Palaeolithic archaeology of the Bytham River: human occupation of Britain during the early Middle Pleistocene and its European context

Running title: Palaeolithic record of the Bytham River

Rob Davis[1,2], Nick Ashton[1], Marcus Hatch[2], Peter G. Hoare[1,2 +] and Simon G. Lewis[2]

[1] Department of Britain, Europe and Prehistory, British Museum, 38-56 Orsman Road, London N1 5QJ, UK

[2] School of Geography, Queen Mary University of London, Mile End Road London E1 4NS, UK

Corresponding author: Rob Davis (rdavis@britishmuseum.org)

[+] deceased

Abstract

The Early and early Middle Pleistocene archaeological record in Britain from c. 900 to 500 ka marks a critical shift in human occupation of northwest Europe, from occasional pioneer populations with simple core and flake technology to more widespread occupation associated with the appearance of Acheulean technology. Key to understanding this record are the fluvial deposits of the extinct Bytham River in central East Anglia, where a series of Lower Palaeolithic sites lie on a 15 km stretch of the former river. In this paper we present the results of new fieldwork and a reanalysis of historical artefact collections of handaxes and scrapers to: 1) establish the chronostratigraphic context of the Bytham archaeological record; 2) examine variability in lithic artefact typology and technology through time; and 3) explore the implications for understanding variation in lithic technology in the European record. Six phases of occupation of Britain are identified from at least marine isotope stage (MIS) 21 to MIS 13, with the last three phases characterised by distinctive lithic technology. We argue that this relates to the discontinuous occupation of Britain, where each phase represents the arrival of new groups derived from different European populations with distinctive material culture.

Key words: Middle Pleistocene; Lower Palaeolithic; Bytham River; Acheulean; handaxe; scraper

Introduction

The Early and early Middle Pleistocene archaeological record of Britain consists of an important corpus of sites that inform our understanding of the early human occupation of northwest Europe. The discoveries at Happisburgh Site 3 (Parfitt et al., 2010) and Pakefield (Parfitt et al., 2005) overturned previous ideas concerning the timing of the earliest expansion of the hominin range into northern Europe (e.g. Roebroeks and van Kolfschoten, 1995; Roebroeks, 2001, 2006), and in the case of Happisburgh Site 3, challenged our understanding of the abilities of hominins to cope with harsh climatic conditions. There is then a wealth of evidence for human occupation of Britain during marine isotope stage (MIS) 13, including assemblages in primary context at Boxgrove (Roberts and Parfitt, 1999; Pope et al., 2020), High Lodge (Ashton et al., 1992) and Happisburgh Site 1 (Lewis et al., 2019), plus a series of secondary context assemblages interpreted as evidence of occupation during MIS 13 and MIS 15 (Wymer, 1999; Keen et al., 2006; Pettitt and White, 2012; Davis et al., 2017). These sites are associated with handaxes and feed into understanding of the spread of Acheulean technology in western Europe (Moncel and Ashton, 2018).

Handaxes are a particularly visible component of a suite of technological and behavioural innovations that mark the appearance of the Acheulean in Europe. Certainly from 500 ka and possibly earlier there are glimpses of the working of bone and wood, more efficient hunting, skilled butchery, hide-working and fire-use (Warren, 1911; Thieme, 1997; Roberts and Parfitt, 1999; Gowlett et al., 2005; Preece et al., 2006; Roebroeks and Villa, 2011; Schoch et al., 2015; Zutovski and Barkai, 2016; Milks et al., 2019; Ravon, 2019; Pope et al., 2020). A broader view has been suggested where handaxes are sometimes, but not always, a component of Acheulean technology and therefore assemblages without bifacial technology can be considered as coming under the umbrella of the Acheulean (Ashton, 2015; Moncel et al., 2015; Moncel and Ashton, 2018; Davis and Ashton, 2019). The considerable variation in European Acheulean assemblages through time and space, including variation in core reduction strategies, tool blank production, flake tool types and handaxe morphology (e.g. Ollé et al., 2013; Moncel et al., 2015; White, 2015; Hérisson et al., 2016; Moncel and Ashton, 2018; White et al., 2018; Davis and Ashton, 2019; Shipton and White, 2020), has been interpreted as representing the flexibility of Acheulean technological behaviour in adapting to local circumstances (Moncel et al., 2015; Ravon, 2019), which may lead to the development of local traditions of production and manufacture (Ashton, 2018; Davis and Ashton, 2019; Ashton and Davis, submitted).

In this paper we examine the early Acheulean of northern Europe through the lens of the Bytham River. A major Pleistocene river of central and eastern Britain until its destruction during the Anglian (MIS 12) glaciation, the Bytham fluvial sediments preserve evidence of human occupation in Britain during the early Middle Pleistocene. We begin with a review of the European record, before focusing on the Bytham sites in the Breckland, an area of central East Anglia where a series of five or six altitudinally distinct aggradations of the Bytham River can be identified (Lewis et al., submitted). This sequence provides a framework for assessing the lithic assemblages. A model of assemblage formation is developed for the Breckland Bytham sites, which reveals a series of chronologically and technologically distinct assemblages. We position these results in the context of the British record and consider the implications for understanding variation in lithic technology in the broader European context.

European archaeological record from c. 1.0 Ma to 500 ka

The British sites form an important body of data that both contribute to and help understand the European record between c. 1 Ma and 500 ka. Most of the earliest European sites that date to the first half of this period contain simple core and flake assemblages, alongside *ad hoc* production of flake tools.

In northern Italy, Cà Belvedere di Monte Poggiolo has been dated by palaeomagnetics, biostratigraphy and ESR to between 990-780 ka (Peretto et al., 1998; Muttoni et al., 2011). The assemblage is made on small flint pebbles with basic knapping techniques. The few flake tools consist of notches, denticulates and simple scrapers (Peretto 2006). In Spain, the open-air site of Vallparadis near Barcelona has been attributed to c. 800 ka based on palaeomagnetics, ESR-U-series ages and biostratigraphy. The lithic assemblage is mainly made on small, local pebbles of quartz with occasional use of bipolar technique and with the production of notches and denticulates (Martínez et al., 2010). The cave site of Gran Dolina, level TD6, at Atapuerca in northern Spain is of a similar age, where a variety of radiometric dates and palaeomagnetics also suggest an age of c. 800 ka (Ollé et al., 2013). The assemblage is composed of a variety of local materials, particularly Neogene flint and quartzite, with cores reduced by a range of reduction techniques. Retouch was typically applied to small flakes to produce notches, denticulates and occasionally scrapers. This time period also sees the first evidence of human occupation in northern Europe, at Happisburgh Site 3 dated to late in either MIS 25 or MIS 21 (c. 950 ka or 850 ka), and Pakefield, dated to late MIS 19 or MIS 17 (c. 780 or 700 ka), both in Britain (Parfitt et al., 2005, 2010). Both produced small lithic assemblages consisting of cores, flakes and occasional flake tools.

None of the assemblages above have evidence of handaxe manufacture. In some instances, the small size of the raw material might be responsible for their absence. One exception seems to be La Boella in northern Spain where several bifacially worked tools have been recovered and date to 1-0.9 Ma (Vallverdú et al., 2014). The two published examples consist of a trihedral pick made on a split cobble or a flake, while the second is a cleaver on a flake. It has been suggested that this could be the *ad hoc* production of bifacial tools, rather than a more widespread introduction of bifacial technology (Moncel et al., 2015). Similarly, a simple limestone handaxe has been reported from Cueva Negra del Estrecho del Quípar in southern Spain. Palaeomagnetic and biostratigraphic evidence support a late Early Pleistocene date, despite previous debate about the site’s age (Scott and Gibert, 2009; Jiménez-Arenas et al., 2011; López-Jiménez et al., 2020; Walker et al., 2020).

More substantive evidence of handaxe manufacture appears in the record between 700 ka and 600 ka. At La Noira in the Cher Valley, France (Despriée et al., 2011; Moncel et al., 2013), the lowest assemblage was recovered from coarse sandy slope deposits that underlie fluvial sediments of Terrace D. ESR dating on quartz has produced age estimates of 690 ± 80 ka for this terrace formation. The authors suggest that the site dates to the beginning of a cold phase (probably MIS 16) due to its position at the base of the terrace, soon after the down-cutting at the beginning of a glaciation. Almost 60 bifacial tools were recovered, which were made on local siliceous ‘millstone’ slabs using a combination of hard and soft hammer. They consist of a mix of triangular, cordiform and ovate handaxes with both pointed and rounded tips. There are also three bifacial cleavers, while other pieces have isolated areas of bifacial working, sometimes opposite a natural back. Recent fieldwork at Moulin Quignon in the Somme Valley at Abbeville recovered 262 flint artefacts including five handaxes and 13 cores from fluvial sands and gravels dated to MIS 16 on the basis of terrace stratigraphy and ESR dating on quartz (Antoine et al., 2019). The handaxes, which show a range of morphologies and modes of shaping, are made by hard hammer, with large deep removals and patches of remnant cortex, often towards the butt. The cores show a range of reduction techniques including centripetal, bifacial and orthogonal.

In southern Italy, Notarchirico consists of a series of volcanic and fluvial deposits infilling a basin, where tephro-stratigraphic correlation and 40Ar/39Ar dates show that the sequence spans 670 ± 4 ka to 614 ± 4 ka (Lefèvre et al., 2010; Pereira et al., 2015; Moncel et al., 2019, 2020). The microfauna and palynology indicate a cold, open environment and therefore the sequence has been attributed to MIS 16. There are 11 archaeological horizons with the assemblages made on a variety of local pebbles of quartzite, limestone and flint. Choppers and simple flake tools predominate, but several levels, including the lowest, contain occasional handaxes. These were shaped by the removal of large bold flakes using a hard hammer, with sinuous cutting edges and patches of residual cortex, often on the butt.

From 600 ka to c. 500 ka there is an increase in the number of sites and the size of the assemblages. There is also evidence for more sustained occupation of northern Europe. For Britain alone there are at least nine sites with Boxgrove (Roberts and Parfitt, 1999), Waverley Wood (Keen et al., 2006), Happisburgh Site 1 (Lewis et al., 2019) and six sites associated with the Bytham River (see below). Elsewhere in Europe, Carrière Carpentier in the Somme Valley in northern France, has been the subject of new fieldwork, where the fluvial sediments have been dated to MIS 15 (Antoine et al., 2015, 2016). The sediments are thought to underlie deposits that contained the handaxe assemblage, collected in the 19th and early 20th centuries, and could be MIS 14 in age. Elsewhere in the Somme, the site of Rue du Manège in Amiens has been attributed to MIS 13, but only a few artefacts and no handaxes have been recovered during the recent fieldwork (Antoine et al., 2015).

The cave site of Caune de l'Arago in southern France has an important sequence dating from MIS 14 through to MIS 12 based on ESR age estimates (Barsky and de Lumley, 2010; Barsky, 2013). The assemblages from Unit I (levels P-K; MIS 14) include 32 handaxes predominantly made on local schist, but also on quartzite and flint from up to 30 km away. Often only the tips survive, which seem to be mainly pointed, but the complete handaxes show a variety of morphologies including a 33 cm long lanceolate and a cordiform made with the use of soft hammer. Most flake tools are pointed or notched forms, but several are described as having scalar or sometimes invasive retouch with the use of soft hammer. The overlying Unit II assemblages (levels J-H; MIS 13) have higher proportions of chopping tools, but lack handaxes, while flake tools are predominantly scrapers, including double and convergent forms. Unit III (levels G-D; MIS 12) shows the reintroduction of handaxes, but irregular in form and made with hard hammer. Scrapers are again an important component of the assemblages.

Despite the long archaeological sequences at the cave sites of Atapuerca in northern Spain, the first appearance of handaxe technology is at Galería II where TL dates suggest that the lowest levels date to c. 500 ka, although other luminescence estimates suggest a younger age (Ollé et al., 2013; Demuro et al., 2014). The assemblage was mainly made on local Neogene flint, quartzite and sandstone. The majority of shaped tools are handaxes made from quartzite. They were invasively flaked, but often retain cortex at the base. Cleavers also form part of the assemblage. Flake tools are mainly notches, denticulates and simple scrapers. In Italy, the open-air site of Isernia la Pineta has been dated by 40K/39Ar and biostratigraphy to c. 600 ka (Coltorti et al., 2005; Gallotti and Peretto, 2015). The large lithic assemblages are made predominantly from small fractured tablets and blocks of locally derived flint. Simple reduction sequences produced a variety of flakes, many of which were retouched into flake tools.

Although there are currently few well-dated sites in eastern Europe, an exception is Korolevo in the Ukraine (Koulakovska, et al. 2010). A series of assemblages were recovered from a complex loess–palaeosol succession that lies above a high terrace of the river Tisza. Level VI, which has been attributed to MIS 14, is dominated by crude cores made on local andesite. There are no handaxes, but of particular note are a series of scrapers that have scalar, sometimes stepped, retouch.

While the evidence from Britain and France after 600 ka points to more sustained occupation of northwest Europe than had been seen previously, it is clear that occupation was not continuous. Discontinuity is likely to have been a feature of Lower Palaeolithic occupation across much if not all of Europe, reflecting the ebb and flow of human populations through time, or, as suggested by Dennell et al. (2011), a source and sink situation of local extinctions and repopulation from source areas elsewhere in Europe or beyond, driven by climatic instability. Dennell et al. suggest that some of the variation in the lithic record, particularly in northern Europe, may be a product of this process. Changes in material culture in a region may represent the extinction of one population due to climatic deterioration and, as climate ameliorates, the subsequent arrival of new groups with different traditions of tool making. For Britain, it is clear that there are periods of extreme cold that would have rendered it uninhabitable to humans, for example during MIS 12 and MIS 16 when ice sheets extended across much of Britain (Batchelor et al., 2019). It is therefore possible to block out periods of time that are likely hiatuses in human occupation. Then, by comparing assemblages from either side of a hiatus, it is possible to explore the influence of abandonment/local extinction and repopulation on the archaeological record.

The Bytham River

The Bytham River (Fig. 1) was a major Pleistocene river that flowed eastwards from the West Midlands, through East Anglia and into the North Sea basin until it was destroyed during MIS 12 by the advance of Anglian ice sheets (Rose, 1987, 1994, 2009; Lewis, 1998). Sediments deposited by or related to the Bytham are preserved along the full length of its course and in places contain important archaeological material related to human occupation prior to c. 450 ka, from Waverley Wood in the west (Lang and Keen, 2005; Keen et al., 2006) to Pakefield in the east (Parfitt et al., 2005). By far the richest area for archaeology associated with the Bytham River is the Breckland, a region of central East Anglia that has an exceptional Palaeolithic record and a long history of Palaeolithic research (see Davis et al., 2017 for a recent summary).

Geological and chronological framework

The regionally extensive tills and associated glaciogenic sediments that were deposited during the Anglian glaciation provide an important stratigraphic marker in the Breckland. In places, these directly overlie sand and gravel deposits attributed to the Bytham River, amply demonstrating that the river existed prior to that glacial episode. The remodelling of the landscape during the Anglian glaciation altered the drainage pattern in the region, with the west-east pre-Anglian drainage replaced by the radial pattern of drainage that characterises the post-Anglian river network. In the area under discussion, this has resulted in a clear distinction in the clast lithological composition and palaeoflow of the pre- and post-Anglian rivers; the post-Anglian river gravels are flint-dominated with a westerly palaeoflow direction (for example the rivers Lark and Little Ouse), while the Bytham gravels have an easterly palaeoflow direction and a significant quartz and quartzite component that originated in the Midlands (Rose, 1987; Lewis, 1993; Bridgland et al., 1995).

The Bytham gravels can be organised, primarily on height considerations, into five, possibly six, aggradational units (Lewis et al., submitted; Fig. 2). With the exception of the lowest deposits, these represent former terraces, which from highest to lowest have been named the Rushbrooke, Seven Hills, Ingham, Knettishall and Timworth Gravel Members of the Ingham

Formation. The lowest and youngest Bytham deposits have been studied extensively at Warren Hill. These consist of a series of finely-laminated sands and silts (the Warren Hill sands and silts Member) overlain by quartz and quartzite-rich gravels (the Warren Hill Gravel Member), which are occasionally open framework and display steeply dipping foreset bedding. In places the sequence overlies Lowestoft till, suggesting it was deposited during the Anglian and represents the final iteration of the Bytham River in the region. The Warren Hill succession has been interpreted as glaciolacustrine sediments that were deposited within a pro-glacial lake, formed as a result of the river being blocked downstream by ice during the early Anglian. These are overlain by sands and gravels deposited in a prograding delta system. A similar sequence is seen at Maidscross Hill (lower sequence), while the altitude of the gravels of the basal sedimentary unit at Frimstone's Pit, Feltwell (Hardaker and Rose, 2019), indicates they correlate with the Warren Hill sands and gravels. This youngest set of Bytham deposits is hereafter referred to as the Warren Hill deposits.

The chronology of the Bytham River sequence can be established from stratigraphical considerations supported by a suite of Electron Spin Resonance (ESR) dates on quartz grains. On the basis that the Warren Hill deposits date to MIS 12, the Timworth Gravel Member, which represents the lowest pre-Anglian terrace, could therefore be suggested to date to MIS 14 and, assuming one terrace per glacial-interglacial cycle, the Knettishall and Ingham members to MIS 16 and MIS 18 respectively. This interpretation is supported by ESR dates from Warren Hill and Maidscross Hill (Warren Hill deposits), Rampart Field (Timworth Gravel Member) and Sapiston (Knettishall Gravel Member), which indicate approximately 100,000 year cycles of terrace formation (Voinchet et al., 2015; Lewis et al., submitted; Fig. 2).

With one exception, pre-Anglian interglacial deposits have not survived in the region. It is likely that these originally overlay the surviving terrace gravels and have subsequently been lost through denudation of the terrace surface. The exception is found at High Lodge, where a series of interglacial floodplain clayey-silts (Beds B and C) can be attributed to MIS 13 on the basis of lithostratigraphy and biostratigraphy. Structures indicate that the clayey-silts have been glacio-tectonised by Anglian ice and shunted as frozen rafts (Ashton et al., 1992; Lewis, 1992; Lewis et al., 2019). Following a re-examination of section drawings from the 1960s excavations in the British Museum archive, it has recently been noted by the authors that the silts and sands of Beds D and E show similar deformation to the underlying Bed C and may therefore also have been glacio-tectonised. If correct, this revision to the original interpretation that Bed E was glacial in origin (Ashton et al., 1992) would suggest that Beds D and E also date to MIS 13. The transported sediments of Beds B and C (and possibly Beds D and E) are unlikely to have moved far from their original stratigraphic position, the most likely place being above gravels of the Timworth Gravel Member.

Bytham archaeology and its geological context

Based on the lithostratigraphical framework for the Bytham River outlined above, there are six sites in the Breckland that are known to have produced Palaeolithic archaeology associated with either the Warren Hill deposits or the Timworth Gravel Member (Fig. 1, Table 1). In addition, sparse evidence of human occupation prior to the aggradation of the Timworth Member has been identified: a small struck flake from the Knettishall Member at Hengrave (Rose and Wymer, 1994), although Wymer subsequently expressed doubt that it was of human origin (Wymer, 1999); and a river-rolled scraper made on a hard hammer flake from the Ingham Member at Fakenham Magna (Rose, pers. comm.). It has been unclear whether the lack of archaeology from the higher gravels is a genuine reflection of human absence or the result of biases introduced by the unsystematic nature of historic collection activities (Hosfield, 1999; Harris et al., 2019).

Lower Palaeolithic artefacts have been recovered from the Timworth Gravel Member at three localities: Brandon Fields, Maidscross Hill and Rampart Field. At Brandon Fields, also known as Gravel Hill, quartzite and quartz-rich gravels, approximately 3 m thick and in places resting directly on the Chalk (Flower, 1869), cap a low hill that reaches 31 m OD. It was the site of gravel extraction from a series of small pits dug during the second half of the 19th Century. Evans (1872, 1897) notes the discovery of several hundred artefacts, distributed throughout the gravels with the greater portion from the base of the sequence.

Maidscross Hill is a low hill to the east of the village of Lakenheath and 4.5 km south-west of Brandon Fields that rises to a height of 30 m OD. The hill is capped by c. 3 m of quartz and quartzite-rich gravel overlying Chalk bedrock (Flower, 1869; Ashton and Lewis, 2005). The summit of the hill is pockmarked by numerous small-scale casual workings dug in the mid-19th Century from which Lower Palaeolithic artefacts were recovered (Flower, 1969; Evans 1872, 1897). Although the vast majority of artefacts are simply recorded as coming from Lakenheath, the only significant gravel workings in the Lakenheath area during the period of artefact collection were located on Maidscross Hill. A further set of Bytham deposits is found at a lower level on the eastern flank of Maidscross Hill (Rose, 1987; Lewis, 1993). Here, disturbed Chalk at c. 11.6 m OD is overlain by 5 m of laminated sands and silts and 4 m of cross-bedded coarse chalky gravel (Ashton and Lewis, 2005; Lewis et al., submitted). This sequence bears a striking similarity to that at Warren Hill and is assigned to the Warren Hill deposits. These deposits were quarried during the mid-20th Century after the period of artefact collection.

Situated 2.5 km southeast of the village of Icklingham, Rampart Field (also known as Rampart Hill or the Town Pit) is the site of a mid-late 19th Century gravel pit excavated into the side of a low hill on the north side of the Lark Valley that reaches 25 m OD. The deposits consist of inter-bedded quartz and quartzite-rich gravels and bedded sands with occasional clay layers resting on rubbly Chalk between 18.5 m and 20.5 m OD (Bridgland et al., 1995; Lewis et al., submitted). A number of artefacts were recovered during recent fieldwork (see below), including a convergent double side scraper recovered from a gravel layer c.2 m below the surface (Bridgland et al., 1995). The site is reported to have been a rich source of Palaeolithic material during the second half of the 19th Century (Evans, 1872, 1897). However, very few are specifically labelled as coming from Rampart Field and, with numerous findspots in the Icklingham area (Roe, 1968b), it is very difficult to determine which artefacts should be assigned to Rampart Field.

There are two archaeological sites associated with Warren Hill deposits in the Breckland: Warren Hill and Feltwell. Warren Hill is one of the richest Lower Palaeolithic sites in Britain, having produced in excess of 2000 handaxes. Most were collected during the second half of the 19th Century (Evans, 1872, 1897) when the gravels capping the hill were worked in a series of small, *ad hoc* pits. Investigations at the site (Wymer et al., 1991; Bridgland et al., 1995; Lewis et al., submitted) have revealed a c. 12 m sequence resting on Chalk at 10 m OD, consisting of c. 5.5 m of finely-laminated sands and silts overlain by c. 6.5 m of sands and gravels as described above. It is likely that much if not all of the Lower Palaeolithic material was found in the sands and gravels in the upper part of the sequence (Bridgland et al., 1995). The assemblage is characterised by a wide range of conditions, from fresh to very rolled, stained and patinated to different degrees and different colours (Solomon, 1933; Wymer, 1985). Studies of the assemblage have identified three distinctive typological elements. Two groups of handaxes have been recognised (Solomon, 1933; Roe, 1968a; Wymer, 1985): a group of thick, hard hammer-struck handaxes that are typically much rolled; and a fresher group of well-made ovate handaxes. Roe (1968a) assigned both groups to his Ovate Tradition, the rolled handaxes to Group V (crude narrow handaxes) and the fresh handaxes to Group VII (less-pointed ovates). The third typological element is a group of scrapers that Solomon (1933) considered to be of 'High Lodge type' (see below).

The sequence at Feltwell consists of three units (Hardaker and Rose, 2019). The basal unit is a quartz and quartzite-rich fluvial sand and gravel overlying Chalk at 20 m that has been correlated with the Warren Hill deposits (see above). *In situ* artefacts have been recovered from these deposits, which are the likely source of most of the other artefacts. These are overlain by a further sand and gravel unit, interpreted as periglacial fan gravels by Hardaker and Rose (2019). The uppermost unit consists of sands, sands and gravels and chalky diamicton (Gibbard et al., 2012). Most of the artefacts are lightly or moderately rolled and consist of flint handaxes, the majority of which are well-made ovates, approximately 140 flint cores and flakes and a group of 23 quartzite artefacts that includes chopping-cores, cores, flakes and retouched flakes (MacRae, 1999; Hardaker and MacRae, 2000; Hardaker and Rose, 2019).

Finally, at High Lodge, clay extraction during the late 19th Century led to the recovery of a large assemblage of artefacts (Evans, 1872, 1897). Early excavations at the site (Marr et al., 1921) followed by major excavations directed by Sieveking between 1962 and 1968 and Cook in 1988 (Ashton et al., 1992) have confirmed the presence of two distinct lithic assemblages. The assemblage associated with the clayey-silts of Bed C2 is in fresh condition and includes some refitting sequences indicating that it has not moved within the sediment. It consists of hard hammer flakes produced from single platform, alternate platform and multi-platform cores made on flint nodules with no evidence of handaxe manufacture. It is in this assemblage that the classic High Lodge scrapers occur, made on large and thick hard hammer flakes. They consist of intensively retouched single, double, convergent and transverse scrapers that have been argued to represent a continuous process of resharpening (Brumm and McLaren, 2011). The second assemblage is associated with the base of the contorted sands of Bed E and includes handaxes alongside cores, flakes and *ad hoc* flake tools (Ashton et al., 1992). The majority of the artefacts are fresh to slightly abraded, suggestive of minimal movement within the sediment. Roe (1968a) assigned the handaxes to his Group VII (less-pointed ovates).

Methods and materials

Our analysis of the Bytham archaeological record is based on two sources of data: recent fieldwork conducted as part of the Breckland Palaeolithic Project; and existing museum collections.

<u>Field investigations, sieving programme and artefact identification</u>

Small-scale field investigations have been undertaken at four sites: Warren Hill (Warren Hill deposits), Rampart Field (Timworth Gravel Member), Sapiston (Knettishall Gravel Member) and Fakenham Magna (Ingham Gravel Member). In each case, sections were cut by JCB and/or by hand in former gravel pits to reveal *in situ* sediments for recording and sampling (Lewis et al., submitted). A sample of known volume from each *in situ* gravel deposit encountered was sieved on site through a 20 mm mesh and all potential artefacts retained for further examination. To assess the likelihood that the flakes are archaeological rather than geological, two separate approaches were used: a blind test involving 10 Palaeolithic archaeologists from Britain, France and Spain (not including any of the authors or those involved in the fieldwork); and the methodology and scoring system adopted by Lubinski et al. (2014). The methods and results from these are described in Appendix S1.

Museum collections research

As the majority of the artefacts were collected rather than recovered through controlled excavation, there is a bias towards handaxes and more elaborate scrapers, with flakes and cores underrepresented. This study is therefore restricted to the handaxe and scraper assemblages. Artefacts from four of the six sites have been analysed to examine variation in handaxe and scraper technology (Table 2). Rampart Field was excluded from the study due to uncertainty over the provenance of the Icklingham collections, while it was not possible to gain access to the Feltwell assemblage. The material studied is held at the British Museum (BM). All of the artefacts from Brandon Fields and Lakenheath in the BM collections were examined, as were all of the handaxes from High Lodge Bed E. For Warren Hill, a sample of 211 handaxes was selected at random from the total of 1164 in the BM collections. The scrapers from Warren Hill fall into two categories. The first group are usually in a rolled condition, usually stained and have discontinuous, often abrupt retouch, some of which might be natural edge damage. The second group of scrapers are usually in a less rolled condition, less stained and generally more patinated. They are further distinguished by having retouch that is often invasive and sometimes on multiple edges. It is this second group of scrapers that have been compared using the same methods to the published data from High Lodge Bed C (Ashton et al. 1992; Brumm and McLaren 2011).

Handaxes were recorded using a standard set of measurements and attributes. Taphonomic attributes, including degree of rolling, edge damage, patination and staining, were recorded by macroscopic observation using a four-point scale (after Ashton, 1998). Handaxe type, tip shape and butt type were recorded following Wymer's (1968) scheme. The term 'crude' refers to Wymer's types D and E – irregular and thick handaxes, shaped by hard hammer with sinuous cutting edges. It does not imply early in age or preceding the development of more refined bifacial technology. Edge shape was recorded in plan and profile. Digital callipers were used to take a series of measurements for morphometric analysis following Roe's (1968a) method. Raw material and blank type were recorded, as was the presence or absence of tranchet flaking. Flake scars larger than 5 mm were counted and a scar index was calculated by dividing total flake removals by length. Cortex retention was measured to the nearest 10%. Bifacial edge length was measured and recorded as a proportion of the total perimeter.

Results

Artefacts from the sieving programme

In total, 54 potential flakes and one handaxe were recovered from seven sections excavated at the four sites (Fig. 3 and Fig. 4). All of the artefacts are made on flint. Using the strict criteria and blind test described in Appendix S1, of the 54 potential flakes, 11 are classified as 'probable', including one from Rampart Field classified as a core (see below). Three were recovered from Warren Hill, four from Rampart Field, three from Sapiston (Fig. 4A-B) and one from Fakenham Magna (Fig. 4C). An additional probable flake was recovered during sampling for ESR dating from a sand unit at the base of the Fakenham Magna section and is not included in the density calculations below. All 11 flakes are hard hammer flakes with pronounced bulbs of percussion, plain platforms, less than 25% cortex retention on the dorsal side and between 2 and 5 dorsal flake scars. The handaxe and core were recovered from a sand and gravel layer 3.5 m below the surface at Rampart Field. The handaxe (Fig. 4D) is ovate or cordate in shape and has been thinned by soft hammer flaking to the entirety of both faces, other than a small patch of cortex at the butt end, interrupting an otherwise continuous cutting edge. It is rolled and stained and has an ancient break that has removed part of the tip. The core is also rolled and stained. It is made on a hard hammer flake with seven subsequent removals via alternate flaking (Fig. 4E).

Table 3 shows the density of artefacts in each deposit calculated from the volume of gravel sieved and the number of artefacts (probable flakes, handaxe and core). There is a clear contrast between the low density of artefacts in the Ingham and Knettishall Gravel Members, and the greater density of artefacts in the Warren Hill deposits and Timworth Gravel Member. The results also highlight the richness of the gravels at Rampart Field, suggesting a similar density of artefacts to the prolific site of Warren Hill.

The small group of artefacts found through the sieving programme adds to understanding of artefact densities in Pleistocene fluvial deposits and the variation between the aggradational units of the Bytham River. However, the much larger collected assemblages from four sites within the Bytham River can also be re-evaluated to understand assemblage variations. This is explored further below.

Handaxes

Almost all the artefacts including the handaxes are made on flint. With its Chalk bedrock, the Breckland is a flint-rich landscape. However, other rock types such as quartzite and chert would have been available in the form of occasional cobbles in Bytham river gravels. The presence of one quartzite handaxe in the Warren Hill sample, and one quartzite handaxe and one chert handaxe in the Lakenheath sample confirm earlier observations by Hardaker (2012; Hardaker and Rose, 2019) that these rarer rock types were used on occasion. The handaxe assemblages are summarised in Tables 4, 5 and 6.

Brandon Fields is characterised by large numbers of crude, hard-hammer struck handaxes (Fig. 5). These are frequently made on cobbles or split cobbles and are relatively narrow, thick and crudely shaped. Sub-cordate handaxes are also common, as are more refined ovate and cordate handaxes, worked by soft-hammer. The tables indicate that the overall assemblage has comparatively low refinement indices (other than tips), low mean scar index, high cortex retention, and often thick, partially-worked butts with shorter working edges. These characteristics all indicate less intensive working of the handaxes. The condition of the handaxes is varied, being generally iron-stained, moderately patinated in some cases and showing comparatively high degrees of abrasion and rolling (Fig. 6). Frost-cracking is also present on some pieces, which is a feature that bears a notable correspondence with handaxe type and condition. The ovates and cordiforms are significantly more patinated with more evidence of frost-cracking than the crude and sub-cordate handaxes (Table 7). This correlation between type and condition suggests that two assemblage types are present with different taphonomic histories.

The Lakenheath assemblage is remarkably similar to Brandon Fields, with the same range of handaxe types, the majority being crude or sub-cordate, made on cobbles with a hard-hammer, but as with Brandon Fields, more-intensively worked ovates and cordiforms are also present in significant numbers. The assemblage bears a similar range of conditions to Brandon Fields, with moderate to high abrasion and rolling, variable staining and patination, but the latter slightly more prominent (Fig. 6). However, there is a further correspondence between handaxe type and condition, where the crude handaxes are generally more rolled than the ovates and cordiforms. As with Brandon Fields, the relationship between type and condition suggests that there are two assemblage types with different taphonomic histories.

Warren Hill has the same range of handaxe types as the two sites above, but the dominant elements are the ovates and cordiforms, with lower numbers of crude and sub-cordate types (Fig. 7). The latter are similar in form to those from Brandon Fields and Lakenheath. The higher ratio of ovates and cordiforms is reflected by the data in the tables with greater refinement, less cortex retention, higher scar index, greater working of the butt and longer edges. The more intense working makes blank type more difficult to discern, but flake blanks are used as well as cobbles. There is a range of conditions with moderate proportions of patination and staining, and varying from slight or moderate abrasion to more rolled (Fig. 6). Again, there is a relationship between handaxe type and condition that is similar to Lakenheath, whereby the crude handaxes show a far higher degree of rolling compared to the ovates and cordiforms, suggesting the presence of two distinct assemblages (Table 8). This supports earlier work where two assemblage types were noted (Solomon 1933; Roe 1968a; Wymer 1985).

The High Lodge handaxes form a much more coherent assemblage, being dominated by ovates and cordiforms (Fig. 7). In overall shape they are very similar to the fresher material from Warren Hill, but significantly larger and with a higher incidence of tranchet-sharpened tips, characteristically producing handaxes with square, cleaver-like distal ends (Fig. 7F). As with the other assemblages there are variable degrees of patination and staining, but significantly the handaxes are fresher in condition, the majority being fresh or only slightly rolled (Fig. 6). High Lodge seems to form a coherent single assemblage that has undergone only slight movement within the sand of Bed E. These observations have always been difficult to tally with previous interpretations that Bed E is glacial in origin (Ashton et al., 1992). The new interpretation (see above) that the contorted sands of Bed E were part of the same set of sediments that were displaced by ice, corresponds better with the characteristics of the assemblage.

In summary, the assemblages from Brandon Fields and Lakenheath bear notable similarities with a dominance of rolled, hard-hammer struck, thick-butted and crudely-made handaxes that retain more cortex, with a smaller element of fresher, ovate and cordiform handaxes. At Brandon Fields the latter are more highly patinated and often have evidence of frost-cracking. Warren Hill contains the same handaxe types, but with considerably more ovates and cordiforms, which are fresher than the more heavily rolled crudely-made handaxes. By contrast, High Lodge forms a single coherent assemblage dominated by ovates and cordiforms.

Scrapers

The 29 Warren Hill scrapers are in a range of conditions tending towards being moderately rolled with some patination and minimal staining. Their condition is very similar to the ovate handaxes and they are generally fresher than the crude handaxes from the same site (Fig. 6D). They are all made on hard-hammer flint flakes and in most cases semi-scalar retouch is applied exclusively to the dorsal face. The High Lodge scrapers, which are also made by semi-scalar retouch on hard-hammer flint flakes, are much fresher, with 58.5% fresh, 37.4% slightly abraded and 4.1% abraded (Ashton et al., 1992).

The Warren Hill scrapers are generally larger than the excavated assemblage at High Lodge and similar in size to the Old Collection but with a narrower range (Table 9). All of the classic High Lodge scraper types are present at Warren Hill and occur in similar proportions (Table 10). These include single scrapers (Fig. 8A-B), double scrapers with retouch to the distal and proximal edges as well as double side scrapers (Fig. 8C-D), convergent scrapers with either a point formed at the distal end or skewed *déjeté* forms (Fig. 8E-F), and transverse scrapers (Fig. 8G-H).

The intensity of retouch is also similar between the Warren Hill and High Lodge scraper assemblages although Warren Hill shows slightly greater retouch intensity (Table 10). Warren Hill has fewer scrapers with 0-40% of edge retouched than High Lodge but more with 41-100% of edge retouched. This is mirrored by the retouched zone index for the two assemblages, which is 5.07 for Warren Hill compared to 4.72 for High Lodge. This is predominantly related to differences in retouch intensity of transverse scrapers, as the retouched zone index is similar for the other three scraper types. With regards to the distribution of retouch, at both sites single and transverse scrapers show a preference for retouch to the right lateral edge and distal end, and convergent scrapers show a preference for retouch to the medial and distal portions of the flake (Fig. 9; Brumm and McLaren, 2011: Fig. 11).

At High Lodge, Brumm and McLaren (2011) note differences between the Old Collection scrapers and the excavated assemblage, in particular the greater size and intensity of retouch of the former, reflecting selection biases introduced by the 19th Century collectors. However, as all of the classic High Lodge scraper types are represented in the excavated assemblage and there are no statistically significant differences between the two assemblages, Brumm and McLaren conclude that the much larger Old Collection assemblage provides a suitably representative sample of material from the site. There is greater potential for biases at Warren Hill given that the artefacts were recovered from sands and gravels and not from fine-grained sediments. The Warren Hill scrapers are likely to be in secondary context and therefore subject to various fluvial processes such as size sorting. Furthermore, the identification of artefacts amongst a gravel matrix is more difficult, which may reinforce any selection biases introduced by the collectors. It is therefore unsurprising that the Warren Hill scrapers show greater similarities to the High Lodge Old collection but with even greater selectivity of large, intensively retouched types.

The samples of artefacts from Brandon Fields and Lakenheath contained two and five retouched flakes respectively. The two from Brandon Fields are both made on thick, hard hammer-struck flakes. One is a single scraper (Fig. 5D), with invasive retouch applied to the dorsal face along the left lateral edge. It is patinated and in fresh condition with minimal edge damage, although a recent break has removed a portion of the proximal end. The other is a rolled denticulate. The five retouched flakes from Lakenheath consist of three denticulates and two scrapers. One of the scrapers is a convergent *déjeté* scraper with invasive retouch to the right lateral and distal edges on the dorsal side (Fig. 5H). It is in fresh condition and patinated. The other is a moderately rolled and patinated single side scraper with invasive retouch to the right lateral edge on the dorsal side.

Interpretation

Figure 10 shows the evolution of the Bytham River, from the aggradation of the Ingham Gravel Member during MIS 18 to the emplacement of the Warren Hill deposits during MIS 12, reconstructed from boreholes and section logs (Lewis et al., submitted). It shows the timing of the occurrence of the key typological elements of the archaeological record, and their relationships to each other, based on the evidence presented above. The rolled flakes from Fakenham Magna and Sapiston were recovered from sediments of the Ingham and Knettishall Gravel Members, attributed to MIS 18 and MIS 16 respectively. Given the unlikelihood of occupation in cold stages, they are likely to be derived from earlier interglacial sediments, suggesting human presence in the area during MIS 19 and MIS 17.

The density of artefacts increases in the Timworth Gravel Member (MIS 14) and Warren Hill deposits (MIS 12). These are also likely to be derived from interglacial sediments, suggesting more intense and/or long-lived occupation during MIS 15 and MIS 13. The results also confirm the presence of chronological variation in the lithic assemblages, based on the stratigraphic separation of three typological elements: crude handaxes, elaborate scrapers and ovate handaxes. A critical component is the High Lodge sequence, dated to MIS 13, which shows the stratigraphic separation of elaborate scrapers (Bed C) and ovate handaxes (Bed E). Crude, hard-hammer struck handaxes do not occur at High Lodge. All three typological elements occur at the other three sites investigated here, with crude handaxes dominating the Brandon Fields and Maidscross Hill assemblages, whilst ovate handaxes dominate the Warren Hill assemblage. These assemblages can be separated on the basis of terrace stratigraphy, with Brandon Fields and Maidscross Hill associated with the Timworth Gravel Member and Warren Hill with the younger Warren Hill deposits. On this basis, it can be suggested that crude handaxe-dominated assemblages are associated with MIS 14 sediments and ovate-dominated assemblages with MIS 13 and MIS 12 sediments.

Variation in the condition of the different artefact types at Brandon Fields, Maidscross Hill and Warren Hill serves to strengthen this pattern. At Maidscross Hill, the ovate handaxes and scrapers are generally fresher than the crude handaxes, suggesting they have not moved as far within a fluvial environment. At Brandon Fields, handaxes that are patinated and frost-cracked are more frequently ovate than crude. Such characteristics may indicate these handaxes were closer to or on the surface, where they could be subject to freeze-thawing and sub-aerial exposure. In combination, the evidence suggests that the ovates and scrapers were recovered from the upper part of the gravels, perhaps originating in overlying interglacial sediments, but through denudation of the terrace surface became incorporated into the top of the Timworth terrace gravels.

At Warren Hill, the handaxes can also be split into two groups on the basis of condition, with the more heavily rolled element dominated by crude, hard-hammer-struck handaxes that share many similarities with the Timworth Gravel Member assemblages, and a fresher but still derived element dominated by refined ovate handaxes that are very similar to the High Lodge handaxes. The intensively-retouched scrapers are so similar to the High Lodge scrapers that it seems likely that they were derived either from High Lodge or a similar site nearby. The condition of the scrapers also suggests that they have been reworked over similar distances as the ovate assemblage. This suggests that at Warren Hill there are three assemblages mixed together. One assemblage characterised by crude handaxes has been reworked from Timworth terrace gravels. The other two assemblages, characterised by ovate handaxes and scrapers, have been reworked from interglacial floodplain sediments that overlay the Timworth terrace. The sedimentological setting within deltaic sediments, where coarse bedload was deposited with little downstream transportation beyond this point may have resulted in the concentration, rather than dispersal, of archaeological material, which may partly explain the abundance of artefacts from Warren Hill.

Our interpretation of the sequence of archaeological events can therefore be summarised as: 1) low-density and/or short-lived occupation during MIS 19 and 2) MIS 17; 3) more intensive and/or long-lived occupation during MIS 15 with assemblages dominated by crude, hard hammer-struck handaxes; 4) occupation during MIS 13 represented by a core and flake industry with elaborate scrapers, followed by 5) occupation later in MIS 13 represented by ovate handaxes.

Discussion

<u>Human occupation of Britain during the Early and early Middle Pleistocene</u>

The Breckland's Bytham River sites are part of a larger dataset that provides evidence of the development and character of pre-Anglian human occupation in Britain (Fig. 1). The earliest evidence comes from Happisburgh Site 3, dated to the end of either MIS 21 or MIS 25 (Parfitt et al., 2010; Ashton et al., 2014), and Pakefield, dated to late MIS 19 or MIS 17 (Parfitt et al., 2005). The small number of flakes from Sapiston and Fakenham Magna suggest occupation of the Breckland during MIS 17 and MIS 19. If correct, this adds a new dimension to our understanding of human adaptations to Early and early Middle Pleistocene environments of northwest Europe. It has been suggested that coastal and marine resources may have played an important role in human survival strategies, particularly during winter months (Ashton and Lewis, 2012; Cohen et al., 2012; Hosfield, 2016). The presence of artefacts in a river valley 60 km from the coast would indicate that humans occupied inland areas for at least part of the year.

The Timworth Gravel Member assemblages, High Lodge and Warren Hill provide evidence of human occupation during MIS 15 and MIS 13, which, assuming abandonment during MIS 14, suggests at least two pre-Anglian Acheulean populations, separated in time and with distinct material culture. There are some indications that this chronological patterning in handaxe typology is repeated elsewhere. All pre-Anglian or Anglian handaxe assemblages in Britain have been characterised by one or both of the same two typological elements (Roe, 2001; White et al., 2018). There is no apparent geographical patterning, with assemblages characterised by each form found across the main concentrations of Lower Palaeolithic sites in southern and eastern England (Fig. 1).

Assemblages characterised by refined ovates are found at Boxgrove, West Sussex (Roberts and Parfitt, 1999; García-Medrano et al., 2019), Highland Farm, Oxfordshire (Wymer, 1999), and High Lodge. Assemblages characterised by crude handaxes are reported from Farnham Terrace A, Surrey (Roe, 1968a; White, 2015), Fordwich, Kent (Roe, 1968a; White, 2015), Kents Cavern, Devon (Lundberg and McFarlane, 2007; White, 2015), Brandon Fields and Maidscross Hill. Assemblages with both types are similarly distributed, with Corfe Mullen (Roe, 2001; McNabb et al., 2012; Davis, 2013) and Ridge Gravel Pit (McRae, 1991; Davis, 2013; Davis et al., submitted) in the Solent Basin, the Black Park Terrace of the Middle Thames (White et al., 2018) and Warren Hill. At all of these latter sites the two typological elements can also be separated on taphonomic grounds, with the cruder handaxes typically more rolled and abraded than the fresher ovate assemblage (Roe, 2001; Davis, 2013; White et al., 2018; Davis et al., submitted). At present, handaxe assemblages from higher terraces in the Thames and Solent are too small to test the hypothesis that the crude handaxes and ovates have been reworked from deposits of different ages.

In contrast, the rest of the British pre-Anglian record provides no parallels for the scraper assemblages from High Lodge Bed C and Warren Hill. The flake tools from Boxgrove (Roberts and Parfitt, 1999) and Happisburgh Site 1 (Lewis et al., 2019) consist of notches, denticulates and marginally retouched flakes. These point to an *ad hoc* approach to flake tool production, whereas the intensively worked High Lodge and Warren Hill scrapers suggest a greater time investment in terms of blank selection, application of retouch and resharpening (Brumm and McLaren, 2011). At present at least, these do represent a regional pattern.

An important question is therefore whether the scrapers were part of a tool kit used by human groups who also manufactured ovate handaxes, or do the two assemblages represent distinct tool making traditions, that were either introduced by different groups of humans or developed *in situ* in Britain? The stratigraphic separation of the scraper and handaxe assemblages and the absence of handaxes and thinning flakes from the floodplain sediments at High Lodge make the first of these scenarios difficult to support. It would require a complete separation in space of the two tool manufacturing sequences, with handaxes and scrapers made and discarded in different parts of the landscape with no overlap. Bearing in mind the 2 m thickness of Bed C is likely to have taken a significant amount of time to form, one would expect overprinting of different activities in a time-averaged assemblage. Furthermore, while there is evidence of structured landscape use in the Lower Palaeolithic, indicated by the fragmentation of reduction sequences and discrete activity areas related to the acquisition of raw material, tool production, use and discard (e.g. Wenban-Smith et al., 2004a; Hallos, 2005; Pope and Roberts, 2005; Parfitt et al., 2010; Antoine et al., 2015), there is little evidence of specialised activity areas demanding the use of different tools. For example, while the various assemblages associated with the Boxgrove palaeolandscape show variation that is structured by landscape features and subsistence opportunities (Roberts and Parfitt, 1999; Pope and Roberts, 2005; Pope et al., 2009; Pope et al., 2020), handaxe manufacture is ubiquitous.

A cultural explanation seems to be much more likely. The introduction of handaxes may have been quite rapid given the abrupt change in technology from scraper to handaxe production without any evidence for a transitional phase. In some areas, the surface of Bed C has a series of shallow, silt-filled runnels (Bed D), which refitting shows contain artefacts from Bed C (Ashton et al., 1992). Both Beds C and D are overlain by the silt and sands of Bed E. Although there is an erosional contact, there is no clear evidence of a major hiatus, but rather a transition to increased water-flow, as initially represented by Bed D and then becoming more persistent in Bed E. The evidence supports the introduction of handaxe technology by a new cultural group.

<u>The early human occupation of Europe</u>

There is now a growing body of data that provides a consistent picture of the earliest human occupation of Europe, which can be divided into a series of phases (Hosfield and Cole, 2018). There are a number of sites dated to before 1.0 Ma that may represent an initial phase focussed on southern Europe where human groups made simple core and flake industries on a variety of raw materials. The sites include Pirro Nord in Italy (Arzarello et al., 2007) and Barranco León and Fuente Nueva 3 in southern Spain (Toro-Moyano et al., 2010; Ferring et al., 2011), all from 1.5 Ma, and Sima del Elefante, Atapuerca (level TE9) in northern Spain dating from 1.2 Ma (Carbonell et al., 2008; Ollé et al., 2013). However, problems with the dating evidence from these sites have been highlighted by Muttoni et al. (2018), who argue that compelling evidence for human presence in Europe is only found from c. 900 ka. From c. 900 ka there seems to be an expansion of human groups into northwest Europe, including Happisburgh Site 3, Pakefield and possibly Fakenham Magna and Sapiston. Sites elsewhere in Europe include Cà Belvedere di Monte Poggiolo (Peretto et al., 1998; Muttoni et al., 2011), Vallparadis (Martínez et al., 2010) and Gran Dolina TD6 (Ollé et al., 2013). Whereas earlier core working was often uni-directional, Ollé et al. (2013) have noted more complex knapping with multi-directional techniques being used. Flake tools are dominated by notches and denticulates with occasional simple scrapers.

The first bifacial technology with handaxes seems to date from 700 ka to 600 ka. At La Noira a range of forms was produced, including bifacial cleavers, and triangular, cordiform and ovate handaxes with both pointed and rounded tips (Moncel et al., 2013). Significantly, both hard and soft hammers were used. At Moulin Quignon (Antoine et al., 2019) and Notarchirico (Pereira et al., 2015; Moncel et al., 2019, 2020), the handaxes are shaped by removing large, bold flakes by hard hammer, with patches of remnant cortex often on the butt and sinuous cutting edges. The core technology utilises a variety of multi-directional techniques and the flake tools are again dominated by simple notches, denticulates and scrapers. The cruder handaxes from Maidscross Hill, Brandon Fields and Warren Hill are likely to belong to this phase, with similar characteristics to the Moulin Quignon and Notarchirico handaxes.

By at least 500 ka there seems to be an expansion in the number of sites and the size of the assemblages across Europe. For Britain alone there are at least six sites with Boxgrove (Roberts and Parfitt, 1999), Waverley Wood (Keen et al., 2006), Happisburgh Site 1 (Lewis et al., 2019), Warren Hill, High Lodge Bed E and Feltwell (see above). Most of these sites are typified by their finely-made ovate handaxes with the use of soft-hammer and often sharpened with a tranchet removal across the tip. Other sites include Carrière Carpentier in

Abbeville, where recent fieldwork recovered a number of refined ovate handaxes including one with a tranchet-sharpened tip, dated to late MIS 15 or early MIS 14 (Antoine et al., 2016), and Caune de l'Arago (Barsky and de Lumley, 2010; Barsky, 2013) and Galería II (Ollé et al., 2013), which display a greater variety of handaxe and other tool forms. There are also assemblages without handaxes, most notably High Lodge, Bed C, but here there is an elaboration of scraper form, with invasive retouch. There are possible parallels at Arago and Korolevo VI (Koulakovska, et al. 2010).

Little is known about the associated hominin species, other than that the earlier sites are more likely to be associated with forms of *Homo erectus*, or *H. antecessor*, whereas later human presence is with *H. heidelbergensis* or possibly early Neanderthals (Lordkipanidze et al., 2007; Carbonell et al., 2008; Stringer, 2011, 2012; Arsuaga et al., 2014; Pereira et al., 2015; Bermúdez-de-Castro et al., 2017; Galway-Witham et al., 2019).

In the broadest sense, the British sequence reflects European scale patterning, with core and flake assemblages preceding the appearance of handaxes c. 600 ka and evidence of more sustained and widespread occupation by 500 ka. However, the review of the European record above shows that the typological patterning in the British MIS 15 and MIS 13 record is not representative of broader patterns of technological change through time. Instead, it reflects some of the variation that can be seen in the European record, but which has been separated out due to the more punctuated nature of human occupation of Britain.

As a cul-de-sac of northwest Europe, Britain was a 'sink' region for population with frequent occupation, extinction or abandonment (Dennell et al., 2011). Although there was a permanent link to mainland Europe through this period, on a European scale it would have been a relatively narrow passage between embayments in the southern North Sea and the English Channel region. This would have diminished the chances of populations entering Britain. Added to this is the effect of glaciation in Britain, with the result of long hiatuses in human occupation. The advantage of this punctuated record is the opportunity to recognise individual population incursions that can be defined by a distinctive material culture (Davis and Ashton, 2019). At the European scale, cultural patterning is difficult to identify, in part due to the large geographical area, the long time period and the fragmented record with relatively coarse chronological resolution, but perhaps also due to the flexibility of technological behaviour at this time (Moncel et al., 2015). So while the British record highlights the distinctive material culture of different human groups, at present it is only possible to discern hints of the source areas for these populations in mainland Europe.

Conclusions

The Bytham River, a major river of the British early Middle Pleistocene, provides a coherent and chronologically constrained stratigraphic framework within which to reassess the Palaeolithic record of early human presence in Britain. It is now possible to construct a robust framework in which successive phases of colonisation prior to MIS 12 can be isolated, compared and contrasted. Increasingly, temporal variation in stone tool assemblages is being recognised in the British record that is likely to reflect the distinctive material culture of human groups occupying Britain at different times, and in turn reflecting the different source areas in Europe for these populations (Roe, 2001; Wenban-Smith, 2004b; Ashton and Hosfield, 2010; Bridgland and White, 2014; White, 2015; Ashton et al., 2016; White et al., 2018, 2019; Davis and Ashton, 2019; Shipton and White, 2020).

Six phases of colonisation can now be recognised from at least 850,000 to 500,000 years ago (c. MIS 21-12). The earlier phases are represented by small assemblages from Happisburgh Site 3, Pakefield, Fakenham Magna and Sapiston, which prevent a full characterisation of lithic technology, and hence prohibit investigation of potential technological change in the British record between MIS 21 and MIS 17. What can be said is that they are all characterised by core and flake technology with occasional production of *ad hoc* flake tools. Assemblage sizes increase in MIS 15 and MIS 13 alongside the appearance of handaxes. Within the Bytham River aggradations of central East Anglia, three distinct assemblages can be identified that are stratigraphically separated and which we argue represent three different human groups. First, during MIS 15, the region is occupied by groups with lithic technology that includes the manufacture of relatively crude handaxes using hard hammers, as seen at Maidscross Hill and Brandon Fields. Then, during MIS 13, two separate phases of occupation can be identified, first by groups with core and flake technology that included the frequent production of elaborate scrapers (High Lodge Bed C), then by groups who manufactured ovate handaxes using soft hammers (High Lodge Bed E). Warren Hill records all three of these in a 'mixed' assemblage that is the result of reworking of material from sites further upstream and deposition within deltaic sediments, resulting in the concentration of archaeological material at this location. Together these sites provide a basis for interpreting other pre-Anglian sites in Britain where rolled crude handaxes and fresher ovates are found in combination. While it can be suggested that these two handaxe types are characteristic of MIS 15/13 occupation across Britain, the High Lodge scrapers so far seem to be a regional pattern.

When viewed in the context of the wider European record, it is clear that the patterning in the British record is not representative of broader patterns of chronological change in lithic technology during the early Middle Pleistocene. The change in Britain from crude to ovate handaxes from MIS 15 to MIS 13 does not reflect an overall trajectory of increasing refinement in bifacial technology. Indeed, refined handaxes made with soft hammer occur in older sediments at La Noira. Instead, the British record provides a sample of some of the variation that can be seen in the European record, but in a framework that allows the recognition of individual populations. That these populations can also be characterised by their distinctive material culture suggests that at least some of the variation in the wider European record is likely to reflect cultural traditions of stone tool manufacture.

Supplementary Information

Appendix S1: Assessment of potential artefacts recovered by coarse sieving of Bytham gravels.

Acknowledgements

We would like to thank Euston Estate for permission to conduct fieldwork at Sapiston and Fakenham Magna, John Browning and Icklingham Parish Council for Rampart Field, and the Forestry Commission for Warren Hill. Thanks also to Joshua Hogue and Claire Harris for their assistance with fieldwork. We are grateful for the constructive comments provided by the two anonymous reviewers. This research was funded by Leverhulme Trust Research Project Grant (RPG-2016-039) for the Breckland Palaeolithic Project and the Calleva Foundation for the Pathways to Ancient Britain project. The authors have no conflict of interest to declare.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

Antoine P, Moncel M-H, Limondin-Lozouet N et al. 2016. Palaeoenvironment and dating of the Early Acheulean localities from the Somme River basin (northern France): new discoveries from the High Terrace at Abbeville-Carrière Carpentier. *Quaternary Science Reviews* **149**: 338–371.

Antoine P, Moncel M-H, Locht J-L et al. 2015. Dating the earliest human occupation of Western Europe: New evidence from the fluvial terrace system of the Somme basin (Northern France). *Quaternary International* **370**: 77-99.

Antoine P, Moncel M-H, Locht J-L et al. 2019. The earliest record of Acheulean Human occupation from Northern Europe and the rediscovery of the Moulin Quignon site. *Nature Scientific Reports* **9**: 13091.

Arsuaga JL, Martínez I, Arnold LJ et al. 2014. Neandertal roots: Cranial and chronological evidence from Sima de los Huesos. *Science* **344**: 1358–1363.

Arzarello M, Marcolini F, Pavia G et al. 2007. Evidence of earliest human occurrence in Europe: the site of Pirro Nord (Southern Italy). *Naturwissenschaften* **94**: 107-112.

Ashton NM. 1998. The taphonomy of the flint assemblages. In *Excavations at the Lower Palaeolithic Site at East Farm, Barnham, Suffolk, 1989-1994,* Ashton N, Lewis SG, Parfitt S (eds). British Museum Occasional Paper Number 125: London; 183-204.

Ashton NM. 2015. Ecological niches, technological developments and physical adaptations of early humans in Europe: the handaxe-heidelbergensis hypothesis. In *Settlement, Society and Cognition in Human Evolution: Landscapes in Mind*, Wenban-Smith F, Coward F, Hosfield R (eds). Cambridge University Press: Cambridge; 138-153.

Ashton NM. 2018. Landscapes of habit and persistent places during MIS 11 in Europe A return journey from Britain. In *Crossing the Human Threshold. Dynamic Transformation and Persistent Places during the Middle Pleistocene*, Pope M, McNabb J, Gamble CB (eds). Routledge: London; 142-164.

Ashton NM, Cook J, Lewis SG et al. 1992. *High Lodge: Excavations by G. de G. Sieveking, 1962–68 and J. Cook, 1988*. British Museum Press: London.

Ashton NM, Davis RJ. submitted. Cultural mosaics, social structure and identity: The Acheulean threshold in Europe. *Journal of Human Evolution.*

Ashton NM, Hosfield RT. 2010. Mapping the human record in the British early Palaeolithic: evidence from the Solent River system. *Journal of Quaternary Science* **25**: 737-753.

Ashton NM, Lewis SG. 2005. Maidscross Hill, Lakenheath. *Proceedings of the Suffolk Institute of Archaeology and Natural History* **41**: 122–123.

Ashton NM, Lewis SG. 2012. The environmental contexts of early human occupation of northwest Europe: The British Lower Palaeolithic record. *Quaternary International* **271**: 50-64.

Ashton NM, Lewis SG, De Groote I et al. 2014. Hominin footprints from Early Pleistocene deposits at Happisburgh, UK. *PLoS ONE* **9**: e88329.

Ashton NM, Lewis SG, Parfitt SA et al. 2016. Handaxe and non-handaxe assemblages during Marine Isotope Stage 11 in northern Europe: Recent investigations at Barnham, Suffolk, UK. *Journal of Quaternary Science* **31**: 837-843.

Barsky D. 2013. The Caune de l'Arago stone industries in their stratigraphical context. *Comptes Rendus Palevol* **12**: 305–325.

Barsky D, de Lumley H. 2010. Early European mode 2 and the stone industry from the Caune de l'Arago's archeostratigraphical levels "P". *Quaternary International* **223–224**: 71–86.

Batchelor CL, Margold M, Krapp M et al. 2019. The configuration of Northern Hemisphere ice sheets through the Quaternary. Nature Communications **10**: 3713.

Bermúdez de Castro J-M, Martinón-Torres M, Martín-Francés L et al. 2017. Homo antecessor: The state of the art eighteen years later. *Quaternary International* **433**: 22-31.

Bridgland DR, Lewis SG, Wymer JJ. 1995. Middle Pleistocene stratigraphy and archaeology around Mildenhall and Icklingham, Suffolk: report on the Geologists' Association field meeting, 27 June, 1992. *Proceedings of the Geologists' Association* **106**: 57–69.

Bridgland DR, White MJ. 2014. Fluvial archives as a framework for the Lower and Middle Palaeolithic: patterns of British artefact distribution and potential chronological implications. *Boreas* **43**: 543–555.

Brumm A, McLaren A. 2011. Scraper reduction and "imposed form" at the Lower Palaeolithic site of High Lodge, England. *Journal of Human Evolution* **60**: 185-204.

Carbonell E, Bermúdez de Castro J, Pares J et al. 2008. The first hominin of Europe. *Nature* **452**: 465-470.

Cohen KM, MacDonald K, Joordens JCA et al. 2012. The earliest occupation of north-west Europe: a coastal perspective. *Quaternary International* **271**: 70 - 83.

Coltorti M, Feraud G, Marzoli A et al. 2005. New 40Ar/39Ar, stratigraphic and paleoclimatic data on the Isernia La Pineta Lower Palaeolithic site, Molise, Italy. *Quaternary International* **131**: 11–22.

Davis RJ. 2013. *Palaeolithic Archaeology of the Solent River: Human Settlement History and Technology*. PhD thesis, University of Reading.

Davis RJ, Ashton NM. 2019. Landscapes, environments and societies: The development of culture in Lower Palaeolithic Europe. *Journal of Anthropological Archaeology* **56**: 101107.

Davis RJ, Ashton NM, Hatch M et al. Submitted. Lower and early Middle Palaeolithic of Southern England: the evidence from the River Test. *Journal of Paleolithic Archaeology*.

Davis RJ, Lewis SG, Ashton NM et al. 2017. The early Palaeolithic archaeology of the Breckland: current understanding and directions for future research. *Journal of Breckland Studies* **1**: 28-44.

Demuro M, Arnold LJ, Parés JM et al. 2014. New Luminescence Ages for the Galería Complex Archaeological Site: resolving Chronological Uncertainties on the Acheulean Record of the Sierra de Atapuerca, Northern Spain. *PLoS One* **9**: e110169.

Dennell R, Martinón-Torres M, Bermúdez de Castro JM. 2011. Hominin variability, climatic instability and population demography in Middle Pleistocene Europe. *Quaternary Science Reviews* **30**: 1511–1524.

Despriée J, Voinchet P, Tissoux H et al. 2011. Lower and Middle Pleistocene human settlements recorded in fluvial deposits of the middle Loire River Basin, Centre Region, France. *Quaternary Science Reviews* **30**: 1474-1485.

Evans J. 1872. *The Ancient Stone Implements, Weapons and Ornaments of Great Britain*. Longmans, Green & Co.: London.

Evans J. 1897. *The Ancient Stone Implements, Weapons and Ornaments of Great Britain (2nd edition)*. Longmans, Green & Co.: London.

Ferring R, Oms O, Agusti J et al. 2011. Earliest human occupations at Dmanisi (Georgian Caucasus) dated to 1.85-1.78 Ma. *Proceedings of the National Academy of Sciences* **26**: 10432-10436.

Flower JW. 1869. On some recent Discoveries of Flint Implements of the Drift in Norfolk and Suffolk with observations on the Theories accounting for their Distribution. *Quarterly Journal of the Geological Society* **25**: 449-460.

Gallotti R, Peretto C. 2015. The Lower/early Middle Pleistocene small débitage productions in Western Europe: New data from Isernia La Pineta t.3c (Upper Volturno Basin, Italy). *Quaternary International* **357**: 264–281.

Galway-Witham J, Cole J, Stringer C. 2019. Aspects of human physical and behavioural evolution during the last 1 million years. *Journal of Quaternary Science* **34**: 355-378.

García-Medrano P, Ollé A, Ashton NM et al. 2019. The mental template in handaxe manufacture: new insights into Acheulean lithic technological behavior at Boxgrove, Sussex, UK. *Journal of Archeological Method and Theory* **26**: 396-422.

Gibbard PL, West RG, Boreham S et al. 2012. Late Middle Pleistocene ice marginal sedimentation in East Anglia, England. *Boreas* **41**: 319-336.

Gowlett JAJ, Hallos J, Hounsell S et al. 2005. Beeches Pit – archaeology, assemblage dynamics and early fire history of a Middle Pleistocene site in East Anglia, UK. *Eurasian Prehistory* **3**: 3-38.

Hallos J. 2005. “15 Minutes of Fame”: Exploring the temporal dimension of Middle Pleistocene lithic technology. *Journal of Human Evolution* **49**: 155-179.

Hardaker T. 2012. The artefacts from the present land surface at the Palaeolithic site of Warren Hill, Suffolk, England. *Proceedings of the Geologists' Association* **123**: 692-713.

Hardaker T, MacRae RJ. 2000. A lost river and some Palaeolithic surprises: new quartzite finds from Norfolk and Oxfordshire. *Lithics* **21**: 52-59.

Hardaker T, Rose J. 2019. The Lower Palaeolithic artefacts of the Bytham River system of central England. *Lithics* **40**: 41–58.

Harris CRE, Ashton N, Lewis SG. 2019. From Site to Museum: a Critical Assessment of Collection History on the Formation and Interpretation of the British Early Palaeolithic Record. *Journal of Paleolithic Archaeology* **2**: 1–25.

Hérisson D, Airvaux J, Lenoble A et al. 2016. Between the northern and southern regions of Western Europe: The Acheulean site of La Grande Vallée (Colombiers, Vienne, France). *Quaternary International* **411**: 108-131.

Hosfield RT. 1999. *The Palaeolithic of the Hampshire Basin. A regional model of hominid behaviour during the Middle Pleistocene*. Archaeopress. BAR British Series 286: Oxford.

Hosfield RT. 2016. Walking in a Winter Wonderland? Strategies for Early and Middle Pleistocene Survival in Midlatitude Europe. *Current Anthropology* **57**: 653-682.

Hosfield RT, Cole J. 2018. Early hominins in north-west Europe: A punctuated long chronology? *Quaternary Science Reviews* **190**: 148-160.

Jiménez-Arenas JM, Santonja M, Botella M et al. 2011. The oldest handaxes in Europe: fact or artefact? *Journal of Archaeological Science* **38**: 3340-3349.

Keen DH, Hardaker T, Lang ATO. 2006. A Lower Palaeolithic industry from the Cromerian (MIS 13) Baginton Formation of Waverley Wood and Wood Farm Pits, Bubbenhall, Warwickshire, UK. *Journal of Quaternary Science* **21**: 457–470.

Koulakovska L, Usik V, Haesaerts P. 2010. Early Paleolithic of Korolevo site (Transcarpathia, Ukraine). *Quaternary International* **223-224**: 116-130.

Lang ATO, Keen DH. 2005. At the Edge of the World. Hominid Colonisation and the Lower and Middle Palaeolithic of the West Midlands. *Proceedings of the Prehistoric Society* **71**: 63-83.

Lefèvre D, Raynal J-P, Vernet G et al. 2010. Tephro-stratigraphy and the age of ancient Southern Italian Acheulean settlements: The sites of Loreto and Notarchirico (Venosa, Basilicata, Italy). *Quaternary International* **223-224**: 360-368.

Lewis SG. 1992. High Lodge - stratigraphy and depositional environments. In *High Lodge: Excavations by G. de G. Sieveking, 1962–68 and J. Cook, 1988,* Ashton NM, Cook J, Lewis SG et al. (eds). British Museum Press: London; 51-85.

Lewis SG. 1993. *The status of the Wolstonian glaciation in the English Midlands and East Anglia*. PhD thesis, University of London.

Lewis SG. 1998. Quaternary Stratigraphy and Lower Palaeolithic Archaeology of the Lark Valley, Suffolk. In *Stone Age Archaeology. Essays in honour of John Wymer,* Ashton N, Healey F, Pettitt P (eds). Oxbow Monograph, 102: Oxford; 43–51.

Lewis SG, Ashton N, Davis R et al. submitted. A revised terrace stratigraphy and new ESR geochronology of the early Middle Pleistocene Bytham River in the Breckland of East Anglia, UK. *Quaternary Science Reviews*

Lewis SG, Ashton NM, Field M et al. 2019. Human occupation of northern Europe in MIS 13: Happisburgh Site 1 (Norfolk, UK) and its European context. *Quaternary Science Reviews* **211**: 34-58.

López Jiménez A, Haber Uriarte M, López Martínez M et al. 2020. Small-mammal indicators of biochronology at Cueva Negra del Estrecho del Río Quípar (Caravaca de la Cruz, Murcia, SE Spain). *Historical Biology* **32**: 18-33.

Lordkipanidze D, Jashashvili T, Vekua A et al. 2007. Postcranial evidence from early Homo from Dmanisi, Georgia. *Nature* **449**: 305-310.

Lubinski PM, Terry K, McCutcheon PT. 2014. Comparative methods for distinguishing flakes from geofacts: a case study from the Wenas Creek Mammoth site. *Journal of Archaeological Science* **52**: 308-320.

Lundberg J, McFarlane DA. 2007. Pleistocene depositional history in a periglacial terrane: A 500 k.y. record from Kents Cavern, Devon, United Kingdom. *Geosphere* **3**: 199-219.

McNabb J, Hosfield R, Dearling K et al. 2012. Recent Work at the Lower Palaeolithic Site of Corfe Mullen, Dorset, England. *Proceedings of the Prehistoric Society* **78**: 35 - 50.

MacRae RJ. 1991. New Lower Palaeolithic finds from gravel pits in central southern England. *Lithics* **12**: 12 - 19.

MacRae RJ. 1999. New Lower Palaeolithic finds in Norfolk. *Lithics* **20**: 3–9.

Marr JE. 1921. Excavations at high Lodge, Mildenhall in 1920 A.D. Report of the geology. *Proceedings of the Prehistoric Society of East Anglia* **3**: 353-373.

Martinez K, Garcia J, Carbonell E et al. 2010. A new Lower Pleistocene archaeological site in Europe (Vallparadis, Barcelona, Spain). *Proceedings of the National Academy of Sciences* **107**: 5762-5767.

Milks A, Parker D, Pope M. 2019. External ballistics of Pleistocene hand-thrown spears: experimental performance data and implications for human evolution. *Scientific Reports* **9**: 820.

Moncel M-H, Ashton NM. 2018. From 800 to 500 ka in Western Europe. The oldest evidence of Acheuleans in their technological, chronological, and geographical framework. In *The Emergence of the Acheulean in East Africa and Beyond. Vertebrate Paleobiology and Paleoanthropology,* Gallotti R, Mussi M (eds). Springer: Cham; 215-235.

Moncel M-H, Ashton N, Lamotte A et al. 2015. North-west Europe early Acheulian. *Journal of Anthropological Archaeology* **40**: 302-331.

Moncel M-H, Despriée J, Voinchet P et al. 2013. Early evidence of Acheulean settlement in north-western Europe - la Noira site, a 700 000 year-old occupation in the Center of France. *PloS ONE* **8**: e75529.

Moncel M-H, Santagata C, Pereira A et al. 2019. A biface production older than 600 ka ago at Notarchirico (Southern Italy) contribution to understanding early Acheulean cognition and skills in Europe. *PLoS ONE* **14**: e0218591.

Moncel M-H, Santagata C, Pereira A et al. 2020. The origin of early Acheulean expansion in Europe 700 ka ago: new findings at Notarchirico (Italy). *Scientific Reports* **10**: 13802.

Muttoni G, Scardia G, Kent DV et al. 2011. First dated human occupation of Italy at ~0.85Ma during the late Early Pleistocene climate transition. *Earth and Planetary Science Letters* **307**: 241-252.

Muttoni G, Scardia G, Kent DV. 2018. Early hominins in Europe: The Galerian migration hypothesis. *Quaternary Science Reviews* **180**: 1-29.

Ollé A, Mosquera M, Rodríguez XP et al. 2013. The Early and Middle Pleistocene technological record from Sierra de Atapuerca (Burgos, Spain). *Quaternary International* **295**: 138-167.

Parfitt SA, Barendregt RW, Breda M et al. 2005. The earliest record of human activity in northern Europe. *Nature* **438**: 1008–1012.

Parfitt SA, Ashton NM, Lewis SG et al. 2010. Early Pleistocene human occupation at the edge of the boreal zone in northwest Europe. *Nature* **466**: 229–233.

Pereira A, Nomade S, Voinchet P et al. 2015. The earliest securely dated hominin fossil in Italy and evidence of Acheulian occupation during glacial MIS 16 at Notarchirico (Venosa, Basilicata, Italy). *Journal of Quaternary Science* **30**: 639–650.

Peretto C. 2006. The first peopling of southern Europe: the Italian case. *Comptes Rendus Palevol* **5**: 283-290.

Peretto C, Amore O, Antoniazzi A et al. 1998. L'industrie lithique de Cà Belvedere di Monte Poggiolo : stratigraphie, matière première, typologie, remontages et traces d'utilisation. *L'Anthropologie* **102**: 343–466.

Pettitt P, White M. 2012.*The British Palaeolithic: Human Societies at the Edge of the Pleistocene World.* Routledge: Abingdon.

Pope M, Parfitt S, Roberts M. 2020. *The Horse Butchery Site: A High-Resolution Record of Lower Palaeolithic Hominin Behaviour at Boxgrove, UK*. SpoilHeap Publications: Portslade.

Pope M, Roberts MB. 2005. Observations on the relationship between Palaeolithic individuals and artefact scatters at the Middle Pleistocene site of Boxgrove, UK. In *The Hominid Individual in Context: Archaeological Investigations of Lower and Middle Palaeolithic Landscapes, Locales and Artefacts*, Gamble C, Porr M (eds). Routledge: New York; 81-97.

Pope M, Roberts MB, Maxted A et al. 2009. The Valdoe: archaeology of a locality within the Boxgrove Palaeolandscape, East Sussex. *Proceedings of the Prehistoric Society* **75**: 239 - 263.

Preece RC, Gowlett JAJ, Parfitt SA et al. 2006. Humans in the Hoxnian: habitat, context and fire use at Beeches Pit, West Stow, Suffolk, UK. *Journal of Quaternary Science* **21**: 485-496.

Ravon A-L. 2019. Early human occupations at the westernmost tip of Eurasia: The lithic industries from Menez–Dregan I (Plouhinec, Finistère, France). *Comptes Rendus Palevol* **18**: 663-684.

Roberts MB, Parfitt SA. 1999. *Boxgrove. A Middle Pleistocene Hominid Site at Eartham Quarry, Boxgrove, West Sussex*. English Heritage: London.

Roe DA. 1968a. British Lower and Middle Palaeolithic handaxe groups. *Proceedings of the Prehistoric Society* **34**: 1-82.

Roe DA. 1968b. *Gazetteer for British Lower and Middle Palaeolithic Sites*. Council for British Archaeology: London.

Roe DA. 2001. Some earlier Palaeolithic find-spots of interest in the Solent region. In *Palaeolithic Archaeology of the Solent River*, Wenban-Smith FF, Hosfield RT (eds). Lithic Studies Society Occasional Paper No. 7: London; 47-56.

Roebroeks W. 2001. Hominin behaviour and the earliest occupation of Europe: an exploration. *Journal of Human Evolution* **41**: 437–461.

Roebroeks W. 2006. The human colonisation of Europe: where are we? *Journal of Quaternary Science* **21**: 425–436.

Roebroeks W, van Kolfschoten T. 1995. The earliest occupation of Europe. *Proceedings of the European Science Foundation workshop at Tautavel (France), 1993*. University of Leiden: Leiden.

Roebroeks W, Villa P. 2011. On the earliest evidence for habitual use of fire in Europe. *Proceedings of the National Academy of Science* **108**: 5209-5214.

Rose J. 1987. The status of the Wolstonian glaciation in the British Quaternary. *Quaternary Newsletter* **53**: 1-9.

Rose J. 1994. Major river systems of central and southern Britain during the early and Middle Pleistocene. *Terra Nova* **6**: 435-443.

Rose J. 2009. Early and Middle Pleistocene landscapes of eastern England. *Proceedings of the Geologists' Association* **120**: 3-33.

Rose J, Wymer JJ. 1994. Record of a struck flake and the lithological composition of 'pre-glacial' river deposits at Hengrave, Suffolk, UK. *Proceedings of the Suffolk Institute of Archaeology and History* **38**: 119–125.

Schoch WH, Bigga G, Böhner U et al. 2015. New insights on the wooden weapons from the Paleolithic site of Schöningen. *Journal of Human Evolution* **89**: 214-225.

Scott GR, Gibert L. 2009. The oldest hand-axes in Europe. *Nature* **461**: 82–85.

Shipton C, White M. 2020. Handaxe types, colonization waves, and social norms in the British Acheulean. *Journal of Archaeological Science: Reports* **31**: 102352.

Solomon JD. 1933. The implementiferous gravels of Warren Hill. *The Journal of the Royal Anthropological Institute of Great Britain and Ireland* **63**: 101–110.

Stringer CB. 2011. The changing landscapes of the earliest human occupation of Britain and Europe. In *The Ancient Human Occupation of Britain,* Ashton NM, Lewis SG, Stringer CB (eds). Elsevier: Amsterdam; 1-10.

Stringer CB. 2012. The status of Homo heidelbergensis (Schoetensack 1908). *Evolutionary Anthropology* **21**: 101-107.

Thieme H. 1997. Lower Paleolithic hunting spears from Germany. *Nature* **385**: 807-810.

Toro-Moyano I, de Lumley H, Barrier P et al. 2010. *Les Industries Lithiques Archaïques de Barranco León et de Fuente Nueva 3.* CNRS éditions: Paris.

Vallverdú J, Saladié P, Rosas A et al. 2014. Age and Date for Early Arrival of the Acheulian in Europe (Barranc de la Boella, la Canonja, Spain). *PloS ONE* **9**: e103634.

Voinchet P, Moreno D, Bahain J-J et al. 2015. New chronological data (ESR and ESR/U-series) for the earliest Acheulian sites of north-western Europe. *Journal of Quaternary Science* **30**: 610–622.

Walker MJ, Haber Uriarte M, López Jiménez A et al. 2020. Cueva Negra del Estrecho del Río Quípar: a dated late Early Pleistocene Palaeolithic site in southeastern Spain. *Journal of Paleolithic Archaeology* **3**: 816–855

Warren SH. 1911. A piece of worked wood, possibly the point of a palaeolithic spear. *Quarterly Journal of the Geological Society of London* **67**: 119.

Wenban-Smith FF. 2004a. Bringing behaviour into focus: Archaic landscapes and lithic technology. In *Lithics in Action*, Walker EA, Wenban-Smith FF, Healy F (eds). Lithic Studies Society Occasional Paper No. 8. Oxbow Books: Oxford; 48-56.

Wenban-Smith FF. 2004b. Handaxe typology and Lower Palaeolithic cultural development: ficrons, cleavers and two giant handaxes from Cuxton. *Lithics* **25**: 11-21.

White MJ. 2015. Dancing to the rhythms of the biotidal zone: settlement history and culture history in Middle Pleistocene Britain. In *Settlement, Society and Cognition in Human Evolution: Landscapes in Mind*, Wenban-Smith F, Coward F, Hosfield R (eds). Cambridge University Press: Cambridge; 154-173.

White MJ, Ashton N, Bridgland DR. 2019. Twisted handaxes in Middle Pleistocene Britain and their implications for regional-scale cultural variation and the deep history of Acheulean hominin groups. *Proceedings of the Prehistoric Society* **85**: 61-81.

White MJ, Bridgland DR, Schreve DC et al. 2018. Well-dated fluvial sequences as templates for patterns of handaxe distribution: Understanding the record of Acheulean activity in the Thames and its correlatives. *Quaternary International* **480**: 118-131.

Wymer JJ. 1968. *Lower Palaeolithic Archaeology in Britain as represented by the Thames Valley*. John Baker: London.

Wymer JJ. 1985. *The Palaeolithic Sites of East Anglia*. GeoBooks: Norwich.

Wymer JJ. 1999. *The Lower Palaeolithic Occupation of Britain (Vol. 1 & 2).* Wessex Archaeology & English Heritage: Salisbury.

Wymer JJ, Lewis SG, Bridgland DR. 1991. Warren Hill, Mildenhall, Suffolk. In *Central East Anglia and the Fen Basin Field Guide*, Lewis SG, Whiteman CA, Bridgland DR (eds). Quaternary Research Association: London; 50-58.

Zutovski K, Barkai R. 2016. The use of elephant bones for making Acheulian handaxes: A fresh look at old bones. *Quaternary International* **406**: 227-238.

Table 1: *Summary of Bytham River archaeological sites in the Breckland. Data from TERPS (Wessex Archaeology 1996), with additions from Bridgland et al. (1995), MacRae (1999), Hardaker and MacRae (2000) and Hardaker and Rose (2019). Many artefacts with general Icklingham provenance are likely to be from Rampart Field. The majority of artefacts from Lakenheath are likely to be from Maidscross Hill. Geological context and age after Ashton et al. (1992) and Lewis et al. (submitted).*

Site	Location	Type	Geological context	Age	Handaxes	Retouched flakes	Cores/Flakes/ Other
Brandon Fields	Brandon Suffolk	19^{th} C. gravel pits	Timworth terrace	MIS 14	148	6	1/2/3
Rampart Field	Icklingham Suffolk	19^{th} C. gravel pit	Timworth terrace	MIS 14	8	1	-/1/1
Maidscross Hill	Lakenheath Suffolk	19^{th} C. gravel pits	Timworth terrace	MIS 14	7	-	-/-/2
High Lodge	Mildenhall Suffolk	19^{th} C. clay pit	High Lodge deposits	MIS 13	82	240	16
Warren Hill	Mildenhall Suffolk	19^{th} C. gravel pits	Warren Hill deposits	MIS 12	2000+	250+	24+/403+/ 140+
Frimstone gravel pit	Feltwell Norfolk	20^{th} C. gravel pit	Warren Hill deposits	MIS 12	66	6	26/129/-
Icklingham general	Icklingham Suffolk	-	-	-	106	9	41/-/2
Lakenheath general	Lakenheath Suffolk	-	-	-	278	5	11/1/7

Table 2: *Typological composition of the collections analysed for this study. The majority of the Lakenheath material is likely to be from Maidscross Hill. Rampart Field was excluded from the study due to uncertainty over the provenance of the Icklingham collections. Analysis of the retouched flakes (scrapers) from High Lodge uses published data (Brumm and McLaren, 2011). It was not possible to gain access to the Feltwell assemblage.*

	Brandon Fields	Lakenheath	Warren Hill	High Lodge
Handaxe	137	193	211	91
Flake	5	5	-	1
Retouched flake	2	5	29	(165)
Core	-	3	-	-
Miscellaneous	7	9	-	1
Natural	-	10	-	-

Table 3: *Summary of the results of coarse sieving of gravel deposits encountered at four Breckland Bytham River sites. Artefact density is calculated from the number of artefacts recovered (handaxe, core and probable archaeological flakes) and the volume of gravel sieved.*

Site	Area	Context	Volume sieved (m^3)	Total no. possible flakes	No. probable flakes	Handaxes	Density (probable flakes + handaxes/ m^3)
Warren Hill (Warren Hill deposits)							
	Section 1	sand & gravel	0.7	10	4	-	5.7
Rampart Field (Timworth Member)							
	Section 1	sandy gravel	0.275	3	2	1	10.9
	Section 1	lower sand & gravel	0.475	6	2	-	4.2
	Total		0.75	9	4	1	6.7
Sapiston (Knettishall Member)							
	Section 1	basal gravel	0.8	2	-	-	-
	Section 1	gravelly seam	0.76	-	-	-	-
	Section 1	middle sand & gravel	0.9	-	-	-	-
	Section 1	upper sand & gravel	0.83	5	1	-	1.2
	Section 2	basal gravel	1.13	1	-	-	-
	Section 2	middle sand & gravel	0.83	5	-	-	-
	Section 2	upper sand & gravel	1.53	11	2	-	1.3
	Total		6.78	24	3	-	0.4
Fakenham Magna (Ingham Member)							
	Section 1	sand & gravel	1.1	3	-	-	-
	Section 2	sand & gravel	0.47	6	-	-	-
	Section 3	sand & gravel	0.56	2	1	-	1.8
	Total		2.13	11	1	-	0.5

Table 4: *Summary of typology and selected attributes of the handaxe assemblages from Brandon Fields, Lakenheath, Warren Hill and High Lodge. The majority of the Lakenheath material is likely to be from Maidscross Hill.*

	Brandon Fields n = 137	Lakenheath n = 193	Warren Hill n = 211	High Lodge n = 85
Typology (after Wymer 1968)				
Crude (Types D and E)	48.2%	42.9%	29.4%	11.8%
Pointed (Type F)	5.8%	5.2%	3.8%	11.8%
Sub-cordate (Type G)	19.7%	15.0%	14.2%	10.6%
Cleaver (Type H)	0.7%	0.5%	2.8%	2.4%
Ovate (Type J and K)	24.8%	31.1%	48.8%	60.0%
Uniface	-	1.6%	0.5%	-
Other	0.7%	3.6%	0.5%	3.6%
Blank type				
Cobble/nodule	37.9%	34.7%	14.7%	8.8%
Flake	8.8%	13.0%	15.2%	17.6%
Unidentifiable	53.3%	52.3%	70.1%	73.6%
Cortex retention				
75-50%	1.6%	.6%	-	-
50-25%	7.9%	8.4%	2.9%	1.3%
<25%	59.1%	60.7%	41.7%	49.4%
None	31.5%	30.3%	55.4%	49.4%
Butt working				
None	.8%	-	-	-
<50%	13.1%	10.8%	2.5%	2.5%
>50%	53.8%	55.7%	40.7%	36.7%
Full	32.3%	33.5%	56.9%	60.8%
Bifacial edge length				
<25%	1.6%	1.1%	-	-
25-50%	4.7%	.6%	1.0%	-
50-75%	17.2%	21.1%	6.5%	5.1%
>75%	45.3%	41.7%	29.4%	23.1%
100%	31.3%	35.6%	63.2%	71.8%
Hammer type				
Hard hammer/uncertain	54.7%	54.7%	24.6%	14.1%
Soft hammer	45.3%	45.3%	75.4%	85.9%
Tranchet removal				
Absent	89.2%	85.9%	82.8%	66.2%
Present	10.8%	14.1%	17.2%	33.8%

Table 5: *Summary of metric (mean and standard deviation) data, shape and scar indices of the handaxe assemblages from Brandon Fields, Lakenheath, Warren Hill and High Lodge. Elongation = Width/Length; Refinement = Thickness/Width; Edge shape = Tip width/Butt width; Profile shape = Tip thickness/Butt thickness; Tip refinement = Tip thickness/Tip width; Butt refinement = Butt thickness/Butt width (after Roe, 1968a). The majority of the Lakenheath material is likely to be from Maidscross Hill.*

	Brandon Fields n = 112	Lakenheath n = 168	Warren Hill N = 197	High Lodge N = 70
Length (mm)	108 ± 23	110 ± 25	103 ± 27	113 ± 31
Width (mm)	65 ± 10	65 ± 12	67 ± 14	71 ± 13
Thickness (mm)	36 ± 10	35 ± 10	29 ± 9	31 ± 10
Weight (g)	254 ± 135	258 ± 152	231 ± 175	273 ± 199
Elongation	0.62 ± 0.10	0.61 ± 0.11	0.67 ± 0.10	0.65 ± 0.09
Refinement	0.56 ± 0.14	0.55 ± 0.16	0.44 ± 0.12	0.42 ± 0.10
Edge shape (pointedness)	0.75 ± 0.18	0.77 ± 0.14	0.83 ± 0.13	0.83 ± 0.11
Profile shape	0.65 ± 0.18	0.69 ± 0.18	0.80 ± 0.16	0.80 ± 0.15
Tip refinement	0.17 ± 0.04	0.17 ± 0.03	0.18 ± 0.04	0.16 ± 0.03
Butt refinement	0.52 ± 0.17	0.50 ± 0.17	0.40 ± 0.12	0.37 ± 0.10
Scar index	0.33 ± 0.11	0.34 ± 0.12	0.44 ± 0.12	0.42 ± 0.09

Table 6: *Results of statistical comparisons between Brandon Fields/Lakenheath handaxes, Brandon Fields/Warren Hill handaxes, Brandon Fields/High Lodge handaxes and High Lodge/Warren Hill handaxes. Mann-Whitney U test for metric data, chi-squared test for nominal/ordinal data. Important differences (p<0.01) in bold. The majority of the Lakenheath material is likely to be from Maidscross Hill.*

Comparison 1 Comparison 2	Brandon Field Lakenheath	Brandon Field Warren Hill	Brandon Field High Lodge	High Lodge Warren Hill
Length	U = 11150, Z = -0.866, p = 0.386	**U = 10719, Z = -2.759, p = 0.006**	U = 4988, Z = -0.195, p = 0.845	U = 6276, Z = -2.585, p = 0.010
Width	U = 12028, Z = -0.194, p = 0.847	U = 12895, Z = -0.758, p = 0.448	**U = 3752, Z = -3.081, p = 0.002**	U = 6480, Z = -2.422, p = 0.015
Thickness	U = 12147, Z = -0.466, p = 0.641	**U = 8178, Z = -6.551, p = 0.000**	**U = 3604, Z = -4.240, p = 0.000**	U = 7794, Z = -1.259, p = 0.208
Weight	U = 13093, Z = -0.036, p = 0.971	**U = 11450, Z = -3.177, p = 0.001**	U = 5451, Z = -0.569, p = 0.569	U = 7437, Z = -2.155, p = 0.031
Elongation	U = 10376, Z = -1.299, p = 0.194	**U = 8753, Z = -4.680, p = 0.000**	**U = 3589, Z = -2.656, p = 0.008**	U = 6490, Z = -1.345, p = 0.178
Refinement	U = 11674, Z = -0.554, p = 0.579	**U = 6414, Z = -8.163, p = 0.000**	**U = 2094, Z = -7.037, p = 0.000**	U = 7536, Z = -0.705, p = 0.481
Edge Shape (pointedness)	U = 10068, Z = -1.285, p = 0.199	**U = 8749, Z = -4.590, p = 0.000**	**U = 3253, Z = -3.567, p = 0.000**	U = 7248, Z = -0.198, p = 0.843
Profile Shape	U = 10334, Z = -1.276, p = 0.202	**U = 7200, Z = -6.651, p = 0.000**	**U = 2569, Z = -5.572, p = 0.000**	U = 7371, Z = -0.449, p = 0.654
Tip refinement	U = 10969, Z = -0.715, p = 0.474	U = 11616, Z = -1.484, p = 0.138	U = 4245, Z = -1.662, p = 0.097	**U = 5888, Z = -3.085, p = 0.002**
Butt refinement	U = 10473, Z = -1.014, p = 0.311	**U = 6431, Z = -7.524, p = 0.000**	**U = 1909, Z = -7.015, p = 0.000**	U = 6787, Z = -1.053, p = 0.293
Scar index	U = 10310, Z = -0.346, p = 0.730	**U = 5967, Z = -7.396, p = 0.000**	**U = 2247, Z = -5.452, p = 0.000**	U = 6337, Z = -1.172, p = 0.241
Typology	χ^2 = 2.788, df = 3, p = 0.425	**χ^2 = 25.377, df = 3, p = 0.000**	**χ^2 = 44.076, df = 3, p = 0.000**	**χ^2 = 15.859, df = 3, p = 0.001**
Blank type	χ^2 = 1.504, df = 2, p = 0.471	**χ^2 = 25.263, df = 2, p = 0.000**	**χ^2 = 26.692, df = 2, p = 0.000**	χ^2 = 3.284, df = 2, p = 0.194
Cortex retention	U = 11230, Z = -0.111, p = 0.912	**U = 9568, Z = -4.505, p = 0.000**	**U = 3923, Z = -2.989, p = 0.003**	U = 7647, Z = -0.763, p = 0.446
Butt working	U = 11643, Z = -0.538, p = 0.591	**U = 9430, Z = -4.984, p = 0.000**	**U = 3482, Z = -4.324, p = 0.000**	U = 7755, Z = -0.570, p = 0.569
Bifacial edge length	U = 10974, Z = -0.758, p = 0.448	**U = 8274, Z = -6.015, p = 0.000**	**U = 2798, Z = -5.746, p = 0.000**	U = 7143, Z = -1.379, p = 0.168
Hammer type	χ^2 = 0.000, df = 1, p = 0.992	**χ^2 = 32.473, df = 1, p = 0.000**	**χ^2 = 36.330, df = 1, p = 0.000**	χ^2 = 3.962, df = 1, p = 0.047
Tranchet removal	χ^2 = 0.774, df = 1, p = 0.241	χ^2 = 2.588, df = 1, p = 0.072	**χ^2 = 16.405, df = 1, p = 0.000**	**χ^2 = 9.074, df = 1, p = 0.003**

Table 7: *Typological composition (after Wymer 1968) of handaxes in different conditions at Brandon Fields and Lakenheath. The majority of the Lakenheath material is likely to be from Maidscross Hill.*

	Brandon Fields		Lakenheath	
	Not patinated and cracked	Patinated and cracked	Rolled	Fresher
	n = 116	n = 21	n = 146	n = 47
Crude (Type D and E)	50.9%	33.3%	46.6%	31.9%
Pointed (Type F)	5.2%	9.5%	4.8%	6.4%
Sub-cordate (Type G)	21.6%	9.5%	14.4%	17.0%
Cleaver (Type H)	0.9%	-	0.7%	-
Ovate (Type J and K)	20.7%	47.6%	28.1%	40.4%
Uniface	-	-	2.1%	-
Other	0.9%	-	3.4%	4.2%

Table 8: *Comparison between the heavily rolled and fresher handaxe groups at Warren Hill. Metric data shows mean and standard deviation. Elongation = Width/Length; Refinement = Thickness/Width; Edge shape = Tip width/Butt width; Profile shape = Tip thickness/Butt thickness; Tip refinement = Tip thickness/Tip width; Butt refinement = Butt thickness/Butt width (after Roe, 1968a).*

	Heavily rolled (n=57)	Fresher (n=154)
Measurements		
Length	111 ± 29	100 ± 27
Width	68 ± 15	67 ± 13
Thickness	34 ± 12	28 ± 7
Weight	291 ± 197	209 ± 160
Elongation	0.63 ± 0.09	0.69 ± 0.10
Refinement	0.49 ± 0.15	0.42 ± 0.09
Edge Shape (pointedness)	0.81 ± 0.12	0.83 ± 0.14
Profile Shape	0.77 ± 0.16	0.81 ± 0.17
Tip Refinement	0.18 ± 0.03	0.17 ± 0.04
Butt Refinement	0.45 ± 0.14	0.38 ± 0.11
Scar index	0.37 ± 0.11	0.47 ± 0.12
Typology (Wymer 19680		
Crude (Types D and E)	52.6%	20.8%
Pointed	7.0%	2.6%
Sub-cordate	12.3%	14.9%
Cleaver	-	3.9%
Ovate (Types J and K)	26.3%	57.1%
Uniface	-	0.6%
Other	1.8%	-
Blank type		
Cobble/nodule	17.5%	13.6%
Flake	10.5%	16.9%
Unidentifiable	71.9%	69.5%
Cortex		
50-25%	5.4%	2.0%
<25%	46.4%	39.9%
None	48.2%	58.1%
Butt working		
<50%	1.8%	2.7%
>50%	50.9%	36.9%
Full	47.3%	60.4%
Edge length		
25-50%	1.9%	0.7%
50-75%	11.1%	4.8%
>75%	29.6%	29.3%
100%	57.4%	65.3%
Hammer type		
Hard hammer/uncertain	47.4%	16.2%
Soft hammer	52.6%	83.8%
Tranchet removal		
Absent	90.9%	79.9%
Present	9.1%	20.1%

Table 9: *Comparison between size and weight (mean and standard deviation) of the Warren Hill scrapers, the High Lodge excavated scraper assemblage and the High Lodge Old Collection scraper assemblage. High Lodge data from Brumm and McLaren (2011).*

Attribute	Warren Hill (n = 25)	High Lodge Excavated assemblage (n = 30)	High Lodge Old Collection (n = 135)
Length (mm)	80 ± 15	77 ± 24	86 ± 23
Width (mm)	77 ± 26	64 ± 16	72 ± 23
Thickness (mm)	25 ± 5	22 ± 6	25 ± 8
Weight (g)	154 ± 66	116 ± 72	157 ± 120

Table 10: *Comparison between scraper typology, retouched zone index and percentage of edge retouched of the Warren Hill and High Lodge scrapers. Retouched zone index = mean number of retouched zones (where each scraper is divided into eight equal zones as shown in Fig. 9) as a measure of extent of retouch around the flake. High Lodge data from Brumm and McLaren (2011).*

	Warren Hill (n = 29)	High Lodge (n = 165)
Scraper Type		
Single	34.5%	33.9%
Double	20.7%	20.0%
Convergent	24.1%	18.8%
Transverse	20.7%	27.3%
Retouched zone index		
Single	4.2 ± 0.8	4.0 ± 1.1
Double	6.3 ± 2.1	6.1 ± 1.8
Convergent	6.4 ± 1.1	6.6 ± 1.5
Transverse	3.7 ± 1.6	2.8 ± 1.3
% Edge Retouched		
0-20	3.4%	15.8%
21-40	37.9%	40.0%
41-60	31.0%	24.8%
61-80	17.2%	12.7%
81-100	10.3%	6.7%

Figure captions

Figure 1: *Location of study sites and other sites mentioned in the text. A) Map of southern Britain showing major pre-MIS 12 river systems and key pre-MIS 12 archaeological sites. B) Map of the Breckland of East Anglia showing sites associated with the Bytham River and its approximate course during MIS 14.*

Figure 2: *Long profile projections and dating of the Bytham River gravel aggradations in the Breckland (after Lewis et al., submitted). ESR age estimates after Voinchet et al. (2015) and Lewis et al. (submitted), with uncertainties given at 2 σ. Profile projected along the axis of the Bytham River, from Shouldham Thorpe (TF 652 100), via Barton Mills (TL 726 725) and Bury St Edmunds (TL 840 675), to Wattisfield (TM 000 740). See Lewis et al. (submitted) for details of geological sections and outcrops.*

Figure 3: *Schematic section diagrams from Breckland Palaeolithic Project fieldwork at Fakenham Magna, Sapiston, Rampart Field and Warren Hill. Arrows indicate context of artefacts (handaxe, core and probable flakes) recovered by coarse sieving of gravels. ESR age estimates with uncertainties given at 2 σ. For sediment descriptions and details of ESR dating, see Lewis et al. (submitted).*

Figure 4: *Examples of artefacts recovered from Bytham gravels during recent Breckland Palaeolithic Project fieldwork. A and B: hard hammer flakes from the Knettishall Member at Sapiston; C: hard hammer flake from the Ingham Member at Fakenham Magna; D: handaxe from Timworth Member at Rampart Field; E: core on hard hammer flake from Timworth Member at Rampart Field.*

Figure 5: *Examples of handaxes and scrapers from the Timworth Member at Brandon Fields and Maidscross Hill, Lakenheath. A and B: crude hard hammer-struck handaxes from Brandon Fields; C: patinated and frost-cracked ovate handaxe from Brandon Fields; D: scraper from Brandon Fields; E and F: crude hard hammer-struck handaxe from Maidscross Hill; G: minimally rolled ovate handaxe from Maidscross Hill; H: Scraper from Maidscross Hill.*

Figure 6: *Comparison of the condition of the handaxes and scrapers from Brandon Fields, Maidscross Hill, Warren Hill and High Lodge. A: the degree of rolling of the handaxe assemblages; B: the degree of patination of the handaxe assemblages; C: degree of staining of the handaxe assemblages; D: the degree of rolling of the crude handaxes, ovate handaxes and scrapers from Warren Hill.*

Figure 7: *Examples of handaxes from Warren Hill and High Lodge. A and B: ovate handaxes from Warren Hill; C and D: crude hard hammer-struck handaxes from Warren Hill; E and F: ovate handaxes from High Lodge.*

Figure 8: *Examples of scrapers from Warren Hill. A and B: single scrapers; C and D double scrapers; E and F: convergent scrapers; G and H: transverse scrapers.*

Figure 9: *Location of retouch on Warren Hill scrapers by scraper type. A: Illustration of retouch zone locations; B: single scrapers; C: double scrapers; D: convergent scrapers; E: transverse scrapers.*

Figure 10: *Reconstruction of the evolution of the Bytham River in the Breckland from MIS 18 to MIS 12, showing the timing of the occurrence of the main typological elements of the Bytham Palaeolithic record and their relationship to each other.* *A: Ingham Gravel Member and the course of the river during MIS 18; B: Knettishall Gravel Member and the course of the river during MIS 16; C: Timworth Gravel Member and the course of the river during MIS 14, with crude handaxes reworked from MIS 15 interglacial sediments; D: MIS 13, interglacial sediments form on top of the Timworth Gravel Member, initial human occupation represented by scraper assemblages; E: later in MIS 13, human occupation is represented by ovate handaxe assemblages; F: the river is blocked by ice during MIS 12, a proglacial lake forms, gravels are deposited in a prograding delta and artefacts from the Timworth Gravel Member and overlying interglacial sediments are reworked and deposited at Warren Hill; G: schematic cross-section illustrating the reworking and mixing of crude handaxe, scraper and ovate handaxe assemblages. Key to sites: 1. Bardwell (A), 2. Brandon Fields, 3. Fakenham Magna, 4. Frimstone's Pit, Feltwell, 5. Hengrave, 6. High Lodge, 7. Honnington, 8. Ingham (Site A), 9. Knettishall, 10. Lackford, 11. Maidscross Hill, 12. Methwold, 13. Northwold, 14. Rampart Field, 15. Sapiston, 16. Timworth, 17. Warren Hill. See Lewis et al., (submitted) for further details.*

Figure 1

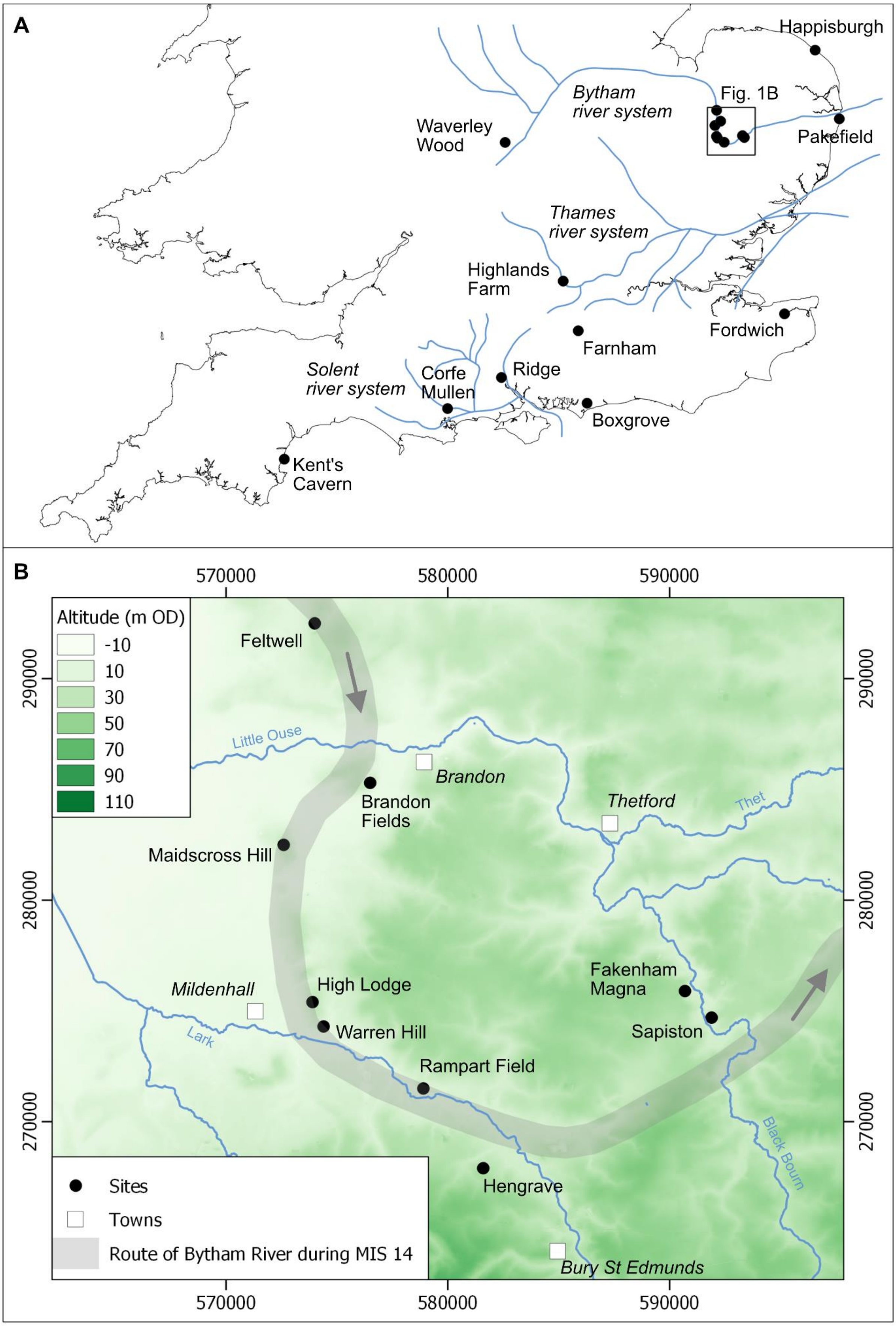
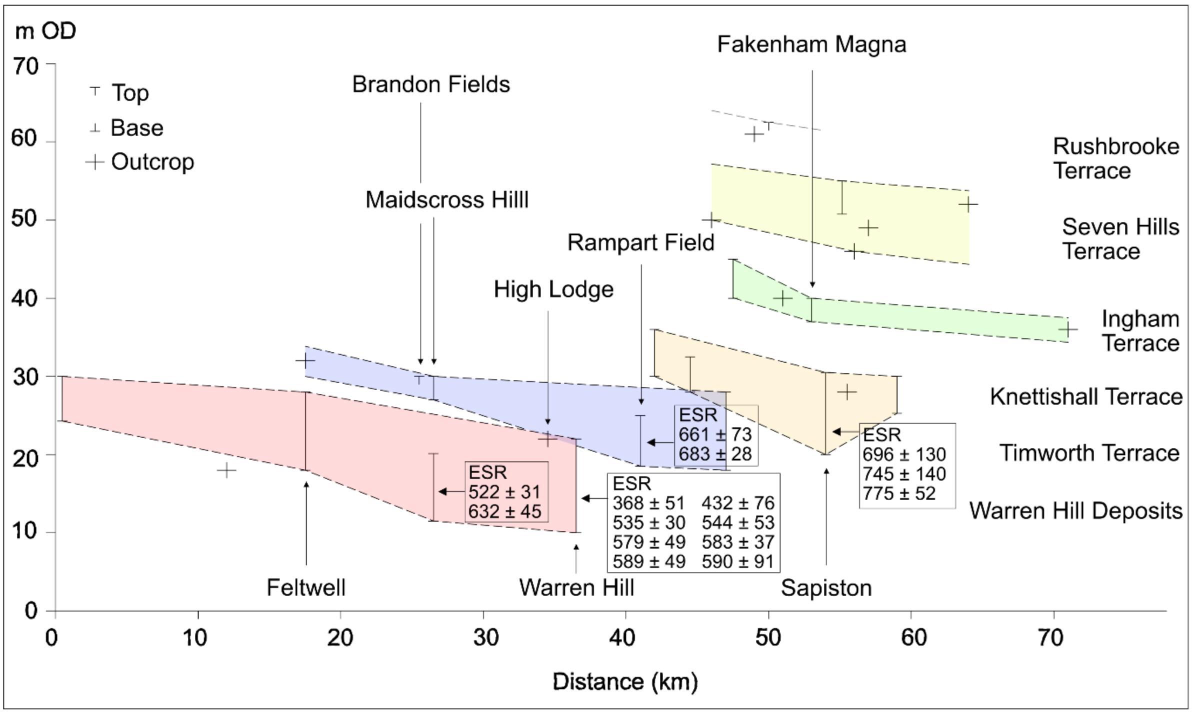

A
Happisburgh
Bytham
river system
Fig. 1B
Waverley
Wood
Pakefield
Thames
river system
Highlands
Farm
Fordwich
Farnham
Solent
river system
Corfe
Mullen
Ridge
Boxgrove
Kent's
Cavern
B
570000
580000
590000
290000
280000
270000
Altitude (m OD)
-10
10
30
50
70
90
110
Feltwell
Little Ouse
Brandon
Brandon
Fields
Thetford
Thet
Maidscross Hill
Fakenham
Magna
Mildenhall
High Lodge
Warren Hill
Sapiston
Lark
Rampart Field
Black Bourn
Hengrave
Sites
Towns
Route of Bytham River during MIS 14
Bury St Edmunds

Figure 2



m OD
Top
Base
Outcrop
Brandon Fields
Maidscross Hilll
High Lodge
Rampart Field
Fakenham Magna
Rushbrooke Terrace
Seven Hills Terrace
Ingham Terrace
Knettishall Terrace
Timworth Terrace
Warren Hill Deposits
ESR
661 ± 73
683 ± 28
ESR
522 ± 31
632 ± 45
ESR
368 ± 51 432 ± 76
535 ± 30 544 ± 53
579 ± 49 583 ± 37
589 ± 49 590 ± 91
ESR
696 ± 130
745 ± 140
775 ± 52
Feltwell
Warren Hill
Sapiston
Distance (km)

Figure 3

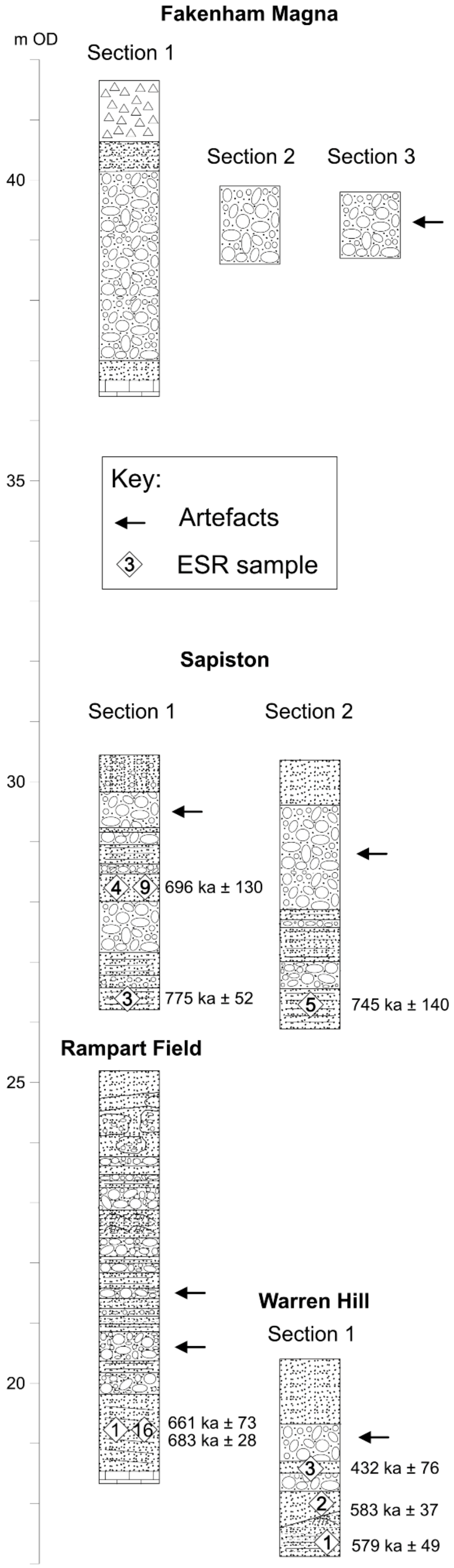

Fakenham Magna
m OD
Section 1
Section 2
Section 3
40
35
Key:
Artefacts
3
ESR sample
Sapiston
Section 1
Section 2
30
4
9
696 ka ± 130
3
775 ka ± 52
5
745 ka ± 140
Rampart Field
25
Warren Hill
Section 1
20
1
16
661 ka ± 73
683 ka ± 28
3
432 ka ± 76
2
583 ka ± 37
1
579 ka ± 49

Figure 4

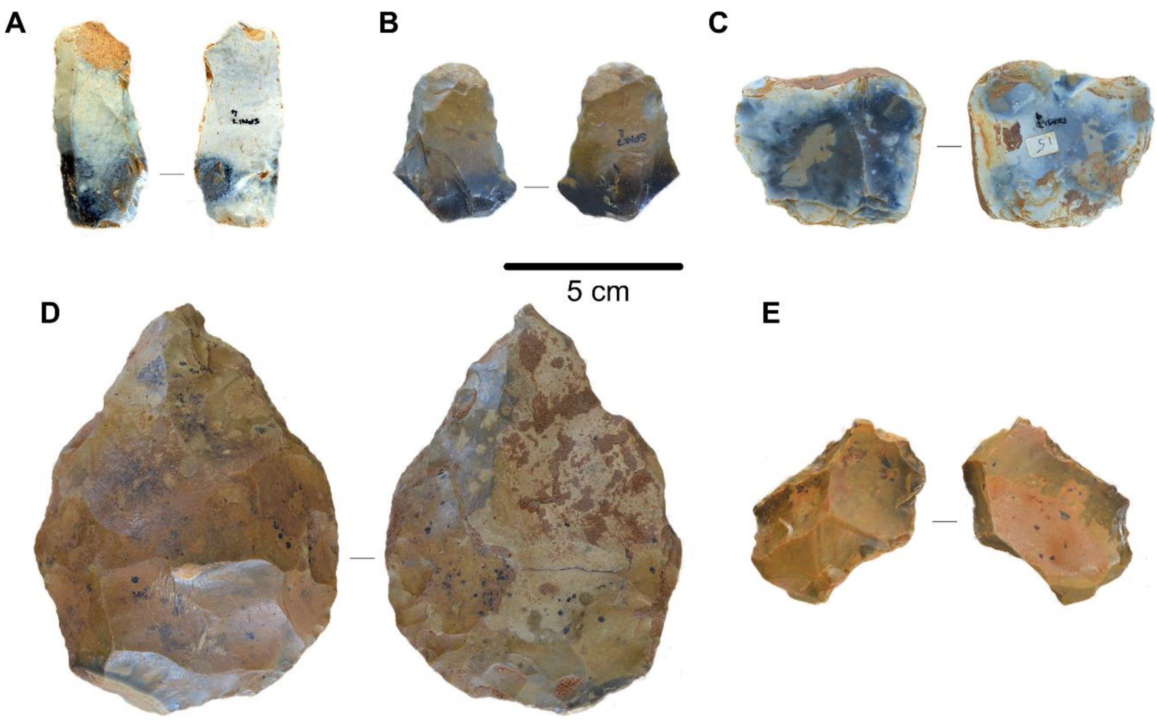


Figure 5

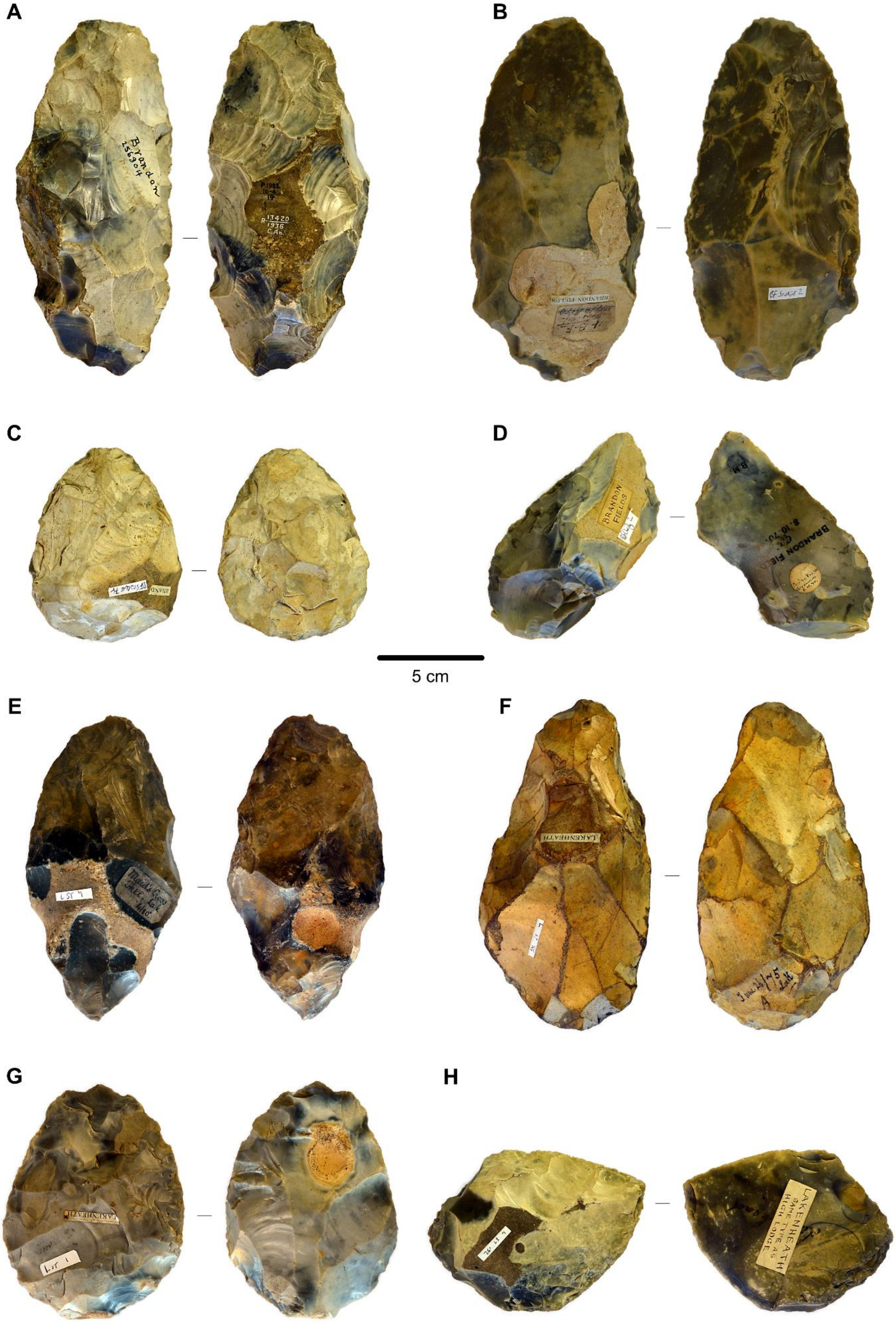


Figure 6

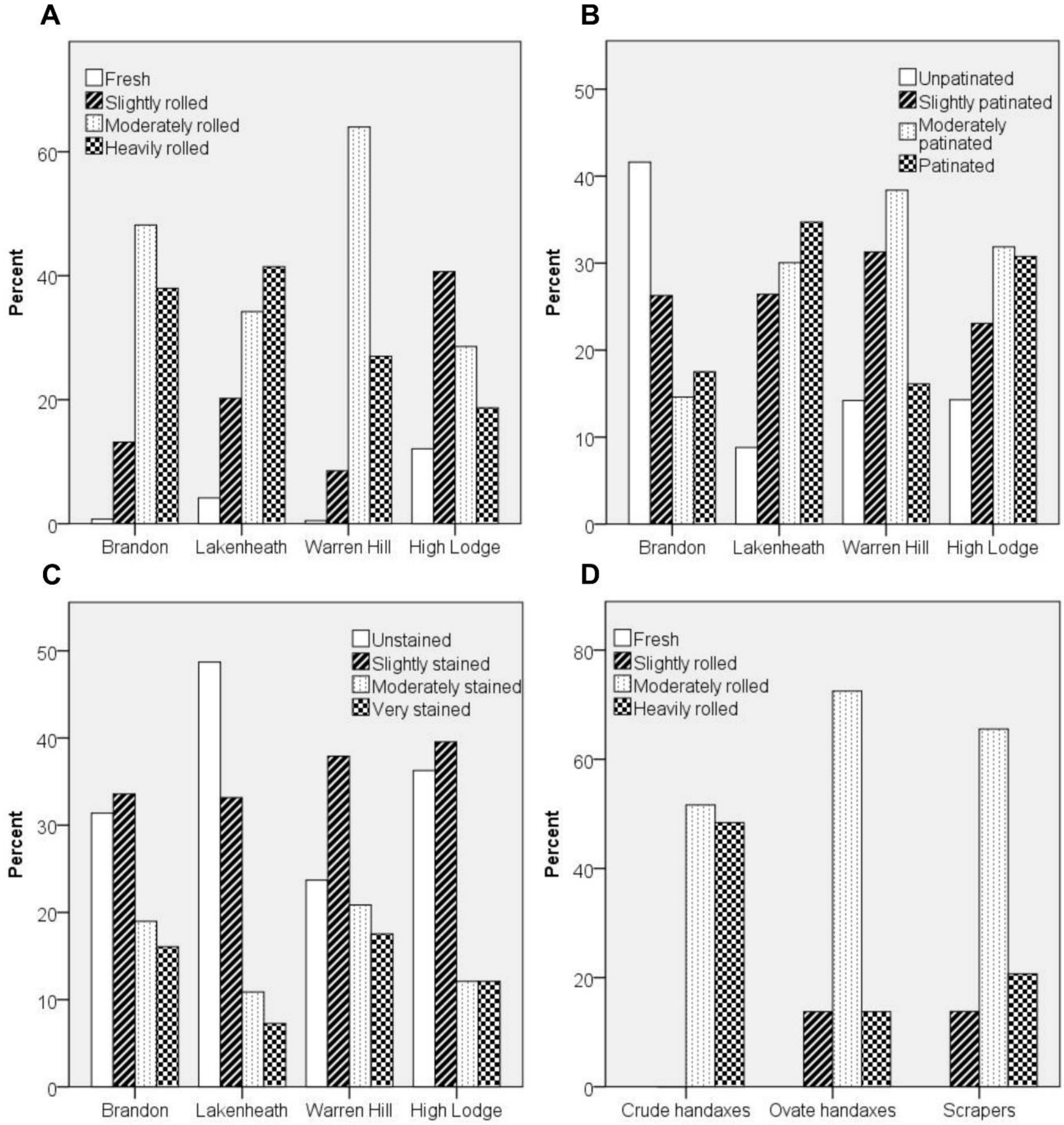

A
Fresh
Slightly rolled
Moderately rolled
Heavily rolled
Percent
0
20
40
60
Brandon
Lakenheath
Warren Hill
High Lodge
B
Unpatinated
Slightly patinated
Moderately patinated
Patinated
Percent
0
10
20
30
40
50
Brandon
Lakenheath
Warren Hill
High Lodge
C
Unstained
Slightly stained
Moderately stained
Very stained
Percent
0
10
20
30
40
50
Brandon
Lakenheath
Warren Hill
High Lodge
D
Fresh
Slightly rolled
Moderately rolled
Heavily rolled
Percent
0
20
40
60
80
Crude handaxes
Ovate handaxes
Scrapers

Figure 7

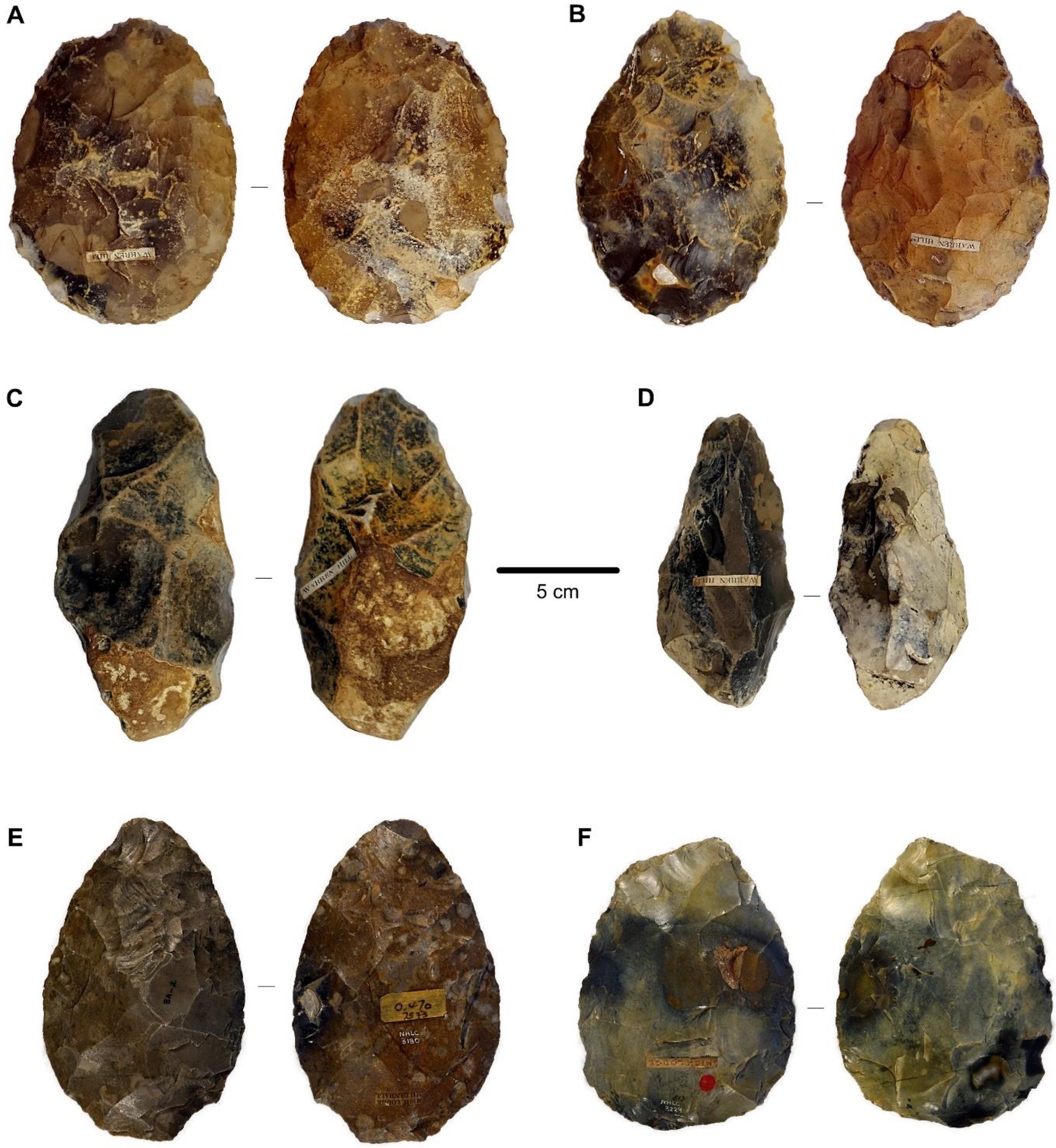


Figure 8

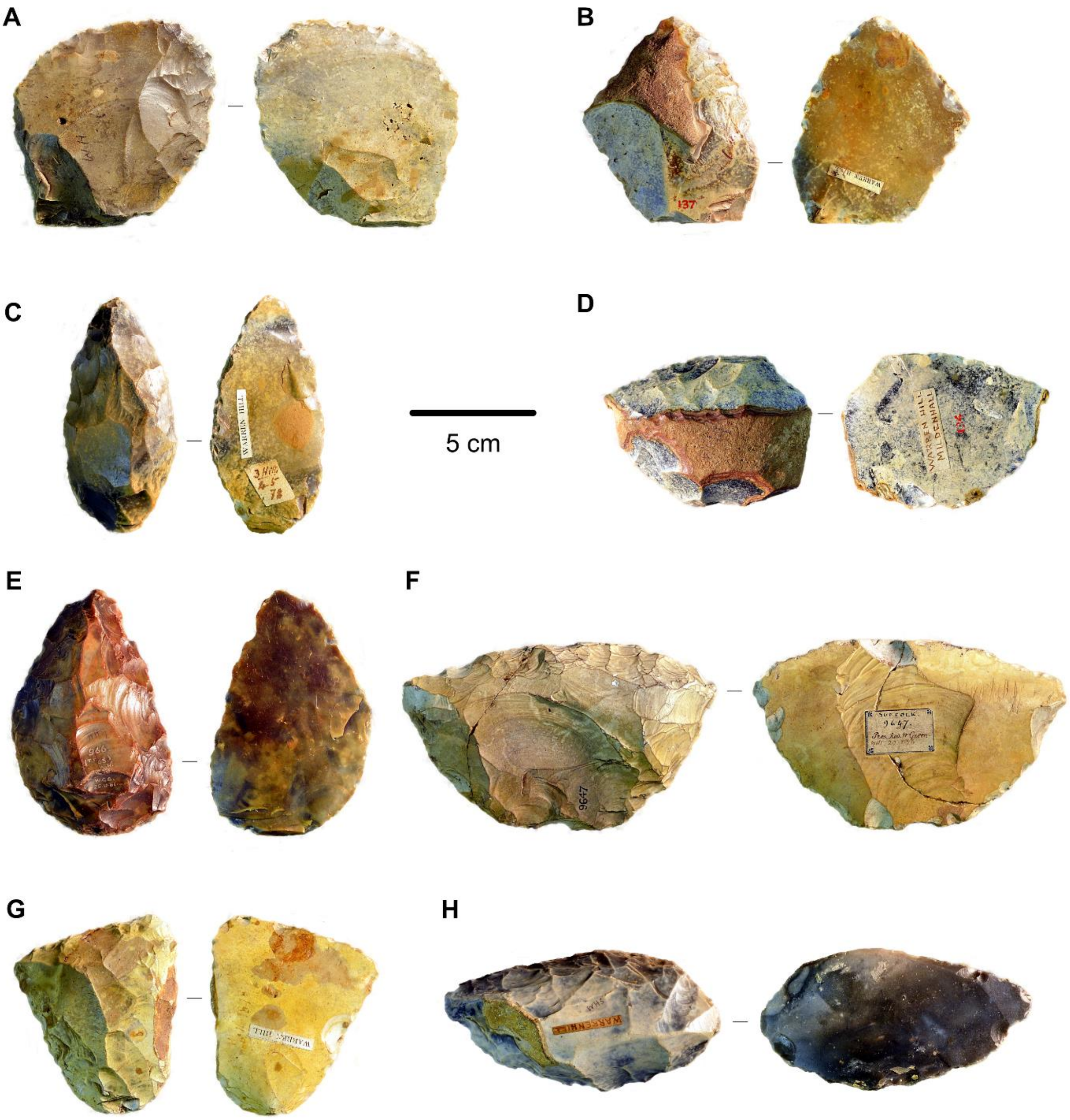

A
B
C
D
E
F
G
H
5 cm
WARREN HILL
WARREN HILL
MILDENHALL
SUFFOLK
9647
9647
WARREN HILL

Figure 9

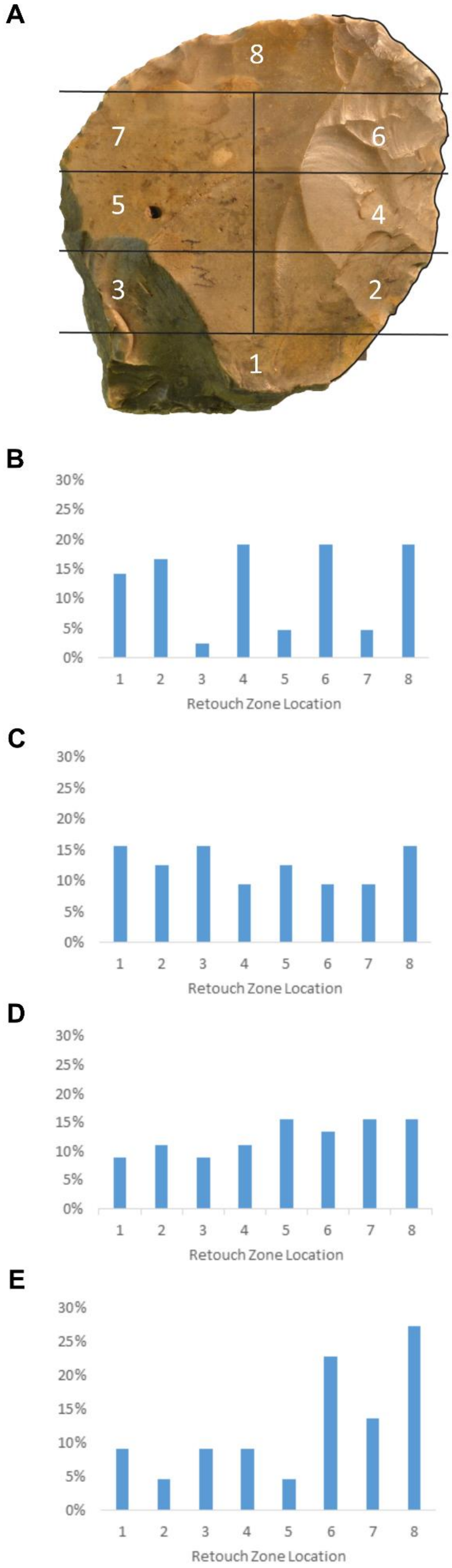
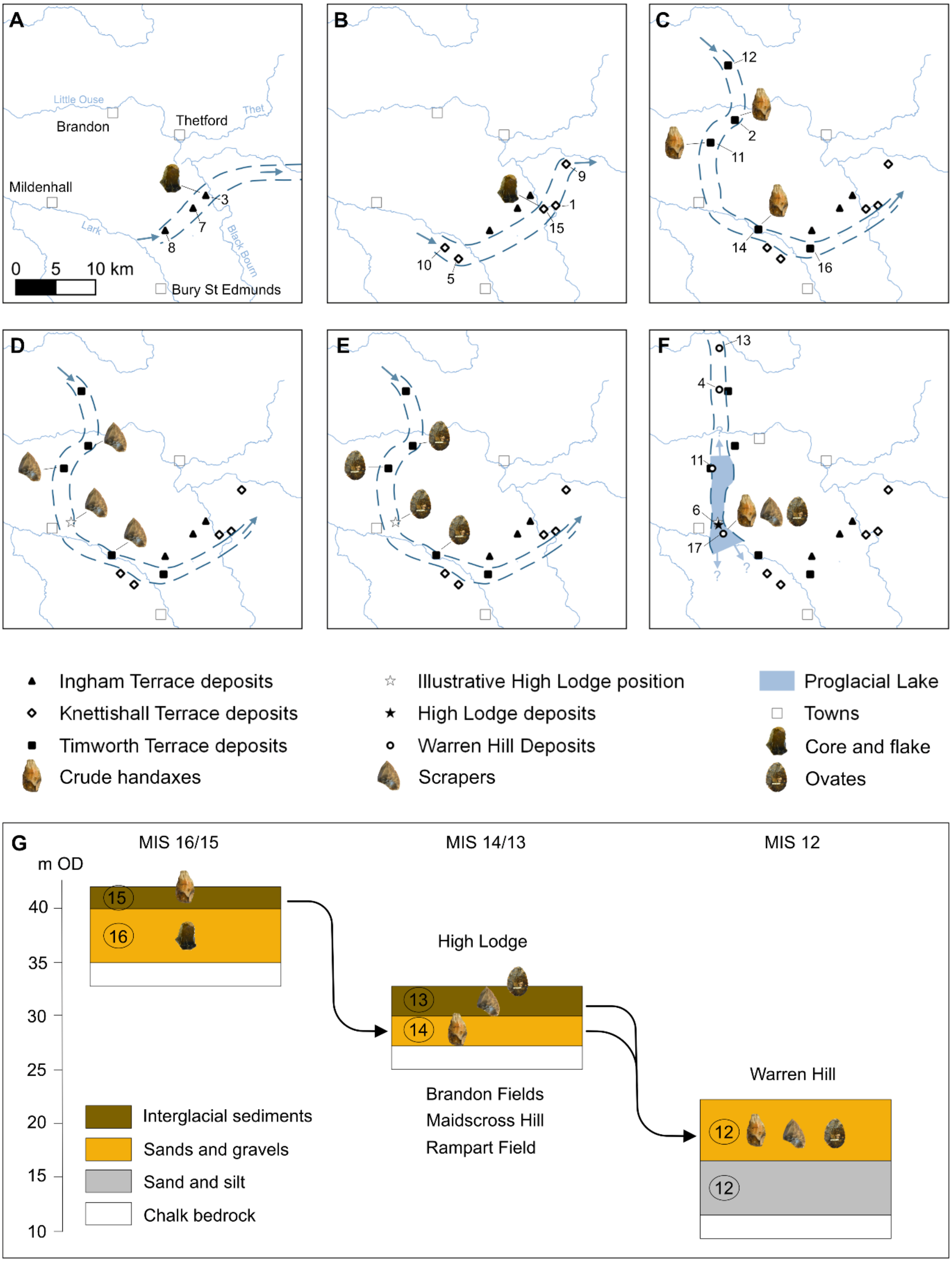

A
8
7
6
5
4
3
2
1
B
30%
25%
20%
15%
10%
5%
0%
1 2 3 4 5 6 7 8
Retouch Zone Location
C
30%
25%
20%
15%
10%
5%
0%
1 2 3 4 5 6 7 8
Retouch Zone Location
D
30%
25%
20%
15%
10%
5%
0%
1 2 3 4 5 6 7 8
Retouch Zone Location
E
30%
25%
20%
15%
10%
5%
0%
1 2 3 4 5 6 7 8
Retouch Zone Location

Figure 10


A
Little Ouse
Brandon
Thetford
Thet
Mildenhall
Lark
Black Bourn
Bury St Edmunds
0 5 10 km
3
7
8
B
9
1
15
10
5
C
12
2
11
14
16
D
E
F
13
4
11
6
17
Ingham Terrace deposits
Knettishall Terrace deposits
Timworth Terrace deposits
Crude handaxes
Illustrative High Lodge position
High Lodge deposits
Warren Hill Deposits
Scrapers
Proglacial Lake
Towns
Core and flake
Ovates
G
MIS 16/15
MIS 14/13
MIS 12
m OD
40
35
30
25
20
15
10
15
16
High Lodge
13
14
Brandon Fields
Maidscross Hill
Rampart Field
Warren Hill
12
12
Interglacial sediments
Sands and gravels
Sand and silt
Chalk bedrock