The upward artesian groundwater pressure in this structural upwarp created a problem at the dam site which was solved by sinking relief wells down-valley from the dam.

Map C: The structural instability of the lower Gwash valley floor, sides and adjacent ridge tops (Clive Jones)



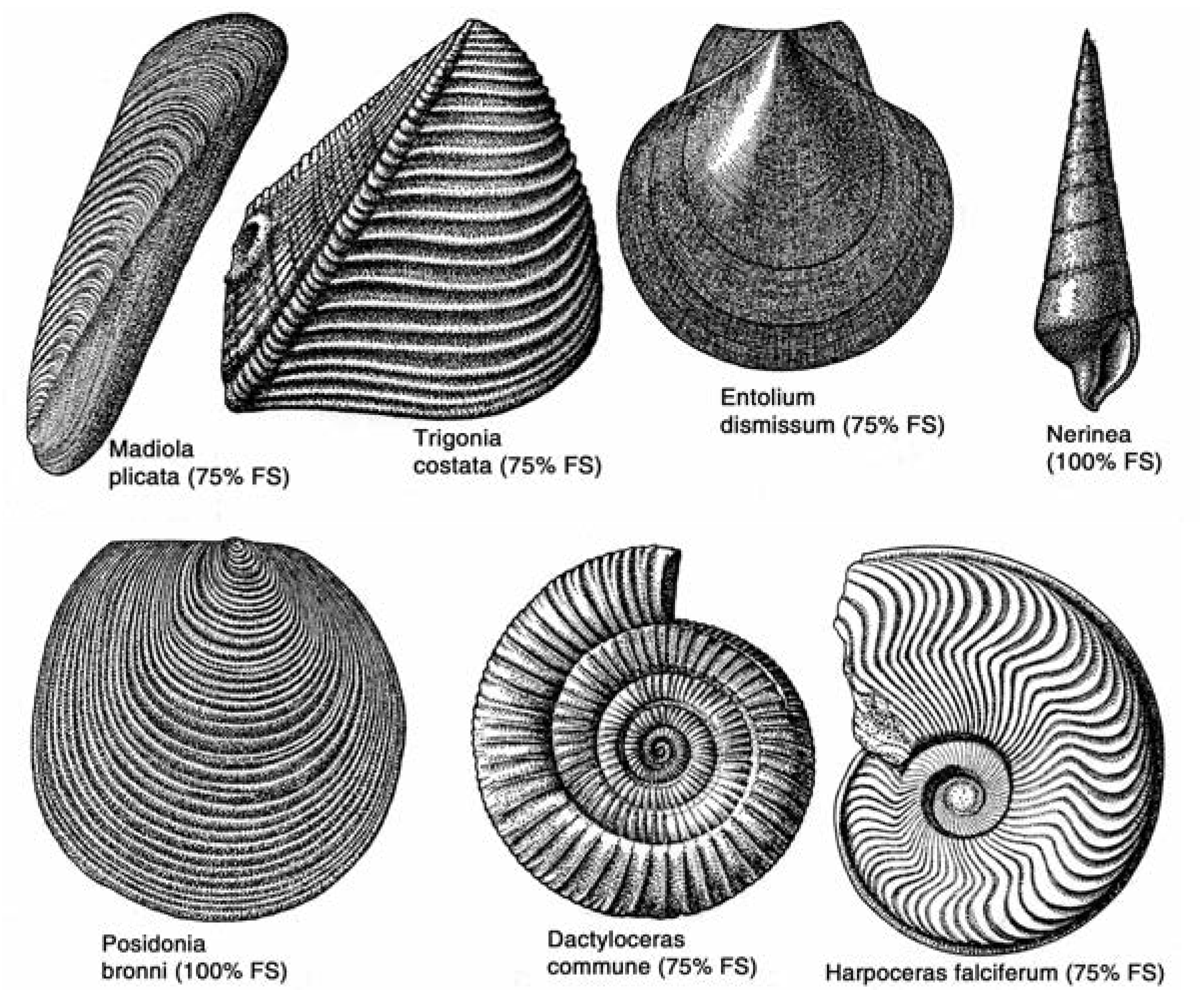
Fossils

Fossils occur in varying amounts in all the bedrock formations. Representative examples from the different units are shown on the following pages. A collection is also on display at the Normanton Church Museum.

Ammonites are particularly well distributed throughout the Jurassic and because they underwent rapid evolution in shell form they have been used to zone or classify the Jurassic. Full dimensional forms such as *Amaltheus* can be found washed out of the Middle Lias siltstones in drainage ditches running into the upper end of Rutland Water. Similarly preserved species of *Dactyloceras, Harpoceras* and *Hildoceras* are abundant in the Cephalopod Limestones Member of the Whitby Mudstone Formation. Elsewhere in the Upper Lias fossils are rarer and when they do occur they are usually squashed flat though occasional specimens in full relief, mineralised by sulphide, phosphate or iron-oxide, can be found. Commonest are perhaps bivalves (seashells), of which *Pholadomya* and *Posidonia* are representative.

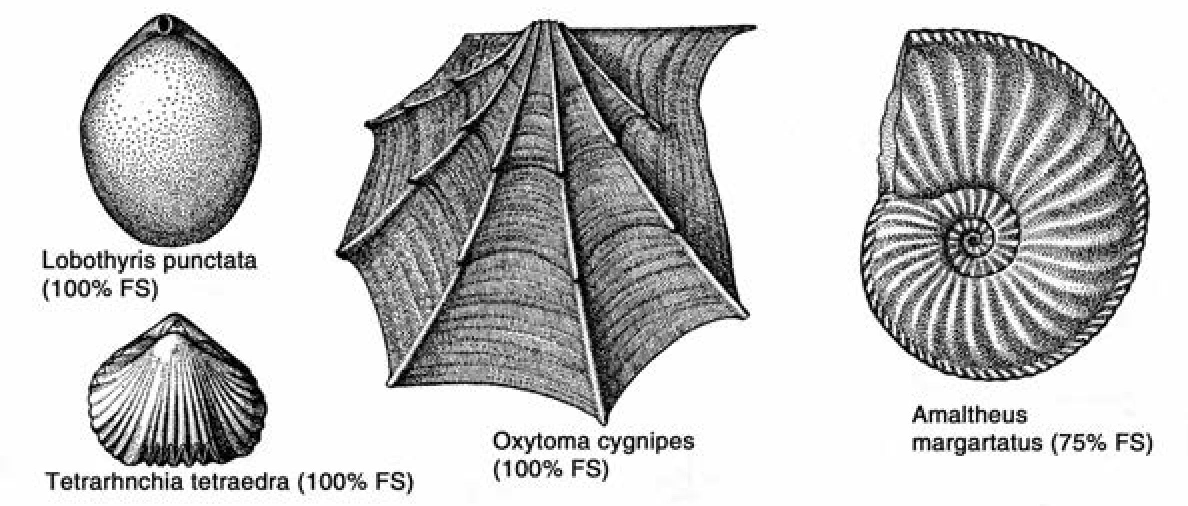
Although the dark colour of the Lias mudstones and siltstones is attributable mainly to finely disseminated iron sulphide, carbonaceous (plant) matter does occur and the fossilised trunks of large trees were found in the Marlstone Rock Formation in an archaeological excavation east of Oakham. Also in the marlstone occur conspicuous nests of brachiopod shells (Lantern Shells) belonging to two distinct species: *Tetrarhynchia tetraedra* and *Lobothyris punctata.*

Inferior Oolite fossils are common both in the Northampton Sand Formation and the Lincolnshire Limestone Formation. The lower beds of the former unit are hard and limey, and are full of both complete and broken bivalves commonly belonging to the scallop and mussel families (*Entolium* and *Modiola* repectively). Ammonites are rarer than in the Lias formations but are occasionally encountered in the Lincolnshire Limestone Formation. The limestone contains much broken shelly matter but complete shells in full relief of the gastropod (snail) *Nerinea* and bivalves like *Trigonia* can be found.



Below Top: Fossils from the Inferior Oolite Formation (©The Natural History Museum, London)

Below Bottom: Fossils from the Upper Lias Formation (©The Natural History Museum, London)



Above: Fossils from the Middle Lias Formation (© The Natural History Museum, London)

Left: Rutland Water dam (RO)

Conclusions

The middle Gwash valley and its bordering interfluves are underlain by a sequence of alternating Lower and Middle Jurassic plastic clays and hard sandstones and limestones. The valley sides are composed mainly of the clays which have been squeezed out onto the hill slopes under the weight of the overlying hard beds which cap the ridges. This situation has produced unstable conditions not only along the valley sides but also beneath the valley floor and on the ridge tops. Empingham Dam was sited where the valley narrows as the hard strata dip eastwards towards the valley bottom. Structural problems caused by cambering, landslip, valley bulge and bedrock permeability were encountered during the planning and construction stages of the dam. Remedial design work was necessary to address these problems in order to secure the viability of the dam.