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Research Paper

The Middle Pleistocene terraces of the central Waveney valley, Earsham, south Norfolk, UK

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ABSTRACT

Although substantial work has been done on the pre-glacial terraces of East Anglia, very little systematic work has been done to understand the origin of river terraces in East Anglia that have formed since ice last covered the region. This paper records the results of studies of exposures and borehole records in 'classical' Quaternary terrace landforms that are considered to have formed since the Anglian (MIS 12) Glaciation, in the middle Waveney Valley. These features have been examined in terms of their morphological and sedimentological properties, in order to provide a detailed record of their form and composition, understand their processes of formation, and identify their stratigraphical status. The results show that the main body of the highest terrace (Homersfield Terrace, Terrace 3) is not composed of river sediments, but of shallow marine sediments, and is a remnant of early Middle Pleistocene Wroxham Crag. River sediments, in the form of Anglian age (MIS 12) glaciofluvial Aldeby Sands and Gravels also exist in the area as a channel fill, cut through the Wroxham Crag, and reflect outwash erosion and sedimentation from a relatively proximal ice margin to the west. The results mean that the interpretations previously presented for the terrace landforms of the middle Waveney valley are not applicable. The issue of why the terrace stratigraphy, hitherto identified in East Anglia cannot be related to that for the River Thames to the south and the rivers of Midland England to the west, still requires further research.

1. Introduction

1.1. Scientific Issues

Although the Quaternary geology of East Anglia has a long history of research, with findings that underpin much of our understanding of the Early and Middle Pleistocene of the southern North Sea region (in both Britain and continental Europe) there have, recently, been a number of significant new discoveries. For instance, we now know that the region experienced Mediterranean-style climate and the earliest human occupation in northern Europe (Parfitt et al., 2005, 2010; Candy et al., 2006; Lee et al., 2006); that a major river system (Bytham River, Rose, 1994, 2009; Westaway, 2009) flowed across the region from midland England prior to the first period of lowland glaciation, and that the geology of the Late Cainozoic shallow marine deposits in the southern North Sea region can be explained by the type of deposit that was transported by the 'preglacial' rivers (Rose et al., 2001; Rose, 2009). The regional context for these changes is shown on Fig. 1.

Likewise, studies of the history of glaciation have been the subject of much debate, with propositions for up-to and including five pre-Last Glaciation (MIS 2) glacial incursions into the region (Perrin et al., 1979; Hamblin et al., 2000, 2001, 2005; Banham et al., 2001; Lee et al., 2004; Clark et al., 2004; Gibbard et al., 2009, 2012; Rose, 2009). Although innovative new research can explain much of the evidence in northern East Anglia (Lee et al., 2016), the issue of the number of glaciations across East Anglia and Midland England is still the subject of debate. Likewise the concept of the Bytham River has been questioned (Gibbard et al., 2009; Gibbard et al., 2013) or reinterpreted (Westaway, 2009), although the validity of the fluvial facies of the Cromer Forest-bed, or the

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[1] Sadly deceased, and on whose work this paper is based and to whom the paper is dedicated.

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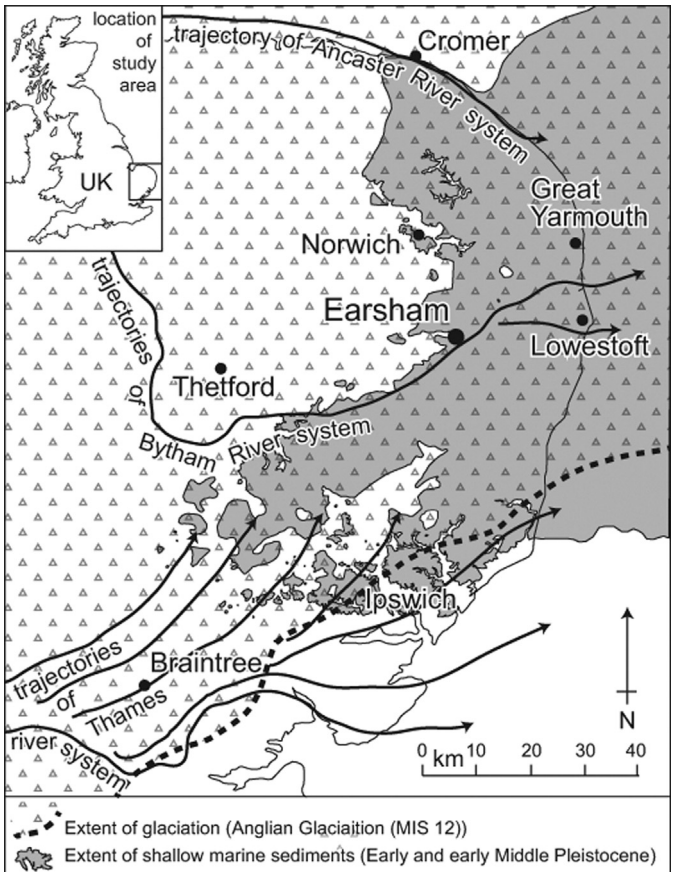

Fig. 1. The regional context for the Early and Middle Pleistocene of East Anglia. The figure shows the distribution of the Early and early Middle Pleistocene shallow marine sediments and the main trajectories of the rivers that transported the sediments into the western North Sea Basin. Also shown is the extent of ice cover across the region, attributed to the Anglian Glaciation (MIS 12).

Kesgrave Sands and Gravels, both of which are the basis of preglacial river systems, remains accepted without question. The debate surrounding the existence of the Bytham river, and the associated sediment records (Gibbard et al., 2008; Westaway, 2009), has implications not only for the regional stratigraphy, but also for the early human occupation of Britain, as many of the early archaeological sites are associated with deposits of this former river system (Rose, 2009).

Clearly there is a need to resolve such major issues, either by further work, acceptable to all involved, or by the establishment of common standards for the interpretation of the evidence published so far. However one topic that has, hitherto, not received such attention is the origin of the river systems that currently drain East Anglia. This is particularly surprising as the River Thames, to the south of the area, has been the subject of substantial work (Bridgland, 1994; Bridgland et al., 2001), and has become an international standard for the response of integrated river systems to global climate forcing (Bridgland et al., 2004), and river catchments such as that of the Trent in Midland England have become a model for understanding the interaction between glaciation and river development during the late Middle and Late Pleistocene (White et al., 2010; Bridgland et al., 2014). Examination of the 1:50,000 scale maps of the British Geological Survey shows that catchments such as the Bure, Wensum, Yare, Waveney, Gipping, Stour, and Colne (Fig. 2B) have variable numbers of aggradations and incisions (British Geological Survey, 1990, 1991, 1996a,b, 2001, 2010, 2014), but in all cases the number formed in the equivalent period of time, generally taken to be since the Anglian (MIS 12) glaciation of the region, is less than the Thames and the Trent. However, of these systems, only the Wensum and Waveney have been the subject of a systematic, climate-constrained, study of incision and aggradation since their initiation (West, 1991; Coxon, 1979, 1993; Moorlock et al., 2000; Westaway, 2009).

Examination of Fig. 2 shows a symmetry between the glacially initiated valleys of East Anglia (Fig. 2A), recognised by Woodland (1970), and the present drainage network (Fig. 2B), implying that

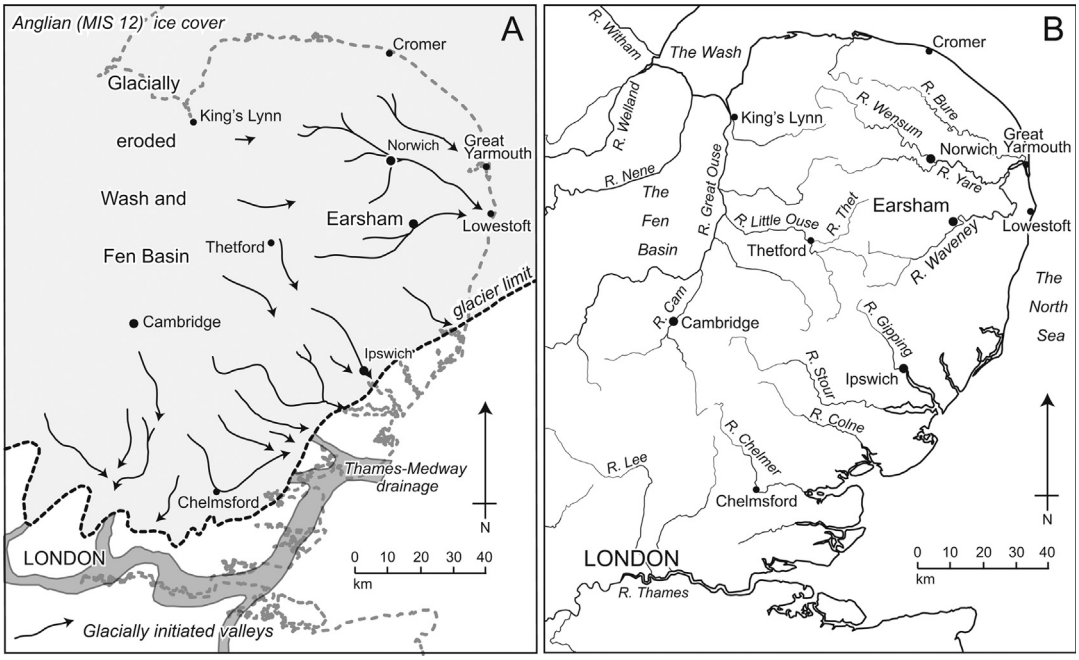

Fig. 2. The glacial and post glacial river systems of East Anglia. A) River systems initiated during the glaciation of East Anglia, assumed to be of Anglian (MIS 12) age. These valleys were formed by sub-glacial meltwater rivers, or by meltwater rivers occupying depressions on a glaciated land surface. The Thames-Medway system at the south transported both meltwater and subaerial runoff from the London Basin and region to the North Sea. B) Present day river systems. The location of Earsham is given on each map.

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