The Mapping of Landscapes, Geology and Soils of Bedfordshire & Cambridgeshire

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We use the words landscape and landform to refer to natural (not man-made) features visible on the surface of the Earth. The word landscape is used for larger areas of varied topography, whereas the word landform is used for smaller features that occur within landscapes, and can often be readily seen to have resulted from the local action of particular surface processes (for example, slope failure or river erosion). In this study we present a group of regional landscape maps (Maps 1-4), and a group of more local maps (Maps 5-8) on a larger scale, where landforms are more easily distinguished. Our work has been part-funded by Natural England and facilitated by Geo-East, the East of England Geodiversity Partnership.

Landscapes and their component landforms have formed during the long-term geological history of an area, and may have been influenced by many factors. These include, a) the materials present just below the Earth's surface, b) movements of the Earth's land or sea surface, and c) the action of ice, rain, wind and living organisms. This study has been concerned particularly with ways of analysing and presenting topographical information, so that members of the general public can gain new insights into the stories that have resulted in their landscapes and landforms.

Maps are routinely used to represent landscapes and landforms, and we have wanted to experiment with the ways that computer-based Geographical Information System (GIS) software, using the digital regional datasets now available, has transformed our ability to provide vivid representations of our surroundings.

The approach we have used has been to derive an elevation model from the OS Opendata Panorama dataset, vertically exaggerated by a factor of 20, and then apply colour and shading to illustrate topographic relief (Maps 1 and 5). We have then added overlays to compare the topography with bedrock geology (Maps 2 and 6), surface geology (Maps 3 and 7), and soil distribution (Maps 4 and 8). The geological datasets are derived from the BGS DiGMap50 dataset, which have been merged and rationalised to provide a consistent coverage across the whole region. The soils datasets are the NSRI National Soil Map of England and Wales (NATMAPvector) which describes soils distribution in the landscape. The GIS processing was done in ArcGIS.

The area covered in this study is Bedfordshire, Cambridgeshire, and the Borough of Milton Keynes (part of Buckinghamshire). As an example of the potential for featuring landforms more clearly at the local scale, we have focused on the area of Marston Vale, southwest of Bedford. This 25 x 20 km area is highlighted on Map 1, and forms the basis for Maps 5-8.

Further information on these topics is covered on the following websites:

Bedfordshire Geology Group
www.bedfordshiregeologygroup.org.uk

Cambridgeshire Geology Club
www.cambridgeshiregeologyclub.org.uk

National Soil Resources Institute, Cranfield University
www.landis.org.uk

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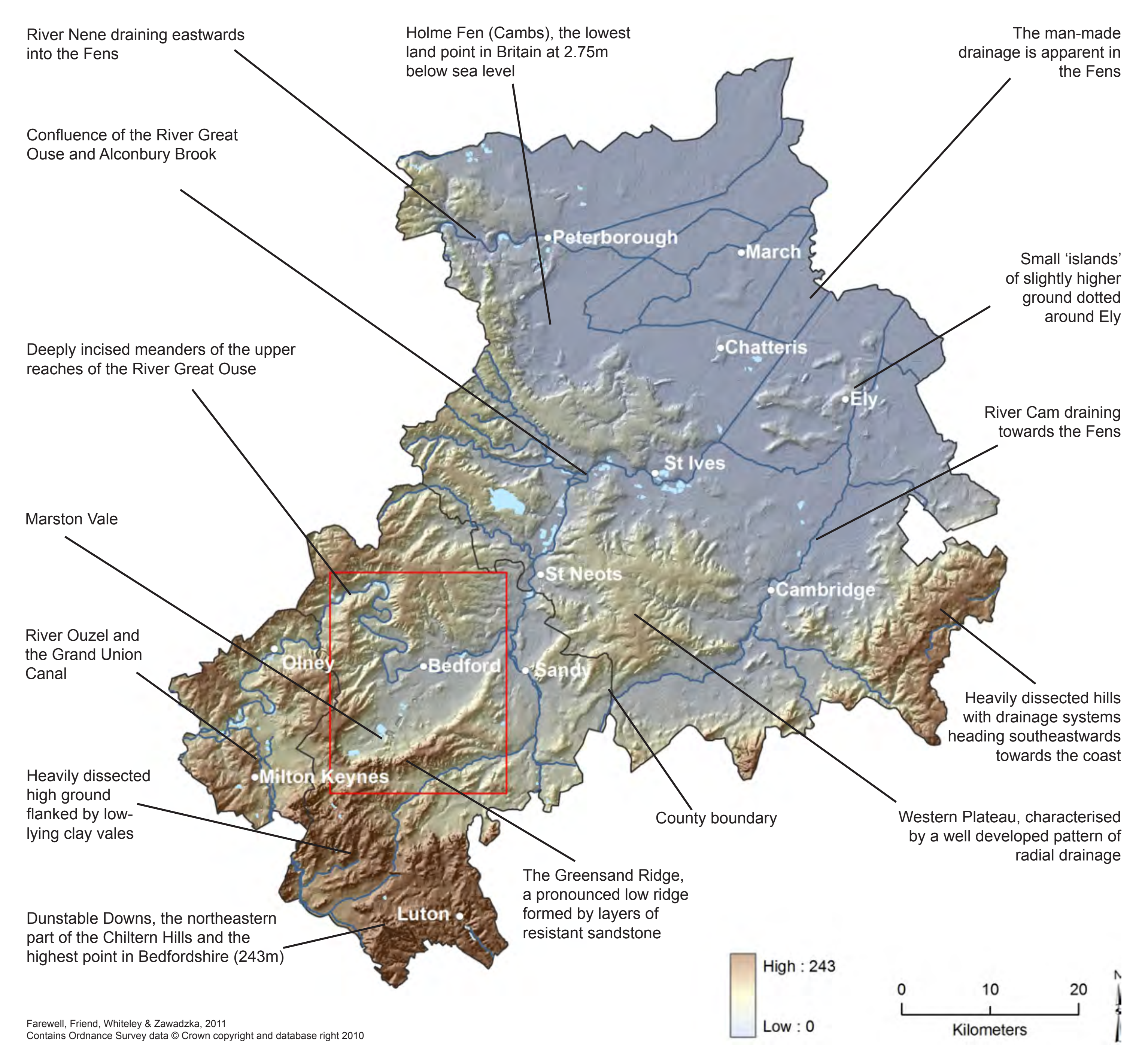


Map 1. Topography

The area is generally low-lying with 50% of the land lower than 30 m. It is drained by two major rivers, the Great Ouse and Nene, and their tributaries. Rivers and water courses are shown on this and all subsequent maps in blue.

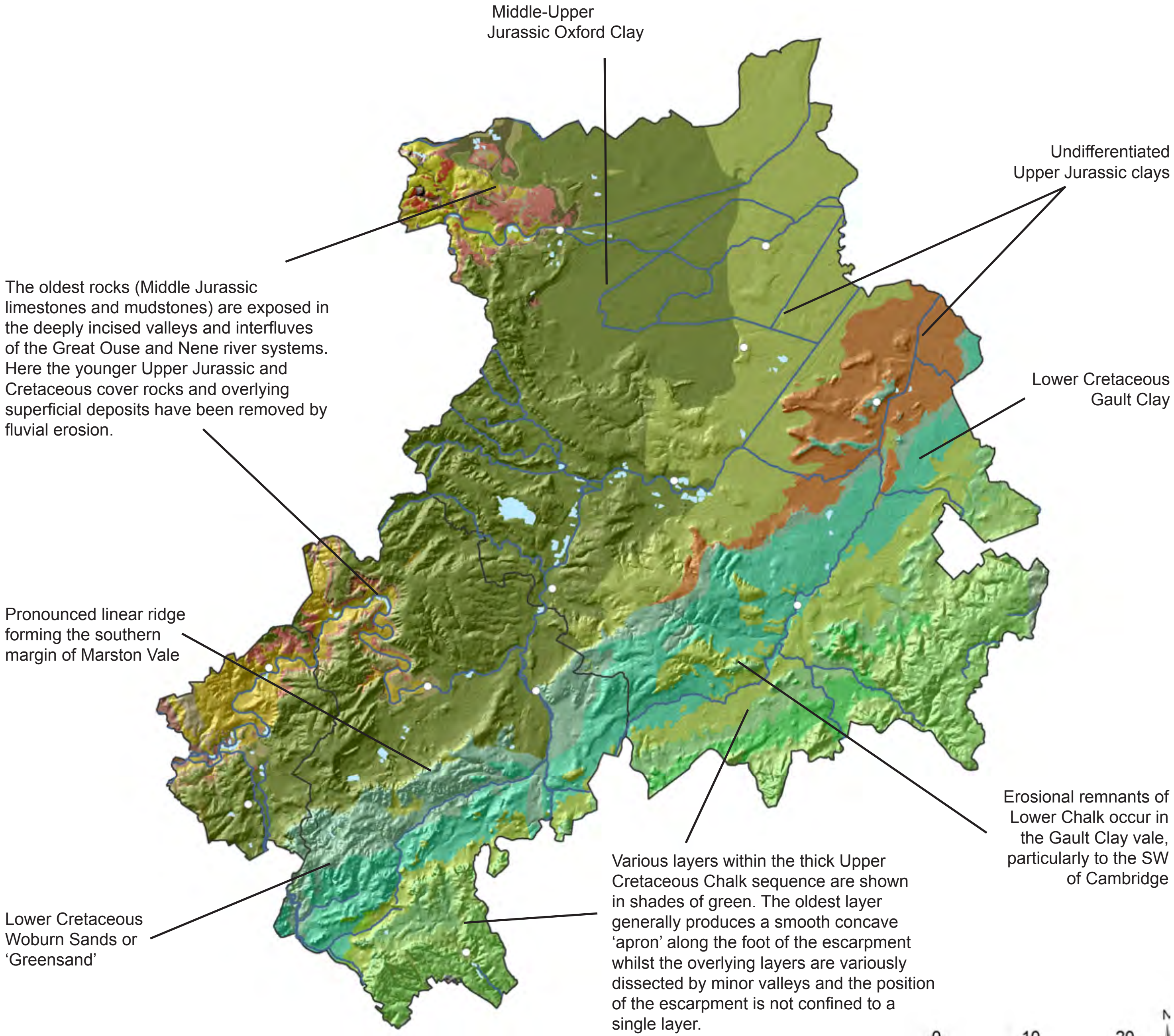
The arc of low hills between Peterborough and Ely define the inland extent of the Fens, a remarkably flat and extensive plain caused by numerous inundations of sea water during the last few thousand years. The Fens are now drained by a series of engineered water courses that have changed the natural river systems completely.

There are several large, flat-topped plateaux in south Cambridgeshire (e.g. the Western Plateau) and north Bedfordshire (e.g. flanking the Great Ouse). They were commonly used in the past as locations for military airfields.

There are many mid-height, linear ridges in Bedfordshire that trend NE-SW. Some result from hard layers within the bedrock geology (see Map 2), but most are formed by flanking valleys cut by streams flowing northeastward towards the lowest part of the region.

High ground to the southeast of Cambridge is formed by the same relatively hard and resistant rock (Chalk) that occurs around Luton at similar elevations. The Chalk ridge continues southwestwards, with increasingly strong definition, as the Chiltern Hills.

The red rectangle highlights the area around Marston Vale (see Maps 5-8).



Map 2. Bedrock Geology

This map shows how the rocks would appear at the land surface if the overlying superficial deposits and soil were removed. Described as bedrock, these rocks are all of sedimentary origin but they vary considerably in terms of their age (from about 185 million to 85 million years old) and their type (mainly mudstones, limestones and sandstones).

The distribution of bedrock geology is not coincident with most of the landscapes. For example, the extensive tract of Middle-Upper Jurassic clays underlies both the flat-lying Cambridgeshire Fens and the heavily dissected hills of north Bedfordshire. A similar pattern is observed along the extent of the Gault Clay outcrop. It is noticeable that the highest tracts of ground occur in the south-west across the complete range of rock types.

Lower Cretaceous sandstones in Bedfordshire are relatively resistant and produce an intermittent escarpment and broad, dissected dip slope known locally as the Greensand Ridge. This feature is particularly clear around Sandy where it is cut by the River Ivel.

The scarp and vale landscape that characterises the southern half of the study area developed initially through differential erosion under sub-tropical and warm temperate climates during the Tertiary. When a major ice sheet advanced and retreated across the area some 450-400,000 years ago it modified that landscape enormously, initially grinding much of it away, then blanketing it with considerable thicknesses of glacial deposits. Since then, alternating cycles of cool temperate and very cold climates have worn away much of the glacial material and revealed some of the underlying bedrock again.

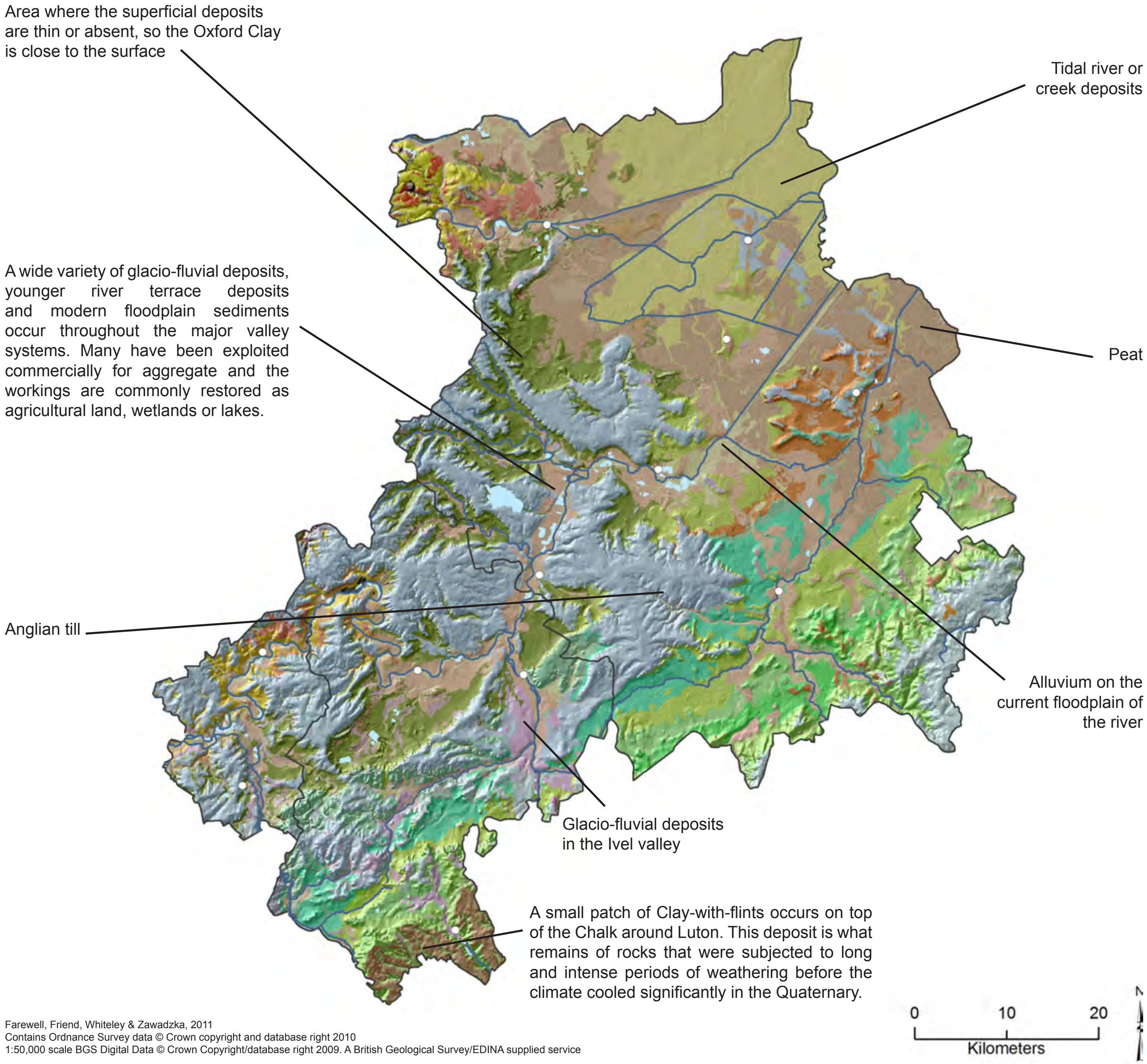
Map 3. Surface Geology

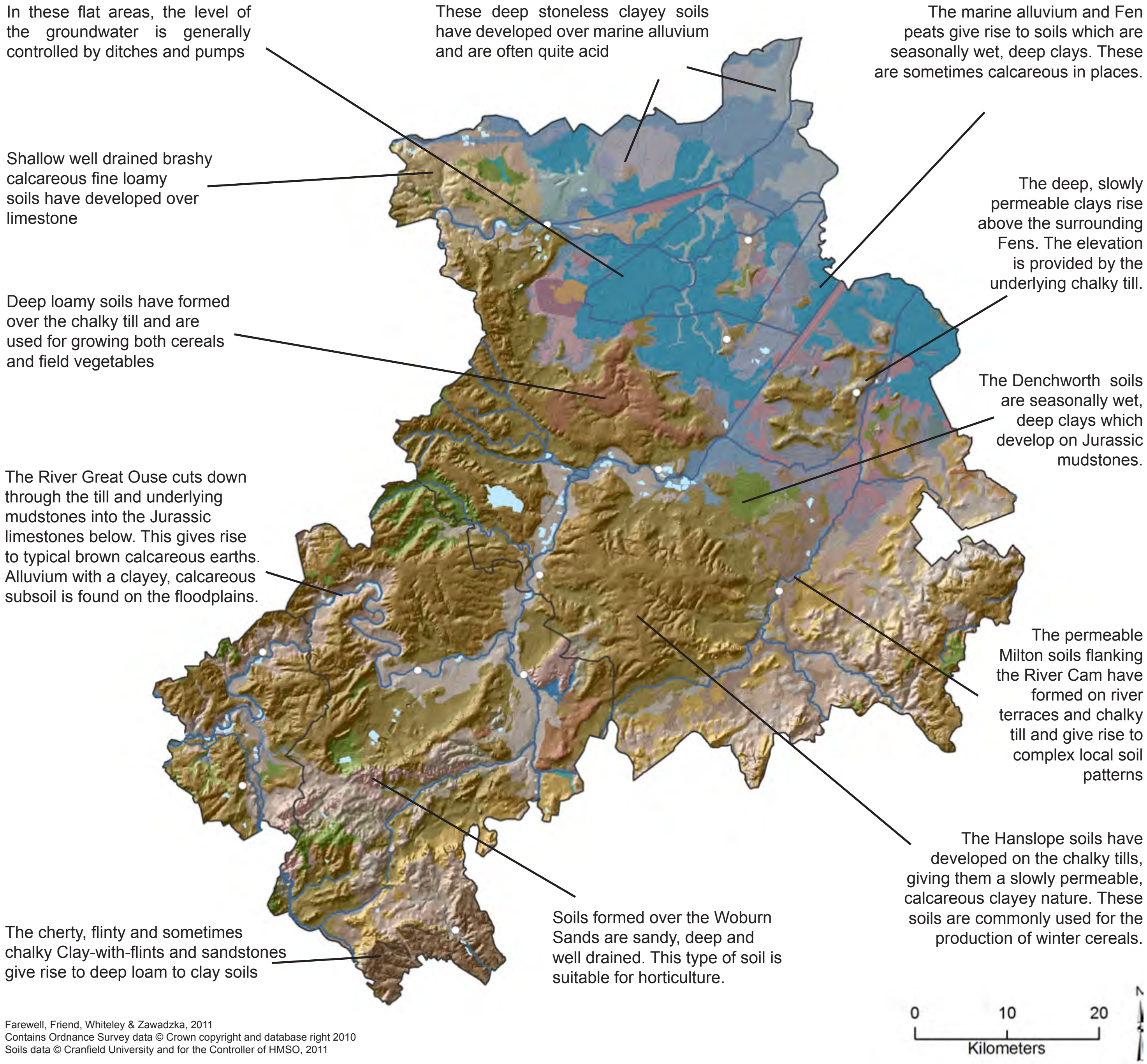
This map superimposes the extensive 'blanket' of glacial and post-glacial deposits on the bedrock geology. Known as superficial deposits, they formed during the Quaternary, a period from about two million years ago to the present day that is characterised by alternating cycles of cold and temperate climate.

The most obvious feature of the superficial deposits are the widespread cappings of glacial till, a clay-rich deposit that includes lumps of chalk, sandstone, limestone and flint. The till is relatively resistant and forms high ground across most of the area. In parts of north Bedfordshire and on the Western Plateau it is >40 m thick and it formed as a major ice sheet (Anglian) pushed southwards towards the Chilterns, churning up the underlying bedrock and re-depositing it when the ice sheet subsequently melted about 400,00 years ago.

Clay-with-flints are limited in extent, suggesting that only the highest hill tops in Bedfordshire were beyond and above the erosive limit of the Anglian ice sheet. Today they form a resistant and impermeable capping on the interfluves of valleys cut deep into the Chalk dipslope.

The Fens provide Britain's largest and flattest landscape. At elevations close to sea level they have been repeatedly inundated by sea water and progressively buried by fine-grained deposits that effectively suppress any underlying topography. Further inland, in a broad arc from Peterborough to Ely, peat has formed as a result of the waterlogged and swampy conditions that existed behind the transient coastal zone.





Farewell, Friend, Whiteley & Zawadzka, 2011

Map 4. Soils

This map shows Soil Associations, which are groupings of soils commonly found in association with each other in the landscape. These are named after type localities.

Soil performs a number of key functions that are essential for our existence. It is well recognized that soil is the growing medium for plants and crops, but it is equally important to note that the soil itself is home to a complex and active ecosystem with bacteria, fungi, protozoa, nematodes, insects and worms driving the cycling of nutrients, regulating plant communities and helping repair soil structure. Soil filters, cleans and breaks down pollutants, thus helping to ensure good water quality. The soil also captures approximately 20% of the anthropogenic carbon we create each year.

Soil development is a function of climate, topography, vegetation, organisms and humans, geological parent material and time. Across this region, the two most important natural factors leading to the observed diversity in soils are the differences in the underlying geological parent material and the relationship between soil and topography.

The soils have developed since the Anglian ice sheet retreated from the area about 400,000 years ago. As such, they have formed on a variety of glacial and post-glacial deposits or directly on the underlying bedrock. The topography interacts with climate and vegetation, directing soil formation and controlling soil-water budgets. For example, steep slopes promote surface run-off and reduced leaching, whilst valley floors are often waterlogged. These interactions continue to affect the ongoing development of the soil.

Northeasterly Great Ouse meander reach (c.50 – 40 m river elevation)

Fluted basin margins

Lowest elevation (c.20 m)

Southerly Great Ouse meander reach (c.40 – 25 m river elevation)

Easterly Great Ouse reach through Bedford (c.25 – 20 m river elevation) and towards the sea

Apparent 'terrace' effect is an artefact of the digital elevation model

Northeasterly trending large ridges with unfluted margins

Unfluted margin on northeasterly trending ridge

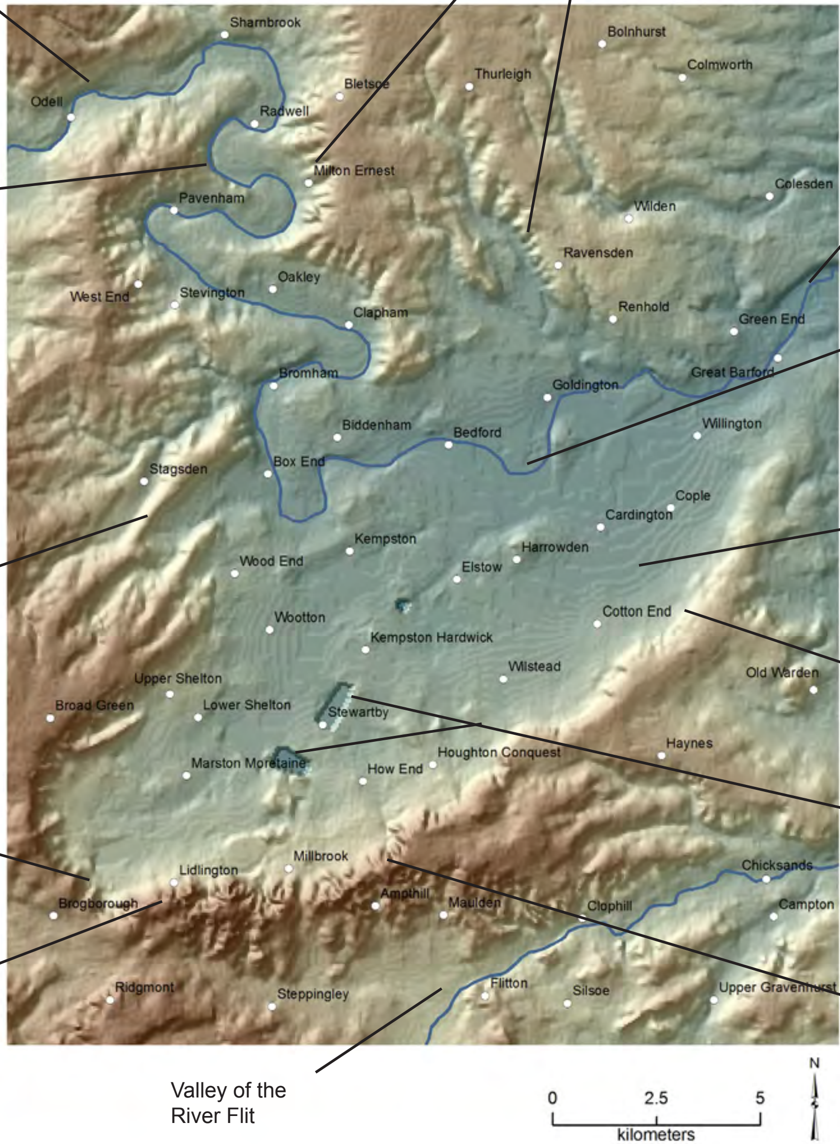
Disused clay pits that provided the raw material for the 20th century brick-making industry

Brogborough 'saddle', elevation (c.92 m)

Highest elevation (c.130 m)

Fluted basin margin

Valley of the River Flit



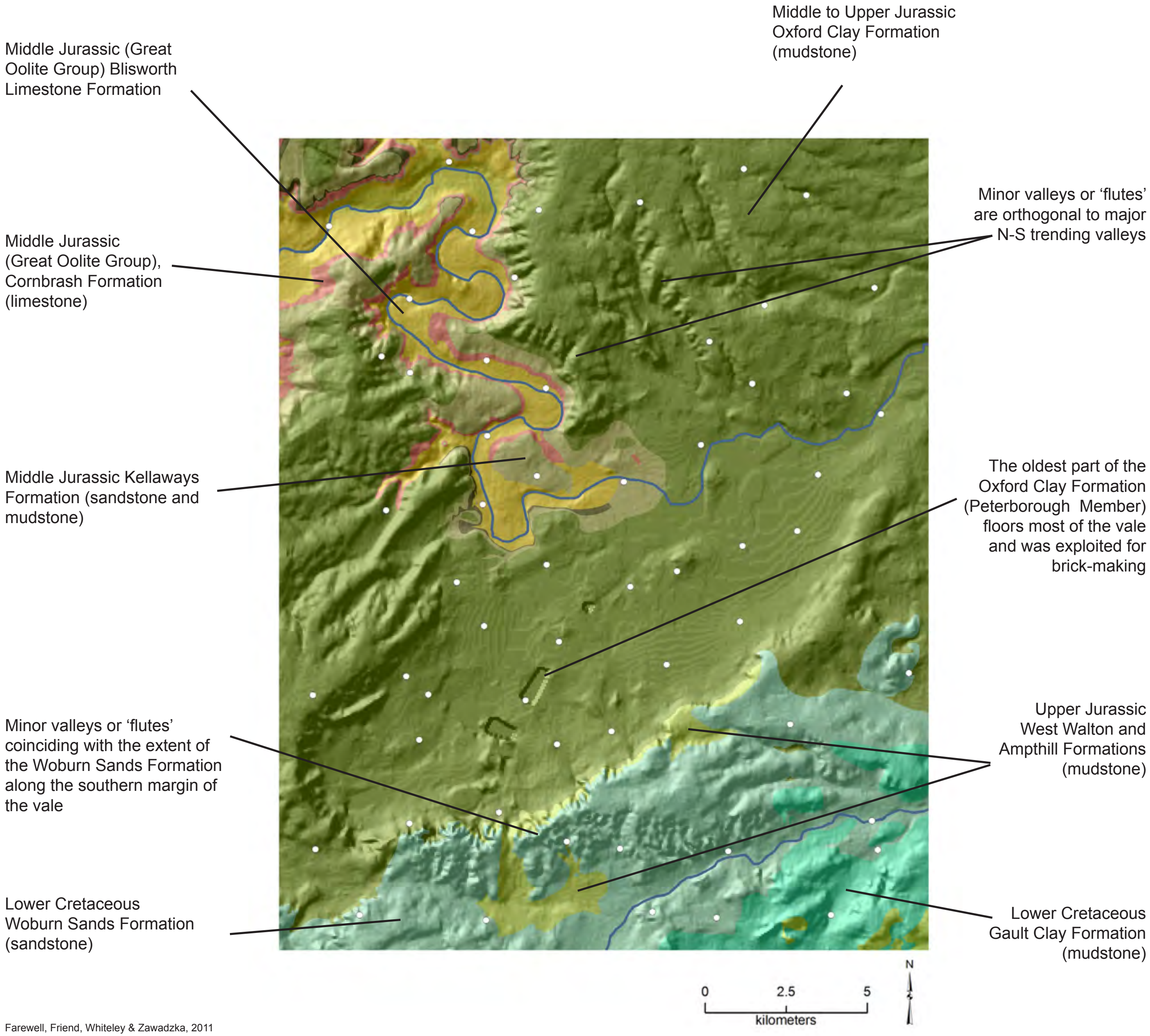
Farewell, Friend, Whiteley & Zawadzka, 2011

Map 5. Topography

Marston Vale (located on Map 1) is a distinctive low-lying basin, extending some 25 km in a southwest to northeast direction. Apart from man-made clay and gravel pits, the vale has a generally flat floor with elevations averaging about 35 m above sea-level. The floor is surrounded by higher ground except at the entry and exit points of the River Great Ouse.

The Ouse is the largest river system in East Anglia. It enters the map area from the northwest with two distinctive reaches of strongly meandering incised valley upstream of Bedford, and then continues flowing eastwards through more poorly defined topography that forms the northeastern end of Marston Vale. South of the Great Ouse, the floor of Marston Vale currently lacks a clearly defined local drainage system of stream channels or valleys.

Many, but not all, of the slopes in this map area provide examples of a distinctive local landform of ridges and small valleys running more or less at right angles to the general trend of the larger slope, and usually tens to a few hundred metres across. In the discussion that follows we find it useful to refer to these landforms as 'flutes'.



Farewell, Friend, Whiteley & Zawadzka, 2011

Map 6. Bedrock Geology

The oldest bedrock visible has been exposed in the northwest of the map area by the erosional down-cutting of the River Great Ouse. It consists largely of limestones, though mudstones are also important at some levels, and these sediments are classified as part of the Great Oolite Group.

Above these mainly Middle Jurassic rocks, the rest of the Jurassic bedrock succession is classed as Ancholme Group, which includes the Kellaways, Oxford Clay, West Walton & Ampthill Clay formations. These are mainly mudstones, some of which have a relatively high organic carbon content that made them particularly useful in the brick-making industry around Stewartby.

Lower Cretaceous bedrock is present in the near surface of the southern part of the Marston Vale area. It consists of the Woburn Sands Formation, up to about 35 m in present-day thickness, followed by up to 10 m of Gault Clay. These sands and mudstones began to accumulate about 120 million years ago in a sea-way, trending southwest to northeast, which formed when the sea flooded across this part of England. Before the flooding, the area had been dry land for some 30 million years and some of the previously deposited Jurassic sediments had been locally eroded by freshwater streams.

‘Flutes’ are a feature of large valley slopes in the north of the area where impermeable glacial till and mudstones of the Ancholme Group promote surface drainage and fluvial erosion. It also appears that flutes are more developed on westward-facing valley slopes that receive more solar radiation (and are therefore warmer) than slopes with other aspects. Daily temperature fluctuations, particularly under permafrost conditions, tend to accelerate the breakdown and transportation of rock grains.

Fluted slopes developed on the west-facing margins of the incised meander belt upstream from Bedford

Downstream from the incised meander belt reaches, the river was free to move laterally and to erode the relatively weak Jurassic mudstones. This lateral shifting, involving large meander loops and perhaps headward erosion by a right bank tributary system, extended the size of the vale to its present form.

Cranfield airfield sited on Anglian till plateau

Fluted margin where resistant sandstones overlie weak Jurassic mudstones to produce a high escarpment (up to c.80 m relief) with local slump features and spring sapped hollows

Streams have eroded through the till to reveal the underlying Jurassic mudstones

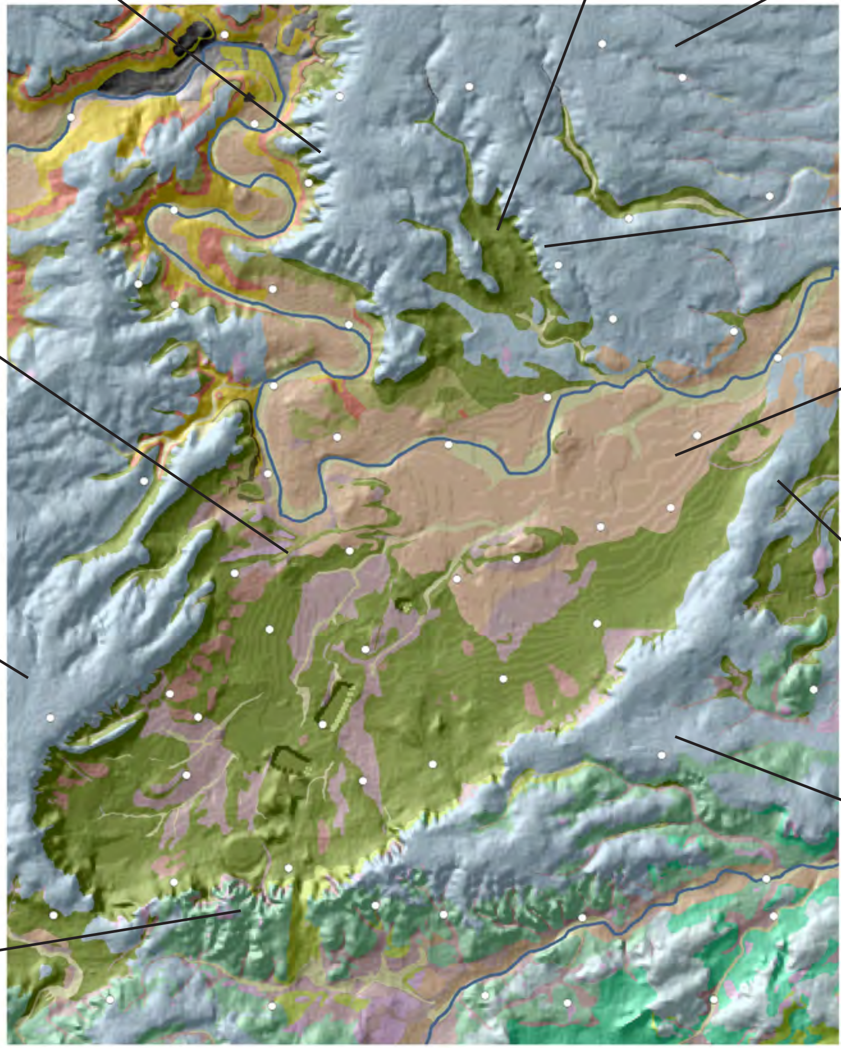
Upland cover of Anglian till deposited by ice sheets about 450,000 to 400,000 years ago

Fluted slopes around Ravensden

Widespread river terrace deposits

Prominent ridge of till with unfluted margins forming the southeast edge of the vale

Upland cover of Anglian glacial till concealing the underlying Woburn Sands Formation



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Map 7. Surface Geology

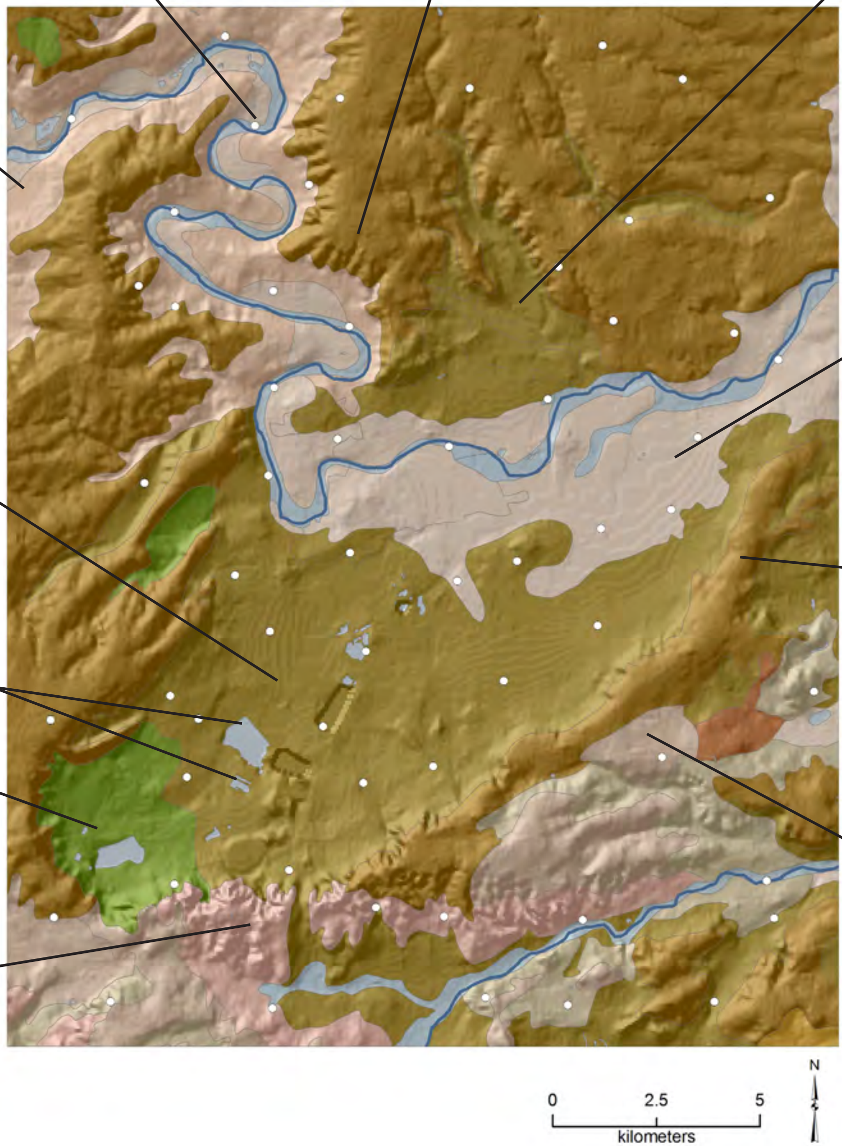
Almost all of the uplands surrounding Marston Vale are covered by Anglian glacial till. The major drainage valleys and the vale itself have clearly been formed by erosion after the deposition of this glacial till. The presence of 'flutes' along the edges of many of the major slopes provides local evidence of slumping and stream valley erosion during the last few hundred thousand years, and yet these features do not occur everywhere.

Other superficial deposits and associated landforms include buried channels, river terraces, alluvium and head, but these are usually too subtle to be detected using the digital elevation data available in our study.

Marston Vale was eroded by the River Great Ouse as it cut downwards through the glacial till and the underlying bedrock. Where the river system became incised, particularly in the resistant Great Oolite limestones, it was constrained within a narrow meander belt. In contrast, the stretch between Biddenham and Great Barford is relatively straight and contains widespread terrace deposits.

Whilst there is no evidence that moving ice reached this area again during the post-Anglian period, there were certainly prolonged periods during which permafrost conditions prevailed. Modern analogues in the Arctic regions show that under these conditions the varying amounts of rain and snowfall, combined with repetitive seasonal or daily freeze-thaw cycles, greatly accelerate downslope sediment movement. This is particularly pronounced on slopes where gravity promotes slumping and sliding and where there is little or no vegetation to bind the surface layers together. Sediment made available in this way throughout the catchment area is then readily transported by fluvial systems of all scales towards the sea.

Map 8. Soils



Much of this area is dominated by the heavy calcareous clay soils of the Hanslope and Evesham Soil Associations. While the Hanslope soils have developed over the clay-rich, calcareous till, the Evesham soils have developed from the Jurassic clays and both result in broadly similar soils. These soils drain slowly and are suitable for winter cereals in drier areas and grasslands where it is slightly wetter.

Because of the areal dominance of these heavy clay soils in Bedfordshire, where differences do occur, local place names often reflect the different geomorphology and soil type. For example, sandy soils occur around Sandy and Chicksands, while Ampthill and Ridgmont are located on elevated areas south of the vale.

Other different soils are found in the lower parts of the river systems. To the north, the shallow and stoney Moreton soils are found on the Great Oolite Group.

On the river terraces, freely draining soils have developed over gravels. Alluvial soils, which have developed on the floodplains, tend to be stoneless, calcareous clays because they are derived from sediment which has been laid down by the river during flood events.