Proceedings of the Geologists' Association 126 (2015) 683–697

Contents lists available at ScienceDirect

Proceedings of the Geologists' Association

journal homepage: www.elsevier.com/locate/pgeola

Fluvial response to Late Pleistocene and Holocene environmental change in a Thames chalkland headwater: the Lambourn of southern England

Andrew J. Newell [a,*], James P.R. Sorensen [a], Jonathan E. Chambers [b], Paul B. Wilkinson [b], Sebastian Uhlemann [b], Colin Roberts [c], Daren C. Gooddy [a], Christopher H. Vane [b], Andrew Binley [d]

[a] British Geological Survey, Maclean Building, Wallingford OX10 8BB, United Kingdom
[b] British Geological Survey, Keyworth, Nottingham NG12 5GG, United Kingdom
[c] Centre for Ecology and Hydrology, Maclean Building, Wallingford OX10 8BB, United Kingdom
[d] Lancaster Environment Centre, Lancaster University, Lancaster LA1 4YQ, United Kingdom

ARTICLE INFO

Article history:
Received 28 April 2015
Received in revised form 26 August 2015
Accepted 26 August 2015
Available online 18 November 2015

Keywords:
Quaternary
Late Pleistocene
Holocene
Thames
Lambourn
Chalk
Berkshire Downs
Fluvial

ABSTRACT

This paper describes the Late Pleistocene to Holocene stratigraphy of the River Lambourn; a minor headwater of the River Thames in the Berkshire Downs. The Quaternary valley-fill comprises around 5–8 m of Late Pleistocene gravels overlain by Holocene peats and chalky clays. Quaternary deposits overlie an irregular rockhead erosion surface with deep scouring particularly evident on prominent bends in the valley. The gravels subdivide into a lower unit of chalky gravels overlain by coarse flint gravels. Ground penetrating radar suggests that gravels at depth are relatively structureless, but at the top show well-developed point-bar accretion surfaces which occur in association with peat-filled sinuous channels. These probably date from around the Pleistocene-Holocene boundary and may have formed in response to climate change and increased groundwater outflow as stream hydrology changed from the short-duration, high-magnitude flows of the Lower Dryas to the uniform, low-magnitude flows of the Holocene. Holocene peats initially infilled abandoned floodplain channels at around 10 kyr BP but later encroached over much of the Lambourn floodplain. A progressive upward decrease in organic material and an increase in the proportion of chalky clays from around 4 kyr BP probably occurred in response to floodplain accretion coupled with increased erosion of the chalk catchment related to agricultural clearance and a wetter climate.

1. Introduction

Late Pleistocene to Holocene fluvial deposits of north-west Europe form an important record of evolving terrestrial environments and major changes in climate since the last glacial cycle which terminated at 11.7 ka (Anderson et al., 2007; Hughes et al., 2013; Lespez et al., 2015). Most fluvial deposits of this age in north-west Europe show a broadly similar stratigraphy, with an abrupt switch from high-energy gravelly deposits of the Late Pleistocene cold stages into fine-grained and often organic-rich floodplain deposits of the temperate Holocene (Gibbard, 1985; Murton and Belshaw, 2011). Fluvial sediments of this age also record the increasing importance of anthropogenic landscape modification in the later parts of the Holocene (Lewin, 2010; Macklin et al., 2010) and in this respect they have an important part to play in the current debate on the existence and timing of the 'Anthropocene', the proposed geological epoch in which human activity has dominated many of the processes acting on the surface of the planet (Waters et al., 2014). While some advocate that the base of the Anthropocene lies within the industrial debris (Waters et al., 2014) and chemical pollution (Vane et al., 2011) of the 20th century, the fluvial stratigraphic record often shows the strong effect of agriculture and land clearance much earlier in the Holocene (Macklin et al., 2010).

In most cases, Late Pleistocene to Holocene fluvial deposits underlie the modern floodplain which immediately imposes difficulties in their observation and sampling. In the Thames Catchment much of our understanding of these deposits is based

* Corresponding author. Tel.: +44 01491 692244.
E-mail address: ajn@bgs.ac.uk (A.J. Newell).

http://dx.doi.org/10.1016/j.pgeola.2015.08.008
0016-7878/

on information gained from gravel pits which tend to be located on the wider floodplains of trunk rivers and major tributaries (Bridgland, 1994; Collins et al., 1996, 2006). This has introduced a bias against the late Quaternary record of minor headwaters, particularly those in chalkland settings, although as noted by Collins et al. (1996) this information is required to understand the full longitudinal variability of river behaviour.

This paper considers the Late Pleistocene to Holocene evolution of the River Lambourn, which drains a small (269 km^2) chalk catchment in the Berkshire Downs of southern England (Grapes et al., 2006). The Lambourn is a minor headwater in the much larger (16,133 km^2) River Thames basin, whose Quaternary history has been studied for over one hundred years and whose fluvial sediments provide a framework for this part of the geological record in Britain (Bridgland, 1994). The primary aims of this paper are to, (1) show how boreholes and non-invasive geophysical techniques can provide an understanding of the stratigraphy and three-dimensional (3D) geometry of the latest Quaternary fluvial record in poorly-exposed headwater settings and, (2) determine the extent to which the Late Quaternary fluvial stratigraphy of minor headwaters compares or contrasts to better known downstream locations (Collins et al., 2006). The paper adds to a growing body of recent hydrogeological work in the Lambourn catchment (Allen et al., 2010; Gooddy et al., 2006; Grapes et al., 2006; Griffiths et al., 2006; House et al., 2015a,b; Mullinger et al., 2007; Musgrave and Binley, 2011) and an additional aim of the paper is to show how a knowledge of the Late Quaternary fluvial stratigraphy has great practical importance in understanding groundwater-surface water interactions in modern chalkland streams; one of Britain's most highly-valued natural environments (Wheater et al., 2007).

2. Background to the River Lambourn

2.1. Modern river and catchment morphology

The River Lambourn is a chalk stream in the Berkshire Downs of southern England (Fig. 1). It rises near Lambourn and is a tributary of the River Kennet, which is itself a tributary of the River Thames. The River Lambourn flows southeast down the regional slope of the Berkshire Downs, a gently tilted block of Cretaceous Chalk approximately 250 m thick which is incised by many valleys, the majority of which are dry with only a few containing perennial rivers (Fig. 1). The Lambourn catchment is elongated in a NW-SE direction and is approximately 30 km long and 10 km wide, covering an area of 269 km^2. It has a mean elevation of 157 mAOD (standard deviation 36 m), ranging from a maximum of 260 m in the northwest to a minimum of 68 m in the southeast at the confluence between the rivers Lambourn and Kennet at Newbury (Fig. 2A). The river falls at a rate of around 2.4 m per kilometre from source to outflow. The river has a perennial length of approximately 16 km, and an upper seasonal section of around 7 km which exhibits characteristic bourne behaviour, where there is absence of flow for around three months of the year coincident with low groundwater levels, typically in late summer (Grapes et al., 2006). This is a predominantly groundwater-fed river, with a baseflow index of 0.96 and a mean flow of 1.73 m^3/s (Griffiths et al., 2006; Hannaford and Marsh, 2008). The modern River Lambourn is mainly a single thread channel commonly around 5 m wide and 1.5 m deep which meanders across a narrow, confined floodplain typically around 200 m wide. The river splits into anastomosing channels in two anthropogenically-modified flood meadow areas at Welford and Boxford (Allen et al., 2010). The whole river is designated as a Site of Special Scientific Interest (SSSI) as it is a classic example of a lowland chalk river (Old et al., 2014).

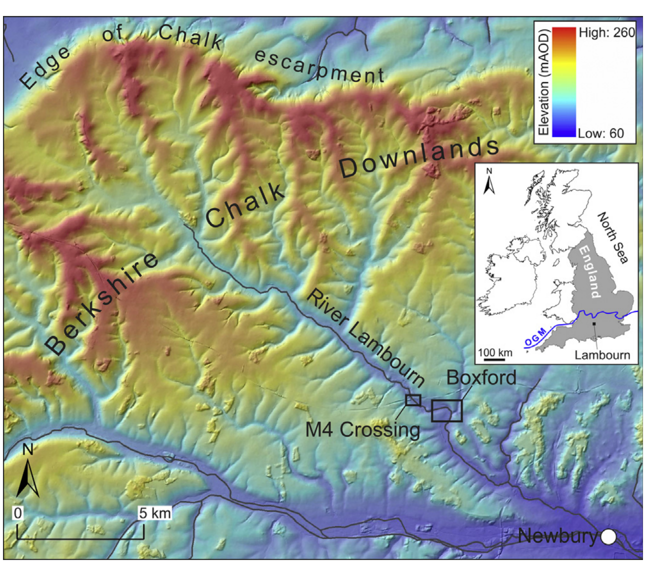

Fig. 1. Map showing the location of River Lambourn in the Berkshire Downs of southern England with the two study sites at Boxford and the M4 crossing. Inset map shows the location of the Lambourn relative to the Overall Glacial Maximum (OGM). Contains Ordnance Survey data© Crown copyright and database right (2010). NEXTMap Britain elevation data from Intermap Technologies.

2.2. Catchment geology

The Lambourn catchment is underlain by Cretaceous Chalk (Fig. 2) which dips at an angle of less than one degree towards the southeast into the western termination of the synclinal London Basin (Bloomfield et al., 2011). Most of the exposed chalk belongs to the Seaford Chalk Formation, a low density and high porosity (up to 50%) fine-grained carbonate rock which includes many horizons of flint nodules, which can range up to 0.5 m in diameter (Aldiss et al., 2006; Bloomfield et al., 1995). Older chalks, which include the high-density chalkstones of the Holywell Nodular Chalk and Lewes Nodular Chalk formations occur in the northwest portion of the catchment, upstream from East Garston (Fig. 2B). Chalks typically have a dense network of joints and fractures which, particularly where they are enhanced by dissolution, contribute nearly all of the aquifer permeability in the high-porosity but low-permeability fine-grained carbonate rock (Bloomfield et al., 1995). The common development of a rectilinear pattern of dry valleys in the Lambourn catchment may reflect an underlying structural control by an orthogonal fracture set with a northeast and southeast orientation (Fig. 2). The River Lambourn itself follows a strongly linear, southeast trending valley for most (but not all) of its length strongly suggesting some underlying structural control. While there is no evidence for the offset of Chalk formations which would indicate a fault (Aldiss et al., 2006), linear fracture swarms often develop where stresses from reactivated basement structures propagate upwards into the Chalk. The Lambourn catchment is located north of the Pewsey-Kingsclere Anticline, a major anticline in the Chalk developed over reactivated Mesozoic extensional faults during late Paleogene to early Neogene compression and basin inversion (Newell, 2014).

Across the northwest half of the Lambourn catchment, the deeply-eroded chalk bedrock is concealed only beneath thin rendzina soils (Catt and Hodgson, 1976) across large areas (Fig. 2). In the southeast half of the catchment, downstream from East Garston (Fig. 2), younger Chalk formations have a much greater cover of Palaeogene and Quaternary sediments. These deposits which include parts of the Reading and London Clay formations, clay-with-flints, head and alluvium are formed from variably stratified admixtures of gravel, sand, silt and clay up to around 25 m thick (Aldiss et al., 2006). They represent a sequence of