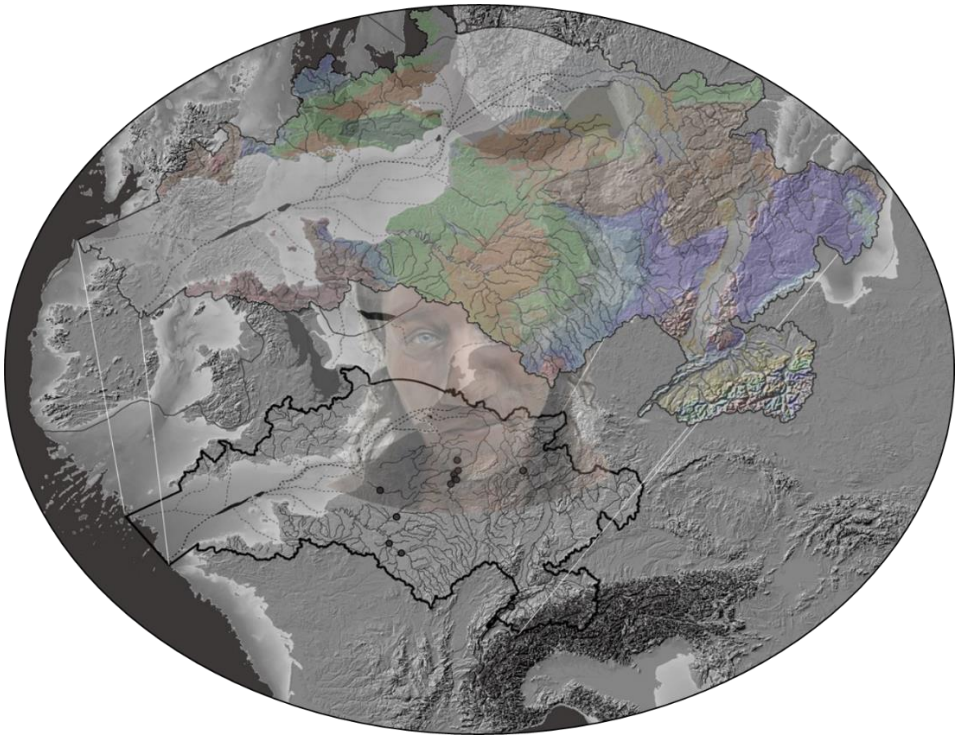
Late Glacial Geography of The Channel River Network. Southeastern England and its Central Position in the British Peninsula and Ties with Northwestern Europe



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Front Cover: Composite map of GIS layers (GEBCO14, EMODnet 2017, OS Topo 50, OneGeology), and model of Cheddar Man (Mesolithic) rendered by Kennis & Kennis Reconstructions features in the Channel 4 television documentary The First Brit: Secrets of the 10,000 Year Old Man © Tom Barnes/Channel 4.

95,008 words

To William Gundry Mills (1942-1987)

and William Gundry Mills (1914-1987)

For their inspiration to learn and explore

Abstract

The subject of this thesis is the Channel River and the initial recolonization of the British peninsula during the Late Glacial, 15 to 12,900 years ago. This period marks the opening of this barren landscape to the first establishment of fauna, vegetation and humans following the Last Glacial Maximum. The Late Glacial is a period punctuated by multiple abrupt climatic fluctuations and environmental transitions. The little-known submerged Channel River, which was the most extensive landscape feature in this region, is here considered as a major pivotal point for human dynamics in southeastern England.

Shifting from cave assemblages located hundreds of kilometres to the west and north of the study region, and focussing on nearly a century of Late Glacial archaeological research, a renewed emphasis is placed on open air-sites in Southeast England building on research commencing in the 1980's, and along the northern tributaries to the Channel River. The thesis combines three themes for the first time in this region: the lithic (stone tool) assemblages, the fluvial record, and prehistoric mobility.

An innovative re-assessment of the lithic assemblages at local, national and Northern European scale is developed as a comparative framework for southern Britain. A compilation of multiple fluvial datasets characterising the Channel River and the regimes of its tributaries is applied to the archaeology record for the first time. By combining these two fields, new mobility and occupation models for the settlement of Southeast England are proposed. A strong connexion with the Channel River and its exceptional resources is highlighted. Cross-Channel links are examined, as is the Channel Estuary, actively flooding this resource rich region with rising sea levels, and rarely integrated in the discussion of Late Glacial archaeology for the region.

This holistic approach to the Late Glacial landscape provides a refreshed framework to assess the lithic assemblages as spatial markers of human activity within a dynamic, evolving landscape. Structured on rare high-resolution sites, multiple scales and resolutions are applied for a broader landscape discussion. This distinguishes the relevance of induvial finds, scatters, and museum archives too often relegated to the back of the archaeological discussion. The outcome is identifying patterns and strategic locations, and developing a framework for future heritage awareness and model building.

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Chapter 1 Introduction: Southeast England and the Late Glacial period

"If a picture is worth a thousand words, a map can be worth a million – but beware. All maps distort reality."

(H.J. de Blij, 1996)

This dissertation examines the archaeological evidence for human activity in northwest Europe during the Late Glacial Interglacial (hereafter LGI) (c. 15000 to 11900 cal BP), with specific reference to Southeast England and the LG Channel River (hereafter Channel River) catchment. The focus is on the influence on human behaviour of evolving river dynamics during this period of transition from fully glacial to interglacial climates and landscapes, and on the concept of 'riverscapes' (Brown 1997). The Palaeo-Rhine and its tributaries are central to this region, and this thesis will focus on its lower course, the Channel River (today submerged by the English Channel), the stretch of the Paleo-Rhine extending from the straights of Dover to the Atlantic (Gibbard 2007a)(Figure 1.2). In particular it examines the central role of the Channel River and its network of important tributaries (Channel River Network, hereafter CRN), and the position of Southeast England within this extensive and dynamic landscape feature. It is proposed that the dynamics of the CRN are a strong factor influencing the location of many of the most important northwest European sites for this period around the main valley. It also proposes the hypothesis that the CRN is a determining factor for LG archaeological distributions in Southeast England.

The Palaeo-Rhine was the largest Late Quaternary landscape feature of northwest Europe when the Channel River segment was active during the LG (Figure 1.2). This river course

flowed throughout the LG for 3000 years into the Early Holocene whilst being gradually submerged by rising sea levels, until its complete submergence linking the English Channel and the North Sea in the Holocene around 6.5 kyr BP (Coles 1998; Ménot *et al.* 2006; Sturt *et al.* 2013; Ward & Larcombe 2008).

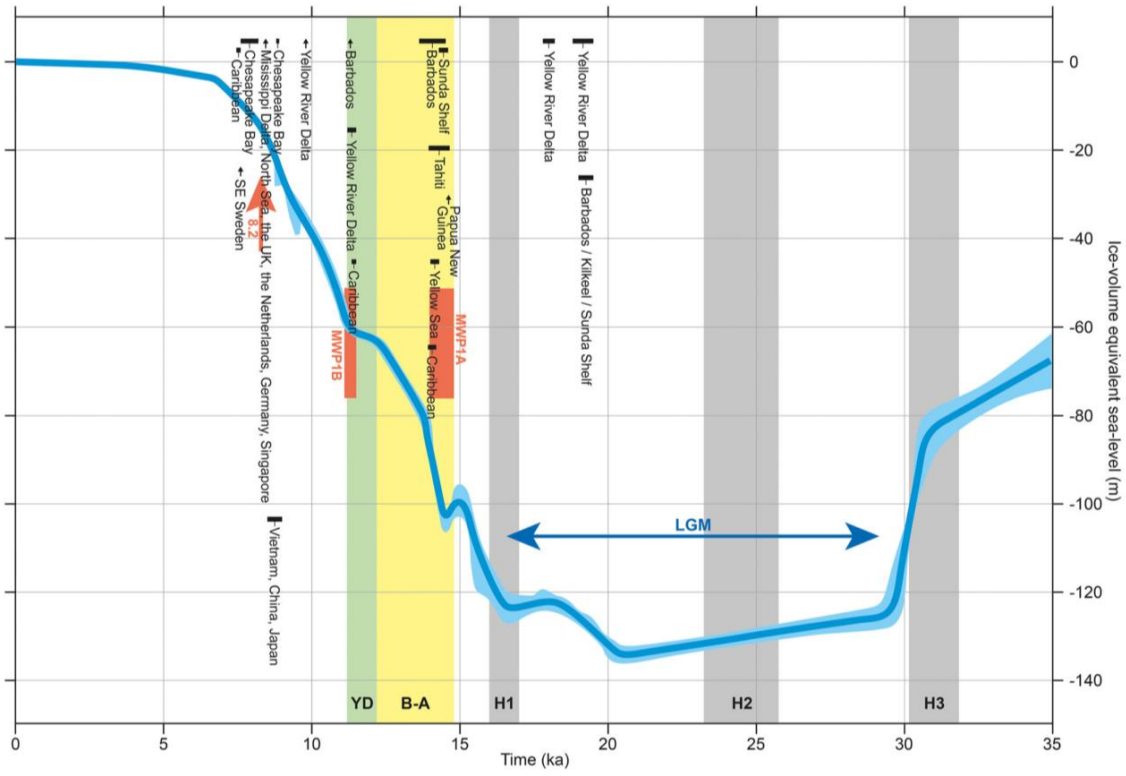


Figure 1.1 Ice-volume Global Mean Sea Level (GMSL) equivalent during the Last Glacial Maximum (LGM) and Lateglacial times (from Lambeck et al., 2014). Shown are major climate events in this period including Heinrich events H1–3, the Bølling–Allerød warm period (B-A), and the Younger Dryas cold period (Y-D) as well as the timing of Melt Water Pulse 1a (MWP1A), 1B, and the 8.2 ka BP cooling events. (Harrison et al. 2019: 5)

Research over the last decade has determined that the Channel River drainage system combines a network of major tributaries (the Palaeo-Rhine, Maas/Meuse, Somme, Seine, Thames and the Palaeo-Solent rivers) flowing through a now submerged landscape (Figure 1.1) (Antoine *et al.* 2003b; Coles 1998). Figure 1.2 shows the extent of the CRN at the onset of the LG period. The main course of the Channel River flowed from east to west, a series of high flow regimes carved out valleys under the influence of Heinrich events (Bond *et al.*

1999; Heinrich 1988; Henry *et al.* 2016; Rasmussen *et al.* 2016) during the Pleistocene, the latest H1 event[1] (Figure 1.1) taking place around 17 kyr BP is related to significant a sea level rise (García-Moreno *et al.* 2019; Harrison *et al.* 2019; Toucanne *et al.* 2010). This is subsequently followed by an intensive glacial meltwater pulse at the onset of the Late Glacial (Figure 1.1), Meltwater Pulse 1a (MP1a), accompanied by another sharp rise in sea levels and impacting the north Atlantic circulation, and considered as a potential trigger for the LG Interstadial (Dutton *et al.* 2015; Harrison *et al.* 2019; Liu *et al.* 2016; Weaver *et al.* 2003). The thesis proposes that the landscape relief created by this major river system would have created axes for animal, vegetation and human movement across northwest Europe during the LG. Although the LG occupations of the British Isles (the northwestern most peninsula of Europe during the Late Glacial) have been the subject of much debate and discussion over the last two decades (Barton & Dumont 2000; Barton 1999a; Barton *et al.* 2003; Charles 1996; Gamble *et al.* 2004; 2005; 2006; Hewitt 1999; Housley *et al.* 1997; Jacobi & Higham 2011a), this dissertation provides the first study of the spatial distribution of archaeological assemblages in relation to a modelled CRC, with fluvial regimes dynamically structuring the landscape and contrasting (concentrated within specific landscape zones) mobility and resource networks around this attractive major river system.

[1] Several pulses have taken place since the Anglian. However, it is the last series of pulses, notably a significant pulse from around 19 to 17 kyr BP that appear to have been significant in the latest formation of fluvial landforms and submerged topography. These meltwater pulses, creating mega-rivers, are considered to be associated in part with Heinrich events (warming events). The Heinrich events are recorded as debris deposits in the North Atlantic, transported by icebergs at the tail end of these warming episodes. The warming and calving of the icebergs, and associated intense melting of the glaciers, would therefore precede the recorded tail of the Heinrich Event.

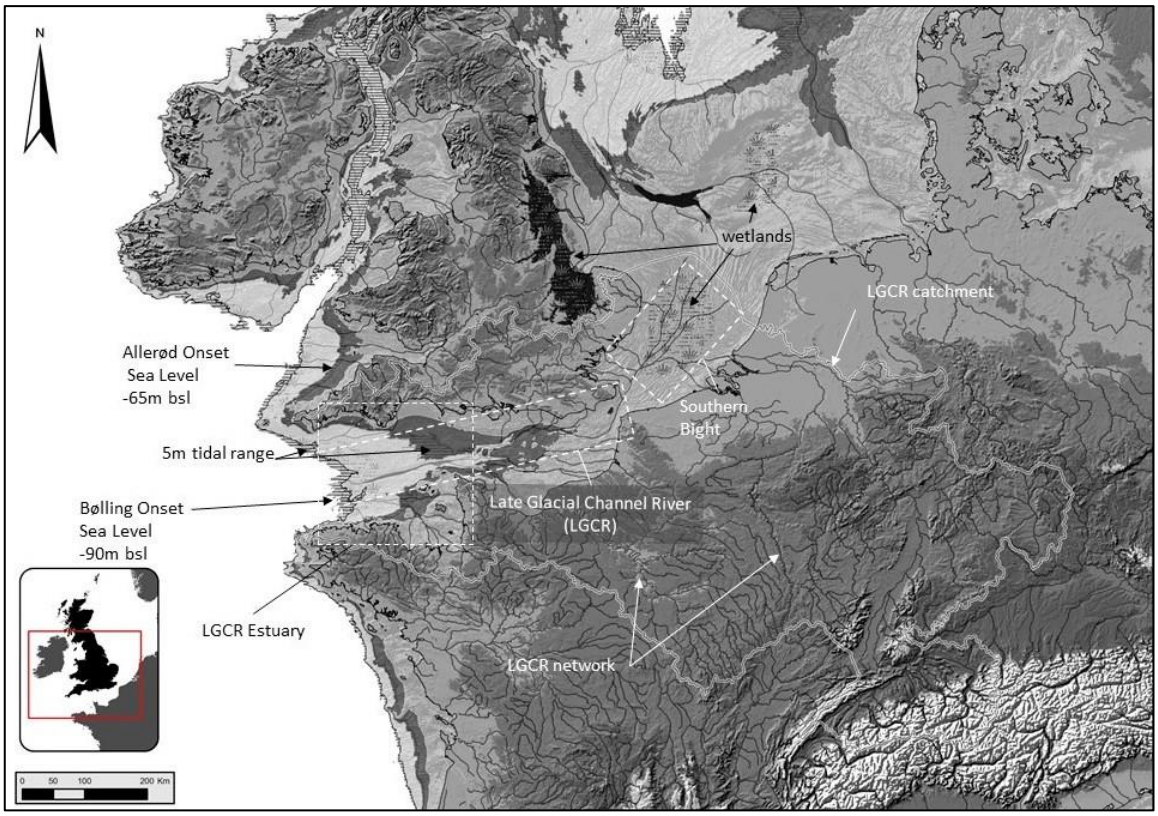


Figure 1.2 The Channel River Network (CRN) catchment. (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

A part of the dissertation is a detailed case study LG open-air sites and land-use patterns in the River Wey-Mole and Avon catchment, in Southeast England. This is a well-defined geographic region which comprises one of the largest - but least well known - concentrations of open-air LG sites and find-spots in southern England. Figure 1.3 shows the area of the catchment, which drains parts of the counties of Hampshire, Surrey, and West Sussex. The research uses a Geographic Information System (GIS) to collate and examine recently available archaeological datasets of the region. It also tests whether there is a bias in the collection and development of these datasets, by cross-referencing multiple datasets. A new techno-typological analysis of lithics undertaken for the dissertation is used for the analysis of the existing archaeological data in the UK and across NW Europe. The new research also integrates location, chronology, content of

museum collections, and the context of collection along the Wey-Mole and Avon catchment. Multiple related environmental datasets are also cross-referenced within the GIS package including spatial, geomorphological, sedimentary, and palaeolandscape data. This has the benefit of bringing together various current datasets at different scales of analysis and helps to contextualise the archaeological locations within a high mobility framework. This is the first time that such a study is applied to the LG of Britain.

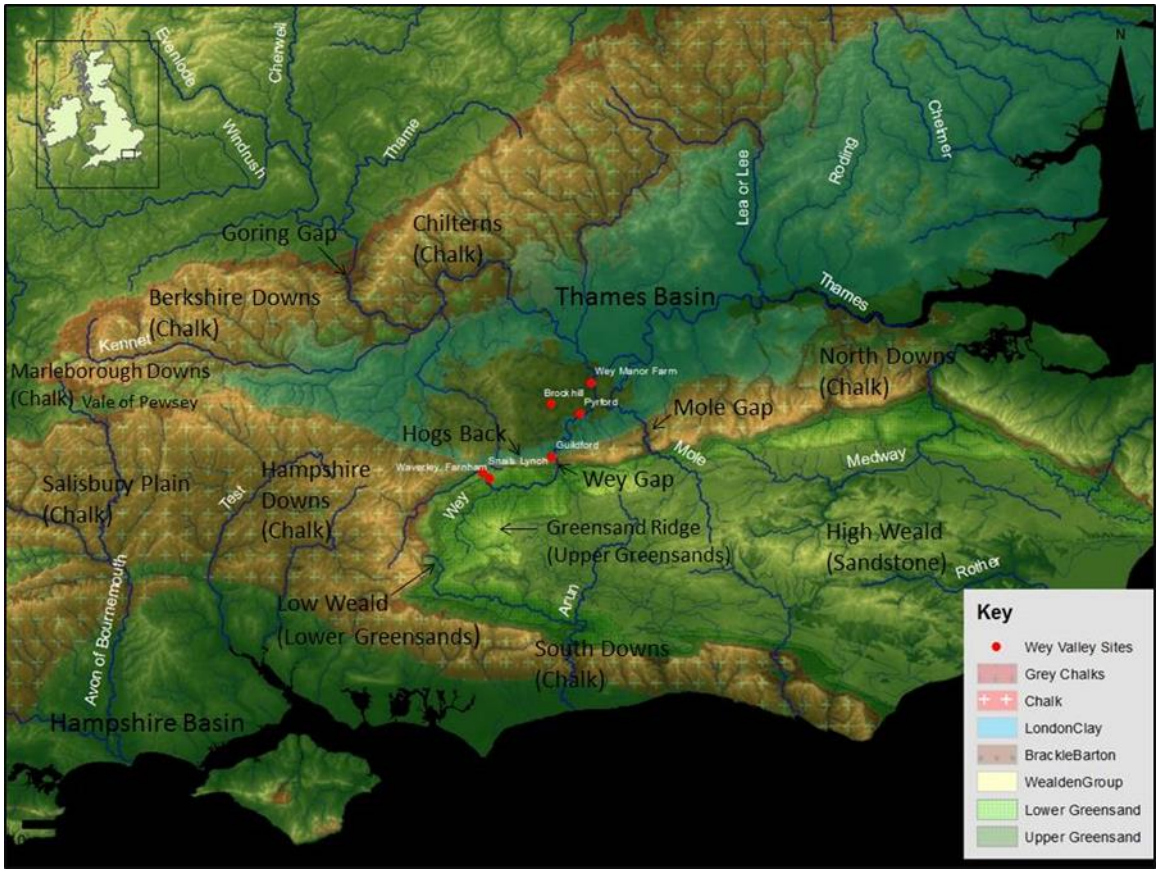


Figure 1.3 Landforms of Southeast England and the extent of the study area

This regional case study is also used to consider afresh the hypothesis that the rivers of England became increasingly important as axes of movement for human groups as Britain became progressively more wooded (section 1.1.1) during the LG (Barton 2010; Jacobi & Higham 2011a; Parker 1995; Parker & Goudie 2007; Simmonds 2017)(Figure 1.3). These

suggestions were presented in relation to the discussion of the processes involved in the re-colonisation of Britain following the Last Glacial Maximum (hereafter LGM). Although they have gained traction they are based on little site-based evidence and need further testing. In the thesis the question is considered from a landscape perspective by comparing the distribution of LG sites and land-use across different scales. The GIS is used to assess whether there is any discernible change in land-use patterning through time and if this could be explained by physical changes in the landscape or by other factors such as site function and migration dynamics.

1.1 Palaeoenvironment and climatic context for the thesis

The thesis uses a combination of event stratigraphy (Lowe *et al.* 2008; Rasmussen *et al.* 2014; Walker *et al.* 2001) with correlations to Greenland ice cores (Rasmussen *et al.* 2014; Seierstad *et al.* 2005; 2014) supra-regional variations and biostratigraphic references for more localised variations (Walker *et al.* 1993; 1994; 2012; Walker & Lowe 2017) as the chronological and palaeoenvironmental framework. The climatic period considered in the thesis is the LG Interstadial (hereafter LGI; c. 15-12.9 cal BP[2]), a period of c. 2000 years marked by an initial abrupt warming followed by a relatively warm but cooling trend with periodic strong cooler to cold climatic fluctuations (Walker *et al.* 2012). The description of juxtaposing periods preceding and following the LGI (GS-2a and GS-1 respectively) are succinctly presented to contextualise this period of climatic variation.

[2] I am including a 500 year advance for the Bølling compared to the Greenland ice core record and a synchronisation of records towards the end of the LGI (Atkinson *et al.* 1987; Walker *et al.* 2003)

The LG succeeded the LGM that lasted from c. 27-15 ka cal BP (Clark *et al.* 2012; Rasmussen *et al.* 2014; Toucanne *et al.* 2010) and included the period of maximum ice cover in north-western Europe and North America which rendered much of the landmass inaccessible to humans or animals. Following a general thawing of the British-Scandinavian ice sheets (which began around 19 ka cal BP), there resulted pulses of high energy river flows creating 'mega-rivers' and the scouring of deep river valleys in Northwest Europe (Gibbard 2007a; Gupta *et al.* 2017). Britain is considered to have been mainly unoccupied during the LGM due to the harsh climatic conditions of the period, although there may be evidence for occasional forays into the region (Jacobi 2004).

After the LGM the dynamic recolonisation of newly exposed regions by animals, humans and plants appears to be related to an abrupt switch to warmer conditions from around 16 ka cal BP (Gamble *et al.* 2006; Housley *et al.* 1997; Jacobi & Higham 2011a). The LG Interstadial period ended abruptly with a rapid return to cold condition during the Younger Dryas (12.5-11.5 cal BP).

The LGI provides an ideal context for studying human responses to climate change as it has been the subject of international research on rapid climate change events for over two decades (Björck *et al.* 1998; Blockley *et al.* 2006; 2012; 2014; Lowe *et al.* 2008; Lowe & Walker 2014; Walker *et al.* 1999; 2001). This includes the availability of high resolution palaeoclimatic proxy data from the Greenland ice core projects (GRIP and NGRIP) combined to create a composite GICC05 curve for the LG (Lowe *et al.* 2008; Rasmussen *et al.* 2014; Seierstad *et al.* 2005; 2014; Walker *et al.* 1999), North Atlantic Marine cores (Blockley *et al.* 2012; 2014), lake varves (Blockley *et al.* 2008; Heiri *et al.* 2011; Lane *et al.*

2011; Litt *et al.* 2009; Lotter *et al.* 2000; 2012; Lowe *et al.* 2008; Magny *et al.* 2003; van Raden *et al.* 2013), advances in direct radiocarbon dating of LG archaeological contexts (Higham *et al.* 2006; Jacobi *et al.* 2009; 2006; Riede *et al.* 2011; Riede & Edinborough 2012), and paleoenvironmental investigation (Antoine *et al.* 2007; Atkinson *et al.* 1987; Baales & Street 1996; Birks & Birks 2014; Bos *et al.* 2017; Coope & Lemdahl 1995; Crombé & Robinson 2017; de Klerk 2004; Debout *et al.* 2014, 201; Derese *et al.* 2012; Heiri *et al.* 2011; Hoek *et al.* 2017; Huntley 1983; Kasse *et al.* 2005; Leesch *et al.* 2012; Limondin-Lozouet & Preece 2014; Litt *et al.* 2001; Lotter *et al.* 1997; Lowe *et al.* 2008; Magny 2013; Mangerud *et al.* 1974; Mortensen *et al.* 2014a; Pastre *et al.* 2000; 2000; van Geel 1996; Walker *et al.* 2012). These provide rich sources of contextual data for the dissertation research.

In the thesis the complex palaeoenvironmental oscillations of the LG Interstadial are referred to on a regional scale using the event stratigraphy terminology developed over the past 25 years by the INTIMATE network (INTegration of Ice-core, MArine, and TErrestrial palaeoclimate records) (Björck *et al.* 1998; Blockley *et al.* 2012; 2014; 2007; Lowe *et al.* 1999; 2008; Rasmussen *et al.* 2014; Walker *et al.* 1999; 2001). The event stratigraphy is based on ice-core annual layers and oxygen isotope records from the Greenland Ice Core Project (GRIP) and North Greenland Ice Core Project (NGRIP) (Björck *et al.* 1998; Blockley *et al.* 2014; Lane *et al.* 2011; Lowe *et al.* 1999; 2008; Rasmussen *et al.* 2014; Seierstad *et al.* 2005; 2014; Walker *et al.* 1999; 2001) correlated with evidence from other proxy data and scientific dating methods (Björck *et al.* 1998; Lowe *et al.* 2008; Rasmussen *et al.* 2014; Walker *et al.* 2012). The event stratigraphy demonstrates short term 'events' present as signatures within the stratigraphy that can be correlated over

large regions (Walker *et al.* 1999, 1145). For the LG the most pronounced climatic event markers are oxygen isotope signatures from marine cores and the presence of tephra (microscopic ash from volcanic eruptions), both of which are calibrated using the higher resolution ice-core data. The 'events' are therefore temporal divisions based on the ice-core counts and are represented as Greenland Stadials/Interstadials (e.g. GS-1/GI-1) and sub-Stadials/ Interstadials (e.g. GI-1e) (Blockley *et al.* 2006; Housley *et al.* 2012; Walker *et al.* 1999).

The regional event stratigraphy based on annual counts of ice-core rings is complemented by the earlier, and often confusing, bio-stratigraphic chronologies (Björck *et al.* 1998; Lowe *et al.* 2008; Rasmussen *et al.* 2014). During the 20th century, the climatic oscillations of the LG were initially described in relation to bio-chronological, climatic, and palaeoenvironmental periods, most of these based on stratigraphic and pollen sequences and biozones recorded around the Baltic Sea (Anderson *et al.* 2007; de Klerk 2004). Over time these bio-stratigraphic periods were repeatedly re-evaluated due to the development of the field and to an increased understanding of the intricacies of the oscillations. This led to a hybrid use of the initial pollen and botanical zones as climatic proxies as chrons or chronozones (Mangerud *et al.* 1974; Walker *et al.* 1999). Although these bio-chronological terminologies based on local resolution are still in common use over smaller areas they are inadequate when trying to relate sites and technocomplexes over an extensive region (Lowe *et al.* 2008).

This thesis follows current recommended practice and uses the event stratigraphy when discussing large regions or precise dating, and earlier bio-stratigraphic terminology on a

local scale where it is available. Table 1-1 summarises the equivalencies between the major LG chronozones, ice core event stratigraphy and regional palaeoenvironmental trends.

Table 1-1 Equivalence of chronozones (Mangerud et al. 1974) to environments (Lowe et al. 2008, Bohncke 1996) and ice-core dating (Rasmussen et al. 2014). There is a probable lag between the recording of the onset of the Bølling warming in Britain and it being signalled in the Greenland Ice Core records, with the Bølling onset in Britain between 16000 and 15500 cal BP, and the two regions falling into phase c. 14000 cal BP until the end of the LG (Blockley et al. 2004; 2006).

Chronozones	GRIP event stratigraphy	GICC05 Ice Core yrs b2k	General Climate and environment
Oldest Dryas	GS-2a	c. 17,480-14,692	Cold/dry/tundra
Meiendorf/Bølling (starting around 15500 cal BP in Britain)	GI-1e	14,692-14,075	Warmest period, open vegetation, increased precipitation, degrading permafrost, pooling, sedges
Older Dryas	GI-1d	14,075-13,954	Cool/dry/park-tundra
Allerød (In phase with GRIP events)	GI-1c-a	13,954-12,896	Warm, wet, cooling towards the end. Increased precipitation, long snow cover, development of open forests, development of soils.
Younger Dryas (In phase with GRIP events)	GS-1	12,896 -11,703	Cold/dry/tundra Arboreal stands along riparian corridors
Pre-Boreal (In phase with GRIP events)	Holocene		Warm, wet, rapid woodland development

There are now several high-resolution palaeoenvironmental sequences providing a good framework for the LG environment in Britain and southern England (Parker 1995; Parker & Goudie 2007; Simmonds 2017; Walker *et al.* 1993; 1999; 2003; 2012). These are mainly based on pollen, coleopteran (beetles) and chironomids (midges) records in association with geoarchaeological information. They include data from the sites of Gransmoor (East Yorkshire), Llanilid (Rhondda Cynon Taf, Wales) and Sluggan Bog (Antrin, Northern Ireland), that can be directly tied into the ice core event stratigraphy (Figure 1.7). The sequences from Elstead, Ockley and Thursley Bogs now represent three of the most valuable vegetation records for southern England (Branch & Green 2004; Macphail &

Scaife 1987; Parker & Goudie 2007; Simmonds 2017). The Belgian and Northern French records (Antoine *et al.* 2000b; Bos *et al.* 2017; 2018; 2001; Crombé & Robinson 2017; Hoek *et al.* 2017; Hoek 2001; Leroyer *et al.* 2014; Limondin-Lozouet 1998; Limondin-Lozouet *et al.* 2002; Pastre *et al.* 2003; Ponel *et al.* 2005) are directly relevant as they are close to southeastern England (the same distance if not closer than many British records). The palaeoenvironmental framework for Southeast England is discussed in further detail in section 1.1.1 and Chapter 6.



Figure 1.4 Analogies for contrasting LG landscape equivalents in the UK. A, the open and treeless environment of Hadangervidda, Norway could be similar to the environment in Denmark during the Bølling period. B. Light, open mountain birch forest (Betula pubescens ssp. czerepanovii) at Ringebu, Norway. Juniper Juniperus communis ssp. nana) and dwarf birch (Betula nana) are seen in the undergrowth. The landscape could be similar to the environment around Hasselø during the second part of the Allerød period. (Photo: Morten Fischer Mortensen). (Mortensen et al. 2014: 178)

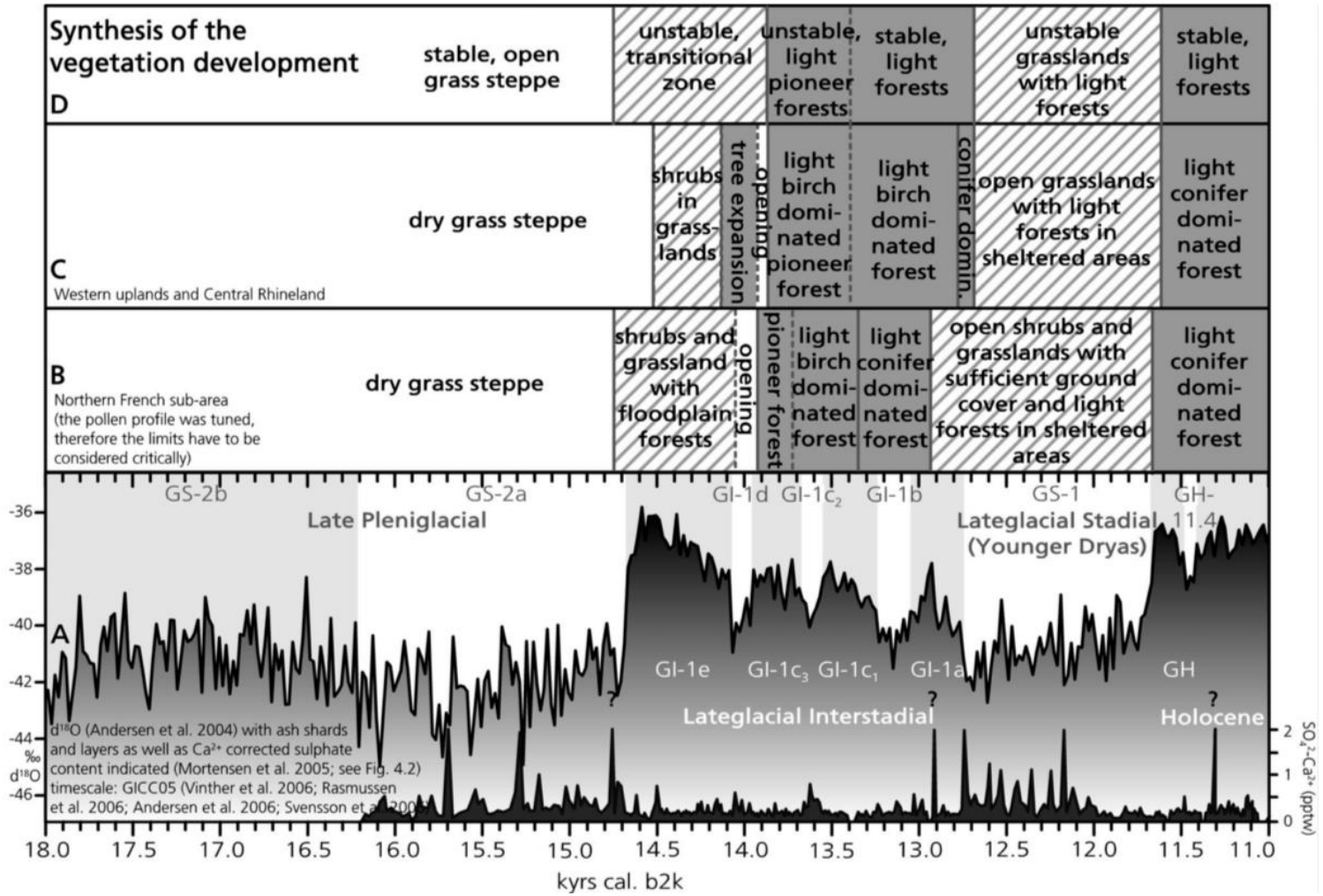


Figure 1.5 Synthesis of vegetation development during the Late Glacial Northern Europe south and east of the Channel River. White backgrounds: cold and open environments; hatched background: transitional environments; grey shaded background: temperate forest (from Grimm 2013: 393)

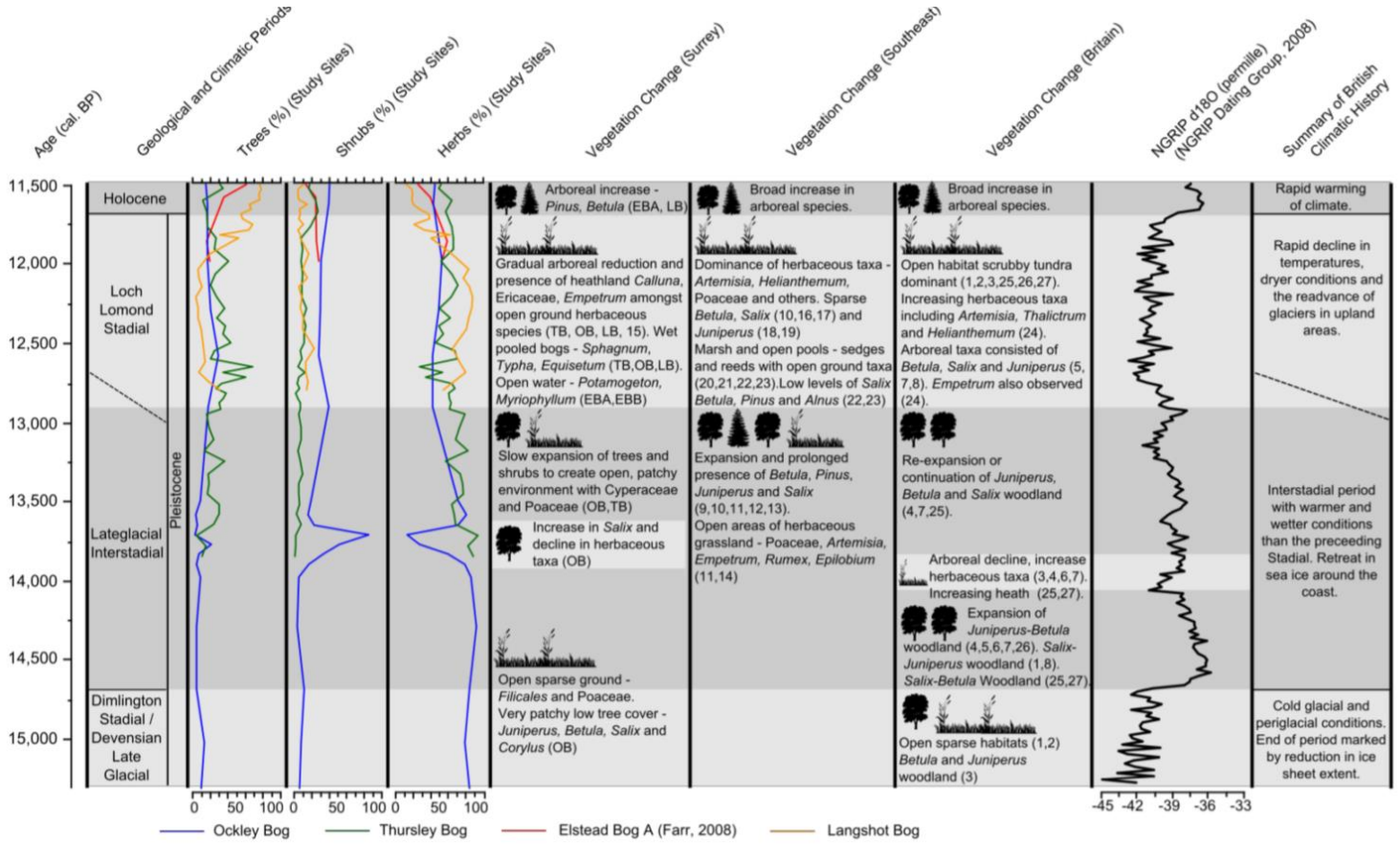


Figure 1.6. *Vegetation and climate synthesis for the Late Glacial in the UK.* *Numbers and abbreviations refer to sites as follows:* ***OB- Ockley Bog****;* ***TB – Thursley Bog****;* ***LB – Langshot Bog****;* ***EBA – Elstead Bog A*** *(Farr, 2009);* ***EBB – Elstead Bog B. 1 - Hallsenna Moor*** *(Walker, 2004); 2 -* ***Gransmoor*** *(Walker et al., 1993); 3 -* ***Llyn Gwernan*** *(Lowe and Lowe, 1989); 4 -* ***Mill House 1*** *(Innes* et al. *2009); 5 -* ***Hockham Mere*** *(Bennett 1983);6 -* ***Church Moss*** *(Hughes* et al. *2000); 7 -* ***Llanilid*** *(Walker et al., 2003); 8 -* ***Finglas River*** *(Turney* et al. *2000); 9 -* ***Minchery Farm*** *(Parker & Preston 2014); 10 -* ***Spartum Fen*** *(Parker and Preston, 2014); 11 -* ***Brook*** *(Kerney et al., 1964); 12 -* ***Rissington*** *(Parker, 2000a); 13 -* ***Church Moor*** *(Parker and Preston, 2014);14 -* ***Sevenoaks*** *(Preece 1994);15 -* ***Bagshot*** *(Groves 2008); 16 -* ***Northmoor*** *(Shotton* et al. *1970); 17 -* ***Standlake*** *(Sandford 1965); 18 -* ***Bramcote Green*** *(Thomas* et al. *1996); Branch and Green, 2004); 19 -* ***Holywell Coombe*** *(Preece and Bridgland, 1999); 20 -* ***West Silvertown*** *(Branch & Lowe 1994); Wilkinson et al., 2000); 21 -* ***Colnbrook, West Drayton*** *(Gibbard and Hall, 1982); 22 -* ***New Ford Road*** *(Corcoran* et al. *2011); 23 -* ***Meridian Point*** *(Corcoran et al.,2011); 24 -* ***The Flasks 69****, (Innes et al., 2009); 25 -* ***Sluggan Bog*** *(Walker et al., 2012); 26 -* ***Tynaspirit Bog*** *(Sutherland* et al. *1993); 27 -* ***Whitrig Bog*** *(Mayle* et al. *1997). (diagram and references from Simmonds 2017: 284)*

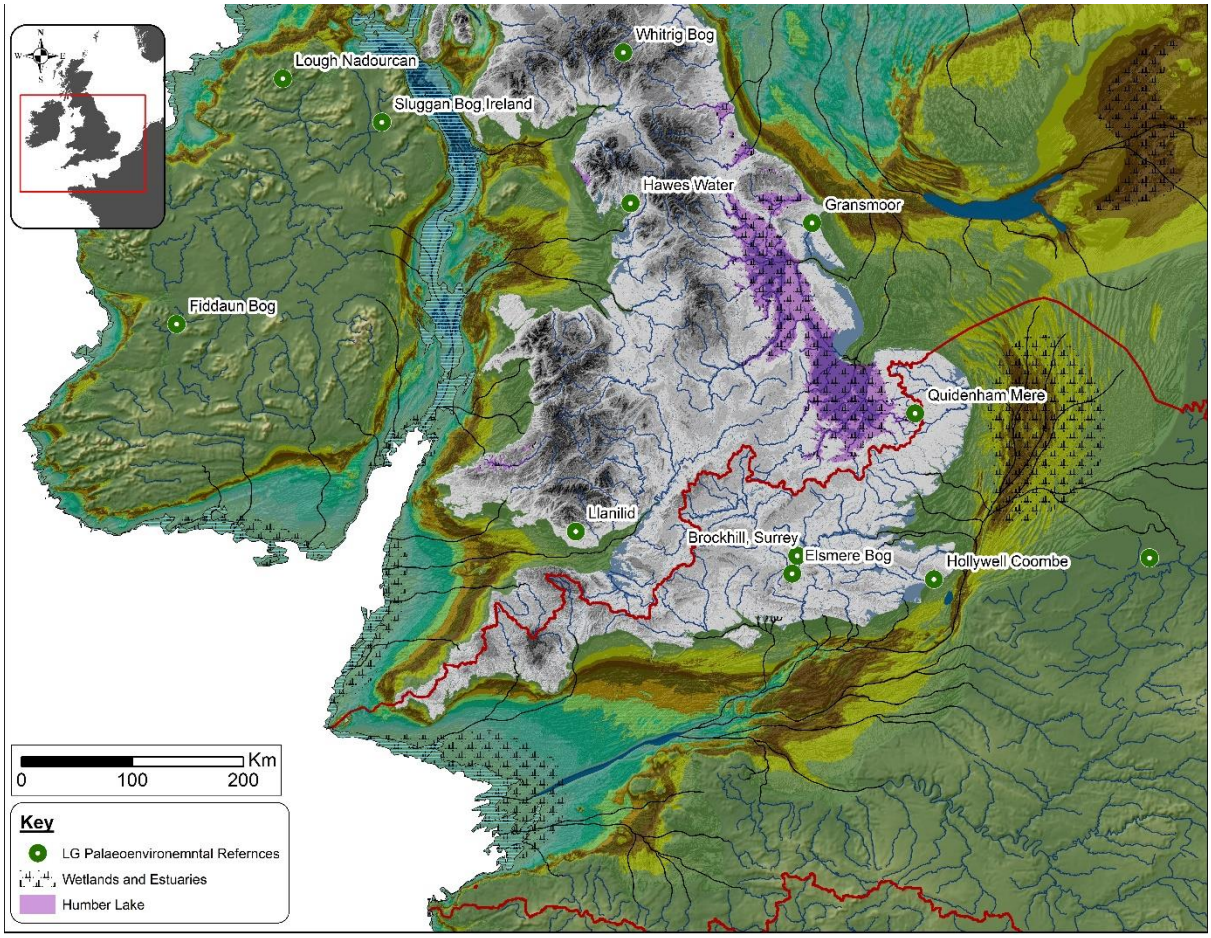


Figure 1.7 Late Glacial palaeoenvironmental reference sites referred to in this chapter. (Source: Author. Basemap modified from OS TOPO 50, GEBCO 2014 elevation and EMODnet17 bathymetry, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

1.1.1 LG open-forests of SE England

The second half of Late Glacial in Northern Europe is marked by the development of open woodland, and a patchy mosaic landscape of woodland and open grasslands areas in southern England (Simmonds 2017). This is accompanied by a transition in faunal records (chapter 6). The ground conditions are marked by discontinuous permafrost during the first half of the LG, with large amounts of meltwater developed during the summer thawing months, most likely a thermokarst like environment with significant ponding on poorly drained bedrock (Figure 1.8) (Bos *et al.* 2006), followed by sporadic permafrost or seasonally

frozen ground during the Allerød (Huijzer & Vandenberghe 1998). The absence of effective precipitation before the onset of the Bølling may have been one of the most limiting factors for the spread of shrubs and trees (Bohncke 1993). The development of vegetation stabilised local sediments and led to the development of soils in the Allerød, which in turn provided stabilisation and reduced runoff leading to the development of meandering mid to lower river courses (chapter 5). This would have had a direct impact on human subsistence, mobility patterns, and made arboreal and significant vegetal resources readily available for the first time following the LGM (chapter 6).

1.1.1.1 The regional LG palaeoenvironmental trend

The general trend for Northern Europe is well represented by numerous directly dated environmental sequences (Figure 1.9) (Lowe & Walker 2000) and chronologically corroborated by direct dating and volcanic ash deposits (tephra and micro tephra) (Blockley *et al.* 2012; Lowe *et al.* 2015). The general trend is described in section 1.1. The focus here is the timing and significance of open woodland development.

The first half of the Bølling is marked by warm summers and cold winters and the development of heliophilous grasslands. Towards the end of the Bølling is the first evidence of birch trees (*Betula pubescens* s.l.) and shrub expansion appearing at the same latitude but immediately east of SE England in the Netherlands (Figure 1.9), and the second half of the Bølling this develops into an open boreal forest (Bohncke 1993). This pattern is also recognised immediately south in Belgium (Crombé & Robinson 2017). After an interruption of woodland expansion during the cold, windy dry phase of the Older Dryas, shrub and woodland expansion resume with the onset of the Allerød. The Allerød was marked by increased precipitation (and probably long lasting winter snowfall) accompanied by the development of juniper and open birch woodland (Bohncke 1993). During the latter phase

of the Bølling there is a dryer, cooler, more continental phase with the expansion of pine, and mixed pine-birch forests (Bohncke 1993). This same woodland development is fossilised at the end of the Allerød by massive ash deposits from the Laacher See eruption in the Rhine, and is compared to open birch-poplar-pine forests found today in Sweden (Baales 2006; Baales *et al.* 2002b). This forestation is accompanied by the development of Allerød palaeosols that are stratigraphic markers in N. Europe (Ussello and Belloy-sur-Somme horizons) (Antoine *et al.* 2012; Fagnart 1988; Kaiser *et al.* 2009; Stapert & Veenstra 1988; van Geel *et al.* 1989), equivalents have been identified in SE England (Kerney *et al.* 1980; Parker & Goudie 2007; Preece & Bridgland 2012). The datasets in Northern France, immediately south of the Channel River, have rich palaeoenvironmental sequences in the Somme Basin and a continuous reference sequence at Conty (Antoine *et al.* 2012; 2003c; Ponel *et al.* 2005). These are the closest southern comparatives to SE England, and indicate a similar environmental pattern (Figure 1.9). Further east the same is recognised in Danish and northern German deposits with macro-organics at a latitude slightly further north of SE England (Figure 1.10) (Krüger *et al.* 2017; Mortensen *et al.* 2014b). Being closer to the Atlantic and the Gulf Stream, slightly wetter and warmer conditions would be expected in Britain, encouraging vegetational development.

A good series of high resolution palaeoenvironmental sequences is available for the Late Glacial in Britain (Figure 1.6). Important sequences covering all of the Late Glacial are found at Llanilid and Sluggan Bog (Walker *et al.* 2003; 2012), and several Allerød sequences in SE England (Parker & Robinson 2003; Parker 1995; Parker & Goudie 2007), complemented by LG reference sections (Figure 1.9). Recently a new series of high resolution continuous sequence macro-organics from covering the LG with Ockley (Figure 1.11) and Thursley Bogs (Figure 1.12) for the onset of the LG and Allerød, and Ealsted Bog B and Langshot for the

Allerød (Simmonds 2017). These sequences have provided direct data for the development of open-birch woodland in SE England and significant willow (*Salix*) and juniper (*Juniperus*) shrub, confirming the presence pine (*Pinus*) at the end of the Allerød and identifying the LG presence of hazel (*Corylus*) and alder (*Alnus*) for the first time in this region (Simmonds 2017). The general sequence of events (Figure 1.6, Figure 1.11, Figure 1.12) corroborates well with sequences in neighbouring regions at the same latitude, as well as east and south of the Channel River as described above. Southeast England had a mosaic vegetation landscape of open woodland (pine, birch, juniper) and areas of open grassland during this phase (Simmonds 2017).

The Bølling and Allerød landscapes would have contrasted strongly in SE England. Following the warm summer marshy/pooling-water grasslands of the Bølling fed by meltwater from the degrading permafrost, the soil stabilisation and development of heath, soils and woodland wood make a remarkable transformation over a few decades to centuries. The presence of open-birch woodland with a developed understorey of shrubs in south to mid England developing throughout the Allerød would be significant for both human and animal populations (Figure 1.10). The 'forest edge' is an important ecotone that is crossed by migrating animals wintering in the woodlands and migrating northwards for summer grass grazing. It is also a biome that invite the presence of beaver and other forms of deers and bovids such as aurochs. For humans living in the region, it provides a new panoply of available resources. There are also challenges with the development of woodland, such as cutting lines of site for mobility, denser understory shrubs, and generally a more dispersed fauna for hunting that is harder to observe. These factors will be developed in Chapter 6.

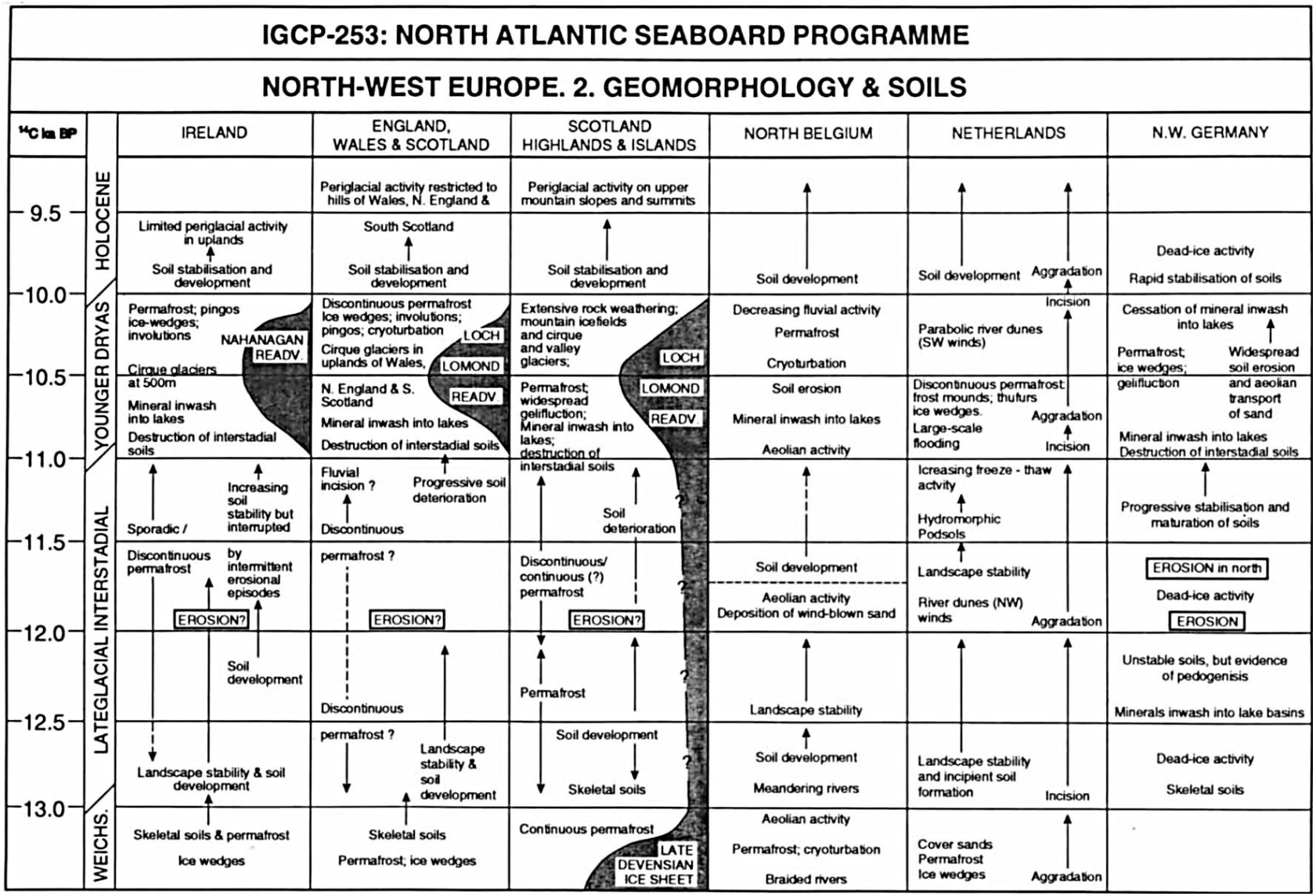


Figure 1.8 Soil conditions north of the 50 degrees latitude. Walker et al. 1994: 112.

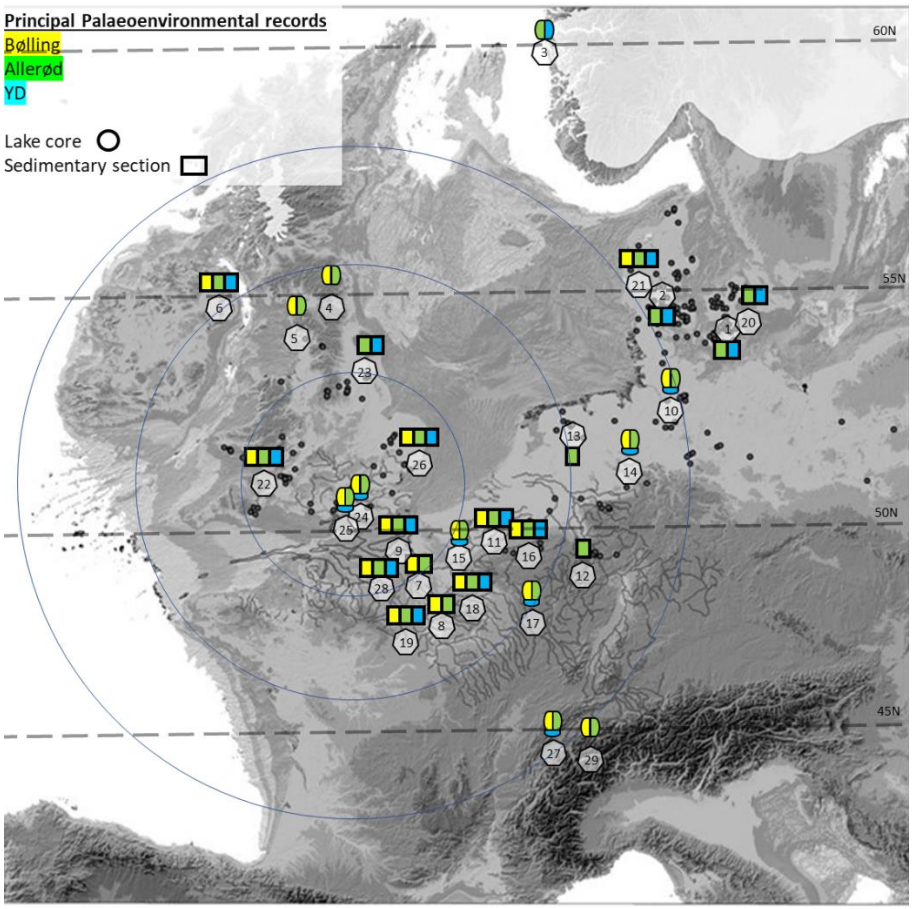


Figure 1.9 Late Glacial palaeoenvironmental sequences referred to in the thesis. 1 - **Slotseng** (Mortensen et al., 2011); 2 - **Hasselo** (Mortensen et al., 2014); 3 - **Kårkenes** (Birks and Birks, 2014); 4 - **Whitrig Bog** (Birks and Birks, 2014); 5 - **Hawes Water** (Birks and Birks, 2014); 6 **- Sluggan Bog** (Walker et al., 2012); 7 - **Conty** (Ponel et al., 2005; Limondin-Lozouet, 2011; Antoine et al., 2007); 8 - **Houdancourt** (Ponel et al., 2005; Limondin-Lozouet, 2011; Antoine et al., 2007); 9 - **Holywell Coombe** (Preece and Bridgland, 1999); 10 - **Nahe Palaeolake** (Krüger *et al.* 2020); 11 - **Moervaart Palaeolake** (Crombé and Robinson, 2017); 12 - **Neuwied Basin Laacher See Ash** (Baales *et al.* 2002b; Birks & Lotter 1994); 13 - **Usselo** (Van Geel et al., 1989); 14 - **Hamelsee** (Krüger *et al.* 2020; Merkt & Müller 1999); 15 - **Scheldt River** (Bogemans, 2011, 2016); 16 - **Dinkel River** (Coversand and Palaeosol sequence) (Hoek and Bohncke, 2001); 17 - **Meerfelt Maars** (Litt *et al.* 2001; 2003; Litt & Stebich 1999); 18 - **Oise Valley** (Limondin-Lozouet 1998; Pastre *et al.* 1997); 19 - **Le Closeau** (Limondin-Lozouet, 1998); 20 - **Allerød** (de Klerk 2004); 21 - **Bøllingsø** (Bennike *et al.* 2004; de Klerk 2004; Iversen 1960); 22 - **Llanilid** (Walker et al., 2003); 23 - **Gransmoor** (Walker et al., 1993); 24 - **Langshot Bog** (Simmonds, 2017); 25 - **Elstead, Thursley and Ockley Bogs** (Simmonds, 2017); 26 - **Sproughton** (Wymer *et al.* 1975); 27 - **Lake Lautrey** (Magny et al., 2006); 28 - **Bazoches** (Leroyer et al., 2014); 29 - **Lake Gerzensee** (Lotter et al., 2000, 2012). (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, rivers European Environmental Agency, projected in ArcGIS 10.6.1).

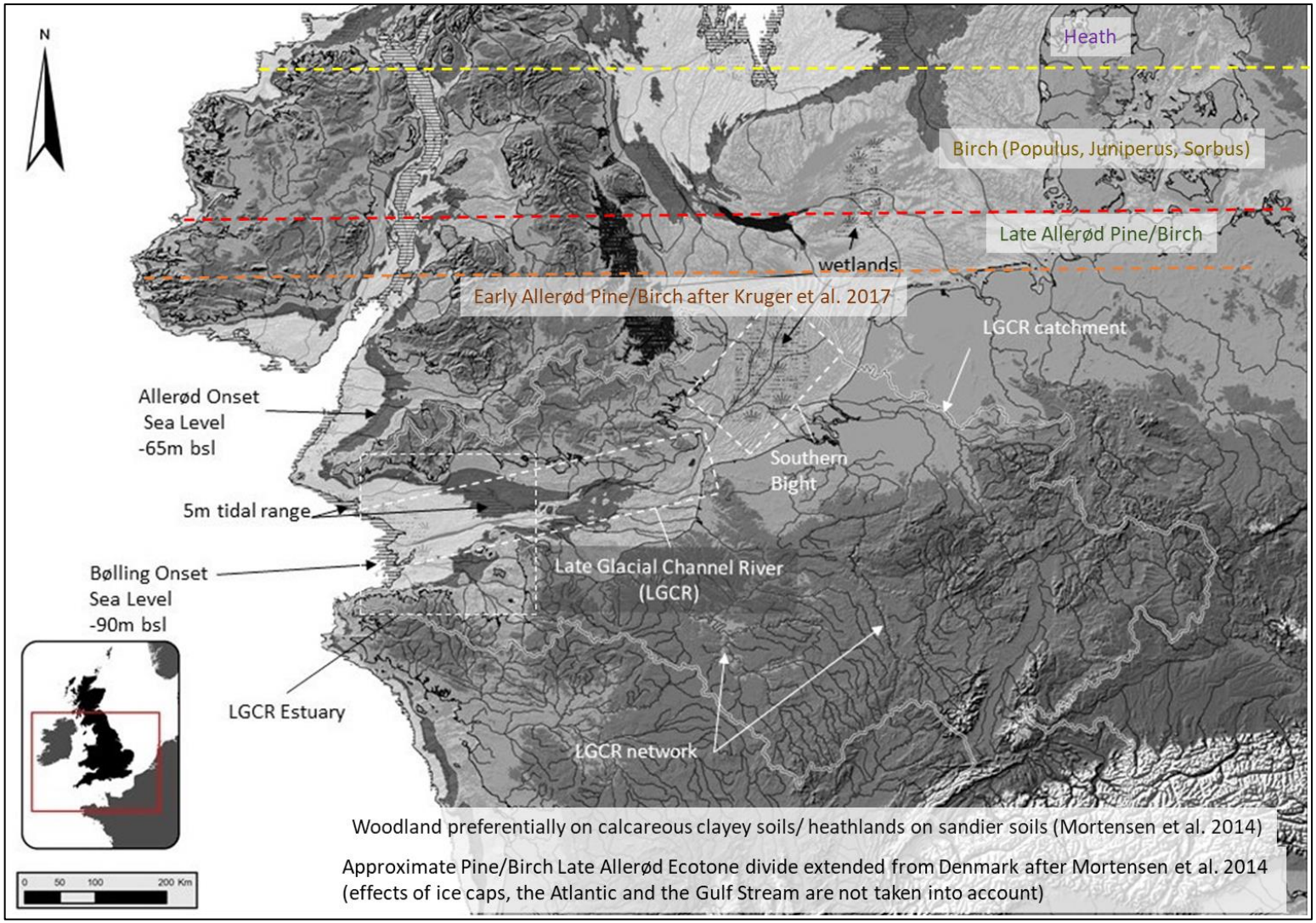


Figure 1.10 Estimation of Late Allerød open woodland extent north of the 50th longitude based on Danish (Mortenson et al. 2014) and Northern German (Kruger et al. 2020) palaeoenvironmental reconstructions. The humid and warming impact of the Atlantic and Gulf stream are not taken into account, these could curve the western prediction lines northwards. (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

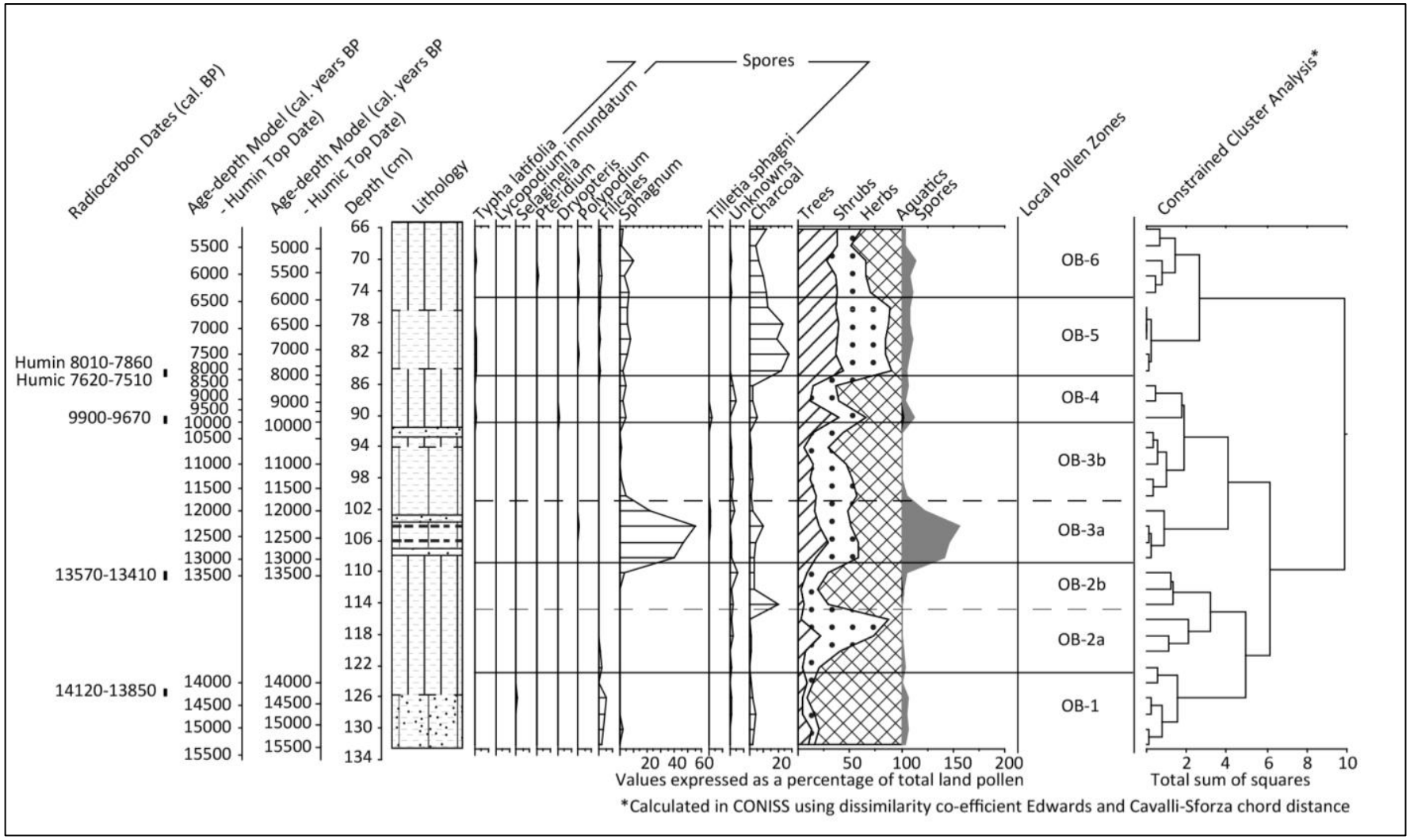


Figure 1.11 Pollen sequence from Ockley Bog indicating a sharp rise in arboreal pollen during the Allerød (Simmonds 2017: 234)

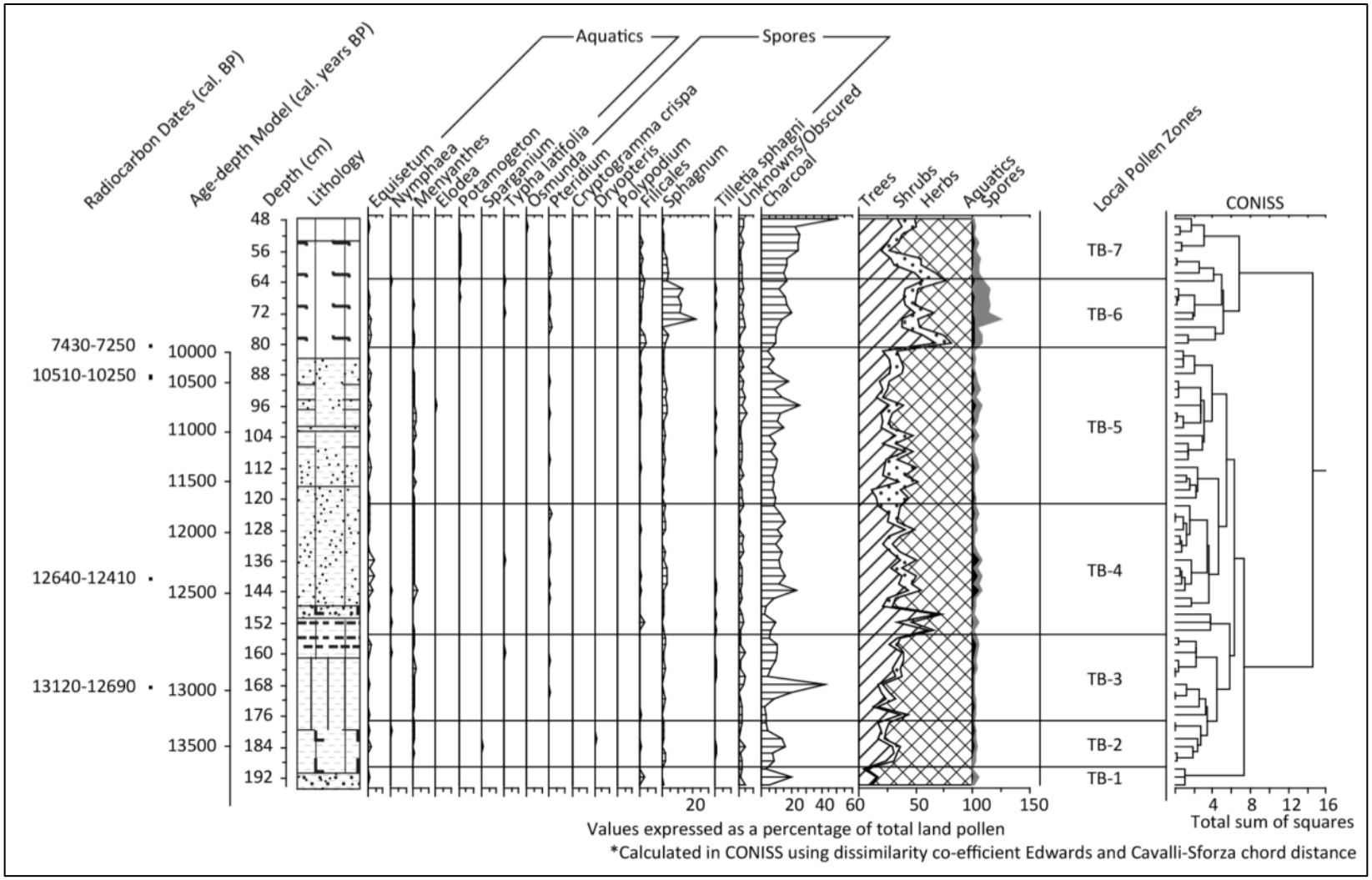


Figure 1.12 Pollen sequence from Thursley Bog indicating a sharp rise in arboreal pollen during the Allerød (Simmonds 2017: 224)

1.2 Chronological context for the thesis

Recent radiocarbon dating programs have demonstrated that there were several phases of occupation in Britain during the LG (Barton & Roberts 1996b; Jacobi & Higham 2011a; 2009a). The current interpretation being that the pulses of human migration roughly coincided with environmental fluctuations (Barton 2010; Conneller 2007; Gamble *et al.* 2006; Jacobi & Higham 2011a; 2009a). However, these dating programmes involved mainly material from cave sites, where organic materials were preserved, and not the growing number of open-air sites and find-spots where organic preservation is poor at best. These open-air sites and find spots are usually attributed to the LG on the basis of techno-typological characteristics of lithic artefacts. These British artefacts and assemblages can be broadly sub-divided into four technocomplexes: the Creswellian, a poorly understood Azilian/early Federmesser transition, Federmesser-type, and Long-Blade/Ahrensburgian (Barton *et al.* 1992; 2009; Barton 2009; 2010; Conneller & Ellis 2007). All of the dates in the thesis have been calibrated using the latest version of OxCal (v. 4.4.2 Bronk Ramsey 2020) against the most recent IntCal20 curve (Figure 1.14) (Reimer et al. 2020), plotted against the GICC05 curve (Figure 1.13). The current calibration curve has significant plateaus in the LG (Figure 1.13). The chronology and dating of the British and Northwest European lithic technocomplexes during the LG Interstadial is discussed in detail in Chapters 3 and 4.

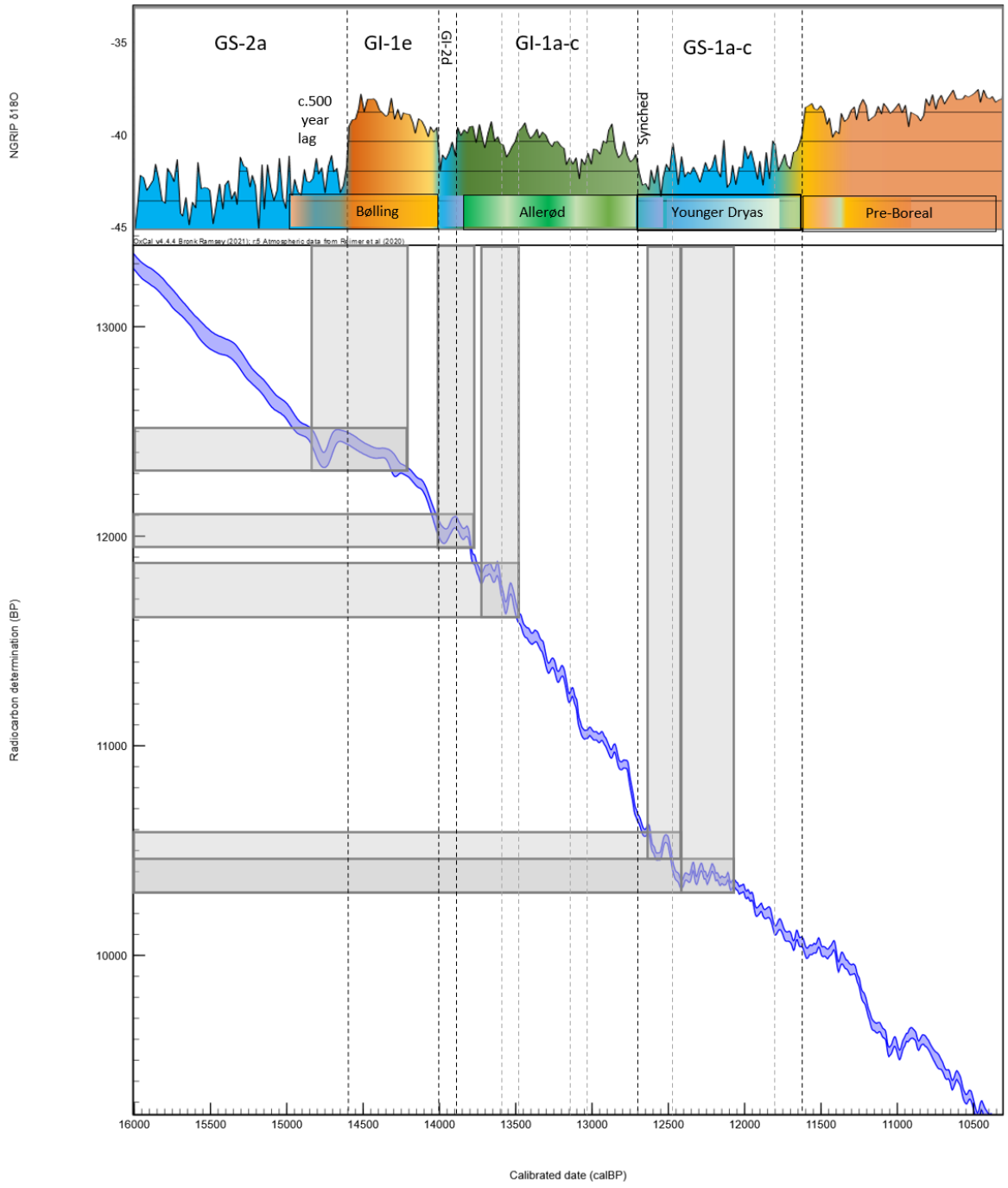


Figure 1.13 *IntCal20 radiocarbon curve (Reimer et al. 2020) projected using OxCal 4.4 (Bronk Ramsey 2021), GICC05 curve (Andersen et al. 2006), areas in grey are "plateaus" where calibrated dates will have a greater spread and lower precision. (Source: Author).*

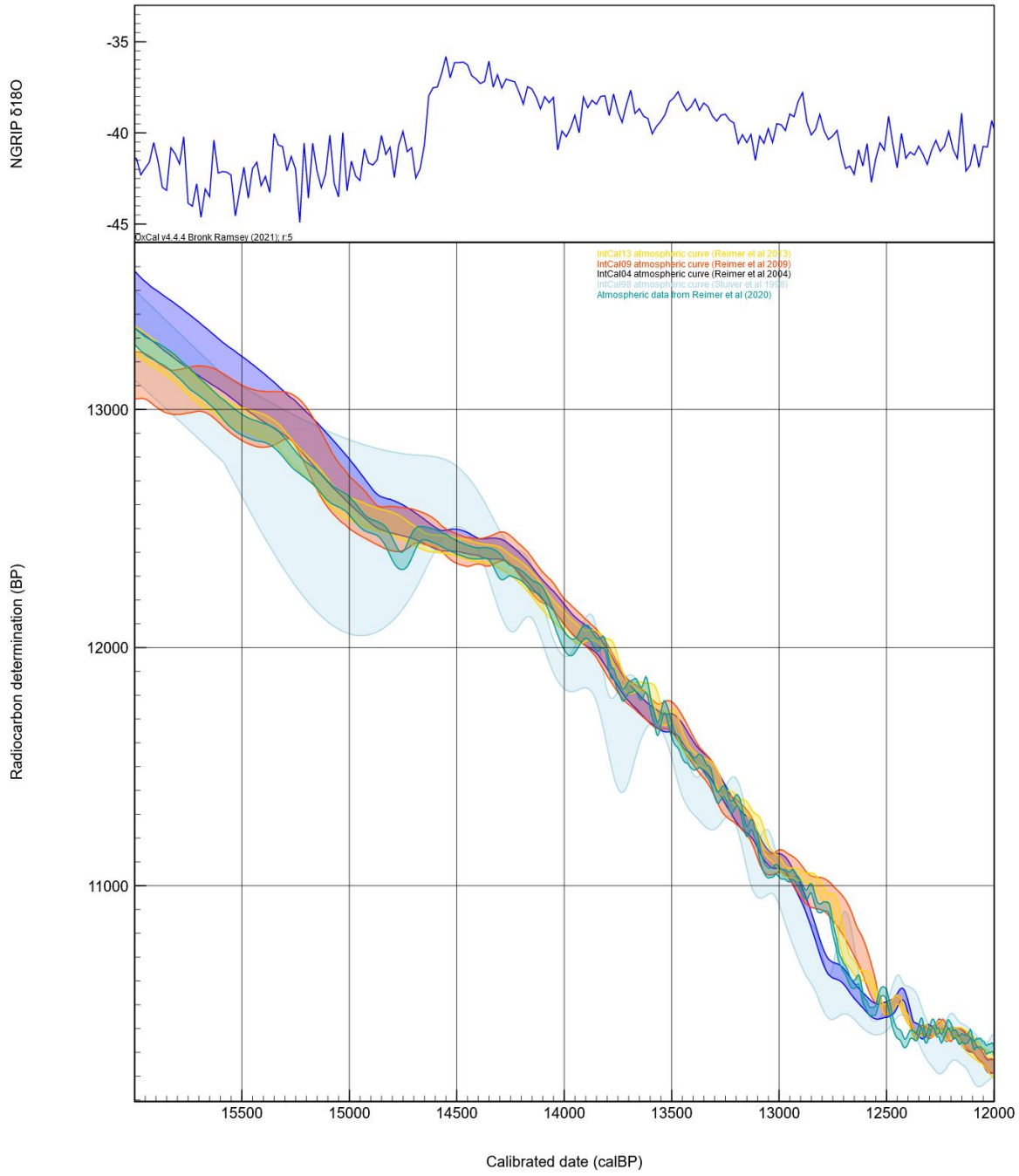


Figure 1.14 Developments in the calibration curve for the Late Glacial, IntCal98 (light blue), 04 (dark blue), 09 (red), 13 (orange) and 20 (green blue). Significant progress has been made on the calibration curve, with the biggest step between IntCal98 and IntCal04. From IntCal 04 to IntCal20, the two areas with the most important change are relatively regular: the end of the LGM (GS-2a) now provides slightly older date and the transition from GI-1a to GS-1 is much more precise. A significant wiggle has appeared with IntCal20 at the onset of GI-1e. Some wiggles and plateaus are persistent and others amplified with IntCal20 (due to its higher precision, thinness) for the Late Glacial, notably at the transition and first half of GS-2a to GI-1e, and as series of wiggles and smaller plateaus at the transition from GI-1d to 1c. (IntCal20: Reimer et al. 2020; projected with OxCal 4.4 Bronk Ramsey et al. 2021) (Source: Author).

1.3 Geographic and Geological Context for the thesis

The geographic focus of this study is Southeast England and its position within the Channel River catchment. For the thesis the term Southeast England is used to refer to the area of Surrey, East and West Sussex, Hampshire, Kent and some adjacent parts of Metropolitan London. The region is bounded to the north by the Thames and to the west by the Solent and Avon. This term is used in preference to that of South East England, the modern official region that also includes the modern counties of Hampshire, the Isle of Wight, Berkshire, Buckinghamshire and Oxfordshire, and which does not include parts of Southeast London. Figure 1.3 shows the landforms of Southeast England and the extent of the study area.

Chalk bedrock is one of the principal features of Southeast England (Hopson 2005). The Cretaceous Chalk deposits of the region have recently been redefined due in large part to work carried out in relation of the construction of the Channel Tunnel in the late 1980s and early 1990s (Mortimore 2012; Warren *et al.* 1996; Warren & Mortimore 2003). This work has also allowed the correlation of the English deposits with Northern European Cretaceous Chalk sequences (Mortimore & Pomerol 1987; 1998; Mortimore 2011). The region's topography is dominated by two east-west oriented chalk/limestone folds produced by the Alpine orogenesis[3], that are known as the South and North Downs. They are defined by a scarp facing the Weald, an anticline[4] with a central eroded region of exposed Tertiary bedrock, which is dominated by Tertiary Gault Clay and sandy deposits (BGS 1992; Evans *et al.* 2013; Goudie 1993; Grapes 2008; Woods *et al.* 2001). As the

[3] Geological processes related to mountain range formation.
[4] A convex upward fold in layers of rock.

exposed Tertiary bedrock is mostly well-drained, the impervious clay beds play a major role in the evolution and location of river and tributary sources fed by local aquifers, and on the location of ground water sources, wetlands and the availability of freshwater throughout the region. When found in elevation the well-drained Tertiary deposits appear to be closely associated with LG human activity, possibly due to the combination of elevation, visibility and the well-drained nature of the bedrock (see Chapter 7).

These Chalk deposits represent the highest elevations of the study area. In addition, the courses of most rivers flowing through the Weald traverse these Tertiary deposits, creating significant river cuttings or "Gaps". A major fault-feature along the northwestern boundary of the North Downs is known as the Hog's Back (Lake & Shephard-Thorn 1985). Both the Rivers Wey and Mole traverse, with "Gaps", this dramatic topographic feature that has strong scarp inclines as well as extensive visibility over both the Weald and London Basin.

The Chalk deposits are also the probable source of the flint used by people in the region during the LG. Flint nodules could be obtained both from primary deposits in the Chalk bedrock, or from secondary sources redeposited in scarps or along river beds. Along the abrupt scarp facing the Weald erosion processes have created scree taluses and exposed cliff lines, notably in the "Gaps". This can in some parts expose horizons rich in high quality flint. The identification of accessible sources of flint is of prime interest for understanding human mobility and resource management during this period (Barton 2010; Pettitt *et al.* 2012; Rockman 2003a; Topping 2004) (see Chapter 6).

The north of the study area is delimited by the west to east flowing River Thames. The landscape south of the Thames is marked by river systems flowing from south to north into the Thames (e.g. the Rivers Mole and Wey) and from north to south into the Channel River (e.g. the Rivers Avon and Test). At the western and southern extents of the study area, this trend gradually changes to a west to east orientation (e.g. the Rivers Stour and Frome in the Hampshire basin). All the river valleys are in-filled with Pleistocene and Holocene alluvial deposits. The relationship of the study area with the adjacent regions of the Thames Basin and the Hampshire Basis is discussed in Chapter 5.

Sections of the southern coastline such as the chalk cliffs where The Downs meet The English Channel and the sandstone cliffs around Hengistbury Head have receded substantially over the last 7000 years of maritime erosion and do not represent the LG topographic setting (Goudie & Brunsden 1994; Sturt *et al.* 2013). This was also the case for preceding interstadials as found as fossil cliff lines during periods of high sea levels along the south coast, notable at places such as Langstone and Chichester Harbour (Allen & Gardiner 2000; Bates *et al.* 2007; Blundell 2017). These would have combined to create a dramatic landscape overlooking the Chanel River. The relationship of the study area to the English Channel region and the LG landscape is discussed in Chapter 5.

1.4 Structure of the thesis

Chapter 1 introduces the thesis, including the palaeoenvironmental, chronological and geographic context for the work. **Chapter 2** discusses the methods used, including critically assessing the major datasets used in the research, the GIS modelling and basemaps developed, and lithic analyses undertaken.

The four major lines of research analysis are presented in **Chapters 3-7.**

First, the chronology and composition of the Northwest European LG lithic technocomplexes is reviewed in **Chapter 3** with specific reference to existing paleoenvironmental and chronostratigraphic data. A focus is placed on variation within the tool types and technological features used to define these technocomplexes. This overview provides a summary of current research on the diachronic and synchronic variation in lithic industries across Northwest Europe during the LG and allows the British industries to be discussed within a broader regional context.

Second, the archaeological evidence for LG human activity in England is reviewed in **Chapter 4**, especially with regard to the concept of 'reference sites' and the ability to correlate the British data with that of Northwest Europe. The existing datasets for the English lithic artefacts and assemblages are assessed, and proposals are made for methods of using these in a systematic manner. The concept of reference sites was developed as part of this work and involves the merging of key data about sites concerning taphonomy, location, dating, refitting analysis, and techno-typological resolutions in order to provide a means for understanding variation and patterning among lithic assemblages during this period.

Third, a Geographic Information System (GIS) was used to represent the site distribution in relation to Northwest Europe and enable the modelling of LG river systems in the region integrating a high resolution palaeoclimatic and chronological framework. The aim

is to provide an understanding of the changing geographical diversity of the Northwest European rivers during the period and consider how this might have affected human activity. **Chapter 5** presents the GIS landscape models and considers the Channel River system during the LG with regard to factors such as: river flow and sedimentation dynamics; the effects of sea-level change on river course; archaeological taphonomic contexts; and the interpretation of site locations. It also considers LG river networks as poles of attraction for resources (migrating animals, fish and riparian vegetation), as seasonally dynamic entities (e.g. water flow-freezing and break-up), and their role in human mobility in linking or separating region, and as maps.

Fourth, archaeological spatial records from Southeast England and surrounding regions are collated within the GIS as a framework for the interpretation of spatial relationships and distribution patterns within the Channel River catchment. **Chapter 6** examines multiple lines of evidence for landscape and LG mobility based on archeologically evidence, and modern, historic, arctic and boreal analogies. These aspects include: the fluvial sedimentary setting of occupation and subsistence activity; concepts of seasonality; mobility systems and distances covered in these environments.

Chapter 7 collates archaeological spatial records from Southeast England and surrounding regions are collated within the GIS as a modular framework for the interpretation of spatial relationships and distribution patterns within the Channel River catchment at different scales. **Chapter 7** discusses the results of this analysis with regard to the landscape during Greenland Interstadial 1 a–e (13.5–11.5 years ago) (Antoine *et al.* 2003c; Derese *et al.* 2012). The archaeological focus is on the Paris Basin and Somme

Valley (France), the Campine region (Belgium), the Neuwied Valley (Germany), the Dutch Coversands, and southern England. The chapter also presents the results of the major case study on the LG archaeology of the fluvial system of the Rivers Wey-Mole and Avon, tributaries of the Thames and Solent respectively, in relation to the wider Channel River network. This is the first integrative investigation of LG lithic assemblages from these areas that considers the Channel River system as physically connecting Northern European populations following the LGM within a shared physical and social landscape.

Chapter 8 provides further discussion and suggestions for further research on two of the key topics raised in the thesis: The LG re-colonisation of Northwest Europe and Britain; and the role of major river catchments as dynamic, quantifiable and a-political frameworks for archaeological analyses of human behaviour during the LG. One major recommendation for future research concerns the potential of researchers working with planning commercial archaeologists regarding predictive modelling in areas where urban expansion is taking place along major river systems. It is hoped that in the future heritage management capabilities relating to LG archaeology will be enhanced using the information generated from this thesis.

Chapter 2 Methodology

This chapter presents the main methods of analysis used in this dissertation. They were developed concurrently and were designed to work together to provide a **qualitative** overview of the Late Glacial (LG) archaeology of Southeast England and the wider Channel River Network (CRN) and to create **quantifiable** frames of references at different scales of analysis and resolutions. They also provide spatio-temporal renderings that enable a better understanding of Northwest European LG lithic technocomplexes and allow for the exploration of the key dissertation question of the potential role played by rivers in LG landscapes to create dynamic environments for human activities.

The main methodologies developed for the dissertation are listed below and are described in sub-sections of this chapter.

1. **The characterisation analysis of the lithic assemblages:** is developed to subdivide the techno-complexes into mappable groups and create a framework and scales of analysis for the reassessment of LG sites and collections from Southeast England.

2. **The regional database development:** consists of the analysis and enhancement of the Colonization of Britain (CoB) database for Southeast England to produce an extensive and consistent dataset for the dissertation analysis. (Section 2.1)

3. **The development of a Geographic Information System (GIS)** for the spatial analysis of the datasets in context with palaeoenvironmental and archaeological data

regarding the development of the Channel River catchment. The GIS methodology enables spatial analyses at specific scales, different chronologies and palaeoenvironmental backgrounds, for an integrated interpretation of archaeological finds, sites and distributions and thematic cross-referencing. (Section 2.2)

4. **Typo-technological analysis of key lithic assemblages** from Southeast England, in order to facilitate inter-site correlations. Data recorded using a modular Microsoft Access database management system that is adaptable for the level of analysis required. Specific diagnostic traits recorded with detailed photography.

The collection and interpretation of the data for the thesis using these methodologies was divided into seven work phases, some of which took place concurrently.

Phase 1. Data collection: LG of Southeast England. Literature review. Analysis of lithic assemblages from Brockhill and Wey Manor Farm (Surrey), La Sagesse (Hampshire) and Hengistbury Head (Dorset). Searches of relevant museum collections for further examples of LG artefacts and assemblages.

Phase 2. Regional database development. Assessment and enhancement of the CoB database to create the regional thesis datasets of the LG of Britain and Southeast England. This consisted of: (1) assessing the consistency and extent of the CoB dataset records; (2) comparison of the CoB database with the Jacobi Card Index (JCI) to assess the potential for further understanding of the CoB records; (3) enhancing the CoB dataset by integrating further information from the JCI; (4) data cleansing and standardisation of

CoB/JCI records; (5) enhancement of the CoB database for Southeast England with additional information from other national databases, and from published and unpublished fieldwork reports. The dataset was developed using the Microsoft Access database management systems.

Phase 3. Development of the thesis Geographic Information System (GIS) using ArcGIS 10.2-10.6. Creation of the topographic templates. Modelling of palaeo-river catchments in Southeast England and Northwest Europe. Modelling of the Channel River and North Sea region during the LG. Initial spatial analysis of the distributions of LG lithic artefacts and assemblages from Southeast England.

Phase 4. Lithic characterisation analysis of Northwest European LG technocomplexes. Literature review. Examination of major lithic assemblages including Pincevent, Etiolles and Le Closeau (Seine catchment), Hangest and Saleux (Somme valley), Siegersbrude and Zeijen (Netherlands), Stellmoor lower level and Poggenwisch, (Schleswig-Holstein). Assessing the diagnostic values of criteria used to interpret LG lithic assemblages in Northwest Europe.

Phase 5. Lithic characterisation analysis of British LG technocomplexes. Developing a revised recording methodology to facilitate comparison between British and Northwest European industries. Reanalysis of principal Southeast England LG assemblages using the revised recording methodology. Updating the terminology and sub-divisions in light of recent excavations.

Phase 6. Enhancement of the Southeast England LG GIS. Addition of data from personal fieldwork and examination of museum collections as well as qualitative assessments (e.g. recovery, taphonomy) and diagnostic elements of lithic artefacts and assemblages. Integration of regional data from palaeoenvironmental and dating datasets within a chronological framework.

Phase 7. Final GIS spatial analysis and modelling in relation to the course of the Channel River in Northwest Europe.

The following sections present details about the methodologies developed and used in the thesis research. And details of the results of the work packages are presented in subsequent chapters.

All dates (unless stated otherwise) are calibrated in OxCal v4.4.2 (Bronk Ramsey 2020) using the IntCal20 calibration curve (Reimer *et al.* 2020).

2.1 Methodology 1: Regional database development

2.1.1 Introduction

The first major work on the Late Glacial (LG) archaeology of Britain was published by Dorothy Garrod in 1926 in her book, *The Upper Palaeolithic of Britain*. In this work she compares the British record with the longer sequences of LG archaeology then known from France. She also coined the term 'Creswellian' to describe the distinctive assemblages with Magdalenian-like traits then known from cave sites at Creswell Crags

(Derbyshire/Nottinghamshire border) and elsewhere in Britain, but with some unparalleled distinctions.

Since that time the understanding of the British LG has been dominated by assemblages recovered from cave sites (Barton *et al.* 2003; Barton & Roberts 1996b; Campbell 1977; Collcutt 1984; Garrod 1926; Jacobi 2004). Recently caves have once again been at the forefront of LG research, with a focus on radiocarbon dating and faunal analysis, as they provide good conditions for preserving organic materials of this age (Jacobi & Higham 2011a; 2009a). It is also recognised that the limestone regions, where most cave sites are located, represent only a small proportion of the potentially occupied land in Britain during the LG (Coles 1998; Reid 1913). Although not as well-known as the cave sites, the distribution of known and recently discovered LG open-air sites and findspots suggests a more extensive human occupation of Britain in this period (Attfield *et al.* 2014; Ballin *et al.* 2010; Barton 1986; 1992; 2010; Barton *et al.* 2003; Barton & Roberts 1996b; Conneller & Ellis 2007; Cooper 2006; Garton & Jacobi 2009; Jones 2013).

The nature of archaeological research in England changed dramatically in 1990 with the introduction of Planning Policy Guidance 16 (PPG16) that set out national policy on how archaeological remains on land should be preserved or recorded .[5] This policy transformed the way archaeology was treated in relation to the planning process, culminating with the introduction of the National Planning Policy Framework (NPPF) in 2012 (Cooper 2012; DCLG 2012; Flatman & Perring 2013; Historic England 2014)

[5] Planning Policy Guidance 16: Archaeology and Planning was published on 21 November 1990 and was replaced by Planning Policy Statement 5: Planning for the Historic Environment (PPS5) published on 23 March 2010. Archived content available on the National Archives website at http://tinyurl.com/y5sty7ah

(Department for Communities and Local Government (DCLG 2012). Indeed, since 1990 almost all fieldwork on LG open-air sites in Southeast England has been developer-led (Cooper 2012; Mills 2013), exceptions being sampling at Avington VI, (Berkshire) (Barton 1998; Dumont 1997), and two test pits dug at Brockhill (Surrey) by the Surrey Archaeological Society (Mills 2013).

The nature of how the results of archaeological interventions are made available has also changed, with the majority now falling within the realms of "grey literature" (unpublished reports for developers), and only rarely being published in academic journals or as monographs (Cooper & Green 2015b; Cooper 2012; Farr 2009). This creates a challenge in tracking current archaeological work on the LG in England and in compiling recognised or "diagnostic" elements (individual finds, scatters, excavations and palaeoenvironmental sequences) within a searchable framework for future cross-referencing and consultation. The Online Access to the Index of archaeological investigations project (OASIS) and Archaeology Data Service (ADS) provide valuable resources for navigating this grey literature and the ADS is currently hosting an initiative to create a Library of Unpublished Fieldwork Reports for Britain (ADS 2019) [6]. These resources have been used to confirm that all possible sources of information on the LG archaeology of Southeast England have been incorporated in the thesis research.

[6] https://archaeologydataservice.ac.uk/archives/view/greylit/, accessed 10/02/2019

2.1.2 The Colonisation of Britain (CoB) database

Over the past 20 years several substantial datasets regarding LG sites and findspots in Britain have been made digitally accessible for research (Cooper & Green 2015a; Evans 2013). Sadly, there is little consistency between the datasets, and the quality of the data cannot be assumed. Preliminary work for this dissertation indicated that a thorough re-examination of a sample of archaeological material recorded in the datasets for Southeast England was needed, and that data standardisation, scaling, and transformation would be necessary before any form of GIS spatial analysis could be attempted.

The principal national dataset used in this dissertation is the Colonisation of Britain (CoB) database, created by Wessex Archaeology Ltd for English Heritage. This dataset is one of the main outputs from the Colonisation of Britain by Modern Humans Project, that aimed to preserve and make accessible the information in the research card index of the late Dr Roger Jacobi (1947-2009). The card index was initially created in the 1970s for the "Gazetteer of Mesolithic sites in England and Wales" (Wymer & Bonsall 1977). Dr Jacobi continued to compile and update the information throughout his long career as a leading researcher of the Mesolithic and Upper Palaeolithic of Britain (Ashton & Harris 2015). The card index is now curated by the British Museum (Harris 2015) and was digitised by Wessex Archaeology as the Palaeolithic and Mesolithic Lithic Artefact (PaMELA) database. The CoB is a standardised and refined version of that database (ADS 2015b).

The CoB database was selected as the basis for the dissertation spatial analysis due to its overall internal consistency, informed level of detail, and concise structure. More importantly it is the most reliable and extensive dataset currently available. Some caution

is required in using the dataset however, as some elements of Dr Jacobi's understanding and recording of the lithic industries were refined, redefined and reinterpreted over the course of his career. It should also be noted that the LG components of the card index do not seem to have been updated in light of his most recent publications (Jacobi & Higham 2011a; 2009a; Jacobi 2004), and it does not include information systematically from excavations that took place after AD 2000.

For the purposes of the CoB dataset, Wessex Archaeology attributed chronological interpretations to the find descriptions based on what were considered as "type fossils" (The Colonisation of Britain Project 2012; wessexarch.co.uk 2015). As a result, LG events in the CoB were divided into four categories: Creswellian, Late Upper Palaeolithic (**LUP**), Final Upper Palaeolithic (**FUP**), and Terminal Upper Palaeolithic (**TUP**). These terms are not fully defined but seem to follow the most frequent usage by Jacobi in his publications (Jacobi & Higham 2011a; 2009a; Jacobi 2004). It is assumed that the term FUP refers to Federmesser-Gruppen-type assemblages, and TUP to Long Blade assemblages, with LUP referring to other LG assemblages including those containing shouldered points and 'zinken' typologies (Jacobi & Higham 2011a). Although these attributions are debatable (see Chapter 4), at a broad scale they enable a preliminary overview of the general LG archaeological spatial distribution in Britain and Southeast England. Figure 2.1 shows the distribution of LG sites and findspots in the CoB dataset ordered by site-type.

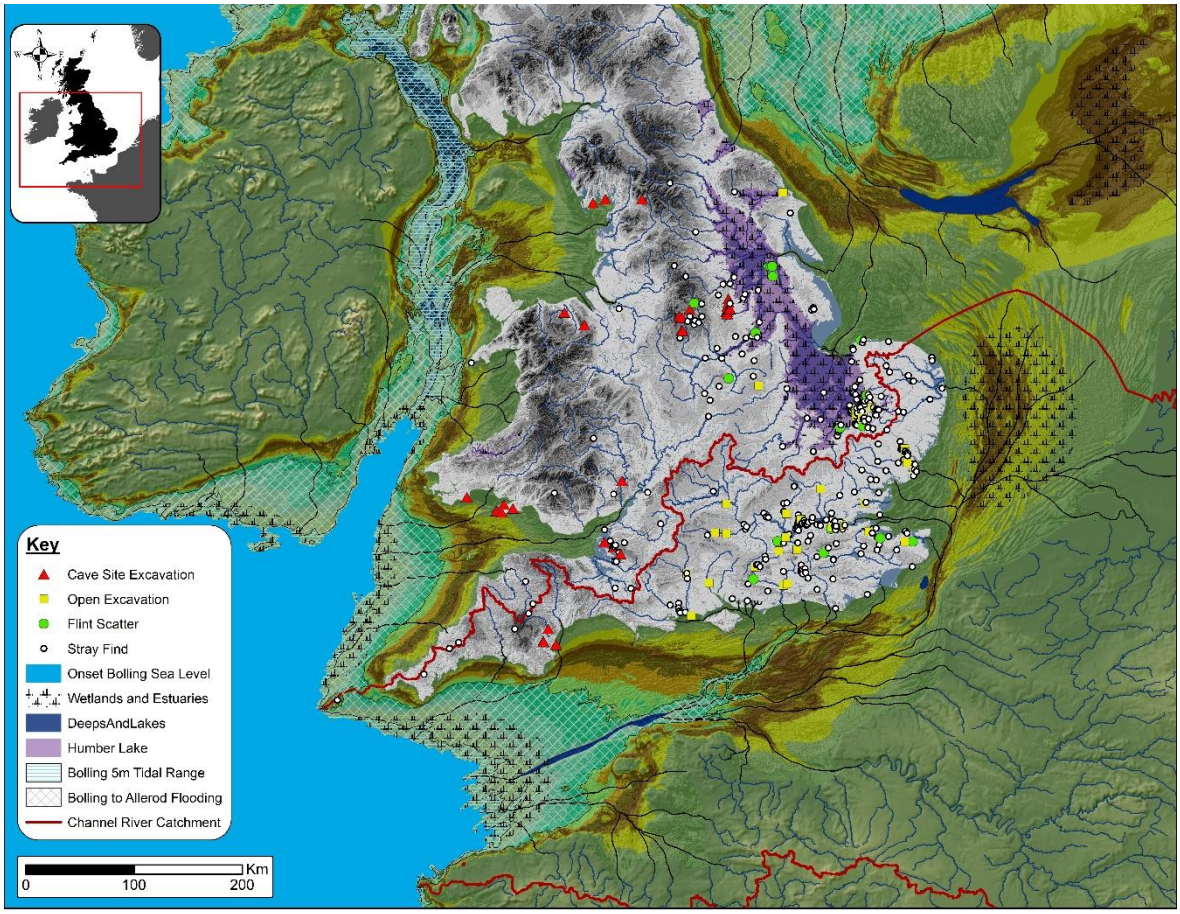


Figure 2.1 Colonisation of Britain dataset: Distribution of Late Glacial sites and findspots. (Source: Author. Basemap modified from OS TOPO 50, GEBCO 2014 elevation and EMODnet17 bathymetry, rivers European Environmental Agency, projected in ArcGIS 10.6.1).

2.1.3 Enhancement of the CoB database for research on the LG of Southeast England

Assessment of the CoB dataset for the dissertation spatial analysis revealed that the records regarding the LG of Southeast England needed to be revised and enhanced, especially regarding the chronological attribution of sites and findspots. This involved refining the original chronological categories to better represent the current LG techno-typological framework for Northwest Europe and Britain. This permitted systematic search by keywords within Dr Jacobi's digitised notes and using Dr Jacobi's coding system.

Data concerning archaeological sites and finds since 2000 also needed to be added systematically.

In order to enhance the CoB LG Southeast records, data was first integrated with information from several other national and regional datasets. These included:

- Historic England National Record of the Historic Environment (NRHE); [7]
- Southeast regional and district Historic Environmental Records (HER's);
- Historic England's NRHE Excavation Index (EI);[8] and
- the Archaeological Data Service (ADS).

Data from recent excavations was then added from both published and unpublished "grey literature" sources identified by OASIS and the ADS. The different datasets and reports contained diverse levels of information and their assimilation enabled a reassessment of past collections within a cohesive research framework, integrating major sites, local museum collections and individual finds at local, regional and national scales. It also enabled their integration for the dissertation research.

A reassessment of past recording methods was also undertaken that considered both the historical context of past work, as well as recent advances in the characterisation strategies for distinguishing LG industries. This reassessment initially focused on archaeological material from the catchments of the Rivers Wey and Mole. Once tested the enhancement was expanded to include the catchments of the River Avon near Bournemouth, and the Rivers Test and Arun.

[7] https://archaeologydataservice.ac.uk/archives/view/398/, accessed 10/02/2019.
[8] https://archaeologydataservice.ac.uk/archives/view/304/, accessed 10/02/2019.

2.2 Methodology 2: Geographic Information System (GIS)

2.2.1 Introduction

A major part of the dissertation research concerned the development of methods for comparing and integrating the thesis datasets with other data sources within a Geographic Information System (GIS) using ESRI ArcGIS 10.2.1 to 10.6. The integration of multiple datasets facilitates cross-referencing at multiple scales of analysis along with advanced relational and spatial analysis of site distributions (Conolly & Lake 2006) and providing a dynamic palaeoenvironmental and chronological platform for further spatial analysis. Spatial work on the LG of Belgium by (Crombé *et al.* 2011a), was taken as an initial model for the GIS analysis, and enabled for the first-time a cross-channel assessment of the LG using an equivalent analytical framework.

2.2.2 Maps, and background topographic representation

The use of Digital Elevation Maps (DEMs) and Digital Terrain Models (DTM) enable a topographic base-plate for the combination and representation of multiple datasets. Modern above sea-level topographic features can be considered overall as approximatively representative of LG landforms and topography, although there have been many changes to climate, ground-cover and soils since that time (Branch & Green 2004; Catt 1979; Macphail & Scaife 1987). The influence of eustatic uplift must also be taken into consideration for southern England (Bradley *et al.* 2011; Bridgland *et al.* 2010; Lambeck 1995; Shennan *et al.* 2006; Westaway *et al.* 2006). The most dramatic difference

compared to current topographic features, other than sea level, is found along the river courses resulting from the sedimentation of floodplains and river valleys during the Holocene, but the river valleys persist (Antoine *et al.* 2003b; 2007; Bridgland 2006; Brown 1997; Green *et al.* 2013; Howard *et al.* 2015; Westaway & Bridgland 2010). Several DEMs, each with their particular pros and cons, and different resolutions, have hence been combined to create a homogeneous land-surface.

The Gebco14 DEM (www.gebco.net) was used to create the palaeo-river flows as it is a continuous surface covering all Northern Europe, including the bathymetry of the English Channel and the North Sea. The continuous nature of this DEM enables the modelling of river courses based on above ground topography and bathymetry (Collier *et al.* 2015; Mellett 2012). This is equivalent to pouring a bucket of water over the modelled landscape and calculating in which direction the water will flow and accumulate to create rivers (Conolly & Lake 2006). These data are supplemented with the Ordinance Survey Land-form Panorama for the topography of Britain, and SRTM90 DEMs for Ireland and continental Europe.

Past sea-levels are a primary factor when considering the LG around the English Channel in relation to the exposure of landforms and their associated topography and fluvial systems. Detailed local and regional studies have considered both LG sea levels (Bradley *et al.* 2011; Brooks *et al.* 2011; Shennan *et al.* 2006; Sturt *et al.* 2013) and palaeochannels (Antoine *et al.* 2003b; Collier *et al.* 2015; Gibbard & Lautridou 2003; Gibbard 2007a; Lewin & Gibbard 2010; Mellett 2012; Westaway & Bridgland 2010). However, these factors have not been considered in relation to LG archaeological distributions around the English

Channel since the seminal work on the now submerged Northern European landscape (Coles 1998) (see Chapter 5).

The topography used in this thesis is based on contemporary bathymetry, with the assumption that most of the major palaeo-valleys apparent in the bathymetry were created pre-LG and guided the river channels during the LG (Brooks *et al.* 2011; Gibbard 2007a; Gupta *et al.* 2007)(see Chapter 5). The exact location of individual channel beds remains uncertain without further ground-testing, due to both Holocene infilling of the channels and erosional events with rising sea levels (Howard *et al.* 2015; Lautridou *et al.* 1999; Lericolais *et al.* 2003; Sturt *et al.* 2013). The resolution is high enough for the consideration of active river valleys and large-scale dynamics (Brooks *et al.* 2011). To test the model for currently submerged areas a higher resolution DEM was used European Marine Observation and Data Network (EMODnet)[9] and compared to recent mapping and analysis of submerged palaeo-channels (Gibbard & Lautridou 2003; Gibbard 2007a; Gupta *et al.* 2007). Comparison using the course overlay indicated a good correlation within a 500m buffer, coinciding with palaeo-geographic publications (Antoine *et al.* 2003b; Brooks *et al.* 2011; Westaway & Bridgland 2010).

When applying the dataset, it was possible to approximate the exposed landforms in relation to different sea levels, enabling a realistic representation of site distributions within the modelled LG landscape. Regional and local analyses were then carried out and integrated based on higher resolution DEMs, and/or relevant to the scale of analysis (Chapters 6 and 7). High-resolution datasets were obtained from the Ordnance Survey

[9] https://portal.emodnet-bathymetry.eu/

and the Environmental Agency for the case study areas of the Wey/Mole river system as well as the Bournemouth Avon and Test Rivers. These provided the more detailed investigation of site locations within the same river valley.

Several thematic geo-rectified datasets were added to the thesis topographic base map for cross-referencing and contextualisation of the archaeological distributions. These are:

1) Geological bedrock (British Geological Society)[10]

2) Drift Geology (British Geological Society)[11]

3) Ground cover (urban, forested, agricultural) (Ordinance Survey[11], European Environmental Agency (EEA[12]))

4) Waterways and wetlands (Ordinance Survey[13], UK Environmental Agency (UKEA) and EEA[14])

5) Current areas susceptible to flooding (Ordinance Survey and UKEA[15])

6) Bedrock Hydrology (British Geological Society[16]).

2.3 Methodology 3: Lithic assemblage characterisation and scales of analysis

A major aim of this research is to quantify usable frames of reference for Late Glacial (LG) lithic assemblages at different scales of analysis and resolution. This is to examine variability in the LG archaeological record within the framework of the landscape of the

[10] https://www.bgs.ac.uk/datasets/bgs-geology-625k-digmapgb/
[11] https://digimap.edina.ac.uk/webhelp/environment/data_information/landcover_data.htm
[12] https://www.eea.europa.eu/publications/COR0-landcover
[13] https://www.ordnancesurvey.co.uk/business-government/products/open-map-rivers
[14] https://data.gov.uk/dataset/c5a3e877-12c3-4e81-8603-d2d205d52d7a/wfd-river-canal-and-surface-water-transfer-waterbodies-cycle-2
[15] https://data.gov.uk/dataset/7792054a-068d-471b-8969-f53a22b0c9b2/indicative-flood-risk-areas-shapefiles
[16] https://www.bgs.ac.uk/datasets/hydrogeology-625k/

Channel River network system. This section outlines methods developed for the thesis to characterise LG lithic assemblages and create a framework of scales of analysis for the reassessment of LG sites and collections from Southeast England. Lithic assemblages provide the primary means for this research as they survive well in the archaeological record and provide the largest macroscopic landscape-wide spatial signature of LG remains in the region (Schofield 1991).

2.3.1 Lithic assemblage characterisation

Lithic assemblage characterisation as developed for this thesis is a techno-typological system of artefact and assemblage definition within the conceptual framework of the '*chaîne opératoire*' and 'a reduced *chaîne opératoire*' (*sensu* Inizan *et al.* 1999; Pelegrin 2000; Soressi & Geneste 2011). This approach enables inter-site comparison and is used for the identification, interpretation and analysis of recurrent lithic production methods, technologies and tool types that may be considered as diagnostic (or not) for the LG. The objective to formulate characterisations of individual sites to facilitate the consideration of groups of sites within an analytical framework. Ultimately the overall aim is to recognise archaeological signatures related to LG behaviours, movements and decision-making patterns in the river valleys of the Channel River catchment.

The concept of '*chaîne opératoire*' goes back to the early 20th century and the formalisation of the study and analysis of 'material culture'. In its broadest sense it encompasses all of the actions and thoughts involved in the creation and use of an object during its 'life' to the present day. In practise, the field of lithic analysis envisages a behavioural extent of the '*chaîne opératoire'*, from the collection of the raw material

block to the abandonment of the lithic piece. This is most often subdivided into the fields of raw material selection and testing, roughing-out of the block, full lithic production, blank selection, tool production, use, curation and abandon. For this thesis a 'reduced *chaîne opératoire*' is utilised, breaking down the choices and stages of production within the fields of preparation, full production and tool development. The aim is to identify to principle characteristics: the aim of the debitage (flake, blades, bladelets) and the specific techniques used to achieve it that are shared dating certain periods.

Lithic technology reference sites from Northwest Europe were identified for the lithic characterisation work (see Chapters 3-4). These sites have all been the subject of extensive lithic refitting programmes and the assemblages can be technologically and methodologically characterised (Barton 1992; Biard *et al.* 2004; Bodu 1994; Coudret & Fagnart 1997; 2006b; Cziesla 1990; de Bie & Caspar 2000; Karlin & Newcomer 1982; Lewis & Rackham 2011). These technology reference sites, in combination with the characterised technological attributes from other well-dated LG sites, form the analytical framework for this research.

2.3.2 Scales of analysis

In this thesis it is recognised that, overall, there are two major factors influencing the resolution at which lithic assemblages may be analysed: (1) the date and type of fieldwork (including the historical context of recovery and analytical techniques that were available at the time); and (2) the inherent resolution of a site or findspot (i.e. stratigraphy and site formation processes). The aim of developing scales of analysis for LG sites is to enable the assessment of the resolution at which archaeological chronological and behavioural

interpretation can be applied to a lithic assemblages, and to distinguish categories of sites that may be analysed at an equivalent resolution. As such, through the use of such scales of analysis it should be possible to achieve a more critical interpretation of LG site distributions and how they reflect LG human behavioural patterns.

Understanding stratigraphic context and site formation processes is of paramount importance for interpreting LG open-air sites in alluvial contexts. Stratigraphic analysis can show where sites have been covered quickly and where artefacts and archaeological deposits have the potential to be *in situ* and undisturbed. It can also show where site formation processes have caused disturbance or redisposition of archaeological deposits (*i.e.* (Brown 1997; Butzer 1982; Needham & Macklin 1992).

Different types of open-air LG site resolutions were defined for Southeast England as part of this process. These levels of resolution have a direct impact on the types of analyses that may be carried out on the dataset. They are:

- individual artefact
- small lithic scatter (2-19 artefacts)
- large lithic scatter (20+ artefacts)
- excavated open-air site
- refitted open-air site (technological reference site)
- dated open-air site (dating reference site)

There is additional variation within the category of excavated open-air site dependant on the stratigraphic integrity of the site and the quality of excavation. Table 2-1 summarises

the characteristics of the different site resolutions. Full details of the definition of different site resolutions can be found in (Mills 2020).

In view of the variation, an adaptive model was developed to consider the nature of each assemblage, the criteria used and associated diagnostic resolution. This has the advantage of being adaptable to the nature of the assemblage, but also having the potential to be expanded to several levels of analysis for landscape considerations.

Table 2-1 Summary of the characteristics used to define LG site resolutions

	# of finds	Spatial marker	Context	Analyses	Interpretation
Individual find	1	Signature	Spatial marker	Typology; Location	Local/regional spatial presence
Small scatter	2-19	Activity	Spatial marker	Typology; Location	Local/regional spatial presence
Large scatter	20+	Definable activity	Spatial marker	Typology; Technology; Location	Developed spatial activity; Basic comparative analyses
Excavated site: Disturbed	20+	Spatially defined activity	Disturbed stratigraphic context	Typology; Technology; Refitting; Location	Site zonation; High-resolution comparative analyses
Excavated site: Occupation horizon	20+	Spatially defined activity	Defined sedimentary horizon	Typology; Technology; Refitting; Location	High-resolution comparative analyses; Spatial behaviours
Excavated site: Living floor	20+	Spatially defined activity	Discrete sedimentary horizon with signs of a 'floor level'	Typology; Technology; Refitting; Location	High-resolution comparative analyses; Spatial behaviours

2.4 Methodology 4: Lithic assemblage analysis

The fourth major methodology developed for this thesis involves the typo-technological analysis of key lithic assemblages from Southeast England, in order to facilitate inter-site correlations with contemporary material from elsewhere in Northwest Europe. The European assemblages are discussed in chapter 3, and the assemblages from Britain and

Southeast England in chapter 4. Terminology mainly follows '*Technology and Terminology of Knapped Stone*' (Inizan *et al.* 1999) with additions as noted from regional and more recent works, as well as from more detailed analyses (Barton 1992).

The **typology** of lithic artefacts has traditionally been the main method of classifying LG lithic assemblages in the UK. During the 1950s-60s, Bohmers developed a framework for Integrating typological and quantitative data suited to the varied nature of sites ranging from well excavated sites to unstratified find-spots (Bohmers 1956; 1961). The method was originally applied specifically to Hamburgian and Tjongerian (now considered a form of Federmesser (Barton *et al.* 2003; Charles *et al.* 1999; De Bie & Caspar 1997; Schild 1984)) assemblages. However, the framework was adapted and 'up-dated' over the years to integrate more recent typological and dating finds (Barton 1992; Barton *et al.* 2009; Barton & Roberts 1996a; Conneller & Ellis 2007; Cooper 2006; Jacobi 1991; 2004; Jones 2013).

The term **technological method** is used to describe the repeated standardised choices made to achieve lithic production aims (cf. Inizan *et al.* 1999; Pigeot 1987). These can include choices in patterns of core reduction, crest preparation, roughing-out of blocks, and debitage systems well as tool curation and recycling (Andrefsky 2012; Binford 1979; Bodu & Mevel 2008; Jacquier & Naudinot 2015; Naudinot *et al.* 2017a; Valentin 2008a; 2008b). The characteristics of these methods have usually been defined based on refitting and analysis of lithic assemblages from high-resolution sites. They can be recognised archaeologically either through refitting or by the occurrence of specific features on artefacts (e.g. directionality of negative flake scars). However, it is also recognised that

methods may vary during episodes of lithic production; for example, a core may start as single platform production and finish as opposed platform.

Techniques are understood to be the practical means by which a technological method is carried out and aim achieved. Both methods and techniques contribute to the understanding of a lithic technology (Leroi-Gourhan 1943). The technological attributes of these techniques may be recognised within assemblages, as opposed to typological attributes based on morphology for finished tools and abandoned cores.

Typological and technological approaches are linked with two schools of archaeological analysis. The typological approach can be associated broadly with lithic assemblages without associated lithic refitting studies. The technological approach is related closely with the extensive open-air excavations and subsequent extensive lithic refitting programmes. The technological approach is further supported by experimental work in analysing lithic refits and reproducing the methods and techniques identified, and in observing and analysing the stigma on the stone tools.

Both typological and technological approaches are used in this thesis to describe and analyse lithic assemblages (Chapters 3-4). The criteria used for recording lithic assemblages in this research were initially based on the system designed by Nick Barton to record Hengistbury Head (Barton 1992; Barton *et al.* 2009) and supplemented with other published data-recording attributes for the British LG (Conneller & Ellis 2007; Cooper 2006; Jacobi 2004). In 2015, the recording criteria were further modified in order to integrate technological attributes identified in recent years by NW European LG

researchers (notably (Biard *et al.* 2004; Pelegrin 2000), and for morphometric analysis. The modification of the recording criteria was undertaken in order to develop a dataset that could be directly compared to Northern European LG reference sites.

A key concept for the thesis is that very few, if any, individual typological or technological traits may be considered as truly diagnostic of a lithic industry. It is only through the combination of multiple traits that assemblages may be assessed on the basis of the resolution of the combined data at different scales of analysis. The following section (2.4.1) outlines the criteria selected for recording and discussing lithic assemblages in this thesis. Section 2.4.2 describes the recording process.

2.4.1 Lithic assemblage production: recording criteria

This section outlines the criteria for recording and discussing lithic assemblages in this thesis.

The **primary aims** and objectives of lithic production concern the types of blanks intended to be produced (for probable transformation into tools). The basic production aims recognised for LG lithic assemblages in NW Europe are:

- curved blade production
- straight blade/let production
- thick blade/let production
- large blade production
- flake production

Three categories of blank were defined for the thesis: blades, bladelets and flakes (following Inizan *et al.* 1999). Blanks were considered as being debitage elements longer than 10mm that could potentially be transformed into formal tools, as no identified formal tools smaller than 10mm have been recognised in the LG so far. The thesis also recognised that cores and core fragments could also be used as tool blanks. Blank type was recorded in order to demonstrate intent in the systematic production of blanks, and to assess the efficiency of the core reduction process. This was examined by comparing finished/abandoned tool dimensions to the overall blank production dimensions (Barton 1992), to identify if there is a consistent selection within the production. It was also used to compare with retouched tool blank data to determine any predilection for a specific blank type in tool production.

The basic **core reduction strategies** recognised for LG lithic assemblages in NW Europe and recognised in the UK (Barton 2010; Barton *et al.* 2003) are:

- Opposed platform
- Preferential single platform
- Single platform

Cores are also recognised being tournant (turning) or semi-tournant depending on the extent of the circumference of the core worked (following (Bodu 1994; Pigeot 1987; Valentin 2008a).

Key **core preparation techniques** for identifying LG lithic production aims and methods are cresting and platform preparation. Cresting is associated with the initial shaping and renovation of blade and bladelet cores to achieve production aims. It involves creating a

ridge on a core to guide succeeding blade/let debitage and to shape the transversal and longitudinal convexities of the volume. In this thesis crests and crested blades/flake were recorded according to the nature of the versants (the two surfaces of the dorsal ridge of a crest or crested blade). Platform preparation involves techniques for modifying the edge of a core striking surface prior to debitage. This includes techniques such as abrasion of a core edge to remove irregularities or overhangs and to reinforce and/or shift the point of impact inwards, tablets (clearing the striking platform and accentuating the striking angle), and methods of isolating a striking platform for blade debitage (e.g. *en-éperon* technique, cf. (Barton 1990) and faceting). Evidence for platform preparation was also recorded, including details of platform abrasion and butt type as well as butt dimensions (Barton 1992; Barton *et al.* 2009; Pelegrin 2000).

The following five criteria were recorded for all artefacts in order to determine post-depositional artefact **integrity**, general morphology and **typo-technological** characteristics (see appendix C): Completeness, Profile, Termination, Burning, Heating.

Completeness records if a piece is complete or if it was a proximal, mesial or distal fragment. This criterion was recorded to assess if there were any disproportion in the representation of fragmented elements within an assemblage, and if such a bias could indicate factors such as blank modification, style of percussion, or intentional breakages. Morphometric analysis was carried out on a sub-sample of complete blades and flakes from Brockhill, Hengistbury Head, Nea Farm and La Sagesse. The criterion was also used to identify potential break refits during the analysis of various assemblages.

Profile records whether the profile of a removal is straight, sinuous or curved. It is most relevant for blades but was also carried out for flakes as a control. The general profile of pieces may be used in combination with other factors to help determine mode of production (i.e. hammer type (Barton 1992; Biard *et al.* 2004; Inizan *et al.* 1995; Naudinot *et al.* 2017a; Pelegrin 2000; Valentin 2008b)). Experimental work has shown that consistently curved debitage may indicate a preferential use of hard organic hammers (e.g. antler or hard wood), whereas consistently straight or sinuous profiles can indicate a tendency towards soft stone or indirect percussion techniques (Madsen 1996; Pelegrin 2000; Valentin 2008b).

Termination describes the distal end of a removal. In this thesis three main termination types were recorded: plunging (overshot), hinged, and plain/feathered (after Barton 1992). Plunging terminations arch inwards and remove an opposing part of a core/blank. They may be considered as either accidents or deliberate core rejuvenation removals (Inizan *et al.* 1999). Hinged terminations are considered as accidents that usually terminate a removal prematurely (Inizan *et al.* 1995). Plain and feathered terminations both result from 'normal' continuous conchoidal fracture. They differ in that plain terminations result from regular fracture and feathered ones from gradual reduction of fracture energy. High proportions of plain/feathered terminations in an assemblage may indicate overall good quality lithic production.

Burning records where artefacts have clear stigma of prolonged firing such as cracking, discolouration and heat fracture.

Heating notes a characteristic smoothness, colouration and lustre that may have been associated with heating, a technique suggested for some Final Late Glacial and Mesolithic industries in France (Barton 1992; Inizan *et al.* 1999; Pelegrin 2000; Tixier & Inizan 2000). This criterion is considered as tentative.

Morphometric data was recorded for all complete artefacts, and for some artefact fragments (e.g. butt characteristics were recorded for proximal fragments). These data were used to assess the cohesion of the assemblage as a whole, as well as to identify potential hiatuses which may be linked to elements removed from a site. It also allows the estimation of the extent of reduction, notably when comparing the dimensions of crested blades to those of blades and cores. These data are also essential for comparison with other LG sites.

The key morphometric characteristics recorded were: weight, length, width, and thickness (bulb and middle). Dimensions were also recorded for butts.

Cumulative weights were used in considering the quantity of material worked on site. It also indicates the general robustness (mass) of the débitage when considered as an average of blades or flakes.

The length and width ratios were used to distinguish blade from bladelet and flake categories.

Thickness at the bulb and middle of an artefact was recorded in relation to determining lithic production. One of the main characteristics of soft-stone hammer production is a relatively thick and elongated débitage. Middle thickness was therefore used as a general indicator for this proportion. Bulb thickness was measured to test whether descriptive bulb characteristics related to knapping mode (e.g. flat, developed) could be quantified. Distal thickness was not recorded as preliminary work showed that this information was superseded by recorded termination type.

Butt length, width, and thickness were recorded in relation to determining both mode of percussion and reduction method when these dimensions were considered with platform preparation and butt type criteria. Other subtle characteristic features helping to determine the mode of percussion by combining multiple stigmas were also recorded: bulbur scars ("esquillement du bulbe"), point of percussion (or absence), 'whiskers' off the bulb, platform preparation type and intensity, platform to removal surface angle, platform thickness indicative of inside or tangential striking (Pelegrin 2000; Valentin et al. 2006). These features are insufficient independently, but when concurrent and found on multiple elements they can be indicative of the mode of percussion(s) (*ibid*). These can be combined with the other features (e.g. curvature of blanks, core discard features) of the production so as to infer a probability of mode(s) of production and distinguish objectives.

For **retouched tools** the following attributes were also recorded: tool type and sub-type; retouch type and location; retouch measurement; position in core reduction strategy; and

typological characterisation. Details of potential use-wear and damage were also recorded, as was the determination of microwear analysis where available.

2.4.2 Lithic assemblage production: recording process

This section outlines the recording process for lithic assemblages in this thesis. Data was recorded using a modular Microsoft Access database management system that was developed to be adaptable for the level of analysis required. Assemblages were also recorded photographically.

The lithic assemblages studied were assessed initially for information regarding condition, techno-typological characteristics and spatial and chronological resolution. All artefacts in a collection were then photographed, weighed and measured, and described using the criteria defined for the research (Mills 2013). Typo-technological details were described in full for all retouched pieces, cores, and other diagnostic artefacts. The main database and entry forms were originally created using iPad 'Numbers' software and subsequently exported (as CSV data) to a Microsoft Access database (Figure 2.2). The typo-technological database was developed using iPad 'Notability' software that contains annotation and sketching tools. For this application a codified notation system was developed to represent visually the modifications and characteristics of complex artefacts, thus enabling a time-effective way of recording and representing this information.

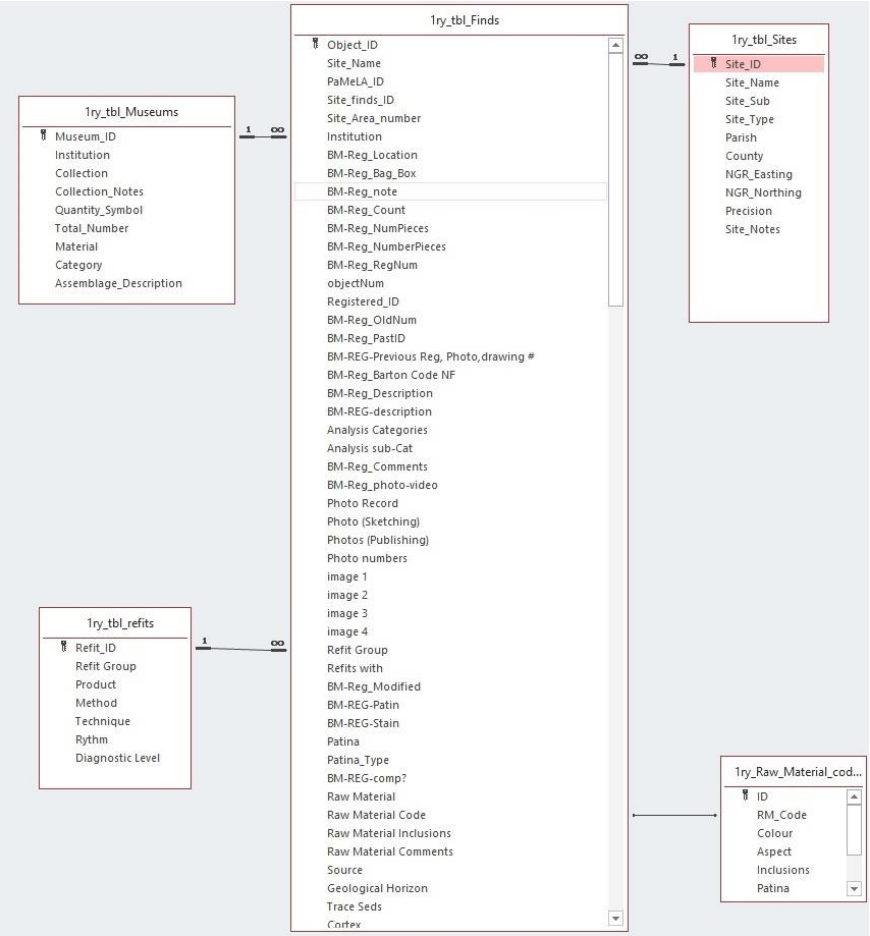


Figure 2.2 Structure of thesis database (Microsoft Access)

All databases and data entry forms were developed by the author for the thesis research. The databases were backed-up daily following University of Oxford research data management guidelines. Figure 2.2 shows the structure of the main Access database. Figure 2.3 shows an example of data in this database. Figure 2.4 shows the notation system for recording complex artefacts and examples of its application in recording retouched tools from the Brockhill assemblage. Figure 2.5 shows the recorded criteria. Figure 2.6 presents diagrams of the theoretical framework to the recording and comparison of lithic assemblages.

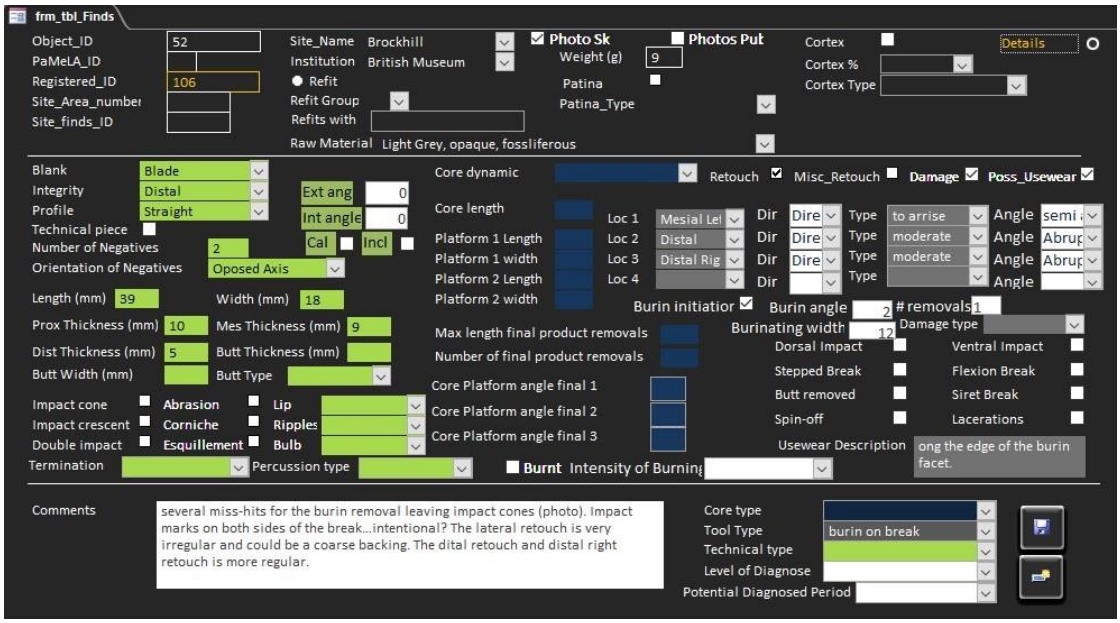


Figure 2.3 Example of data entry in the database

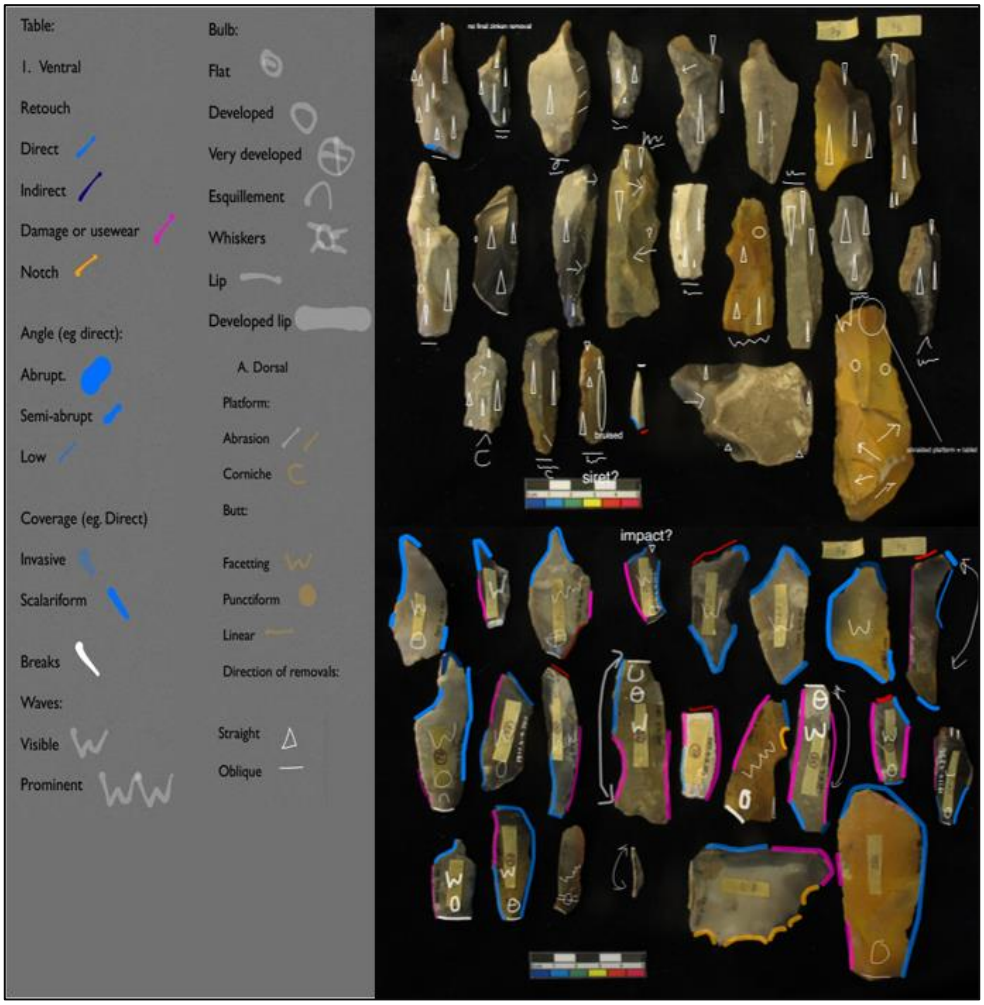


Figure 2.4 Lithics recording notation system

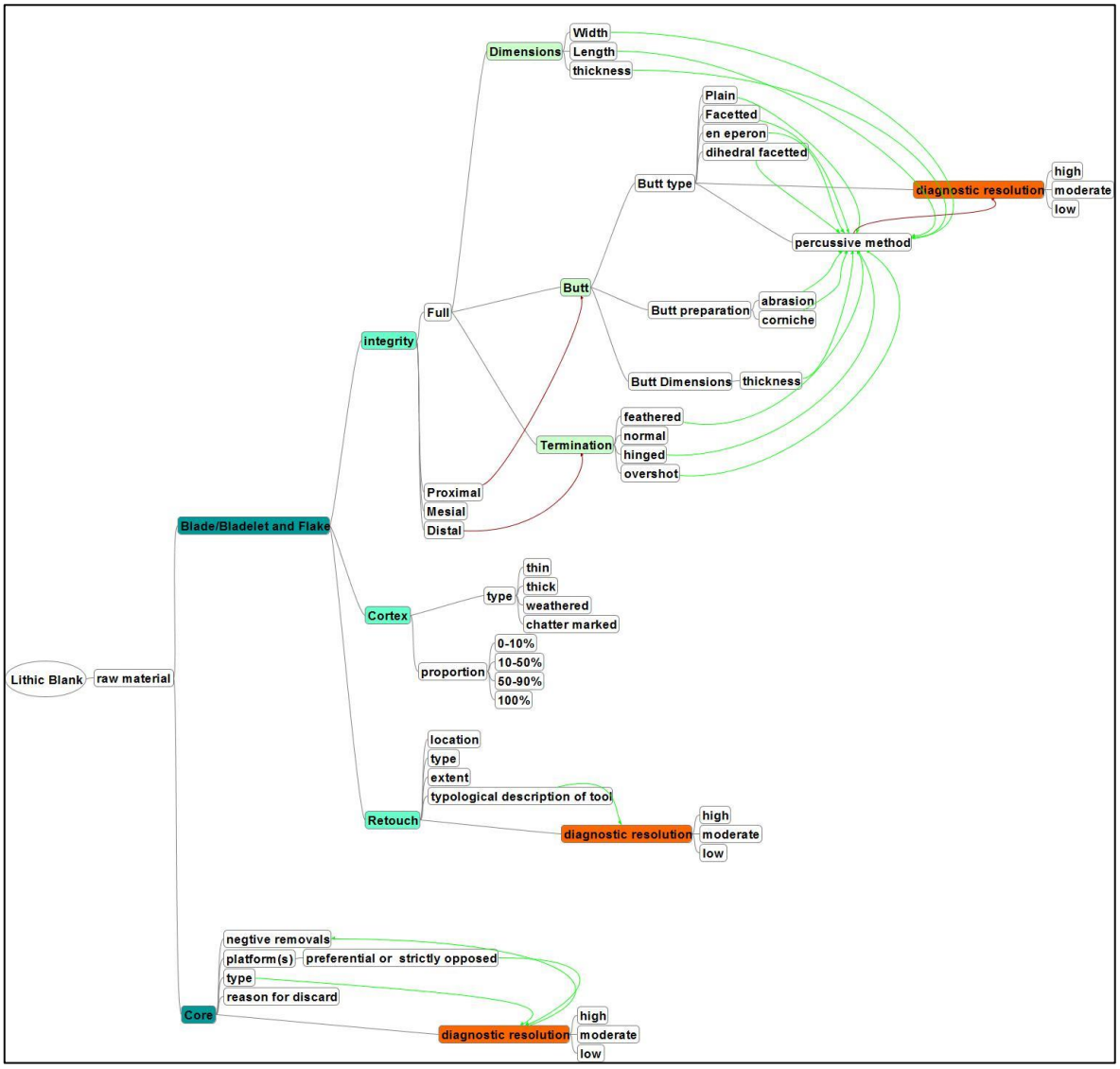
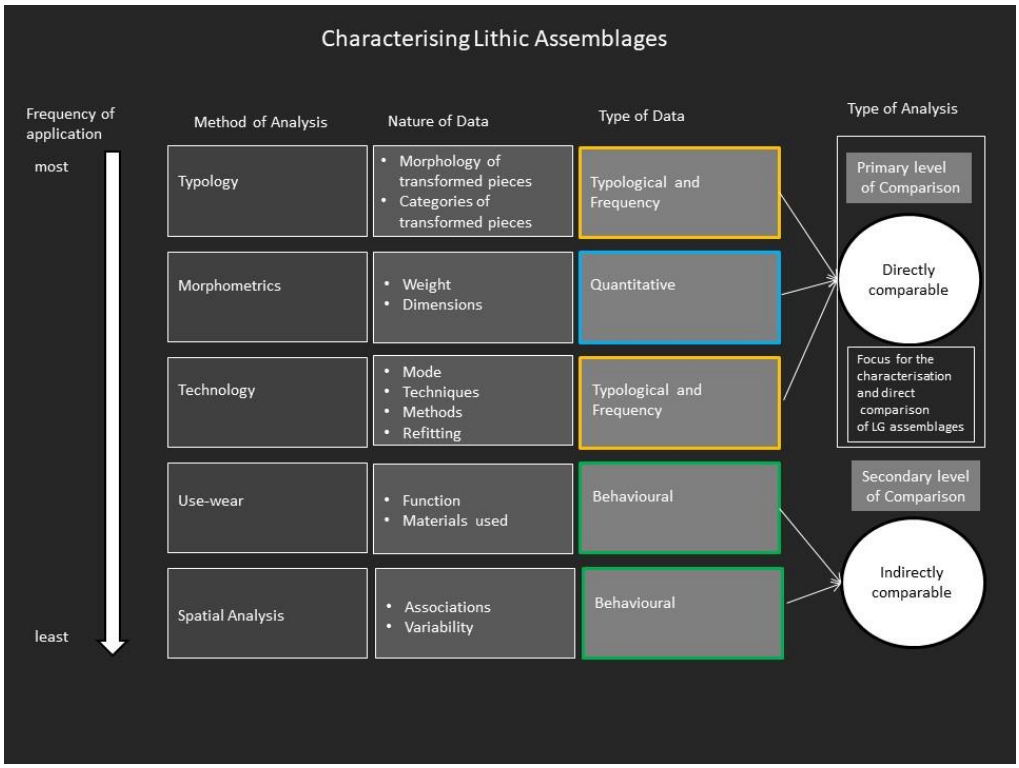


Figure 2.5 Lithics recording criteria



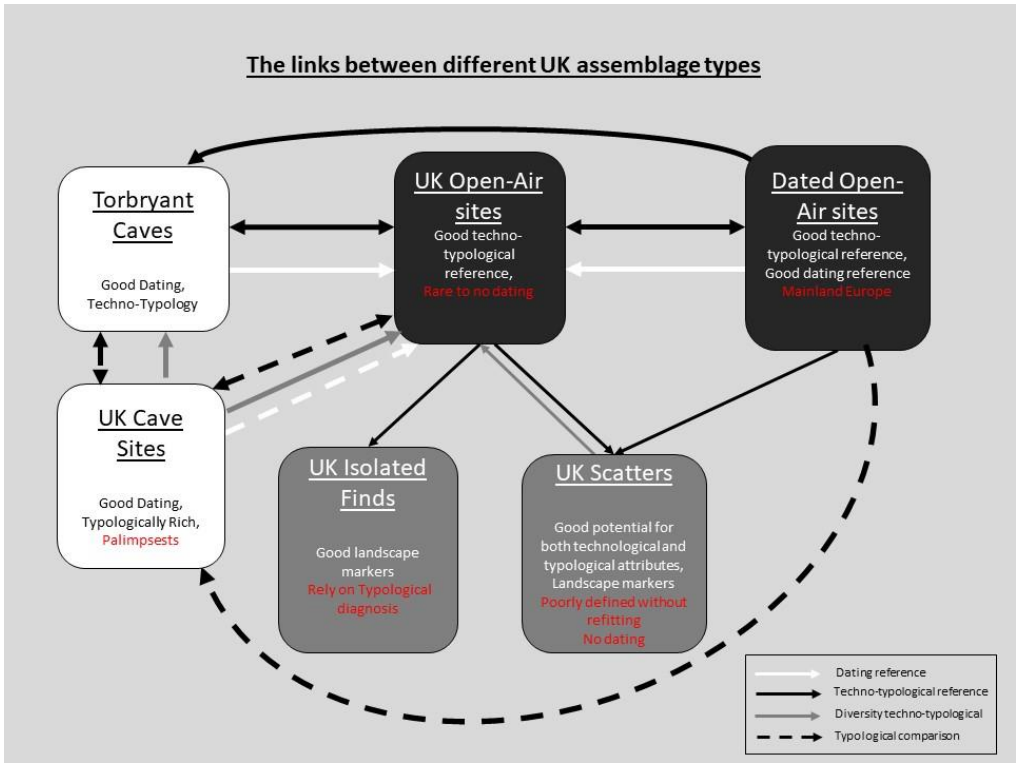


Figure 2.6 Diagrams of lithics methodological framework

The major LG lithic assemblages recorded using the thesis methodology were:

- Brockhill, Surrey (Lawson excavations, British Museum)
- Wey Manor Farm, Surrey (SCAU excavations, University of Bradford)
- Hengistbury Head, Dorset (Mace excavations, British Museum)
- La Sagesse Convent, Hampshire (Wessex Archaeology excavations, Hampshire County Archaeology Centre)

Equivalent data for the Nea Farm (Hampshire) LG assemblage was provided by Professor Nick Barton. His data for this site was integrated with the thesis database for comparison with the other assemblages.

Two main phases of artefact photography were undertaken as part of the recording of lithic assemblages, both using Canon G12 and S100 cameras. First, general reference photographs of groups of artefacts were taken at the start of the recording process. This involved each museum box and/or excavation context/square grouping of artefacts being laid out on a black velvet background and photographed from the zenith angle (perpendicular) on both dorsal and ventral, as well as on its sides. All artefacts were recorded using this method.

Second, each diagnostic artefact was individually photographed to scale from the zenith angle at different exposures and with a tangential light from the upper left corner imitating illustration protocols (Inizan *et al.* 1995). Two black velvet covered polystyrene platforms for supporting the lithics at the appropriate angles for photography were made by the author, so as to consistently photograph the artefacts both vertically on their sides

and obliquely towards the proximal and distal ends. All photographs were taken on a black velvet background using a monopod developed by Ian Cartwright (Institute of Archaeology, Oxford) and a timer for stability and longer exposures. Images were saved in both RAW (archival) and JPG (working) formats. Photographs were processed, named and backed-up daily, and a database of the content was created. Following the photography, multiple annotation methods were experimented with in parallel with database recording. The favourite method of using annotation on a touchpad (iPad followed by Microsoft Surface Pro) was used for typo-technological inventory in parallel with direct annotation. Video was used for objects requiring a 3D description such as cores.

2.5 Methodology 5: The Chronological Framework

2.5.1 Recalibrating dates in OxCal 4.4 using IntCal20

Dates were collected from publications that have filtered the dates through strict selective criteria. 1. Dates directly associated to assemblages or with direct evidence of human modification (e.g. cut marks) (Jacobi & Higham 2011a; Stevens *et al.* 2009b); 2. Dates that have appropriate counts and deviations (under 100 years) (Higham and Jacobi 2011, Stevens et al. 2009, Grimm and Webber 2009); 3. Specific techniques used to extract the best quality material to date and removing potential contaminants (e.g. ultrafiltration) (Brock *et al.* 2007; Jacobi & Higham 2011a; Stevens *et al.* 2009a; Stevens & Hedges 2004); 4. Dates that have undergone a secondary check based on isotopic counts that verify the quality of the material dated (Brock et al. 2007; Stevens and Hedges 2004). The second level of decision was made with OxCal 4.4 (Bronk Ramsey 2021). The simply calibrated dates do not provide the best modelling of their results, and often are too

dispersed. Furthermore, whilst modelling some problematic dates may become apparent. The modelling has therefore the dual function of optimising the results within a given framework (prior) and highlighting potential deviations from this assumed model (outliers) (Bronk Ramsey 1998). With additional stratigraphic information (rarely accessible for British Late Glacial dates, but in some part reconstituted from past field notes (Jacobi and Higham 2009a, 2009b, 2011), a higher level of assumption (stratigraphic order, a "sequence" prior) can be applied for a stricter Bayesian model resulting in a more precise overall modelling of the dates.

Agreement levels (calculated for models and individual sites in OxCal 4.4), were used as a further verification of both individual dates and the overall models. When agreement levels were on the limit or below acceptable Outlier Models were applied, and testing different priors without selected dates were applied to find the best overall model for the dates when possible.

Different methods were used for modelling the dates where appropriate:

1. "simple plot": where no prior is added to the dates and they are simply presented as raw counts with projected probabilities in relation to the calibration curve (both 68% and 95% probabilities are shown here).
2. "uniform phase": where the dates are assumed to part of a same period (of occupation) but not necessarily in stratigraphic order. It still applies Bayesian statistics to constrain the dates assuming that they are of similar age relative to other such groupings. This was the method applied by default for British sequences by Jacobi and Higham (2009, 2011), and was applied systematically to the datasets (with a minimum of two dates) used for this thesis. The more dates that are used, more robust the model. The overall agreement model and

individual date agreement indexes were used to assess the potential validity of the prior and model.

3. "Overlapping uniform phase": this model was applied where multiple groups of dates could be identified and placed in a relative sequence.
4. "Uniform sequence": this priori was applied to series of dates where there was a known stratigraphic relationship between the dates.
5. "KDE Models": these models were also systematically applied to groups with more than two dates, as a way of testing the dates distribution and coherence within a phase. The Kernel Density (KDE) model uses a different statistical method to Bayesian, and works well with groups of dates with internal variability (Bronk Ramsey 2017). This was also important as many of the groups of dates had no or only approximate stratigraphic ordering. The KDE model was also used to corroborate the "uniform phase" models. It provided less constrained results and was preferred when an "uniform phase" had a low agreement index, and when summarising multiple sites for comparative results as it works best with larger datasets.
6. When agreement indexes were below acceptable (<60%), "outlier models" were used so as to detect potential problems with the assumed phase. Outliers models were also applied to sites with charcoal (0.05% probability), taking into account the possibility of older wood being burnt, and weighting the model appropriately (Bronk Ramsey 2009b).

Additional information was added depending on the model used. Further information on dating is found in Catalogue A.

Table 2-2 Prior and model setup

	Sum	KDE plot	Boundaries	Outlier models	reference
Simple plot					Bronk Ramsey 1998, 2001
Uniform Phase	x	x	x	x	Bronk Ramsey 1998, 2009
Overlapping Phases	x	x	x	x	Bronk Ramsey 2009
KDE Model				x	Bronk Ramsey 2017
References	Bronk Ramsey 2017	Bronk Ramsey 2017	Bronk Ramsey 2009	Bronk Ramsey 2009	

Table 2-3 For illustrating the results

	Single date (68 & 95%)	68%	95%	Multiple plot (68%)	Curve plot (sigma)	Sum (median)	KDE plot (median)	Agreement index
Simple plot	x	x	x	x	x			
Uniform Phase		x	x	x	x	x	x	x
Overlapping Phases		x	x	X	X	X	X	X
KDE Model		x		x	x		x	X

Conventions used

* = cut marked/modified material (bone, antler, ivory)

AF = ultrafiltration pretreatment (see Jacobi and Higham 2011: 225)

AI = ion-exchange gelatin date (see Jacobi and Higham 2011: 225)

AC = activated charcoal treatment (see Jacobi and Higham 2011: 225)

c = conventional date

= charcoal

OxCal (concatenation in Excel): “site abbrev”, “area/layer”, “excavation”, “species”, “date code”, “AF” * etc…

Eg: “GNC, Area I, NHM 1987-1989, Homo, OxA-17849 *”

Chapter 3 Northwest European Late Glacial Technocomplexes: Lithic Characterisations, Key Site Distributions and Resolutions

3.1 Introduction

This chapter describes eleven identified Northwest European Late Glacial (LG) lithic technocomplexes from within the area of the LG Channel River catchment (CRC) and its nearest neighbours. Reference sites for each technocomplex are also identified. The aim is to highlight the principal defining characteristics for each lithic technocomplex in order to provide a referential framework for regional landscape-based comparative study and spatial analysis. As such, the lithic characterisations provide a basis for the evaluation of the LG archaeological evidence from Southeast England within the Northwest European research framework (Chapter 4). The ultimate goal is to provide a means for addressing questions of dynamic landscape use and mobility paradigms for the LG of Southeast England and the CRC (Chapters 6 and 7).

An outline of the eleven technocomplexes discussed in the chapter is presented in Table 3-1. They are grouped based on their techno-typological attributes and ascribed to chronological period with their equivalent Greenland ice-core dates, based on current evidence.

Table 3-1 Outline of technocomplexes highlighted in this study

Principal Industries	Main aims of lithics production	Technocomplexes	Chronological and Palaeoenvironmental Context
Magdalenian (sections 3.2 and 3.3)	Blades and bladelet morphologies determine tool blanks	• Late Magdalenian • Cepoy-Marsangy • Classic Hamburgian • European Early Creswellian	GI-1e to GI-1d
Transitional-Azilianization (section 3.4)	Blades and bladelet morphologies determine tool blanks	• Havelte Hamburgian • Early Federmesser/ Azilian • European Late Creswellian	End GI-1e to GI-1d
Federmesser/ Azilian (section 3.5)	Mostly retouch to create tool morphologies	• Early Allerød Federmesser • Late Allerød Federmesser	GI-1c to GI-1a
Ahrensburgian/ Long Blade/ Belloisian (section 3.6)	Blades and Bladelets as tool blanks	• Ahrensburgian • Long-Blade/Belloisien	GI-1a to GS-1

In the following sections, information about chronology and dating is provided for each technocomplex. Chronozone and equivalent Greenland ice-core dates are given as standard, and direct scientific dating information is discussed where available. These data enable the contextual integration of contemporary climatic and palaeoenvironmental conditions for the landscapes associated with the technocomplexes. Table 3-2 reviews the dating and duration of the Greenland ice-core dates. Chapter 1 provides information about ice core dates.

Table 3-2 GRIP phases with associated dates , error factors, duration and equivalent Chronozones. (1) Rasmussen et al. 2014; (2) Mangerud et al. 1978)

GRIP phase (1) by		***Date (years b2K), start dates***	***Max. cumulative error i.c.y. (ice core years)***	***Duration & error (approx.)***	***Chronozone equivalent (2)***
start of GS-2a		*17,480*	*330*	*2788*	
GI-1e		*14,692 ± 4*	*186*	*617 (+-17)*	*Bølling*
GI-1d		*14,075*	*169*	*121 (+-4)*	*Older Dryas*
GI-1c	***GI-1c3***	*13,954*	*165*	*294 (+-7)*	*Early Allerød*
	GI-1c2	*13,660*	*158*	*60 (+-2)*	
	GI-1c1	*13,600*	*156*	*289 (+-7)*	
GI-1b		*13,311*	*149*	*212 (+-5)*	*Inter Allerød Cold Stage*
GI-1a		*13,099*	*143*	*203 (+-5)*	*Late Allerød*
GS-1		*12,896 ± 4*	*138*	*1193 (+-39)*	*Younger Dryas*
Start of Holocene		*11,703 ± 4*	*99*		

Three main topics are discussed for each of the lithic technocomplexes. These are:

- **objectives** of the knapping strategies and the nature of the intended products;
- **production strategies** including debitage and core preparation and reduction techniques used;
- **toolkit**, the range of tool types created and used and typological variation in design, especially with regard to armatures.

Within these topics, any **idiosyncrasies** of knapping strategies and products are identified for each technocomplex. The aim being to distinguish the **Strongest Identification Factors**, which are the most coherent and distinct elements for identification of the technocomplexes. Specific technological terms are defined where they first occur in the text.

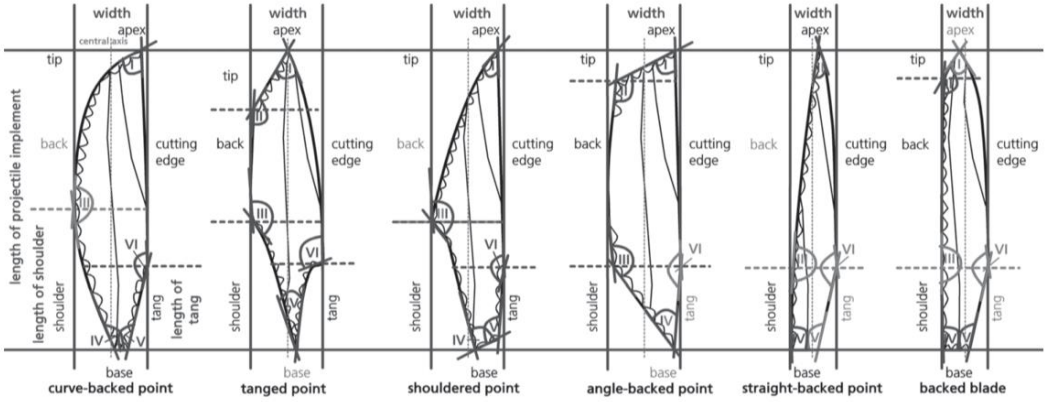


Figure 3.1 Main variations and descriptive elements referring to diagnostic point types. "Schematic outlines of various Lateglacial LMP. Terms and measured characters on various projectile implement types as applied in the present work (cf. *(Burdukiewicz & Schmider 2000, 98; Ikinger 1998, 41; Riede 2011)*. Characters, which are difficult to be distinguished and / or measured are given in light grey and were not measured. Angles are numbered: I – tip-cutting edge angle, II - tip-back angle, III - back-shoulder angle, IV - shoulder-base angle, V - base-tang angle, VI – tang-cutting edge angle. For further details see text." (Grimm 2013: 277).

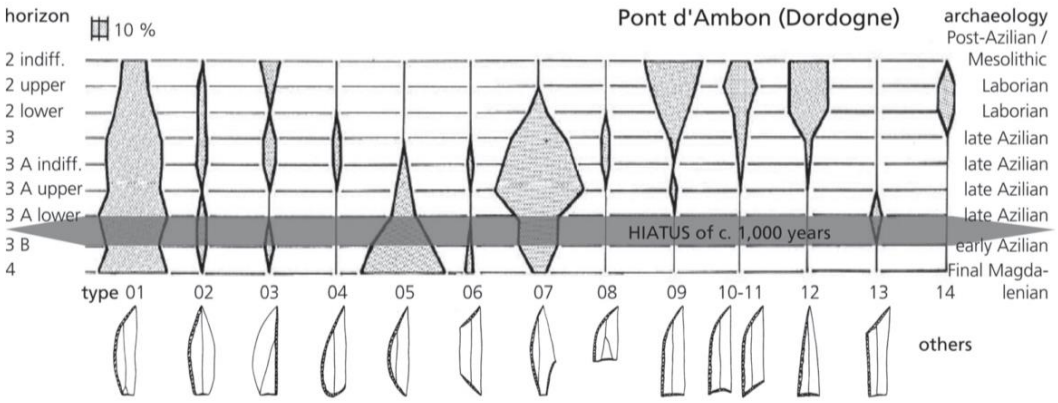


Figure 3.2 Typological variation of points at Pont d'Ambon. "Frequency distribution of various point types at the rock shelter Pont d'Ambon (Dordogne). Point types are: 1 – common Azilian point which is curve-backed without modification of the base; 2 – symmetric point which has a curve-backed retouch symmetrical to the opposite, unretouched edge; 3 – bulbous point which is a straight-backed point with a convex, opposite edge; 4 – point with rounded base is a curve-backed point with a retouch forming a rounded or ogival base; 5 – segment or bipoint which is formed by a regularly curved retouch affecting tip and base; 6 – double-truncated point with an usually unretouched edge between the two oblique truncations; 7 – point with narrowed base which is a curve-backed point with an oblique retouch on the base causing an almost tang-like impression; 8 – short point is the shortened variant of type 1 meaning the length-width proportions of the point are <2:1; 9 – typical Malaurie point with an almost straight-backed curved retouch and straight basal retouch; 10 – Malaurie point with concave basal retouch; 11 – Malaurie point with oblique basal retouch; 12 – straight-backed point with various basal modifications (comparable to a Gravette point); 13 – angle-backed point; 14 –others" (Grimm 2013: 76, modified after Célérier et al. 1993: 92).

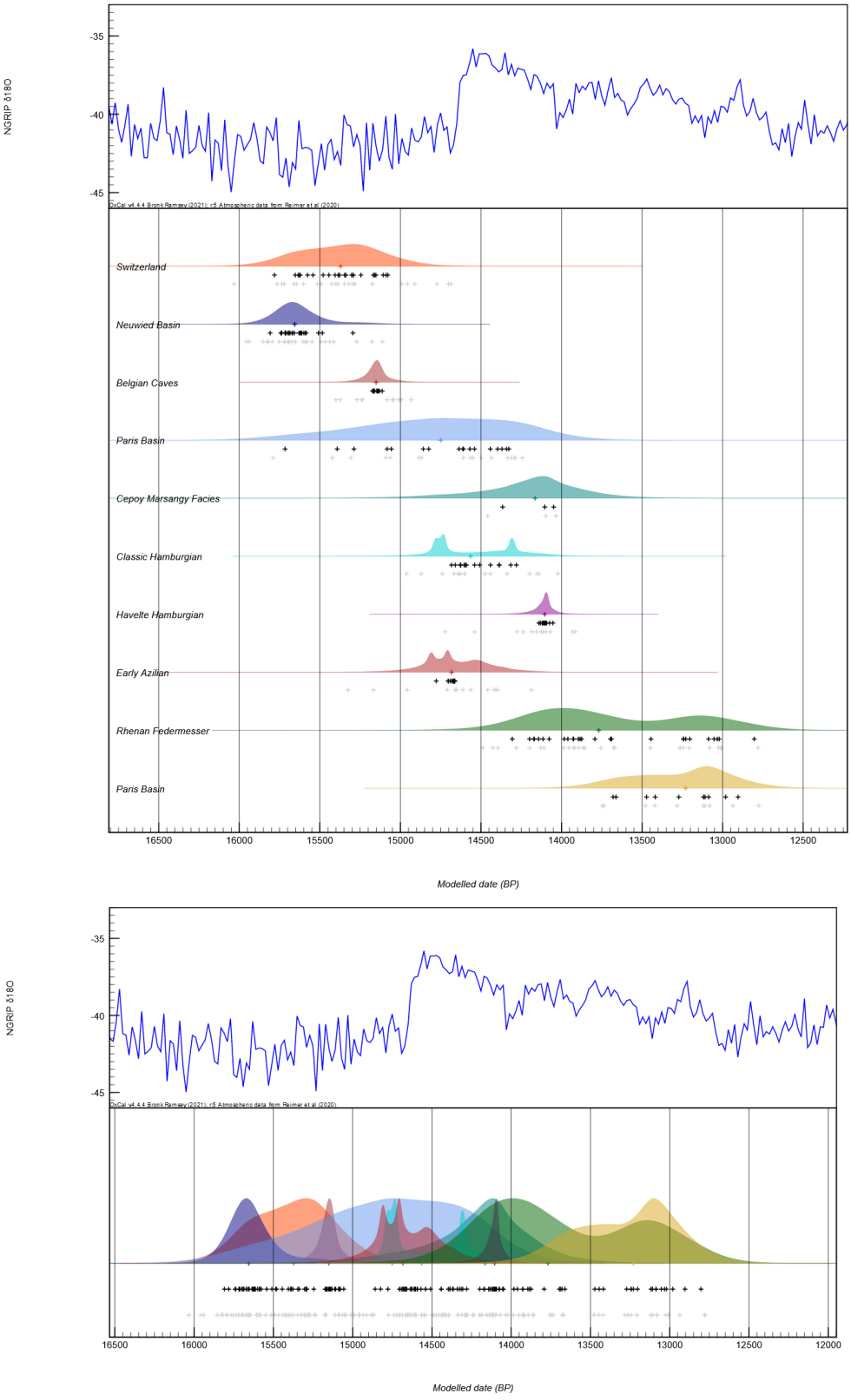


Figure 3.3 Summary of directly dated European technocomplexes by region discussed in this chapter.

3.2 'Classic' Late Magdalenian straight-backed bladelet technocomplexes (GS-2a to GI-1e, pre-Bølling and Bølling)

3.2.1 Introduction

The 'Classic' Late Magdalenian in Northern Europe is characterised by multiple high-resolution open-air sites. The quality of site preservation combined with extensive horizontal excavation methodologies has enabled the refitting of hundreds of lithic and bone debitage sequences on sites with successive occupations (Bodu 1994; Bosinski 1979; Brézillon & Leroi-Gourhan 1966; Cziesla 1990; Karlin & Newcomer 1982; Street & Turner 2016). This systematic refitting has enabled the reverse-engineering of the preferred methods and techniques for lithic production and strategies. These lithic assemblages are associated with organic materials (bone, antler, ivory), hearths and structures enabling a detailed analysis of not only the production of stone tools, but also of their usage and discard patterns (Bodu et al. 1990; Karlin & Julien 2012; Leroi-Gourhan 1972; Moss & Newcomer 1982; Street *et al.* 2006; Zubrow *et al.* 2010). Table 3-3 provides a summary of the key features of the 'Classic' Late Magdalenian technological reference sites considered in this section.

3.2.2 Landscape context

The well-defined Late Magdalenian sites are located south of the Channel River and along its course, with a presence of both cave sites and open-air sites in all landscape zones. The caves and rockshelters occur mainly in karstic regions, and open-air sites predominate in the Paris Basin and European lowlands. The Paris Basin sites are aggregated close to rivers and there is a concentration directly downstream from the

confluence of the Marne and Seine rivers (Schmider 1982). The Late Magdalenian site at Belloy-sur-Somme (La Plaisance, niveau inférieur) is located on the lowest terrace near the River Somme (Fagnart & Coudret 2000b, 116). Figure 3.4 shows the location of the directly dated 'Classic' Late Magdalenian sites mentioned in the chapter in relation to the Channel River catchment.

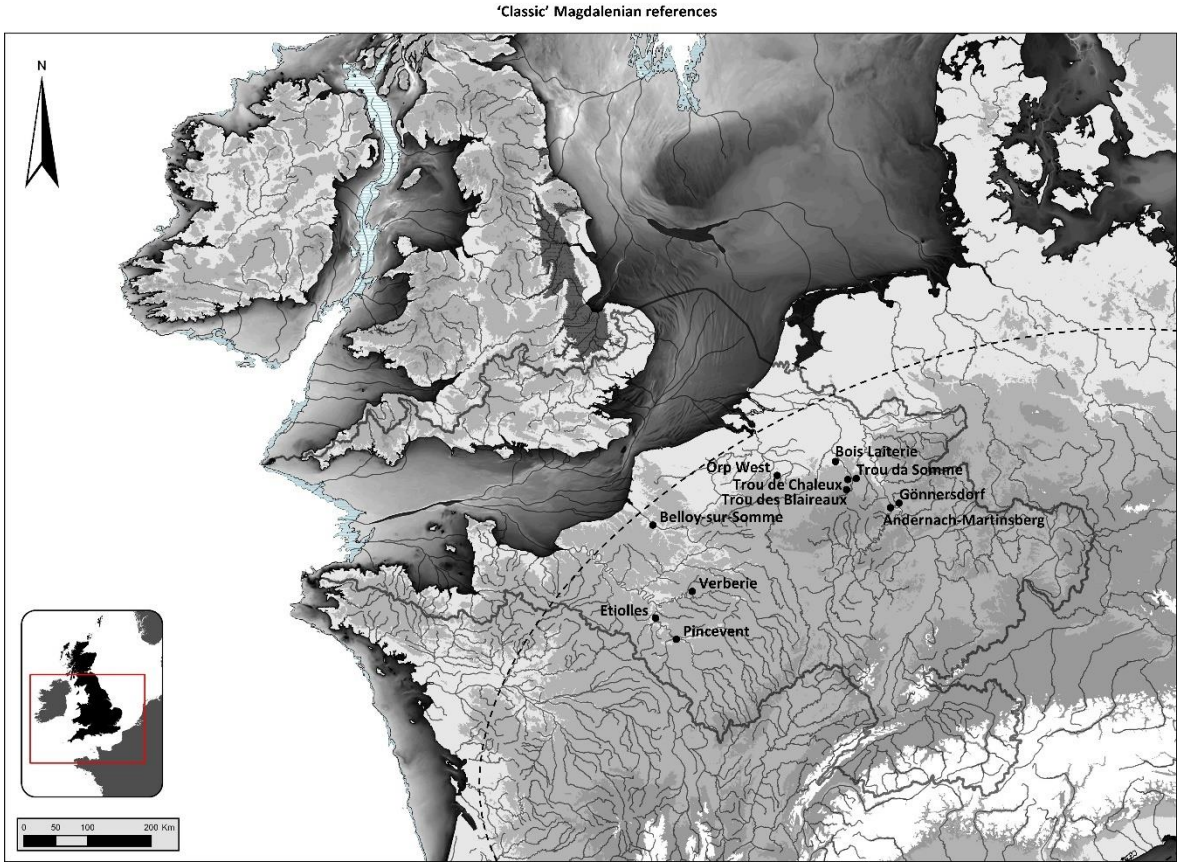


Figure 3.4 'Classic' Late Magdalenian reference sites. (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

3.2.3 Chronological Setting

The Late Magdalenian technocomplex within the catchment of the Channel River Network can be divided into two principal phases: pre-Bølling, and pre-Bølling to Bølling (Figure 3.5). The latter is represented in the Paris Basin, whereas the earlier occupations

are found in the Swiss Alps, the Neuwied Basin, the Lowlands Coversands and the Ardennes karstic region. The technocomplex covers a period of over 1000 years and is associated with the initial colonisation of Northern Europe following the LGM. Similar characteristics are maintained throughout the period. This section focusses on the pre-Bølling to Bølling Late Magdalenian in the Paris Basin, and contemporary to dated British Creswellian assemblages. Some assemblages in the Belgian Ardennes may also date to this period, however they are not discussed as they may represent palimpsests (Charles 1998a; Miller & Noiret 2009; Sano *et al.* 2011; Stevens *et al.* 2009a).

The dating evidence for the Late Magdalenian Paris Basin sites is predominantly Bølling (GI-1e), and in the case of Pincevent possibly even the Older Dryas (GI-1d) based on the interpretation of the fine sedimentary sequence (Chaussé 2003; Debout *et al.* 2014; Julien & Karlin 2014b; Leroyer *et al.* 2014; Orliac 1994; 1975; 2006; 2014; Pastre *et al.* 2000; Roblin-Jouve 1984; 2014; Roblin-Jouve *et al.* 2016). The earliest dates at Étiolles suggested a pre-Bølling age (Bodu *et al.* 2011; Caron-Laviolette *et al.* 2018; Debout *et al.* 2014; 2012; Roblin-Jouve *et al.* 2016; Valentin 2008a), although recent work also places later phases in the Bølling with the majority of Paris Basin sites (Debout *et al.* 2014).

Questions remain concerning the ages of the Paris Basin sites. Elsewhere in Northern Europe, the Late Magdalenian appears considerably older (Debout *et al.* 2014, 59; Stevens *et al.* 2009a; Straus *et al.* 2012; Street & Terberger 2004; Street *et al.* 2012; Valentin 2008a). This discrepancy could be a variation over time and space or a product of the dating method: i.e. over-reliance on conventional charcoal dates combined with a lack of ultra-filtrated AMS dates on anthropogenically modified organic material (Debout

et al. 2014; Higham *et al.* 2006; Jacobi & Higham 2011a; 2009b; Jacobi *et al.* 2009; Pettitt 2003). Recent AMS dates on bone from the Swiss sites of Champréveyres and Monruz confirm earlier charcoal dates and place the Magdalenian occupation in the pre-Bølling, preceding the Paris Basin sites by several hundred years and ending at the same time as its earliest occupations (Leesch *et al.* 2012, 202).

There are several open-air Late Magdalenian sites in Northeast France (Fagnart & Coudret 2000a), Belgium (Vermeersch & Symens 1988), the Netherlands (Rensink 2010; 2012) and north and central Germany (Holzkämper *et al.* 2013; Maier 2015; Street *et al.* 2006; 2012; Weber & Grimm 2008). These have no associated direct dates and, when available, sedimentary contexts indicate a pre-Bølling context (De Bie & Vermeersch 1998; Fagnart 1992; Rensink 2012; Stapert 1985; Vermeersch & Symens 1988; Weber & Grimm 2007).

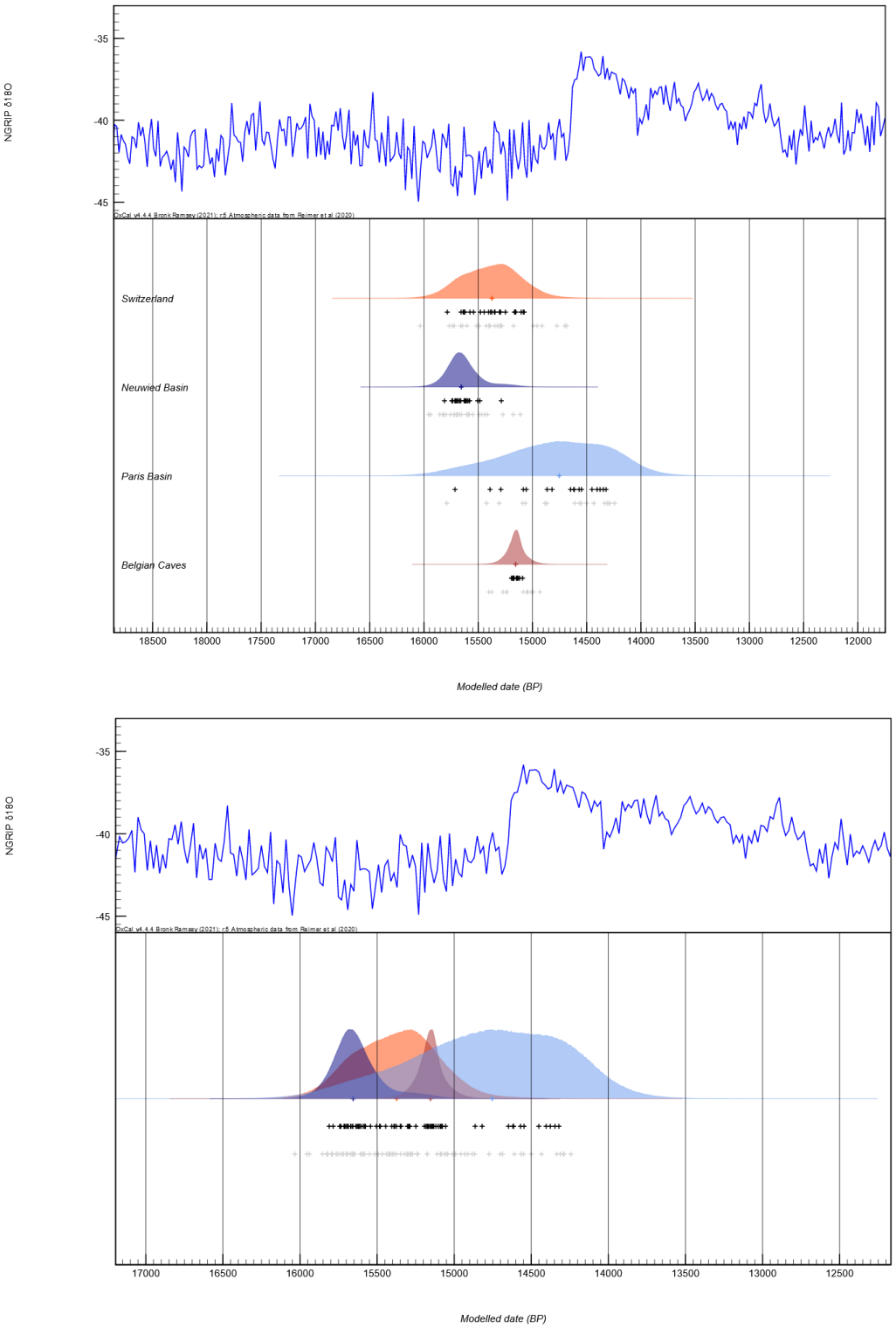


Figure 3.5 Synthesis plots of 'Classic Late Magdalenian" regions discussed in the thesis. KDE Model, OxCal 4.4 (Bronk Ramsey 2021) using IntCal20 (Reimer et al. 2020).

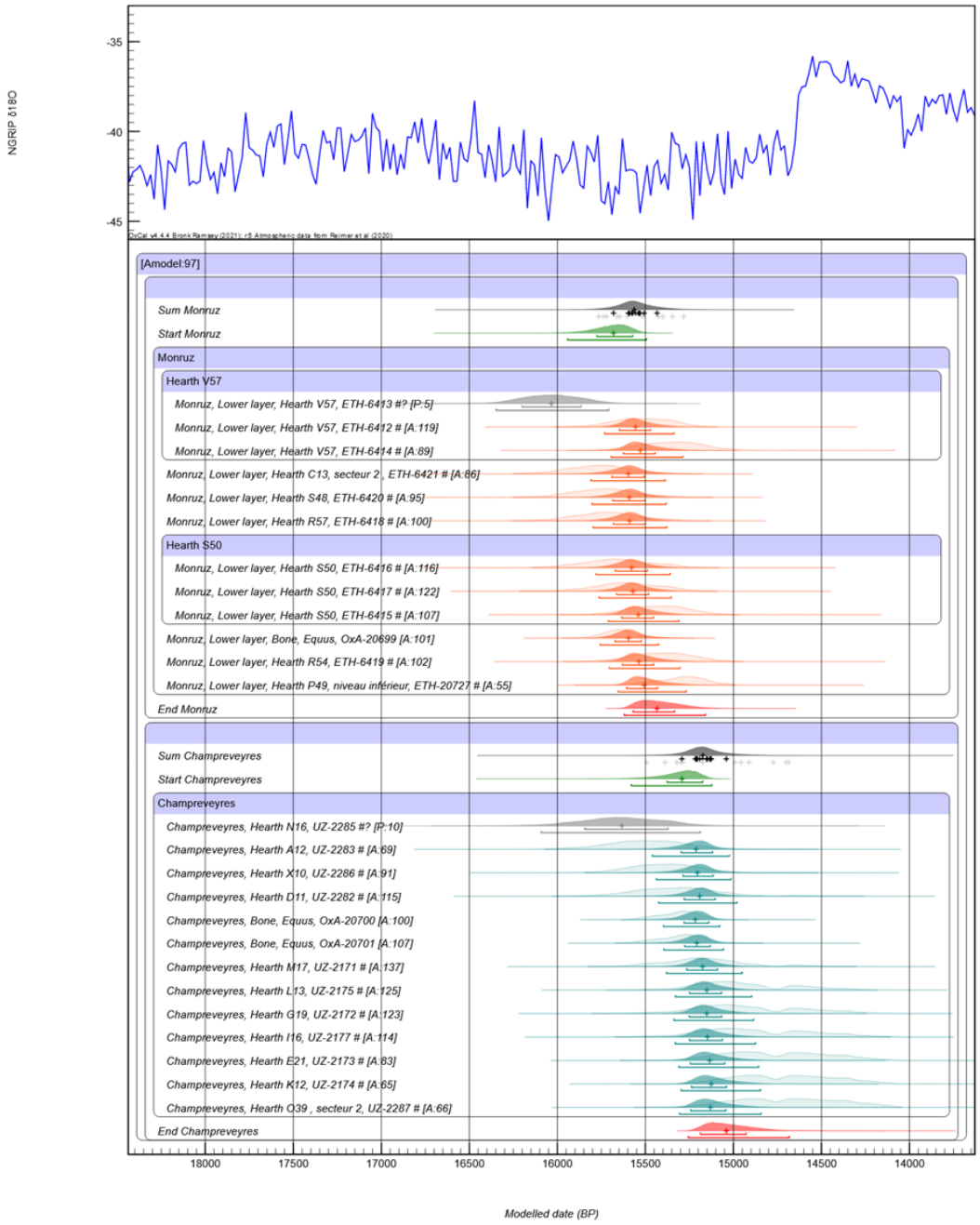


Figure 3.6 Swiss Magdalenian, Monruz and Champréveyres , selected dates after Leech 2012 and Debout et al. 2014. ETH-6413 and UZ-2285 are shown but have been excluded from the model as outliers (grey). Overlapping uniform phases of the two sites (one phase per site)

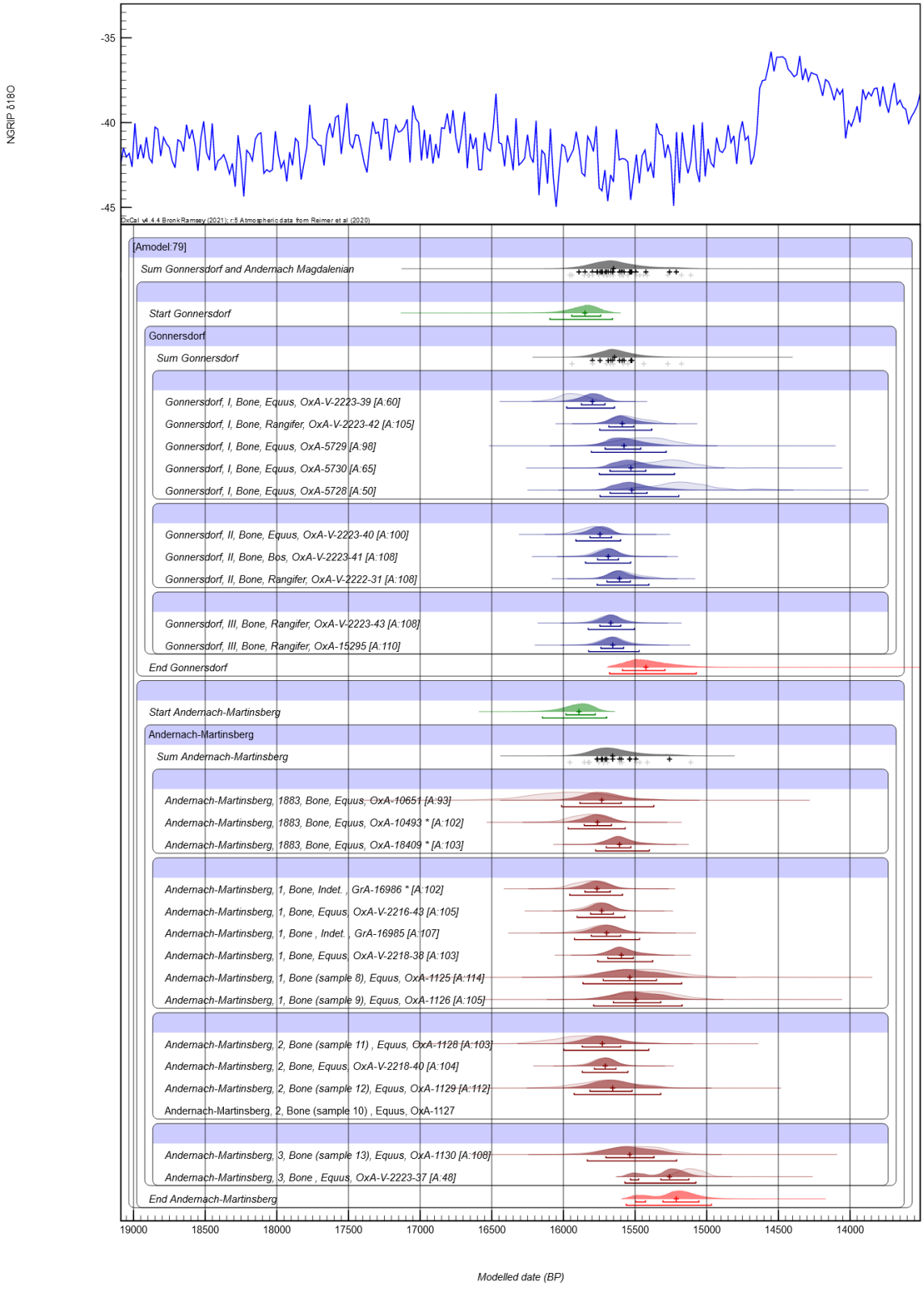


Figure 3.7 Andernach and Gönnersdorf Magdalenian horizons. Dates selected from Stevens et al. 2009, overlapping phases. The dates are contemporaneous with the Swiss sites and earlier than the Paris Basin.

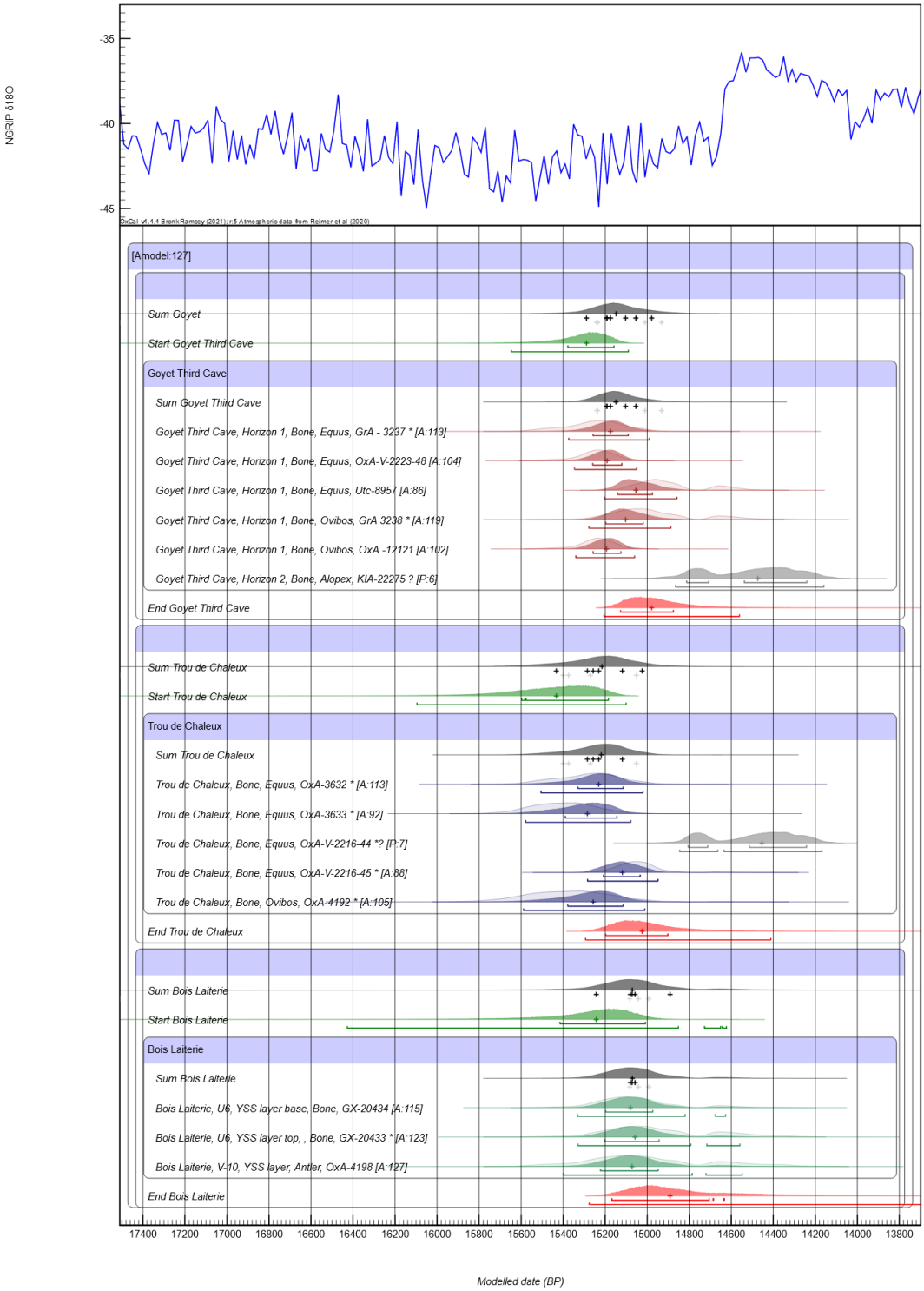


Figure 3.8 Belgian Magdalenian cave site horizons. Selection of dates from Sano et al. 2011 and Stevens et al. 2009. Overlapping phases. Both Goyet and Chaleux may have two Magdalenian occupations (see Stevens et al. 2009). It appears that the dates from La Bois Laiterie group within the second Magdalenian group. Date KIA-22275 from Goyet Third Cave and OxA-V-2216-44 from Trou de Chaleux are considered as outliers (grey) in this model. Good agreement of the model A:119. Preceding and contemporary with the Paris Basin Magdalenian and contemporary with the Creswellian.

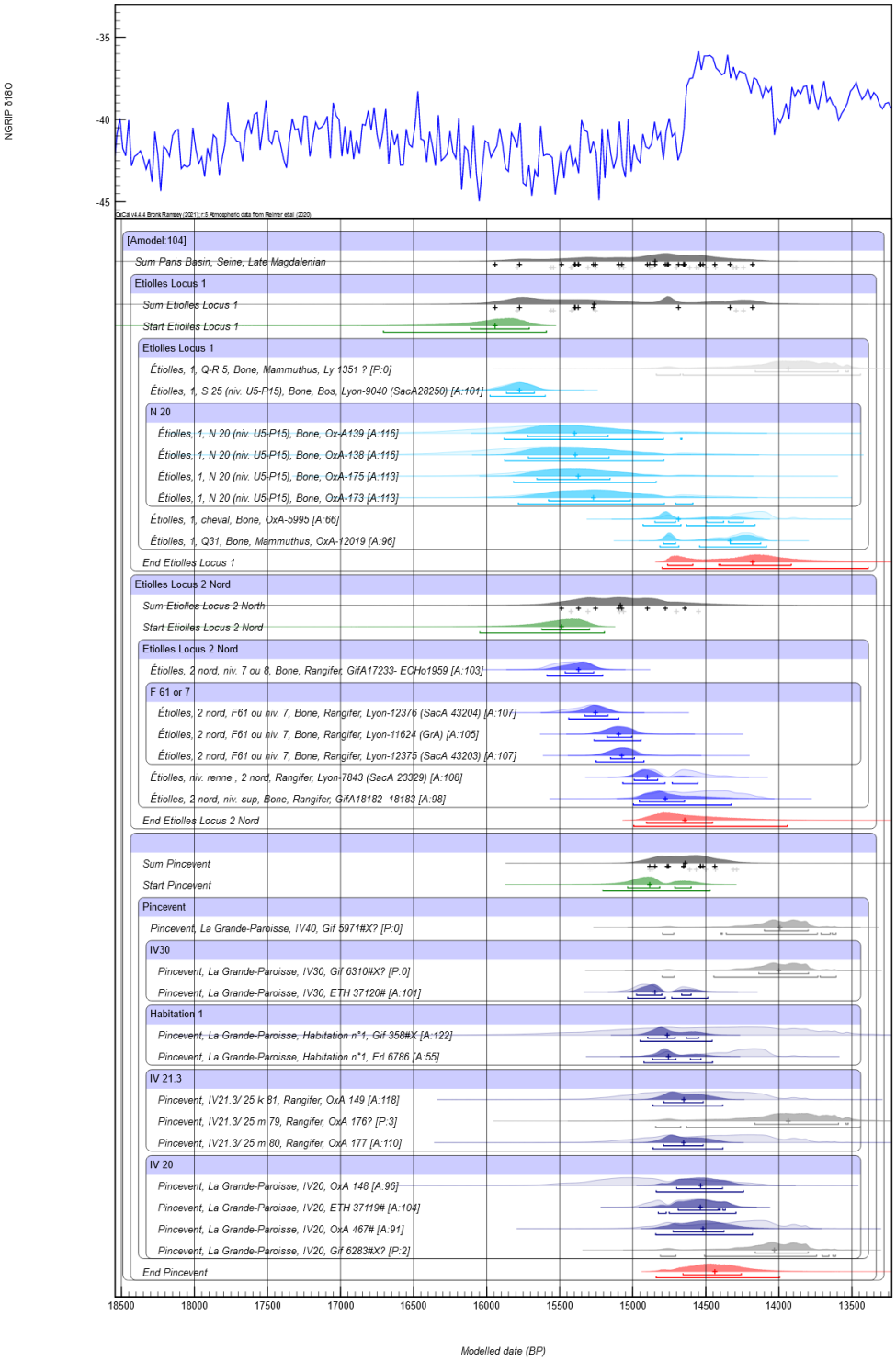


Figure 3.9 Seine catchment Late Magdalenian , Etiolles and Pincevent overlapping sequences. Etiolles in stratigraphic order (Roblin-Jouve et al. 2016 and Olive et al .2019) and Pincevent dates in stratigraphic order (Bodu 2004, Debout et al. 2014 and Karlin and Julien 2018). These dates have not undergone isotopic and recent collagen control. Some dates were obvious outliers due to their stratigraphic position, and removed from the model (light grey), two other dates had low agreement index values in previous models and are marked as outliers.

3.2.4 Techno-typological Description

Several debitage 'objectives' for this technocomplex have been highlighted through systematic refitting of material from some zones of the occupation horizons of Pincevent IV20 and IV0. These 'objectives' include the production of well-made elongated blades (mostly 70-80mm long) that serve multiple purposes (Figure 3.10), and the production of straight blanks (mostly 40-50mm) well-calibrated for transformation into straight-backed bladelets (Figure 3.12) (Bodu *et al.* 2006b; Julien & Karlin 2014a; Ploux *et al.* 2014). Other tools were made on a variety of blanks (Figure 3.11), either blades or general debitage morphologies depending on the tool/form produced (Bodu *et al.* 2006b; Julien & Karlin 2014a).

Detailed refitting at Pincevent has shown that the early stages of core preparation took place mostly on-site (Bodu *et al.* 2006b; Julien & Karlin 2014a). This is common for the Paris Basin sites that are located near primary and secondary flint deposits. Étiolles is the reference example of a knapping locality near good raw material sources and the assemblage demonstrates technical expertise and the intent of producing long regular blades (Olive 2004; Olive *et al.* 2005). In contrast, an apparent absence of cortical material related to initial core shaping was noted for regions further afield from good flint sources. For sites in these areas it appears that good quality flint was brought in as pre-prepared cores or blades (Floss 2002; 2010; Miller & Noiret 2009; Rensink 2010; Sano *et al.* 2011; Street *et al.* 2006). Table 3-3 summarises the lithic technological characteristics of the Paris Basin Late Magdalenian assemblages.

Table 3-3 Paris Basin Late Magdalenian: Lithic technological characteristics

Technological Characteristics	Summary description of the defining features of the Late Magdalenian
Objectives	Carefully prepared, regular, long and calibrated blades, presence of a specialised straight bladelet component for armatures.
Core preparation	Systematic use of crests to develop cores, can have two or three crests; preferential acutely angled platform; multiple tablets to preserve platform angle; abrupt angle between platform and removal enabling the use of soft hammer (organic); opposed platform for correction; some cores reduced to bladelet cores, other cores/large flakes prepared for bladelet production.
Debitage	Hard-stone hammer in the early stages of volumetric core shaping; frequent if not sole use of organic hammer for the production of long blades; possible use of soft-stone hammer to produce straighter shorter bladelets; careful preparation of striking platform: Éperon technique; abrasion; semi- or complete rotation around a platform to produce blades. Backing of blades and bladelets with direct abrupt retouch and the use of an anvil.
Tools	End-scrapers on long blades; dihedral burins; backed bladelets; piercers/becs, Lacan-type burins
Armatures	Backed bladelets, marginally backed points
Idiosyncrasies	Selection of high-quality raw material. Often raw material transported to site pre-prepared (absence of cortical and early stage debitage); rare exceptions of in-situ core preparation near high-quality sources indicating the early stages of preparation (Étiolles, Pincevent) selection of high-quality raw material; very curved long blades.
Distinct absences	There is an absence of finely laterally retouched blades, 'skimming retouch' as in the Early Azilian.

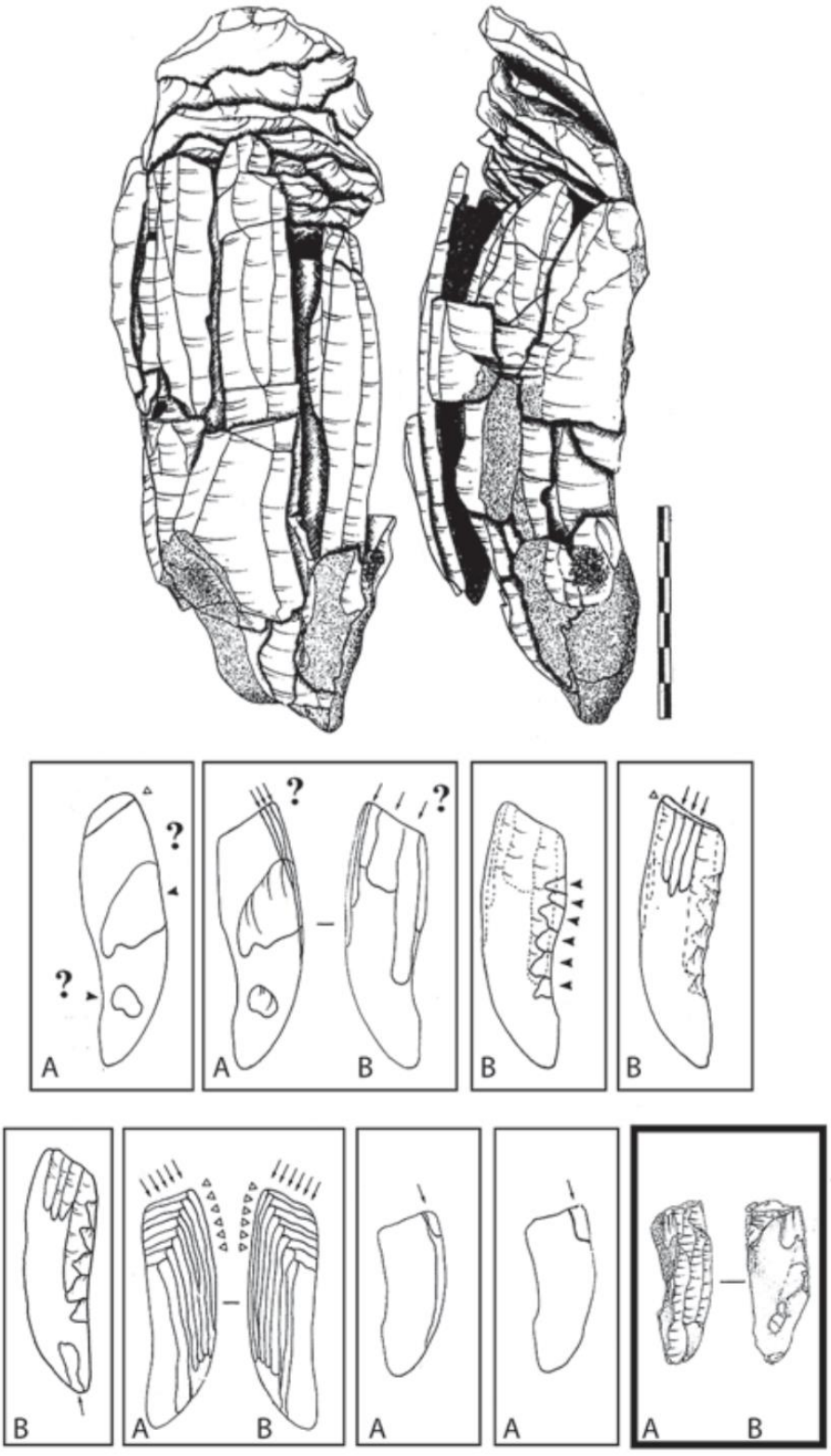


Figure 3.10 Sequence 45-N128.1, Pincevent IV20: The production of long blades with a minimum of volumetric preparation, applying a unipolar semi-rotating knapping sequence, with sporadic interventions from an opposed platform. Produced by an experienced knapper who demonstrates very advanced knapping and adaptive skills. (drawings D. Molez). (Translation W. Mills). Ploux et al., in Julien and Karlin 2014: 96.

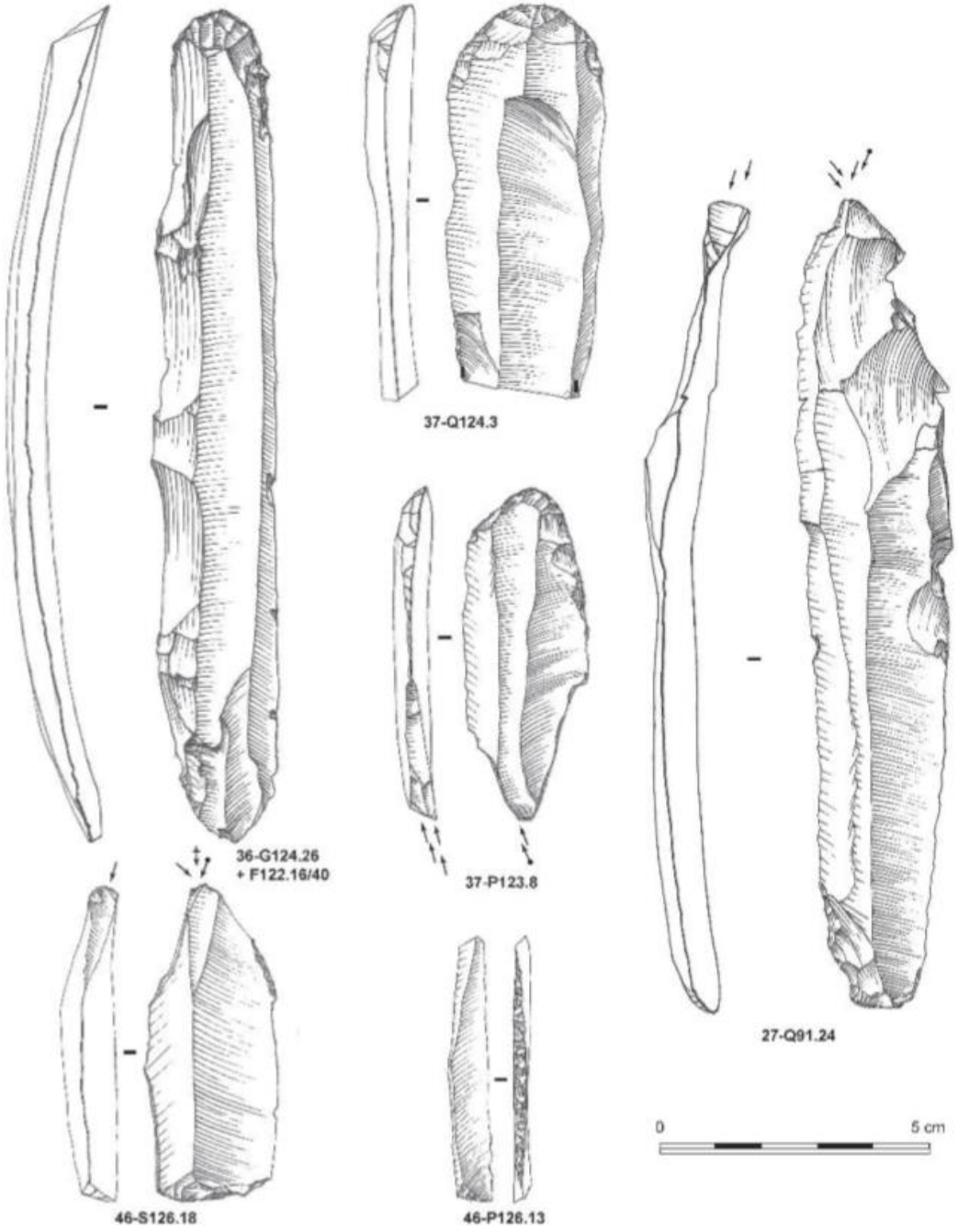


Figure 3.11 Selection of Late Magdalenian domestic tools from Pincevent, level IV20. End-scrapers on blades, burin end-scraper, burins and backed point. Drawings M. Ballinger. From Julien and Karlin 2014:84.

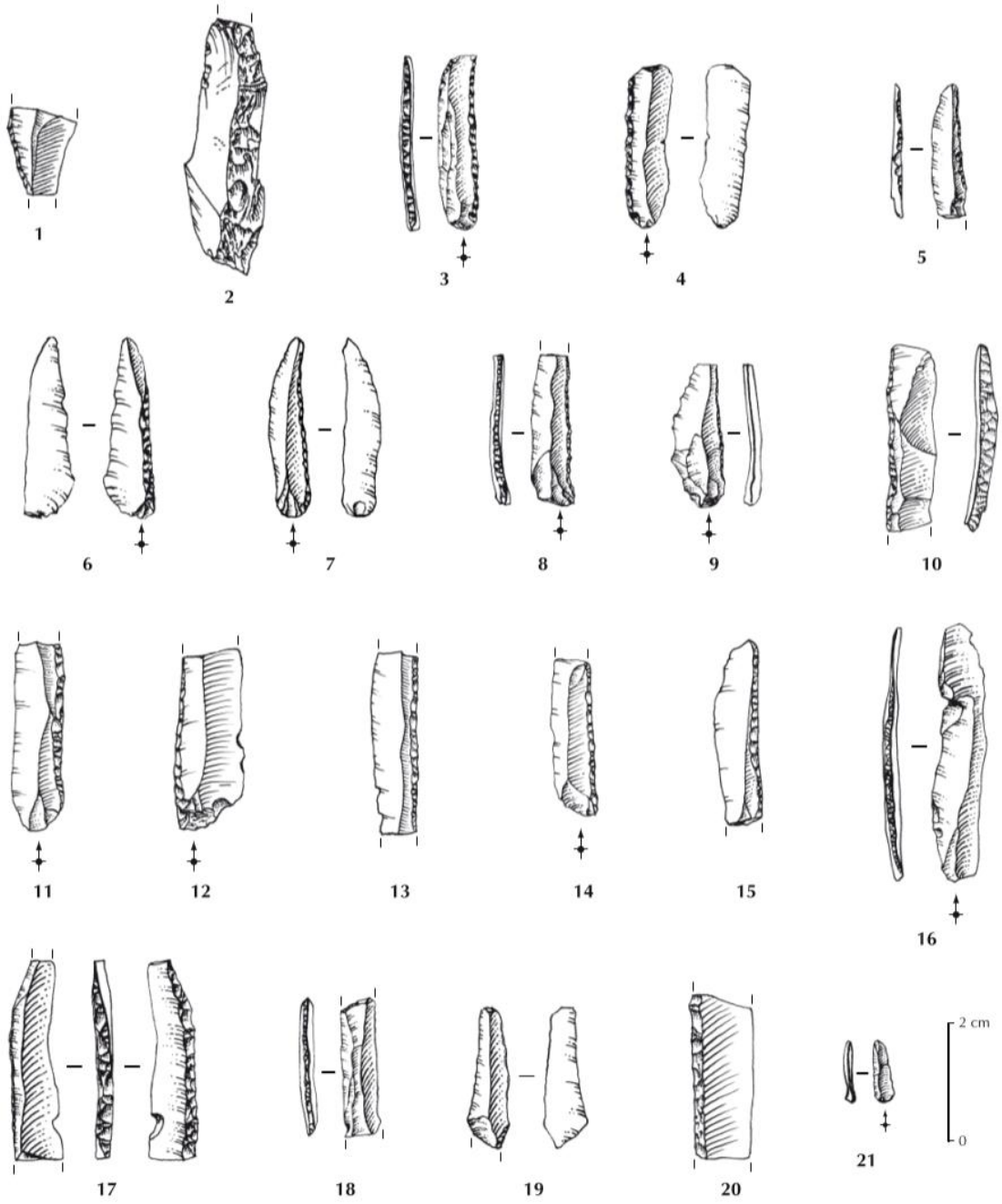


Figure 3.12 Examples of backed bladelets (3-21) and possible backed points (1-2) from Pincevent level IV0. Drawings D. Molez. Valentin in Bodu et al. 2006:73.

3.3 'Northern' Final Magdalenian angle-backed and shouldered point technocomplexes (GI-1e to GI-1c, Bølling and Older Dryas)

3.3.1 Introduction

The 'Northern' Final Magdalenian technocomplex dates to the initial LG warming phase (GI-1e) based on only a few sites. Various facies (variants) are recognised, and some may have been contemporary with the Paris Basin Classic Late Magdalenian. Two of the industries, the Classic Hamburgian and Early Creswellian, provide archaeological evidence for renewed and sustained human occupation following the LGM in regions above the 49th parallel north in Northwest Europe (Britain, Netherlands, Germany). There is also limited evidence of human activity in this period from Doggerland (Amkreutz *et al.* 2018; Gaffney *et al.* 2017; Ward *et al.* 2016).

The technocomplex has technological parallels with the Late Magdalenian, but with distinct typological variations including the occurrence of angle-backed and shouldered points. It has been suggested that the development of these points was a functional adaptation to new hunting practices in the changing environmental setting (Bodu 2003; Jacobi & Higham 2011a; Leesch *et al.* 2012). However, this is difficult to assess due to variation in the nature of sites across the region. Geographically, the western part of the region contains mainly cave sites with horse faunas, while open-air sites with reindeer faunas dominate in the east (Barton *et al.* 2003; Eriksen 2002; Weber & Grimm 2008).

In this thesis the term 'Northern' Final Magdalenian is used to distinguish these industries from the 'Classic' Final Magdalenian technocomplex of southern France and Switzerland.

Both ’Northern’ and ‘Classic’ industries contain angle-backed and shouldered points as well as Late Magdalenian-style blade and bladelet production strategies. However, there are significant differences between the two technocomplexes including the absence of several diagnostic ‘Classic’ elements in the ‘Northern’ industries: for example, Laugerie Points, Teyjat points, and denticulate backed bladelets (Barton *et al.* 2003; Langlais *et al.* 2012; Schmider 1982). As such, the two are considered to be separate at present. There are few high-resolution sites for these industries, and questions remain concerning the genesis of these distinct regional traditions that share many Late Magdalenian traits.

3.3.2 Cepoy-Marsangy Facies

The Cepoy-Marsangy facies is named after two Paris Basin sites with Late Magdalenian-style assemblages containing angle-backed points: Cepoy and Marsangy (Schmider 1982; Valentin 1995a; 2008a). At these sites the production of blanks for the angle-backed points seems to favour short, straight and thick blades. The transition to a predominant or alternating soft organic and soft stone mode of percussion has also been highlighted (Valentin 2008b; Weber 2012). It has been speculated that the use of angle-backed points might be associated with a non-reindeer hunting strategy or even the use of the bow as opposed to the spear-thrower (Burdukiewicz & Schmider 2000). Faunal assemblages indicate the presence of bovids (Cepoy), red deer (Marsangy), and horse (Tureau des Gardes and Le Grand Canton) (Alix *et al.* 1993; Debout *et al.* 2011; Weber 2012). Table 3-4 provides a summary of the key features of the Cepoy-Marsangy 'facies' reference sites considered in this section.

3.3.2.1 Landscape Context

The Cepoy-Marsangy facies is spread throughout the Channel River catchment, with both open-air (Paris Basin) (Valentin 1995a; Weber 2006; 2012) contexts and parallels made with angle backed forms in cave sites (Swiss Alps and Belgian Ardennes (Leesch *et al.* 2012; Sano *et al.* 2011). The presence of the facies north of the Channel River remains to be formally demonstrated despite the occurrence of angle-backed points in Britain. Figure 3.13 shows the location of the directly dated Cepoy-Marsangy sites mentioned in the chapter in relation to the Channel River catchment.

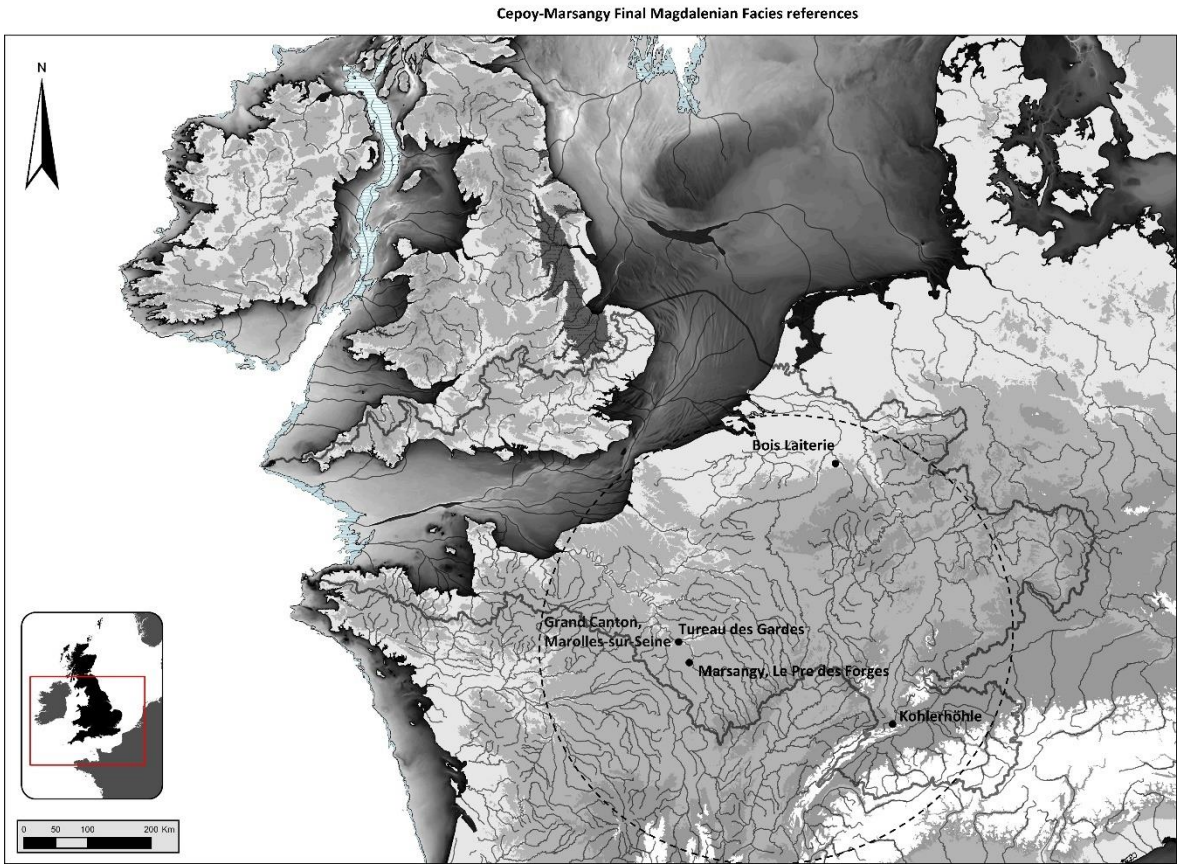


Figure 3.13 Cepoy-Marsangy facies reference sites. (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

3.3.2.2 Chronological Setting

The Cepoy-Marsangy facies is not well-dated but appears to have developed during the Late Bølling and Older Dryas (Figure 3.14, Figure 3.15) (Bodu 2003; Schmider 1982). The dating is problematic for two reasons: (1) the absence of well-isolated stratigraphic horizons with material for radiocarbon dating; and (2) a reliance on old AMS dates with large error margins. The Marsangy site is dated to the Older Dryas or Allerød, and Le Grand Canton to the end of the Bølling or Early Allerød (Alix *et al.* 1993). The site of Tureau des Gardes is dated to the pre- or Early Bølling based on stratigraphy and is contemporary to the Late Magdalenian and the British Early Creswellian.

'Classic' Final Magdalenian assemblages with angle-backed and shouldered points have been dated in the Swiss Alps to the same period. These come from relatively poorly defined cave horizons, but with clear separation from earlier straight-backed bladelet Late Magdalenian horizons (Leesch *et al.* 2012, 197). The cave site of Kohlerhöhle in the Swiss Jura has angle-backed points and relatively late dates (Early Allerød), but is a mixed assemblage (Leesch *et al.* 2012, 203). The Swabian Alps assemblages with angle-backed points are dated to the Early Allerød (Schmider 1982, 267). The site of Gönnersdorf SW that has angle-backed points and a red deer fauna dated to the Bølling (Street *et al.* 2006, 762). In the Belgian Ardennes, Le Bois Laiterie has angle-backed pieces but pre-Bølling to Bølling dates and is possibly an early transitional assemblage (Sano *et al.* 2011).

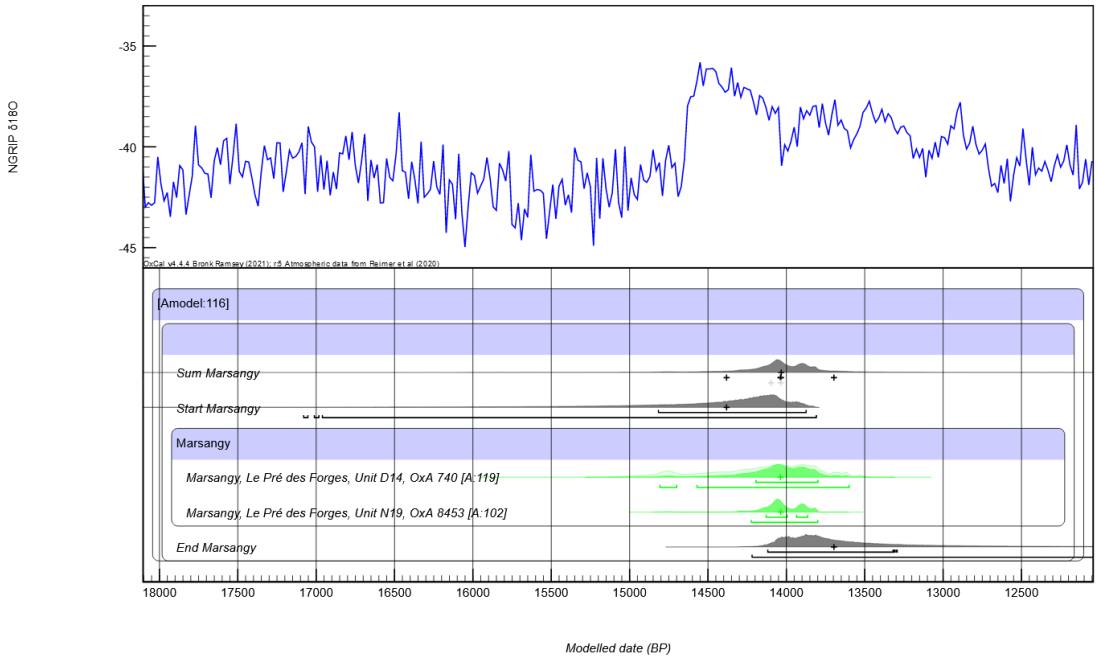


Figure 3.14 Marsangy. Dates from Debout et al. 2014. Single uniform Phase.

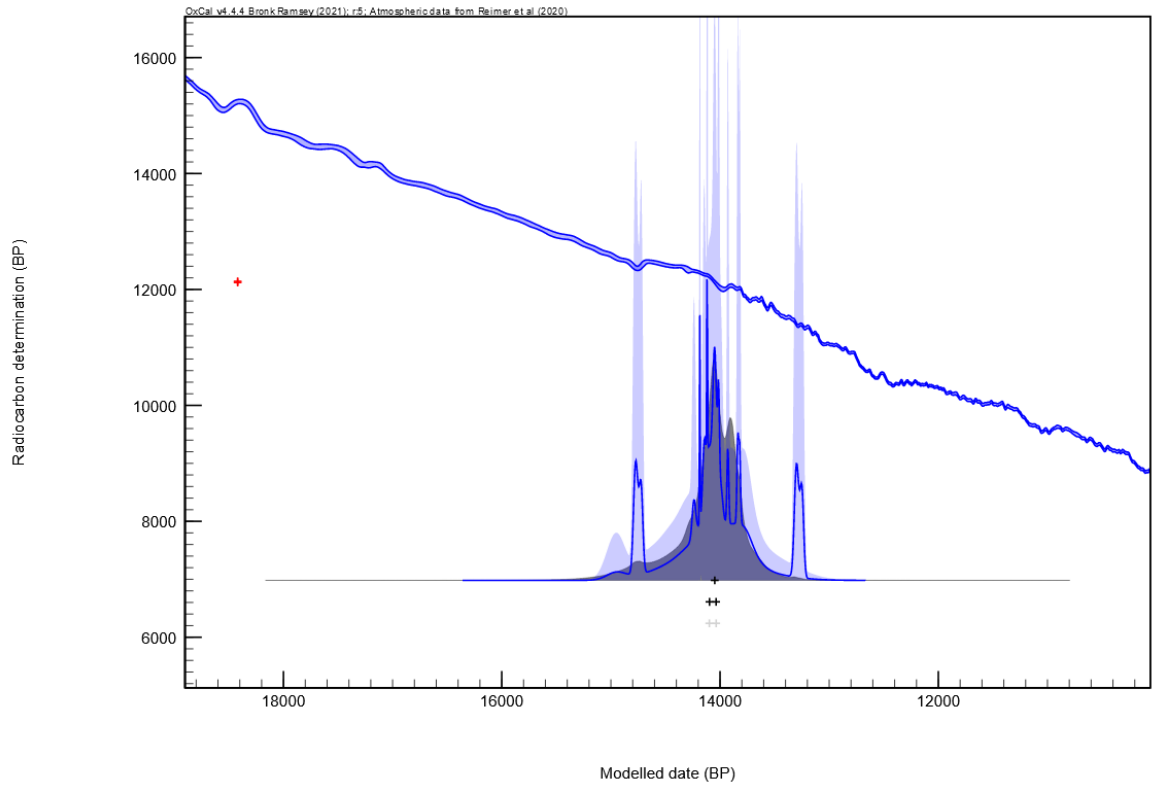


Figure 3.15 Marsangy dates, KDE plot , modelled in OxCal 4.4 (Bronk Ramsey 2021) using IntCal20 (Reimer et al. 2020).

3.3.2.3 Description of techno-typology

The presence of angle-backed (Figure 3.16, Figure 3.18, Figure 3.19) and shouldered points and of variations in the proportions of domestic tools (scrapers, burins, piercers) (Figure 3.17) distinguish the Cepoy-Marsangy sites from the Classic Late Magdalenian (Schmider 1982; Valentin *et al.* 2006). Straight-backed bladelets are also present but quantities vary in inverse proportion to those of angle-backed pieces (i.e. there are fewer straight-backed bladelets in assemblages with more angle-backed points and *vice versa*) (Burdukiewicz & Schmider 2000). There may be a chronological component to this factor as at Marsangy (earlier) there are many straight-backed and few angle-backed pieces, but at Cepoy (later) the proportions are reversed (Alix *et al.* 1993; Burdukiewicz & Schmider 2000; Valentin 2006a).

There has been little refitting work on these assemblages, the most recent being at Tureau des Gardes (Valentin 2006a; Weber 2006) and possibly Bois-Laiterie (Sano *et al.* 2011). One technological variation associated with the angle-backed point assemblages is a higher occurrence of soft-stone percussion with the aim of creating more robust and straighter blades and bladelets. The predominance of soft-stone hammer to produce short straight blades, and absence of a predominantly bladelet production are recurring features of this facies (Bodu *et al.* 2006a; Sano *et al.* 2011, 472; Valentin 1995a, 101; Valentin *et al.* 2004b).

Angle-backed points are the most characteristic element of these assemblages. They are usually made on the mesial portion of narrow robust straight blades and are truncated across the long axis (Burdukiewicz & Schmider 2000, 101; Valentin 1995a). Valentin

further defines the type “the only morphological constant is the presence of a sharp point formed by a truncation and a straight un-retouched edge” (1995, 436; translation by W Mills). The Cepoy-Marsangy angle-backed points often have a basal truncation, and occasionally retouch opposite the shoulder, distinguishing them from Hamburgian points (Burdukiewicz & Schmider 2000, 104). The angle-backed points from the Paris Basin have been divided into two groups based on morphology: a longer narrower group from Marsangy (with straight-backed bladelets) and a shorter broader group with points from Cepoy and Marolles (Burdukiewicz & Schmider 2000, 105).

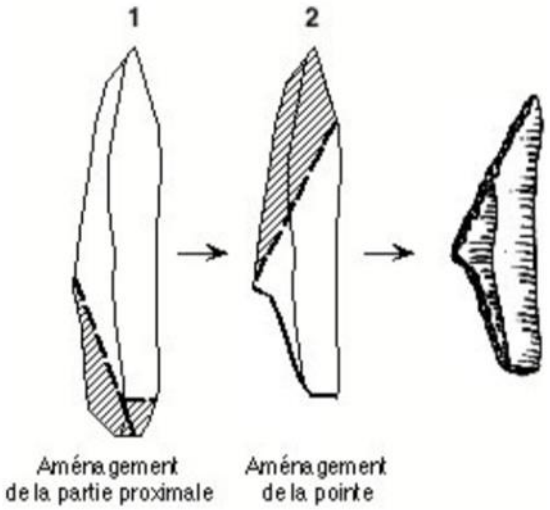


Figure 3.16 Process of making angle backed points at Cepoy (left), by initially removing the proximal (1) followed by (2) an oblique truncation (Valentin 1995: 340-341).

These angle-backed points do not occur at other North European Late Magdalenian sites dominated by straight-backed bladelets. They are also different from the southern French Late Magdalenian shouldered and tanged points (Laugerie and Teyjat points respectively) (Célérier *et al.* 1997). A tentative link between the Cepoy-Marsangy facies and the Hamburgian has been proposed, notably for Cepoy where there are few backed bladelets and the assemblage also contains tools such as becs (Figure 3.17, Figure 3.20), some with

shorter points resembling Hamburgian 'zinken' (Burdukiewicz & Schmider 2000; Schmider 1982, 267). The basal retouch of the Cepoy-Marsangy angle-backed points distinguishes them from Early Creswellian bi-truncated Cheddar points. A possible link to the development of the Early Azilian has been proposed as angle-backed points have been found in association with curved or straight-backed points at Marsangy, Le Bois Laiterie, and Étouvie (Sano *et al.* 2011; Valentin 2008a). Table 3-4 summarises the lithic technological characteristics of the Cepoy-Marsangy facies assemblages.

Table 3-4 Cepoy-Marsangy Facies: Lithic technological characteristics

Technological Characteristics	Summary description of the defining features of the Cepoy-Marsangy Facies
Objectives	Well-made blades, straight blades/bladelets
Core preparation	Use of crests, preferential platform; multiple tablets to refresh platform angle; bladelet angles less acute (soft-stone debitage)
debitage	Use of crests, preferential platform; multiple tablets to refresh platform angle; bladelet angles less acute (soft-stone debitage); long curved blades (soft-organic) and short straight blades (soft stone); use of both organic and soft stone hammers
Tools	End-scrapers on long blades; becs
Armatures	Angle-backed points, obliquely-backed points, curve-backed bipoints, straight-backed bladelets,
Idiosyncrasies	Debitage has both 'Classic' Magdalenian and Azilian characteristics. Angle-backed points are the most characteristic element.
Strongest identification factors	Angle-backed points, soft stone hammer

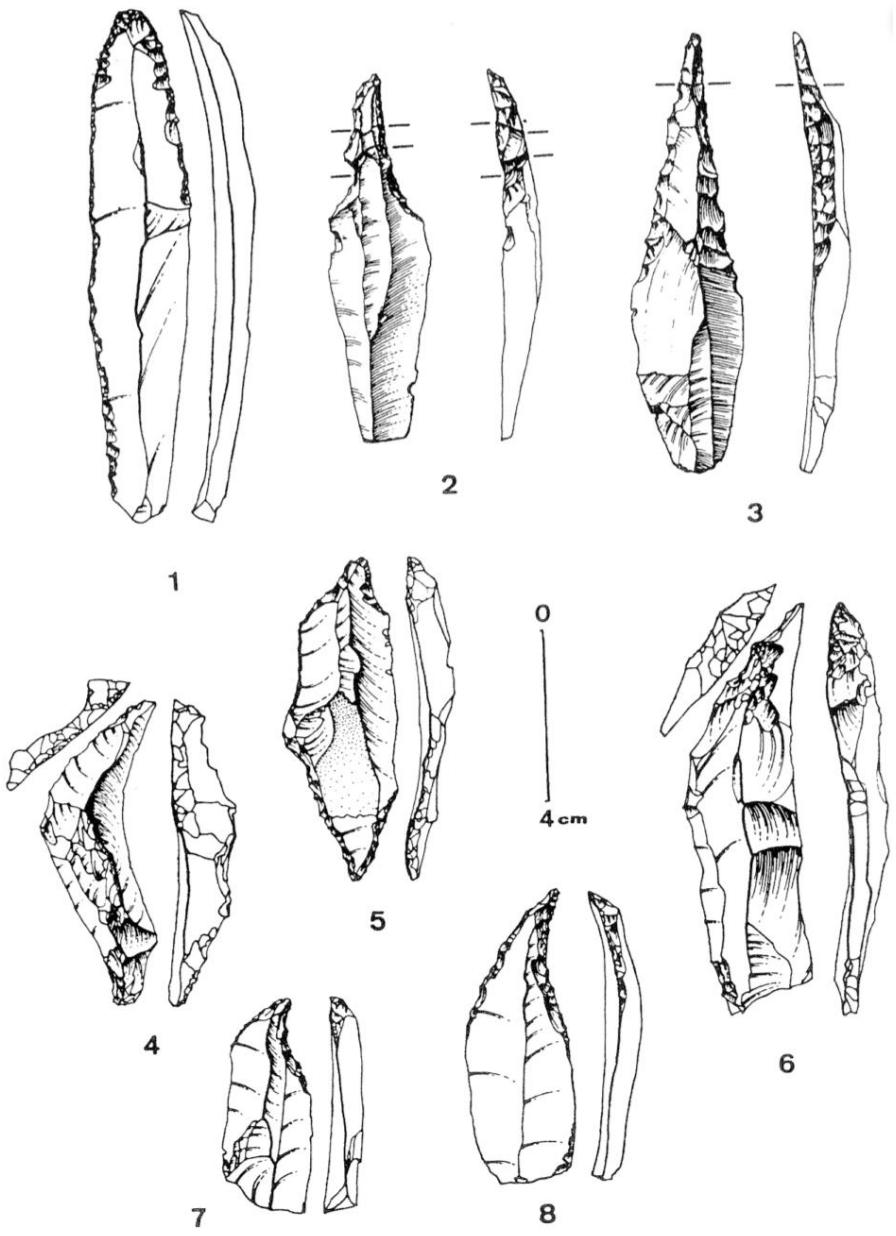


Figure 3.17 Marsangy: Magdalenian becs , Schmider 1982

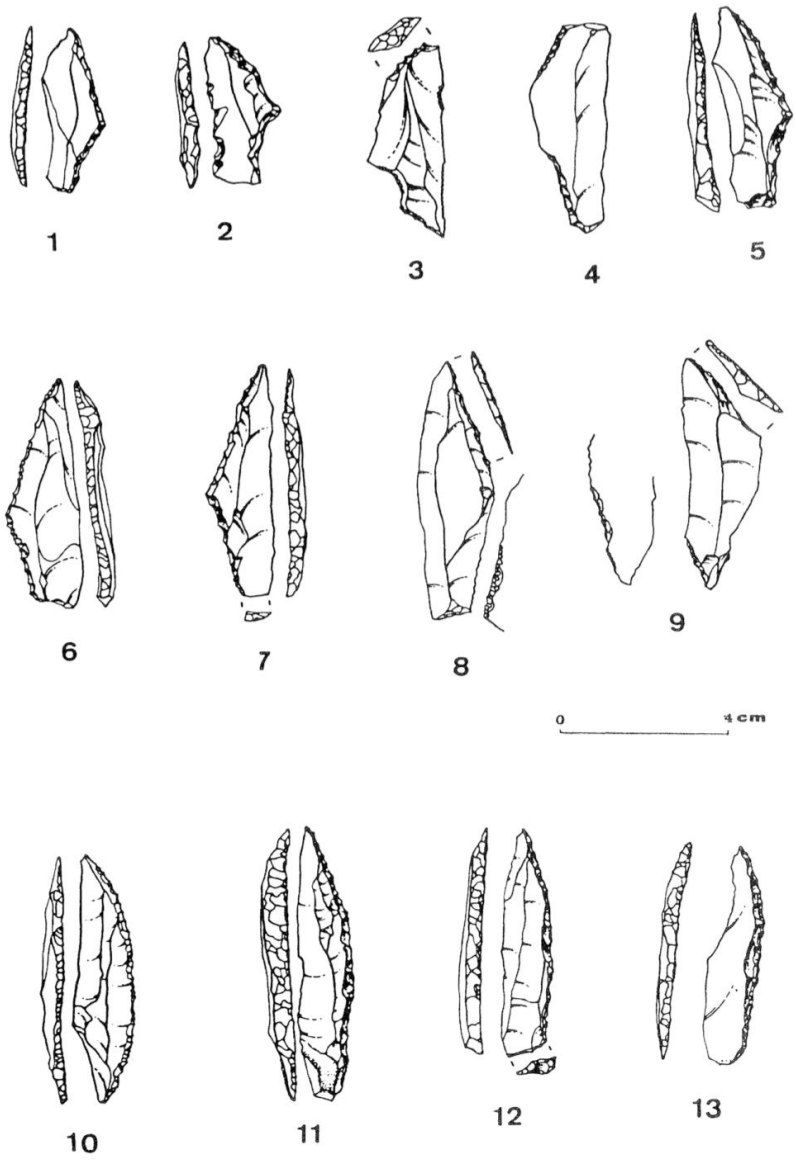


Figure 4 Marsangy: Magdalenian truncated points (nos 1–9); curved-backed points (nos 10–13).

Figure 3.18 Angle backed points (1-9), curved backed points (10-13), Marsangy (Schmider 1982).

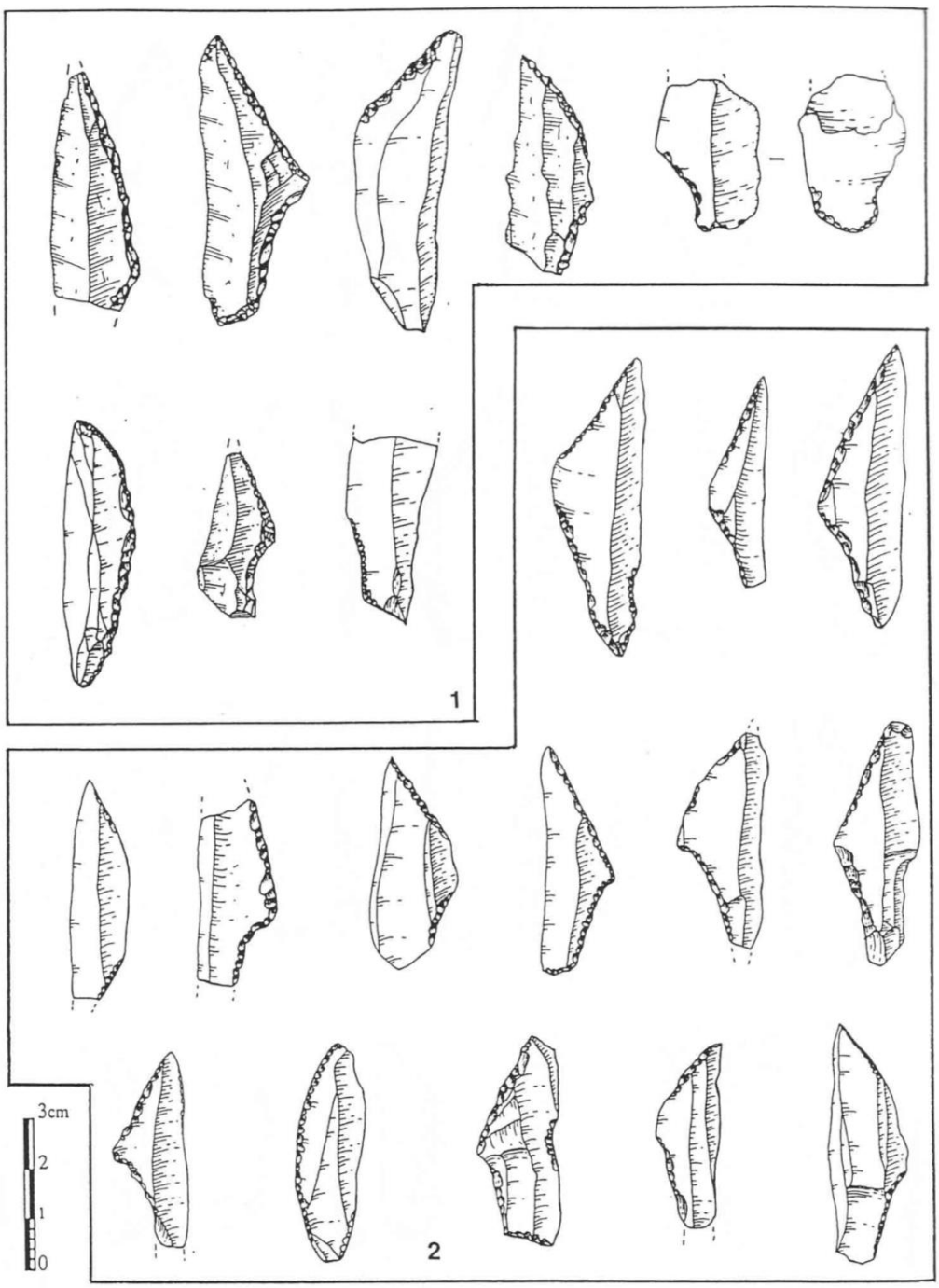


Figure 3.19 Angle and curved backed points from Le Tureau des Gardes (1) (drawings P. Alix and A. Hantai) and Cepoy (2) (drawings A. Hantai). Valentin 1995:451

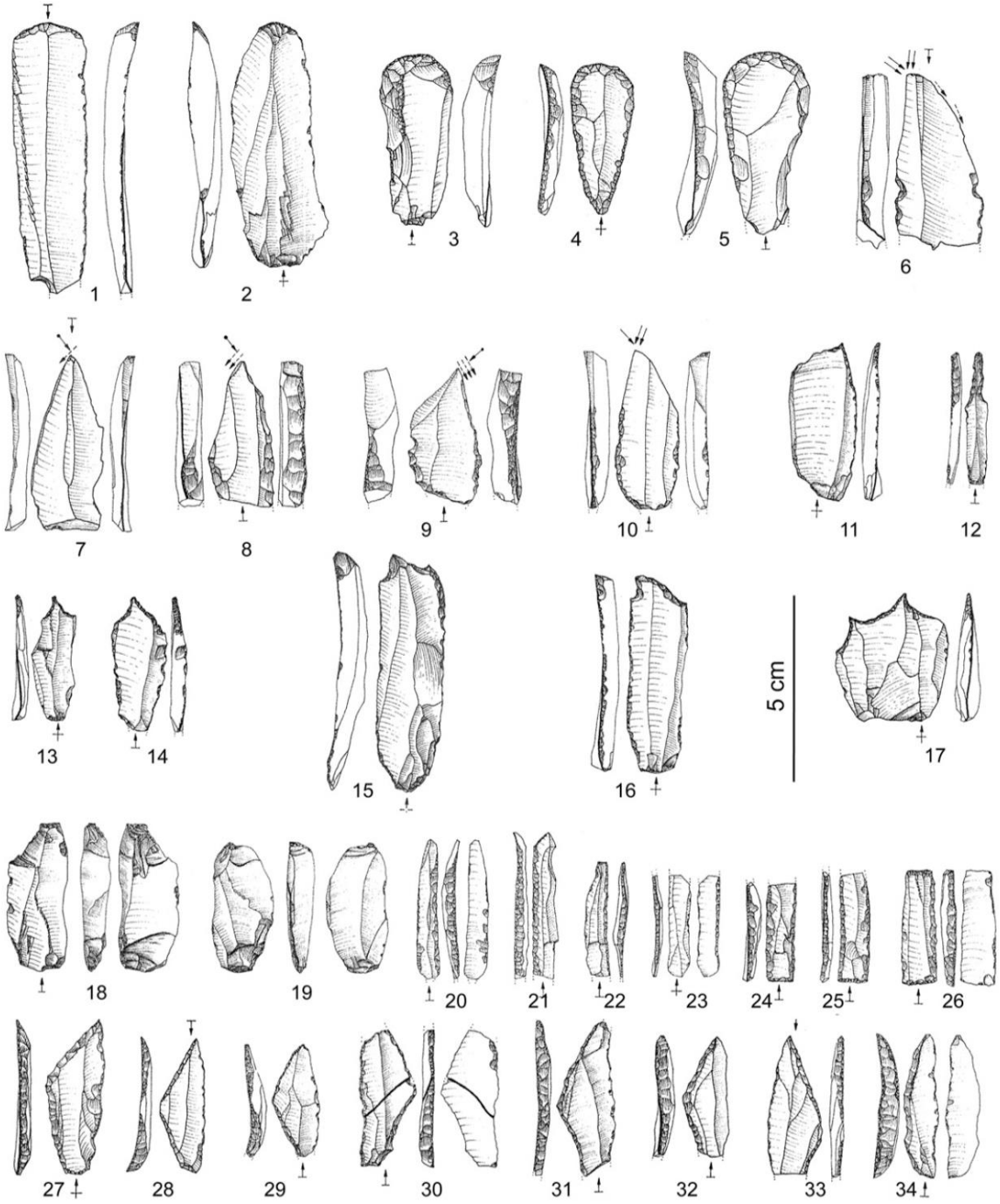


Figure 3.20 Selection of Final Magdalenian artefacts from Kohlerhöhle. Characteristic backed bladelets (20-26) and angle backed points (27-33). Leesch et al. 2012.

3.3.3 Early 'Classic' Hamburgian

The early or 'Classic' Hamburgian is a regional technocomplex first defined for sites in northern Germany and the Meiendorf Tunnel Valley (Rust 1943; Weber & Grimm 2008). It is associated with the expansion of humans (and animals) into northeast Germany and northwest Poland with the onset of post-LGM climate amelioration (GI-1e) and environmental development (Burdukiewicz 1989; 1986; Weber & Grimm 2008). Recent research has demonstrated a wide regional distribution for the Classic Hamburgian with a presence in Denmark, towards the Netherlands, and possibly in the now-submerged region of Doggerland although no finds have been recovered thus far (Weber & Grimm 2008; Weber *et al.* 2011). Typo-technological crossovers between the peri-contemporaneous Classic Hamburgian, Cepoy-Marsangy and the Creswellian technocomplexes, in the Paris Basin and Britain respectively, have been highlighted and even grouped by some as 'Nordic Late Magdalenian', but with distinct techno-typological traits (Burdukiewicz 1989; Burdukiewicz & Schmider 2000; Schmider 1982; Valentin *et al.* 2006; Valentin 2006a).

Recent excavations at Ahrenshöft LA 73 (Schleswig-Holstein) have demonstrated a stratigraphic separation between an earlier Bølling Classic Hamburgian and a later Havelte Hamburgian (see 3.4.2) which is dated to the end of the Bølling (Weber & Grimm 2008, 23–24). The Classic Hamburgian has a Late Magdalenian-type core management strategy combined with the production of distinctive shouldered points and double zinken piercers[17] (Weber *et al.* 2011). This toolkit was found associated with reindeer

[17] The zinken is a distinct form of perforator with an off-set ('beaked') tip, often with a direct removal along the axis of the tip, as well as a notch creating a shoulder for the tip. The single form is present in

migration kill sites in the Meiendorf Tunnel Valley and is assumed to be linked with this hunting strategy (Bratlund 1991; Eriksen 2002; Weber & Grimm 2008; Weber 2012). Table 3.5 provides a summary of the key features of the 'Classic' Hamburgian technological reference sites.

3.3.3.1 Landscape Context

There is a large concentration of open-air Classic Hamburgian sites in the Elbe region of northern Germany (Grimm *et al.* 2012). These are associated with faunal remains indicative of specialised reindeer hunting and are often placed at strategic points on annual migration routes such as river crossings or near small lakes and glacial kettle holes (Bratlund 1991; Eriksen 2002; Weber & Grimm 2008). The sites are all open-air locations. Figure 3.21 shows the location of the directly dated and refitted early Hamburgian sites mentioned in the chapter in relation to the Channel River catchment.

Magdalenian, Creswellian and Hamburgian assemblages. The double zinken, with tips at both ends of a blade is the diagnostic type, so far only recognised in 'Classic' and Havelte Hamburgian sites (Weber 2011).

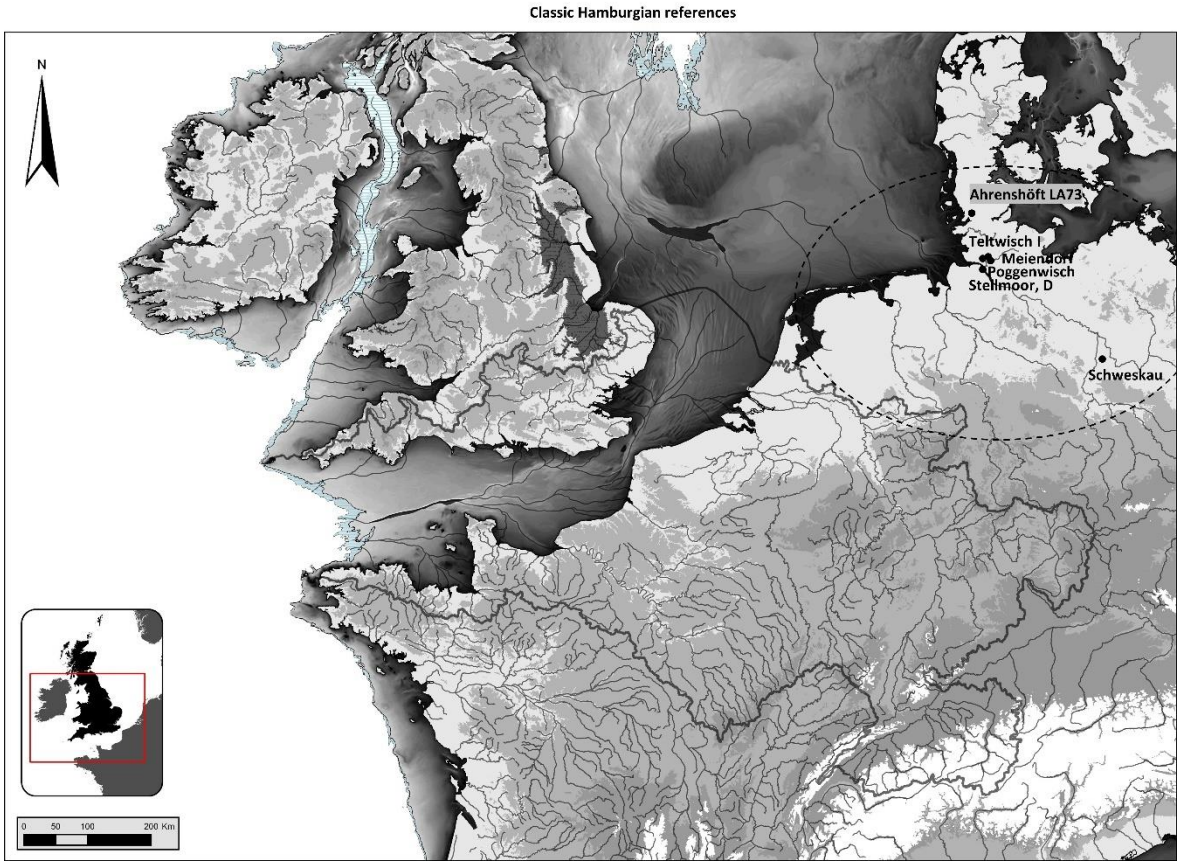


Figure 3.21 Early 'Classic' Hamburgian reference sites. (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

3.3.3.2 Chronological Setting

Recent re-dating of the Classic Hamburgian (Figure 3.22, Figure 3.23, Figure 3.24) places it in the period between the onset and mid-Bølling (Weber & Grimm 2008). The best AMS radiocarbon-dated sites of early to mid Bølling age (GI-1e) are Stellmoor, Meiendorf and Poggenwisch (Fischer & Tauber 1986; Weber & Grimm 2008; Weber 2012). The main reference sites for the period have a combination of technological, dating and refitting analyses: these are Meiendorf, Stellmoor; Poggenwisch; and Teltwisch I.

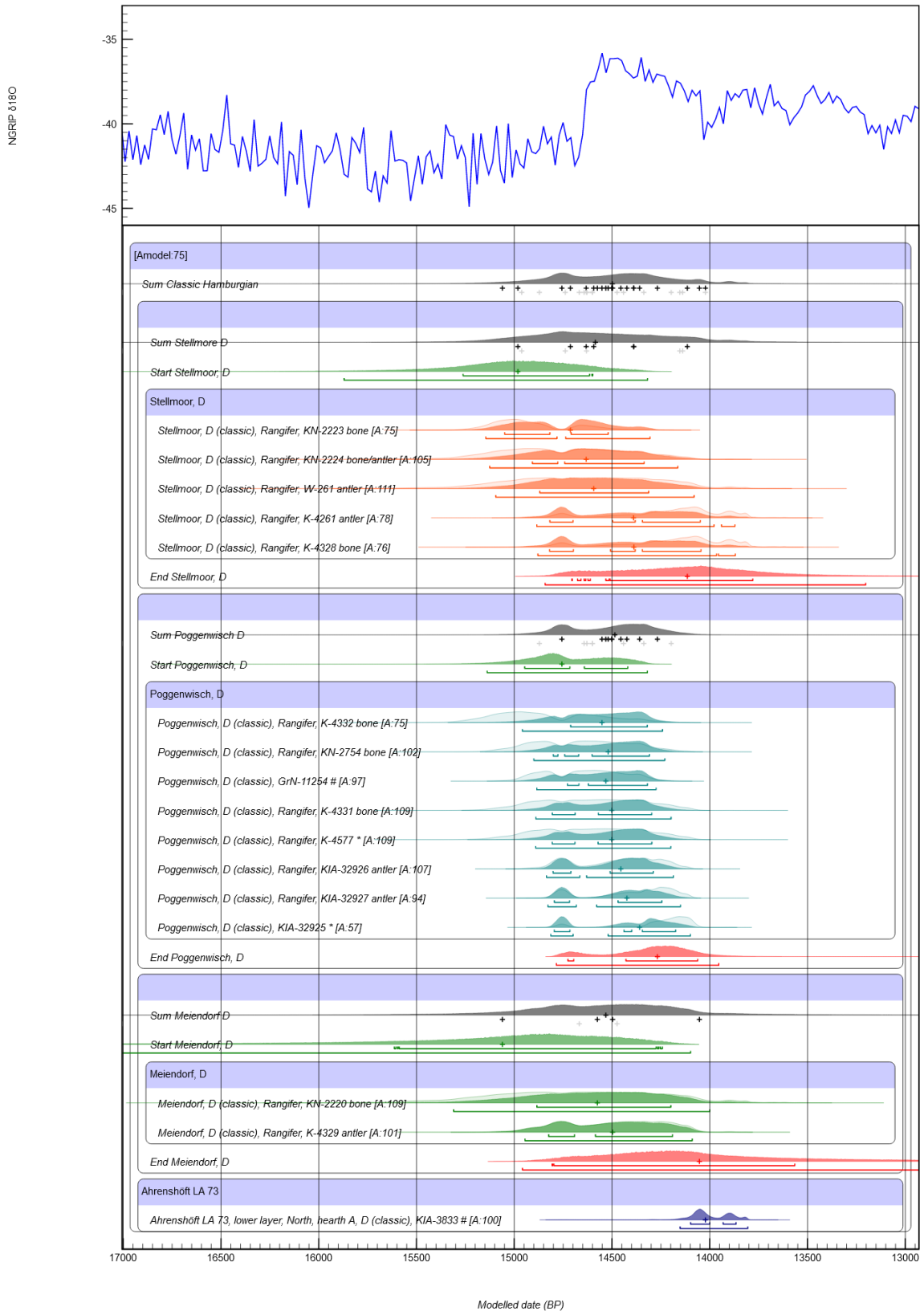


Figure 3.22 Classic Hamburgian dates, Uniform single phase model. (Weber and Grimm 2009), not in stratigraphic order, subdivided by site. There is a significant reduction of the earliest and latest dates. There appears to be a concentration just following the onset of GS-1e.

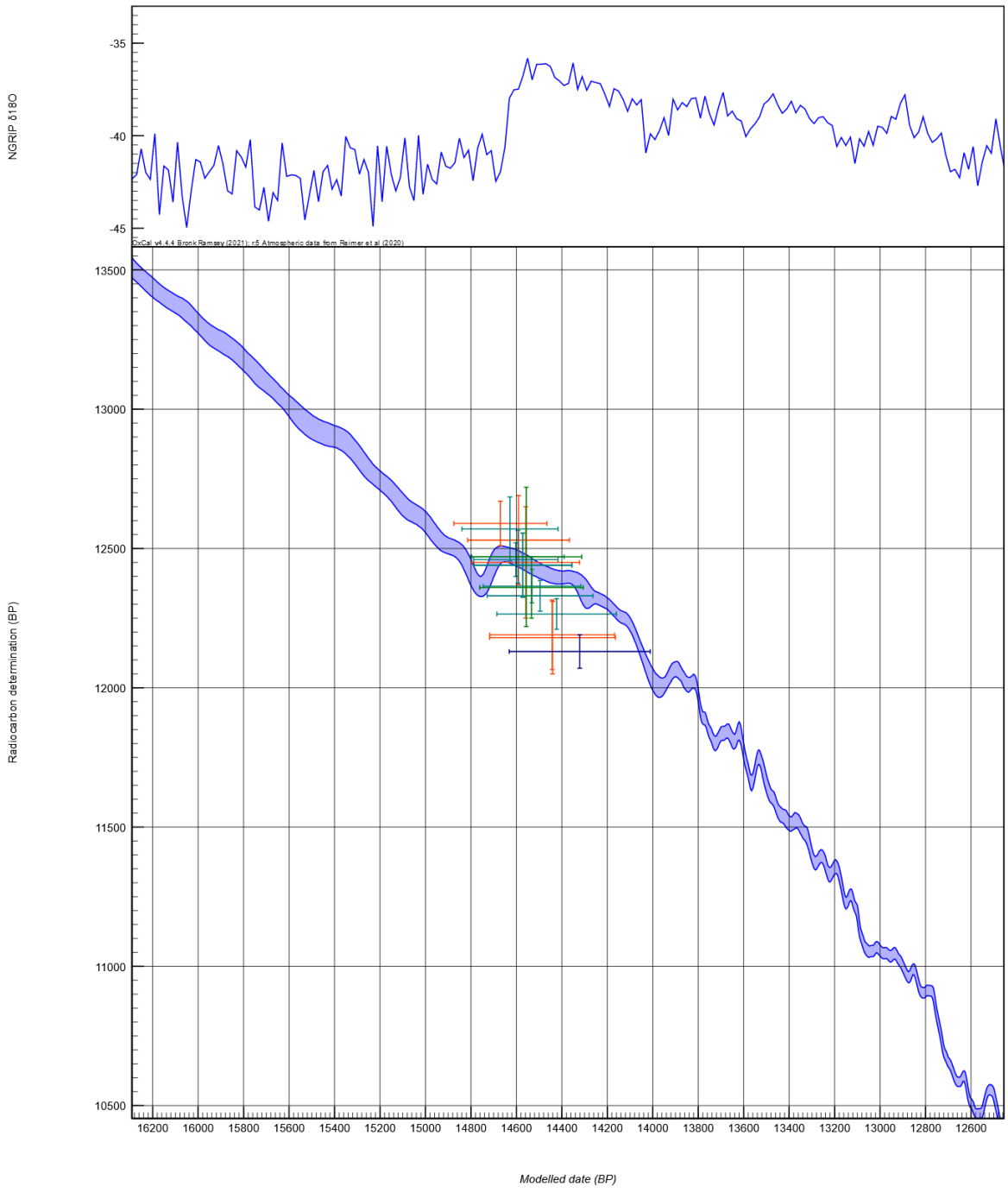


Figure 3.23 Classic Hamburgian, dates, KDE model after Grimm and Weber 2009.

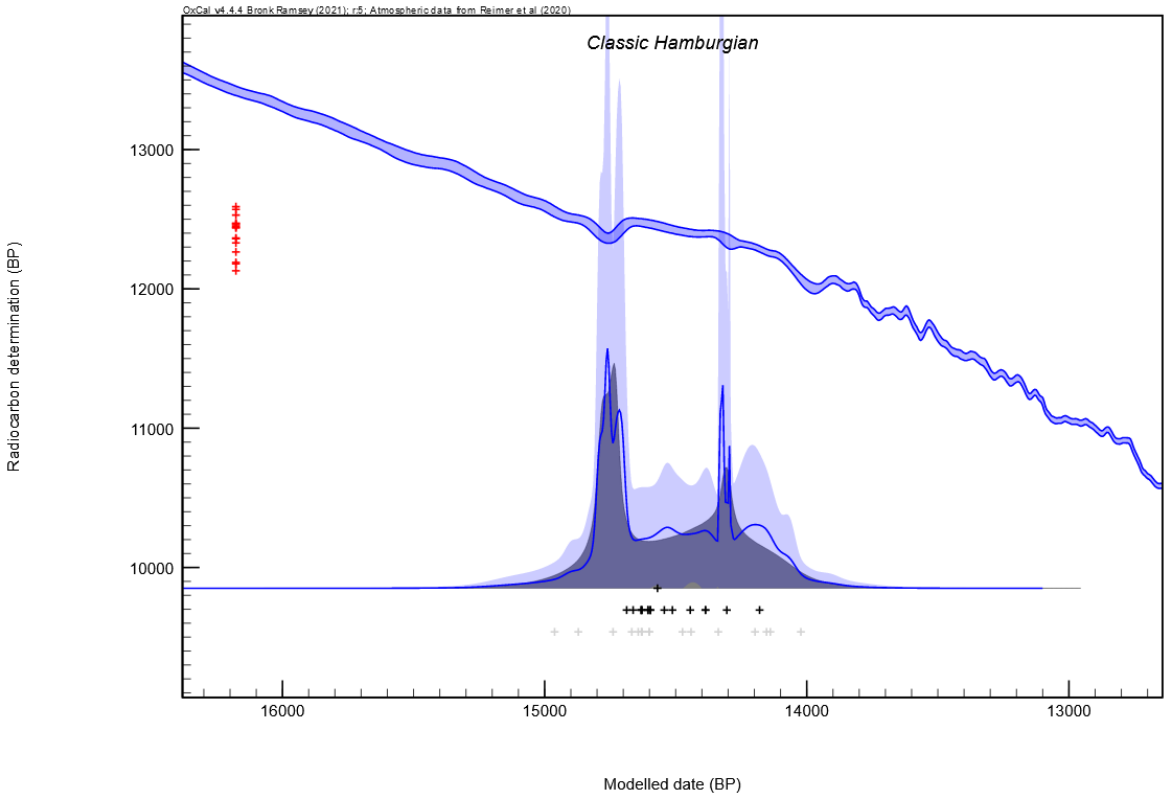


Figure 3.24 Classic Hamburgian, dates KDE model summary. after Grimm and Weber 2009.

3.3.3.3 Description of techno-typology

The Classic Hamburgian was initially defined by diagnostic shouldered points (Figure 3.25, Figure 3.26, Figure 3.27, Figure 3.29, Figure 3.30) and zinken (Figure 3.31, Figure 3.32) (Burdukiewicz 1989; Rust 1943; Taute 1968). Recent re-evaluation of the industry combined with a radiocarbon dating program has provided more detailed characterisation based on techno-typological attributes (Weber & Grimm 2008; Weber 2012). The assemblages from Teltwisch and Poggenwisch have had extensive refitting analysis and provide detailed technological information (Weber 2009; 2012). The debitage is similar to the Late Magdalenian with mainly unipolar prismatic cores and the occasional use of opposed platforms for corrections. However, the éperon technique was rarely used, but this may also be related to the shorter lengths produced (Weber 2012).

The knapping strategy was aimed at producing long regular, slender blades and bladelets to be used as blanks for armatures and other tools. There is evidence for the use of both soft-organic (antler) and soft-stone percussion, with soft-stone appearing prevalent in the later phases (Weber 2012). Steep-angled platforms were maintained on cores by frequent rejuvenation of the striking platform (Weber 2012). Volumetric strategies varied depending on the size and shape of the original nucleus and were similar to those of the Late Magdalenian. The microburin technique for sectioning blades and bladelets is found in both the Classic Hamburgian and the Havelte phase (section 3.4.2) (Burdukiewicz & Schmider 2000, 99; Weber & Grimm 2008, 255; Weber 2009). This technique is absent in both the Late Magdalenian and the Cepoy-Marsangy but may be present in the Creswellian (Barton *et al.* 2003; Jacobi 1991; 2004). Similar to the Late Magdalenian, Hamburgian sites located away from raw material sources have an absence of cortical debitage and cores appear to have been brought in pre-prepared (Weber 2012). Table 3-5 summarises the lithic technological characteristics of 'Classic' Hamburgian assemblages.

Table 3-5 'Classic' Hamburgian: Lithic technological characteristics with short description

Technological Characteristics	Summary description of the defining features of the 'Classic' Hamburgian
Objectives	Blanks objectives: well-made blades, no apparent bladelet production
Core Preparation	Use of crests; preferential platform; multiple tablets; abrupt angle between platform and removal; opposed platform for correction,
Debitage	Hard-stone hammer early stages; use of organic hammer for main blade production, possible use of soft stone; careful preparation of striking platform; platform abrasion; general absence of éperon technique; semi-tournant or tournant; presence of microburin technique for point manufacture
Tools	End-scrapers on long blades; dihedral burins; piercers; zinken, double zinken
Armatures	'Classic' Hamburgian points, also presence of curved backed points at Teltwisch 1
Idiosyncrasies	Raw material often transported to site pre-prepared (no cortical/early stage debitage); selection of high-quality raw material; use of microburin technique
Strongest identification factors	Difficult to distinguish from debitage alone due to similarities with general Late Magdalenian characteristics. Rare presence of the éperon platform preparation technique. Absence of straight-backed bladelets. Classic Hamburgian points combined with significant proportions of zinken, and double zinken are indicators of this industry.

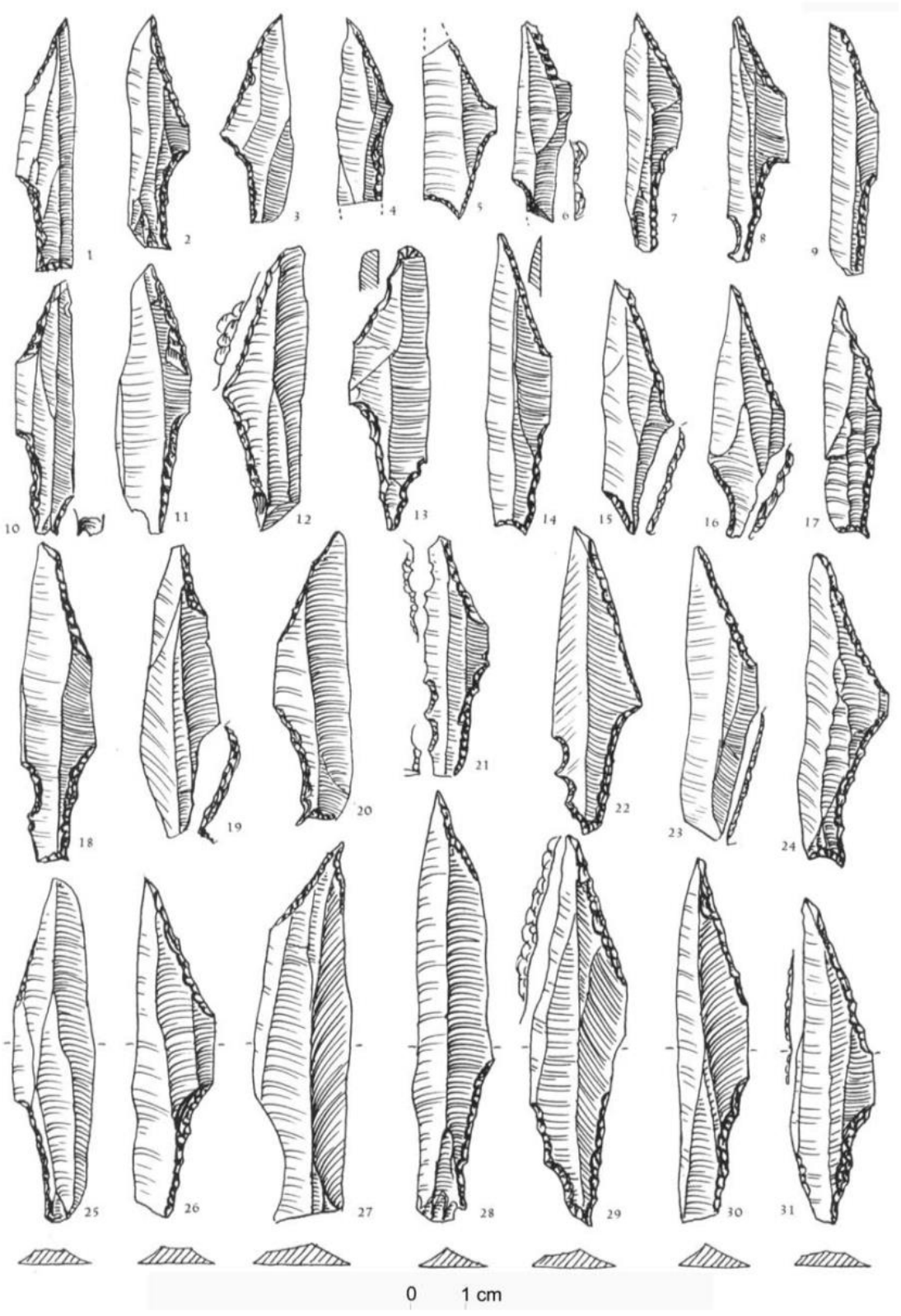


Figure 3.25 Classic Hamburgian points from Poggenwisch after Rust 1958, plate 44. (Weber in Petillon et al. 2009: 102)

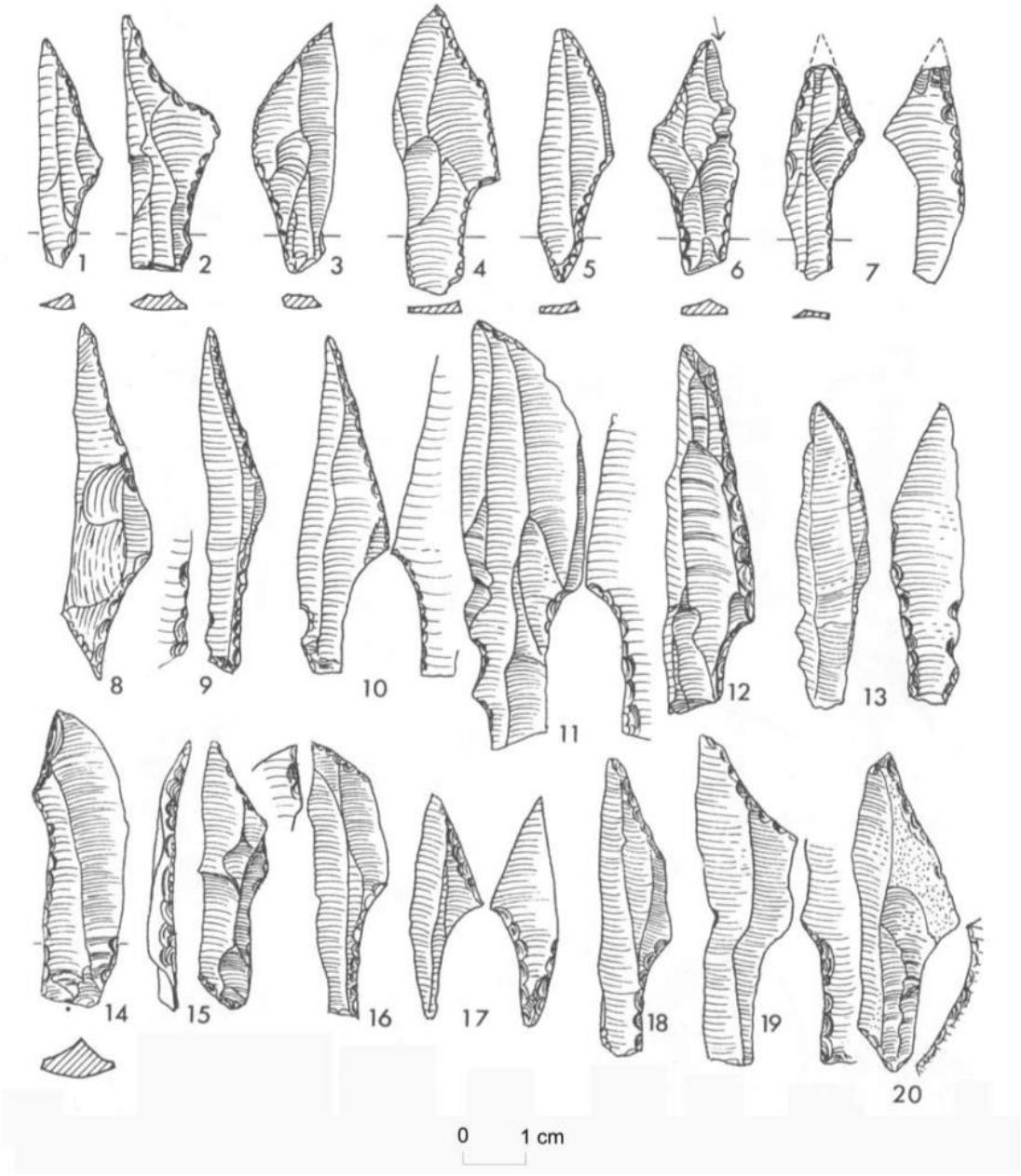


Figure 3.26 Classic Hamburgian points from Teltwisch after Tromnau, 1975, plate 1. (Weber in Petillon et al. 2009: 104)



Figure 3.27 Hamburgian shouldered points and profiles from Teltwisch I (1-5, 6) and Poggenwisch (5, 7). Weber 2009



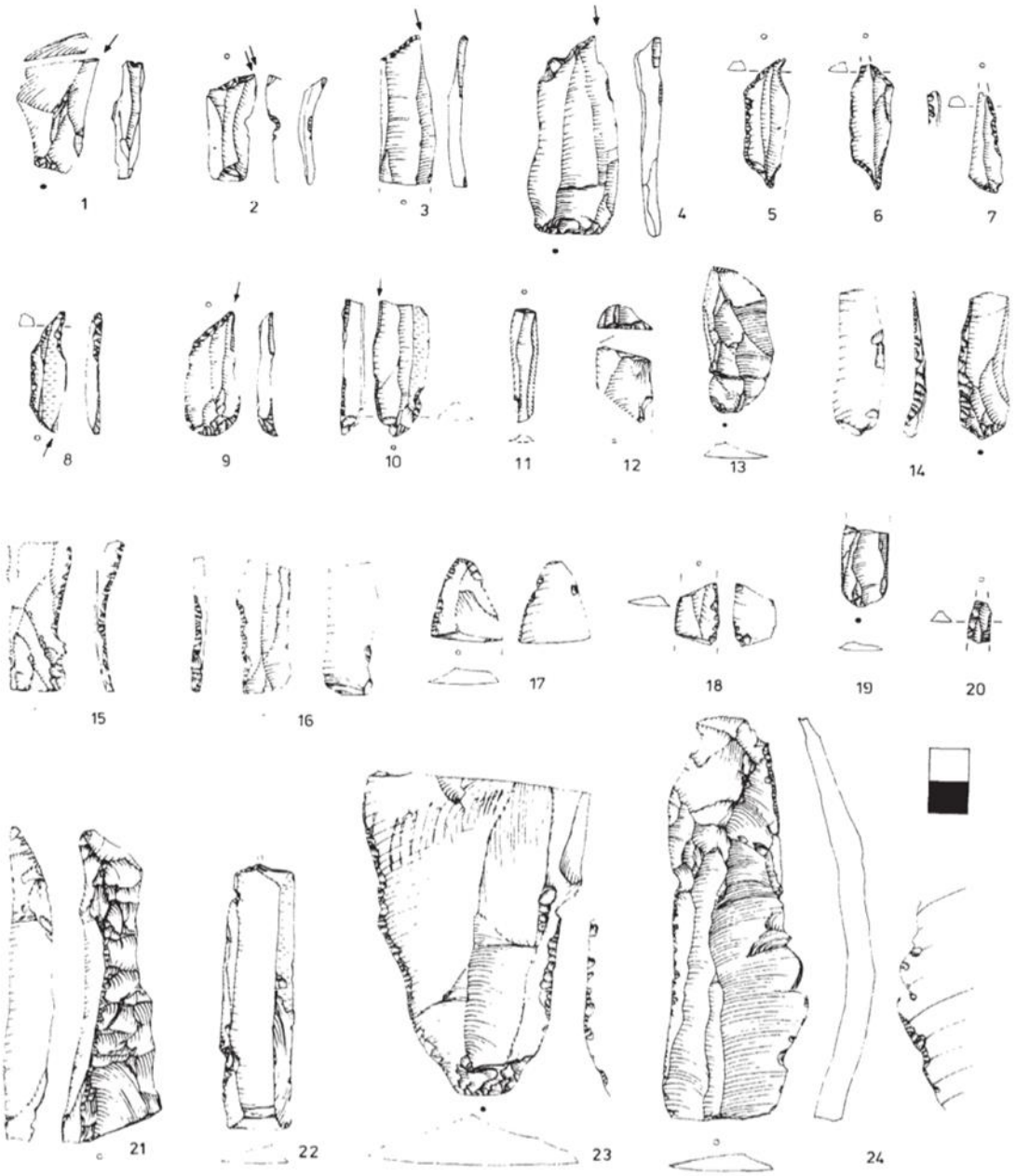
Figure 3.28 Éperon butt from Teltwisch 1 (Weber 2004)



Figure 3.29 Classic Hamburgian points, Teltwisch 1 (Weber 2004)

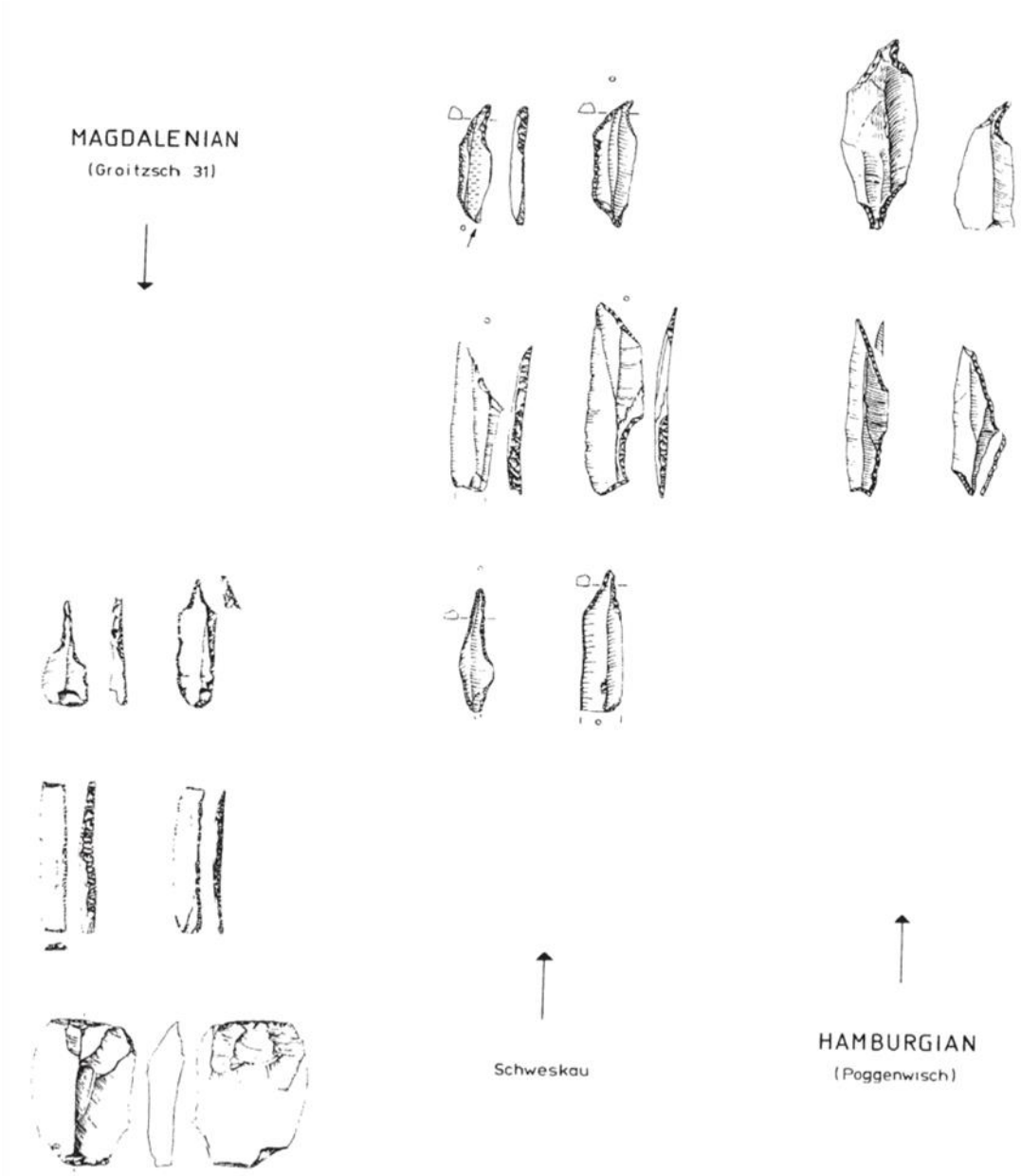


Figure 3.30 Classic Hamburgian points from Poggenwisch (Weber 2004)



Burins, composite types and truncations: 14) burins; 5, 6) borers/Zinken; 7) borer/truncation; 8, 10) burins/Zinken; 9) burin/scraper; 11–13) truncations; 14–19, 23–24) retouched blades/bladelets; 20–22) miscellaneous. 2 cm scale

Figure 3.31 Schweskau diagnostic lithics in context (Breest and Veil 1991: 89)



The spectrum of typical tool types from Schweskau in relation to characteristic forms from north German Hamburgian (Poggenwisch, after Rust 1958, Tafln 42, 44) and central European Magdalenian contexts (Groitzsch D1, after Hanitzsch 1972, Tafln 61–4)

Figure 3.32 Schweskau in relation to the Classic Hamburgian and the Magdalenian. (Breest and Viel 1991: 94)

3.3.4 European Early Creswellian

This section considers todays mainland European[18] Early Creswellian technocomplex, south of the Channel River, and the British Creswellian is described in Chapter 4. The term 'Creswellian' was attributed originally to a British LG industry of Magdalenian-type that contained obliquely-truncated points then considered unique to these assemblages (Garrod 1926). This typological definition continues to be debated (Barton *et al.* 2003; Barton & Roberts 1996b; Bohmers 1956; Campbell 1977; Jacobi 1991; Schwabedissen 1954; Stapert & Johansen 2001).

Creswellian assemblages are traditionally characterised by the presence of obliquely truncated angle-backed points ('Creswell points') and trapezoidal backed and obliquely bi-truncated points ('Cheddar points'). In 1956, Bohmers proposed splitting the Creswellian into a phase dominated by Cheddar Points, the 'Cheddarian', and a phase dominated by Creswell points, the 'Creswellian' (Bohmers 1956). This proposal caused some confusion as it is now known that individual Creswell Points are found amongst Magdalenian, Hamburgian, Federmesser and Ahrensburgian industries (Stapert & Johansen 2001). More recently Stapert and Johansen have proposed that the term 'Cheddarian' should be used for European assemblages dominated (over 50%) by Cheddar points and 'Late Creswellian' for assemblages dominated by Creswell points (2001). Within this framework Britain would contain only 'Cheddarian' sites, and 'Late

[18] The term European is not truly appropriate as Britain is part of the European continent, and even more so in the past. 'Continental' or 'Continental European' was not adequate either. The most descriptive term possible is 'Creswellian south of the Channel River' however this was considered as too long. Perhaps even simply "southern Creswellian" (preferred by the author, but not as clear). 'European' in the context of mainland Europe, although far from ideal is used here for lack of a better term."

Creswellian' sites would be restricted to Europe south of the Channel River. However this has been revised by R. Jacobi remarking that many of the identified Creswell point dominated sites in Britain reported by Campbell (1979), had multiple refits of Creswell points making them Cheddar points (Jacobi 2004). A bipartite division of European and British Creswellian is used in this thesis as it accords with recent AMS dating of British and European Creswellian assemblages. The term Early Creswellian is used here in preference to 'Cheddarian' to prevent confusion with a typological distinction and to facilitate comparison with the British industries.

Most European Early Creswellian are found in Belgium and the Netherlands. Other sites with angle-backed (Schweskau, Germany) and bi-truncated points (Etigny, Paris Basin) are interpreted as Hamburgian and Late Magdalenian respectively. Re-evaluation of Belgian cave sites suggests that only Presles appears to contain a significant Creswellian component with the presence of numerous Cheddar points (Charles *et al.* 1999). Le Bois Laiterie is now considered Late Magdalenian on the basis of dating evidence and as the assemblage contains many more backed bladelets than Cheddar points (Sano 2012). The same applies to the open-air sites in the Netherlands where most sites are now considered palimpsests of Magdalenian and Creswellian material (Kramer *et al.* 1985; Stapert & Johansen 2001; Stapert 1985). Former terms such as Creswello-Tjongerian and Creswello-Hamburgian are not considered helpful and have therefore been largely abandoned (Charles *et al.* 1999; Stapert & Johansen 2001). Table 3-6 provides a summary of the key features of the European Early Creswellian technological reference sites considered in this section.

3.3.4.1 Landscape context

There are few known European Early Creswellian sites, and all but Presles (Belgium) are from open-air locations. Etigny le Brassot locus sud (Etigny hereafter) is an open-air site located on the River Yonne (France), a principal tributary of the Seine (Debout *et al.* 2012; Lhomme *et al.* 2004, 734). Its occurrence there expands the potential territory of Early Creswellian groups in Northern Europe. All the open-air sites particularly in the Netherlands appear to be of Late Creswellian type (see section 3.4.4). Figure 3.34 shows the location of the directly dated potential Early Creswellian sites mentioned in the chapter in relation to the Channel River catchment.

3.3.4.2 Chronological Setting

Northern European Early Creswellian assemblages remain poorly dated, all based on sedimentary context, and cluster around the Older Dryas and Allerød (Charles *et al.* 1999; Stapert & Johansen 2001). La Bois Laiterie is dated to the pre-Bølling/Bølling (Sano 2012), but this site is considered Late Magdalenian due to the backed bladelet assemblage despite the presence of Cheddar, obliquely-truncated, angle-backed, and bipoints (Sano *et al.* 2011). This site might instead have parallels with the Cepoy-Marsangy facies, although at La Bois Laiterie it has been noted that the angle backed points could also be discarded rough outs for bipoints, and the layer shows signs of disturbance (Sano *et al.* 2011). The fabrication of angle backed points at Cepoy appear to have some clear constants (Figure 3.16) that can facilitate their recognition (Valentin 1995a, 340–41). Considering the other aspect of the assemblage, such as technology, site taphonomy and dating it has been preferentially associated to the Magdalenian (Sano *et al.* 2011).

The open-air site of Etigny (Paris Basin) (Figure 3.34, Figure 3.35) is here considered as potentially Early Creswellian due to the presence of Cheddar points and bipoints in the assemblage.[19] The presence of both red deer and reindeer at this site suggests the environmental transition towards the end of the Bølling. The older of two radiocarbon dates from this site (OxA-10096, 12,630 ± 90 BP, 15,325-14,486 cal BP[20]) is on reindeer bone and places the assemblage in the Late Bølling or Older Dryas, and the sedimentary context is favourable for the latter end of this bracket. Based on the chronological setting

[19] Analysis and refitting of the assemblage are still in progress by French researchers (G. Debout first pointed out the Creswellian attributes to me).
[20] Calibrated using OxCal 4.4 (Bronk Ramsey 2021) with the IntCal20 curve (Reimer *et al.* 2020).

it is distinctly earlier than Later Creswellian assemblages (section 3.4.4) and contemporary or preceding the earliest British Creswellian sites (section 4.1.2). However, the younger of the dates would place it towards the end of the Allerød, which is unlikely at the moment. This date remains problematic as it is part of a series affected by contamination during the pre-treatment of the samples (Higham *et al.* 2007), however not all samples were affected and the date fits the initial assessment of the assemblage. It remains possible that the date is correct and is considered so with much caution herein. Such a unique site south of the Channel River merits a redating.

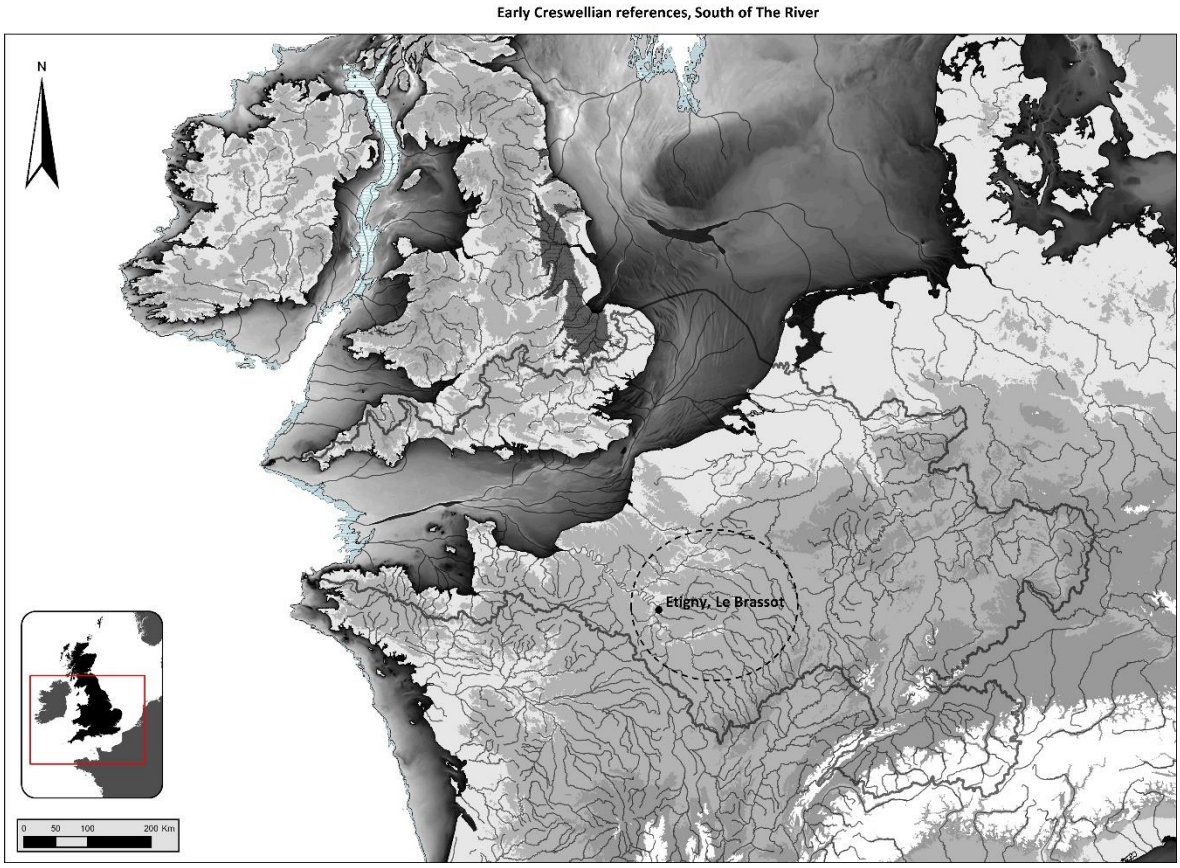


Figure 3.34 Early Creswellian facies reference sites. (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

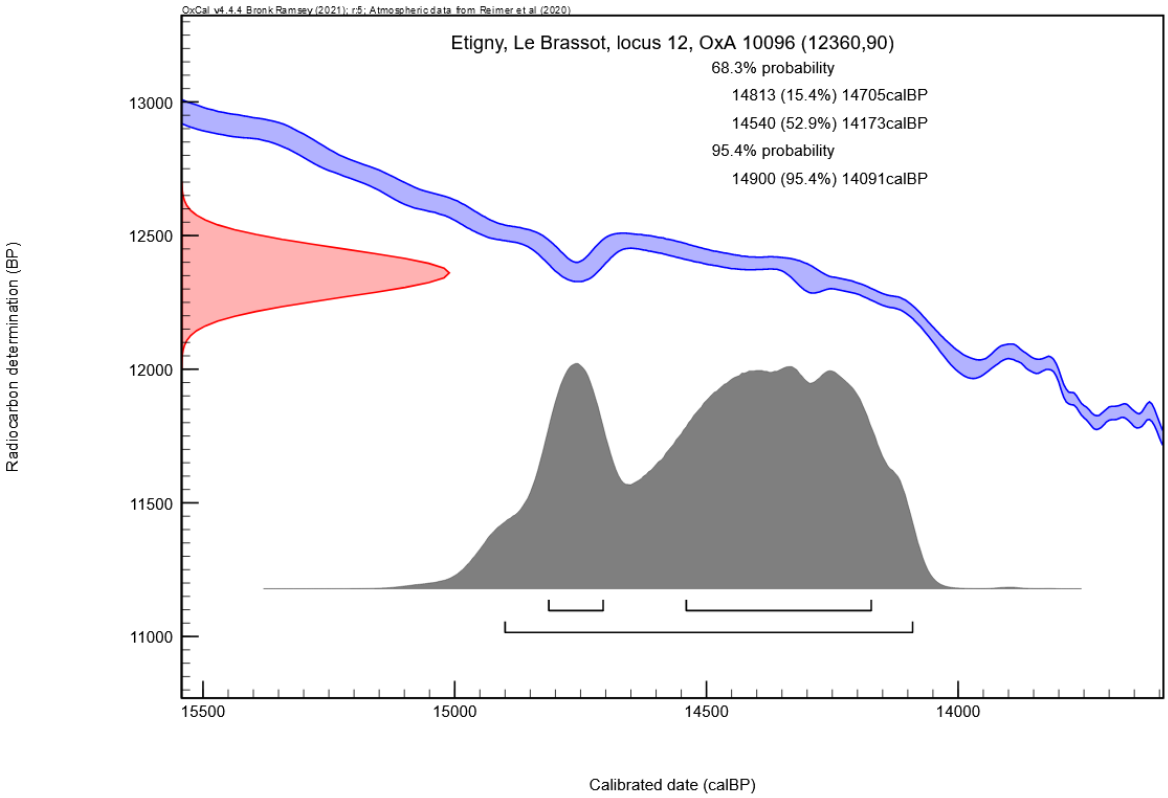


Figure 3.35 Etigny, Le Brassot, Locus 12 (Debout et al. 2016, Lhomme), one date in the middle of the early GS-1e plateau but with its highest probability at 1 sigma (68.3%) towards the latter half of GS-1e. This date is contemporary to the British Creswellian.

3.3.4.3 Description of techno-typology

The only potential Early Creswellian assemblage is from the open-air site of Etigny and remains to be fully published (Debout *et al.* 2012; Lhomme *et al.* 2004). Two types of reduction sequences have been identified at this site. One method uses large blocks of flint to produce long regular blade blanks. In this method both anterior and posterior crests are applied, and the cores are managed with a preferential platform and an occasional opposed platform for corrections. The blades are mostly made using an organic hammer and transformed into either end-scrapers or burins. The second reduction method uses smaller nodules with the aim of producing short straight blades. The cores have truly opposed platforms and the use of soft-stone hammers was identified as in the Early Azilian/Federmesser (see section 3.4). The blades are transformed into

backed projectile points and knives. The presence of en-éperon platform preparation is not mentioned, but this is an indicative trait and not necessarily a defining factor if the other diagnostic factors are there. The use of the éperon must be considered as an adaptive technique, considered as characteristic when present in Creswellian assemblages, but necessarily discarding assemblages by its absence. Furthermore, the assemblage from Etigny is partial and some remains to be excavated, and the full assemblage and techno-typological analysis is remains to be published.

The end-scrapers and burins on blades would fit either a Late Magdalenian or Early Creswellian typology. However, the backed material (Figure 3.36) from Etigny contains Cheddar points, Creswell points, curve-backed bipoints and mono-points. This variety of point types would be unusual in one assemblage and highlights the danger of over-emphasising typological attributes. Etigny may be considered as a site undergoing Azilianization with a variety of techniques and projectile types (Pelegrin 2000; Valentin 2008b), and could play an important role in unravelling the relationship between the British and European Creswellian, especially as it has strong techno-typological correlations with the site of Guildford Fire Station (see section 4.1.4). Table 3-6 summarises the lithic technological characteristics of the Early Creswellian assemblages.

Table 3-6 European Early Creswellian: Lithic technological characteristics

Technological Characteristics	Summary description of the defining features of the technocomplex
Objectives	Blanks objectives: Well-made elongated blades, some bladelets (no refitting so hard to distinguish if these are a primary objective)
Core preparation	Use of crests, can have two; preferential platform; multiple tablets; abrupt angle between platform and removal; opposed platform for correction
Debitage	Hard-stone hammer early stages (although poorly defined); use of organic hammer; careful preparation of striking platform: en-éperon technique; abrasion; semi-tournant or tournant; possible use of soft stone
Tools	End-scrapers on long blades; dihedral burins; piercers; truncated blades, blades with lateral 'skimming' retouch
Armatures	Cheddar and Creswell points; curved and angle-backed points
Idiosyncrasies	Often raw material transported to site pre-prepared (absence of cortical and early stage debitage); selection of high-quality raw material; curved long blades; blades with rubbed ends (strike-a-lights, see Jacobi 1991)
Strongest identification factors	Debitage similar to Late Magdalenian with frequent éperon and acutely angled platforms in the early stages. Early stage cores and crests are strong indications as are the end-scrapers on long blades. Creswell and Cheddar points are the most distinguishing trait. Trapezoidal curved and angle-backed points.

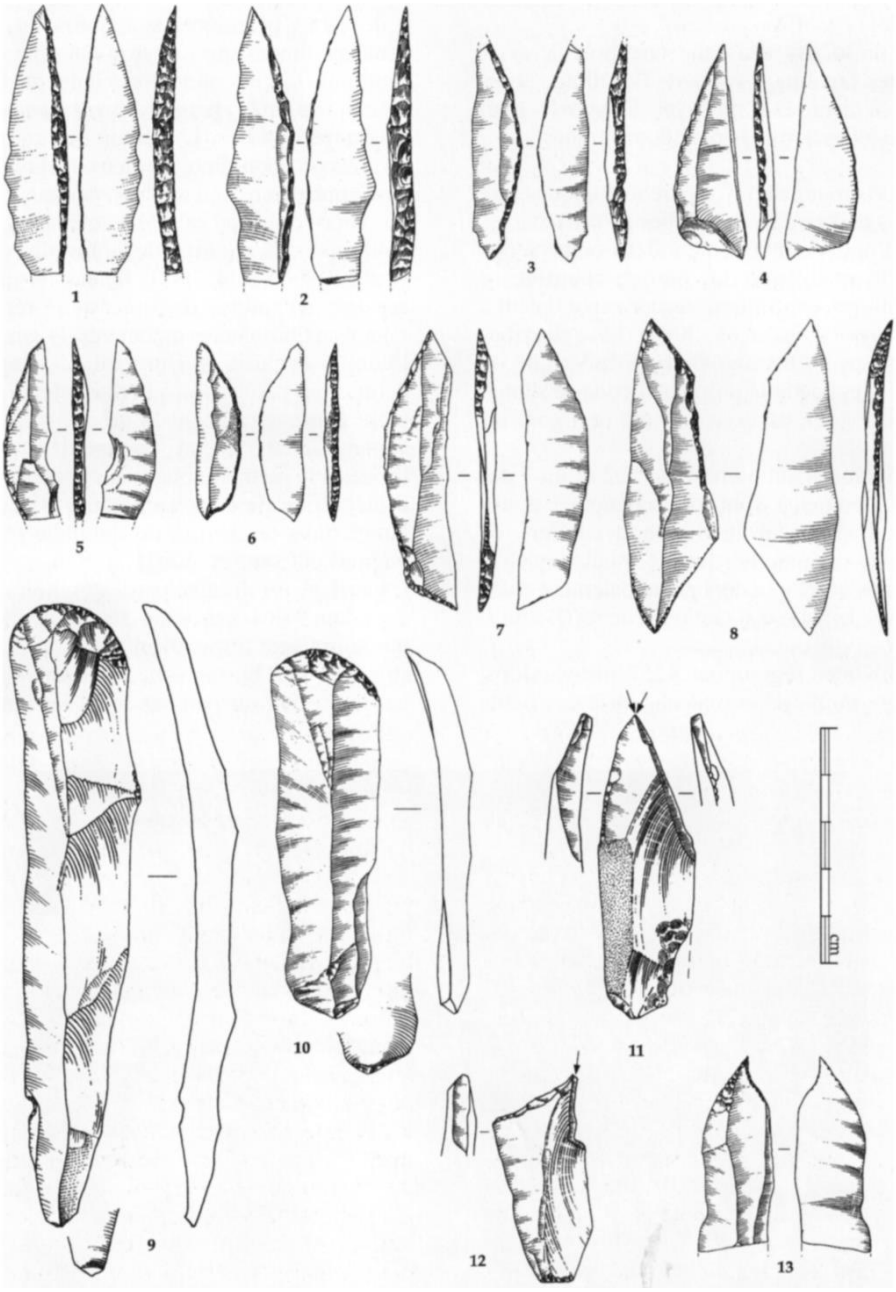


Figure 3.36 Le Brassot (locus south), Etigny, with a bitruncated trapezoidal points ('Cheddar' points) (7) with similarities to the Creswellian in Britain, and large curved backed points (1-2) similar to artefacts in the Early Azilian and Federmesser assemblages of northern France (as well as some Creswellian sites, see sections 4.1.2 and 4.1.3). 1-8: backed points, 9-10 end-scrapers, 11-12 burins and 13 piercer. Lhomme et al. 2004: 734

3.4 Transitional 'Azilianization' technocomplexes: Havelte Hamburgian, Early Azilian; Early Federmesser; 'Late' Creswellian? (GS-1e to GI-1d, Bølling and Older Dryas/Early Allerød)

3.4.1 Introduction

Throughout the Bølling (GI-1e) and into the Early Allerød (GI-1d/c) there is a diversification of typological armatures amongst similar technocomplexes in Northern Europe. One of the cultural-chronological changes seen is the major shift from the Late Magdalenian strategy of producing long curved blades to one in which the main objective was in manufacturing straighter, shorter blades (Célérier 1998; Pelegrin 2000; Valentin 2008a) as well as changes in the proportion, frequency and morphology of various typological elements (Bodu *et al.* 2006a; Bodu & Valentin 1997; Fagnart & Coudret 2000a). This process and shift in objectives is termed 'Azilianization' (Valentin *et al.* 2006; Valentin 2008a) to emphasise the multi-stepped phasing of the transition. The transition appears to have started during the mid-Bølling and continued into the early Allerød where a more abrupt transition occurred and technocomplexes became fully Federmesser/Azilian (Coudret & Fagnart 1997; Valentin 1995a; 2008a).

To avoid terminological confusion, the process of 'Azilianization' is distinguished from the typo-technological terms Azilian and Federmesser, that refer to two similar, if not identical, industries in this region. The Federmesser is considered to originate in southern Central Europe and the term is used for assemblages in the Somme and Rhine regions. The Azilian is considered to originate in the South of France and Pyrenean Spain and the term is preferred for southern Paris Basin and western French assemblages (Bodu *et al.*

2011; Célérier 1993; Célérier *et al.* 1997; Fagnart 1988; Langlais *et al.* 2015; Naudinot *et al.* 2017b; 2019; Valentin 1995a; 2008a).

Some of the best sequences for the transition thus far within the Channel River catchment are from the Paris Basin. The key site being Le Closeau, a multiple occupation site recording the process of 'Azilianization' with direct dating and refitting (Bodu *et al.* 2011; 2006a; Bodu & Mevel 2008; Bodu & Valentin 1997; Valentin 2008a). In the Somme catchment, the transition covers multiple sites with good stratigraphic correlations (i.e. Belloy-sur-Somme, Conty, Hangest-sur-Somme, Saleux), with refitting, direct dating and a high-resolution palaeoenvironmental records (Antoine *et al.* 2012; 2003c; Coudret & Fagnart 1997; 2006b; Fagnart 1988; Fagnart & Coudret 2000a).

It is possible that the typological aspects of this transitional period may not be representative of different groups but instead represent shifting strategies of living in a changing landscape or even site-specific situations. The chronology and techno-typological framework of the technocomplexes simply facilitates comparisons between sites and the reading and representation of the transition. It is not a linear chronological evolution of styles and techniques, other than the broader switch from Magdalenian to Federmesser/Azilian oriented lithic management strategies. There may also be strong functional pulls and variability throughout this 200-300-year period. The Havelte Hamburgian and Late Creswellian industries are also both regional developments around the transition from the Bølling to the Allerød that have distinct yet similar changes in lithic production strategies and morphologies comparable to those recognised for the Early

Azilian and Federmesser. Whether it is the same Azilianization process has not been demonstrated.

In this thesis, the term Azilianization is used for the transition process (Valentin 1995a), and the terms Early Federmesser and Early Azilian have been grouped as they share common traits (although they have some clear differences), initial Allerød Federmesser and Late Allerød Federmesser have also been grouped as they share common traits (with their differences). At the time of writing the thesis (submitted 2019) distinctions were not clear enough to the author to distinguish these groups in relation to British assemblages, and they appeared to share much in common. A more recent publication has clearly defined these distinctions (Naudinot *et al.* 2019). The main sequence referred to here is based on the model developed for the Somme region that was directly associated with sedimentary and palaeoenvironmental records (Antoine *et al.* 2000a; Coudret & Fagnart 1997). Using this framework will facilitate discussion of the distribution of Late Glacial sites and the Channel River network in subsequent chapters. Table 3-7 summarises the process of Azilianization in Northwest Europe.

Table 3-7 The Process of Azilianization in Northwest Europe. Based on Valentin et al. 2006, with additions of the Creswellian and Hamburgian. The transition ('Azilianization') occurs between the two shaded rows, represented at Hangest-sur-Somme, France.

Techno-complex	Chronozone	Main knapping objectives	Hammer type - blade production	Backed bladelets	Backed points	Other 'markers'
Late 'Classic' Magdalenian (Pincevent etc.)	Pre-Bølling to Bølling	Long well-calibrated blades; Bladelets	Antler	Frequent	Frequent & polymorph (often angle-backed)	No blades with 'skimming' retouch
'Early' Creswellian (Sun Hole)	Bølling	Long well-calibrated blades; Short blades	Antler; Soft stone?	Absent	Frequent (often bi-truncated)	No blades with 'skimming' retouch
Classic Hamburgian (Teltwisch I etc.)	Mid-Bølling	Long well-calibrated blades; Short blades	Antler; Soft stone?	Absent	Frequent (often shouldered)	No blades with 'skimming' retouch
Magdalenian Cepoy-Marsangy *facies*	Bølling (early/mid to end?)	Long well-calibrated blades; Short blades	Antler; Soft stone	Variable	Frequent & polymorph (often angle-backed)	No blades with 'skimming' retouch
Early Federmesser/ Azilian (Hangest III.1 lower)	End of Bølling and/or Older Dryas	Long well-calibrated blades; Short blades	Soft stone	Frequent	Frequent & standardised (bipoints)	No blades with 'skimming' retouch
Havelte Hamburgian (Arenshoft LA73)	End of Bølling	Long well-calibrated blades; Short blades?	Antler; Soft stone?	Absent	Frequent (often shouldered, bipoints?)	No blades with 'skimming' retouch
Europe'Late' Creswellian (Zeijen etc)	End of Bølling	Long well-calibrated blades; Short blades?	Antler; Soft stone?	Absent	Frequent & polymorph (angle/curve-backed)	Rare blades with 'skimming' retouch ?
Early Federmesser/ Azilian (Le Closeau lower)	End of Bølling	Long well-calibrated blades; Short blades	Soft stone	Absent	Frequent (bipoints)	Frequent blades with 'skimming' retouch
Early Allerød Federmesser/ Azilian (Conty)	Early Allerød	Long well-calibrated blades; Short blades	Soft stone	Absence	Frequent & standardised (mono-points)	Backed knives
Late Allerød Federmesser (Hangest-sur-Somme, upper)	End of Allerød	Short blades; Elongated flakes; Short flakes	Soft-stone Hammer/ Hard Hammer?	Presence	Frequent (mono-points)	Backed knives

3.4.2 Havelte Hamburgian

The Havelte Hamburgian technocomplex was previously identified based on typological variations of shouldered points (Bohmers 1956; Schwabedissen 1951; Weber & Grimm 2008, 251)(Schwabedissen 1937). It has been confirmed stratigraphically by recent work at Ahrenshöft LA 73 in northern Germany (Weber & Grimm 2008, but see Riede & Pedersen (2018) for a different interpretation). The Havelte has a more extensive western distribution than the Classic Hamburgian, with a concentration of assemblages identified in the Netherlands and as far northwest as Scotland (Ballin *et al.* 2010; Ballin & Wickham-Jones 2017; Stapert & Johansen 2001; Stapert & Krist 1987; Stapert 1982; 1982). There is a significant variability in site sizes, ranging from small to extensive assemblages (Johansen & Stapert 2005; Weber & Grimm 2008). Table 3-8 provides a summary of the key features of the Havelte Hamburgian technological reference sites considered in this section.

3.4.2.1 Landscape context

All known Havelte sites are from open-air sites locations, with the biggest concentration in the lowland regions of the Northern European Plain (Netherlands, northern Germany and Denmark) (Johansen & Stapert 2005; Weber & Grimm 2007; Weber *et al.* 2011). It is often assumed that the sites were located on reindeer seasonal migration routes, as suggested by the presence of cut reindeer antler at Slotseng, but none of the sites have extensive preserved faunal assemblages (Weber & Grimm 2008). Figure 3.37 shows the location of the directly dated Havelte Hamburgian sites mentioned in the chapter in relation to the Channel River catchment.

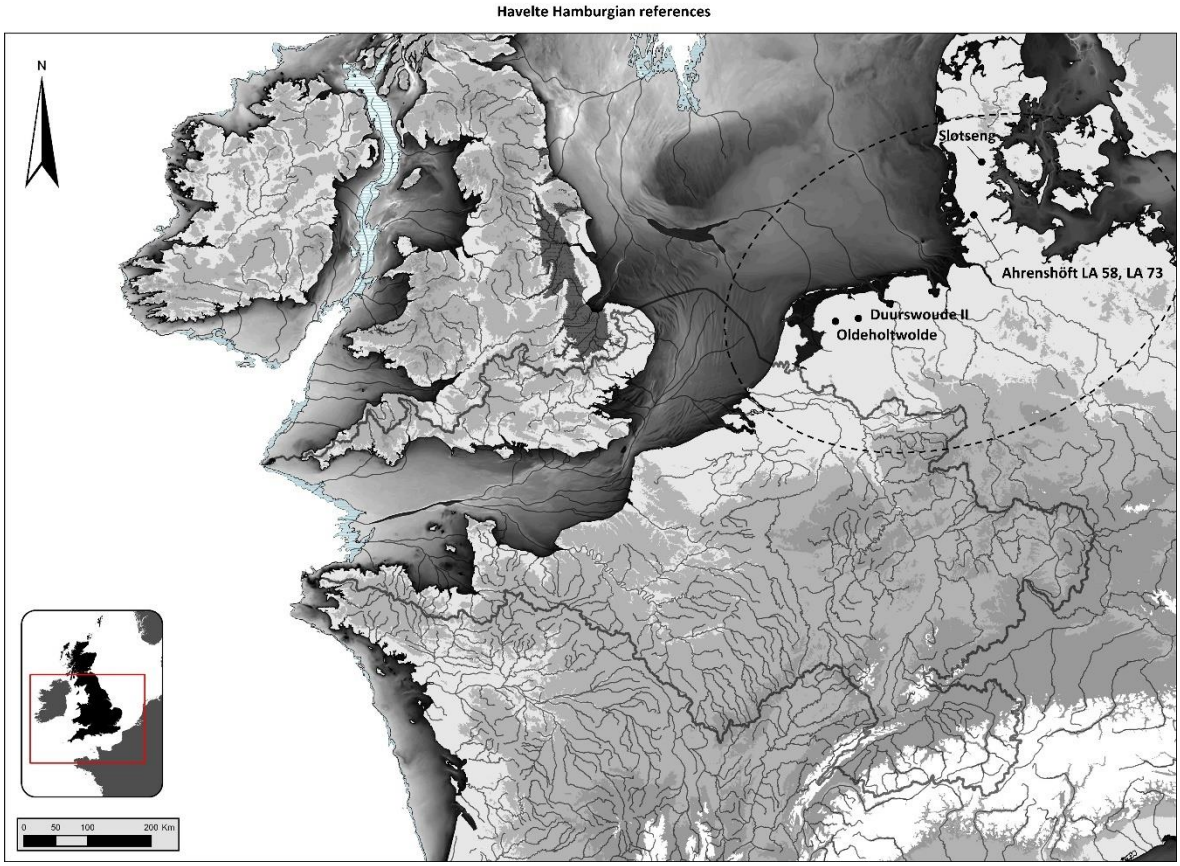


Figure 3.37 Havelte Hamburgian facies reference sites. (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

3.4.2.2 Chronological setting

Oldeholtwolde in the Netherlands is one of the only Havelte sites with both direct dating and extensive refitting evidence (Johansen & Stapert 2005). The site is located below the mid-Allerød Usselo palaeosol horizon (Stapert 1986; Stapert *et al.* 1986) and so falls within the Older Dryas or near the onset of the Allerød, fitting the sedimentary context of the Younger Coversand YCS1 (Johansen & Stapert 2005; Weber & Grimm 2008). Elsewhere in the Netherlands other Havelte assemblages are found in the YCS1 (e.g. Sassenhein, Texel) and some contain Creswellian-type points (e.g. Luttenberg) (Rots *et al.*

2003; 2005; Stapert 1986, 37). Sites with diagnostic Hamburgian elements (double zinken and Havelte points), such as Duurswoude I and II, are found above the Bølling 'bleached' sand horizon (palaeosol) and probably date to the Older Dryas. Duurswoude IV, with distinct Havelte-type points, is within the 'Bleached band' and would therefore indirectly date to the Bølling (Bohmers 1961; Stapert *et al.* 1986). Recent direct dating of cut-marked antler from the Slotseng kettle hole (Denmark) (Figure 3.38, Figure 3.39) in proximity to Havelte occupations appears to indicate a Late Bølling date and this correlates with the sedimentary and palaeoenvironmental data (Mortensen *et al.* 2011; 2014a). However, it is not directly associated with diagnostic Havelte artefacts and there are nearby Federmesser assemblages. There are now several Havelte sites in Scotland, based on diagnostic artefacts, but none are securely or directly dated (Ballin & Wickham-Jones 2017; Saville & Ballin 2009).

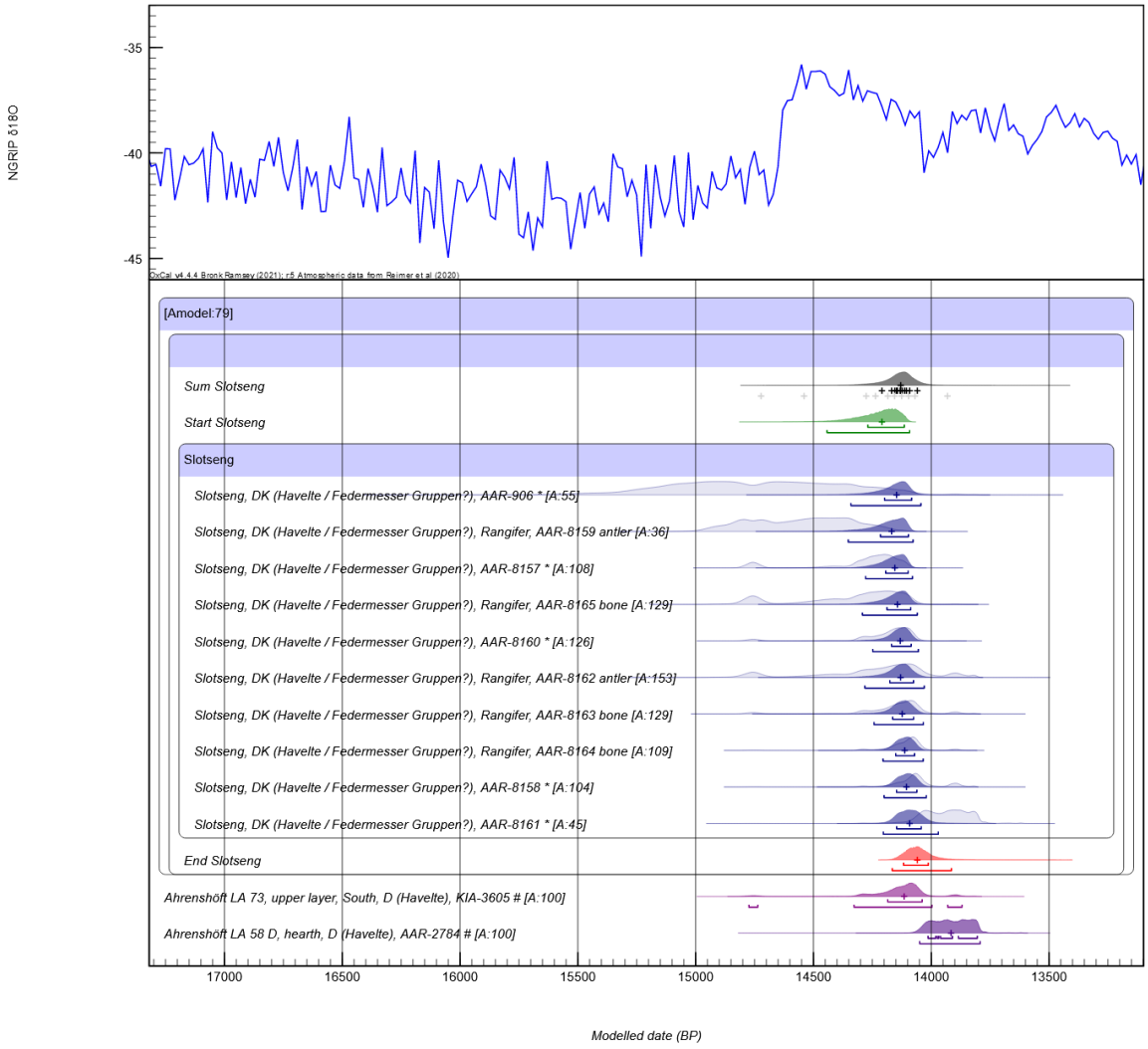


Figure 3.38 Havelte Hamburgian dates (after Weber and Grimm 2009), not in stratigraphic order, subdivided by site. Single uniform phase plot. Questions remain to whether the Slotseng dates are Havelte or Federmesser as they are not directly associated to archaeology.

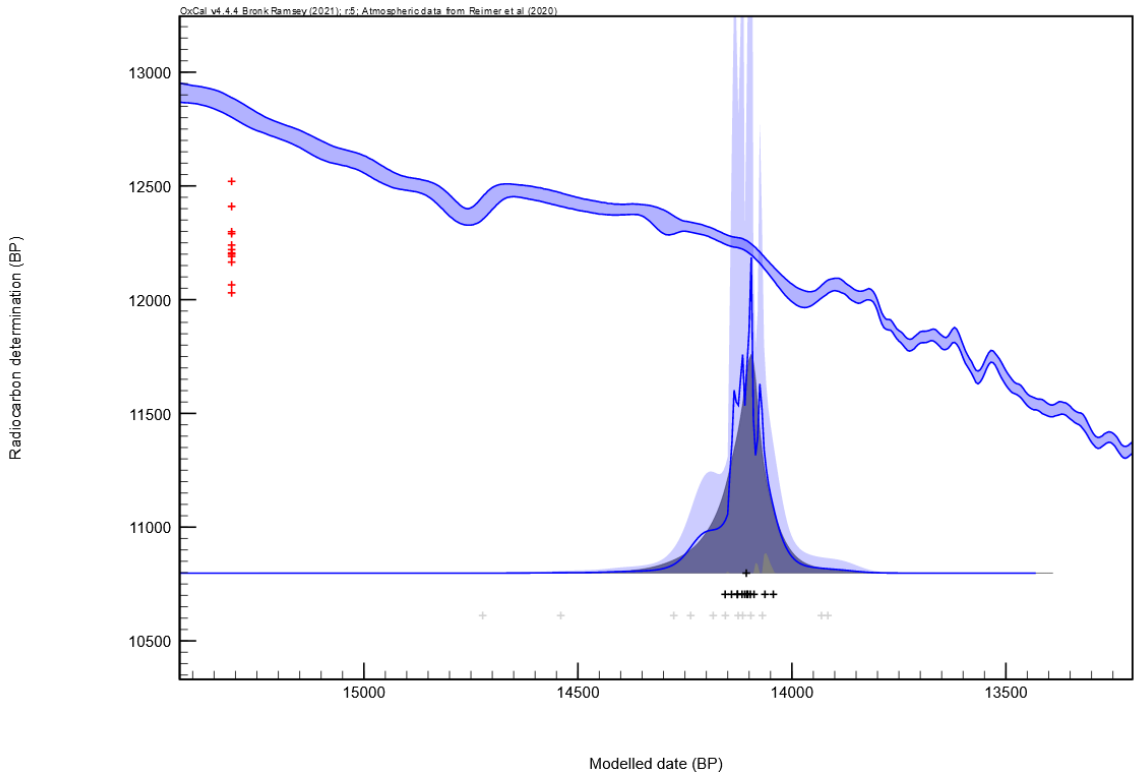


Figure 3.39 Havelte Hamburgian dates , Grimm and Webber 2009, KDE model. Amodel: 83 is good.

3.4.2.3 Description of techno-typology

The two main reference sites for the Havelte are Oldeholtwolde with good refitting and spatial analysis and Ahrenshöft LA 74A, with a stratigraphic separation from the Classic Hamburgian (Weber & Grimm 2008; Weber 2012). Technologically Havelte industries resemble the Classic Hamburgian and utilise the same tradition of blade production. However, there is a distinct variation in point types and a more frequent use of the éperon technique is identified in the Dutch Lowlands Havelte assemblages than found in northwestern Germany (Johansen & Stapert 2005; Weber 2012). It has also been highlighted that the éperon technique may be an adaptation to the quality and size of raw material than a systematic component of these technocomplexes (Johansen & Stapert 2005; Stapert & Johansen 2001). There is a preference for soft-stone rather than organic

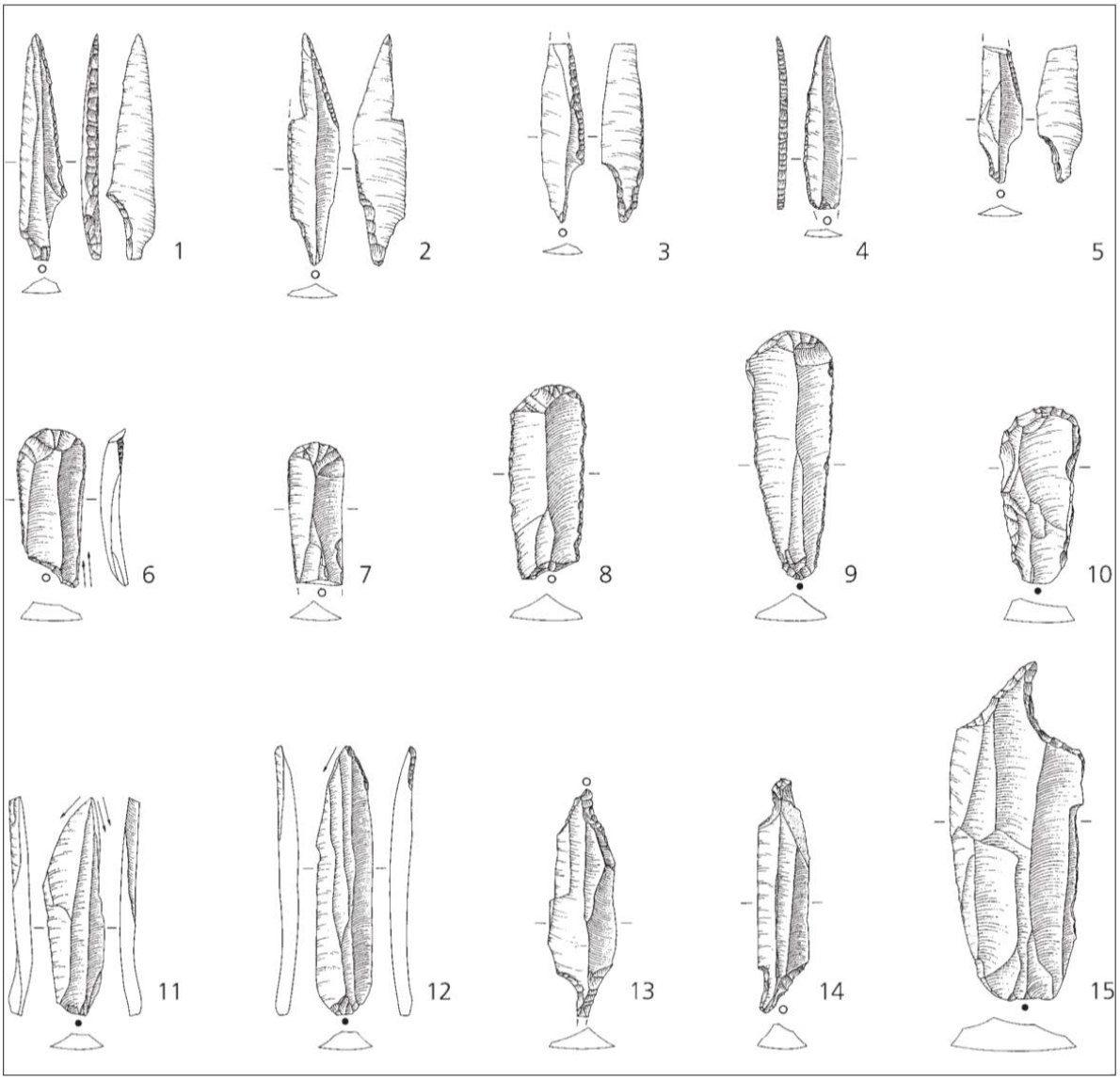
hammers, and for creating straighter blades – a trait recognised amongst multiple industries during this period (Pelegrin 2000; Stapert & Johansen 2001; Valentin *et al.* 2006; Weber 2012).

The Havelte point is a distinct typological feature of the industry (Figure 3.40, Figure 3.41). They are generally made on elongated blades or bladelets with a direct oblique distal truncation that crosses over the central axis, as opposed to stopping on the central axis as with Classic Hamburgian points (Weber 2012). Instead of a shoulder, the tang (double shoulder) is usually created with an inverse retouch at the other end of the blank (Stapert 2000; Weber & Grimm 2008). Some Havelte points are not tanged but have opposed notches, like a shouldered point (Bohmers 1961; Bohmers and Houtsma 1961 in Stapert 1986, p.38). Usually, the proximal end is tanged with a truncation at the distal end. Sometimes the bulb was removed using the microburin technique (Weber & Grimm 2008, 254–55). Generally, Havelte points are narrower and more elongated than Classic Hamburgian shouldered points (Weber & Grimm 2008; Weber *et al.* 2011).

Many Havelte assemblages, including Oldeholtwolde, contain curve-backed points (formerly known as Tjonger points) (Johansen & Stapert 2005; Stapert 1986). Previously some have considered this as evidence that Oldeholtwolde is not typical of the Havelte (Holm 1991; 1996, 56) and might be later (Johansen & Stapert 2005; Stapert 1986, 29), or a product of mixing (Weber & Grimm 2008, 254). In this thesis the curve-backed points are considered part of the Havelte as they are present at all reference sites. Table 3-8 summarises the lithic technological characteristics of the Havelte Hamburgian assemblages.

Table 3-8 'Havelte' Hamburgian: Lithic technological characteristics

Technological Characteristics	Summary description of the defining features of the technocomplex
Objectives	Blanks objectives: Long blades, some bladelets (limited refitting so hard to distinguish if these are a primary objective)
Core preparation	Use of crests, can have two; preferential platform; multiple tablets; abrupt angle between platform and removal; opposed platform for correction
Debitage	hard-stone hammer early stages; frequent use of organic hammer; careful preparation of striking platform: Éperon technique; abrasion; semi-tournant or tournant. Debitage similar to Late Magdalenian with acutely angled platforms in the early stages. Use of micro-burin on point tips
Tools	End-scrapers on long blades; dihedral burins; piercers; zinken
Armatures	'Havelte' points
Idiosyncrasies	Often raw material transported to site pre-prepared (absence of cortical and early stage debitage); selection of high-quality raw material; curved long blades.
Strongest identification factors	The use of soft-stone hammer, early stage cores and crests are strong indications as are the end-scrapers on long blades. Presence of zinken. 'Havelte' points are the most distinguishing trait, sometimes microburin on point.



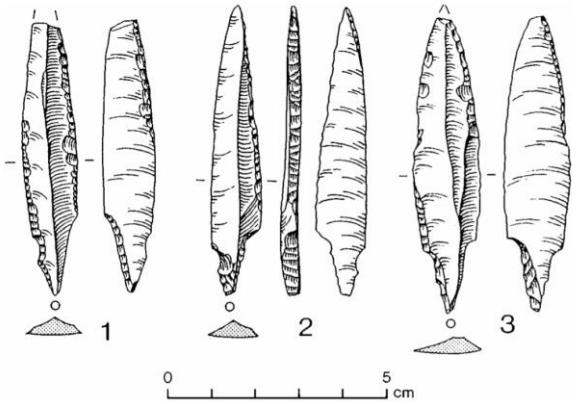


Fig. 5. Ahrenshöft LA 73 (Schleswig-Holstein): Tanged points typical for the Havelte phase of the Hamburgian (after Clausen, 1998a).

Figure 3.40 Upper: Modified pieces from the 1995 Ahrenshöft LA 58D excavation. 1-3 and 5 Havelte tanged points, 4 backed point, 6 combination tool, 7-10 scrapers, 11-12 burins, 13-15 Zinken (drawing: A. Hebel and G. Hagel-Bischof). Modified after Clausen 1998, fig. 19. Weber et al. 2010: 15. Lower Modified pieces from the 1995 Ahrenshöft LA 73 excavation with scale, Street et al. 2002 (after Clausen 1998).

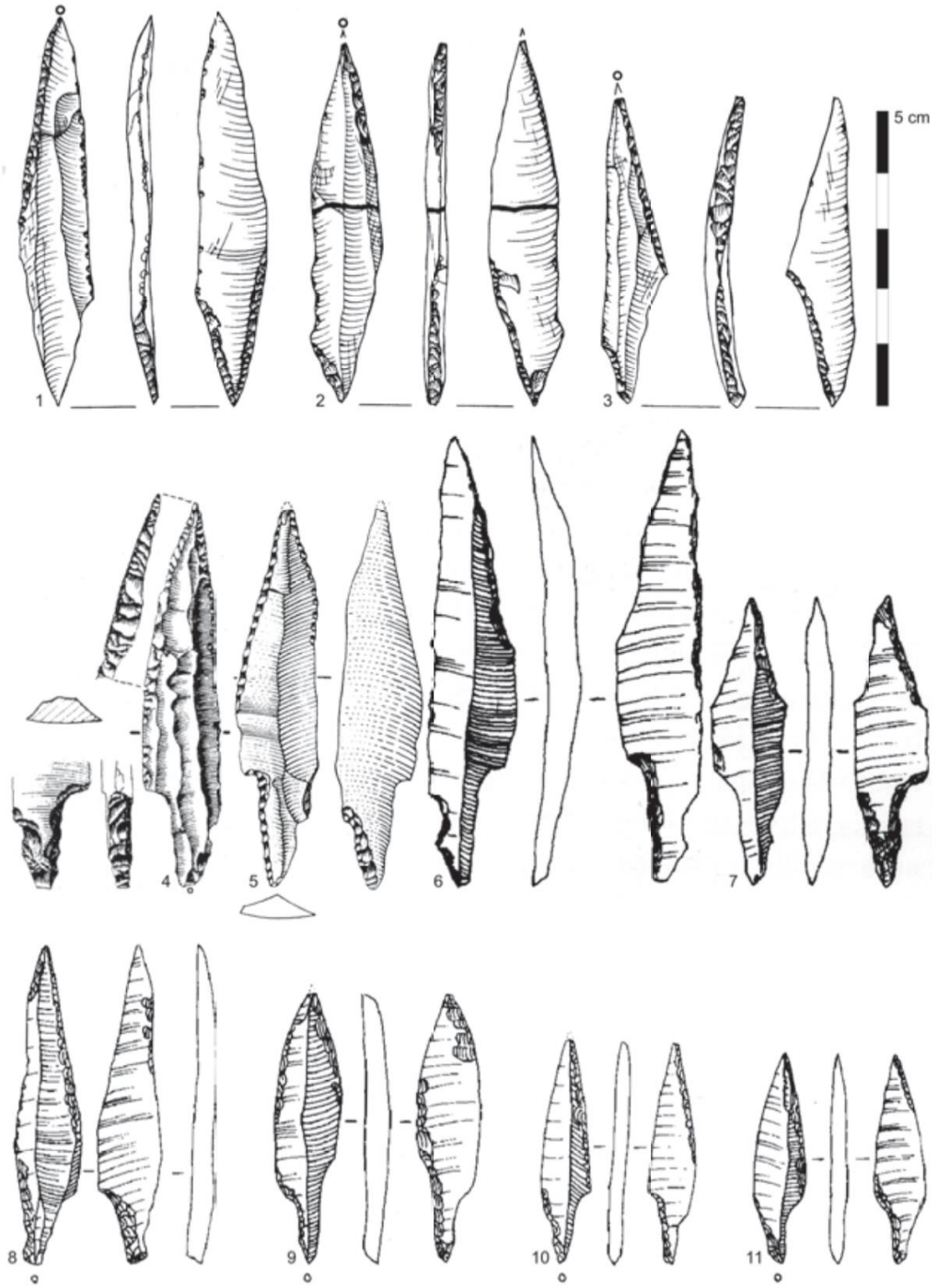


Figure 3.41 Examples of Havelte tanged points from Oldeholtwolde (nos. 1-3), Havelte-Holtingerzand (no. 4), Dörgener Moor (no. 5), Slotseng c (nos. 6 & 7) and Jels 2 (nos. 8-11) (sources Schwabedissen, 1937; Holm & Rieck, 1992; Stapert, 2000; Johansen & Stapert, 2004). Grimm et al. 2008: 253

3.4.3 Early Azilian/Federmesser; Curve-backed Points (CBP) (Bølling to Older Dryas)

Although the Federmesser (Bohmers 1961; Schwabedissen 1954; Taute 1963) and Azilian (Célérier *et al.* 1997; Peyrony 1936) technocomplexes have long been independently characterised, the Early Federmesser/Azilian (Early Federmesser hereafter) was only recently defined technologically and typologically based on excavations in the Paris Basin (Bodu 2000; Bodu & Valentin 1997; Coudret & Fagnart 2006a; Fagnart 1988; Valentin *et al.* 2006). This section focusses on the pre-Allerød Paris Basin Early Federmesser reference sites, the subsequent Allerød Federmesser is described in the following section (3.5).

The Early Federmesser is considered to be part of the initial European Azilianization process before the onset of the Allerød (Bodu & Valentin 1997; Coudret & Fagnart 1997; Naudinot *et al.* 2017b; Valentin *et al.* 2006; Valentin 2008a). It is dated to the second half of the Bølling, when conditions became cooler and possibly more arid (Crombé & Robinson 2017; Hoek & Bohncke 2001; Hoek & others 1997; Kasse 2002) and when sparse woodland developed in regions south of the Channel River (Antoine *et al.* 2012; 2007; Naudinot *et al.* 2017b; Pastre *et al.* 2000).

There are two key reference sites for the early Azilian and Federmesser respectively: Le Closeau lower level (Le Closeau inf.) within the Seine catchment, and Hangest-sur-Somme lower level (Hangest III.1 inf.) within the Somme catchment. Both sites have high-resolution and complementary paleoenvironmental, technological and typological datasets (Bodu & Valentin 1997; Coudret & Fagnart 1997). Both were hunting sites

occupied repeatedly during the second half of the Bølling but without preceding Late Magdalenian occupation. This may indicate a change in use of strategic topographic locations and a consistency through time for the Federmesser technocomplexes (Bodu *et al.* 2011; Coudret & Fagnart 2006a; 1997).

3.4.3.1 Landscape context

So far, the Early Federmesser has only been identified west of the main Channel River System and north of it in Britain (e.g. Hengistbury Head). There may also be some sites in Brittany (Naudinot *et al.* 2017b). This suggests a mainly east to west influence for the Federmesser (Fagnart & Coudret 2004), or west to east and blocked by the Rhine.

One element of importance is the multiple occupation of both Le Closeau and Hangest-sur-Somme during this period and continuing into the subsequent Allerød (Bodu 2000; Coudret & Fagnart 1997). These sites appear not to have been used by Late Magdalenian groups and perhaps indicate a new landscape strategy linked to Late Bølling (south of the LGCR) and Allerød woodland development in this region (Chapter 7). The afforestation of the landscape has been interpreted as a possible adaptive pressure on animal populations that favoured small group (e.g. red deer, roe deer and aurochs) or solitary species (e.g. elk) rather than large migratory herd species (e.g. reindeer) (Fagnart 1988). This could also have led to significant human behavioural changes with hunting becoming more solitary and perhaps with a heavier reliance on precision projectile technologies such as the bow and arrow (Fagnart 1988; Stapert 1985). This might also have been reflected in the transformation of lithics technologies and production processes (Pelegrin 2000; Valentin 2008a).

This technocomplex is well defined with refitting assemblages from open-air sites in the Paris Basin but has not yet been widely recognised on the Northern European plain. If the presence of Federmesser points or curved bipoints are considered as a diagnostic indication, then the Havelte Hamburgian and Late Creswellian might be considered as part of this technocomplex as well. However, these relationships have still to be convincingly demonstrated.

Both reference sites are from open-air locations. However, the cave site of Grotte du Cheval at Gouy (hereafter Gouy), with similar typological material to Hangest, indicates that there was a probable use of both caves and open-air locations. Due to the similarities of the technocomplex with both preceding and subsequent industries, cave assemblage palimpsests could be hiding a broader distribution pattern. Figure 3.42 shows the location of the directly dated Early Federmesser sites mentioned in the chapter in relation to the Channel River catchment.

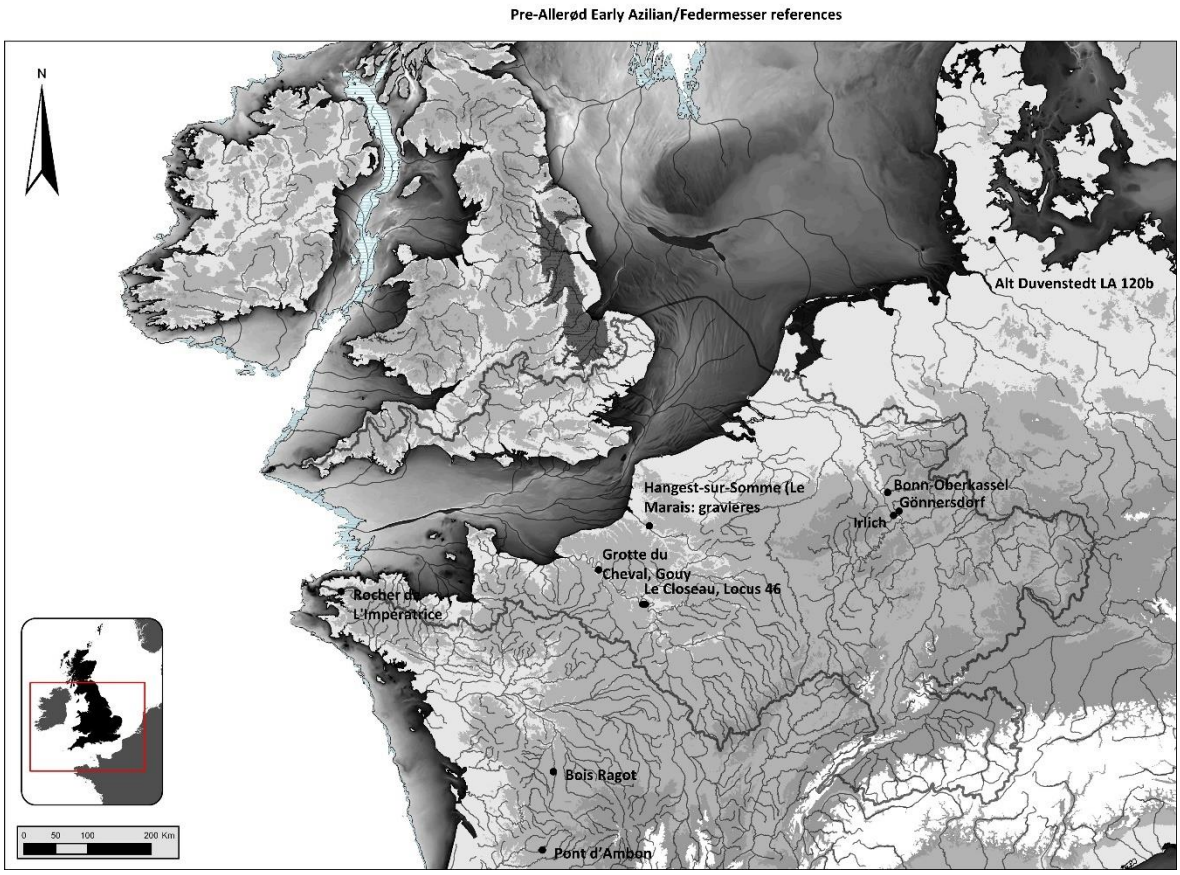


Figure 3.42 Early Federmesser/Azilian facies reference sites . (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

3.4.3.2 Chronological setting

Le Closeau is one of the best dated Early Federmesser sites in the Paris Basin with consistent AMS dates covering the later part of the Bølling and Older Dryas (Figure 3.43, Figure 3.44, Figure 3.45) (Bodu 2000; Bodu & Valentin 1997). The AMS dates are direct dates on worked bone and unlike other sites in the Paris Basin, these do not appear to be problematic (Debout *et al.* 2012). The bone is not in particularly good condition, but collagen preservation was sufficient for dating purposes (Bodu *et al.* 2011). However, a significant radiocarbon 'plateau' exists at this period (Figure 1.13, Figure 1.14) (Debout *et al.* 2014; Stevens *et al.* 2009b; Weber & Grimm 2008) between the GI-1d (Older Dryas) and the GI-1c (Allerød).

In the Somme Basin dating of the Early Federmesser industry at Hangest III.1 inf (Antoine *et al.* 2012; Coudret & Fagnart 1997), is largely reliant on well-dated regional stratigraphies that place the site in the Bølling chronozone (Coudret & Fagnart 2006a; Fagnart 1998). Other than the two reference sites, the cave site of Gouy is dated (albeit using early ^{14}C dates) to the Bølling (Bodu *et al.* 2011; Valentin 2008b).

Overall, the Early Federmesser appears to date to the second half of the Bølling to the Older Dryas or possibly to the Early Allerød. The Older Dryas was a short episode of about 200 years duration and unfortunately is not always found stratigraphically in the Somme region and is difficult to directly date (Debout *et al.* 2012). It is however better defined stratigraphically in the Dutch Coversands, and this implies a certain peri-contemporaneity between the Early Federmesser, the Havelte Hamburgian and Late Creswellian (see below). This also applies to the Late Creswellian in Britain (Chapter 4). Two burial sites in the Neuwied Basin are also dated to this period (Bonn-Oberkassel and Neuwied-Irlich), however no lithic assemblages with techno-typological features were associated with them (Martin Street pers comm.).

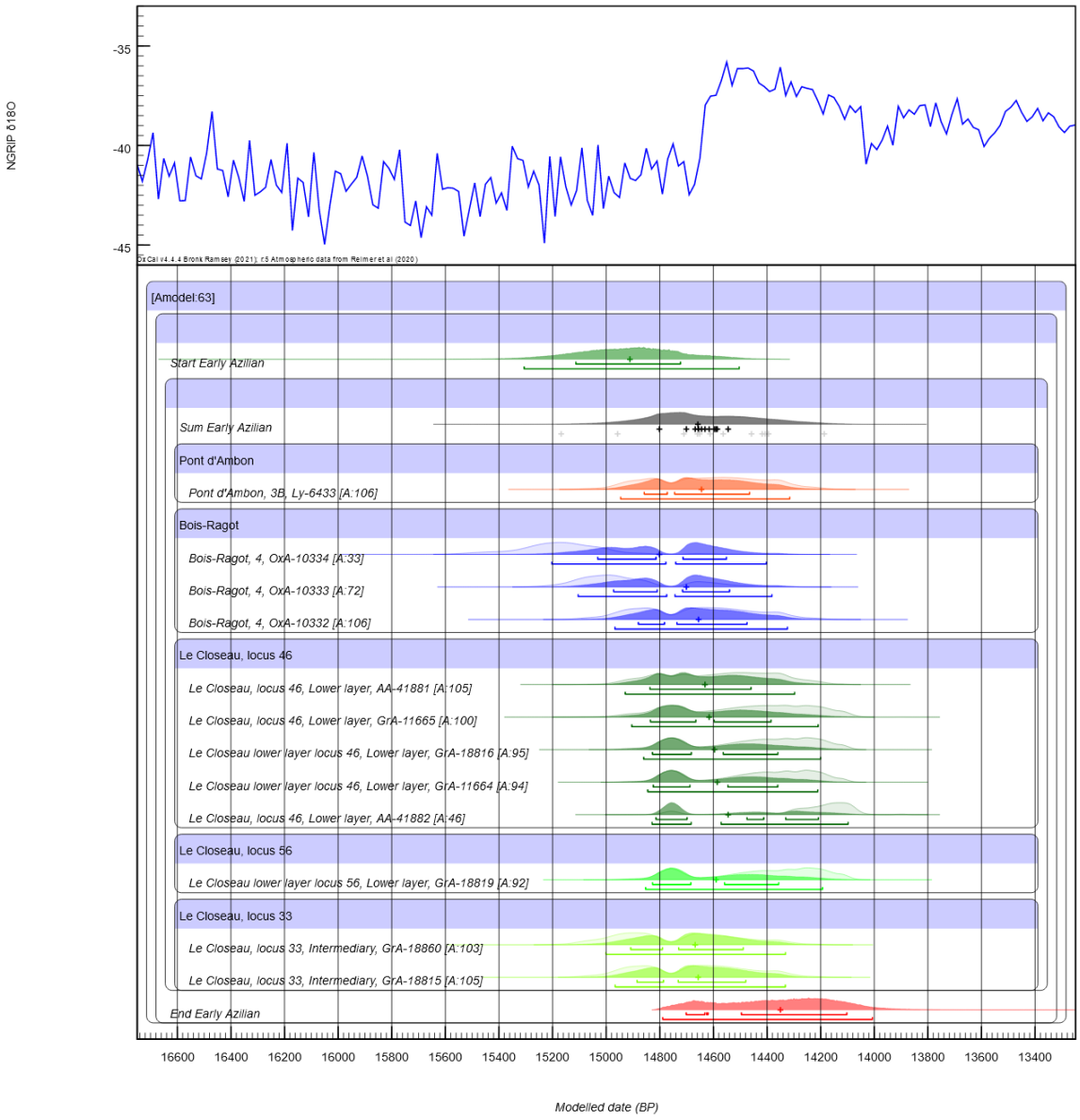


Figure 3.43 Early Azilian dates for reference assemblages mentioned in the thesis, dates from Naudinot et al. 2017. Not in stratigraphic order, subdivided by site. Uniform single phase. The Paris Basin dates (Le Closeau) overlap and appear later than sites further south (Bois-Ragot and Pont-d'Ambon). The earliest date from Pont d'Ambon, layer 4, is from the Magdalenian horizon, and the following date in layer 3b marks the Early Azilian (Célérier et al. 1993). Caution is needed with the dates from Bois Ragot as they are part of a series of potentially contaminated dates due to the preparation method applied (Higham et al. 2007).

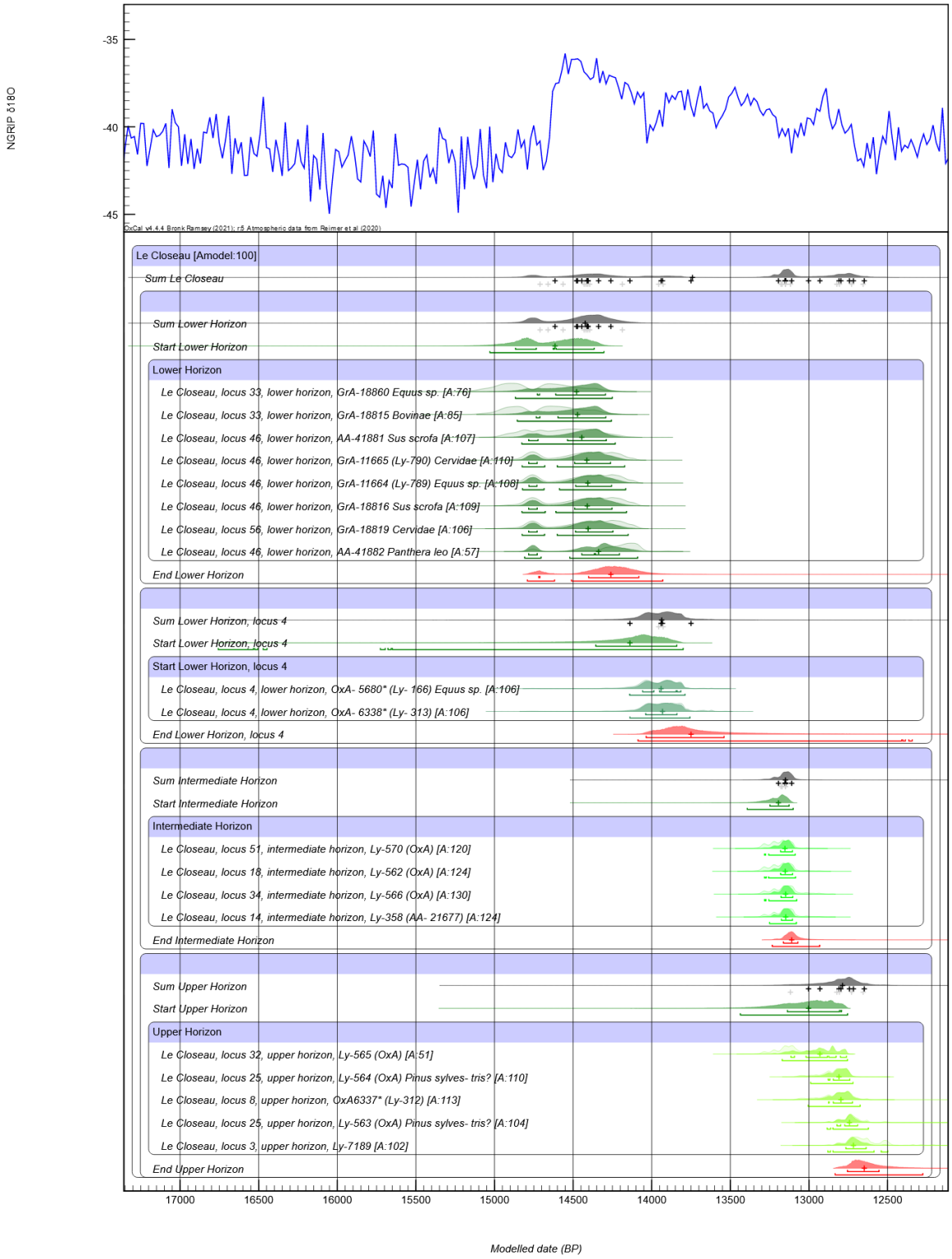


Figure 3.44 Le Closeau, Early Azilian in relation to Later Azilian dates, grouped by horizon (Bodu 2004 and Grimm 2013). Not in stratigraphic order, subdivided by locus. Overlapping uniform phases. A distinct hiatus lies between the Early Azilian lower horizons and the intermediate and upper horizons around 13500 cal BP.

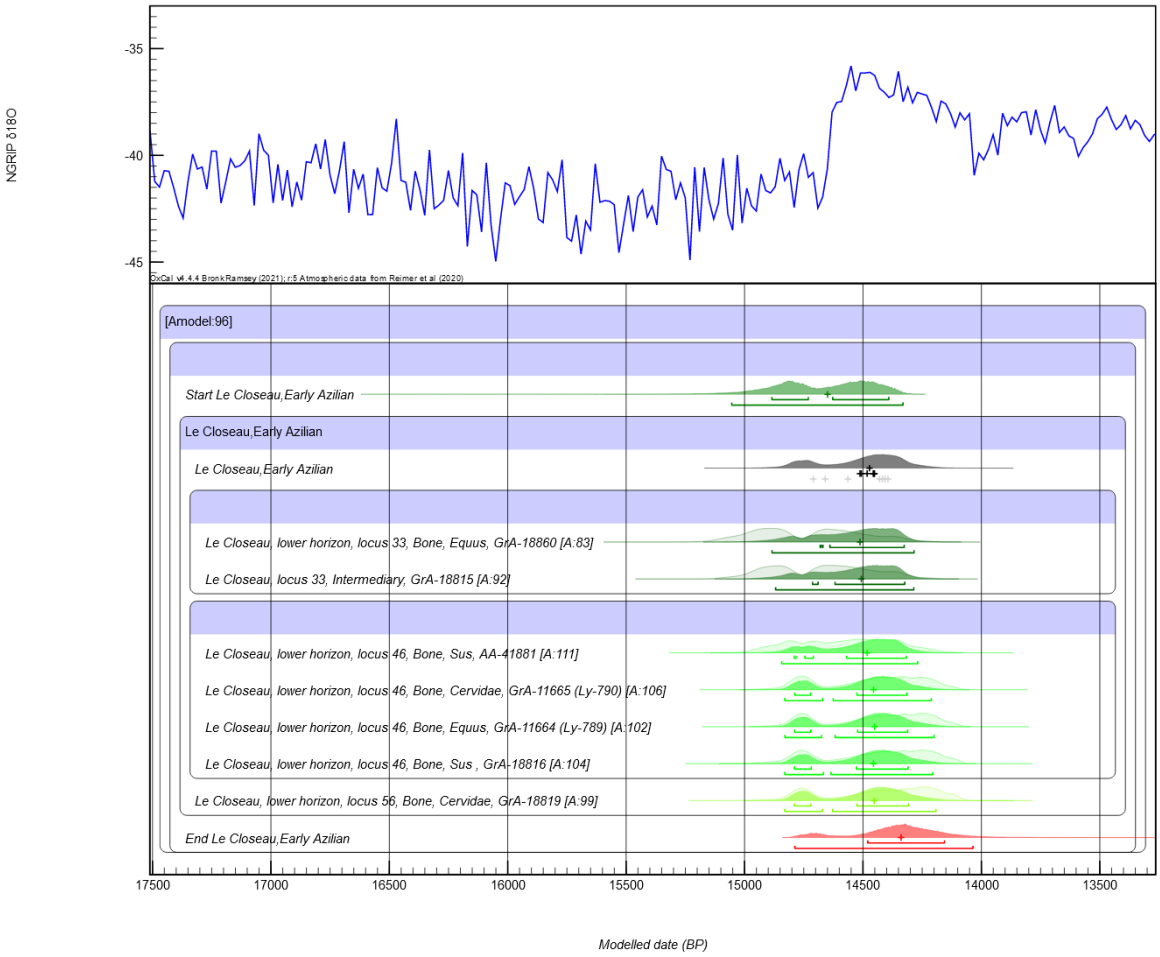


Figure 3.45 Le Closeau Early Azilian dates, grouped by area (Bodu 2004, Grimm 2013, Naudinot et al. 2017). Not in stratigraphic order, subdivided by locus. Single Uniform Phase. Amodel: 96% is over the acceptable threshold of 60%.

3.4.3.3 Description of techno-typology

Lithic production in the Early Federmesser at both Le Closeau inf and Hangest-sur-Somme III.1 was focused on making regular well-made straight blades (Bodu *et al.* 2011; Coudret & Fagnart 1997; Valentin 2008a). Soft-stone hammers were preferred to soft-organic hammers for the whole reduction sequence (Bodu *et al.* 2011; Bodu & Valentin 1997; Coudret & Fagnart 1997; Debout *et al.* 2012; Fagnart & Plisson 1997; Pelegrin 2000). This involved a truly opposed-platform strategy, to correct and maintain the removal surface and produce straighter blades (Pelegrin 2000). The move to preferential soft-stone blade

production is an important transition in the approach to raw material and blank and tool making (Pelegrin 2000; Valentin *et al.* 2006; Valentin 2008a). The selection of high-quality raw materials and minor core preparations before transport appear to be similar to strategies that were used in the Late Magdalenian (Pelegrin 2000; Valentin 2008a).

Although there continued to be common elements in the domestic tool kit with the Late Magdalenian (e.g. dihedral burins, end-scrapers on blades, piercers), there are significant difference in the armatures, most notably in the appearance of curve-backed bipoints (Figure 3.47, Figure 3.48, Figure 3.49, Figure 3.50, Figure 3.51) and a reduction (Hangest III.1) (Figure 3.46) or absence (Le Closeau) of small backed bladelets (Valentin *et al.* 2006; Valentin 2008a). There is also a lack of bladelet oriented debitage sequences and small blade cores within the Early Federmesser technocomplex at Le Closeau (Valentin *et al.* 2006). The change in blank forms and point types (from straight-backed bladelets to bipoints) is also found in the transition from Late Magdalenian to Azilian assemblages south of the Loire, notably at the Bois Ragot and Pont d'Ambon (Célérier *et al.* 1997; Valentin 2008a).

The significant number of slender abruptly backed curved bipoints and blades with scalar retouch are considered the foremost typological marker for this industry (Bodu & Mevel 2008; Coudret & Fagnart 1997; Naudinot *et al.* 2019; Valentin *et al.* 2006). The blanks are regular straight small blades with direct abrupt backing up to the central arise (Valentin 2008a). There may be cross-backing and/or the use of an anvil for thicker pieces (Naudinot 2009). Often proximal ends are removed but there is no evidence for the use of the microburin technique (Valentin 2008a).

Le Closeau has a significant number of blades with a distinct re-sharpening retouch called 'rasante' in French (Bodu & Mevel 2008) and translated by the author as 'skimming'. These blades with a 'skimming' retouch are considered as a diagnostic typological marker for this technocomplex in the Paris Basin (Bodu & Mevel 2008; Naudinot *et al.* 2019; Valentin *et al.* 2006). This form of retouch does not occur in the Early Federmesser sites like Hangest-sur-Somme iii.1 in the Somme basin, and is strongly associated to Early Azilian sites in France (Bodu & Mevel 2008). It is potentially present in British Creswellian assemblages such as Gough's Cave (Jacobi 2004) and the recently excavated open-air site of Guildford Fire Station with curved backed bipoints which is currently undergoing analysis (Attfield *et al.* 2014; Jacobi 2004)(see section 4.1.4). Table 3-9 summarises the lithic technological characteristics of the Early Federmesser assemblages.

Table 3-9 Early Federmesser/Azilian: Lithic technological characteristics

Technological Characteristics	**Summary description of the defining features of the technocomplex**	
	Early Azilian	**Early Federmesser**
Objectives	Blanks objectives: Continuous reduction strategy for long straight blades.	Blanks objectives: Continuous reduction strategy for long straight blades.

	Generally aiming for straighter blanks than in the 'Late Magdalenian'	Generally aiming for straighter blanks than in the 'Late Magdalenian'
Core preparation	Use of crests, can have two; preferential platform; reduced angle between platform and removal (flatter than Late Magdalenian); opposed platform for correction.	Use of crests, can have two; preferential platform; reduced angle between platform and removal (flatter than Late Magdalenian); opposed platform for correction.
Debitage	Soft-stone hammers for straighter blanks; careful preparation of striking platform: absence of éperon; frequent and heavy abrasion; semi-tournant or tournant	Soft-stone hammers for straighter blanks; careful preparation of striking platform: absence of éperon; frequent and heavy abrasion; semi-tournant or tournant
Tools	End-scrapers on long blades and flakes; dihedral burins; burins on truncation; long blades with 'skimming retouch'	End-scrapers on long blades and flakes; dihedral burins; burins on truncation
Armatures	Bipoints, curved backed points, backed blades	Bipoints, curved backed points, backed blades
Idiosyncrasies	Use of soft stone hammer. Abruptly backed bipoints, and retouched straight blades are the most distinguishing traits. **No** backed bladelets.	Use of soft stone hammer. Abruptly backed bladelets, diversity of backed points. **No** long blades with 'skimming retouch'

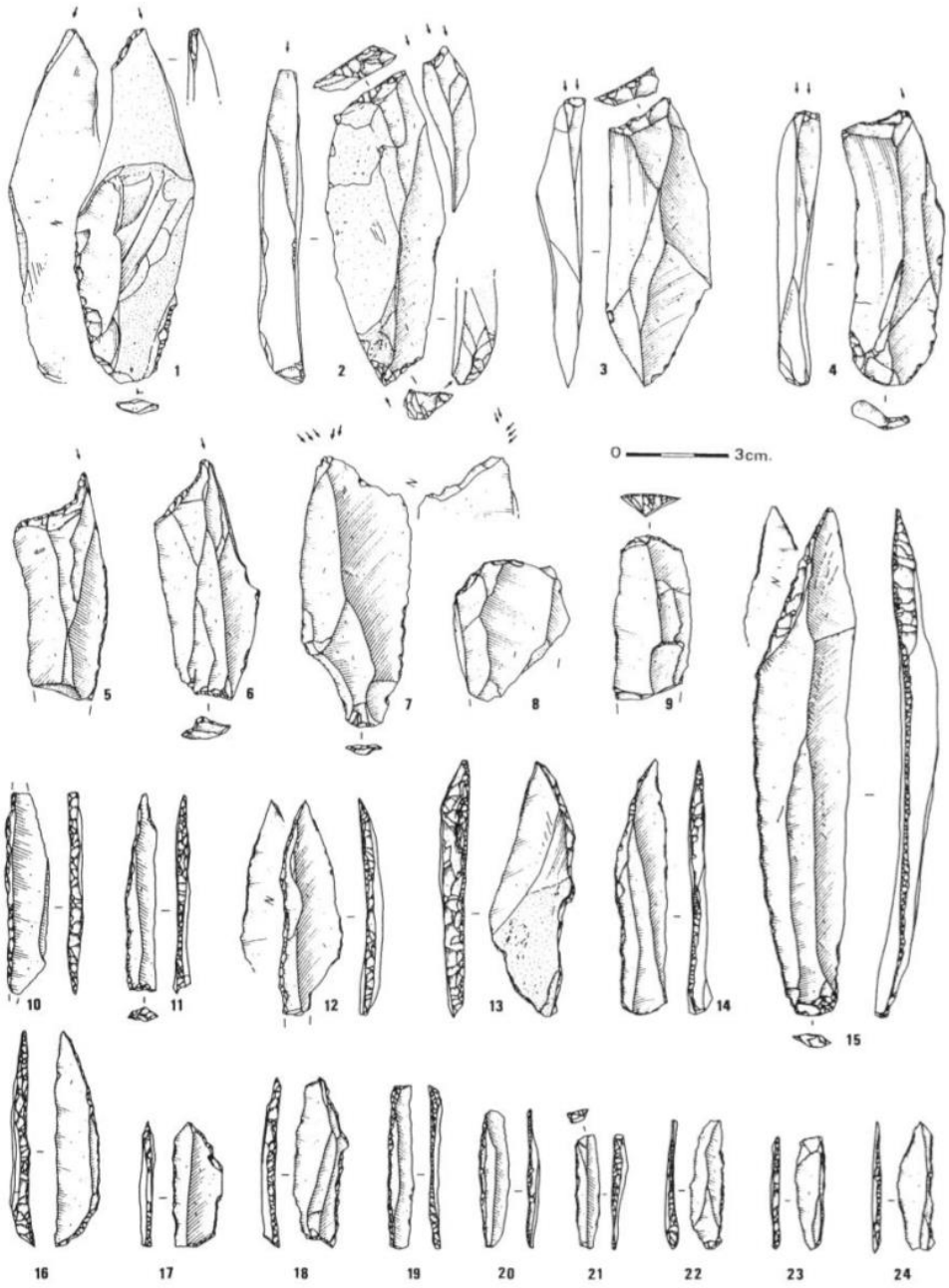


Figure 3.46 Lower level of the site of Hangest-sur-Somme III.1 , pre-Allerød (drawings P. Alix). This assemblage has been compared to the assemblage at Hengistbury Head (Barton 1992) see section 4.1.6. Coudret and Fagnart 1997 (Drawings P. Alix).

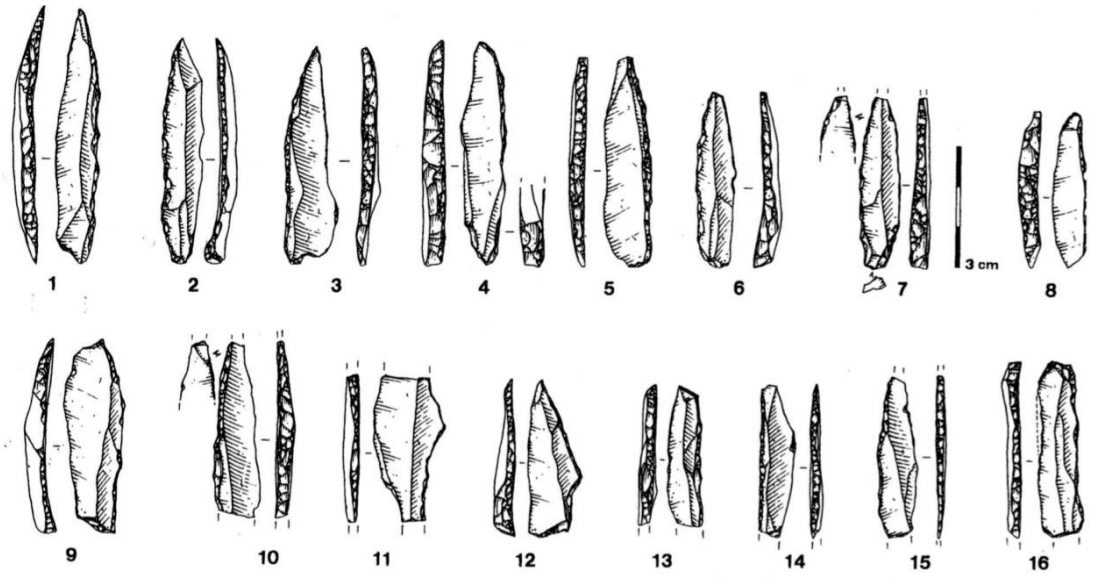


Figure 3.47 Saleux, Les Baquets, locus 244. Patinated pieces. Backed points. (Coudret and Fagnart 2004)

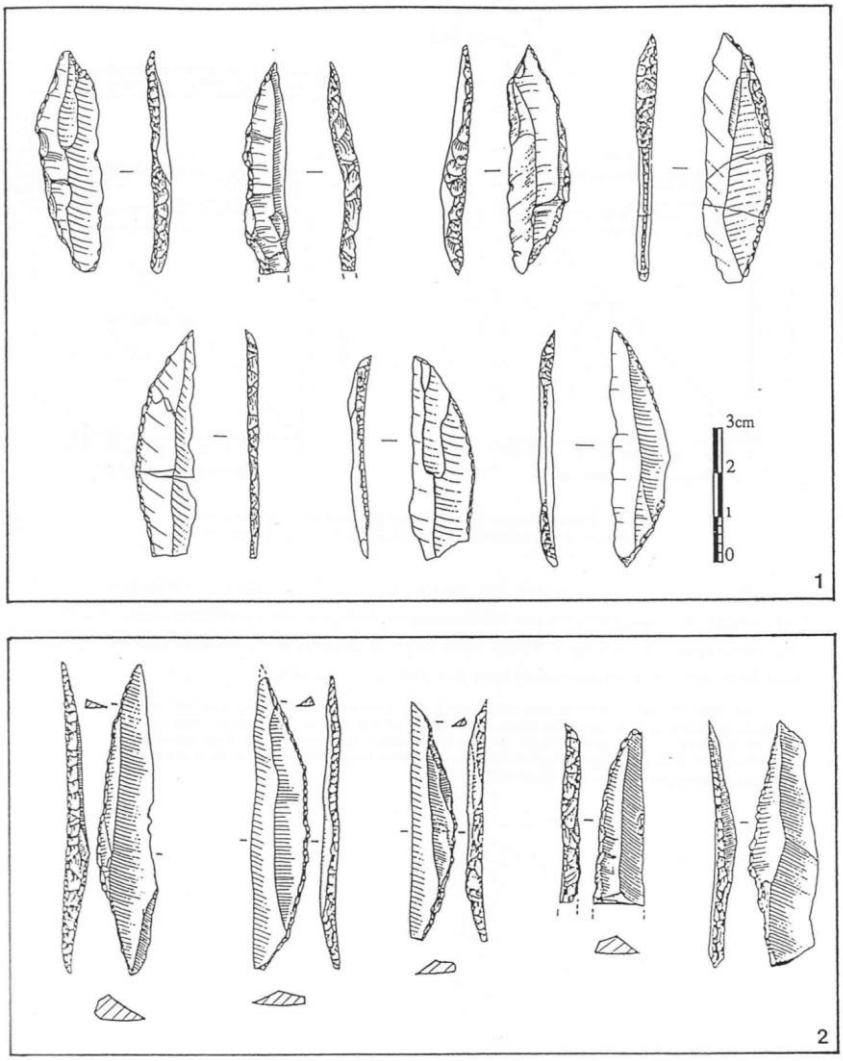


Figure 3.48 Early Azilian bipoints from Le Closeau, directly dated assemblages (Bodu 1995)(1) and La Grotte du Cheval at Gouy (Bordes et al. 1974)(2). Valentin 1995: 570-73.

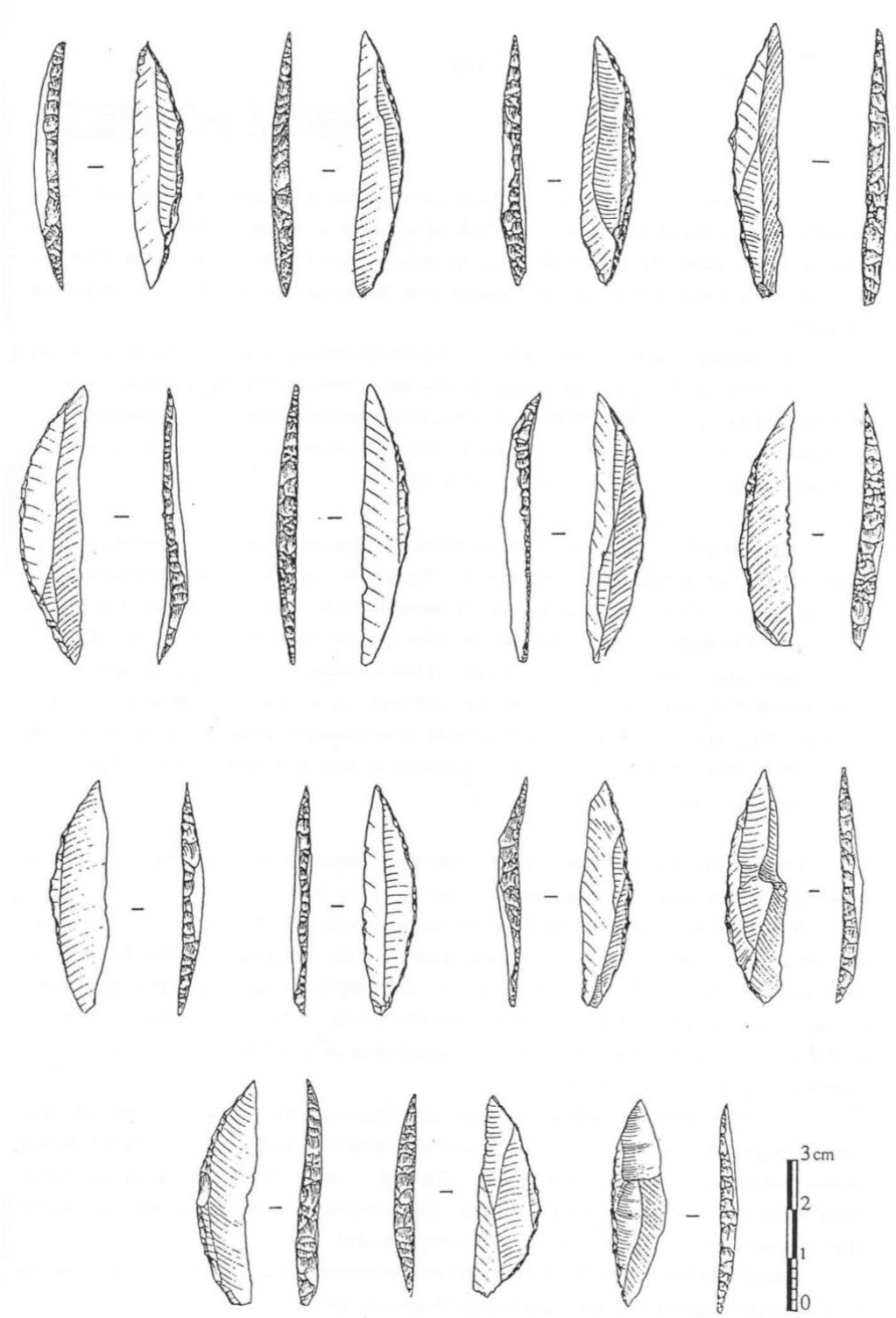


Figure 3.49 Early Azilian bipoints from layer 4, Le Bois-Ragot. (Valentin 1995: 574)

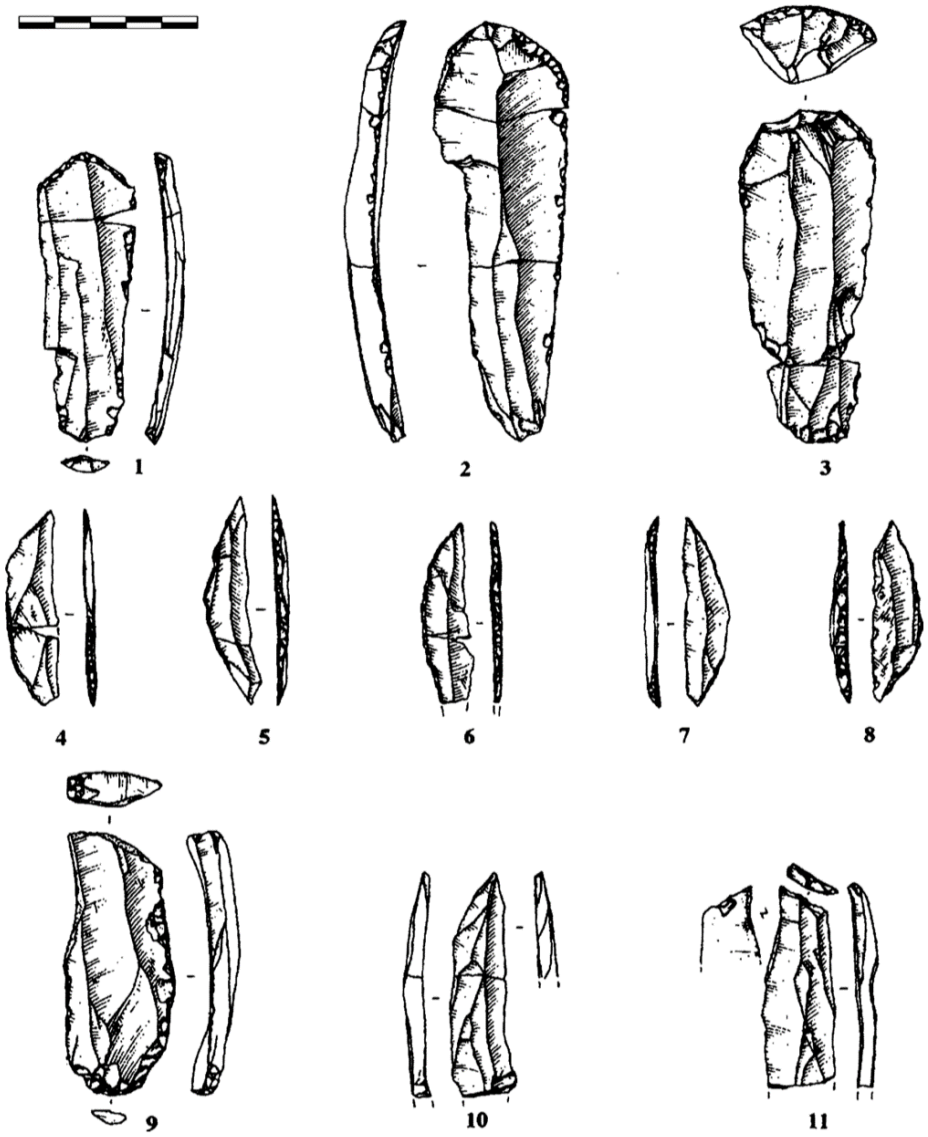


Figure 3.50 Early Azilian bipoints from Le Closeau. (Bodu and Mevel 2008)

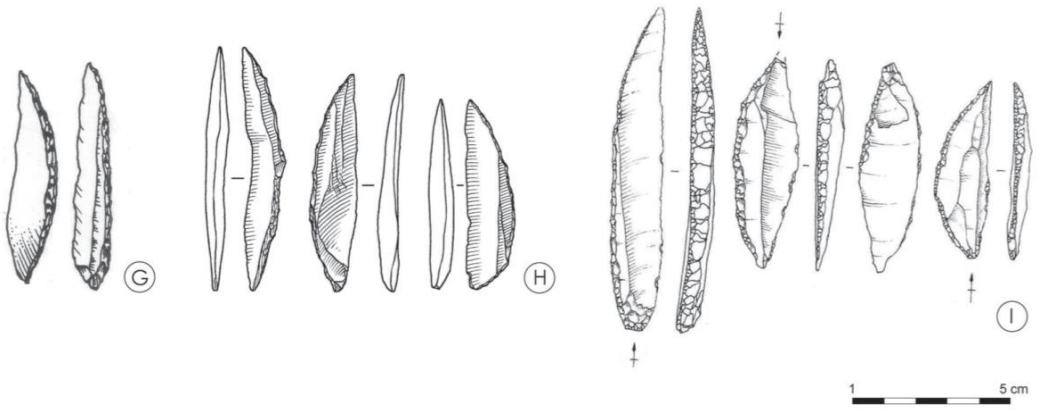


*Figure 3.51 Early Azilian armature examples from the western half of France. **G**. Murat (after Lorblanchet 1996); **H**. Le Morin (after Mallye et al. 2018, drawings S. Pasty); **I**. Le Rocher de l'Impératrice (after Naudinot et al. 2017a, (drawings F. Blanchet). Naudinot et al. 2019: 23.*

3.4.4 European Late Creswellian (Late Bølling, Older Dryas to Early Allerød)

A Late Creswellian grouping for mainland Europe was proposed by Stapert in 1985, based on both chronological (Older Dryas to Allerød) and typological attributes (predominance of Creswell points) from three open-air assemblages from the Netherlands: Zeijen, Emmerhout and Siegerswoude II (Kramer *et al.* 1985; Stapert & Johansen 2001; Stapert 1985; van de Lagemaat 2012). This followed a similar subdivision proposed by Bohmers in 1956 based on a typological division of the two main point types associated with the Creswellian: Cheddar and Creswell points (section 3.3.4). A temporal division has been confirmed by the re-dating of some of the British Creswellian assemblages, but it remains to be confirmed typologically (Jacobi & Higham 2011a; 2009a)(see Chapter 4).

Late Creswellian assemblages may be part of a major diversification of assemblages seen across northwestern Europe during the Older Dryas and Allerød. This could be reflected by the occurrence of Creswellian tools in various assemblages although this is not universally accepted. For example, in the Netherlands, Creswellian typological elements have been found in both Havelte and Federmesser groups and are sometimes thought to be the result of taphonomic mixing (de Bie & Caspar 2000; van de Lagemaat 2012).

3.4.4.1 Landscape context

The Netherlands Late Creswellian reference sites are distributed to the east of the Channel River system and are all open-air sites located on well-drained coversands. They are found on elevations of a few meters (significant for this region) above the lowland

coversand flats (Kramer *et al.* 1985; Stapert & Johansen 2001). All of the sites are located close to small watercourses, notably the specialised site of Emmerhout (Stapert 1985).

Two of the sites have evidence for the presence of hearths: Zeijen and Emmerhout (Stapert & Johansen 2001; van de Lagemaat 2012; van de Lagemaat *et al.* 2012). There has been an attempt to distinguish different categories of open-air sites based on the size of the assemblages and principal components of the assemblages (Stapert & Johansen 2001; Stapert 1985). An initial distinction was made between point-dominated sites (e.g. Siegerswoude II and Emmerhout) interpreted as hunting and retooling locations, and sites with a diversity of domestic tools (Zeijen) that could be interpreted as short-term seasonal camps (Stapert & Johansen 2001). Larger aggregation sites and seasonal camps have not been recognised in mainland Europe for this period (Stapert & Johansen 2001).

Judging from the number of isolated diagnostic finds, the distribution of Late Creswellian sites is likely to have been much greater in the Netherlands than is so far apparent. Figure 3.52 shows the location of the directly dated European Late Creswellian sites mentioned in the chapter in relation to the Channel River catchment.

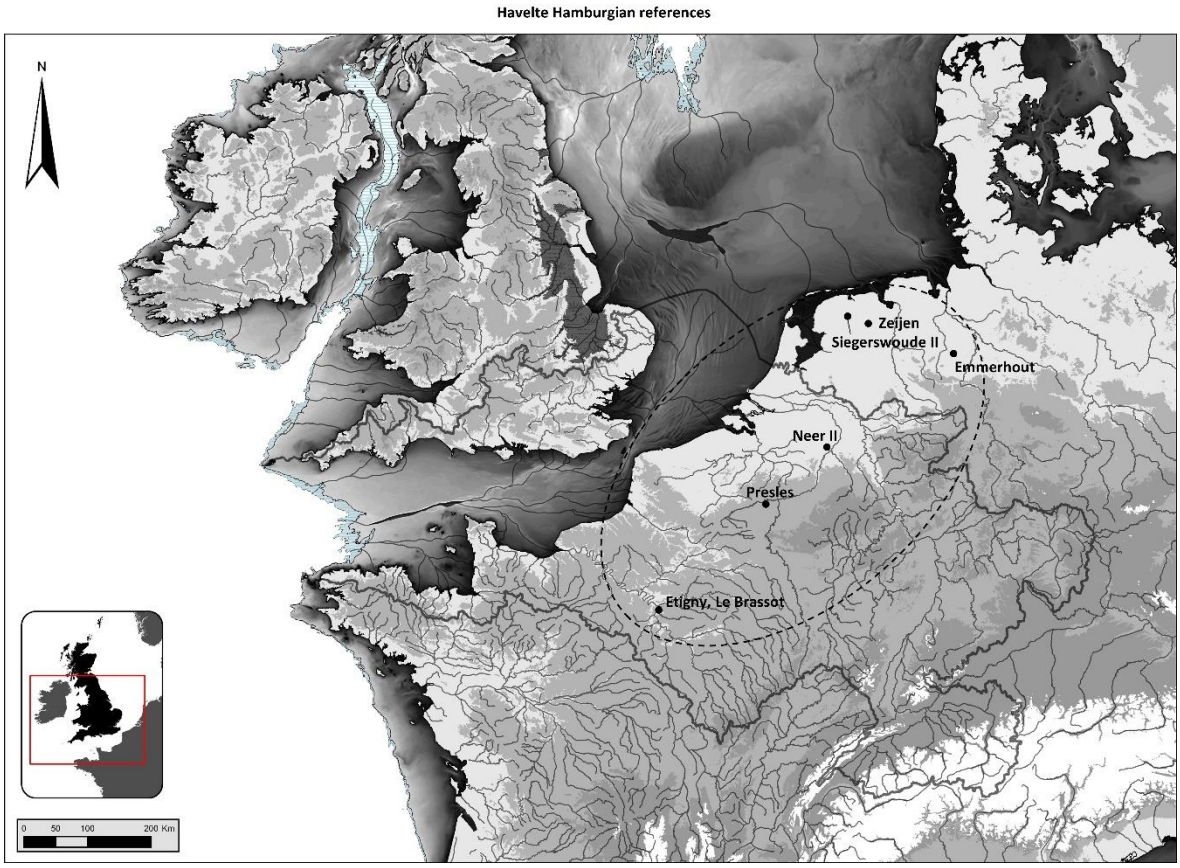


Figure 3.52 Distribution of reference sites with Late Creswellian facies. (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

3.4.4.2 Chronological setting

Of the Late Creswellian reference sites from the coversand region of the Netherlands, Siegerswoude II was found in the YCS1 (Older Dryas or Early Allerød) and Emmerhout from the base of YCS2, which may be slightly earlier. Both lie below the Usselo mid-Allerød palaeosol horizon (Derese *et al.* 2012; Kramer *et al.* 1985; Stapert & Johansen 2001; Stapert & Veenstra 1988; van de Lagemaat *et al.* 2012). Other Creswellian finds have been reported from the Usselo area and were also situated in the coversands below the Usselo Horizon (Stapert & Veenstra 1988).

The assemblage from Zeijen has neither stratigraphic nor direct dating evidence but is interpreted as earlier than the other two based on the presence of Cheddar Points. It is usually dated to the Late Bølling or Older Dryas based on dating of comparable British sites ((Stapert & Johansen 2001; van de Lagemaat *et al.* 2012).

3.4.4.3 Description of techno-typology

The Late Creswellian in the Netherlands is characterised according to point types and a general Magdalenian-type blade reduction sequence (Figure 3.53, Figure 3.54, Figure 3.55, Figure 3.56, Figure 3.57, Figure 3.58, Figure 3.59 , Figure 3.61, Figure 3.60) (Stapert & Johansen 2001; van de Lagemaat *et al.* 2012). Zeijen is the only assemblage with both Creswell (most numerous) and Cheddar points, as well as some refitting evidence. Both Siegerswoude and Emmerhout have Creswell points and an absence of Cheddar points (Kramer *et al.* 1985; Stapert & Johansen 2001; Stapert 1985; van de Lagemaat *et al.* 2012) It is importance to note that the Cheddar point is only one variant of angle-backed point. Another variant typified by an angle and curved-backed form was identified at Oldeholtwolde and Etigny, both dating to either the Older Dryas or the Early Allerød and may hint at an older dating for Zeijen and Siegerswoude II as well (Jacobi & Roberts 1993; Lhomme *et al.* 2004; Stapert & Johansen 2001).

More widely, the angle and curve-backed point type also resembles some Early Federmesser/Azilian bipoints with basal retouch (*cf*. Le Closeau). Angle-and curve-backed points have also been found at Hangest III (lower level) amongst the Early Federmesser material (Coudret & Fagnart 1997). Could this possibly be used as a widespread marker of the Late Creswellian, akin to the Havelte point and the Late Hamburgian?

As with the Early Creswellian there appears to be a total absence of straight-backed bladelets in these assemblages. There is also an absence of Havelte points and double zinken, and these absences distinguish it from the Late Magdalenian and Havelte respectively. Table 3-10 summarises the lithic technological characteristics of European Late Creswellian assemblages.

Table 3-10 European Late Creswellian: Lithic technological characteristics

Technological Characteristics	**Summary description of the defining features of the technocomplex**
Objectives	Not enough refitting for definition. Assumed similar to Early Creswellian, long blades.
Core preparation	n/a
debitage	n/a
Tools	n/a
Armatures	Creswell Points, occasional Cheddar points and variations of.
Idiosyncrasies	Presence of bipoints and Federmesser points on the same sites
Strongest identification factors	Creswell and Cheddar Points

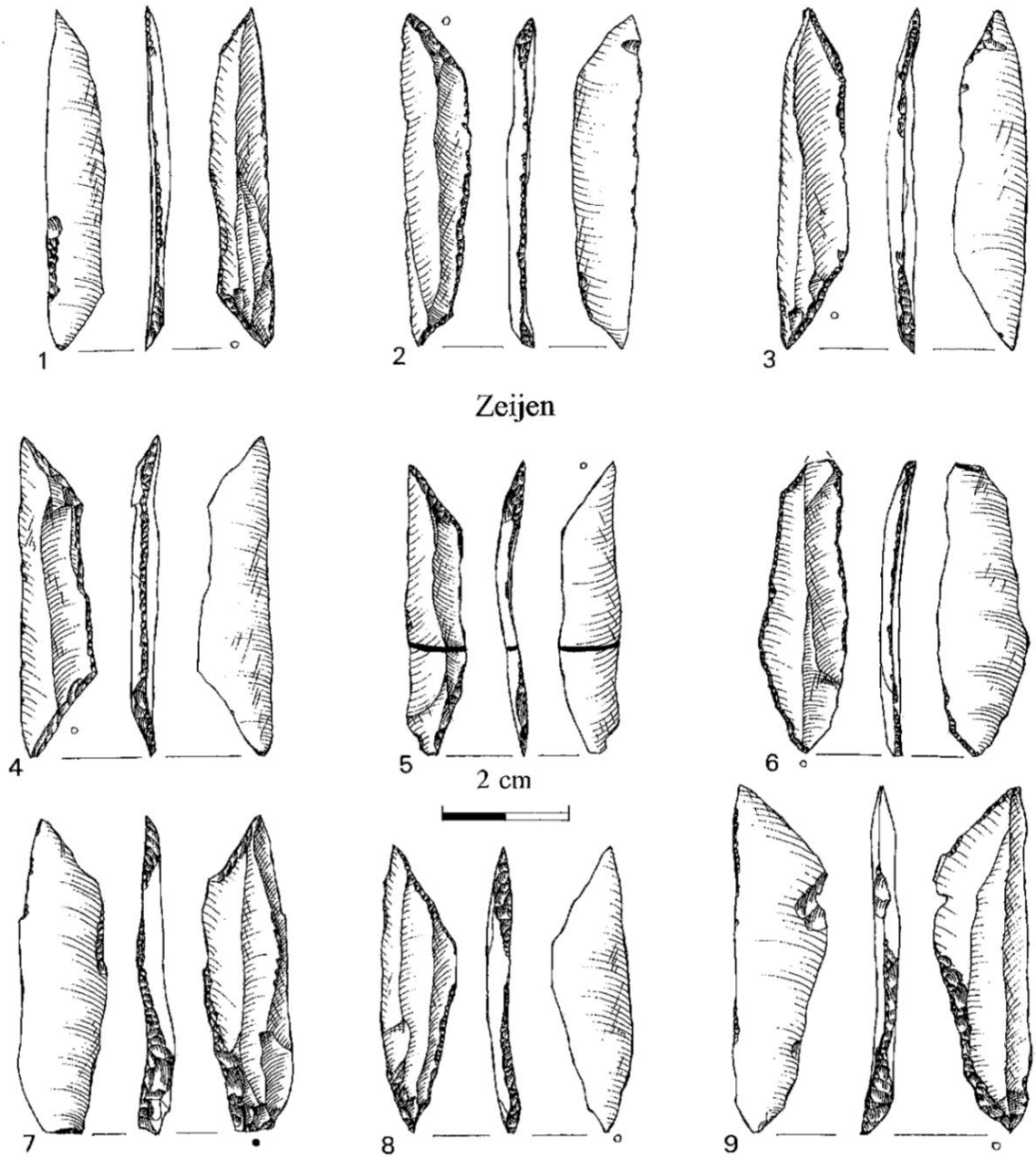


Figure 3.53 Points from the site Zeijen , 1-6 are Cheddar points, 7-9 Creswell points. (Stapert and Johansen 2001, drawings Johansen)



Figure 3.54 Examples of Cheddar points from Zeijen (Photo W. Mills 2014)

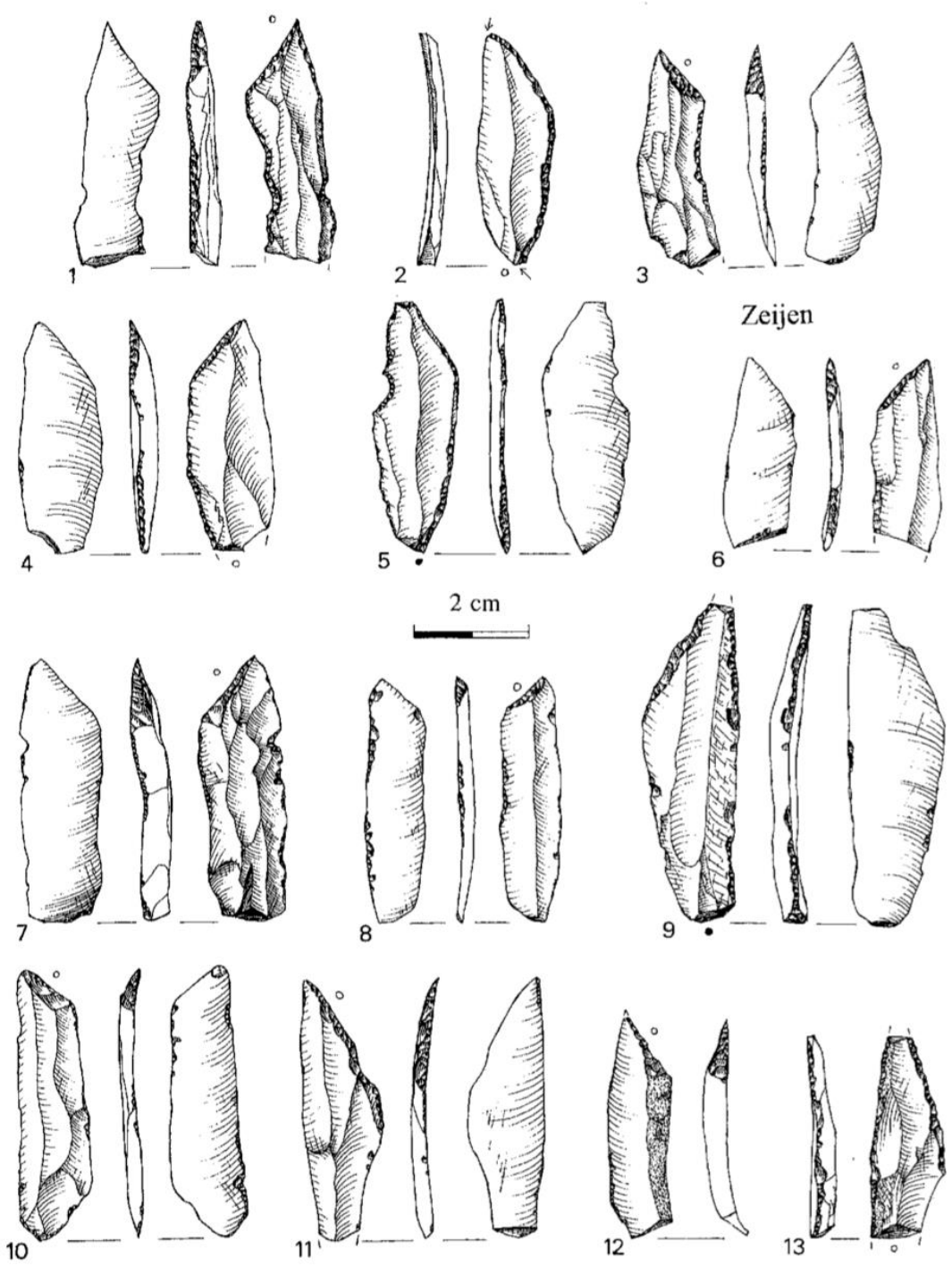


Figure 3.55 Points from Zeijen , 1-8 are 9 Creswell points, 9-13 long B-points. (Stapert and Johansen 2001, drawings Johansen)

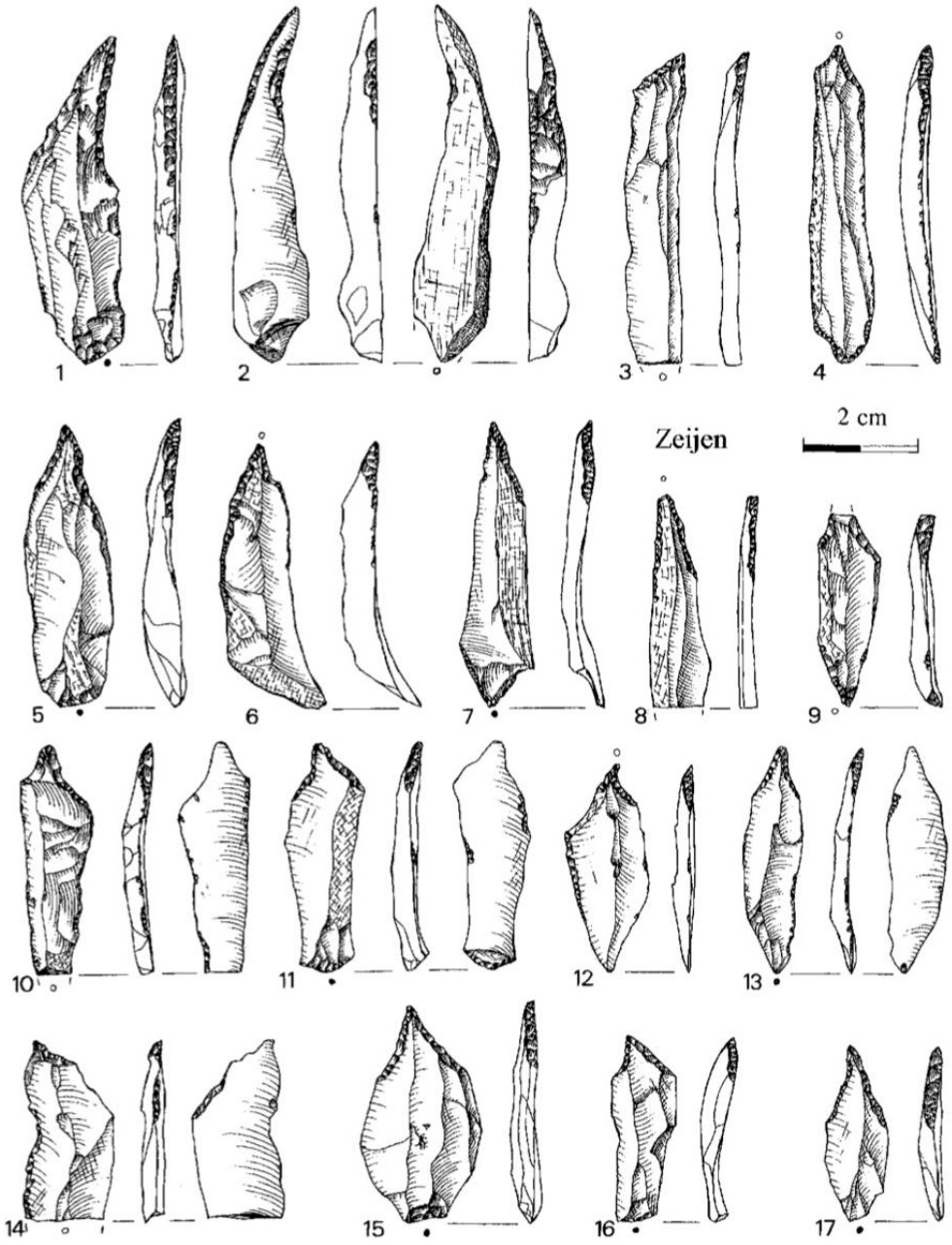


Figure 3.56 Borers/piercers from Zeijen (Stapert and Johansen 2001, drawings Johansen)

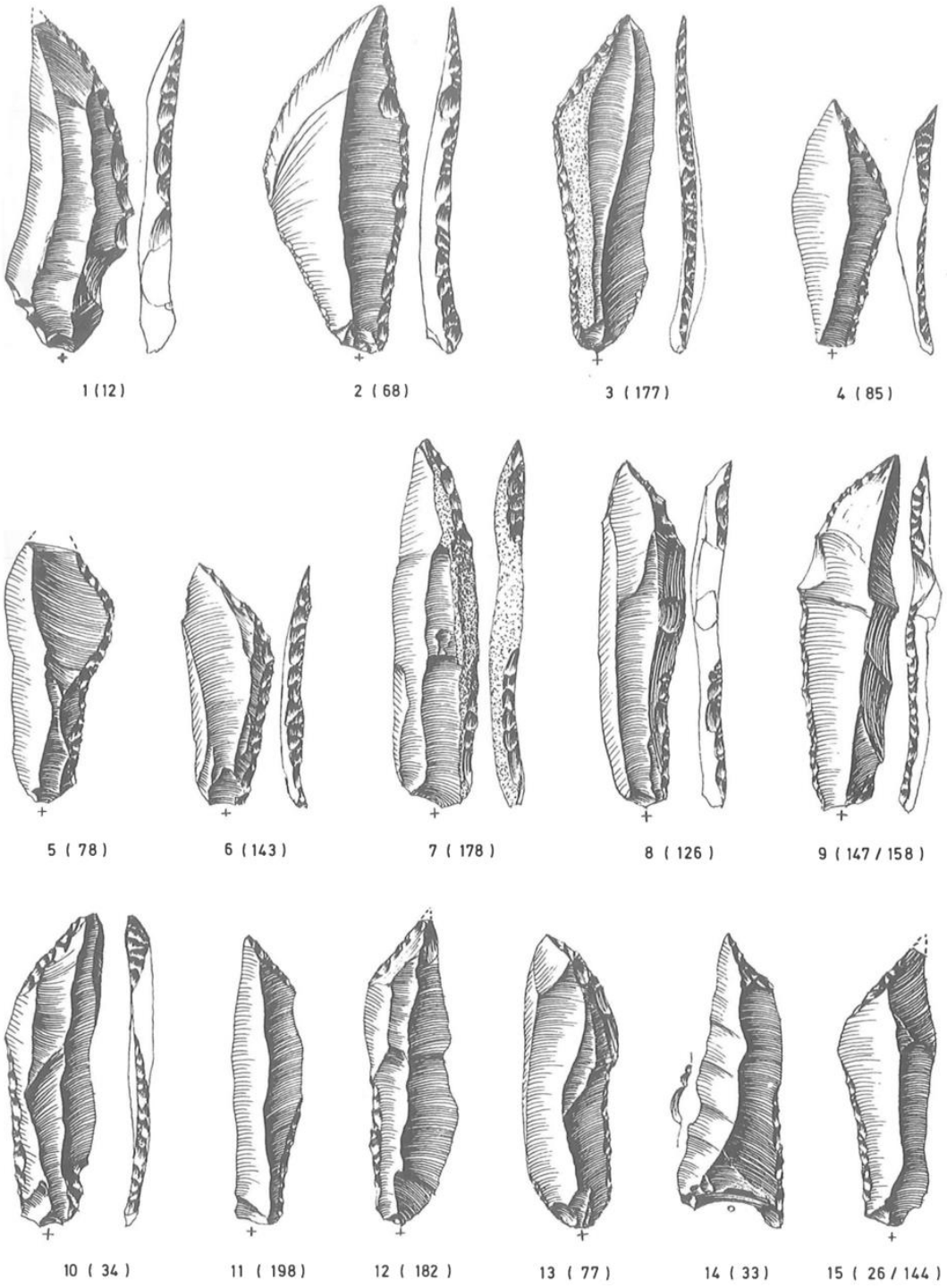


Figure 3.57 Backed points from Siegerswoude II. 3-15 Creswell points. Kramer 1985 (no scale).

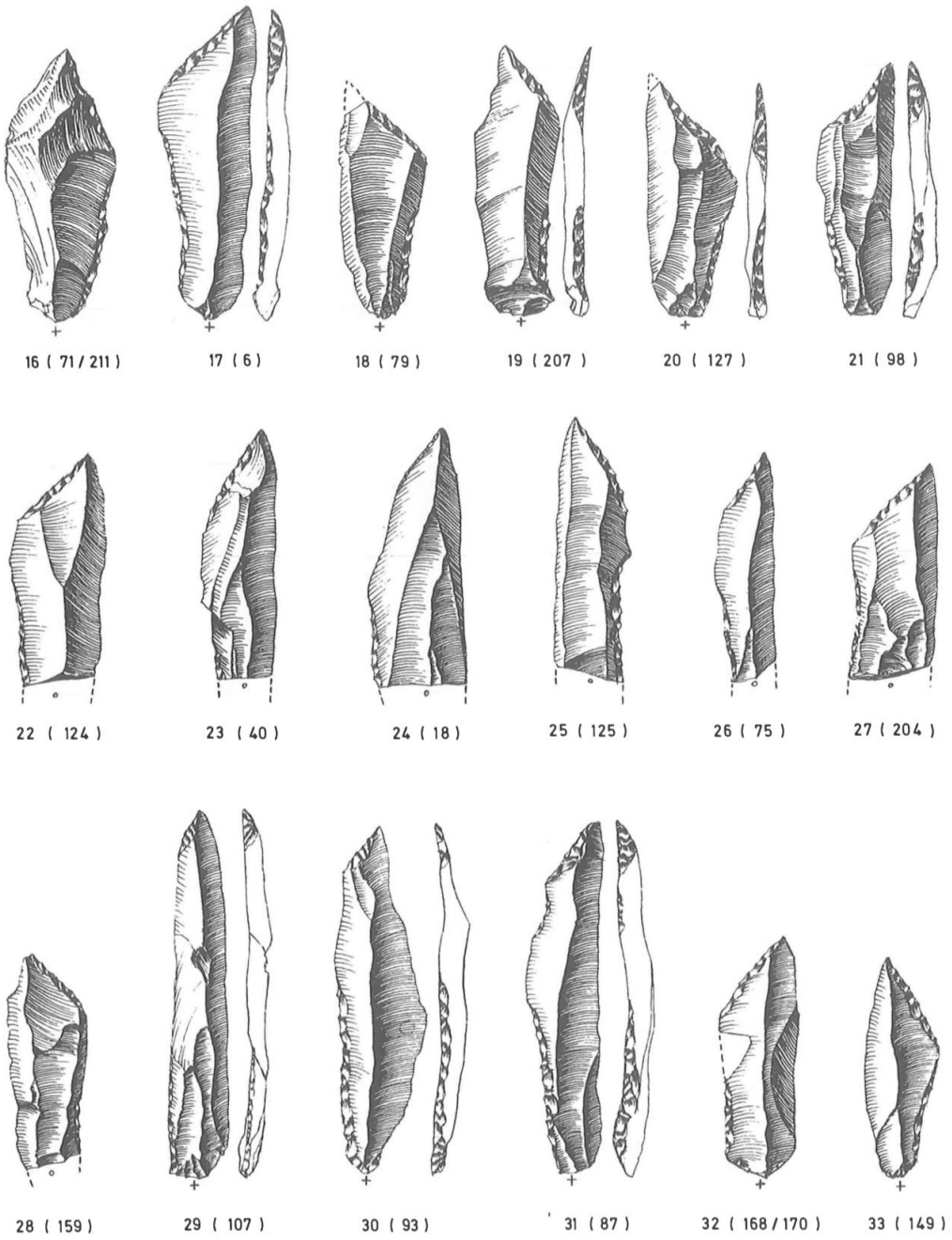


Figure 3.58 Backed points from Siegerswoude II. 16-33 Creswell points. Kramer 1985 (no scale).

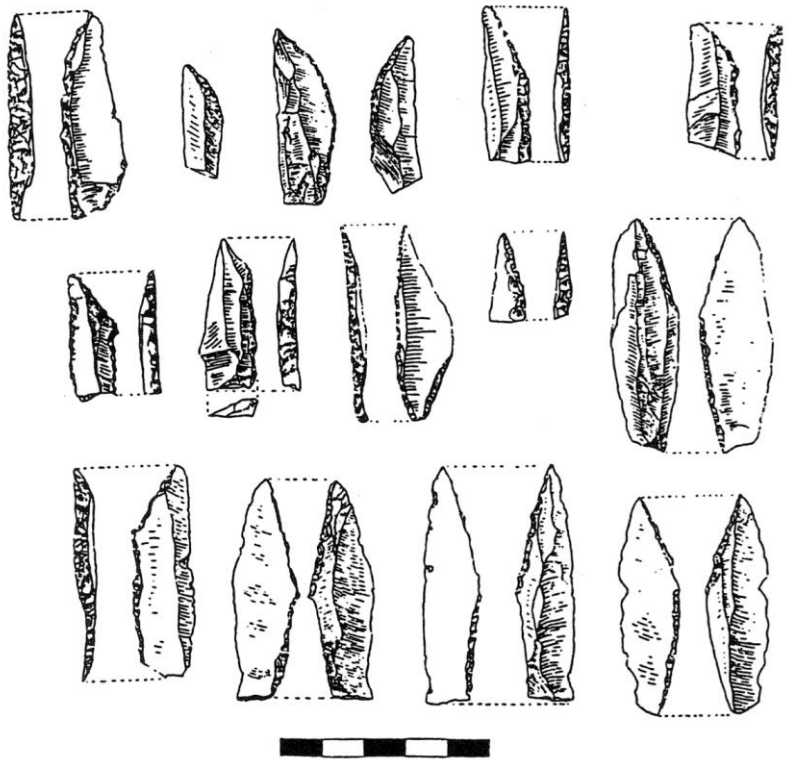


Figure 3.59 Backed points from Presle (After Danthine 1955-60,. Charles 1988).

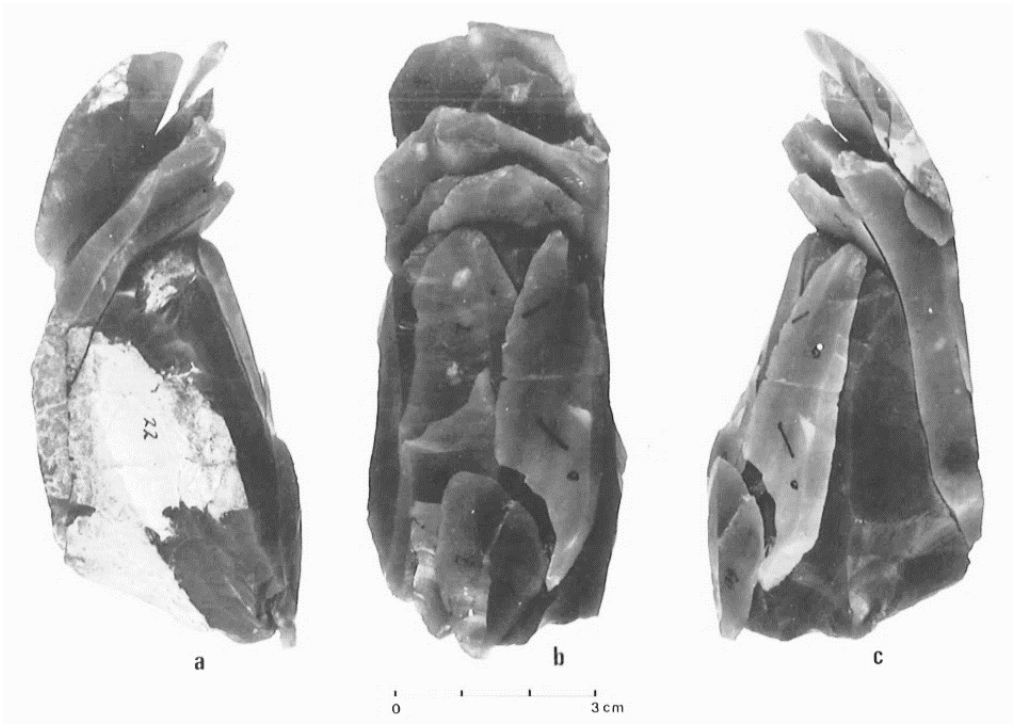


Figure 3.60 Refitting group N, Emmerhout. (Stapert 1985).

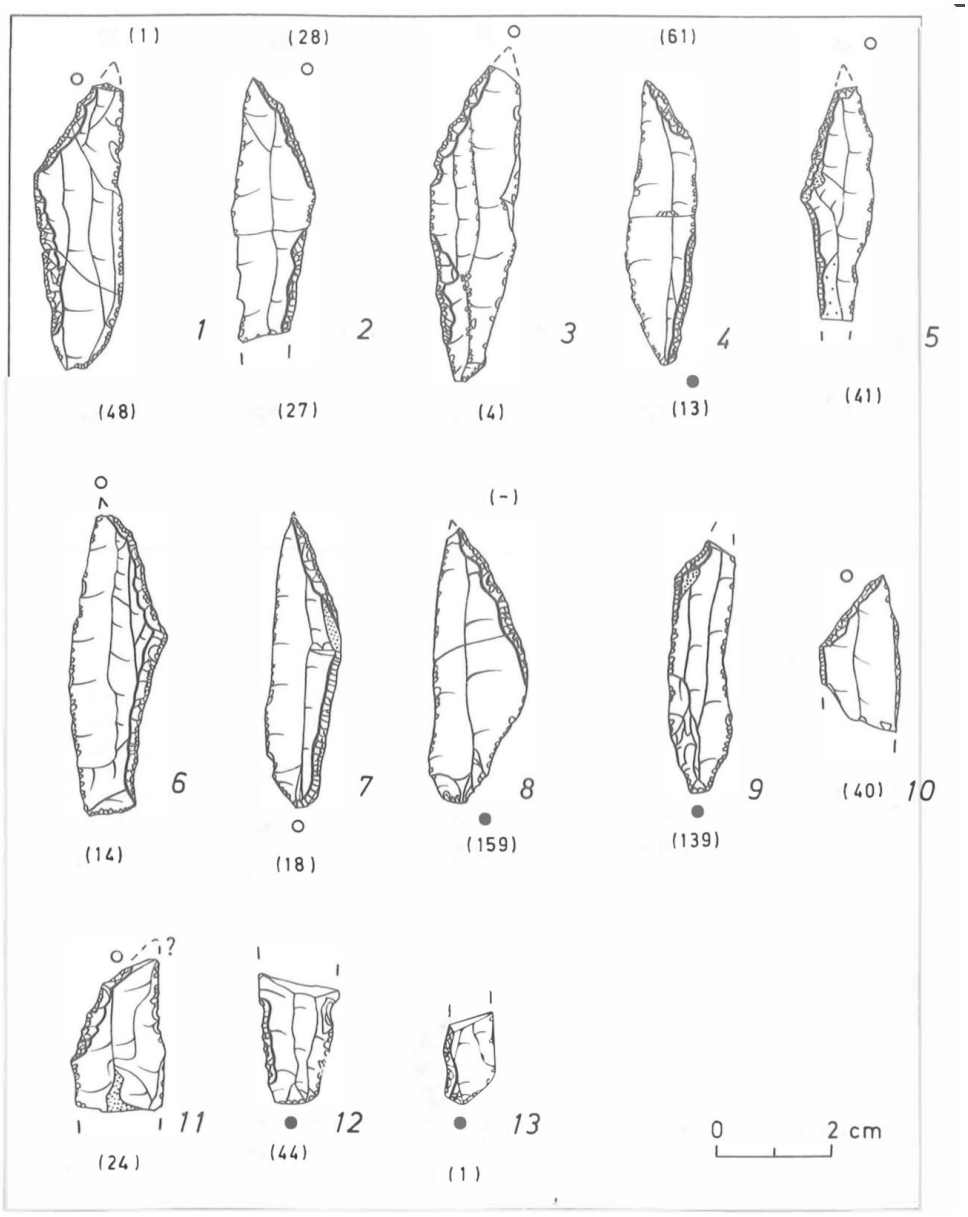


Figure 3.61 Points and probable point fragments from Emmerhout. (Drawing D. Stapert/J.M. Smit)

3.5 Allerød Federmessergruppen, CBP, Late Azilian; straight-backed Federmesser technocomplexes (GS-1c to GI-1a)

3.5.1 Introduction

The framework used here is based on the tri-partite subdivision of the Federmesser in the Somme Basin (Coudret & Fagnart 1997; Fagnart 1998) with additional observations from the Seine Basin (Bodu 2003; Bodu & Valentin 1997; Pelegrin 2000; Valentin *et al.* 2006). The framework consists of an Early Federmesser (section 3.4.3), the Early Allerød (Middle) Federmesser (section 3.5.2) and the Late Allerød (Late) Federmesser (section 3.5.3). The Somme Basin scheme was built-up by research over a period of more than 20 years (Antoine *et al.* 2012; 2000a; Coudret & Fagnart 1997), and bears a close resemblance to the sequence in Southeast England.

The scheme described here is slightly different from the classic Federmesser succession in northern Germany (Bohmers 1961; Schwabedissen 1954; Taute 1963) which is mainly based on typological criteria. It does not have the same standard of chronological control as in the Somme Basin, although an exceptionally high resolution for the terminal phases of the Allerød (Baales 2006). Nevertheless the Federmesser industries in Germany (partly synonymous with the Curve-Backed Complex) probably incorporates some if not all of the stages mentioned in this chapter (Weber *et al.* 2011). The Federmesser technocomplex would therefore appear to span the period from prior to the Allerød to the main phases of the Allerød, covering a period of at least 1000 years in the Greenland Ice Core record (Rasmussen *et al.* 2014).

Table 3-11 Development of characteristics of the Federmesser technocomplex in the Somme Basin. Based on Coudret and Fagnart 1997, with additions by the author

Chronozone	Pre Allerød Phase	Early Allerød Phase	Final Allerød Phase
Raw Material	Excellent quality (Turonian)	Excellent quality (Turonian)	Good Quality (Coniacien)
Core Shaping	Elaborate	Simplified	Simple or absent
Debitage	Preferential platform	Opposed platform	Opposed platform
Percussion technique	Soft-stone hammer (sandstone)	Soft-stone hammer (sandstone)	Hardstone hammer (flint)
Blade production	Average productivity Well calibrated blanks	Average productivity Well calibrated blanks	Low productivity Poorly calibrated blanks
Projectile insets and points	**Variety of elements** Curve-backed (sometimes bipoints) Straight backed Shouldered with truncation Truncated base Bi-truncated	**Mono-points** (Federmesser) Curve-backed Straight backed Rare other types	**Mono-points** (Federmesser) Curve-backed Straight backed
Fauna	Aurochs and red deer	Aurochs and red deer	Horse
Sites	Hangest III.1	Conty Dreuil-Etouvie?	Saleux 114, Hangest III (upper), Belloy-sur-Somme (patinated white); La Chausse Tirancourt

3.5.2 Early Allerød Azilian/Federmesser

The four main reference sites are Conty in the Somme Basin (Antoine *et al.* 2012), Le Closeau, middle level, in the Paris Basin (Bodu & Valentin 1997), and two other sites with strong techno-typological affiliations with Conty, both in the Somme Basin: Étouvie-Amiens and Dreuil-les-Amiens (Antoine *et al.* 2012; Fagnart 1988). The typo-technological characteristics are supplemented by refits, particularly at Conty and Dreuil-Étouvie.

3.5.2.1 Landscape context

All of the Early Allerød Federmesser sites mentioned here lie south of the Channel River and are exclusively from open-air locations. They are situated in broadly similar topographic settings, in proximity to the floodplain of major rivers (Somme and Seine), with a similar bedrock and palaeoenvironmental records (Antoine *et al.* 2000a). Figure

3.62 shows the location of the directly dated Early Allerød Federmesser sites mentioned in the chapter in relation to the Channel River catchment.

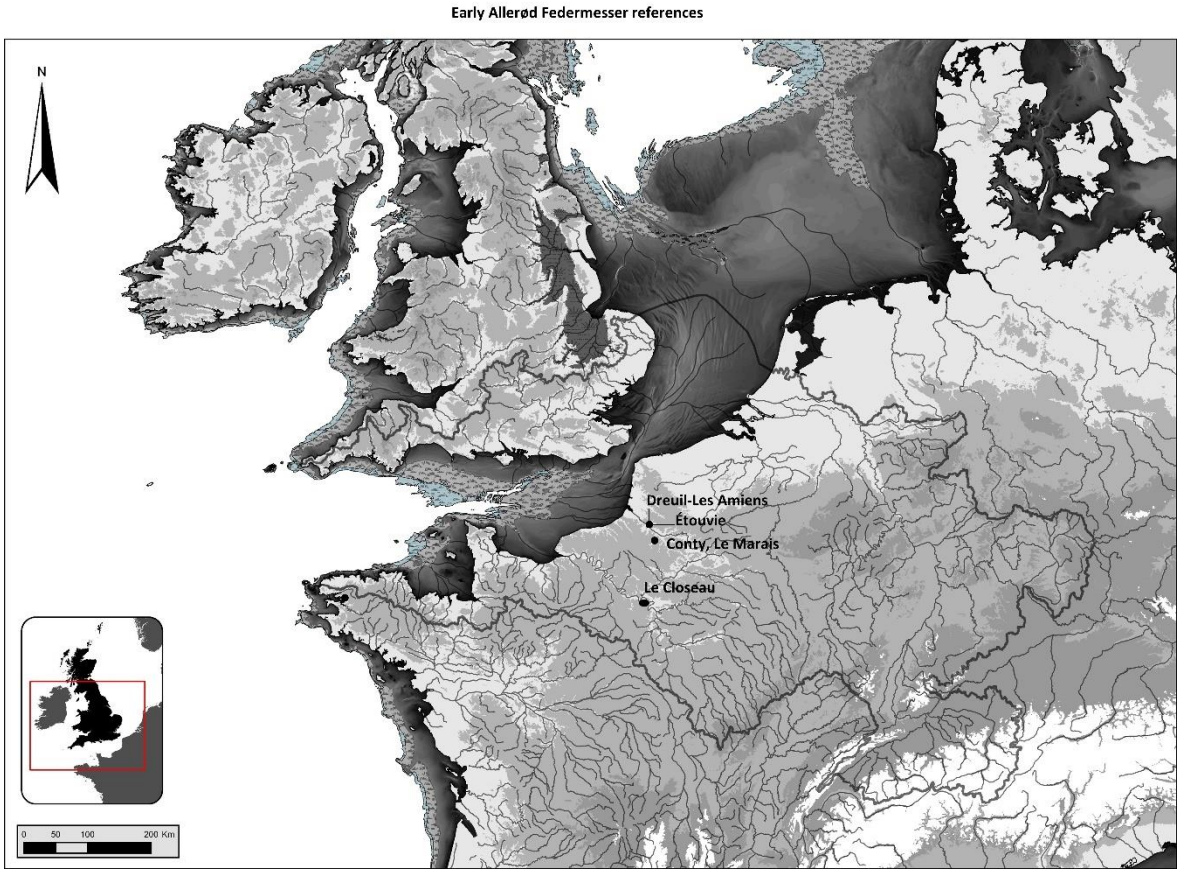


Figure 3.62 Early Allerød Federmesser facies reference sites. (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

3.5.2.2 Chronological setting

The Early Allerød (Middle) Federmesser is best dated at Conty (Figure 3.63; Figure 3.64), which is one of the only high resolution stratigraphic and palaeoenvironmental sequences in northern France with a good record of both the Older Dryas and the Early Allerød (Antoine *et al.* 2003c; Coudret & Fagnart 1997). This sequence was recorded in the context of a rescue excavation, and the lithics horizon was recovered as best as possible. The palaeoenvironmental and dating context was on the other hand extremely well-

preserved in an alluvial sequence, enabling a precise date and contextualisation of the site (Antoine *et al.* 2012). Conty remains the only reliably dated site for the Early Allerød Federmesser at the onset of the Allerød (Antoine *et al.* 2012). Some of the Havelte Hamburgian and Late Creswellian sites may also date to this period.

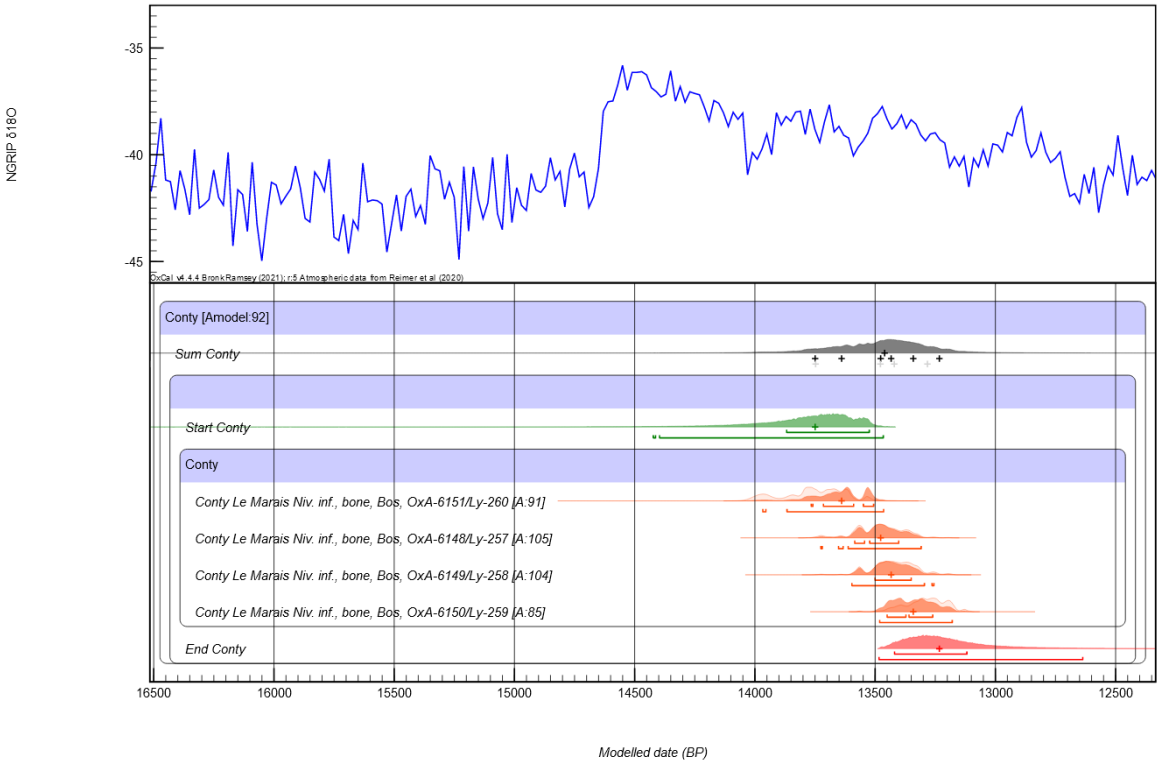


Figure 3.63 Lower level dates from Conty associated to the lithic assemblage attributed to the beginning of the later Federmesser (Antoine et al. 2012, Grimm 2013). Single uniform phase. Although the dates are from the same archaeological horizon, the earliest date (OxA-6151) in GI-1c is the best fit with the rest of the stratigraphic and environmental data (Antoine et al. 2012).

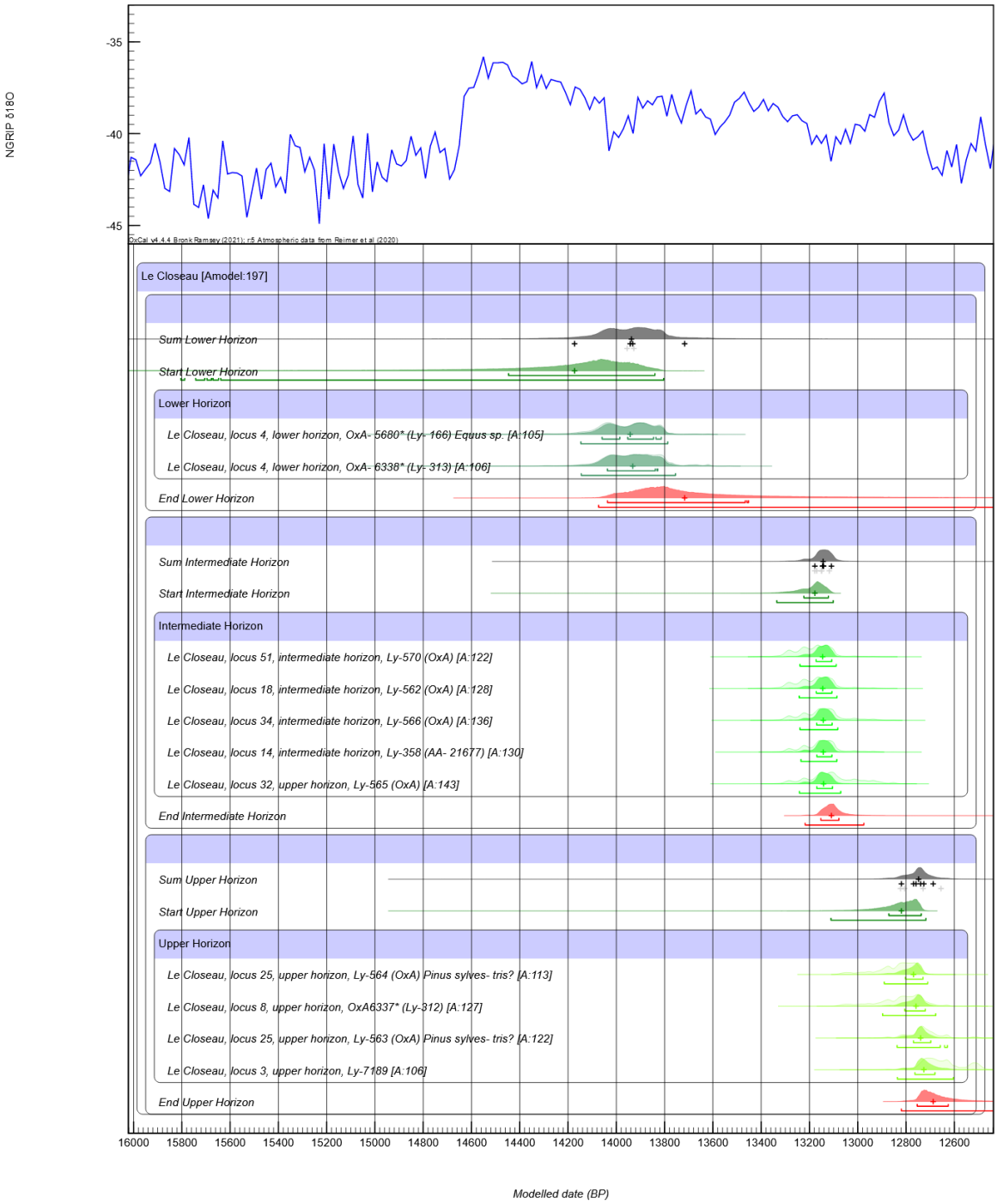


Figure 3.64 Le Closeau intermediate and upper horizons, Allerød Azilian dates, grouped by horizon (Bodu 2004 and Grimm 2013). Phases in stratigraphic order, subdivided by locus. Overlapping Uniform Phases. There is a distinct hiatus between the latest Lower Horizon Early Azilian (niveau 4) and the beginning of the intermediate horizons (see also Figure 3.44 for the full Early Azilian sequence).

3.5.2.3 Description of techno-typology

The Early Allerød (Middle) Federmesser technocomplex is marked by a significant shift of emphasis to the production of short straight blades (Coudret & Fagnart 1997). This is accompanied by a change in the methods and techniques in maintaining the core to optimise this production. It is reflected in a transition to the sole use of soft-stone hammers that that when struck tangentially enable the production of straighter broader blades. The platforms are less acute, and the regular alternation of platforms enables the maintenance of a flat extraction surface. There is still a careful preparation of the striking platform with abrasion and faceting, with great care in calibrating blade extraction (Fagnart & Coudret 2000a). Although there are some bladelets there is no evidence for an intentional bladelet production.

The main difference is in the transformation of blanks into tools (Figure 3.65, Figure 3.66, Figure 3.67, Figure 3.68). The focus of the production of small blades was to create curved backed single pointed forms or *mono-pointes à dos courbe* (sometimes with a basal retouch). The other characteristic element is the significant presence of large backed knives. There are few backed bladelets (absent at Conty but present in small numbers at Étouvie-Amiens).

Amongst the domestic toolkit, mostly made on the larger thicker blanks or flakes, end-scrapers become shorter and more robust. Burins were frequently made on truncations or consisted of dihedral forms on thicker blade blanks. Becs and piercers were notably

much scarcer than, for example, in the Late Magdalenian technocomplex (Fagnart & Coudret 2004). The frequent use of thick backing and truncations is one of the distinguishing factors of this Federmesser. Another important characteristic of this Early Allerød Federmesser is the choice of high-quality raw material contrasting with the subsequent Federmesser technocomplexes (Coudret & Fagnart 2006a; 1997; Valentin *et al.* 2006; 2004b; Valentin 2008b). Table 3-12 summarises the lithic technological characteristics of Early Allerød Federmesser assemblages.

Table 3-12 Early Allerød Federmessergruppen: Lithic technological characteristics

Technological Characteristics	Summary description of the defining features of the technocomplex
Objectives	Blanks objectives: well calibrated robust straight blades and short blades
Core preparation	Absence of crests; usually opposed platform reduction to correct hinges and maintain a flat removal surface; multiple tablets; angles closer to 80 degrees between platform and removal;
Debitage	Hard-stone hammer early stages; possible organic; most debitage is either soft-stone or hard stone; high proportion of unprepared or simple platforms (linear); near systematic heavy abrasion of the platform edge
Tools	End-scrapers short thick blades; dihedral burins; frequent truncations and burins on truncations
Armatures	backed bladelets
Idiosyncrasies	Often local raw material; presence of cortical material indicating on-site preparation variability in raw material quality
Strongest identification factors	Backed points; blade dimensions; platform preparations

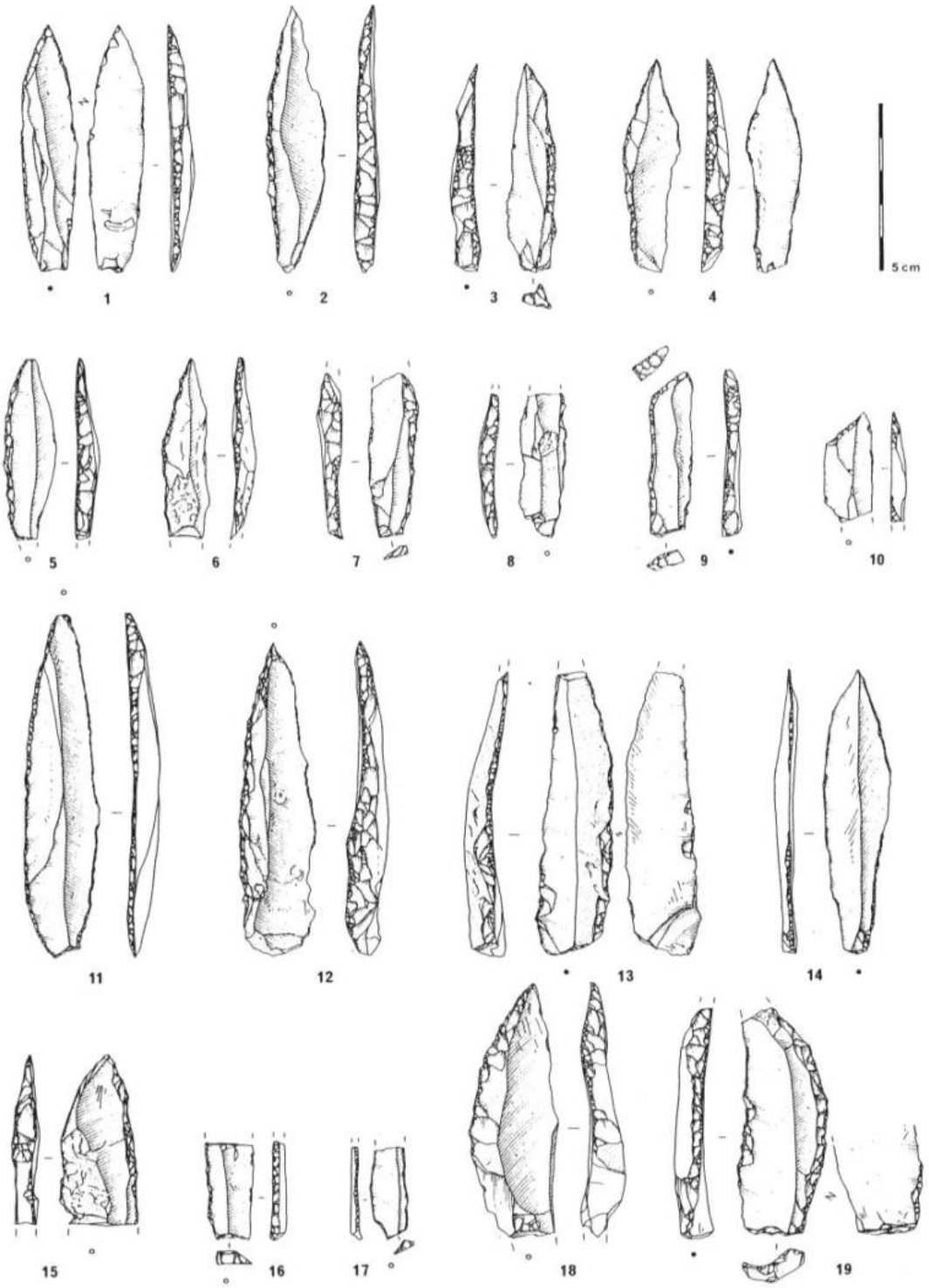


Figure 3.65 Reference assemblage for the Early Allerød at Conty , Le Marais, lower level. 1-8, 14, 16 backed points. 9-10 truncated pieces, 15,18 and 19 backed knives. 17 backed bladelet with truncation. Coudret and Fagnart 1997: 354.

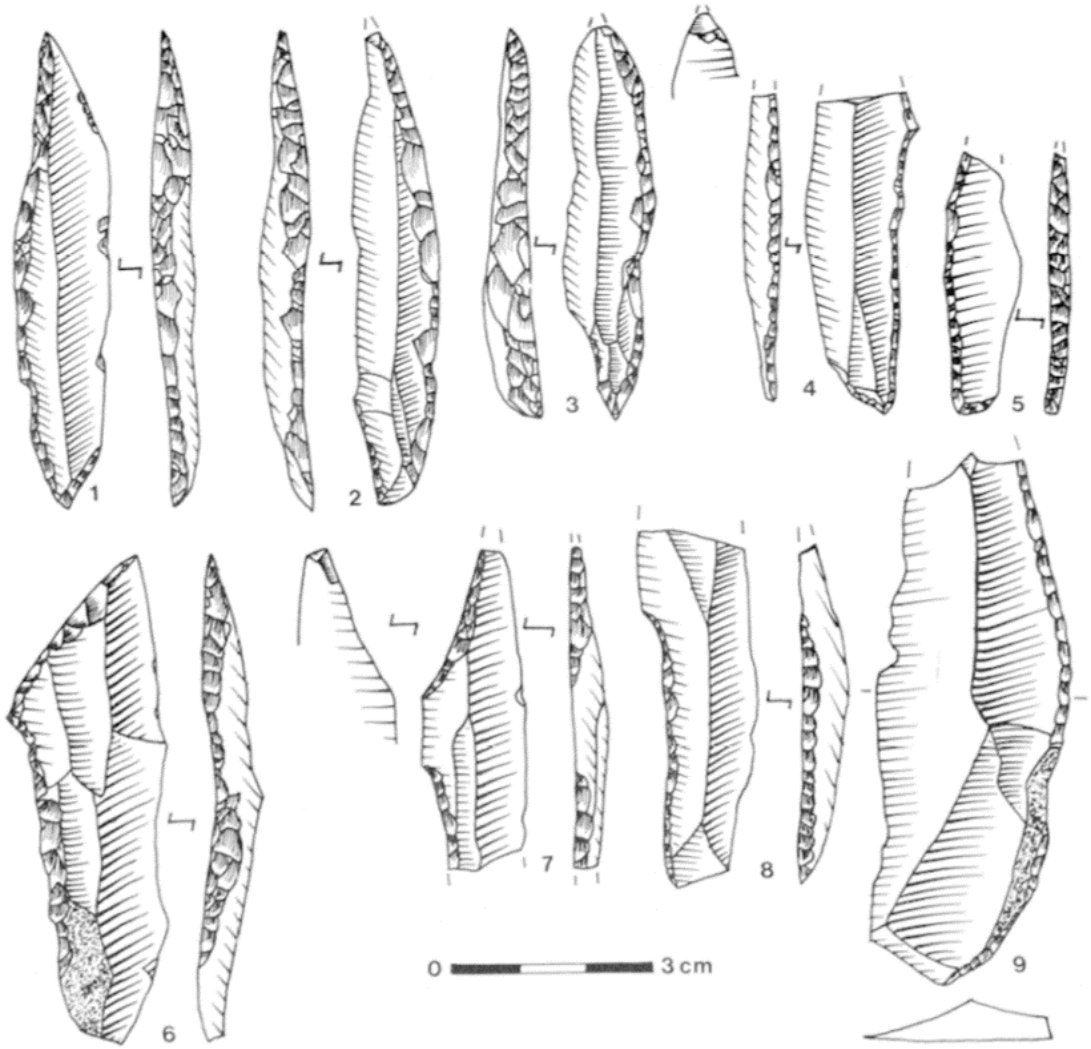


Figure 3.66 Amiens-Étouvie, Graviere Jourdain. Early Allerød Federmesser based on similar characteristics to Conty.(see Naudinot et al. 2019). N.b. 6-8 are shouldered, 6 resembles a Creswell point with an oblique truncation and 7 has a Classic Hamburgian point profile. These are both incomplete and could also be stages of abandonment of backed blades or points. Fagnart 1988: 43

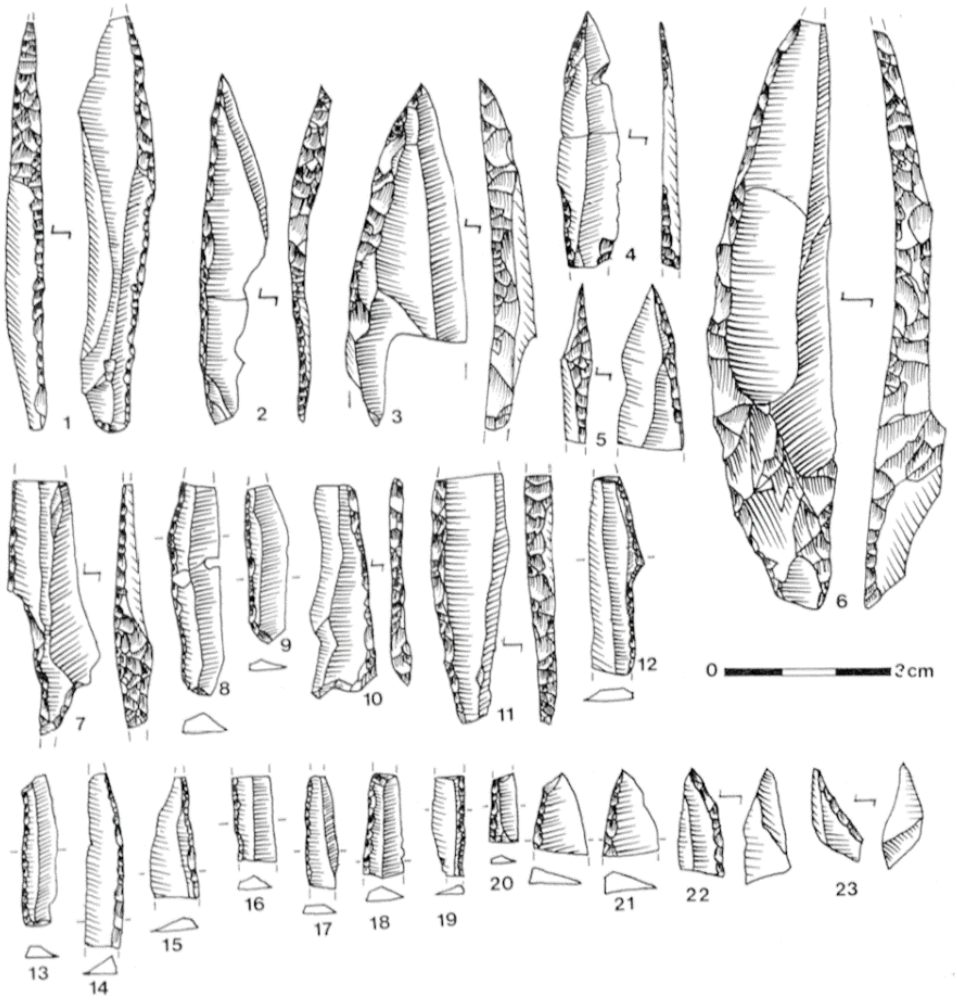


Figure 3.67 Amiens-Étouvie, Graviere Petit. Early Allerød Federmesser based on similar characteristics to Conty (see Naudinot et al. 2019). Fagnart 1988: 39

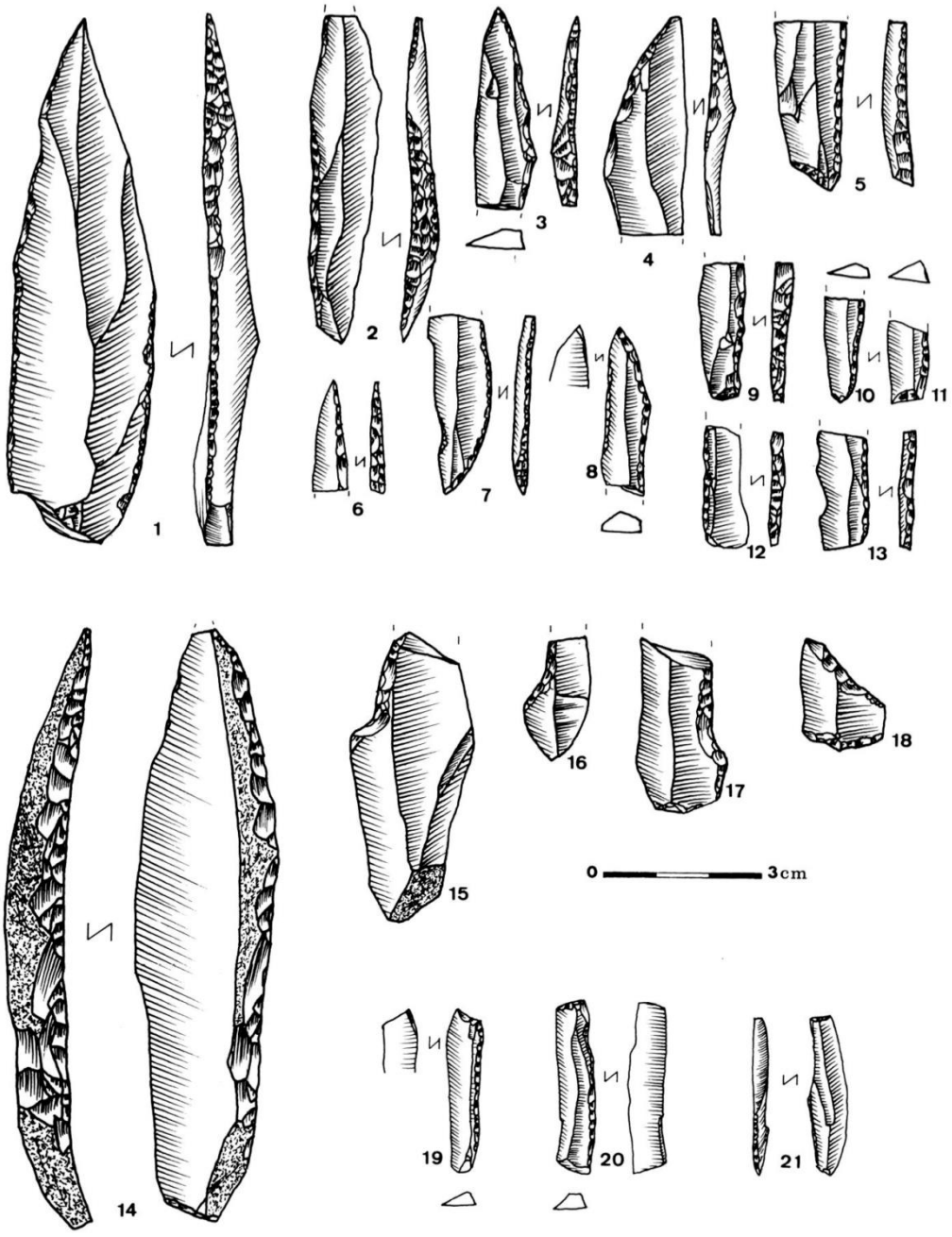


Figure 3.68 Dreuil-les-Amiens, Early Allerød Federmesser based on similar characteristics to Conty (see Naudinot et al. 2019). Fagnart 1988.

3.5.3 Late Allerød Federmessergruppen (GS-1b to GI-1a)

There is a distinct change in both the technology and typology in Late Allerød Federmesser-type industries. Whereas some of the traits of Magdalenian core management and production were still apparent in the Early Federmesser and Early Allerød (Middle) Federmesser, a major transition appears to take place in the Late Allerød (Coudret & Fagnart 2006a; 1997; Valentin *et al.* 2006; 2004b; Valentin 2008b).

There are many hypotheses to explain this change, most of them focussing on adaptations to forested environments, significant population mobility (Gamble *et al.* 2004; Housley *et al.* 1997), demographic expansion and population turnover (Amkreutz *et al.* 2018; Posth *et al.* 2016; Riede & Edinborough 2012). More recently mitochondrial DNA evidence also suggests the by possible arrival of new groups from the Near East (Fu *et al.* 2016; Posth *et al.* 2016). The changes will be discussed in Chapters 6 and 7.

This Late Allerød technocomplex is marked by a wide distribution of sites across Northern Europe (Weber & Grimm 2008), with numerous high-resolution examples in the Channel River catchment. Throughout LGCR catchment there is a consistency in this technological transition from the Alps (Mevel 2013), to the Neuwied Basin in Germany (Baales and Street 2002; Baales and Jöris 2011; Grimm), and across the North European Plain (de Bie & Caspar 2000; Riede & Edinborough 2012; Weber & Grimm 2008). Elsewhere the same changes are noted in the Paris Basin (Bodu 2000; Coudret & Fagnart 2006a; Valentin 2008b; Valentin *et al.* 2004a), in England and Wales (Barton *et al.* 1992; 2009; Barton 1999a; Barton & Roberts 1996b; Jacobi & Higham 2011a; 2009a) and as far north as Scotland (Saville & Ballin 2009). Although the technocomplex is best characterised from

open-air sites, there are also a significant number of cave sites in the Ardennes and possible variations such as the British 'penknife point' tradition (Barton 1999a; Barton *et al.* 2009; Barton & Roberts 1996b; Jacobi 1991; 2004; Jacobi & Higham 2009a).

3.5.3.1 Landscape context

The Late Allerød Federmesser sites are found throughout the Channel River catchment. There is a much more extensive representation of sites throughout the landscape for this period and most of northwestern Europe seems to have evidence of this technocomplex as far north as Scotland (Saville & Ballin 2009) and as far west as Brittany and the Scilly Isles (Berridge & Roberts 1986). There appears also to be a lesser use of cave sites in karstic regions with a Bølling history of use of cave sites (Belgium and Britain) when (Barton 2010; Barton *et al.* 2003; de Bie *et al.* 2009; De Bie & Vermeersch 1998, 35). The most extensive open-air sites appear to be strongly linked with river courses (e.g. Saleux, Rekem, Le Closeau) but this includes higher ground with strategic views (e.g. Niederbieber) with an otherwise much more extensive signature throughout the landscape (Barton & Roberts 1996b; Eriksen 2002; Jacobi 1991). Figure 3.69 shows the location of the directly dated Late Allerød Federmesser sites mentioned in the chapter in relation to the Channel River catchment.

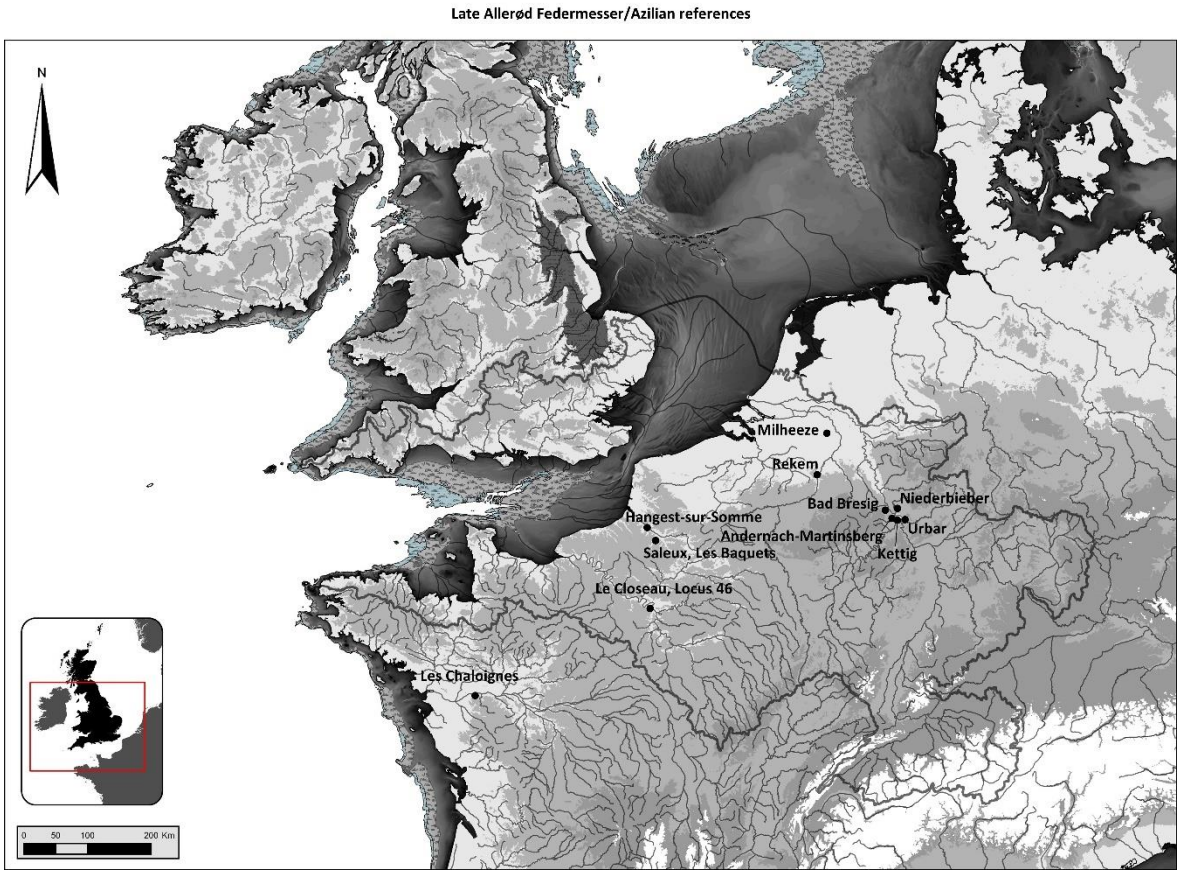


Figure 3.69 Late Allerød Federmesser/Azilian reference sites. (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

3.5.3.2 Chronological setting

The exact dating of the beginning of this technocomplex is problematic, but was probably a gradual transition (Figure 3.70, Figure 3.71) as indicated by the assemblage from the site of Ambenay (Valentin *et al.* 2006; 2004b). Few sites can be dated with precision to the middle Allerød but there is greater clarity towards the end of the Allerød, with dates for the sites of Saleux (Somme), Rekem (Belgium), Bad Bresig, Niederbieber and Kettig (all in the Neuwied basin of Central Germany) and Le Closeau upper level (Paris Basin). The sites from the Neuwied Basin include ultra-filtrated AMS dates.

Sites from this period can also be dated using two clear sedimentary markers: the Usselo soil horizon and the Laacher See tephra horizon. The Usselo soil horizon developing within coversands across the north European plain marks the development of soils and vegetation dating to the mid-Allerød until the onset of the Younger Dryas (Johansen & Stapert 2005; Stapert & Veenstra 1988). This may have its equivalent in the Belloy pedogenic horizon found in the Somme sequences (Coudret & Fagnart 1997; Fagnart 1988). These soil horizons provide a relative chronology for many Federmesser sites before or after the mid-Allerød, with most of the Late Federmesser assemblages found in direct relation to the soil development. The second major marker, and potentially the most precise, is the extensive deposit of ash following the Laacher See volcanic eruption which can be dated to the end of the Allerød (12,916 cal BP or 200 varve counts (years) before the onset of the Younger Dryas in Greenland ice cores (Baales *et al.* 2002b; Reinig *et al.* 2021)[21]. The ash cloud blew to the east and north-east either sealing or containing sites, and in some exceptional cases there are sites that lie directly above the eruption indicating a late Allerød continuation of this technocomplex (Baales *et al.* 2002b; Baales & Street 1996).

[21] During the corrections of this thesis an earlier date of 13,006 +- 9 cal BP has been proposed (Reinig et al. 2021). This is important as it is the principal correlation between the European palaeoenvironmental records and the Greenland ice cores for this period.

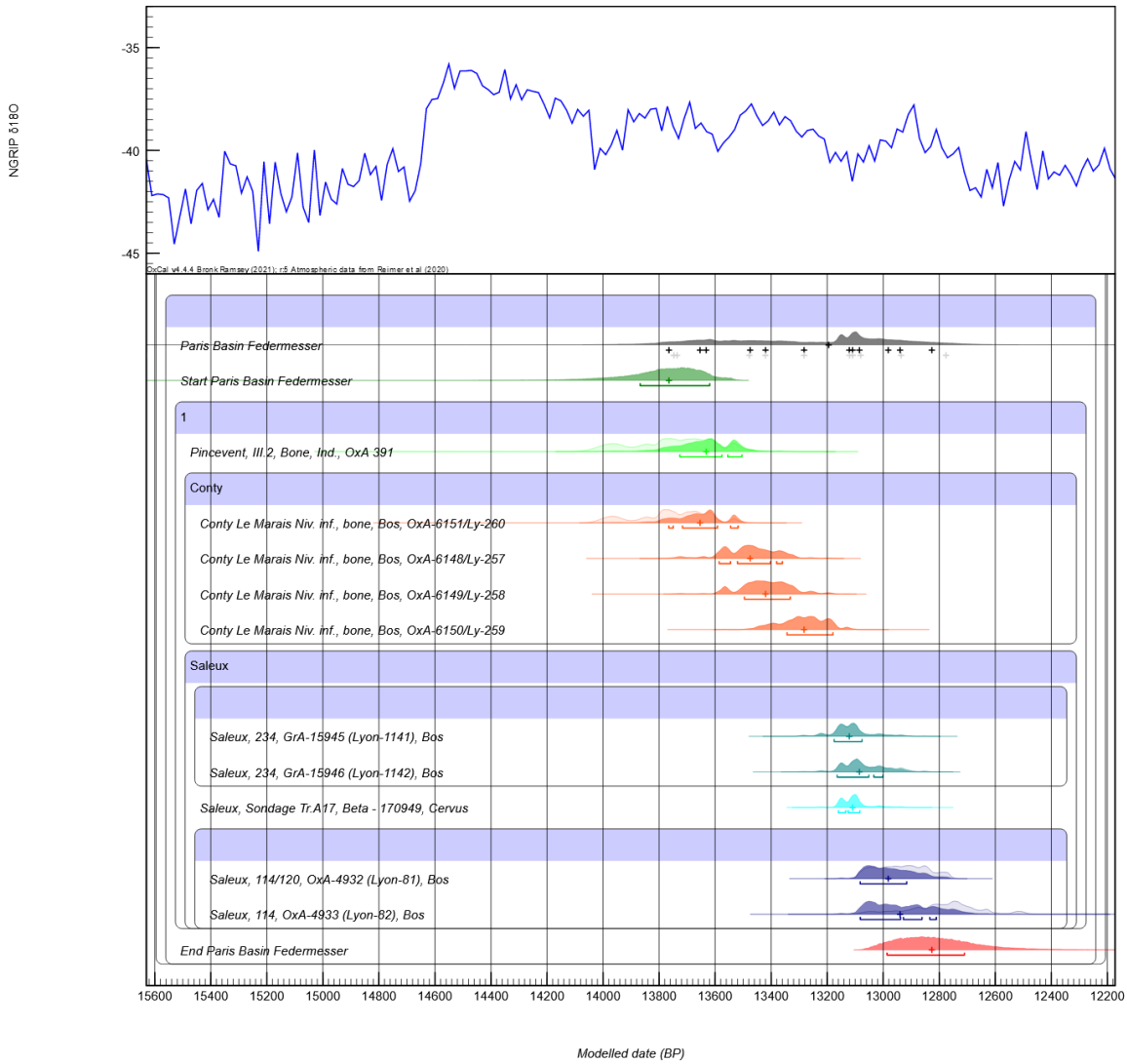


Figure 3.70 Somme catchment, Late Allerød Federmesser dates.

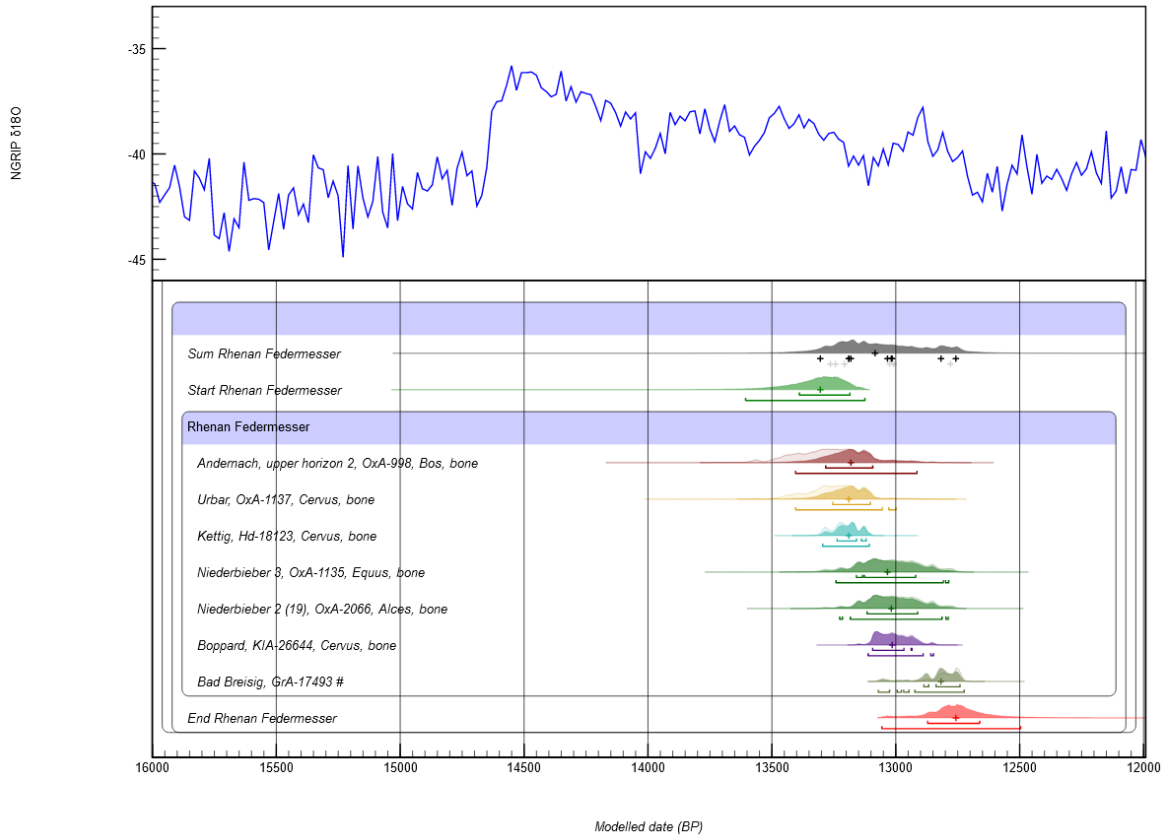


Figure 3.71 Directly dated GI-1b-a Rhineland Federmesser assemblages. Single uniform phase.

3.5.3.3 Description of techno-typology

The subdivision of this technocomplex is mostly typological, with two major influences, the concentration of sites on the North European Plain (Schwabedissen 1957; Bohmers 1960), and those of the Late Azilian, south of the Loire (Célérier et al. 1997). The system used here is a technological and typological characterisation based on significant sites with good palaeoenvironmental, refitting and chronological data from the Somme Basin that is closest to Southeast England (Coudret & Fagnart 2006a), with some extra information from sites in the Neuwied Basin (Bad Bresig; Niederbieber; Andernach-Martinsberg; Kettig), in Belgium (Rekem) and other sites in the Paris Basin (Le Closeau and Ambenay).

One of the most striking features of this technocomplex is the change in raw material selection and core dynamics. The objective transitions to the production of thick sturdy short blades and elongated flakes as blanks for the domestic and hunting toolkits by striking into the core rather than tangentially as in the Early phase (Coudret & Fagnart 1997; de Bie & Caspar 2000). There is also a significant transformation in the selection of raw material to obtain these goals, frequently relying on local material and not as critical of the quality and transport, as in preceding technocomplexes, although in some cases raw materials may still travel over long distances. The methods and techniques used to produce the blades are in stark contrast with the Magdalenian-type and even the Early Federmesser, with little core preparation and generally the use of hard-stone hammers striking well into roughly created platforms. There is limited or no block shaping and no use of the cresting technique. Opposed platforms are used to keep the removals straight and for corrections, but these were not well calibrated or regular (Coudret & Fagnart 2006a). The aim was clearly not oriented towards optimizing the productivity of high-quality raw material, but to create short sturdy blanks, with the emphasis on the transformation phase of blanks into tools of any form needed (Coudret & Fagnart 2006a; 1997; de Bie & Caspar 2000; Valentin *et al.* 2006; Valentin 2008b). Tool types were therefore not as pre-determined by blank types as in the preceding industries; a retouched shaping of the blank became more important.

The point types become more varied (Figure 3.72, Figure 3.73, Figure 3.74, Figure 3.75, Figure 3.76, Figure 3.77, Figure 3.78) (Baales *et al.* 2001; 2002a; Coudret & Fagnart 2006a; de Bie & Caspar 2000), but the most diagnostic and common in the Somme Basin, at Saleux 114, is

the straight-backed point or mono-point, in some case with a basal retouch/ truncation (Coudret & Fagnart 1997). These points were made on short thick blades and were steeply backed (Coudret & Fagnart 1997; Valentin 2008b). An important variant is the 'penknife point' found in Britain (Chapter 4). These types are also found at Kettig and Bad Bresig in the Neuwied basin. There are also significant steeply backed large knives as in the Early Allerød Federmesser. In some of the bigger sites such as Rekem, there is a significant amount of variability in the point types, notably with a presence of shouldered points (de Bie & Caspar 2000).

The domestic tool types are dominated by scrapers and burins, with a near absence of piercers and becs, contrasting once again with Magdalenian type technofacies (Coudret & Fagnart 2006a). The scrapers and burins (mostly dihedral and on truncation) have significant variability (de Bie & Caspar 2000), but there are some characteristics that stand out. The scrapers are made on either elongated flakes or stout flakes rather than well-made blades. There is also a significant number of short end-scrapers, and small thumbnail scrapers become quite common (Coudret & Fagnart 2006a; de Bie & Caspar 2000). Table 3-13 summarises the lithic technological characteristics of Late Allerød Federmesser assemblages.

Table 3-13 Late Allerød Federmesser: Lithic technological characteristics

Technological Characteristics	Summary description of the defining features of the technocomplex
Objectives	Blanks objectives: stout broad straight blades/short blades
Core preparation	Absence of crests; usually opposed platform reduction to correct hinges and maintain a flat removal surface; multiple tablets; angles closer to 80 degrees between platform and removal;
Debitage	hard-stone hammer; high proportion of unprepared or simple platforms (linear)
Tools	End-scrapers short thick blades; Wehlen scraper; dihedral burins; frequent truncations and burins on truncations; backed bladelets;
Armatures	backed bladelets, curve-backed points, straight backed points
Idiosyncrasies	Often local raw material; presence of cortical material indicating on-site preparation variability in raw material quality.
Strongest identification factors	Backed points; Wehlen scraper; backed knives; blade dimensions; platform preparations

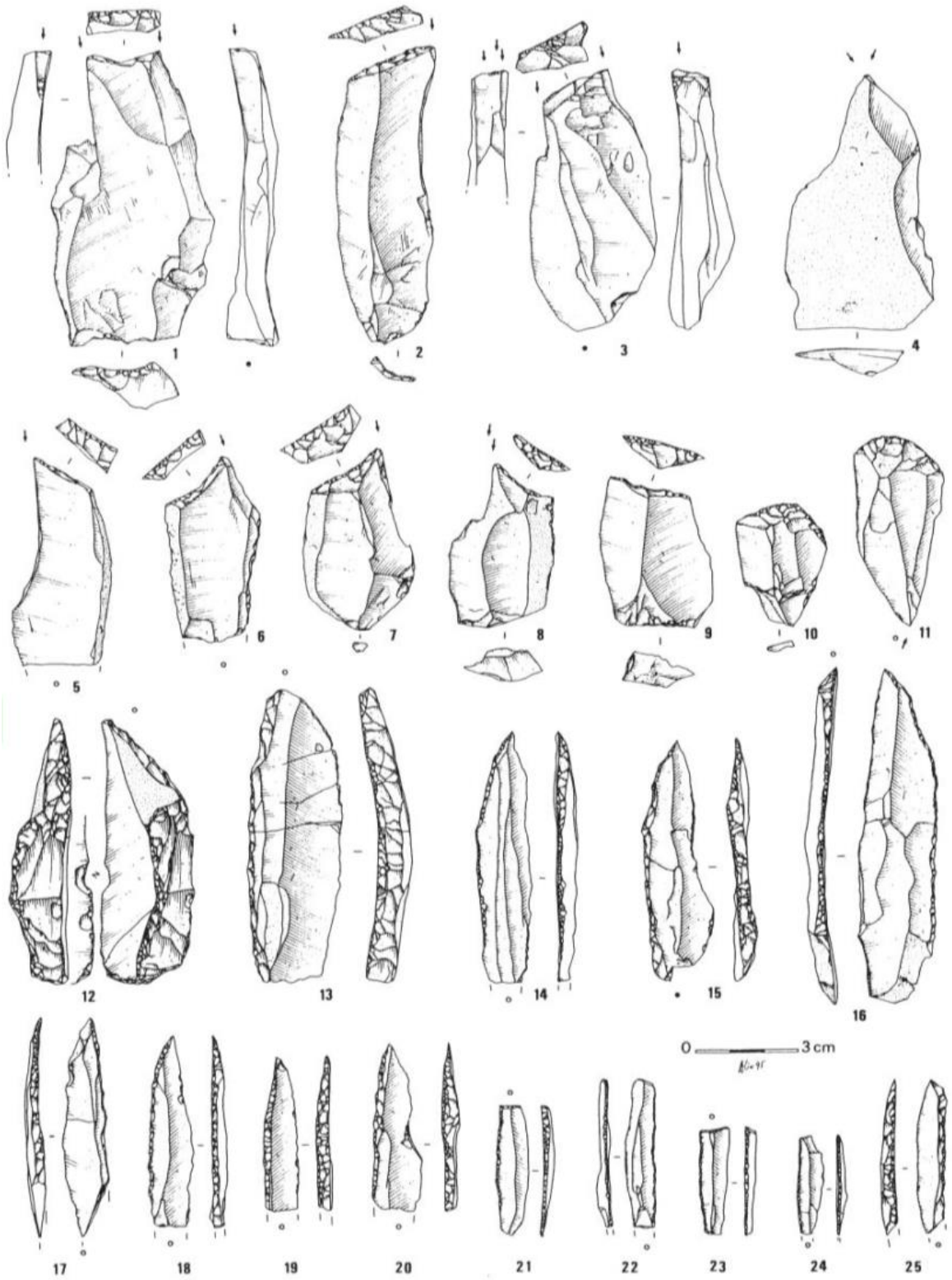


Figure 3.72 Hangest-sur-Somme III-1 upper, final Allerød.1-8 burins, 9 truncated blade, 10, 11 end-scrapers, 12-16 backed knives. Coudret and Fagnart 1997 (drawings P. Alix).

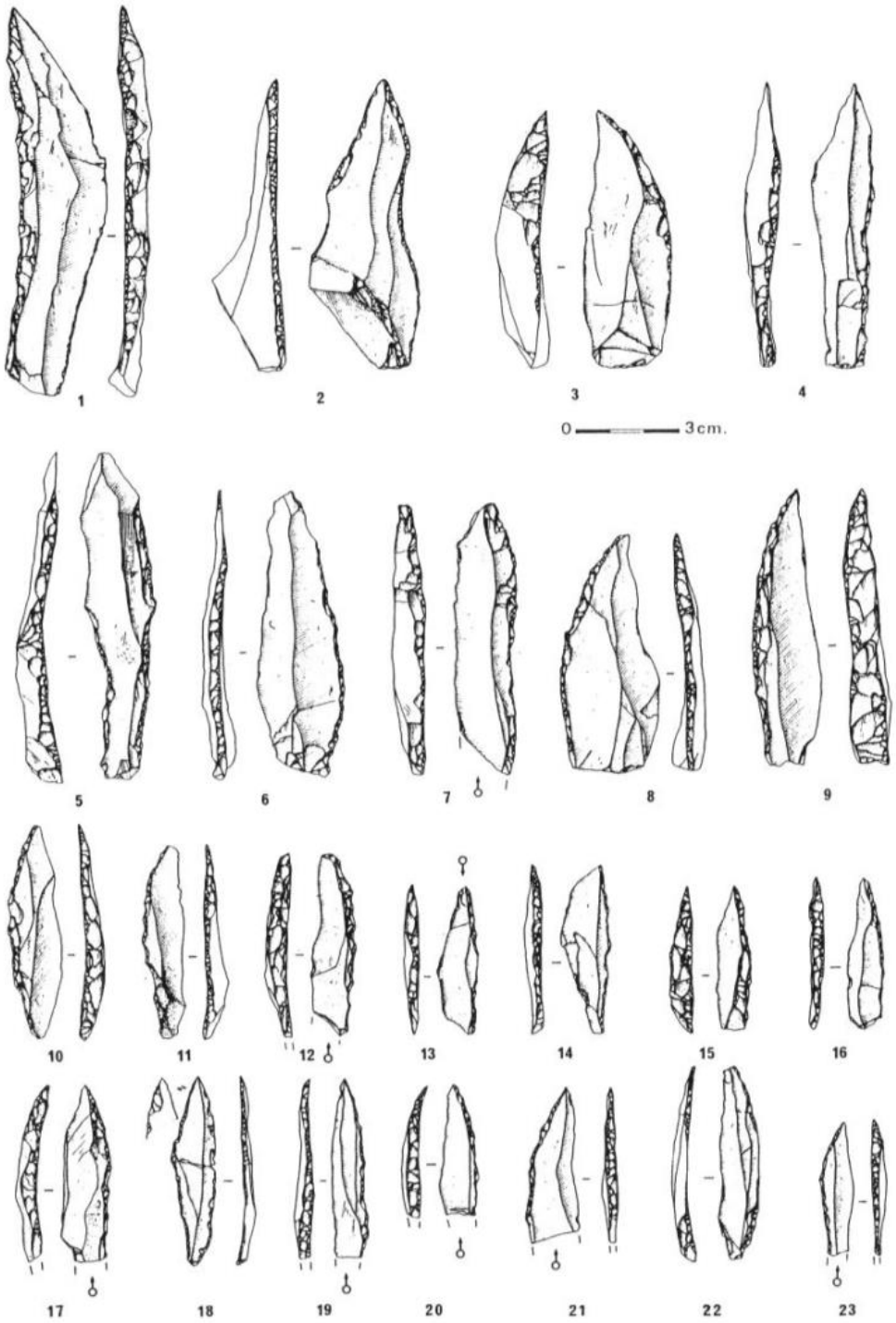


Figure 3.73 Saleux, La Vierge Catherine, area 114, final Allerød. 1-9 backed knives, 10-23 backed points. Coudret and Fagnart 1997 (drawings P. Alix).

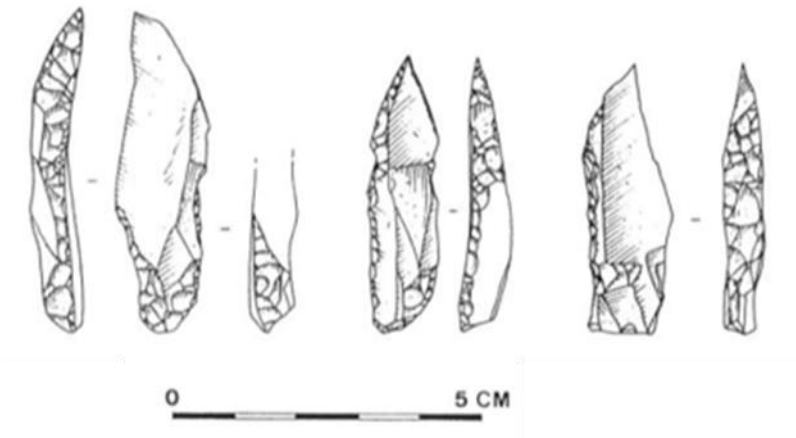


Figure 3.74 Le Closeau Late Allerød backed pieces. Bodu and Valentin 1997 (drawings P. Alix)

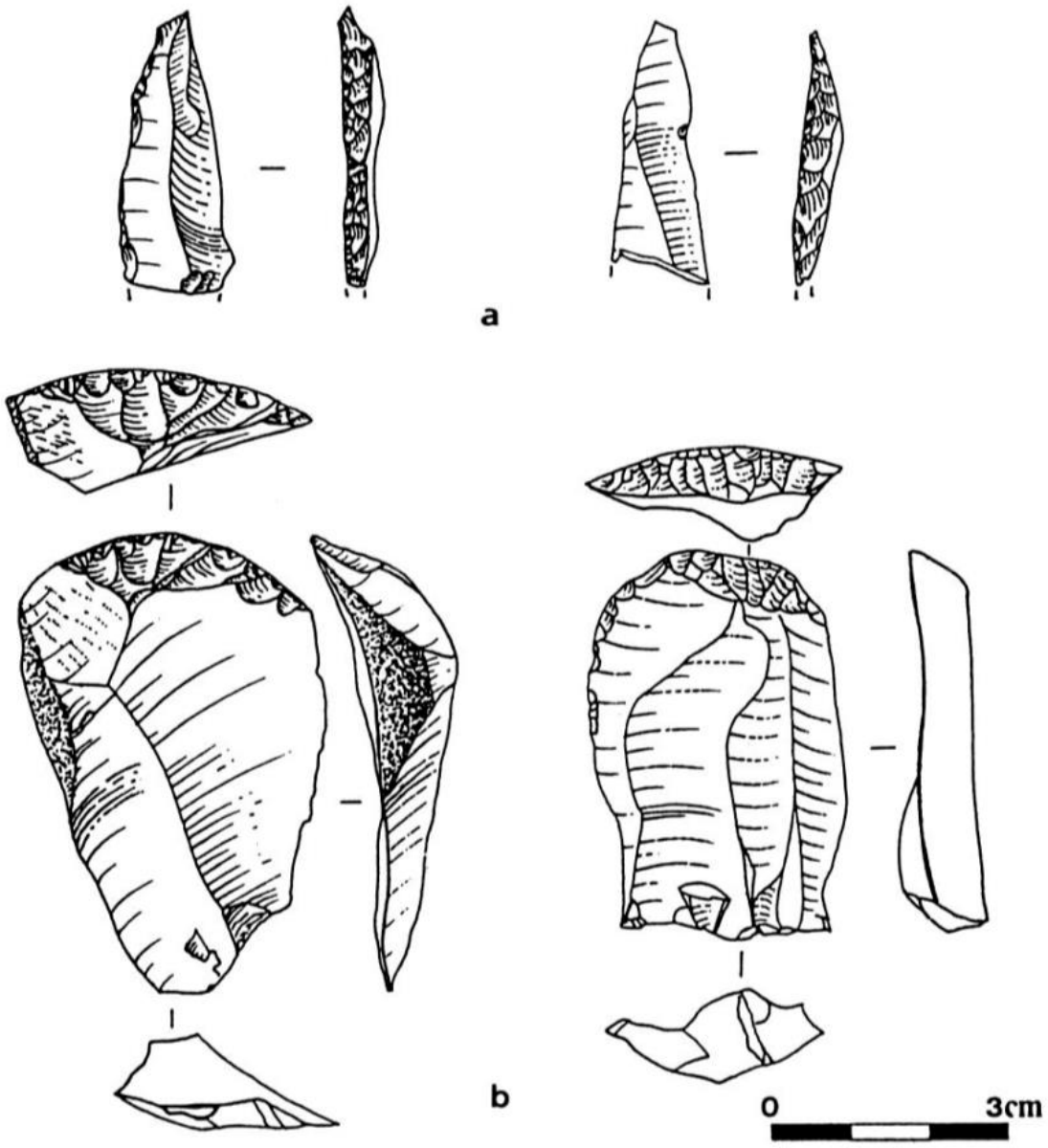


Figure 3.75 Le Closeau, Late Allerød Federmesser. Bodu 1995. (Drawing G. Boulay)



Figure 3.76 Niederbieber, Late Allerød backed points and end-scrapers. Baales et al. 1997, after Bolus 1992.

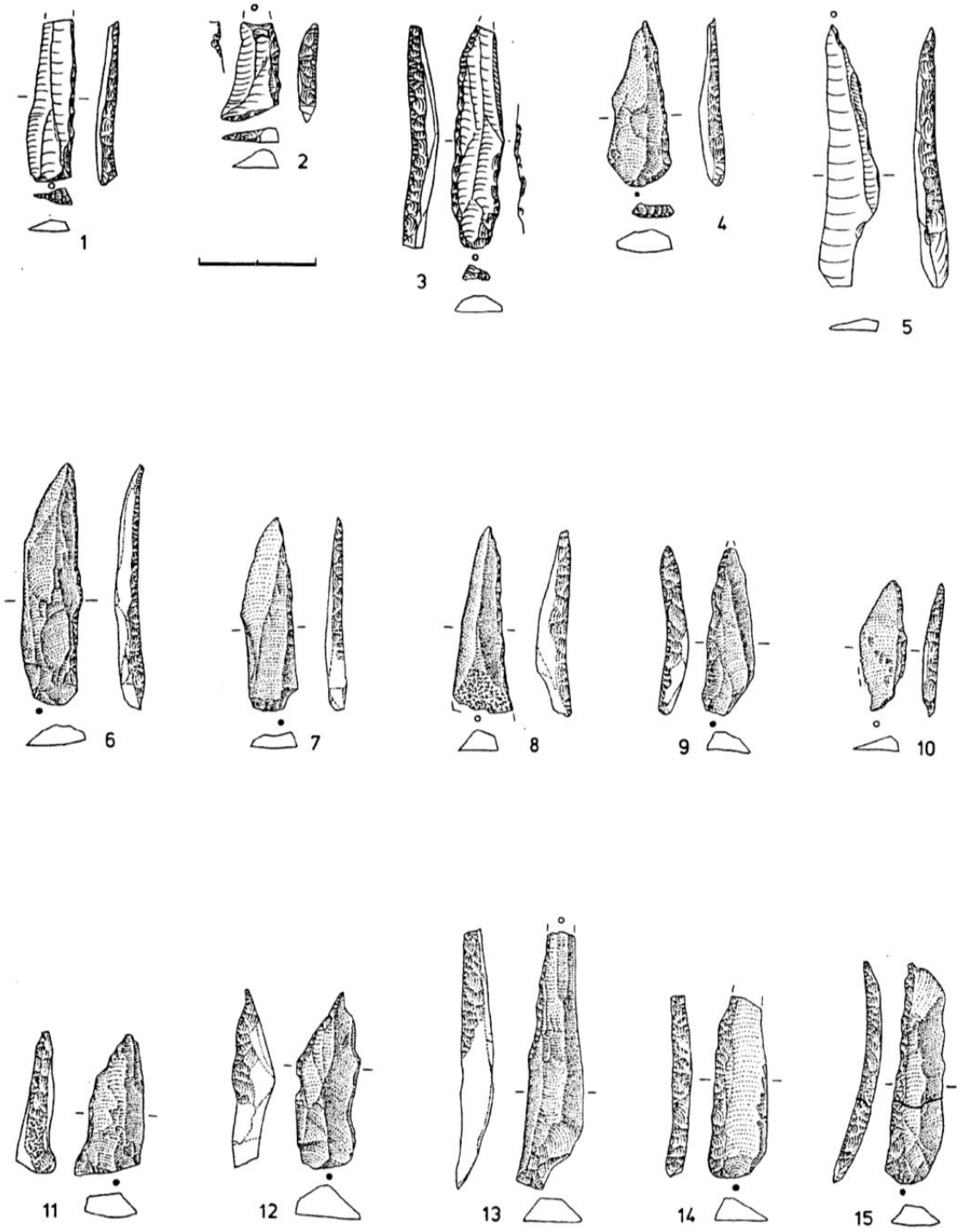


Figure 3.77 Bad Breisig, Late Allerød Federmesser (on the surface of Laacher See ash deposit). 1–3. Malaurie type points (1, 2 basal fragments). 4. Backed point with basal retouch. 5, 7. Points with partially convex-retouched backing. 6. Straight-backed point with slight shoulder (peu à cran). 8, 9. Straight-backed points. 10. Segment-shaped backed point. 11, 12.Compact backed points. 13. Pre-form of a point. 14. Federmesser point. 15. Backed bladelet. Baales and Joris

2002:260 (drawings G. Rutkowski)

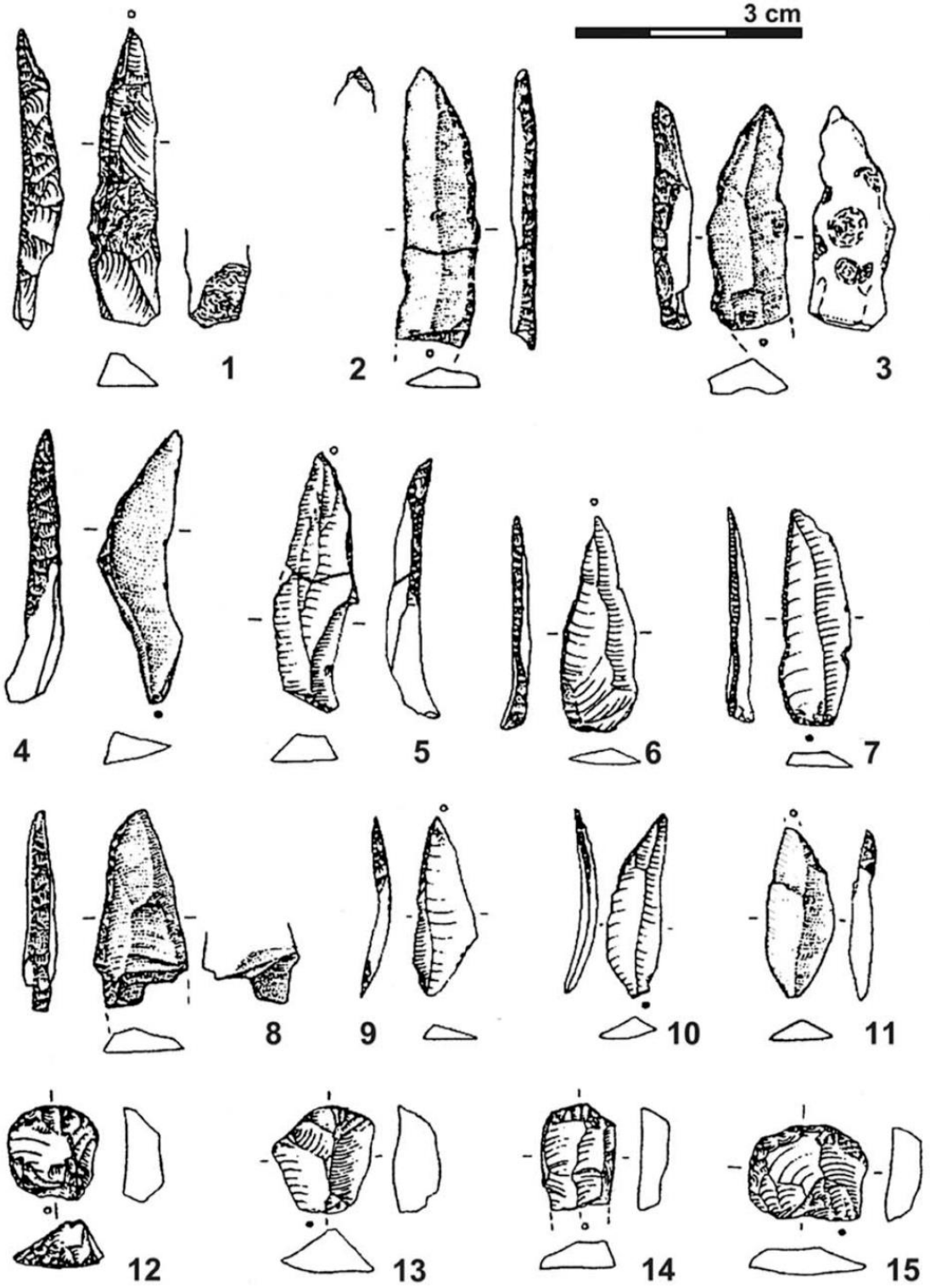


Figure 3.78 Kettig, Late Allerød. Typical lithic tools of the Central Rhineland Final Palaeolithic Federmessergruppen. 1-3: Federmesser (penknife) backed points; 4-8: different backed points; 9-11: simple microliths; 12-15: small end scrapers (different raw materials). 1 and 3 burnt. Drawings by G. Rutkowski, Neuwied-Monrepos. Baales 2006:434.

3.6 Conclusions

This chapter has described LG technocomplexes in Northwest Europe. It sets the scene for the next chapter in which the British assemblages are considered in detail with respect to chronology, techno-typology and landscape setting. In this chapter, continuity can be shown in the blade-making traditions of the Late Magdalenian which continued into the Early Federmesser and Azilian, despite some changes in blank form and tool production. There is an initial transition in the objectives of producing straighter blades and a change in mode of debitage shifting from organic to tangential soft-stone blade production. The aims remain similar, producing long blades, but the general morphology of these blades is transitioning from curved to straighter blades, and the final products are also changing with less backed bladelets and more backed short blades and blades, as well as variations within the base toolkit (burins, scrapers, piercers) (Valentin 2008). The transition from organic to tangentially struck soft stone hammer is accompanied by less angulation of the striking platform. Whilst production of objective of long regular blades and selection of high-quality raw material remained similar in the Late Magdalenian (Bølling) and Early Federmesser (late Bølling and Older Dryas), a significant transformation took place during the early to mid Allerød with a complete change in technology and toolkit, associated to the process of 'azilianisation' (Valentin 2008). This is also linked with different raw material selection, site location and spatial adaptations and faunal locations that will be further discussed in Chapters 6 and 7.

Chapter 4 British Late Glacial Archaeological Distributions

4.1 Review of British Late Glacial Lithic Technocomplexes

4.1.1 Introduction

This chapter builds on the discussion of Late Glacial (LG) lithic technocomplexes in Northern Europe in Chapter 3 and focusses on the archaeological record for this period in Britain. The chapter is divided into three main sections. The first (**4.1**) presents an overview of the LG archaeological record in England and Wales[22] and identifies the presence of six lithic technocomplexes with their diagnostic elements. The next section (**4.2**) considers how these groups can be represented spatially using the Colonisation of Britain (CoB) database by focussing on the diagnostic elements. The chapter concludes with section **4.3** that focusses on the rivers Wey and Mole catchments (Palaeo-Thames tributaries) and the Bournemouth Avon and Test (Palaeo-Solent Tributaries) as a case study in applying these techniques. The chapter provides the template for the discussions in chapters 5-7 of the role of the LG Channel River Network in understanding the LG archaeology of Britain and Northwest Europe.

The first major work on the LG archaeology of Britain was published by Dorothy Garrod in 1926 as her book, *The Upper Palaeolithic of Britain* (Clarendon Press, Oxford). In this work she compares the British record with the longer sequences of archaeology then known from France. She also defined the term 'Creswellian' to describe the distinctive

[22] The area covered in the Colonisation of Britain (CoB) database.

assemblages with Magdalenian-like traits known from cave sites at Creswell Crags in Nottinghamshire and elsewhere in Britain.

Since the publication of *The Upper Palaeolithic of Britain* (Garrod 1926), understanding of the British LG archaeological record and the Creswellian industry have undergone significant revision and refinement (Barton 1999b; 2010; Barton *et al.* 2003; 2009; Barton & Roberts 1996b; Bohmers 1961; Campbell 1977; Conneller & Ellis 2007; Cooper 2006; Garrod 1936; Jacobi 1981; 1991; Jacobi *et al.* 2009; Jacobi & Roberts 1993; Jacobi & Higham 2009a; 2011b). Most revisions were linked to new discoveries and advances in archaeological methods and analytical techniques; for example, controlled stratigraphic excavation, systematic sieving of deposits, lithic refitting studies, and refinement of radiocarbon sample pre-treatment methods. Catalogue A is a collated list of radiocarbon dates for the British LG. Catalogue B reviews the history of recovery of the main reference collections used in this chapter. This thesis proposes that six different LG lithic technocomplexes can now be identified in Britain, with Northwest European affinities.

The six technocomplexes can be grouped chronologically according to three chronozones: Bølling, Allerød and Younger Dryas (Chapter 1). Previously this involved a simple three-phased cultural scheme which broadly fitted the climatic framework: Late Upper Palaeolithic (LUP); Final Upper Palaeolithic (FUP) and Terminal Upper Palaeolithic (TUP) respectively (Barton *et al.* 2003; Barton & Roberts 1996b; Cooper 2006). However, in this study the LUP is sub-divided into four groupings: The Early 'Classic' Creswellian (**ECres** - section 4.1.2), the Late Creswellian 'with Early Azilian traits' (**LCres** - section 4.1.3), and the LUP facies with early Hamburgian traits (**LUP-Hamb** - section 4.1.5). A fourth grouping

is the 'Early' Federmesser-type straight-backed blade assemblages (**EFed** - section 4.1.6) which are considered to be independent of both the LUP facies and FUP (Barton *et al.* 1992). The FUP is coarsely representative of a broader alignment of Federmesser-type assemblages (**LFed** - section 4.1.7). This group may be sub-divided into assemblages containing penknife points and curved backed points (CBP) or both (Barton 1999b; 2010; Barton & Roberts 1996b). Finally, the TUP group contains assemblages with characteristics of Long Blade and Ahrensburgian technocomplexes (**TUP** - section 4.1.7) (Cooper 2006). This terminology is summarised in Table 4-1. Only lithic industries are considered in this chapter. Some associated faunal and organic tool assemblages are discussed in relation to LG landscapes in Chapters 6 and 7.

Table 4-1 Late Glacial Technocomplex terminology used in this thesis.

Previous subdivision of LG industries in Britain	Six Late Glacial technocomplexes in this thesis	Abbreviations used in this thesis
Late Upper Palaeolithic (LUP) Pre Bølling to Bølling	Early ('Classic') Creswellian	**ECres**
	Late Creswellian 'with Early Azilian traits'	**LCres**
	Late Upper Palaeolithic facies with Hamburgian traits	**LUP-Hamb**
Final Upper Palaeolithic (FUP) Late Bølling and Allerød	Early Federmesser straight backed blade assemblages	**EFed**
	Allerød Federmesser curve-backed and penknife point assemblages	**LFed**
Terminal Upper Palaeolithic (TUP) Transition YD to Pre-Boreal	Terminal Upper Palaeolithic (Long blade and epi-Ahrensburgian assemblages)	**TUP**

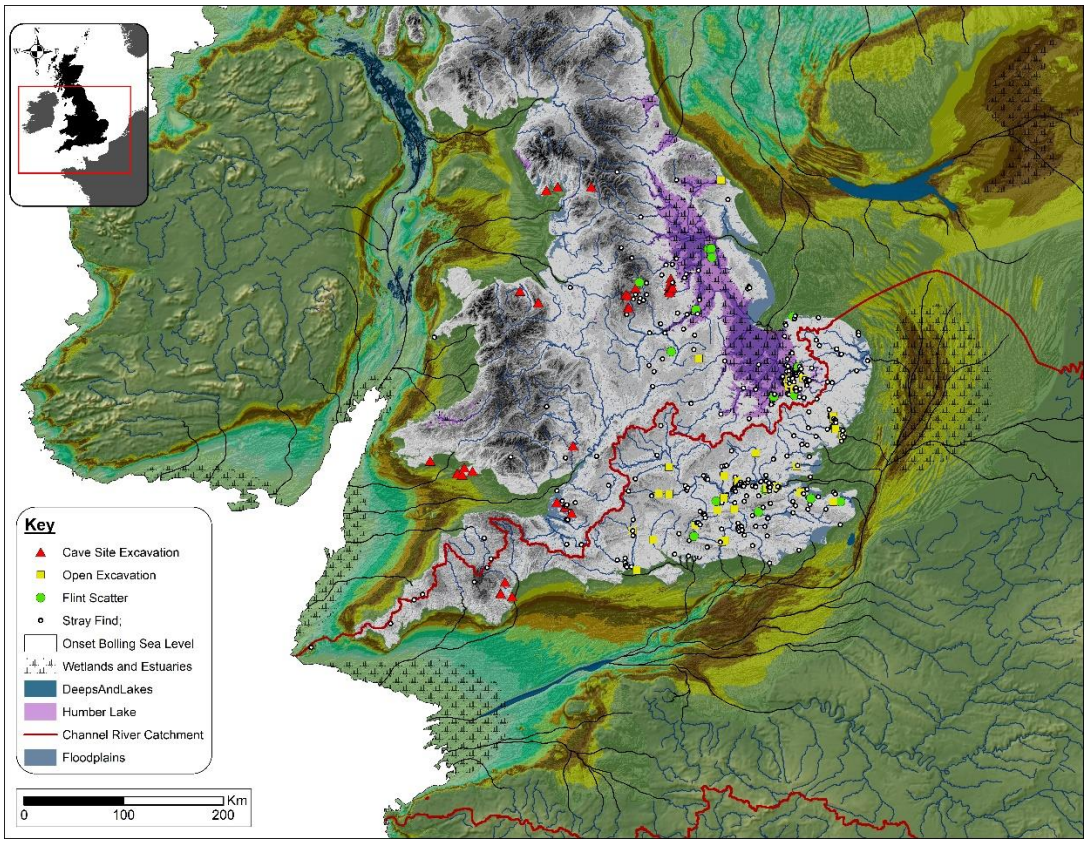


Figure 4.1 Cumulated 'Colonisation of Britain' (CoB) chronological and keyword searches. (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, rivers European Environmental Agency, projected in ArcGIS 10.6.1).

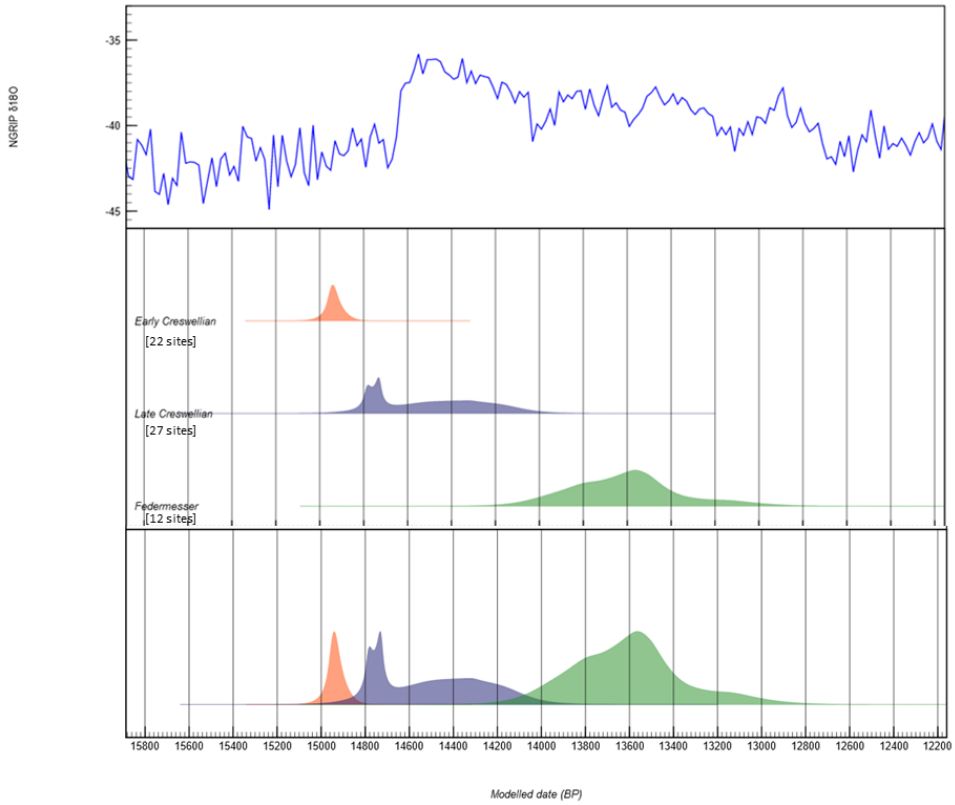


Figure 4.2 Summary of the dated assemblages considered in Chapter 4, KDE models.

4.1.2 Early ('Classic') Creswellian (ECres)

4.1.2.1 Introduction: ECres

In this thesis the term 'Classic' Creswellian (ECres) refers to the earlier phase of the period, that dates to the pre-Bølling (or onset of the Bølling) and early Bølling (Jacobi & Higham 2009a; 2011b), and which contains specific techno-typological characteristics (Barton 1999b; Barton *et al.* 2003; Barton & Roberts 1996b; Jacobi 1991). The Creswellian was initially described for cave assemblages from Creswell Crags and Cheddar Gorge and was linked to typologically eponymous Cheddar and Creswell points (*sensu* Garrod 1926). It was originally seen by Garrod as a variant of the French Magdalenian, as did some subsequent authors who considered it to be a Nordic or Northern facies of the Magdalenian (Schmider 1982) (see Chapter 3). However, due to the scarcity of discrete archaeological assemblages, the Creswellian remains a relatively poorly defined entity (Barton *et al.* 2003; Barton & Roberts 1996b; Jacobi 1991).

In recent decades the Creswellian has been the subject of reassessment: technologically (Barton *et al.* 2003; Barton & Roberts 1996b), typologically (Jacobi 2007; 2004; 2005) and chronologically (Higham *et al.* 2006; Jacobi *et al.* 2009; 2006; Jacobi & Higham 2009a; 2011b). A major clarification of the sequence of these technocomplexes was with the excavation at Three Holes Cave and the stratigraphic isolation of Creswellian and Federmesser industries, with associated direct dating (Barton & Roberts 1996b). Recent Accelerator Mass Spectrometry (AMS) radiocarbon dating programs of British LG assemblages have used pre-treatment and ultra-filtration to remove contaminants from samples, focussing on humanly modified bone, ivory and antler (Higham *et al.* 2006;

Jacobi *et al.* 2009; 2006; Jacobi & Higham 2009a; 2011b). The new dating indicates a potential two-phase chronological separation of the Creswellian cave assemblages, although there is no stratigraphic representation of this division (Jacobi & Higham 2011b). At present there are no well-dated open-air sites to confirm this pattern, and it is dependent on techno-typological comparisons. Table 4.2 summarises the recent dating evidence for key sites.

Table 4-2 Jacobi and Higham's chronological model based on recent dating programme

Time period (Greenland)	Dated Sites	Technocomplex	References
Pre-Bølling (GS-2a)	Sun Hole; King Arthur's Cave	Creswellian (cheddar point dominated)	3
Early Bølling (GI-1e)	Gough's Cave	Creswellian (cheddar point dominated with bipoints)	1, 3
Late Bølling (GI-1e)	Gough's Cave; Kent's Cavern	Creswellian (Creswell point dominated)	1, 2, 3
Older-Dryas/Early Allerød (GI-1d-1c3)	Kent's Cavern?; Pixies Hole?; Hengistbury Head	Creswellian/Early Federmesser with basally truncated Creswell points	1, 2, 3
Allerød (GI-1a-c)	Mother Grundy's Parlour, Robin Hood Cave	Federmesser with Penknife points	1, 2, 3

1. Jacobi and Higham 2009a; 2. 2009b; 3. 2011

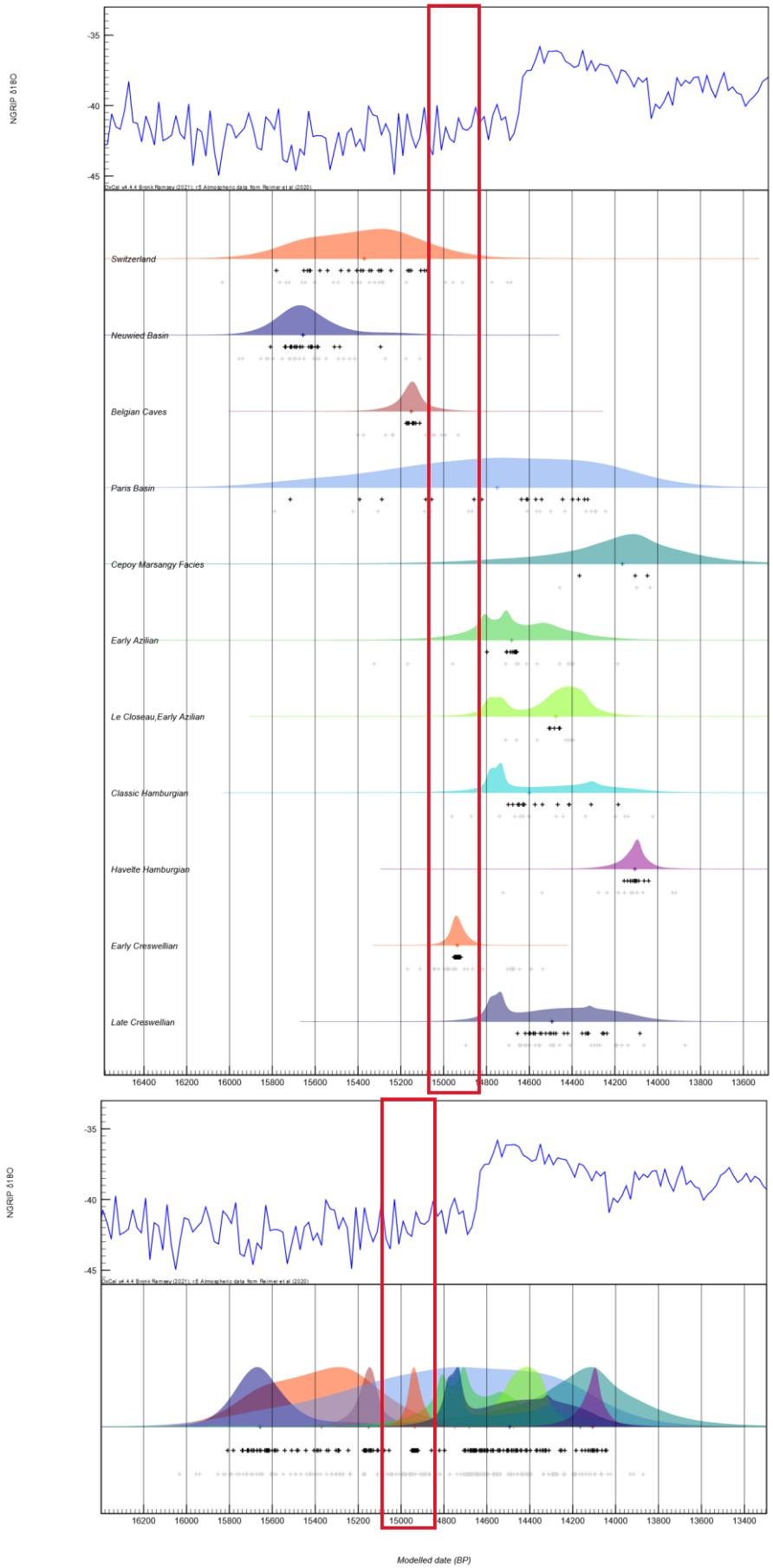


*Figure 4.3 Early Creswellian subdivision based on the grouping of dates in relation to the plstesu in GI-1e (and **not** two distinct technocomplexes) and compared to mainland European technocomplexes dating to the same period.*

4.1.2.2 Reference sites and chronology: ECres

The 'Classic' Creswellian (ECres) group is here a cluster of sites that pre-date the onset of the climatic warming of the LGI in the Greenland Ice Cores (GI-1e) (Walker et al. 2012) (Figure 4.4, Figure 4.5), and appears to be contemporary to the British initial warming of the Bølling biochronozone (Blockley *et al.* 2006.; Mangerud et al. 1974). Assemblages dated to this phase are from Sun Hole and King Arthur's Cave. Further dates from potentially heterogeneous assemblages also fall within this time period: e.g. Gough's Cave and King Arthur's Cave (Jacobi & Higham 2011b). With the most recent IntCal20 curve, the earliest Creswelian dates are projected c. 300 years earlier onto a clear part of the curve when compared to IntCal06 (Figure 4.5; Jacobi and Higham 2011) and clearly precede GI-1e by several centuries (c. 15000 cal BP). The accordance of the dates are not only tighter than with IntCal06 (see Jacobi and Higham 2011), which was already exceptional, but also shifts approximately to 300 years earlier. This earlier date is significant as it supports an earlier onset of the Late Glacial warming in the UK than recorded in the Greenland Ice cores (GI-1e), and is corroborated by the coleopteran datasets (Blockley *et al.* 2006). This also reduces the potential lag between warming and animal and human migration, and tends to indicate a synchrony of these events. When modelled together there is a very tight correlation to c. 14 950 cal BP, with a probable span of occupation of less than 100 years. The start and end boundaries span from 14820 to 15060 cal BP at 68% (see Catalogue A, Figure A.83, for the cumulated span: 0-108 years at 68%, with a tendency towards the shorter end of the bracket). This phase contains Magdalenian-styled organic objects that Garrod (1926) observed to have continental comparisons. Radiocarbon dating of human remains from Sun Hole and Gough's Cave suggests they should belong to this phase (Jacobi & Higham 2011b). The human remains from Gough's

Cave show evidence of postmortem processing of the cadavers, which has led to claims of cannibalism (Bello *et al.* 2015).

There are no completely refitted knapping sequences for the ECres, but several sequences of conjoins and refits have been identified at Three Holes Cave and Gough's Cave. This is complemented by discrete ECres horizons at Three Holes Cave and Sun Hole, both of which have been dated to the early phase (Barton 1995; 1996; 1997; Jacobi & Higham 2009a; 2011b).

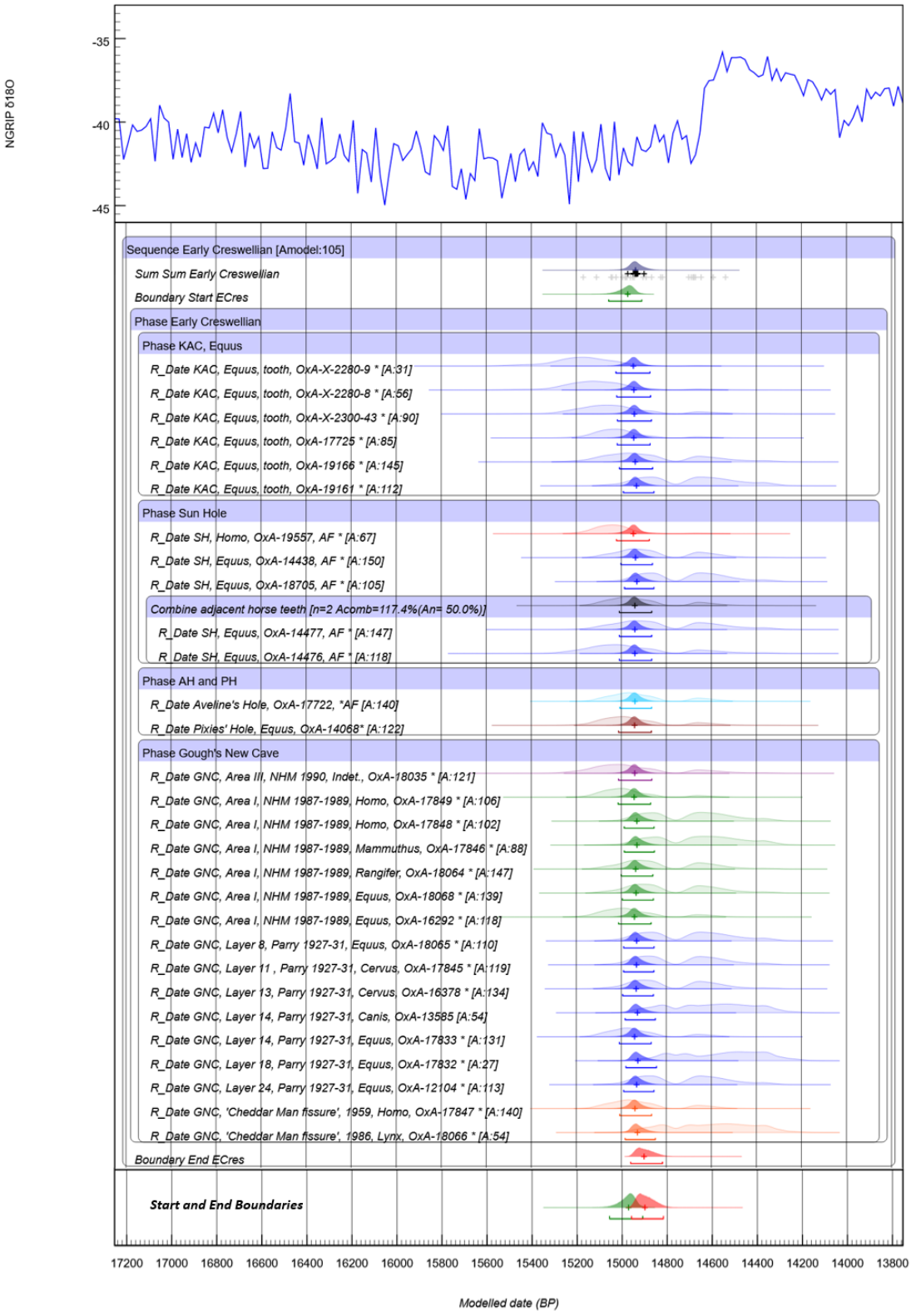


Figure 4.4 Early Creswellian. Dates from Jacobi and Higham 2009, 2011. Overlapping uniform phases. There is a very good agreement overall, Amodel: 106, with only the first date from KAC, OxA-X-2280-9 (A: 31%) being forced into the model (suggesting a probable earlier occurrence). Several of the dates from GNC also have low agreements, notably OxA-17832 (A:28%). Although the overall model agreement is high, there is probably more background variability. However the dates are very strongly associated to around 14 950 cal BP, with a probable span of occupation of less than 100 years. The start and end boundaries span from 14820 to 15060 cal BP at 68%. See Catalogue A, Figure A.83, for the cumulated span: 0-108 years at 68%, with a tendency towards the shorter end of the bracket.

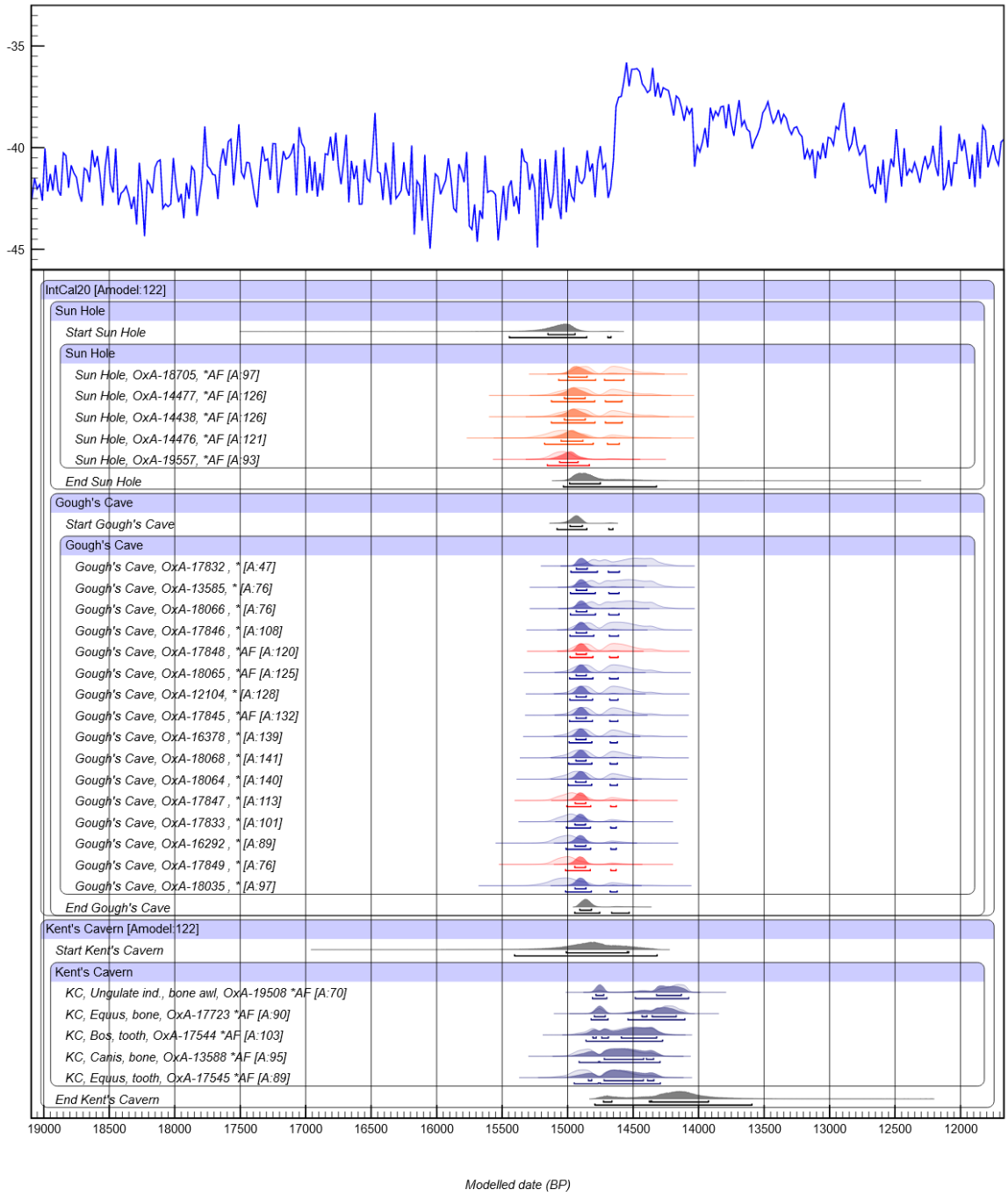


Figure 4.5 Bayesian model comparing the single-phase model for Sun Hole, Gough's Cave and Kent's Cavern. Remodelled after Jacobi and Higham (2011: 232). The dates have shifted by nearly 300 years earlier (see Catalogue figure A.193 for a direct comparison). The data are modelled using OxCal 4.4 (Bronk Ramsey, 2021) and INTCAL20 dataset (Reimer et al. 2020) and compared against the NGRIP (GICC05) δ18O record (data from Andersen et al. 2006; Svensson et al. 2006, 2008). "In the absence of contrary stratigraphic data, each site model consists simply of a single phase constrained by boundaries. Individual likelihoods are shown by the light-shaded distributions, whilst the darker outlines represent posterior probability distributions. In each phase, the agreement index values were all >60%, indicating acceptable levels of agreement" Jacobi and Higham (2011:232).

4.1.2.3 Debitage: ECres

Debitage during the ECres appears to focus on the production of blades, with no clear indication of an independent method of preparing bladelets and backed bladelets. This distinguishes it from the Late Magdalenian of the Paris Basin and Belgian Ardennes (Chapter 3). The current model is based mostly on the preliminary publication from Three Holes Cave and Sun Hole assemblages, and indicates a continuous reduction sequence focussing on the production of blades for domestic tools and smaller straighter blades to be transformed into hunting armatures (Barton 1999b; 2010; Barton *et al.* 2003; Barton & Roberts 1996b). This makes it more closely comparable to the Classic Hamburgian and Early Azilian technocomplexes (Chapter 3). However, there is still a lack of clarity since some of the British cores fall within bladelet sizes at their time of abandon (Barton 1999b; 2010; Barton & Roberts 1996b; Jacobi 2004), and without the benefit of refitting it is uncertain whether these began as blade cores. Moreover, no tools or armatures are made specifically on bladelets (cf. backed bladelets of the Paris Basin Magdalenian), and bladelet production does not appear to have been a strong objective in the production strategies.

Core reduction appears to have been initiated with the use of bidirectional crests, and in some cases the use of anterior bidirectional cresting (Jacobi 2004). The striking surfaces angulation were regularly adjusted, and surfaces and angles maintained by removing tablets. Blade blanks were made with care and skill, beginning with an initial selection (and transportation) of high-quality flint (up to 160km in the case of Three Holes Cave) (Barton 2010; Barton & Roberts 1996b), and a possible pre-shaping of the cores before transportation, recognised in the general absence of cortical material. Both long-distance

transport and pre-preparation of cores are lithic strategies that also occur in the Late Magdalenian, the Classic Hamburgian and Early Azilian (Debout *et al.* 2014; Floss 2010; Valentin 2008a; Weber 2012) contrasting with the general tendencies of the Allerød Federmesser (see Chapter 3).

The knapping strategy is usually a unipolar blade exploitation with occasional opposed platform 'corrections' (Barton 1999b; Barton & Roberts 1996b). Blade blanks have bulbs and platforms with features indicative of organic and possible soft-stone hammer use: flat diffuse bulbs, bulbar scars and thin plain and punctiform striking platforms (Barton 1999b; Madsen 1983; Pelegrin 2000). The presence of the éperon technique is also a strong indication of the use of an organic hammer (Barton 1990; Karlin 1973; Pelegrin 2000), probably of red deer or reindeer antler (Bello *et al.* 2016; Bodu *et al.* 2006b). The use of an organic hammer is also reflected in the long and curved morphology of the blades.

The preferential platform, long curved blades and use of the éperon technique are all characteristics of the Late Magdalenian (Barton *et al.* 2003; Bodu *et al.* 2006a). They also occur in the Classic Hamburgian, although use of the éperon technique is rare (Weber 2012). The éperon technique is apparently not in use by the time of the Early Azilian technocomplex, and this is probably related to a change in preference from the use of soft organic hammers and production of long curved blades to the use of soft-stone hammers and the production of straighter blades (Bodu & Valentin 1997; Pelegrin 2000; Valentin 2006a; 2008a). The use of soft-stone hammers to produce small straight blades also occurs in Cepoy-Marsangy and Classic Hamburgian assemblages (Bodu 2003; Valentin

2008a; Weber 2012) and cannot be ruled out in the ECres although this remains to be clearly demonstrated (Jacobi 2004). Most Creswellian hunting armatures (Cheddar and Creswell points) appear to be made on relatively thick and broad small blades indicating that this was a main objective of the debitage process (Jacobi 2004), whereas the longer curved blades were preferentially used as endscrapers.

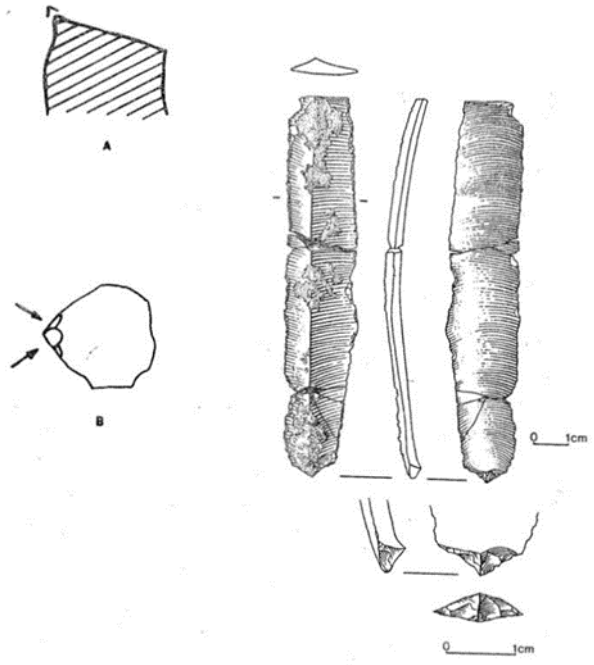


Figure 4.6 Éperon, Barton 1990

4.1.2.4 Domestic tools: ECres

The domestic toolkit is mostly made on carefully prepared parallel-sided blade blanks (Barton 2010). The end-scrapers are characteristically made on the distal end of long well-made blades (Barton *et al.* 2003). Other forms such as burins are made on blades, with assemblage proportions dominated by dihedral forms (Barton 1999b; Barton *et al.* 2003; Garrod 1926; Jacobi 2004). Both scrapers and burins have parallels in the European Late Magdalenian, as do the presence of becs and piercers, however these are less prevalent

in British Creswellian cave assemblages than in Late Magdalenian open-air sites (Beyries *et al.* 2005; Schmider 1988). It should be noted that the Paris and Somme basin Late Magdalenian sites are mainly open-air locations and differences with the British cave sites may be related to site type and function. The Belgian cave assemblages have similar palimpsest issues to the British assemblages (Charles 1998a; Miller 2012; Sano *et al.* 2011; Stevens *et al.* 2009a).

There are multiple forms of piercers. Becs are a category of large piercer, most often axial, and occur in the Magdalenian and in significant proportions in Cepoy-Marsangy assemblages (Schmider 1988). They are also one of the defining elements of the Creswellian (Barton *et al.* 2003, 633). A distinct form of piercer, zinken, is also occasionally present. This robust form of piercer is most often associated with the Classic Hamburgian, but sometimes also present in Late Magdalenian assemblages (Burdukiewicz 1989; 1986; Schmider 1988; Weber 2012). Its double form (not found in the 'Classic' Creswellian), is considered diagnostic of Classic and Havelte Hamburgian assemblages (Weber 2012). The single form does occur in ECres assemblages but in low proportions (Barton 1999b; Jacobi 2004). It may be relevant that the 'Classic' Hamburgian is only known from open-air sites and associated to reindeer hunting (Weber 2012) (Chapter 3) so typological variability due to site function cannot be ruled out (Audouze *et al.* 1981; Schmider 1988).

4.1.2.5 Hunting armatures: ECres

Creswellian lithic assemblages were initially distinguished from the Late Magdalenian by the presence of distinct bi-truncated trapezoidal blades called 'Cheddar Points' (Barton *et al.* 2003; Bohmers 1956; Garrod 1926). These points have been considered as hunting

armatures. Use-wear analysis has confirmed this function, but also provides evidence for some usage in slicing and cutting (Jacobi 2004; Rots *et al.* 2003; 2005; Sano *et al.* 2011). There is morphological variation amongst the 'Cheddar points', mainly in the symmetry of the oblique truncations (Jacobi & Roberts 1993). Cheddar points are rare or absent in both Late Magdalenian and Classic Hamburgian sites, and although similar forms of angle-backed points are known from Cepoy-Marsangy assemblages, they are generally atypical examples (Burdukiewicz & Schmider 2000; Schmider 1982).

There are also obliquely truncated and backed 'Creswell' points, and forms of angle-backed and rare shouldered points in Creswellian assemblages, but these are more prevalent in sites that date to the latter half of the Bølling (here Late Creswellian). The backed bi-point from Sun Hole (Jacobi 2004) has marginal retouch at both proximal and distal ends resembling the bipoints from Le Closeau (Early Azilian technocomplex, Chapter 3) potentially linking the Early Creswellian to this phase. Table 4.3 provides a summary of characteristic Creswellian debitage, tools and armatures in relation to the reference sites.

Table 4-3 Diagnostic debitage, tools and armatures: Early Creswellian sites

Diagnostic element	**Sites**
En-éperon butts	Three Holes Cave, Sun Hole, King Arthur's Cave, Aveline's Hole
Unipolar debitage	Three Holes, Sun Hole, King Arthur's Cave, Aveline's Hole
Long regular curved blades	Three Holes, Sun Hole, King Arthur's Cave, Aveline's Hole
End-scrapers on blades	Three Holes, Sun Hole, King Arthur's Cave, Aveline's Hole
Becs	Three Holes Cave, Sun Hole
Blades with scalar retouch	Three Holes, Sun Hole
Rubbed-end blades	Three Holes, Sun Hole
Cheddar Points	Three Holes, Sun Hole
Creswell Points	All Creswellian assemblages
Bipoints with marginal retouch	Sun Hole, Aveline's

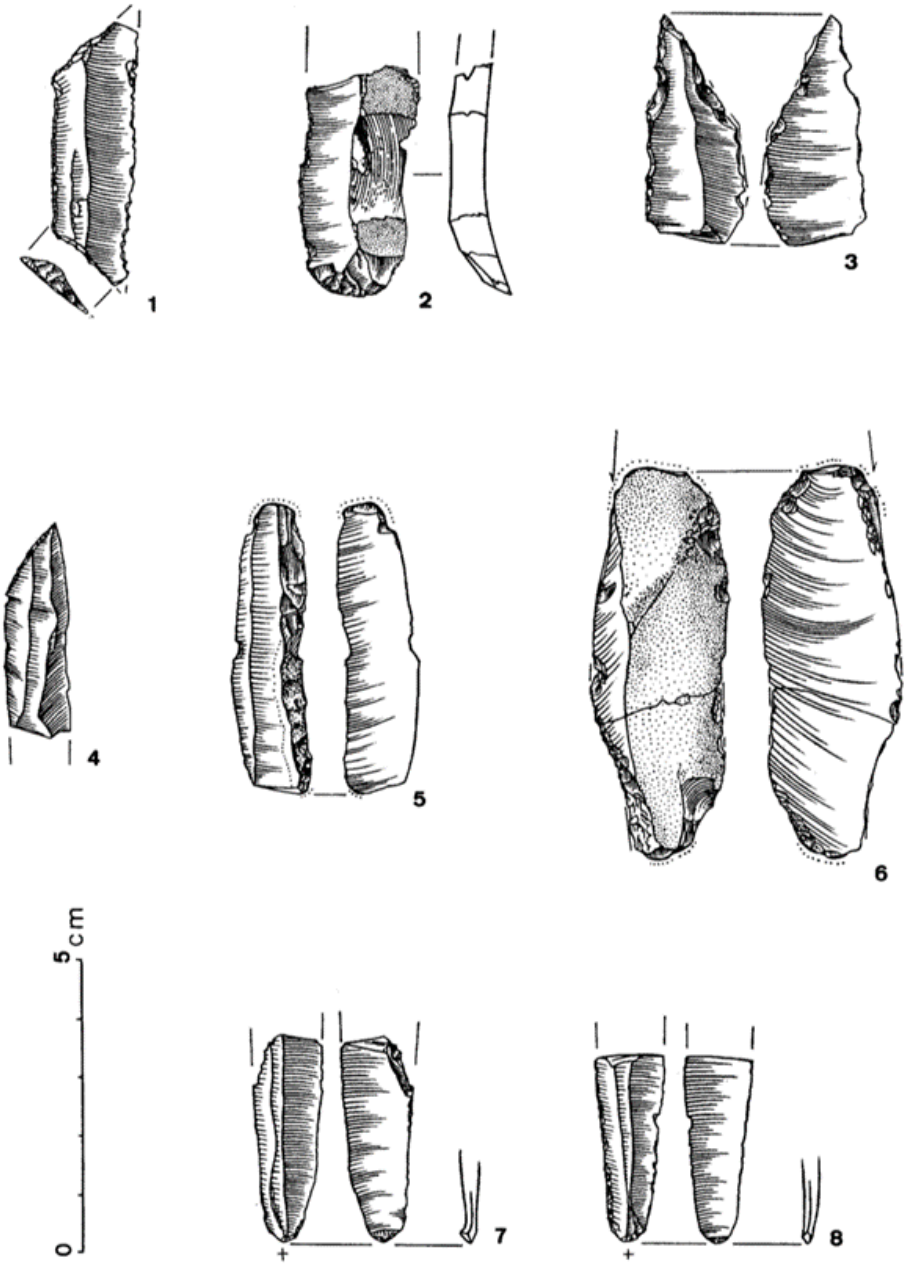


Figure 4.7 Sun Hole, 1951-3 : 1. Abruptly modified piece; 2. End-scraper; 3. Piercer; 4. Blade with burin facet overlain by rounding and damage; 5. Retouched truncation; 6. Retouched truncation overlain by rounding; 7. Blade with rounded end; 8-9. Broken blades with talons en-éperon. Museum of the University of Bristol Spelaeological Society. Jacobi 2004:55 (Drawings H. Martingell).

4.1.2.6 Landscape Context: ECres

Currently ECres assemblages have only been dated in caves in Britain, and these are concentrated on the edge of the uplands of England and Wales (Barton *et al.* 2003; Jacobi & Higham 2011b). Isolated Cheddar and Creswell points are known from open-air settings

elsewhere in Britain (Jacobi & Higham 2011b), and Wey Manor Farm is the only site in Southeast Britain with a variant of Cheddar points as well as Creswell points. Figure 4.8 shows the distribution of ECres sites and finds.

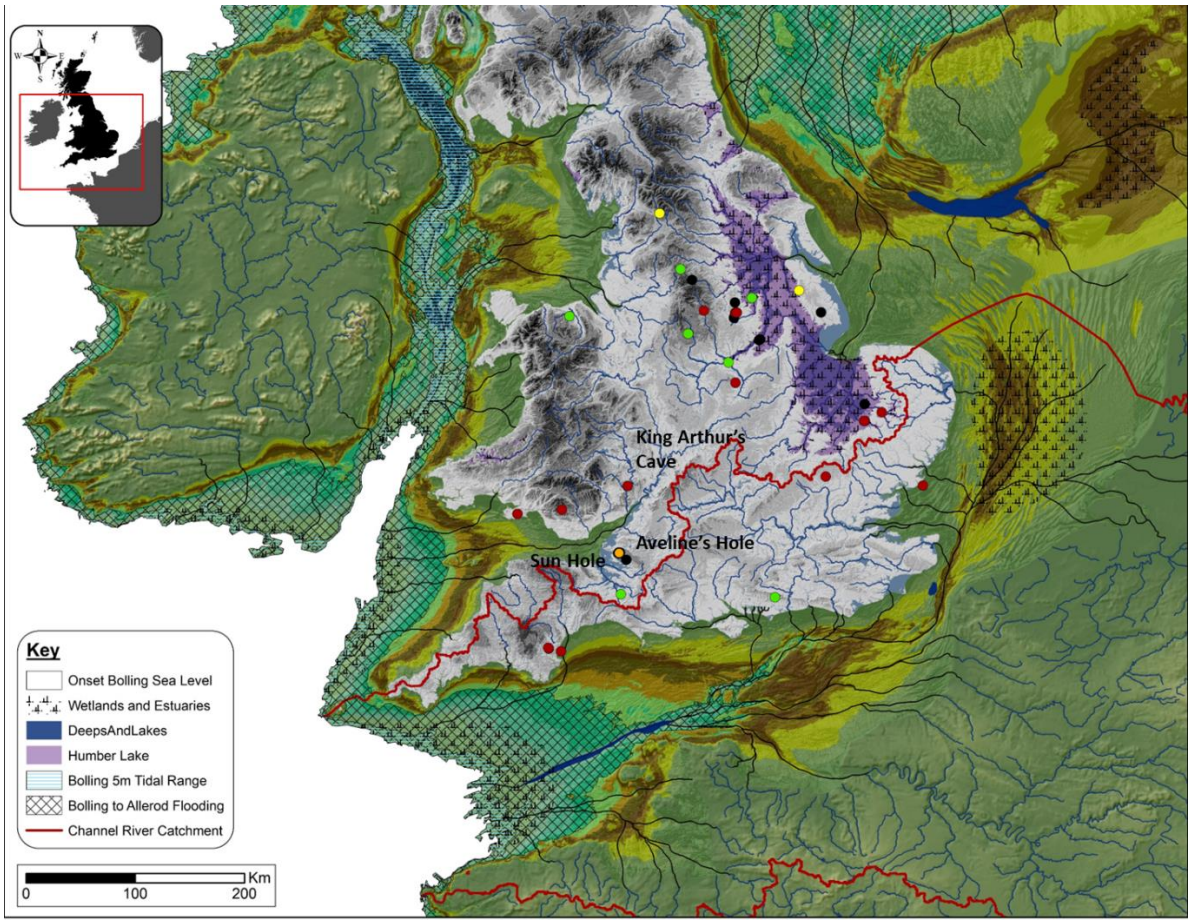


Figure 4.8 ECres distribution. CoB keyword "en-éperon" (red), "bec" (white) and "cheddar point" (black) as well and codes (green): 5001, 4001, 4001b, 3001, 3001b, 2001, 4004 (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, rivers European Environmental Agency, projected in ArcGIS 10.6.1).

4.1.3 Late Creswellian 'with Azilian traits' (LCres)

4.1.3.1 Introduction: LCres

The term Late Creswellian 'with Azilian traits' (LCres) is used here for assemblages that contain additional tool and armature forms (bipoints) as well as Early ('Classic)

Creswellian (ECres) lithic features. These assemblages are dated to the second half of the Bølling (Jacobi & Higham 2009a; 2011b), and it is possible that some may represent palimpsests. The term Late Creswellian is used here in similar manner to Stapert's usage that incorporates assemblages with Cheddar and Creswell points with an additional form found also in the Hamburgian, the single zinken, and often confused with the diagnostic Hamburgian double zinken (Barton *et al.* 2003; Stapert 1985; Weber 2012).

4.1.3.2 Reference sites and chronology: LCres

There are no discrete reference sites for this technocomplex. At present the largest assemblages with LCres artefacts are from Gough's Cave and Kent's Cavern, which contain admixtures of Early and Late Creswellian forms and poor stratigraphic control (Barton *et al.* 2003; Jacobi 2004; Jacobi & Higham 2009b). LCres artefacts, such as high proportions of Creswell points and bipoints, are known from other cave sites (e.g. Aveline's Hole, Somerset), and also open-air sites. Radiocarbon dating of modified bone and antler objects to the Late Bølling may be used as indications of LCres human activity (Figure 4.9, Figure 4.10, Figure 4.11). There appears to be a significant overlap of the LCres and Early Azilian dates (Figure 4.12). Figure 4.25 shows the distribution of LCres.

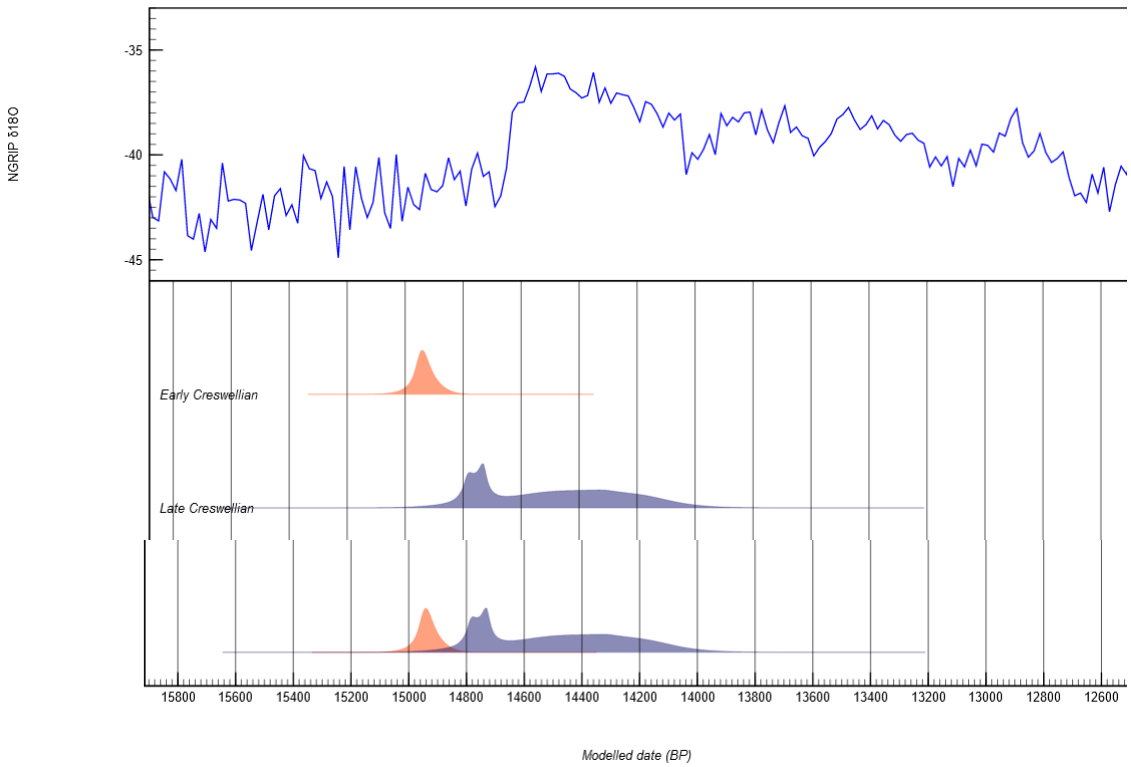


Figure 4.9 The distinction used between the Early and the Late Creswellian is based on dating and assemblage resolution and not on clear distinctions in the technocomplex.

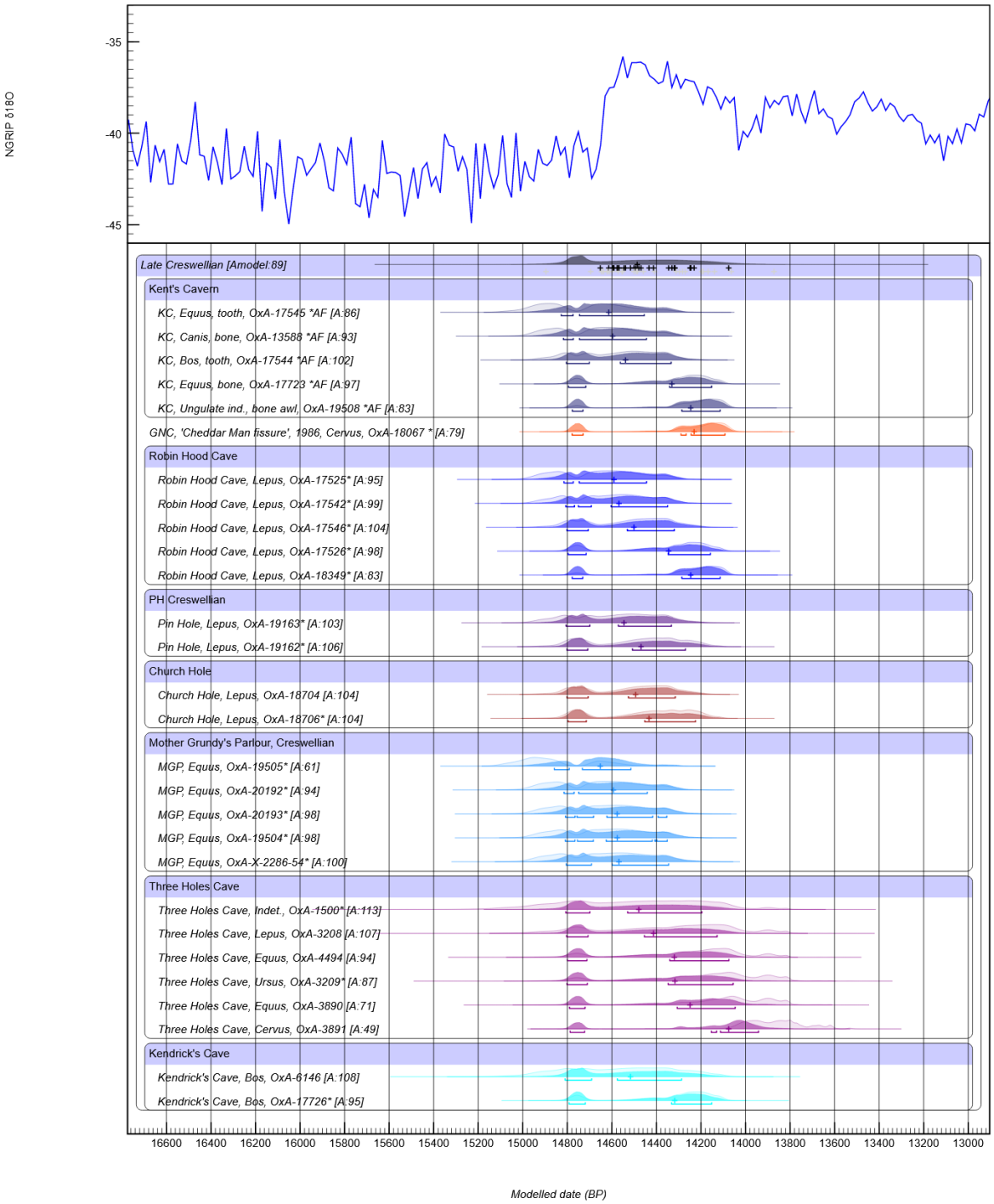


Figure 4.10 Single phase KDE model. Selected sites grouped as Late Creswellian as they fall on the GS-2a and Early GI-1e wiggle and plateau. The dating resolution is very different to the Early Creswellian group, as the wiggle and plateau spreads over nearly 700 years. The early excavation and recovery resolution (very little stratigraphy and reliable unmixed assemblages) combined with the dilated dating resolution were the main criteria for separating the Earlier dated assemblages from the Later dated assemblage within this work. The main reference site for these later dated assemblages is Three Holes Cave, the only Creswellian assemblage with both a discreet refitting archaeological horizon and associated dating (Barton and Roberts 1996).

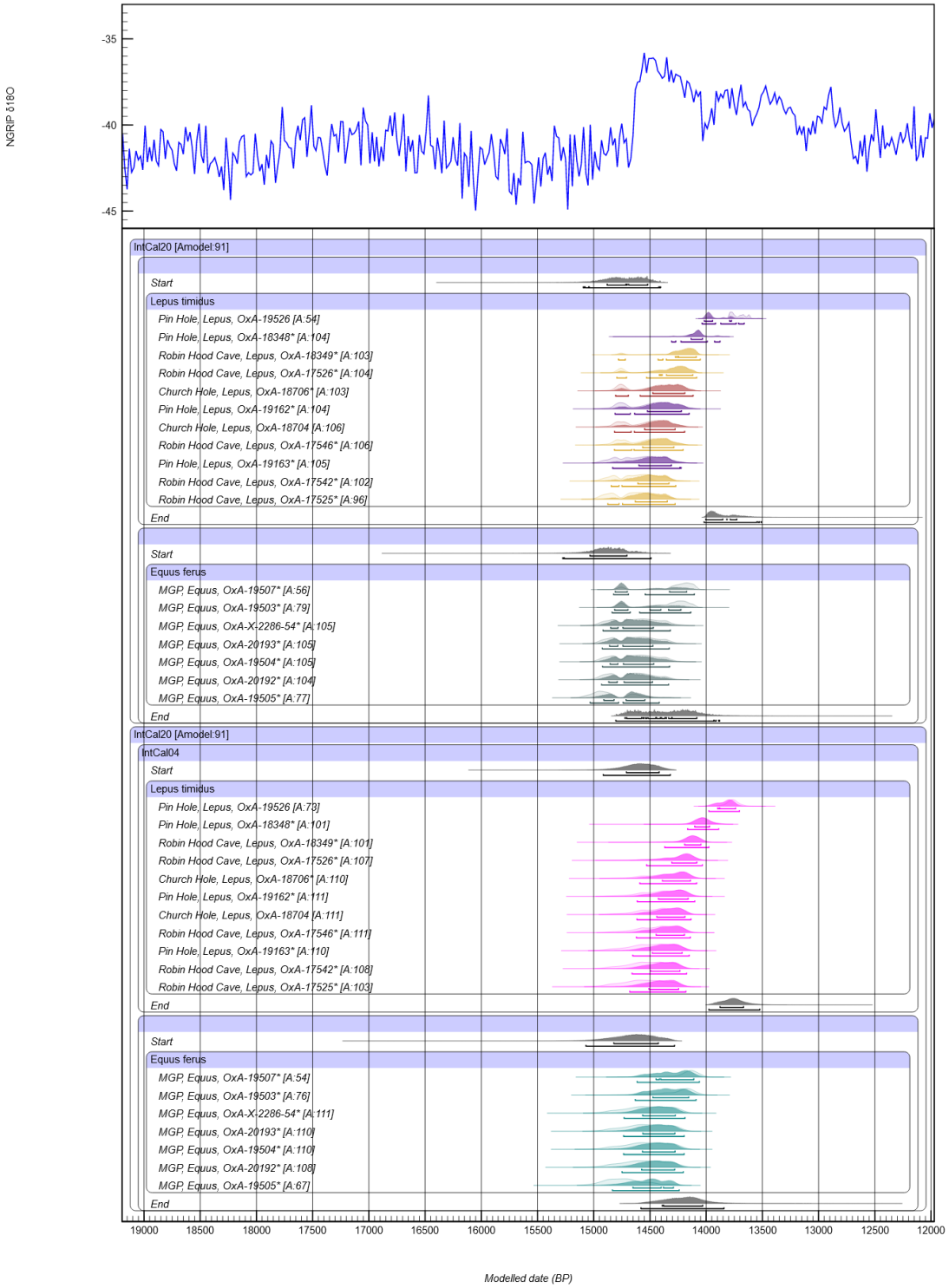


Figure 4.11 Remodelled after figure 12.13, Jacobi and Higham 2011, comparing the arctic hare (Lepus timidus) and horse (Equus) from Cave assemblages at Creswell Craggs and demonstrating their contemporaneity. The mixed lithic assemblages from these caves contain elements identified as Creswellian. The results with the new OxCal20 curve tend to indicate a slightly earlier trend for horse. However, there is an overall similar pattern with a tightening (higher precision) of the IntCal20 dates. There is a significant shift of the Equus ferus dates at Mother Grundy's Parlour to before 14500 cal BP,and considered as part of the Late Creswellian grouping here.

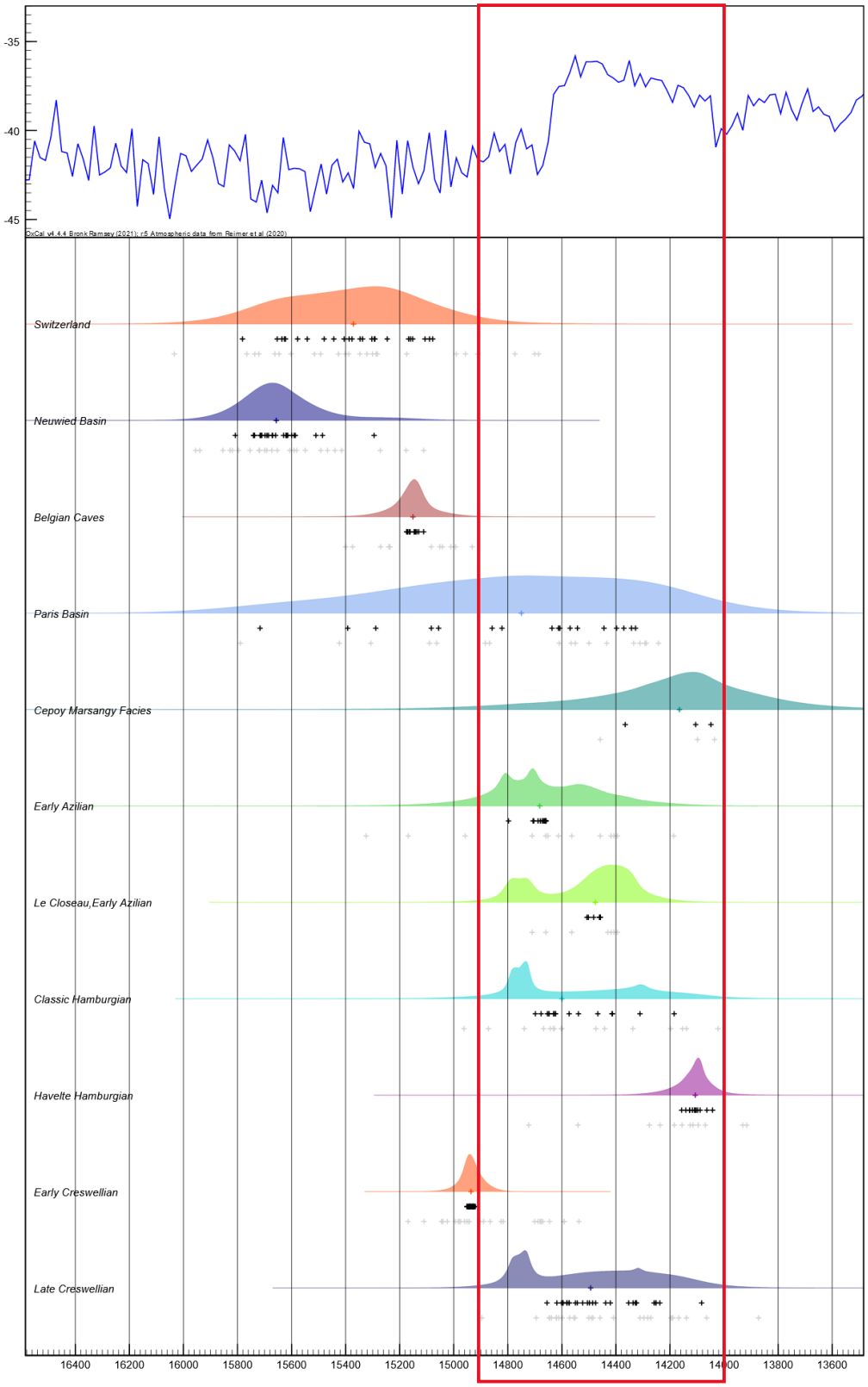


Figure 4.12 Late Creswellian compared against contemporary LG mainland European dates. This is the same image as 4.3, with a focus on the Late Creswellian context.

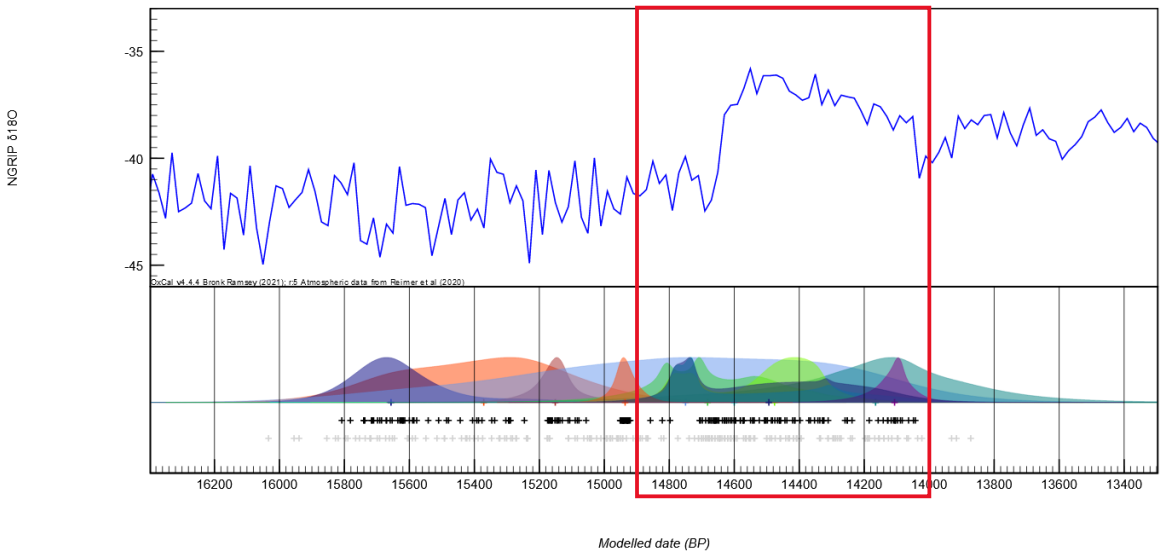


Figure 4.13 Late Creswellian compared against contemporary LG mainland European dates, stacked.

4.1.3.3 Debitage: LCres

There are no diagnostic debitage elements for this group, and most features are similar to that of the ECres. This is in part to a sparsity of refitted assemblages (some conjoins and limited refit from Gough's Cave) (Jacobi 2004). The debitage is typified by the presence of cresting preparation, en-éperon butts and the probable use of soft-stone hammer percussion (Jacobi 2004).

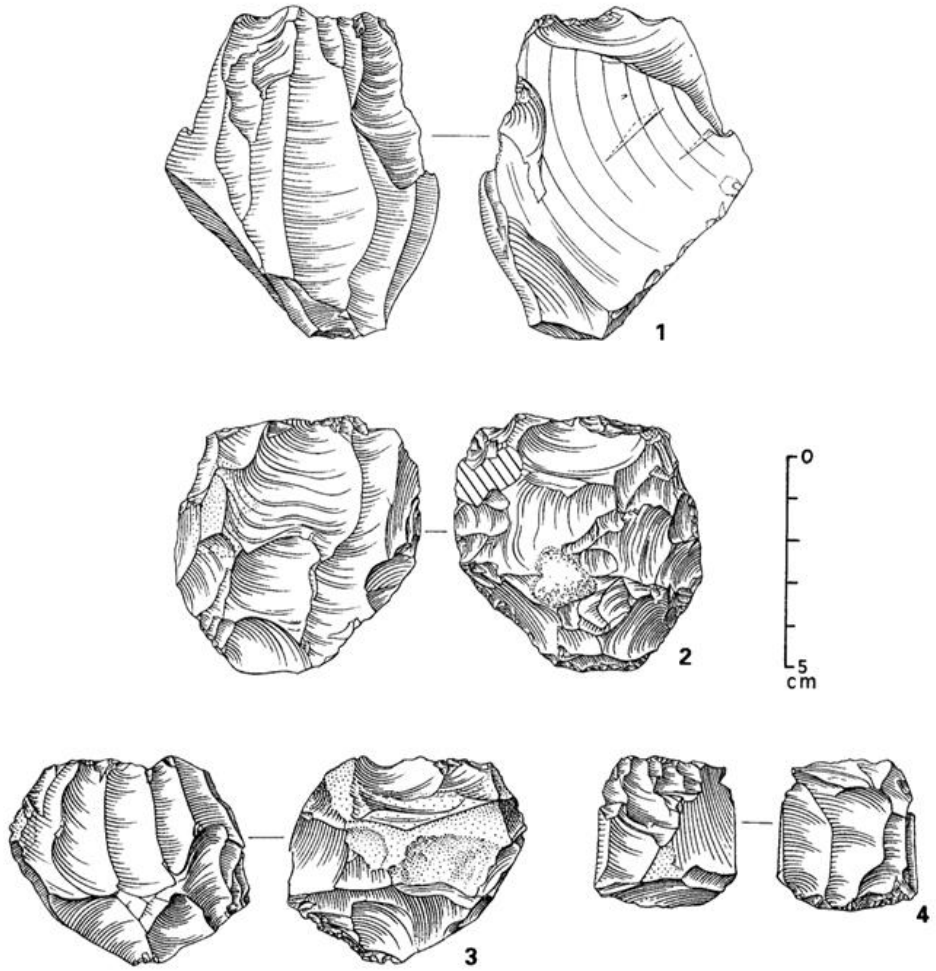


Figure 4.14 Gough's Cave artefacts, cores : cores: 1-4. Jacobi 2004: 21. (Drawings H. Martingell)

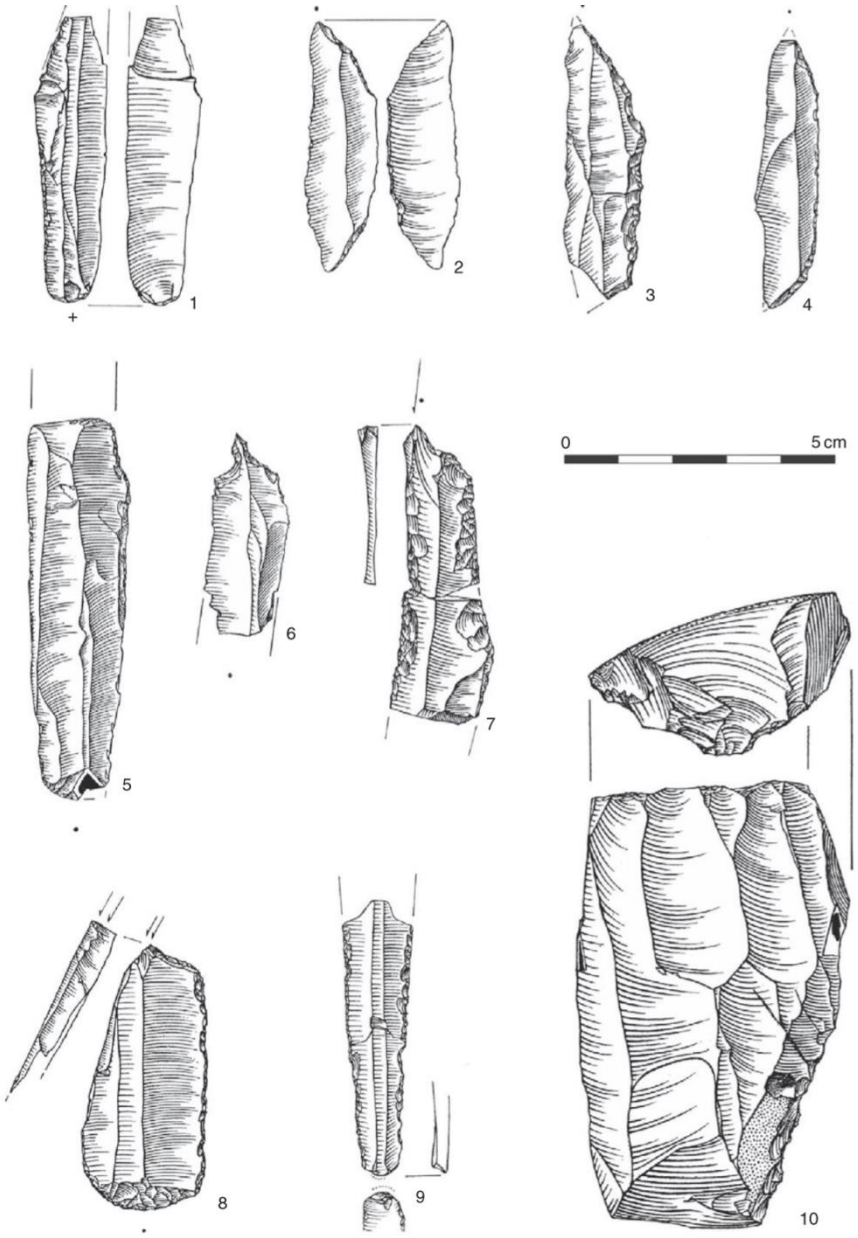


Figure 4.15 Robin Hood Cave artefacts , Creswell Point: 1, Cheddar points: 2-4, end-scraper: 5, piercer: 6, burin on truncation on blade with lateral retouch: 7, combined end-scraper and burin on truncation: 8, retouched blade with en eperon butt: 9, blade core: 10. Jacobi and Higham 2011: 237.

4.1.3.4 Domestic tools: LCres

The tools from both cave and open-air sites are fabricated on well-made blades. The end-scrapers are characteristically on long carefully produced blades, and there are significant amounts of burins and rare piercers. As with the debitage, many of the same tool forms

occur in the ECres and other contemporary neighbouring LG industries (Classic Hamburgian, Late Magdalenian).

Blades with scalar retouch are distinctive for this group. Previously identified as Magdalenian retouched blades (Barton *et al.* 2003; Jacobi 2004), with reference to Late Magdalenian sites in Southwest France (De Sonneville-Bordes & Perrot 1956, 552; Demars & Laurent 1989, 76–77). The form of retouch appears to vary between these technocomplexes, and in the Paris Basin the retouched blade is now considered as a diagnostic tool specific to the Early Azilian (Bodu & Mevel 2008). Whereas the French Magdalenian blades have a marginal form of retouch, the Early Azilian blades have an invasive skimming ('*rasante*') retouch along one or both edges of the blade. In some cases the retouch is scalar and overlapping indicating several phases of modification, perhaps related to resharpening and use as a knife (Bodu & Mevel 2008). These blades with this distinct retouch are present at Gough's Cave (Jacobi 2004) and Guildford Fire station, and absent at the Early Federmesser site of Hangeste III.1, but are present at Hengistbury Head (Barton *et al.* 1992, 117).

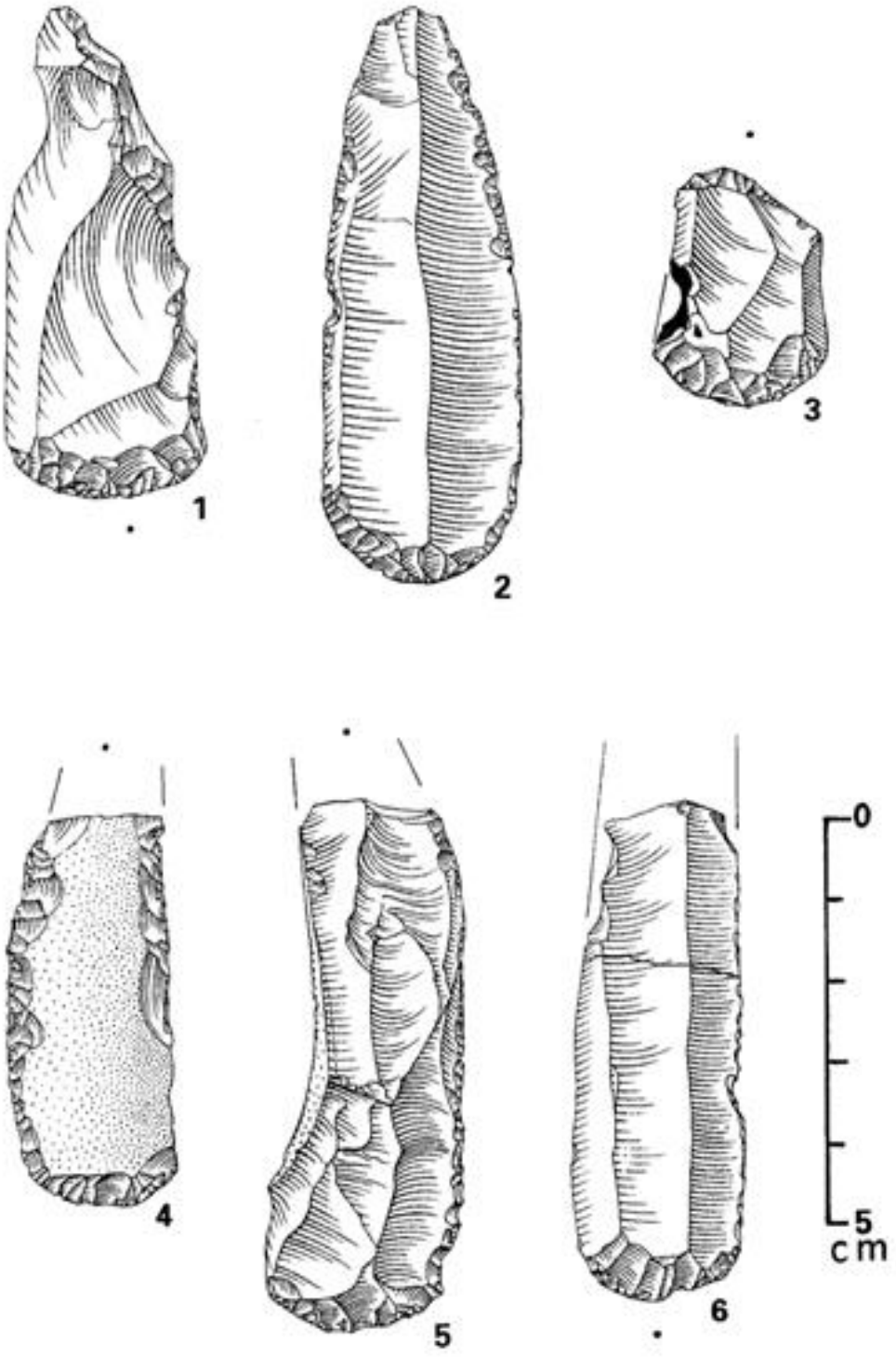


Figure 4.16 Gough's Cave artefacts , end-scrapers: 1-6. Jacobi 2004: 25

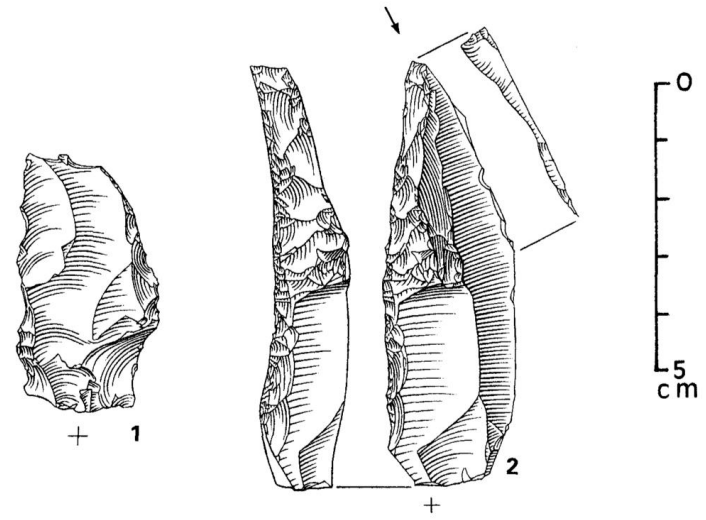


Figure 20.
Gough's Cave: 1–2. Knives. For descriptions see text. Cheddar Man Museum. Scale in cm.

Figure 4.17 Gough's Cave, Knives: 1-2. Jacobi 2004.

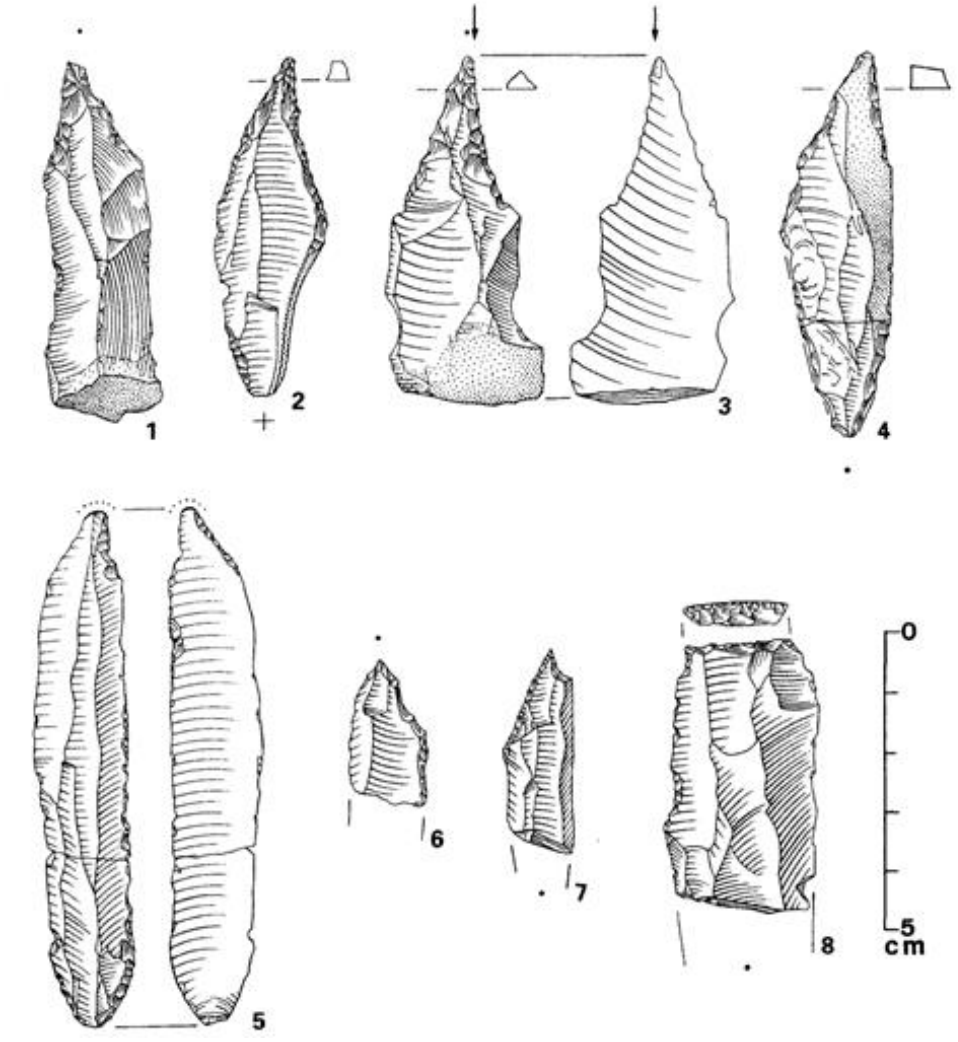


Figure 4.18 Gough's Cave, piercers: 1-8. Jacobi 2004.

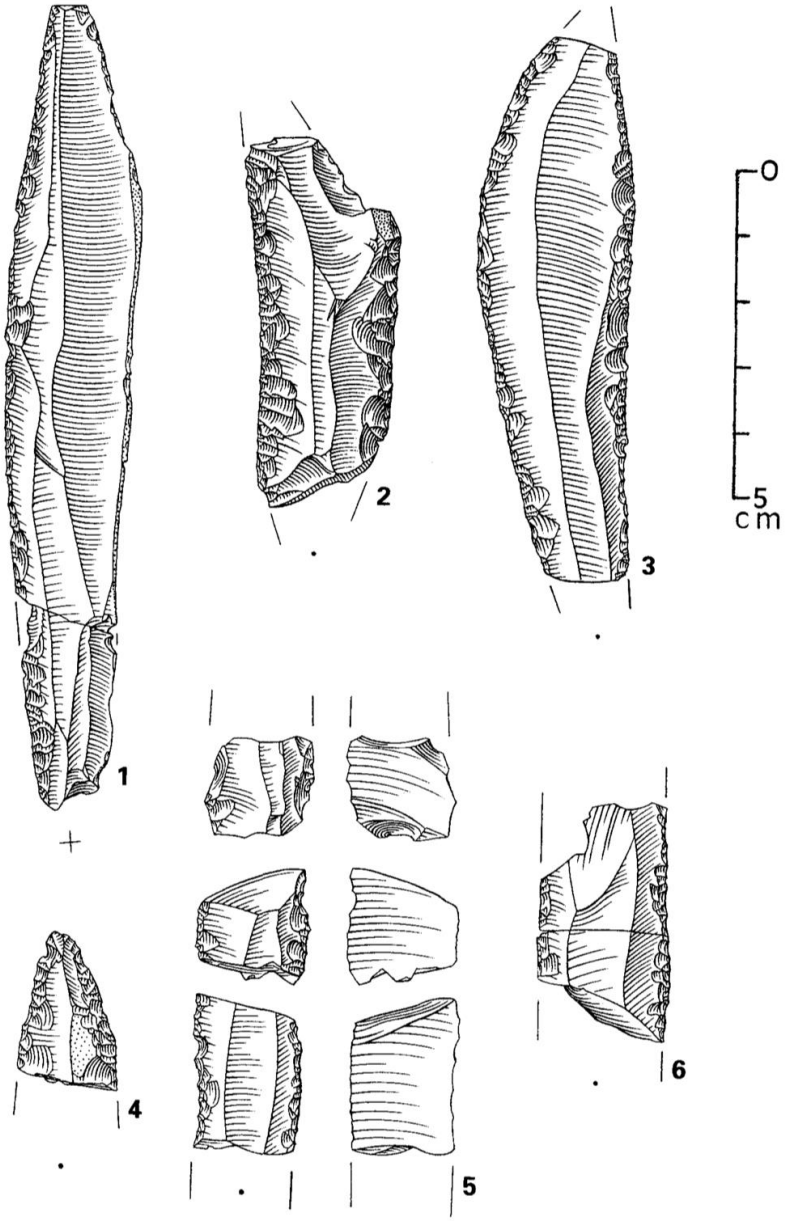


Figure 4.19 Gough's Cave, Blades with lateral retouch. Jacobi 2004: 36

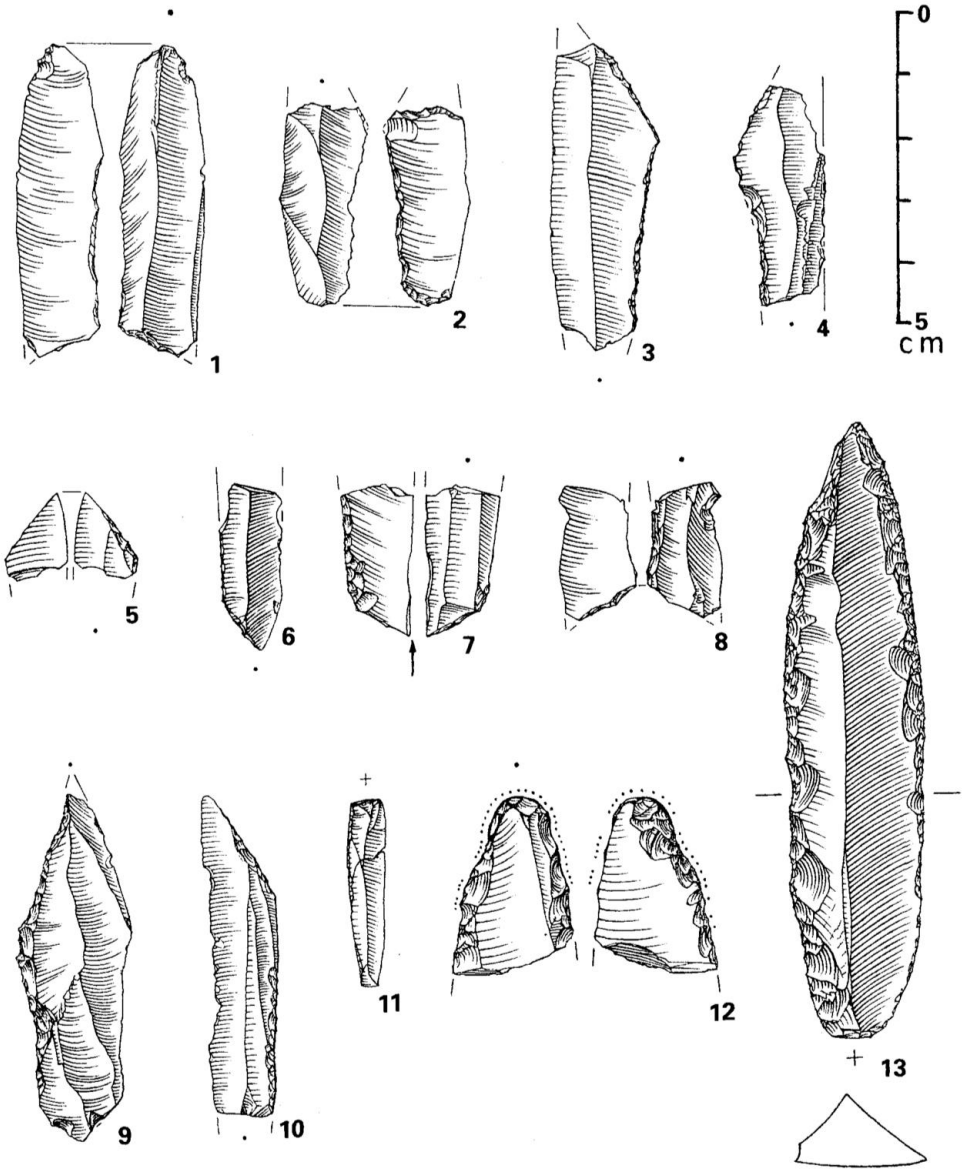


Figure 4.20 Robin Hood Cave, 1969 excavation , abruptly modified pieces: 1-10, retouched bladelet: 11, broken retouched piece with rounded end: 12, Pointed 'Magdalenian' blade: 13. Jacobi 2004

4.1.3.5 Hunting armatures: LCres

There is a potential typological division between the ECres and LCres based on a lower proportion of Cheddar points in favour of Creswell points in the LCres industries (Stapert & Johansen 2001). The LCres Cheddar points may also have less symmetrical oblique truncations. The presence of Azilian-like bipoints (curve-backed points) is a key distinguishing feature of the LCres, especially when combined with the above mentioned

scalar retouched blades. The bipoints have a relatively abrupt and invasive retouch, resembling those from Hangest-sur-Somme, niveau inférieur, in the River Somme catchment. These bipoints are also found at Hengistbury Head, Dorset, and as isolated examples at potentially Early Federmesser sites in Southeast England.

The presence of obliquely truncated blades or Long B-Points has recently been highlighted as a potential indication of LG, and in some cases Late Creswellian, assemblages in Europe (Holzkämper *et al.* 2013; Stapert & Johansen 2001). The term is poorly defined, and the points are often just described as 'obliquely truncated blade/bladelet' (Holzkämper *et al.* 2014). Such forms are also known from some British open-air LCres sites.

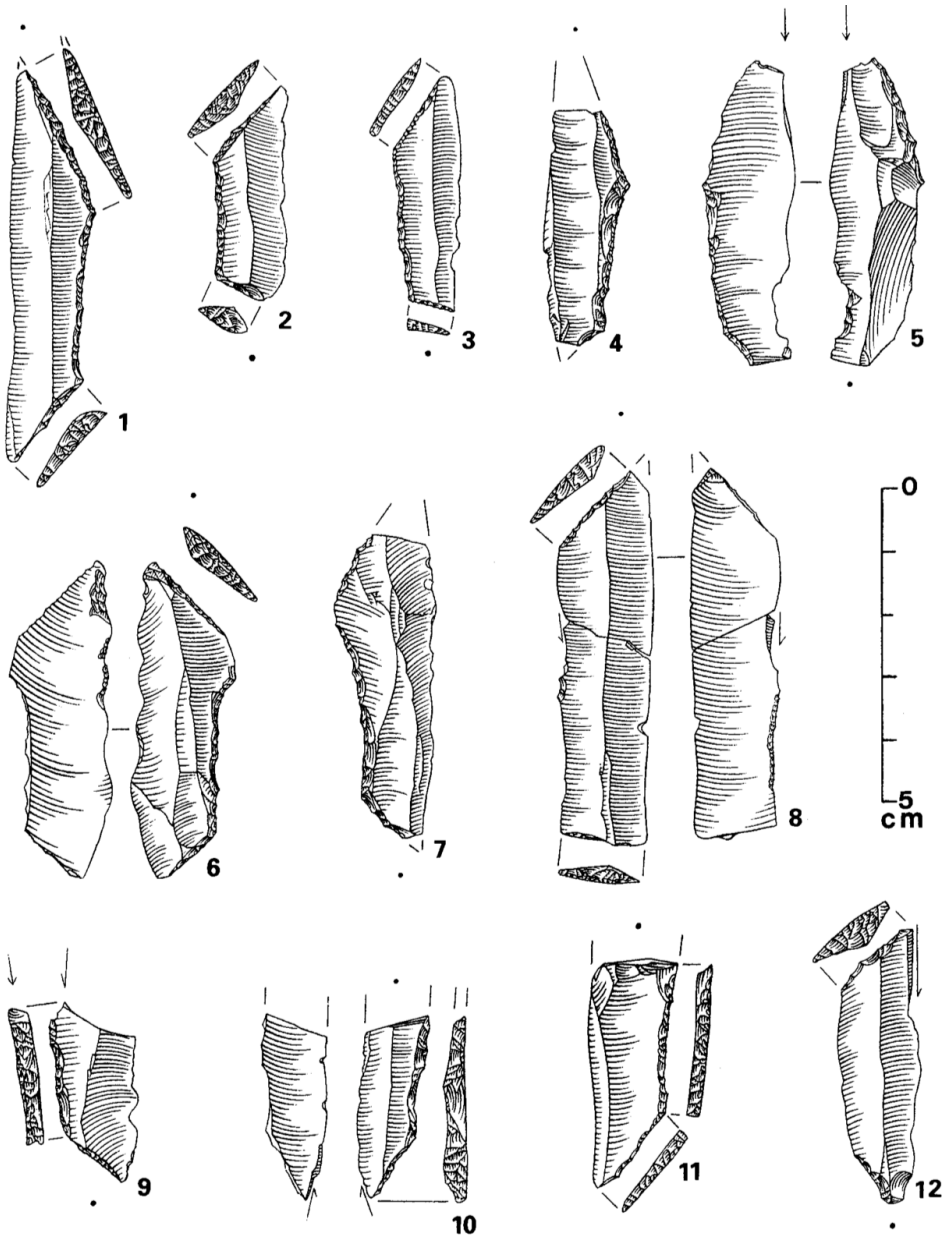


Figure 4.21 Gough's Cave, abruptly modified pieces: 1-12. Jacobi 2004: 37

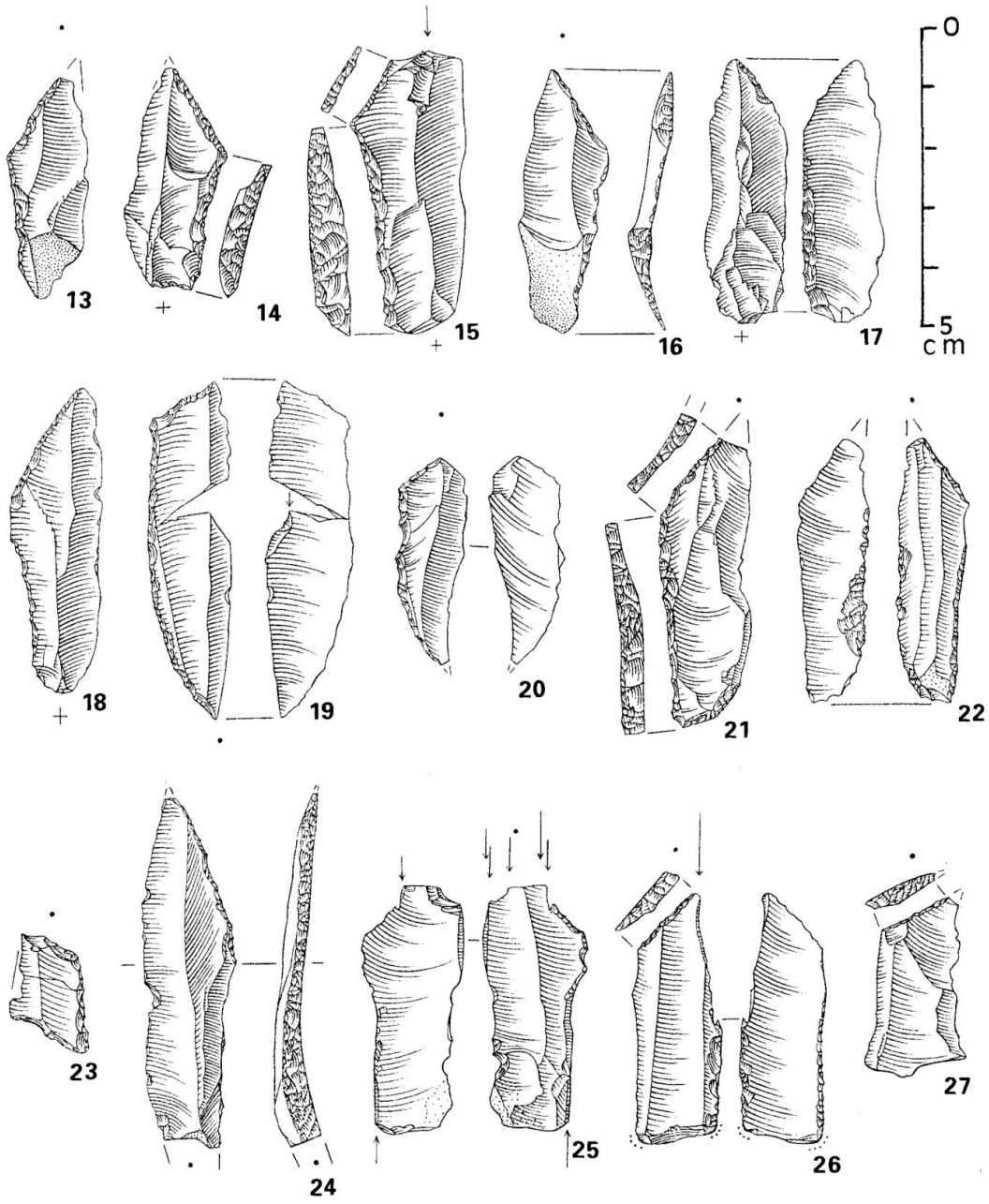


Figure 4.22 Gough's Cave, abruptly modified pieces: 13-27. Jacobi 2004: 37.

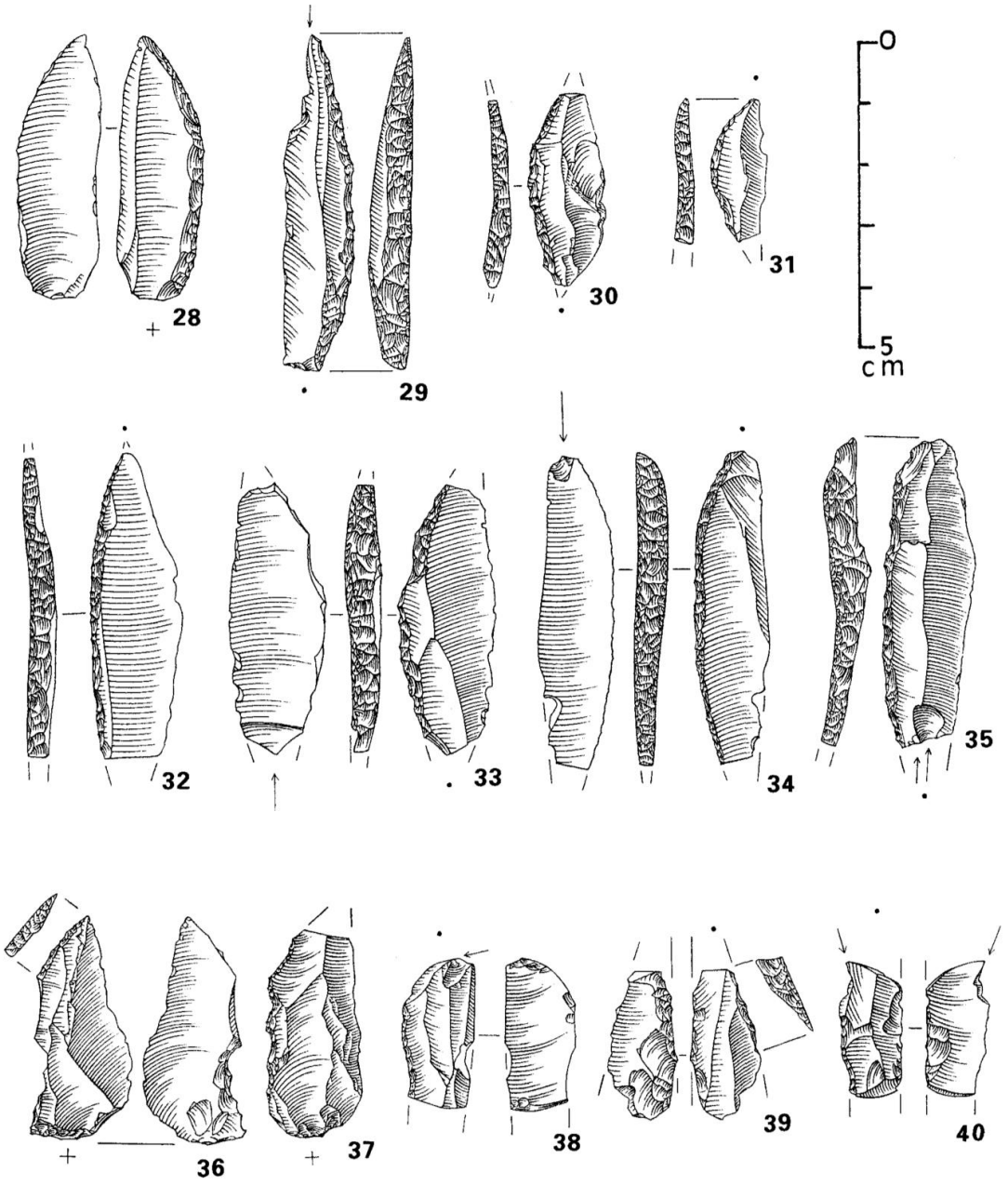


Figure 4.23 Gough's Cave, abruptly modified pieces: 28-40. Jacobi 2004: 39

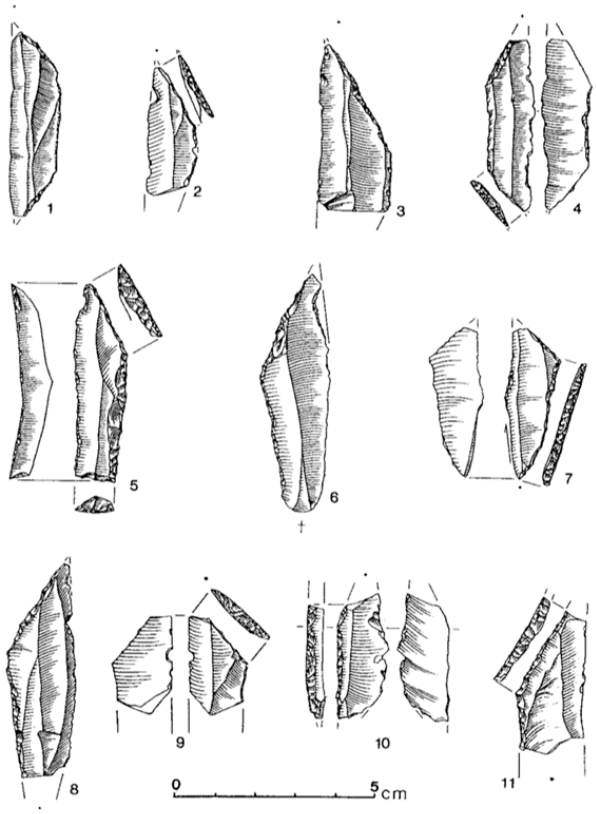


Figure 2 Creswellian from Kent's Cavern. Cheddar Points 1–4. Creswell Points 6, 8. All from the 'Black Band' except 6, which is from the topmost spit of the cave earth in the Vestibule. 1, 3, 5, 6, 10 Torquay Museum; 2, 9, 11 Bolton Museum and Art Gallery; 4, 8 The Natural History Museum; 7 Liverpool Museum. Drawing by Hazel Martingell

Figure 4.24 Kent's Cavern abruptly backed pieces (Barton et al. 2003).

4.1.3.6 Landscape Context: LCres

The main difference between the distribution of ECres and LCres assemblages in Britain is in the prevalence of cave sites for the former. The LCres is represented at more open-air find locations, including some from Southeast England. Figure 4.25 shows the distribution of LCres sites and finds.

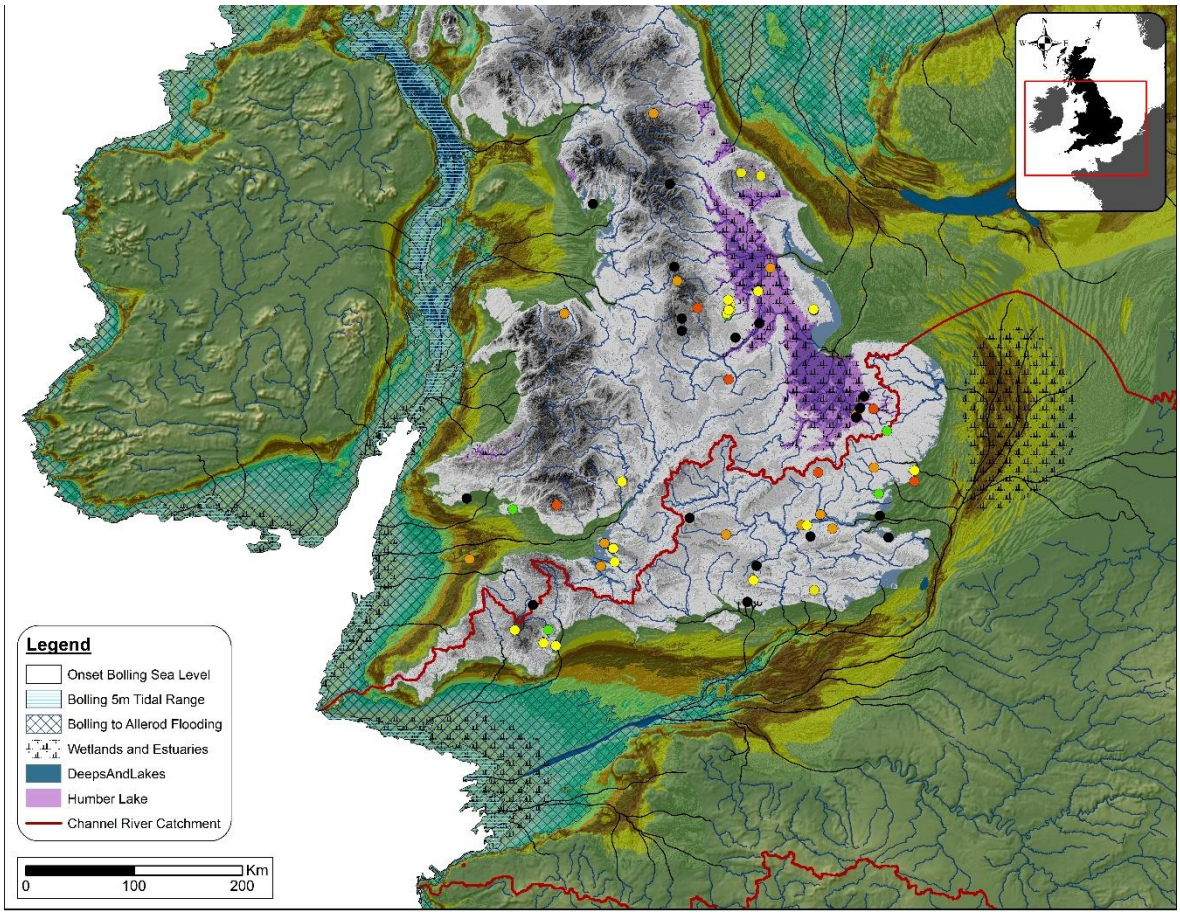


Figure 4.25 LCres distribution. Selection of finds (counts in brackets) based on attributes within the CoB dataset. Yellow: Creswell points and Angle Backed points; Green: Cheddar points; Black coded typologies (1101, 3003, 3007, 4002, 4003, 5000, 5002-5); Orange: bi-points and Azilian points; Red: en-éperon. (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, rivers European Environmental Agency, projected in ArcGIS 10.6.1, Colonisation of Britain database overlay).

4.1.4 Open-air sites of Creswellian types (undifferentiated)

Open-air sites of broad Creswellian-type are difficult to classify except in general terms due to a general lack of datable organic materials. At present there are four known sites of this type, two from Surrey in the Southeast England study area: Wey Manor Farm (Jones 2013) and Guildford Fire Station (Attfield *et al.* 2014). The other two sites are from the East Midlands: Farndon Fields, Nottinghamshire (Barton *et al.* 2013; Garton & Jacobi 2009) and Bradgate Park, Leicestershire (Cooper 2006; 2012). Of these four only Wey Manor Farm is fully published, Bradgate Park has a preliminary analysis, and at present

there is little information available about the debitage and retouched tools from the others. On the basis of typology Wey Manor Farm may be related to the Later Creswellian and is therefore probably of Late Bølling age. The two Surrey sites will be discussed in section 4.3. Figure 4.26 shows the distribution of Open-air Creswellian (undifferentiated) sites.

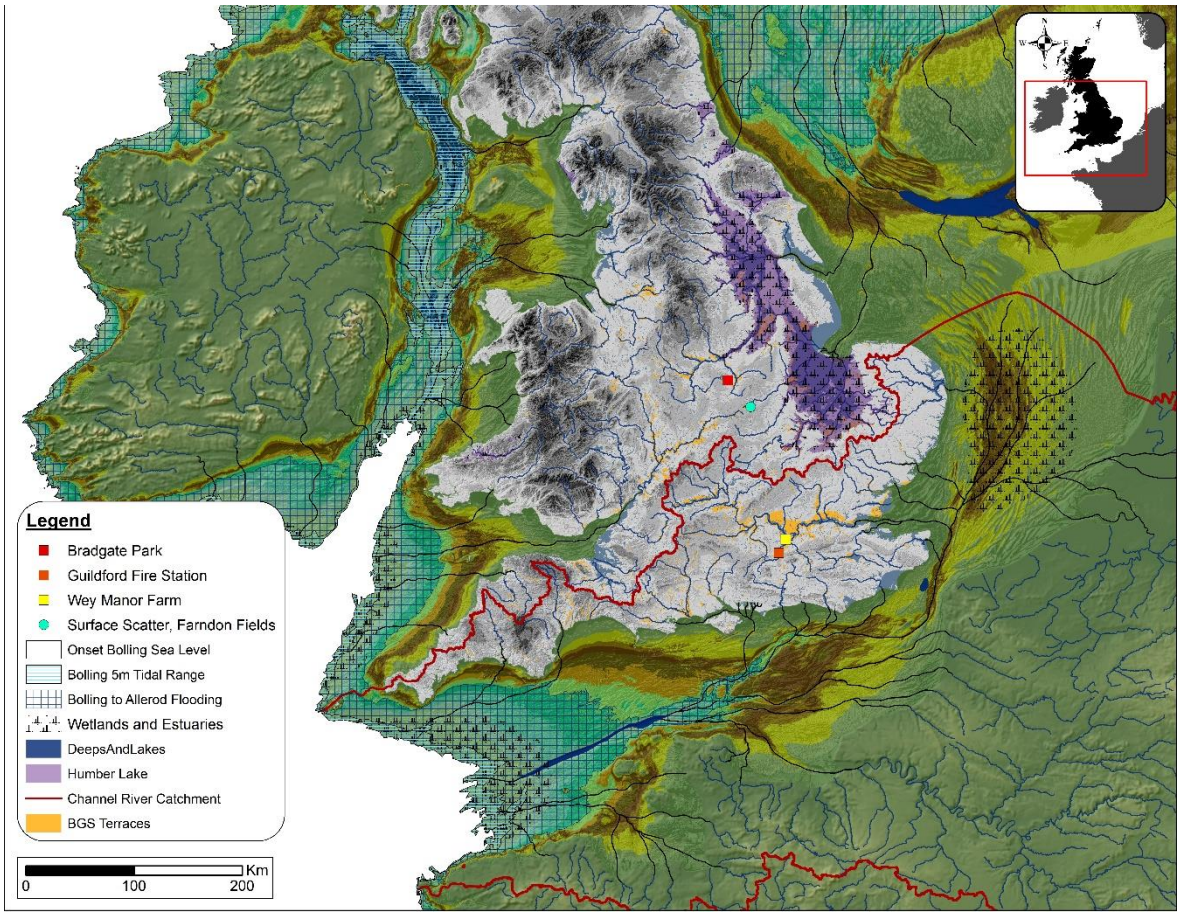


Figure 4.26 Distribution of Open-air Creswellian (Undifferentiated) assemblages. (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, rivers European Environmental Agency, projected in ArcGIS 10.6.1).

4.1.5 Late Upper Palaeolithic facies with Hamburgian traits (LUP-Hamb)

4.1.5.1 Introduction: LUP-Hamb

This section considers British LG assemblages characterised by shouldered and angled-backed armatures with parallels to Classic Hamburgian and/or Cepoy-Marsangy assemblages (Schmider 1982; Valentin 2008a; Weber & Grimm 2008; Weber 2012). The assemblages have been considered as having a Hamburgian influence (Pettitt 2012).

4.1.5.2 Reference sites and chronology: LUP-Hamb

There are no reference sites for this group. The defining features include the presence of shouldered and angle-backed armatures, that have been found at some cave sites and at open-air scatters and isolated find spots such as Oare, Kent and Mildenhall, Sussex. These assemblages are thought to belong to the Latest Bølling or Early Allerød based on techno-typological comparison with European sites (see Chapter 3). The presence of late Hamburgian Havelte assemblages are identified in Scotland (Ballin *et al.* 2010), but are so far unknown from England or Wales (Pettitt 2012).

4.1.5.3 Debitage: LUP-Hamb

There are as yet no refitting assemblages from this group, and no clear characterisation of the debitage is possible as yet.

4.1.5.4 Domestic tools: LUP-Hamb

Zinken are controversially one of the diagnostic tool types for this group. It is a distinct piercer type with a characteristic curvature on the outside of the active area and a notch on the inside. There is also a diagnostic removal along the axis of the piercer tip. There are multiple stages involved in its creation and it is a strong indicator of complex deliberate manufacture. Double zinken (a piercer on both distal and proximal ends of a blade blank) are considered as one of the diagnostic elements within both Classic and Havelte Hamburgian assemblages (Weber 2012), and are so far absent in the British assemblages. The function has been associated with antler working (Weber 2012). In Europe, double zinken appear to be absent from the Late Magdalenian as in the Creswellian, although both industries have rare single zinken.

4.1.5.5 Hunting armatures: LUP-Hamb

Shouldered points are the main armatures known from assemblages and find spots of this type. In the past shouldered points from Oare and Mildenhall have been compared to Classic Hamburgian forms, although the Oare example is atypical and closer to a Havelte morphology (Burdukiewicz 1986; Grimm *et al.* 2012; Weber 2009). Other shouldered points from England may resemble southwestern French Late Magdalenian shouldered points (Langlais *et al.* 2015). Tanged points with a distinctive inverse retouch (Havelte points), have been identified in Scotland (Ballin *et al.* 2010), but not yet in England or Wales. Some obliquely-truncated and curve-backed points and asymmetrical Cheddar points may also fall into the shouldered points category due to the morphology of their backing (Jacobi & Roberts 1993; Jacobi 2004). These are different from the shouldered points from Hengistbury Head that have a distinctly fashioned shoulder. The Hengistbury Head assemblage could be either late Bølling or Early Allerød age, and is described as

predominantly Early Federmesser (Barton *et al.* 1992). None of the shouldered points can be refitted to the cores from the site, however, and they may be a separate LG component. The stray shouldered point recovered from Langston Harbour, as well as the shouldered points at Brockhill have close affinities to the Hengistbury Head shoulder points (Mills 2013).

The typological elements diagnostic of this group (zinken, angled-backed and shouldered points) have their closest parallels with two European technocomplexes that have been compared in the past: Classic Hamburgian and Cepoy-Marsangy facies (Burdukiewicz & Schmider 2000; Schmider 1982; Valentin 2008a). The three typological elements have not yet been found together at a British site.

4.1.5.6 Landscape Context: LUP-Hamb

Artefacts and assemblages of this group have been found in both cave and open-air locations as part of assemblages and as stray finds. Figure 4.27 shows the Late Upper Palaeolithic facies with Hamburgian traits distribution.

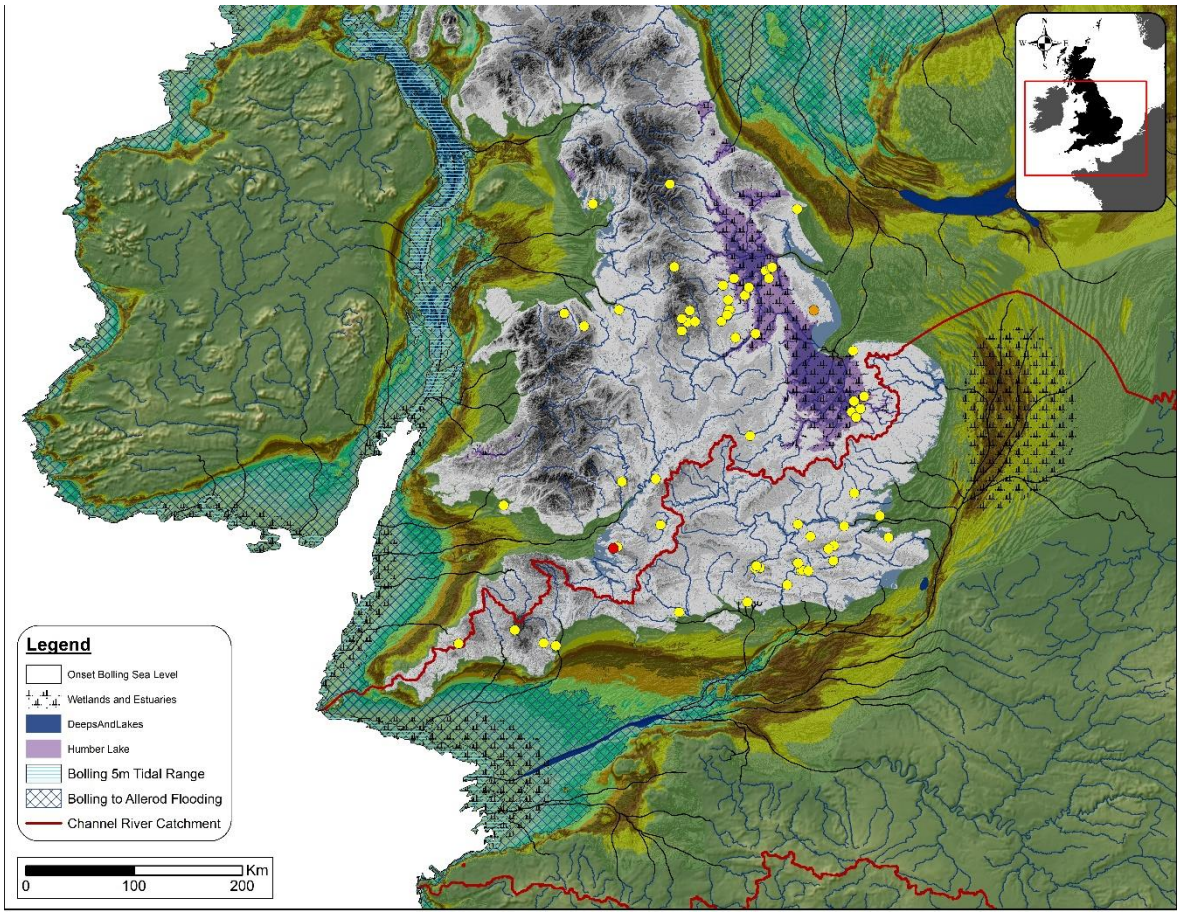


Figure 4.27 Late Upper Palaeolithic facies with Hamburgian traits distribution. CoB distribution based on Key terms "Zinken" (red), "Hamburgian" (orange), "shouldered points" (yellow) and CoB code for shouldered points: 5001. (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, rivers European Environmental Agency, projected in ArcGIS 10.6.1).

4.1.6 Early Federmesser with straight backed blade assemblages (EFed)

4.1.6.1 Introduction: EFed

The Early Federmesser technocomplex is currently one of the best defined for the LG of Britain and includes sites with multiple refitting sequences and, in some cases, discrete assemblages. It is included in the Final Upper Palaeolithic (FUP) grouping of sites (Barton 1999b; Barton & Roberts 1996b), but will here be treated separately. Despite the relatively high-resolution data available for this group, there are no examples where it occurs in stratigraphic association with the Creswellian. The best evidence for this grouping comes from open-air sites in southern Britain which offer closest comparisons

with assemblages in the Somme region. The latter are from well-stratified contexts and have a reasonably well-defined chronology (Barton *et al.* 1992; 2009; Fagnart 1984). In the past the term 'Hengistbury-type' has been used to describe these assemblages (Conneller & Ellis 2007), but that term is not used here although it remains the largest reference assemblage.

4.1.6.2 Reference sites and chronology: EFed

The reference sites for the EFed, are the open-air locations of Hengistbury Head (Barton *et al.* 1992) and Nea Farm (Barton *et al.* 2009), and possibly Brockhill (Barton et al. 2009; Mills 2013). The La Sagesse Convent site is tentatively associated with this technocomplex (Conneller & Ellis 2007), but taphonomic problems and an absence of diagnostic markers make its interpretation difficult. There are no direct dates and the assemblages are considered to be either late Bølling or Early Allerød in age (Barton *et al.* 1992) based on techno-typological similarities with assemblages from northern France, especially the Somme Region (Coudret & Fagnart 1997; Fagnart 1988).

4.1.6.3 Debitage: EFed

Early Federmesser debitage is focused on the production of well-made long, straight and broad blades. Both Hengistbury Head and Nea Farm sites are close to high-quality flint sources, although at Hengistbury some of the abandoned cores are on poor material with signs of frost-action (Barton *et al.* 1992; Barton 2010). One of the differences with earlier technocomplexes (Creswellian and Magdalenian) is the decline in regular long-distance transfers of raw material, sometimes as whole cores or prepared blades (Barton *et al.* 1992; Barton 2010). There also appears to be a tendency to use soft-stone percussion

methods (Barton *et al.* 1992). True opposed-platform core debitage is preferred, along with a preponderance of plain butts, only occasional faceting, and an absence of the éperon technique. Refitting shows that occasionally, single platform cores began as opposed platform examples with the later stages of reduction aimed at producing thicker straighter blanks (Barton *et al.* 1992; 2009). The use of bi-directional cresting for initial blades is often employed for the front of the core but rarely for the back, distinguishing it from Classic Magdalenian reduction strategies. Cores are carefully prepared and pre-formed before full debitage (reminiscent of Magdalenian core reduction strategies). There are also frequent striking platform rejuvenations with tablet removals, combined with, and possibly due to, the use of faceting techniques on a small proportion of products. Refits show a gradual reduction from large to small blades without specific bladelet or small blade production.

4.1.6.4 Domestic tools: EFed

The domestic toolkit commonly includes burins, end-scrapers, piercers, becs and truncations. The main distinction from the Creswellian and Magdalenian is that the tool blanks are made on broader and straighter blades (Barton *et al.* 1992; 2009). Another notable distinction is in the frequent use of truncations, both as burins on truncation, and truncated blades (that may have been blanks for future burins or used independently) (Barton *et al.* 1992; 2009). In contrast to the Creswellian there are significant numbers of burins from these assemblages: e.g. Hengistbury Head, Nea Farm and notably Brockhill (Barton *et al.* 1992; 2009; Mills 2013). The end-scrapers include many made on flakes, and even those made on elongate blanks do not resemble the Creswellian and Magdalenian scrapers made on regular long curved blades. Many of the blanks used for

end-scrapers come from the initial stages of core preparation (Barton *et al.* 1992). Piercers and becs are both made on blades and small blades.

4.1.6.5 Hunting armatures: EFed

The production of straight-backed blades is another distinct typological feature of the EFed. These blades are interpreted as lateral armatures based on macro- and microscopic evidence of impact-damage (Barton *et al.* 1992). They resemble Late Magdalenian 'backed bladelets' but are distinguished by their larger overall size and by the absence of bladelet production in the EFed. Backed blades of this type have been found at Hengistbury Head, Nea Farm, Brockhill and La Sagesse Convent (a single find not directly associated or refitted to the main scatter). Hengistbury Head and Brockhill both contain a large variety of armatures including: straight backed blades, thick bipoints with abrupt retouch, shouldered points, tanged points and curved backed mono-points. A similar diversity is found amongst the closest analogy on mainland Europe at Hangest-sur-Somme, niveau inférieur (Coudret & Fagnart 1997).

There is also a presence of shouldered points in this technocomplex (Barton & Roberts 2001; 2001). The negative dorsal scars on the points indicate a lithic production strategy with opposed removals along the axis of the blade blanks (Barton *et al.* 1992). There is also a presence of large tanged points (over 55mm length) at Hengistbury Head, which remains problematic (Barton *et al.* 1992; Barton & Roberts 2001; Barton 1999b). The only other LG industries with tanged points of these large dimensions in Northern Europe are the Brommian in south Scandinavia, the Swiderian in Poland, and the earlier Late Magdalenian of southwestern France (Teyjat points). Both Brommian and Ahrensburgian

date to several hundred years later than the latest supported date for Hengistbury Head. The Hengistbury Head tanged points do not appear to fit precisely into any of these typologies (Barton *et al.* 1992; Barton 1999b), and their association with the rest of the assemblage remains unclear.

4.1.6.6 Landscape Context: EFed

The only sites attributed to this technocomplex so far are the open-air sites of Hengistbury Head, Nea Farm, Brockhill and potentially La Sagesse Convent. Whereas Hengistbury Head is located on a promontory overlooking two major river confluences, the other three sites are located on lower terraces in proximity to river systems. Figure 4.28 shows the Early Federmesser distribution.

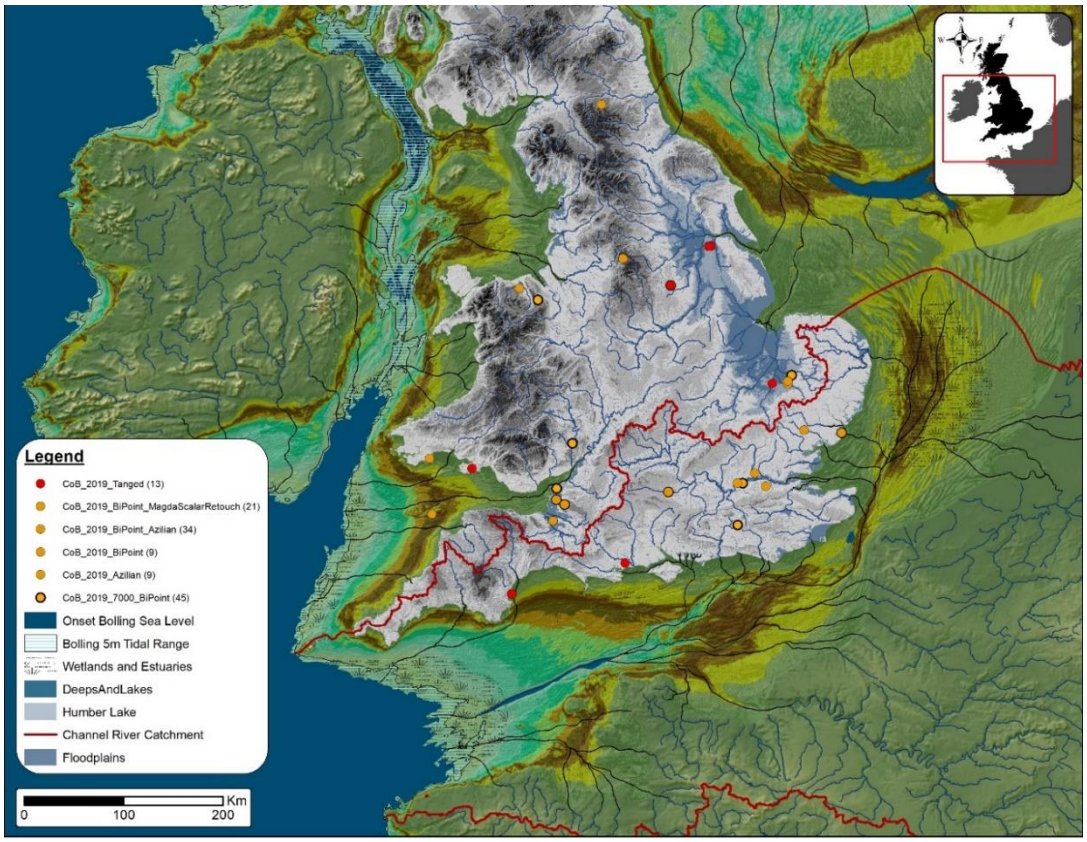


Figure 4.28 Early Federmesser distribution . CoB keywords: "tanged" (red), potential Azilian keywords "scalar retouch, Azilian, bipoint" as well as CoB bipoint codes 7000 (orange). (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, rivers European Environmental Agency, projected in ArcGIS 10.6.1).

4.1.7 Allerød Federmesser with curve-backed and Penknife point assemblages (LFed)

4.1.7.1 Introduction: LFed

There are few well-defined assemblages associated with the LFed (previously FUP) (Jacobi 1991), and the 'reference' assemblages in Devon and the Wye Valley in Herefordshire remain only partially published (Barton 1995; 1996; 1997; Barton & Roberts 1996b; Collcutt 1986). The armatures are generally characterised by 'Penknife points' (Garrod 1926). These are thick curve-backed blades with additional basal retouch at one end on the opposite side to the backing that can resemble a tang (Barton & Roberts 1996b; Garrod 1926). Clarification is needed on the use of the term 'Penknife point' in a British

context, as the eponymous German Federmesser (translated as 'penknife') backed tools usually have an abrupt backing only on one side (Schwabedissen 1954; Taute 1963). However examples of British-type Penknife points occur within the European Curved Backed Point (CBP) complex (Grimm *et al.* 2012) which incorporates the Federmesser technocomplex, although mostly atypical and with a much greater morphological variability.

4.1.7.2 Reference sites and chronology: LFed

The reference assemblages are from Three Holes Cave and Broken Cavern in the Torbryan Valley, Devon (Barton & Roberts 1996a), and from Symonds Yat East, Wye Valley, Herefordshire (Barton 1997). They also include findspots described by Roger Jacobi (Jacobi 1991; Jacobi & Higham 2009a), which comprise Penknife points and less distinct **thick** curve-backed mono- and bipoints. The distribution includes a high proportion of open-air locations dominated by isolated finds (Jacobi 1991; Jacobi *et al.* 2009).

It is believed that the British Penknife point assemblages probably date to the latter half of the Allerød, but this is difficult to assess because of the paucity of reliable dating evidence. Techno-typological similarities with other Northern European sites lends plausibility to this dating (Barton *et al.* 1992; 2009; Barton 1999b; Barton & Roberts 1996b; Jacobi 2004; Jacobi & Higham 2009a).

4.1.7.3 Debitage: LFed

The characterisation of LFed debitage remains difficult due to the suspicion of palimpsests amongst representative assemblages (Barton 1999b; Barton & Roberts 1996b; Jacobi 1991). Only the cave sites of Three Holes Cave, Broken Cavern, and Symonds Yat rockshelter have discrete archaeological assemblages with penknife points (Barton & Roberts 1996b). The site of Pyrford in the Wey Valley (Mills 2013) is a surface collection with material bearing various degrees of patination and cannot be considered as homogeneous. The material from Pyrford appears to be of good quality flint that is found locally. The Three Hole Cave and Broken Cavern assemblages both indicate the use of smaller local flint nodules. The assemblage at Symonds Yat is slightly different as it appears to be on small, good quality flint raw material not found locally. This contrasts with the established pattern for Federmesser-type industries which seem to rely more heavily on local raw materials as demonstrated in Southwest England (Barton 2010; Barton & Roberts 1996b) and Northern Europe (Coudret & Fagnart 1997).

The debitage appears to be dominated by stone hammer mode of percussion with an internal strike (Barton 1999b; 2010; Barton & Roberts 1996b). The use of soft-stone hammer percussion and tools made on small blade blanks can be noted for both Penknife point assemblages and others of similar age containing curve-backed blades (Barton 1999b). A technological transition towards the use of hard-hammers took place during the final phases of the Allerød in neighbouring regions of Northern Europe (Baales 2004; Bodu & Valentin 1997; Coudret & Fagnart 1997). This is not apparent in the British LFed assemblages (Barton 1999b; Barton & Roberts 1996b) either indicating an earlier to mid-Allerød period for their development or cultural differences north and south of the Channel River.

True opposed platform debitage continues during this period for both Penknife point and curve-backed point assemblages, a characteristic also noted in later Federmesser industries in Northern Europe (Baales 2004; Barton 1999b; Bodu & Valentin 1997; Coudret & Fagnart 1997; Grimm *et al.* 2012). The advantage of opposed platforms cores is the production of broader irregular but straighter blades (Barton 1999b; 2010). There is also less care invested in core preparation, blank removals are less systematic, and a high proportion of flakes is produced. It has been hypothesised that this may be perceived as part of a transition in raw material economy from the transport of blades and pre-prepared cores to a greater exploitation of local raw materials (Barton 2010). Embedded within the more opportunistic approach to lithic procurement and production is a simplified method of producing short straight blanks (Barton 1999b; 2010; Fagnart 1984). This transition in debitage methods and choice of local raw materials may have been in response to adaptations to increasing forest cover in the Allerød (Barton 1999b; 2010; Fagnart 1984).

4.1.7.4 Domestic tools: LFed

The morphology of tools in the LFed broadly follows the shape of the short and straight blanks, including flakes as well as blades and bladelets, although shaping using abrupt retouch is more significant. A distinct type of large abruptly backed flake/blade, knives are characteristic (and also present in the early Federmesser). End-scrapers are generally made on short thick blades or on elongated flakes. As with the EFed there is not a selection for curved blanks as in some of the preceding technocomplexes. Tools tend to be shorter because of nodule size and production methods (Barton 1999b). Small round,

thumbnail scrapers shaped by intensive retouch occur in the LFed, and are mainly absent in older technocomplexes (Barton 1999b). Assemblages with thumbnail scrapers date to the second half of the Allerød in assemblages in Northern Europe (Baales *et al.* 2001; Coudret & Fagnart 1997; de Bie & Caspar 2000; Naudinot *et al.* 2019; Valentin 1995b). Burins are mostly made on truncations (Barton 1999b), which is also characteristic of Later Allerød Federmesser assemblages in Northern Europe such as at Rekem and Saleux (see Chapter 3)(Coudret & Fagnart 1997; de Bie & Caspar 2000).

4.1.7.5 Hunting armatures: LFed

The LFed hunting armatures are distinct and can be considered as type-fossils when associated with the debitage described above. The general category is that of Curved Backed Points (CBP), with the Penknife points appearing to be an important sub-type limited to Britain with a few isolated exceptions (Grimm *et al.* 2012). CBP are made on small blades and sometimes bladelets, with one abruptly backed edge and, in some cases, a basal modification. In contrast Penknife points always have a basal modification which can form a distinctive tang. Most Penknife points also appear to be made on small blades rather than bladelets. In relation to dimensions, the smaller penknife points, such as at Symonds Yat, have similar dimensions to Ahrensburgian points (section 4.1.8), but are rare.

4.1.7.6 Landscape Context: LFed

The FUP has generally been associated with open-air sites rather than cave sites, in reverse manner to the landscape distribution of Creswellian sites (Barton *et al.* 1992;

Barton 1999b; Jacobi 2004; Jacobi & Higham 2011b). The distribution of the distinctive Penknife points that are characteristic of this period is well-documented thanks to a detailed catalogue prepared by Roger Jacobi about a decade ago (Jacobi & Higham 2011b). They are best known as isolated finds and cave sites. Some points have also been recovered from cave assemblages: notably at Mother Grundy's Parlour and Robin Hood Cave (Creswell Crags), Pixie's Hole (Devon), and Symonds Yat rockshelter (Herefordshire). Figure 4.29 shows the Late Federmesser with curved backed blades distribution.

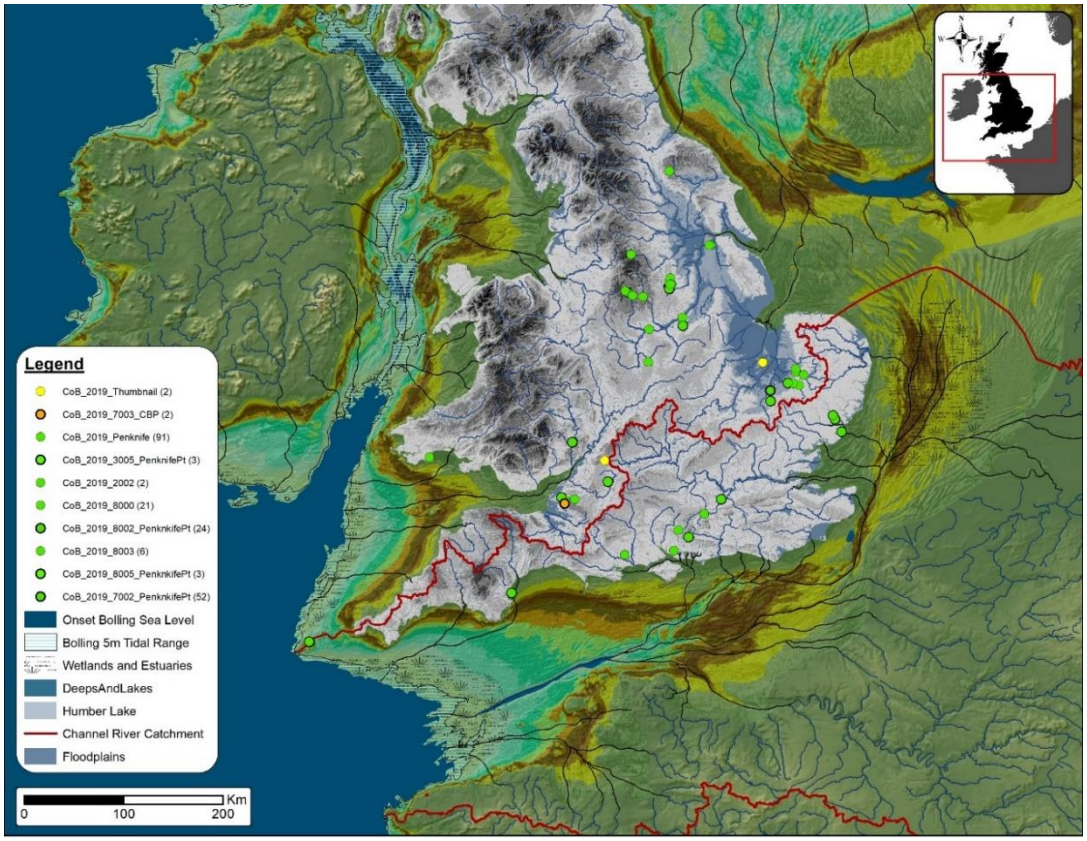


Figure 4.29 Late Federmesser with curved backed blades distribution. (Source: Author. Basemap modified from GEBCO 2014 elevation and EMODnet17 bathymetry, rivers European Environmental Agency, projected in ArcGIS 10.6.1).

4.2 The Colonisation of Britain (CoB) dataset and Late Glacial site distributions in England and Wales

4.2.1. Introduction

This section discusses the Colonisation of Britain (CoB) database and how it was critically applied and developed into the thesis dataset for the spatial analysis of LG site distributions in Britain and Southeast England. In order to distinguish the thesis dataset from the original CoB the thesis dataset will be referred to as the CoB-LG. As discussed in Chapter 2, the CoB database originated with the late Roger Jacobi's records of Upper Palaeolithic and Mesolithic artefacts and findspots from England and Wales (index cards and supporting files). The index card system was started in the 1970s and continued to be updated until it was digitised in 2008 (Harris 2015; The Colonisation of Britain Project 2012; wessexarch.co.uk 2015; Whyte 2008). The cards contain information on site (name, location), excavation or field collection (notes), and museum (accession numbers), as well as of individual artefacts (coding and quantity). Jacobi's artefact coding was often accompanied by descriptive details indicating characteristics of artefacts, and also often including a chrono-cultural attribution. The CoB that derives from these cards is currently the most detailed systematic recording of LG artefacts and sites for England and Wales. Chapter 2 provides information about the CoB and the underlying PaMELA (Palaeolithic and Mesolithic Lithic Artefact) database.

4.2.2 CoB typological and chronological coding

During the PaMELA digitisation project a series of 'tag terms' was developed for the CoB database. These 'tag terms' used codes and descriptive elements considered as diagnostic

from the index cards to attribute typological and chronological determinants for the artefacts (Whyte 2008). The types and attributions were derived from Jacobi's artefact coding system that provides morphological detail on point types, core types, some blades, and broken fragments.[23] Figure 4.30 shows a schematic diagram of armature types with typological codes used in the CoB. The detail in the artefact coding is of particular importance in assessing the validity of the CoB typological attributions in relation to the variation of armatures from the Northwest European technocomplexes. Caution is required in accepting the 'tag term' determinations especially for stray finds of artefacts. In addition, unsurprisingly for a dataset developed over several decades some of terms from the index cards are now out-of-date. These terms were checked and updated for the thesis database.

[23] A copy of the typological coding used in the CoB is available from Wessex Archaeology on request. It is based on the coding developed by Jacobi in the 1970s for his doctoral research.

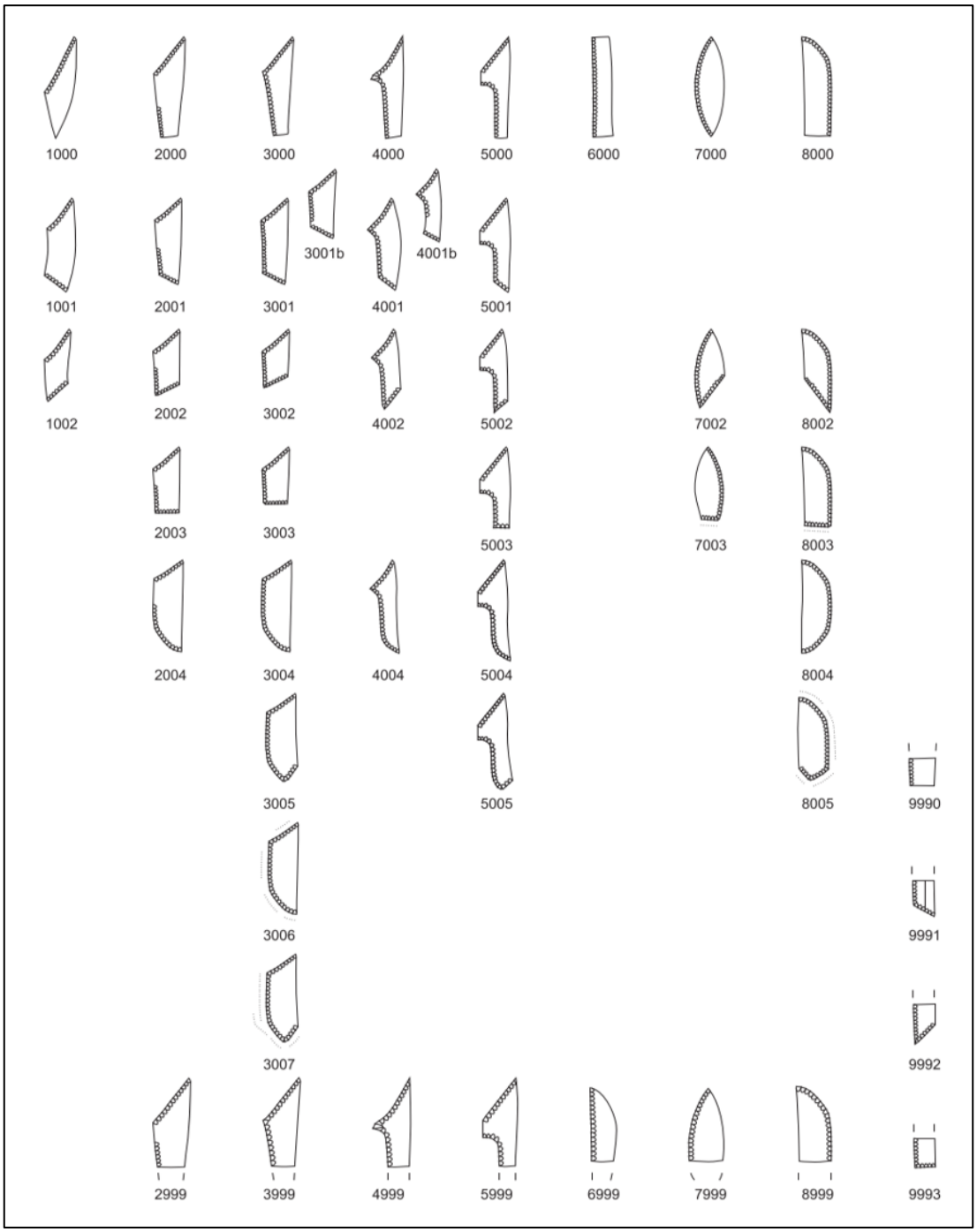


Figure 4.30 Schematic diagram of armature types with typological codes used in the CoB dataset (provided by Wessex Archaeology)

There are undoubted shortcomings in relying on typology for diagnostic chronological interpretation and technocomplex resolution ('cross-over' of types, presence of palimpsests, chronological resolution). However, if treated carefully it is possible to derive from typology a general pattern of distribution, and the CoB is currently the most useful

dataset available for interpreting LG finds at a landscape scale. The thesis analysis draws a distinction between individual 'diagnostic' finds and assemblages with multiple 'diagnostic' artefacts. The probability of a correct technocomplex attribution being significantly higher where there are multiple 'diagnostic' finds. It also recognises that there are certain '*fossile directeur*' that may be considered as more diagnostic, especially those with no cross-over between industries. For example, a Penknife point has several levels of modification that clearly distinguishes the type from other transformed pieces (Figure 4.31). Furthermore, recent high-resolution dating programs have also provided a reliable supporting chronological framework, at both a local and regional level (Barton & Roberts 1996b; Conneller & Higham 2015; Jacobi & Higham 2009a; 2011b).

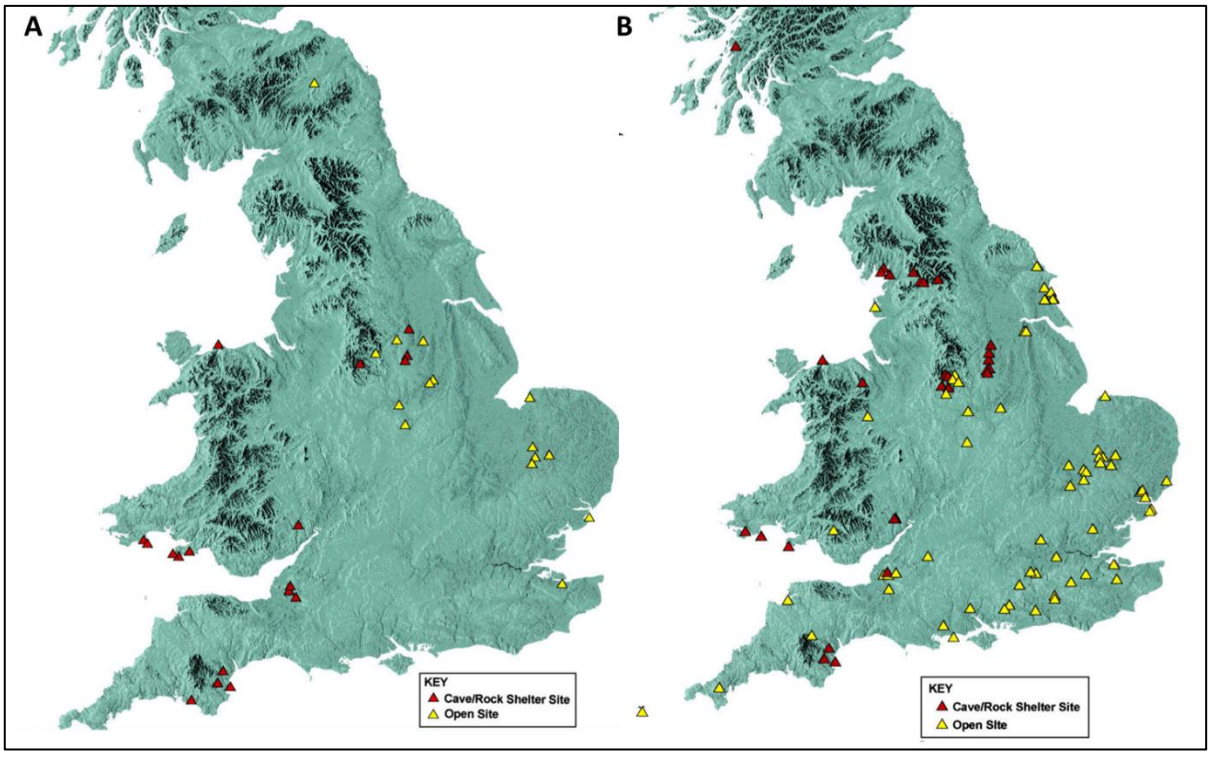


Figure 4.31 British Creswellian and Federmesser distributions. ***A.*** *Map of find-spots from the British Isles attributed to the earlier* ***Magdalenian/Creswellian*** *part of Lateglacial human re-colonization. Mapped are bi-truncated trapezoidal-backed blades (Cheddar points), pieces with talons en éperon and early radiocarbon determinations.* ***B.*** *Map of find-spots of certain* ***Federmessergruppen*** *age. Mapped are penknife points (blades), straight-backed blades/bladelets and bone points with notches formed by crisscross cutting. Also plotted are finds of bone and antler artefacts with direct radiocarbon determinations which date them to the second half of the Lateglacial Interstadial. (Jacobi and Higham 2009: 1909-1910)*

4.2.2 CoB and chronological and typological attributions

The CoB "GIS Flat File" contains 22357 records, of which over half were not tagged with a chronological attribution although in many cases this could be identified by associated type and/or descriptions. Data cleansing of CoB records for the thesis database also revealed that it contained some duplication of records.

The thesis database (CoB-LG) only concerns the LG period. The original CoB database was transformed for the thesis by removing the records for Mesolithic and Palaeolithic artefacts, integrating the detail of records with no chronological tags to identify and retrieve further LG material, and by removing redundancies. The database was then cleansed and standardised. For reasons of consistency the use of the CoB chronological tags was retained in the CoB-LG (Creswellian, LUP, FUP, TUP)[24], and these were grouped into material from the LG overall, and from the Late Glacial Interstadial (LGI). The CoB chronological divisions do not exactly match those of the thesis, and Table 4.1 shows how the terms relate to each other. Table 4-4 shows the quantity of chronologically characterised LG records from CoB-LG database.

[24] See section 4.1.1 for description of the terms LUP, FUP and TUP.

Table 4-4 Total counts for LG artefacts and sites in the CoB-LG database

Row Labels	Artefacts	Sites
Creswellian	118	34
Late Upper Palaeolithic (LUP)	153	80
Final Upper Palaeolithic (FUP)	170	77
Terminal Upper Palaeolithic (TUP)	231	119
Total: Late Glacial Interstadial (Creswellian, LUP, FUP)	702	163
Total: Late Glacial (Creswellian, LUP, FUP, TUP)	1083	374

Artefacts are categorised at three levels within the CoB dataset: 'type', 'sub-type' and 'tool-type'. Types are the most descriptive level e.g. blade, backed blade, backed etc. Sub-types either identify a specific typological category or/and have a code associated with them extracted from the notes. Tool-types identify formal tool categories e.g. burins, end-scrapers etc. Figure 4.30 shows the codes used in the CoB to attribute 'sub-types' to artefacts. Within the CoB-LG, 570 sites with artefacts are identified with chronological attributes to the LG. Of these 570 locations, 118 are Creswellian, 130 are LUP, 203 are FUP and 119 are TUP (Table 4-4). For the purpose of this study, only the material typologically attributed to the Creswellian, LUP and FUP will be analysed as they have the most diverse set of attributes enabling a critical assessment as well as a spatial comparative. The TUP material will be commented on but not analysed here as most are only single finds and the recorded characteristics consist mainly of dimensions.

The additional LG records retrieved from the CoB entries with no previous chronological tag were identified by keyword searches in the 'assemblage notes' field that contains

Jacobi's free-text descriptions including typological and technological terms. Therefore, keyword searches on terms with specific typological and technological significance enabled the identification of specific types and periods (e.g. en-éperon, penknife point, cheddar point etc.). The results of some keyword searches are presented in Table 4-5, along with the number of records returned.

Table 4-5 Keyword searches using the CoB database

KEYWORD SEARCHES IN ASSEMBLAGE NOTES IN COB DATABASE	# of entries
en-éperon	65
Penknife point	57
Cheddar point	43
Creswell point	42
b-point	11
bi-point	14
zinken	2
Magdalenian blade and retouch	21
bruised	41
Riesenklinge	103
abrupt	676
crest	540
machurée	31
opposed	24
Azilian	476
Hamburgian	4
Federmesser	1

While the CoB typological 'tag terms' are a useful tool for initial overview of LG distributions in Britain, in order to use the dataset to its full potential the specific codes and keyword terms need to be utilised. Table 4-6 summarises the typological codes used within the CoB with regard to each of the four recognised chronological periods. This demonstrates the many apparent crossovers within the typological attributions. This is also represented in Figure 4.10.

Table 4-6 CoB artefact codes in relation to chronological tags.

CoB code/ term	Creswellian	LUP	FUP	TUP	Interpretation
1a		1 end		1a	Single platform columnar blade core
1a/2a	1a/2a				Single platform columnar blade core with opposed platform corrections
2a		2a		2a	Core prismatic opposed platform
2b				2b	Core prismatic
2000	2000				Creswell Point
2001	2001				Cheddar Point
2002	2002				Cheddar point?
2999		2999			Fragment of Shouldered point
3000	3000				Creswell Point
3001	3001				Cheddar Point
3001b	3001b				
3002	3002		3002		Cheddar or Penknife Point
3003	3003				Angle-backed, Cheddar or Azilian point
3004	3004		3004		Angle-backed, Cheddar or Curve-backed point (CBP)
3005			3005		Penknife point
3007	3007				Curved and angle-backed Cheddar point
3999			3999		? Penknife point fragment?
4000	4000	4000			Creswell, angle-backed, or shouldered point
4001	4001	4001			
4002	4002				
4003	4003				
4004	4004				
5000		5000			Shouldered Point
5001	5001	5001			Cheddar point or shouldered point
5002		5002			Shouldered Point
5003	5003	5003			Cheddar point or Shouldered point
5004	5004	5004			
5005		5005			
5999		5999			Distal Shouldered Point
6000			6000		Straight-backed blade or bladelet
7000			7000		Curve-backed Point (CBP)
7002			7002		Penknife Point

CoB code/ term	Creswellian	LUP	FUP	TUP	Interpretation
7999			7999		Distal of Curve-backed or Penknife point
8000			8000		Straight-backed point, Malaurie point
8002			8002		Penknife Point
8003			8003		Straight-backed point, Azilian point
8004	8004				Curve- or straight-backed bi-point
8005			8005		Curve-backed or Penknife point
8999			8999		Distal of curve-backed point
9991	9991	9991			Proximal of Cheddar Point or Shouldered Point
9992	9992		9992		Proximal of Cheddar point, Bi-point or Penknife point
Éperon	Éperon				Platform prep technique (Cr)
Magdalenian blades	Magd. blades				Edge-retouched blades (Creswellian/Early Azilian)
Zinken		Zinken			Piercer (Hamburgian)
Bruised				Bruised	Intense lateral damage (LB)
Opposed platform				Opposed platform	Core reduction method (LB, Creswellian)
Riesenklinge				Riesenklinge	Long blades over 12cm (LB)

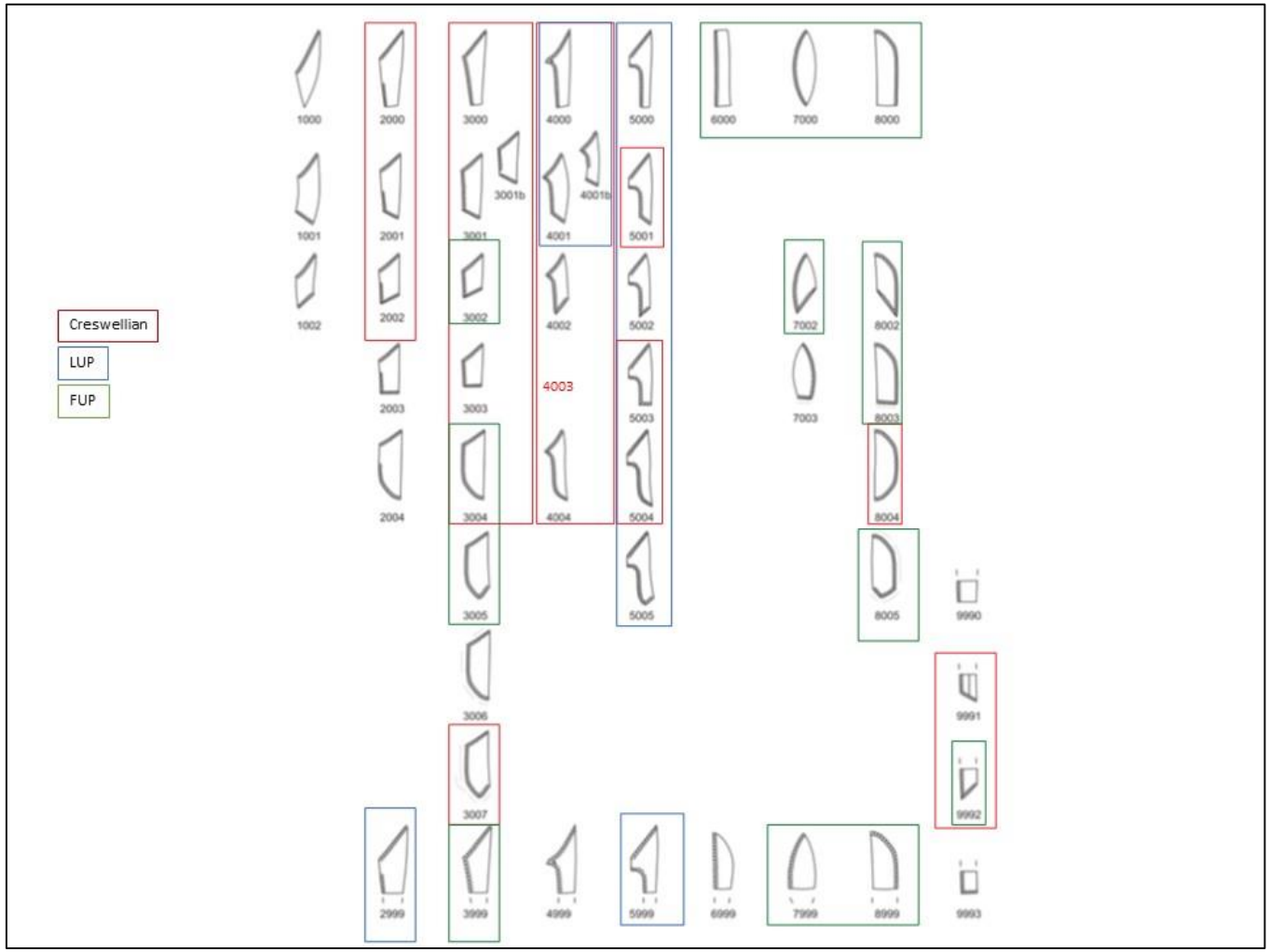


Figure 4.32 Codes used in the CoB to attribute 'sub-types' to artefacts

4.3.3 Analysis of the CoB-LG database

4.3.3.1 Introduction

The following distribution maps are based on the entries from the CoB-LG, and follow the diagnostic attributes described in section 4.1. In some cases, these are either subdivided based on morphological code (e.g. 'Cheddar points' into 'curved and angle-backed points' and 'equilateral trapezoidal points') or have further additions based on the descriptions from the individual notes. There are three phases for characterising the distributions: firstly, the main 'diagnostic' typological pieces; secondly diagnostic technological traits (e.g. abandoned core morphologies and direction of removals, crests, tablets) are added to test if they can support the initial typological determinations from a database distribution and interpretation perspective; finally, the elements with question marks "?" will be added to consider the maximum potential concentrations and extent of a specific type.

Six types of search are used with the CoB:

1. Chronological (e.g. Creswellian, LUP, FUP)
2. Typological (e.g. Cheddar point, burin)
3. Typological code (e.g. 4004, 4003)
4. Technological (e.g. éperon, crest, etc.)
5. Site name
6. Site type (open-air, cave, surface scatter, stray find)

The searches were made using Microsoft Access and imported into Arc GIS 10.6 for the creation of distribution maps.

The GIS was also integrated with various aspects of the geological bedrock, hydrology, current ground cover (vegetation), plus relationships of sites to rivers as well as buffer overlaps based on walking distances between sites (Chapter 7). The GIS analysis demonstrates that the nature of underlying bedrock and drainage patterns are of considerable significance in understanding LG human activity in Britain, and these factors exerted a strong influence on the distribution of predated animals and occupations (see Chapters 6 and 7).

4.3.3.2 Creswellian

The CoB-LG shows a total of 118 artefact entries from 34 sites identified as Creswellian. Four of the sites dominate the database: Gough's Cave (49%), Kent's Cavern (8%), Robin Hood Cave (7%) and King Arthur's Cave (3%). Gough's Cave[25] has by far the largest representation and is likely to be due to Jacobi's publication of the assemblage (Jacobi, 2004). Other sites are represented by one or two artefacts. Twenty-nine codes are used for the artefacts, with 92% of the entries for Cheddar (49%) and Creswell (53%) points. The artefacts are for the most part from cave assemblages, and risk being parts of palimpsests (see section 4.1). All of the sites and 94% of the finds are from active bedrock aquifers. Figure 4.33 shows the distribution of Creswellian sites and find-spots in England and Wales. Figure 4.34 shows this distribution in relation to bedrock hydrology. Figure 4.35 analyses Creswellian site types in relation to site hydrology.

[25] Also known as Gough's New Cave.

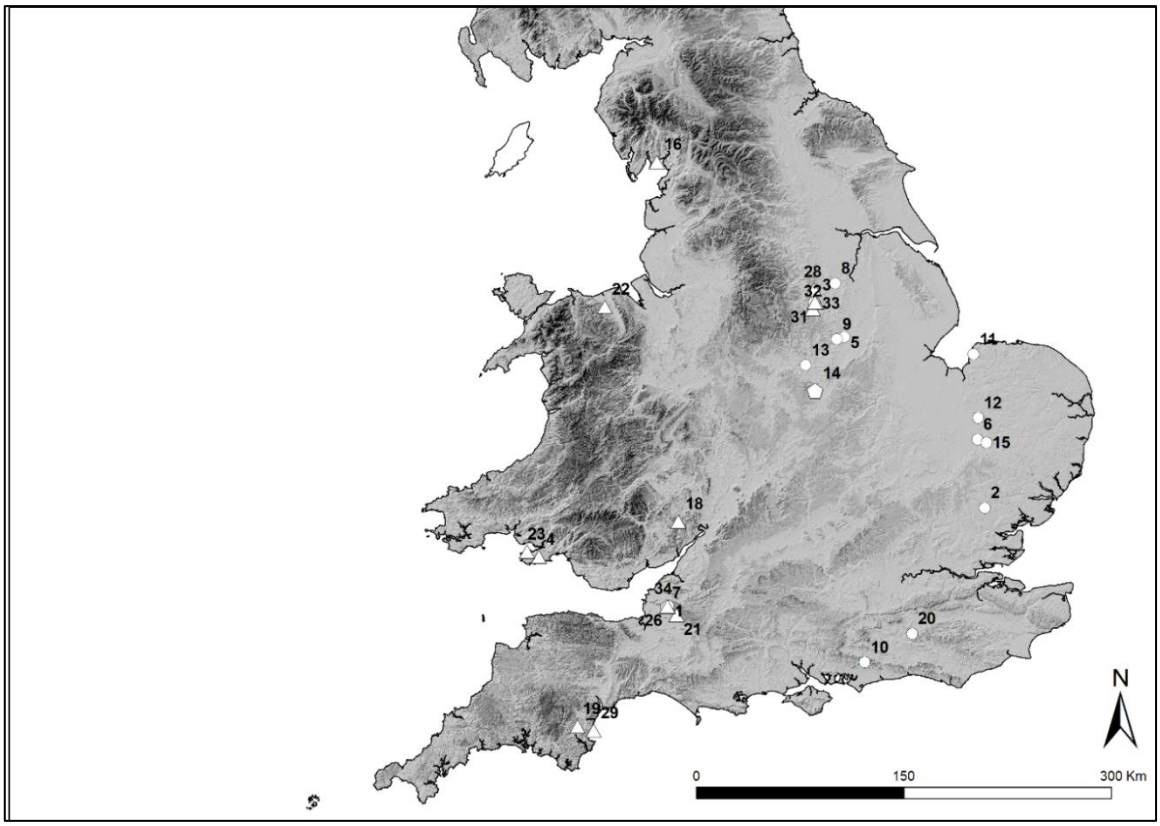


Figure 4.33 Distribution of British Creswellian sites and find-spots. (Source: Author. Basemap OS TOPO 50, projected in ArcGIS 10.6.1).

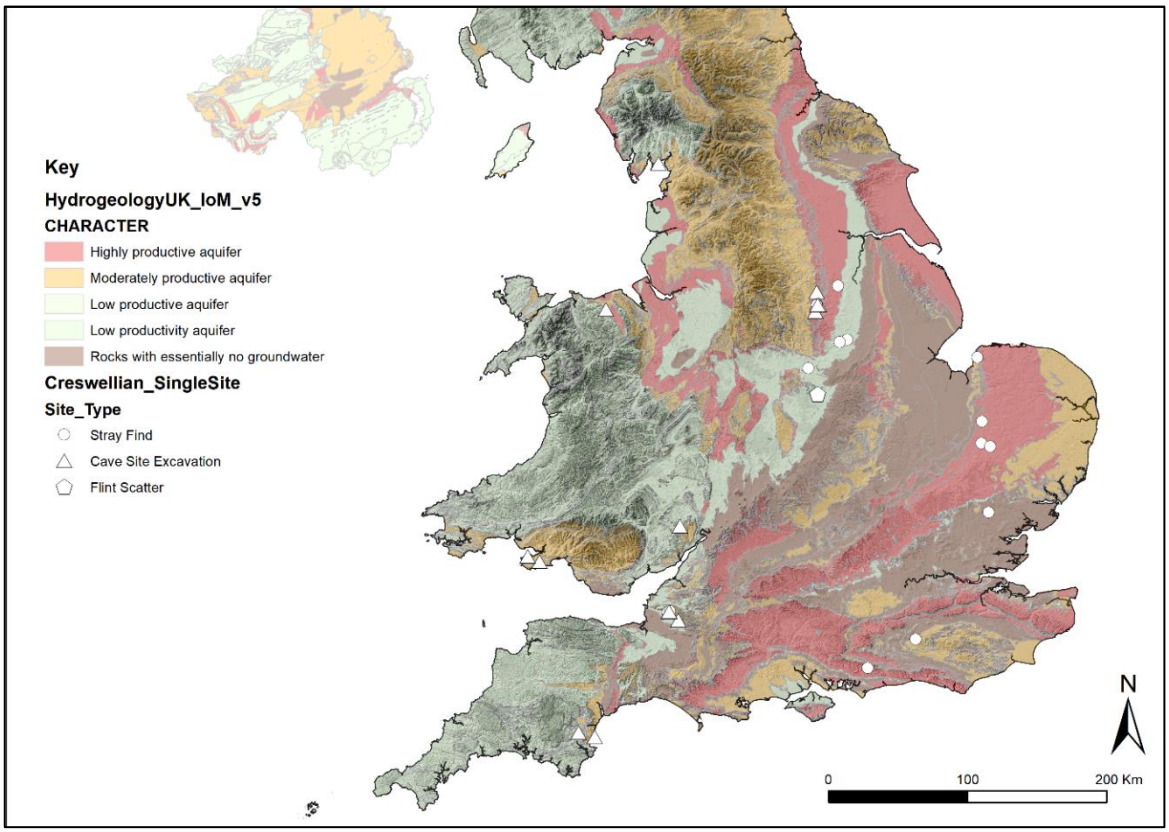


Figure 4.34 Distribution of British Creswellian sites in relation to bedrock hydrology. (Source: Author. Basemap OS TOPO 50, BGS Hydrogeology layer, projected in ArcGIS 10.6.1)

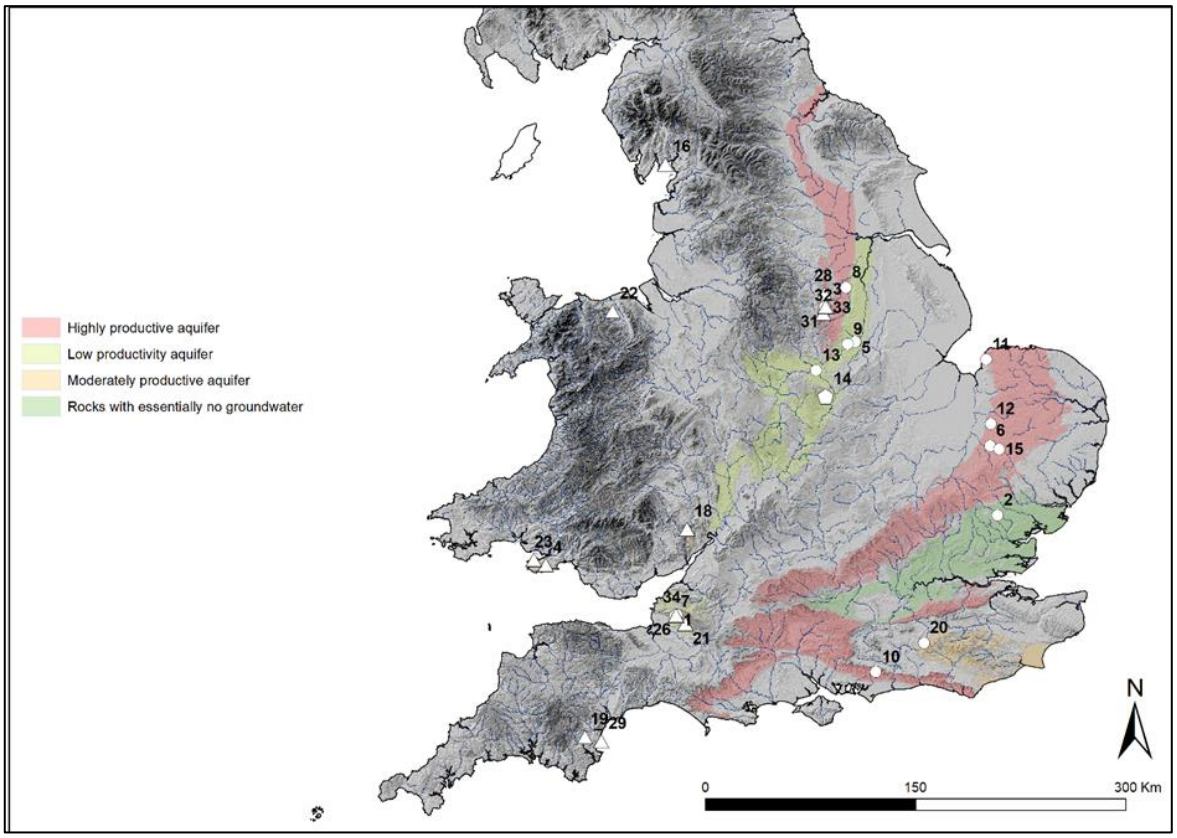


Figure 4.35 Distribution of British Creswellian site types in relation to site hydrology. (Source: Author. Basemap OS TOPO 50, BGS Hydrogeology layer, projected in ArcGIS 10.6.1)

4.3.3.3 Generalised LUP

The CoB-LG shows a total of 153 artefact entries from 80 sites identified as LUP. There are no dominant assemblages, and there is usually only one artefact per site. There are 23 different codes used for these artefacts, with 51% for shouldered points. The artefacts are dominated by two tool types: shouldered points (51%) and giant knives (12.5%). It is interesting to note that shouldered points and zinken are usually indications of the Hamburgian, while large backed knives can be associated with Federmesser industries.

The artefacts are for the most part from open air locations (56%), contrasting strongly with the Creswellian distribution. The distribution of cave sites with shouldered tools also

appears to be different from the Creswellian cave sites. As with the Creswellian there is a high proportion of sites on bedrock with an active aquifer (82%), but also a significant number on bedrock without an active aquifer, for the most part in the Weald and the London Basin. Shouldered points are found mostly on geology with moderate and absent groundwater. Interestingly larger concentrations of artefacts contain both Creswellian and LUP signatures: for example, in the vicinity of Faygate, Icklingham and Farndon Fields (see Chapter 7). The distribution of find locations in the Thames Valley appears to only be LUP. Two important open-air sites associated with the LUP have shouldered points and are likely to be Federmesser: Hengistbury Head and Brockhill. As described in section 4.1.5, both single zinken and shouldered points are not necessarily very characteristic of a single technocomplex, and therefore grouping is not of great use.

Figure 4.36 shows the distribution of the LUP sites[26] (comprising all sites of the Bølling (eg. Creswellian and potential Hamburgian), distinguished from Allerød FUP sites (Barton & Roberts 1996b; Jacobi 2004; Pettitt 2012)) and find-spots in England and Wales. Figure 4.37 shows this distribution in relation to bedrock hydrology. Figure 4.38 represents LUP site types in relation to site hydrology.

[26] See sections 4.1.1 and 4.2.2 for description of the tag terms LUP, FUP and TUP.

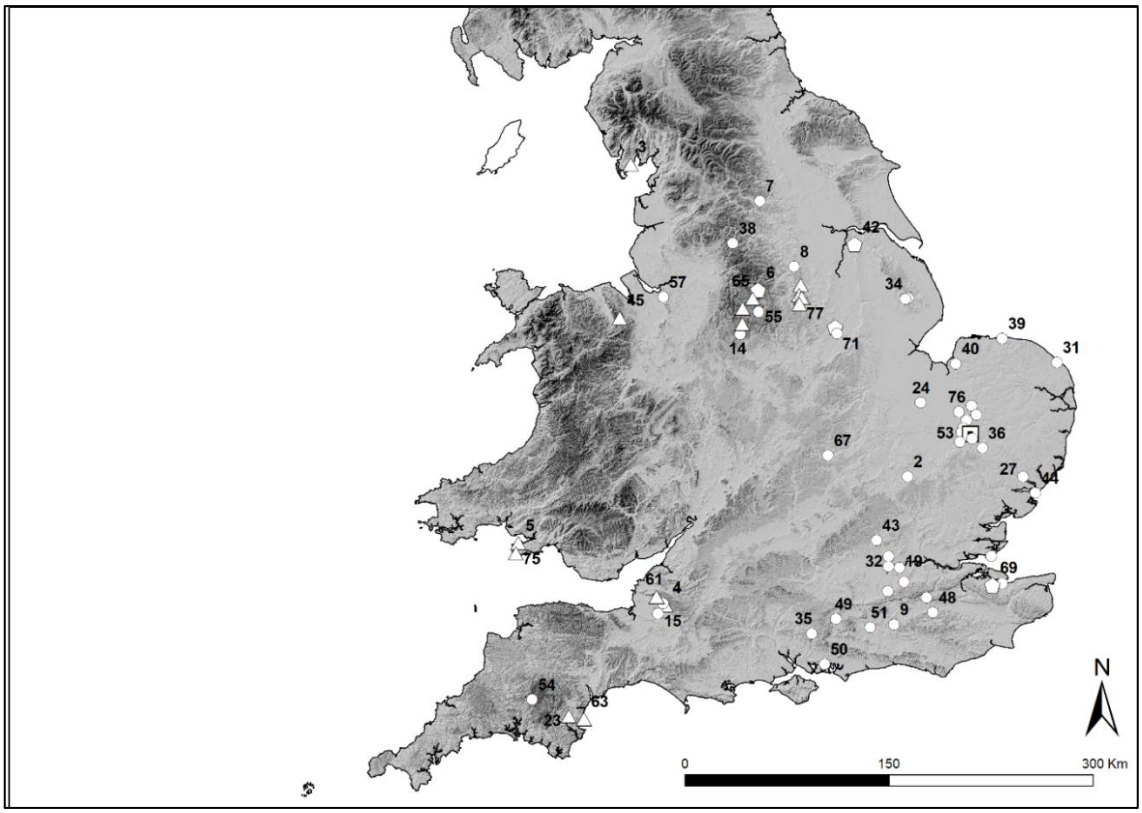


Figure 4.36 Distribution of LUP sites and find-spots in England and Wales. (Source: Author. Basemap OS TOPO 50, projected in ArcGIS 10.6.1)

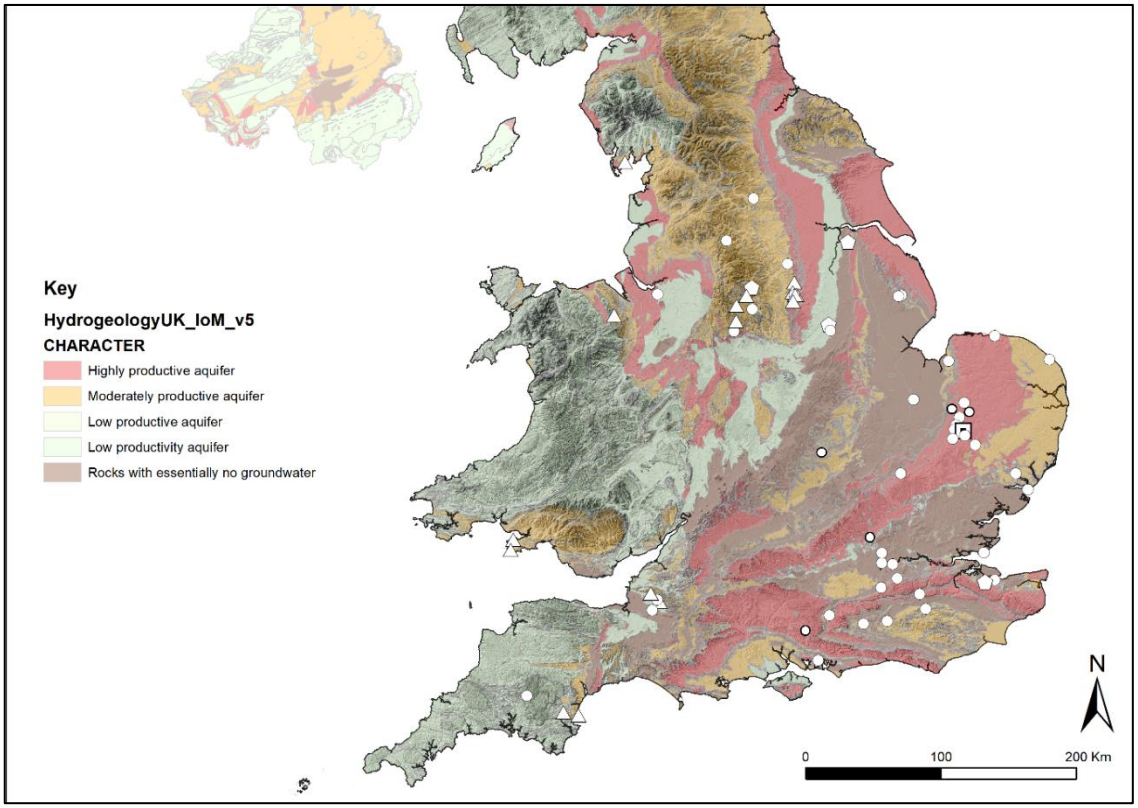


Figure 4.37 Distribution of Late Upper Palaeolithic sites in relation to bedrock hydrology. (Source: Author. Basemap OS TOPO 50, BGS Hydrogeology layer, projected in ArcGIS 10.6.1)

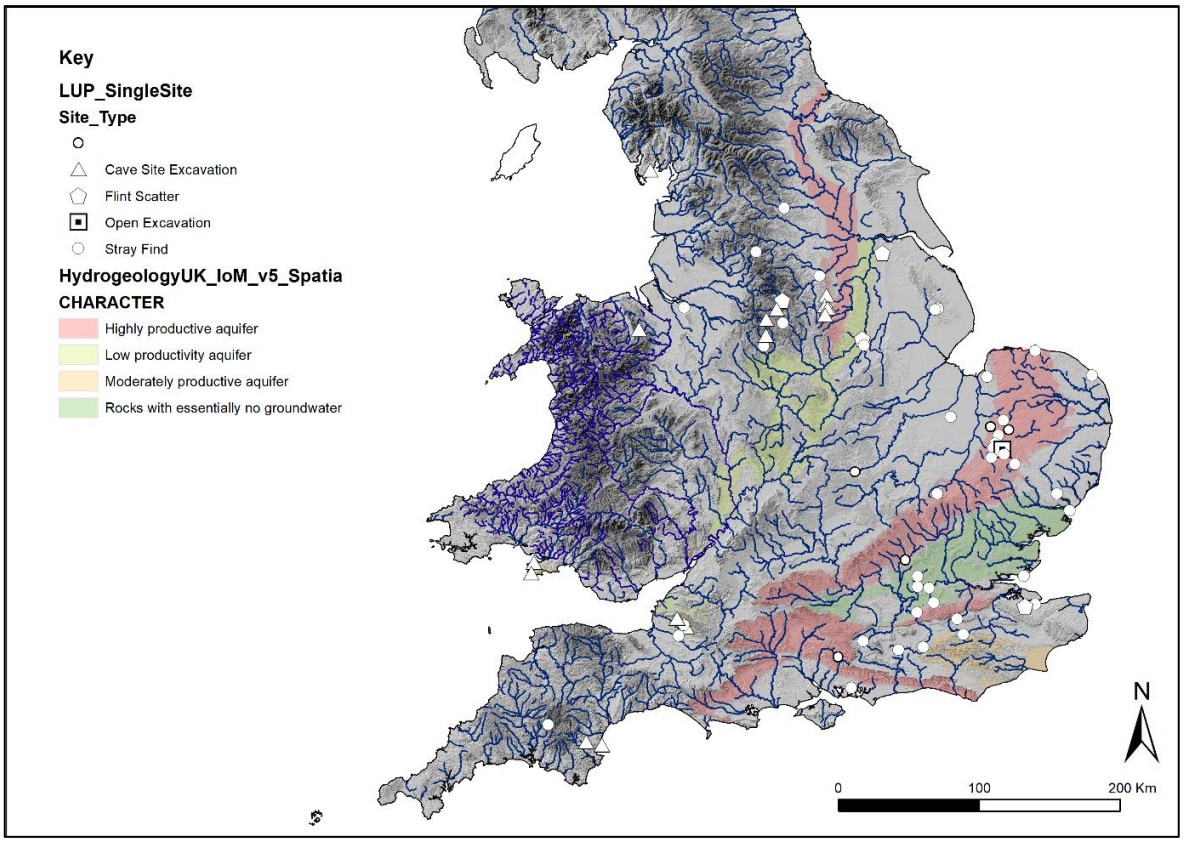


Figure 4.38 Distribution of Late Upper Palaeolithic site types in relation to site hydrology. (Source: Author. Basemap OS TOPO 50, BGS Hydrogeology layer, projected in ArcGIS 10.6.1)

4.3.3.4 Final Upper Palaeolithic (FUP)

The CoB-LG shows a total of 170 artefact entries from 77 sites identified as FUP. There are 13 different codes used for these artefacts, with 51% as shouldered points. These are for the most part found amongst stray find and open-air locations (71%), contrasting strongly with the Creswellian cave distribution. Also, in contrast to the Creswellian and LUP, most sites are found in locations either on low or with no active aquifer (62%), for the most part in the Weald and the London Basin as with the LUP.

Figure 4.39 shows the basic GIS distribution of generalised FUP sites and find-spots in England and Wales. Figure 4.40 shows this distribution in relation to bedrock hydrology. Figure 4.41 represents LUP site types in relation to site hydrology.

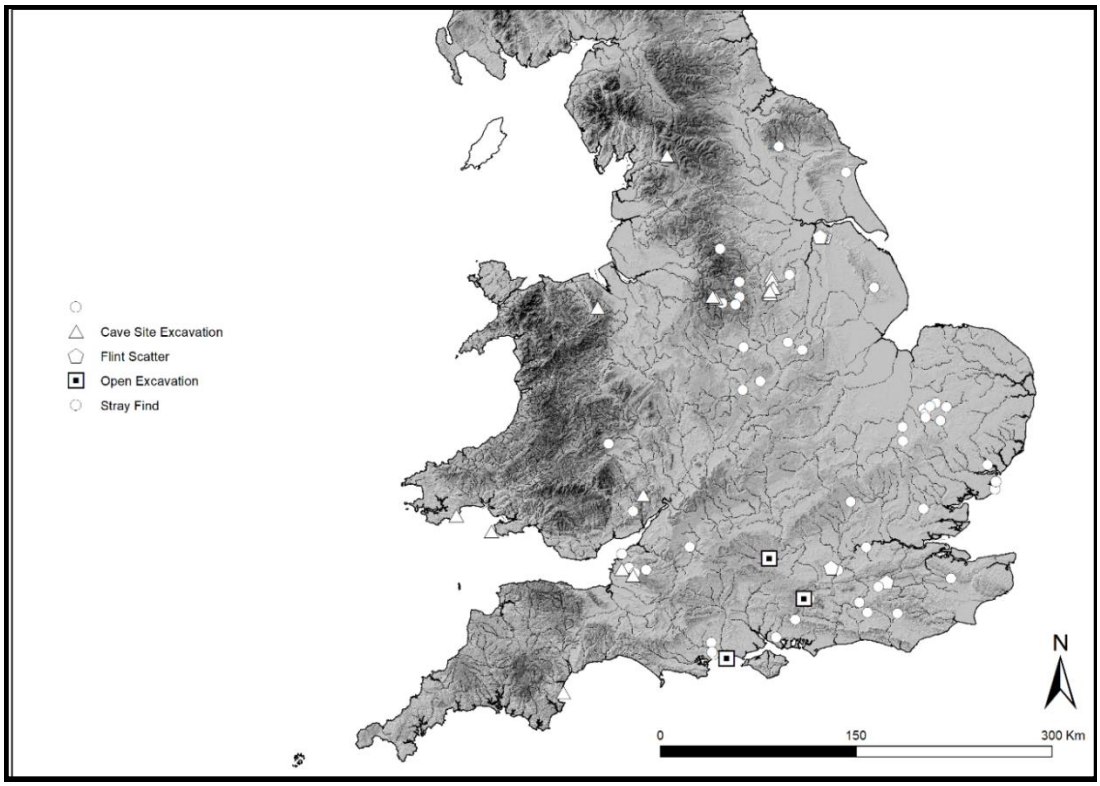


Figure 4.39 Distribution of FUP sites and find-spots in England and Wales. (Source: Author. Basemap OS TOPO 50, projected in ArcGIS 10.6.1).

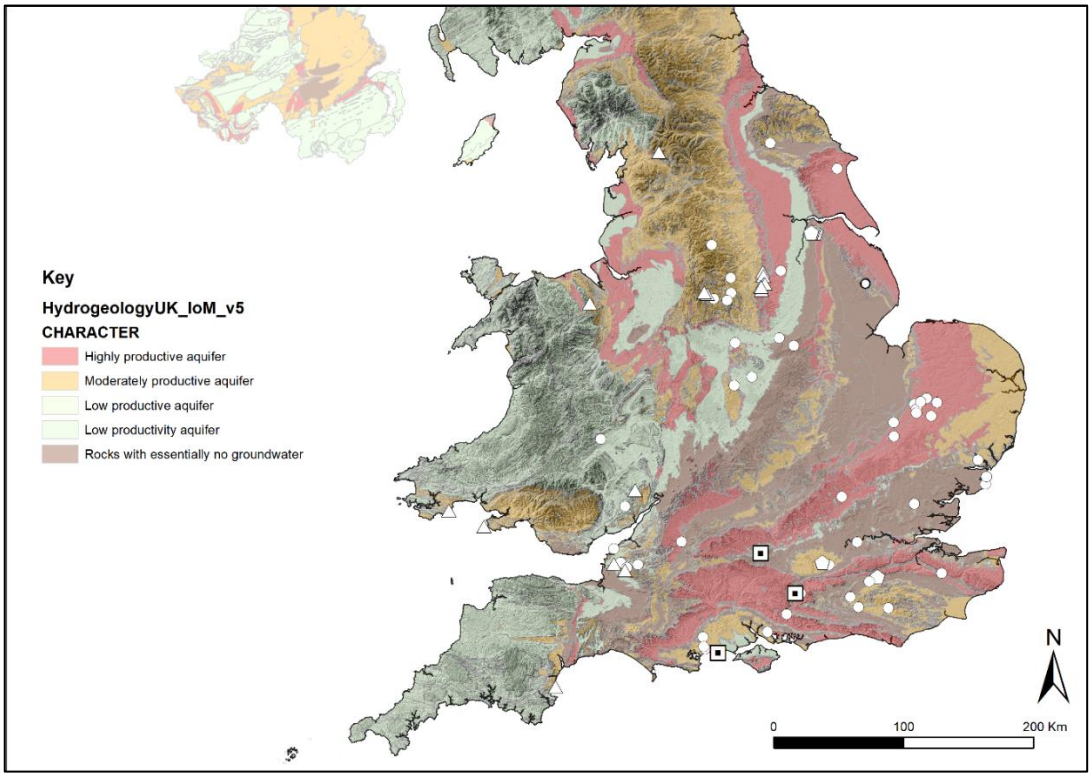


Figure 4.40 Distribution of FUP site types in relation to bedrock hydrology. (Source: Author. Basemap OS TOPO 50, BGS Hydrogeology layer, projected in ArcGIS 10.6.1).

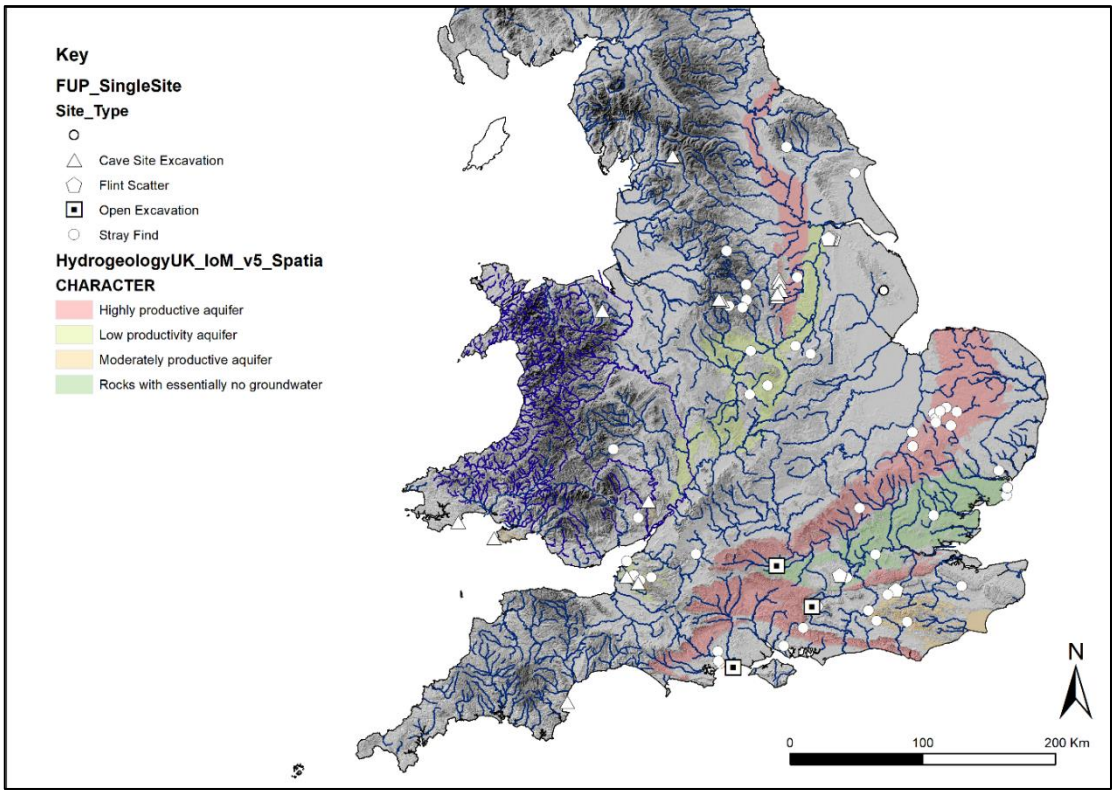


Figure 4.41 Distribution of Final Upper Palaeolithic sites in relation to bedrock hydrology. (Source: Author. Basemap OS TOPO 50, BGS Hydrogeology layer, projected in ArcGIS 10.6.1)

4.3 Regional Case Study: Rivers Wey-Mole catchment

4.3.1 Introduction

This section expands on the previous section's discussion and considers at a higher resolution the LG find and site distributions in the area of the River Wey-Mole catchment Southeast England, with additional reference to the adjacent palaeo-Solent catchment where appropriate. Both the Wey-Mole and palaeo-Solent are tributaries of the Channel River: the Wey-Mole flowing from south to north into the Thames and the palaeo-Solent flowing north to south into the Channel River. Whereas the Thames joins the palaeo-Rhine east of the Straits of Dover, the palaeo-Solent flows into the Northern Valley of the Channel River (Chapter 5). The case study area contains a high concentration of LG sites

and findspots facilitating the ArcGIS landscape analysis. Figure 4.42 shows the cases study area within Southeast England. Figure 4.43 shows the Wey-Mole catchment and the location of sites and findspots from the CoB-LG and recent excavations.

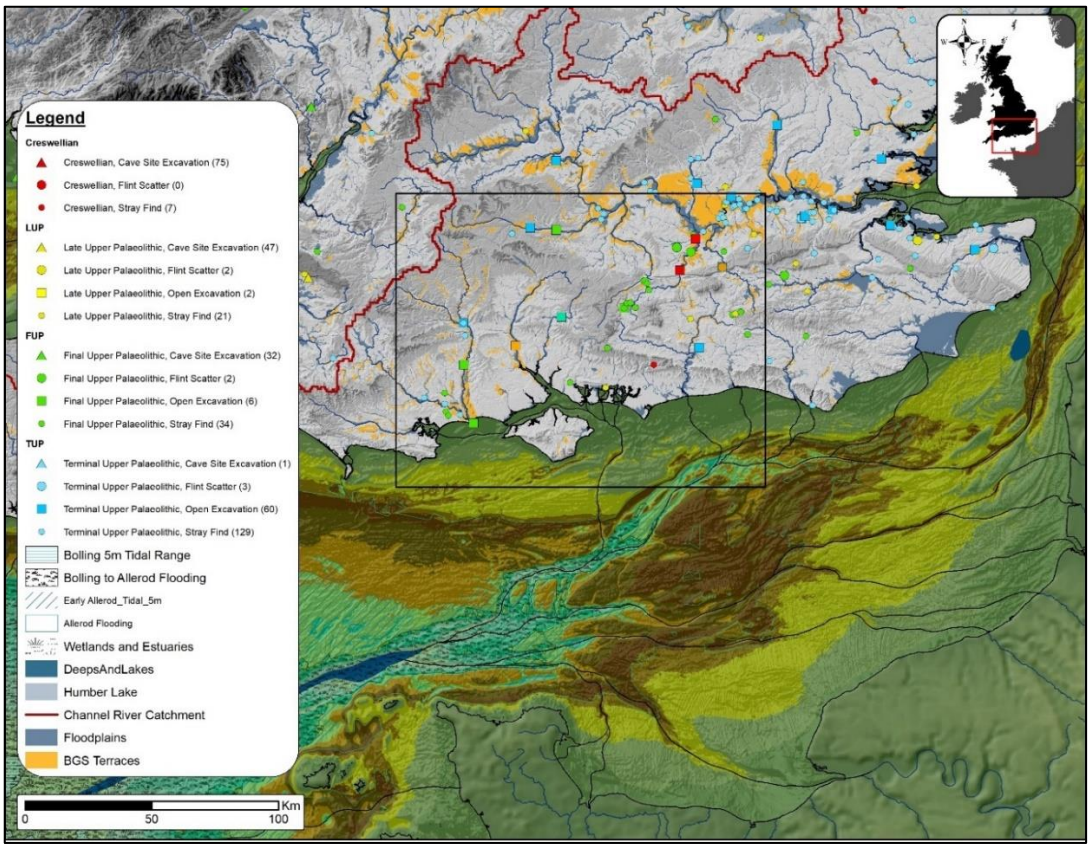


Figure 4.42 Sample of Late Glacial sites within the case study area in Southeast England. (Source: Author. Colonisation of Britain database, Basemap OS TOPO 50, EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

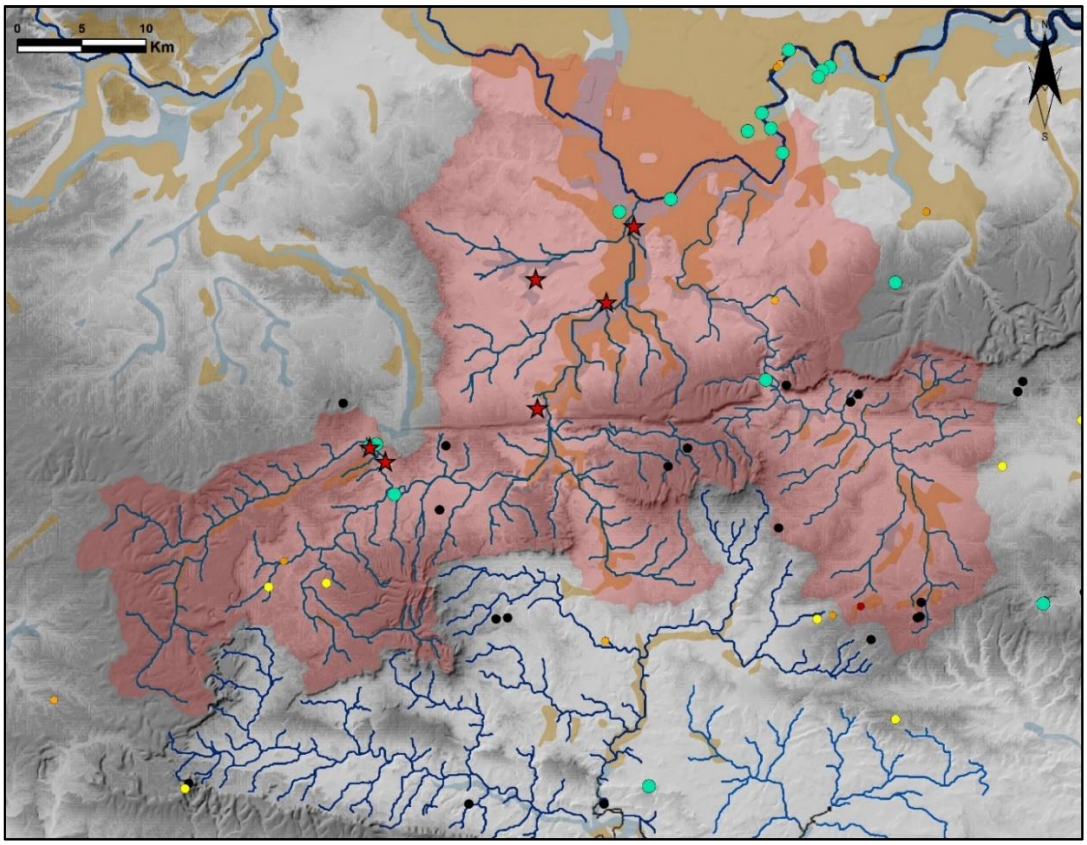


Figure 4.43 The Wey-Mole catchment with find (dots) and site-scatter locations (red stars). LG: Black, Creswellian: red, LUP: Orange, FUP: yellow, TUP: teal. (Source: Author. Colonisation of Britain database, Basemap OS TOPO 50, projected in ArcGIS 10.6.1)

The section is organised chronologically with reference to the British technocomplexes identified in section 4.1. For each technocomplex, an overview of reference sites is made at a regional scale, followed by a closer fluvial catchment scale examination of the Wey-Mole area. A major advantage of using the CoB-LG dataset at a local resolution is that it can be enhanced with detailed records of individual findspots and finds beyond those listed in the original CoB. This is an invaluable tool to assess the local distribution of LG material. The CoB-LG for the Wey-Mole catchment was enhanced with the author's literature and museum collection search conducted initially for the M.Phil. thesis (Mills 2013) and expanded for the current work.

4.3.2 Classic Creswellian

Rare isolated finds have been associated with the Creswellian in Southeast England. Two of them are typical Cheddar Points: One from the South Downs, with the other from New Faygate close to the headwaters of the Mole River. There are relatively few examples of other diagnostic artefacts of this technocomplex such as blades with en-éperon butts. An isolated Cheddar Point is not a very diagnostic marker, especially if in isolation as it could be early or late Creswellian. Figure 4.44 shows the distribution of find spots for the ECres.

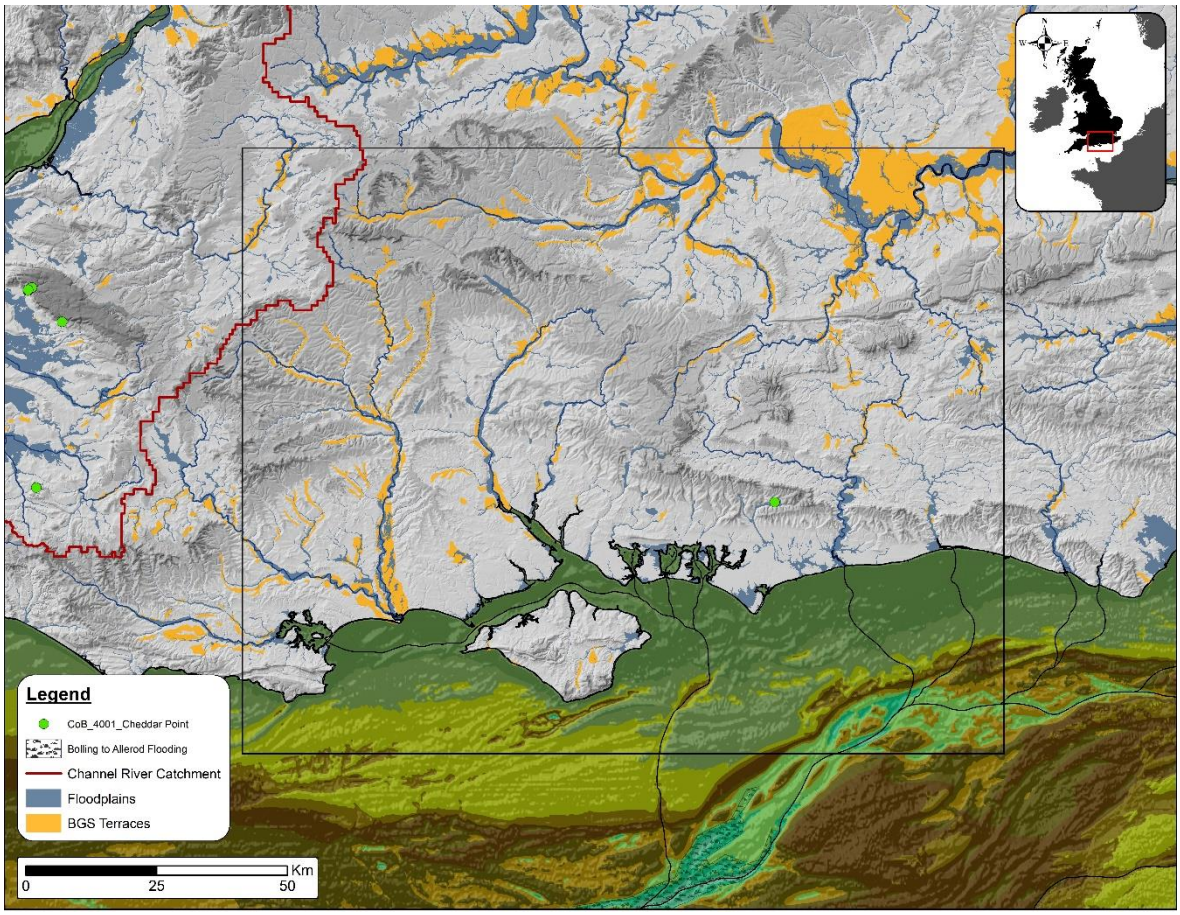


Figure 4.44 SE England potential Early Creswellian, CoB code: 4001, Cheddar point. (Source: Author. Colonisation of Britain database, Basemap OS TOPO 50, EMODnet17, GEBCO18, BGS superficial 650k layer, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1)

4.3.3 Open-Air Creswellian and Late Creswellian

Two sites in the Wey Valley have Creswellian affinities. Wey Manor Farm is located near to the confluence of the River Wey with the Thames. The site was excavated in 2004 with systematic sieving of sediments. The assemblage also underwent technological, refitting and use-wear analyses. This is the techno-typological reference site for this period in the region, but the absence of direct dating means that it cannot be assigned specifically to an early or late Creswellian context (Jones 2013). Another more recently excavated assemblage from Guildford Fire Station (Attfield *et al.* 2014) has similarities with Wey Manor Farm (A Roberts, personal communication) and is currently undergoing analysis.

At Wey Manor Farm (Jones 2013) the assemblage is dominated by curve-backed and angle-backed points that compare to assemblages dating to the second half of the Bølling (section 4.1.5). At Guildford Fire Station the retouched tools consist of at least one curved bi-point as well as blades with marginal scalariform retouch that are characteristic of the Early Azilian (Bodu & Mevel 2008; Bodu & Valentin 1997), but also present at Gough's Cave (Jacobi 2004), so may be of broadly contemporary age. These also compare well with the Dutch Creswellian open-air sites and Etigny in the Paris basin.

In terms of debitage Wey Manor Farm has only minimal evidence for use of the éperon technique and more indication of the possible use of soft-stone hammer percussion. The cores from Wey Manor Farm are preferential unipolar with opposed platform corrections (Jones 2013) a method commonly used in the Early Azilian (Valentin 2006a). At both sites there was access to high-quality flint.

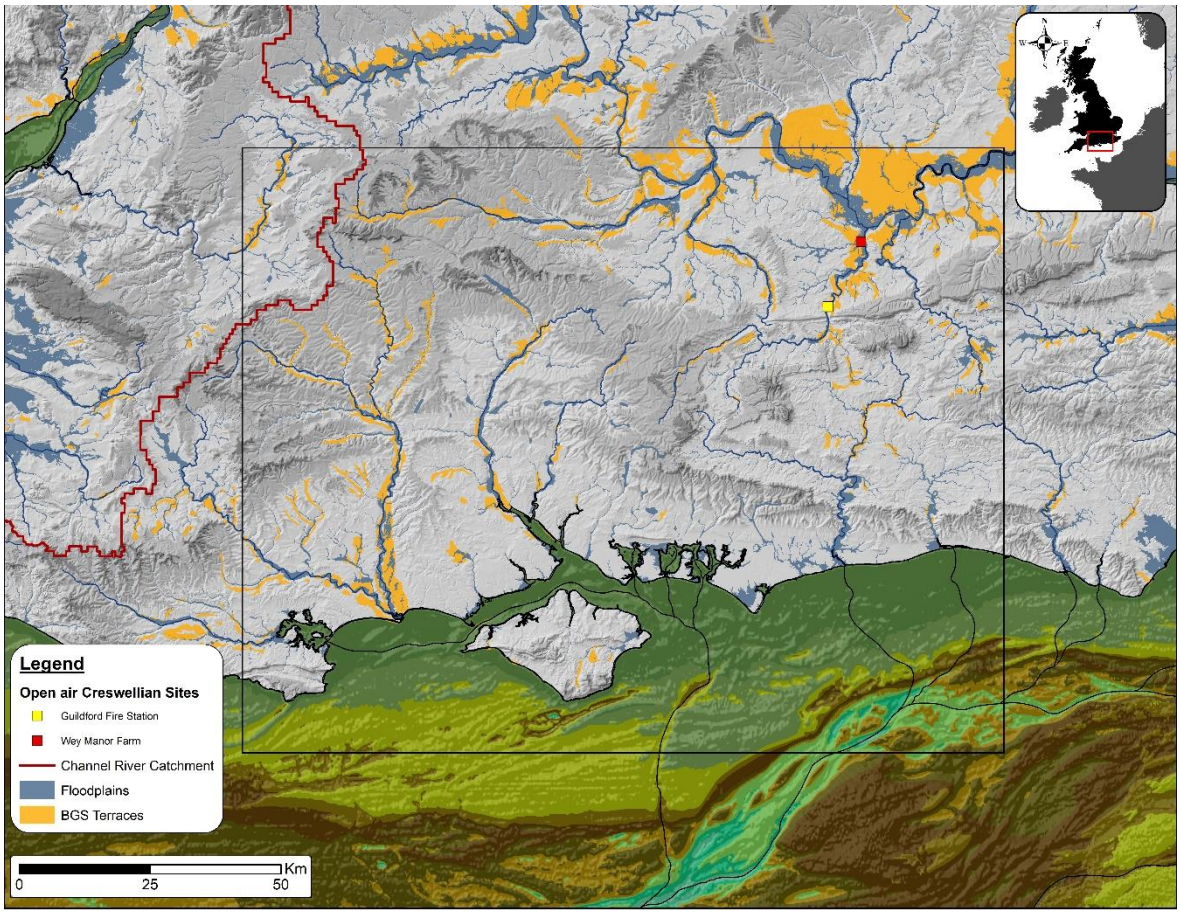


Figure 4.45 SE England Open air Creswellian sites. (Source: Author. Colonisation of Britain database, Basemap OS TOPO 50, EMODnet17, GEBCO18, BGS superficial 650k layer, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

4.3.4 LUP facies with shouldered points

As discussed previously, the LUP as defined in the CoB is not a technocomplex in the strict sense but an amalgamation of distinct typological pieces. The most notable retouched tools identified in the CoB are shouldered points and zinken. However it appears none of the British artefacts fit Hamburgian typological descriptions (Weber & Grimm 2008; Weber 2012). Their distribution has a significant landscape signature; for example, the shouldered point at Langstone Harbour.

Although there are no reference sites where shouldered points can be refitted to core sequences, similar forms of shouldered point have been found at both Hengistbury Head and Brockhill of the Early Federmesser. Some argue that the presence of shouldered points may be an Early Hamburgian signature (Pettitt 2012) but this has not yet been clearly demonstrated for Britain, and these shouldered points do not fit the description of classic Hamburgian or Havelte shouldered points (Weber & Grimm 2008; Weber 2012) (see Chapters 3 and 4). Figure 4.46 shows the distribution of LUP facies with shouldered points.

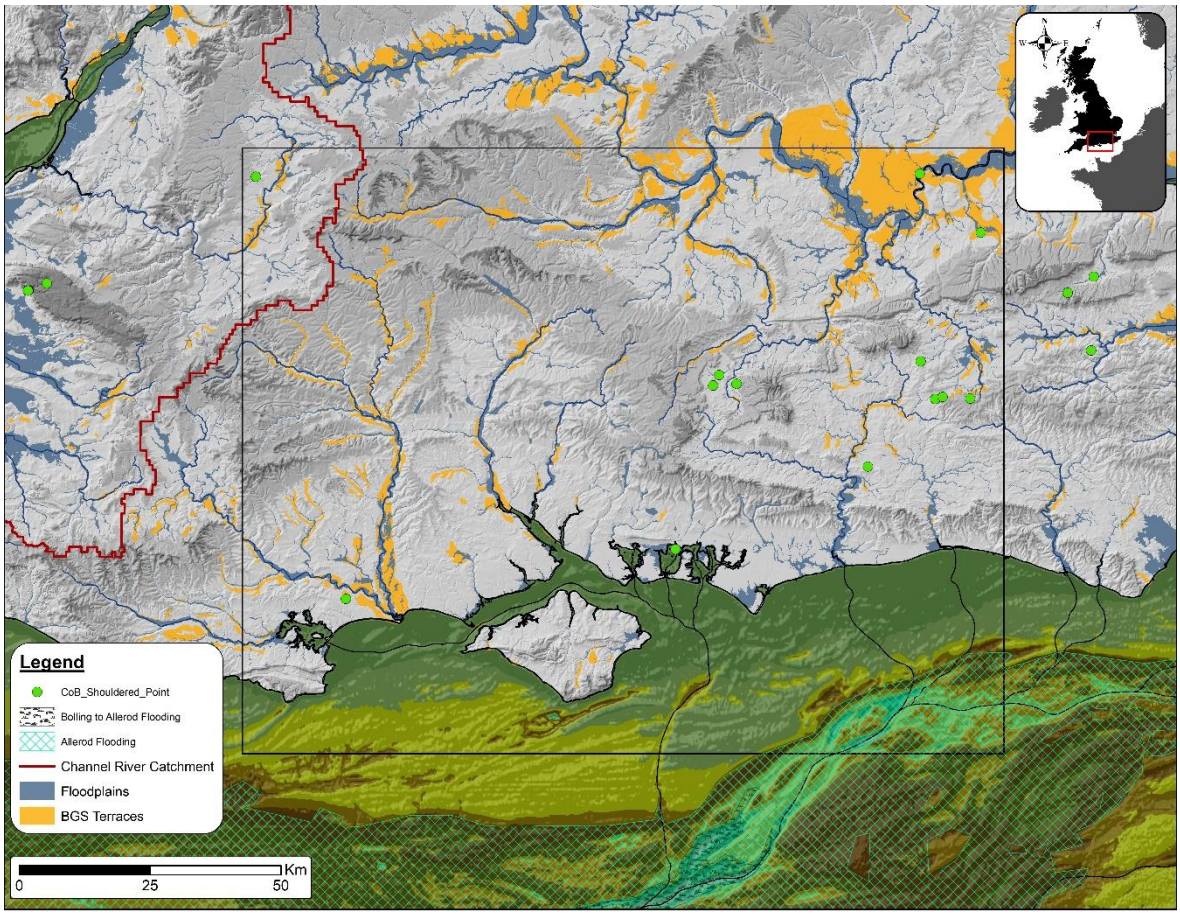


Figure 4.46 LUP facies with shouldered points. (Source: Author. Colonisation of Britain database, Basemap OS TOPO 50, EMODnet17, GEBCO18, BGS superficial 650k layer, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

4.3.5 Early Federmesser

The situation for the Early Federmesser in Southeast England contrasts sharply with that of the LUP. There are three large open-air Early Federmesser sites: Hengistbury Head, Nea Farm and Brockhill. La Sagesse Convent is also a possibility but remains unclear.

Along the River Avon, 26km apart, are Hengistbury Head and Nea Farm. Hengistbury Head is the largest excavated LG open-air site in Southern Britain (Barton 1992a). It is well defined both typologically and technologically with a large retouched tool assemblage and extensive refitting evidence, but its proposed chronological position between the Bølling and the Early Allerød is open to question (Barton 1992) (section 4.1). Nea Farm is a smaller site with comparable techno-typological features to Hengistbury Head and is a more recent excavation also with systematic sieving, refitting and use-wear analysis (Barton *et al.* 2009). The similarities are not only in the techno-typology but also in the raw materials and the possibility that the two sites were contemporaneous is advocated (Barton 2010).

The site of Brockhill, a surface collection from the 1920's and donated to the British Museum in the 1970's, has many shared techno-typological characteristics with the other two sites, and is attributed to the Early Federmesser (Barton 1992; Mills 2013). It is located in the Wey-Mole catchment but has comparable landscape features to the two

River Avon sites, such as being located on elevated terrain, on a sandy substrate and in proximity to wetlands (Mills 2013). The diagnostic straight-backed blades at Brockhill are comparable to Hengistbury Head and northern French assemblages (see Chapter 3 section xx). Furthermore, other associated tools such as burins and end scrapers also fall within the same typological framework of these sites. The range of different point types from the three assemblages is significant: angle-backed points, angle-backed and obliquely truncated points, shouldered points; straight backed points, bipoints, thick Penknife points, and curve-backed mono-points. The variety of points in some ways renders the chrono-typological attribution difficult as all can occur in other LG technocomplexes. The question thus remains: to what extent are the major components of these assemblages (e.g. Brockhill and Hengistbury) representative of multiple occupation although the lithic assemblages appear to be homogenous technologically? Figure 4.47 shows the distribution of locations with Early Federmesser characteristics.

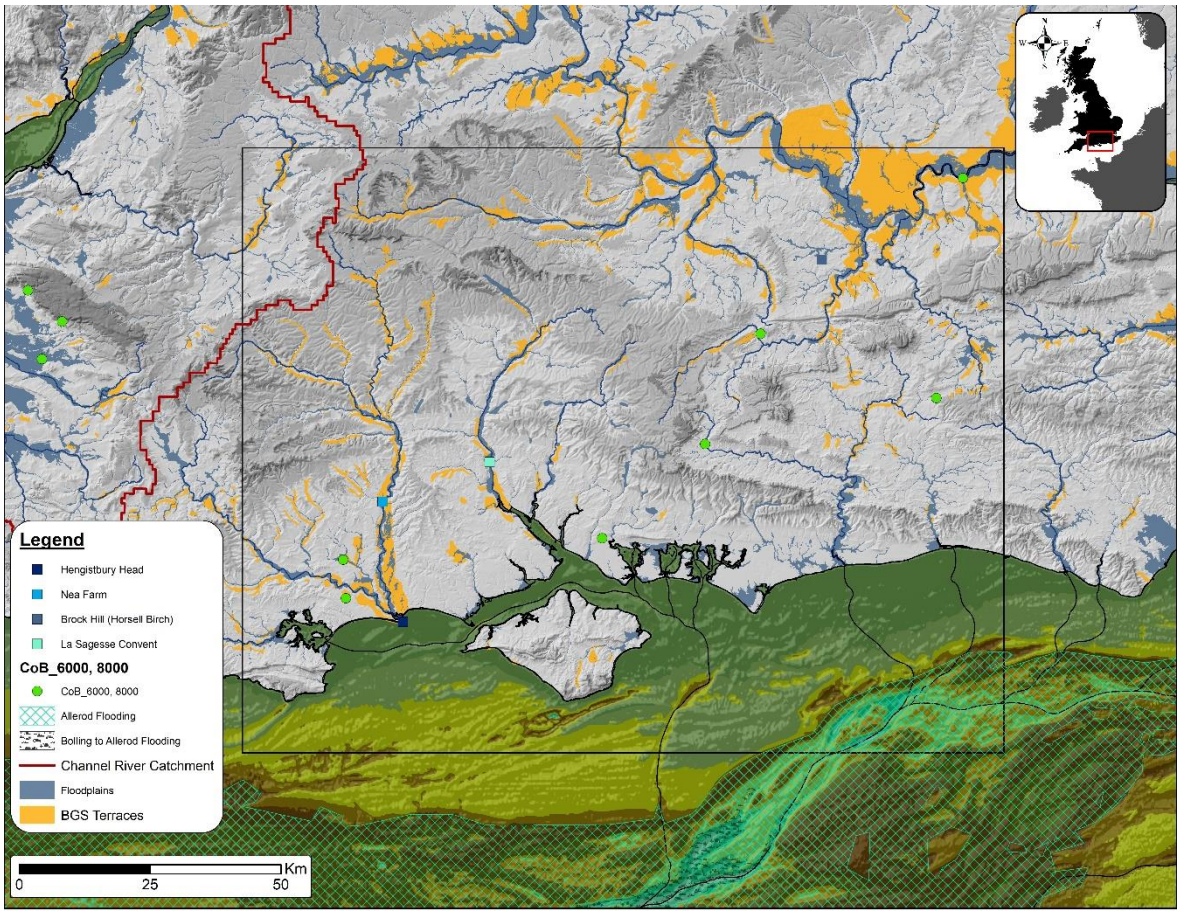


Figure 4.47 SE England Early Federmesser. CoB codes: 6000, 8000. (Source: Author. Colonisation of Britain database, Basemap OS TOPO 50, EMODnet17, GEBCO18, BGS superficial 650k layer, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

4.3.6 Allerød Federmesser-type assemblages and 'Penknife' Points

There are no clear reference sites with refitting or dating for grouping in the case study area. Pyrford in the Wey valley is the only site to have yielded a penknife point (Mills 2013). It is a surface-collected assemblage and the characterisation of the debitage is challenged by varying degrees of patination of the artefacts. It is unclear whether the assemblage can be considered homogeneous, although techno-typologically it is coherent. The material from Pyrford appears to be in the same good quality flint that is found locally. Figure 4.48 shows the Allerød Federmesser-type assemblages and 'Penknife' Points distribution.

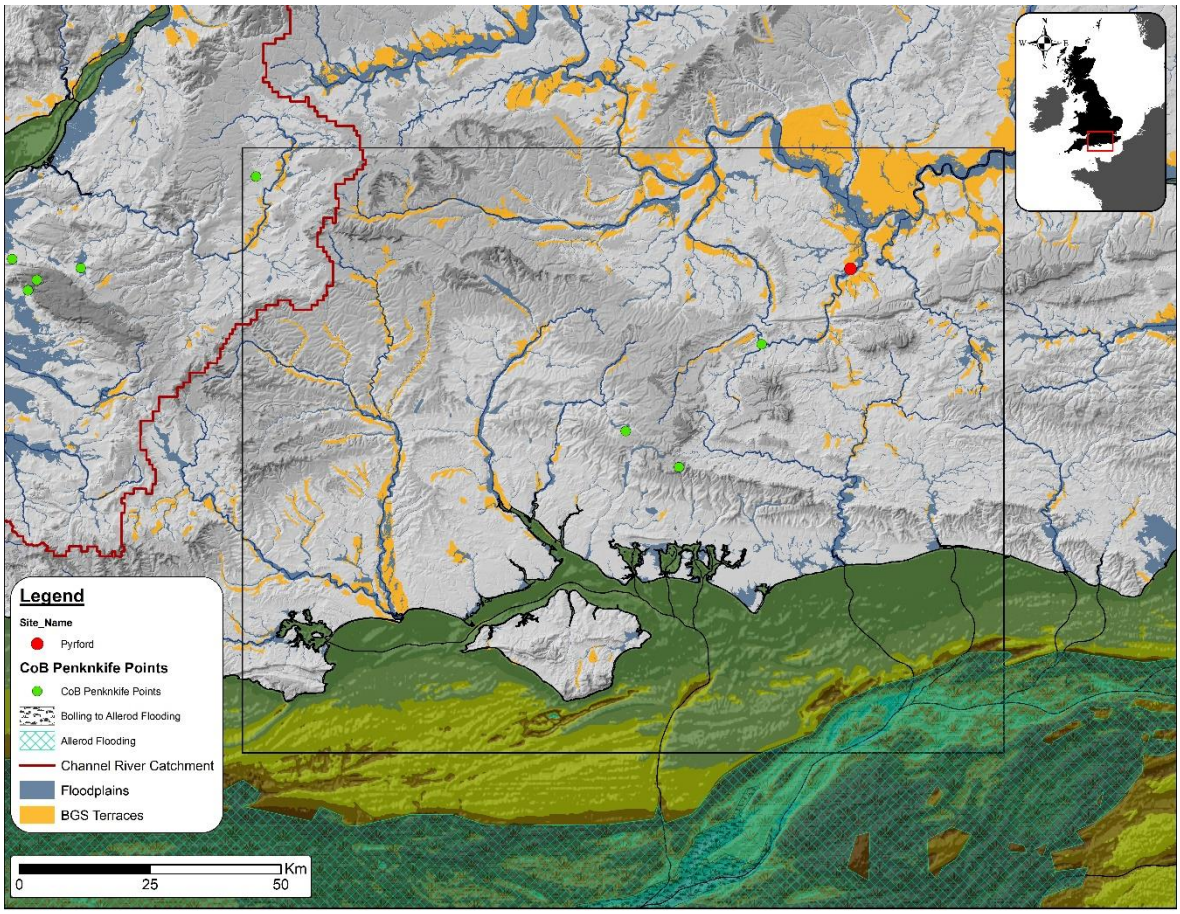


Figure 4.48 Allerød Federmesser-type scatter and 'Penknife' Points, CoB keyword "penknife" and code 7002. (Source: Author. Colonisation of Britain database, Basemap OS TOPO 50, EMODnet17, GEBCO18, BGS superficial 650k layer, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

4.3.7 Conclusions

At a national scale there proved to be difficulties in using a precise or specific breakdown of CoB sites and entries for landscape analysis of LG sites and finds, and a grouping strategy was most efficient (section 4.2). This case study shows the potential for using the enhanced CoB-LG database on the regional and local scale to subdivide sites and begin to generate a diachronic reading of the distribution of sites across the LG landscape.

The Wey-Mole river catchment appears to contain archaeological signatures from all of the British LG technocomplexes from at least the Bølling onwards, and possibly even from

the Early Creswellian. This evidence is from open-air sites and findspots and suggests more extensive human activity of the landscape during the LG than has been inferred traditionally, with signature of all LG technocomplexes represented in SE England. The case study region contains large well-preserved open-air sites, notably Wey Manor Farm and Guildford Fire Station both excavated recently. Earlier collections such as Brockhill, Pyrford and Westhumble indicate that there is an extensive diachronic use of this landscape throughout the LG and suggests the possibility of potential future discoveries. Of particular interest is the evidence for human activity in the landscape in relation to the River Thames catchment and successively the Palaeo-Rhine, this linking the Weald with Northern Europe and the north European Plain. The adjacent Avon/Test Palaeo-Solent catchment has significant open-air archaeological reference sites, notably Early Federmesser. However, spatial landscape analysis suggests a deeper time depth within the local region. This region also has a physical connection with Northern Europe, as a direct tributary/conduit into the Channel River system.

Overall, perhaps the most striking European parallel for the case study region is with the Late Creswellian and the Early Federmesser of northern France. In particular, the presence of bipoints and re-touched blades have been noted (Barton 1999b; Bodu 2003; Bodu & Valentin 1997; Coudret & Fagnart 1997; Jacobi 2004; Jacobi & Higham 2009a; 2011b; Valentin 2006a; 2008a). Even so there is variation amongst the continental bipoints, with the bipoints from Hangest-sur-Somme (Coudret & Fagnart 1997) having abruptly backed invasive retouch, and ones from Le Closeau in the Paris Basin having a marginal retouch sometimes focused on the distal and proximal apexes (Bodu & Valentin 1997)(see section 3.xx). The following chapters will explore in more detail the

connections between Britain and the case study region with Northwest Europe and in relation to the Palaeo-Rhine and Channel River Network.

Chapter 5 The Late Glacial Channel River Basin (LGCRB)

At the onset of the Late Glacial (LG) the Late Glacial Channel River Basin (LGCRB) had a catchment of over 550,000 km^2, and a length of over 3000km from its source in the Alps to its estuary in the Atlantic. This compares with the present-day rivers Danube, with a catchment of nearly 817,000 km^2 (Figure 5.1). The LGCRB was the largest topographic feature in Northwest Europe during the LG with nearly half of the main course and a third of the catchment submerged today. The Channel River has not been integrated into discussions of the archaeology of this period with research focused on mapping, sedimentology, and sea-levels (Antoine *et al.* 2003b; Coles 1998; 1998; Collier *et al.* 2015; Gupta *et al.* 2017). The important role of the LGCR on the archaeological and faunal agents operating in temperate to arctic LG environments of Northwest Europe has not yet been assessed (see section 6.2). This is now possible with high-resolution radiocarbon dating and palaeoenvironmental records suggesting a complex series of fluctuating re-colonisations of the region (Gamble *et al.* 2006).

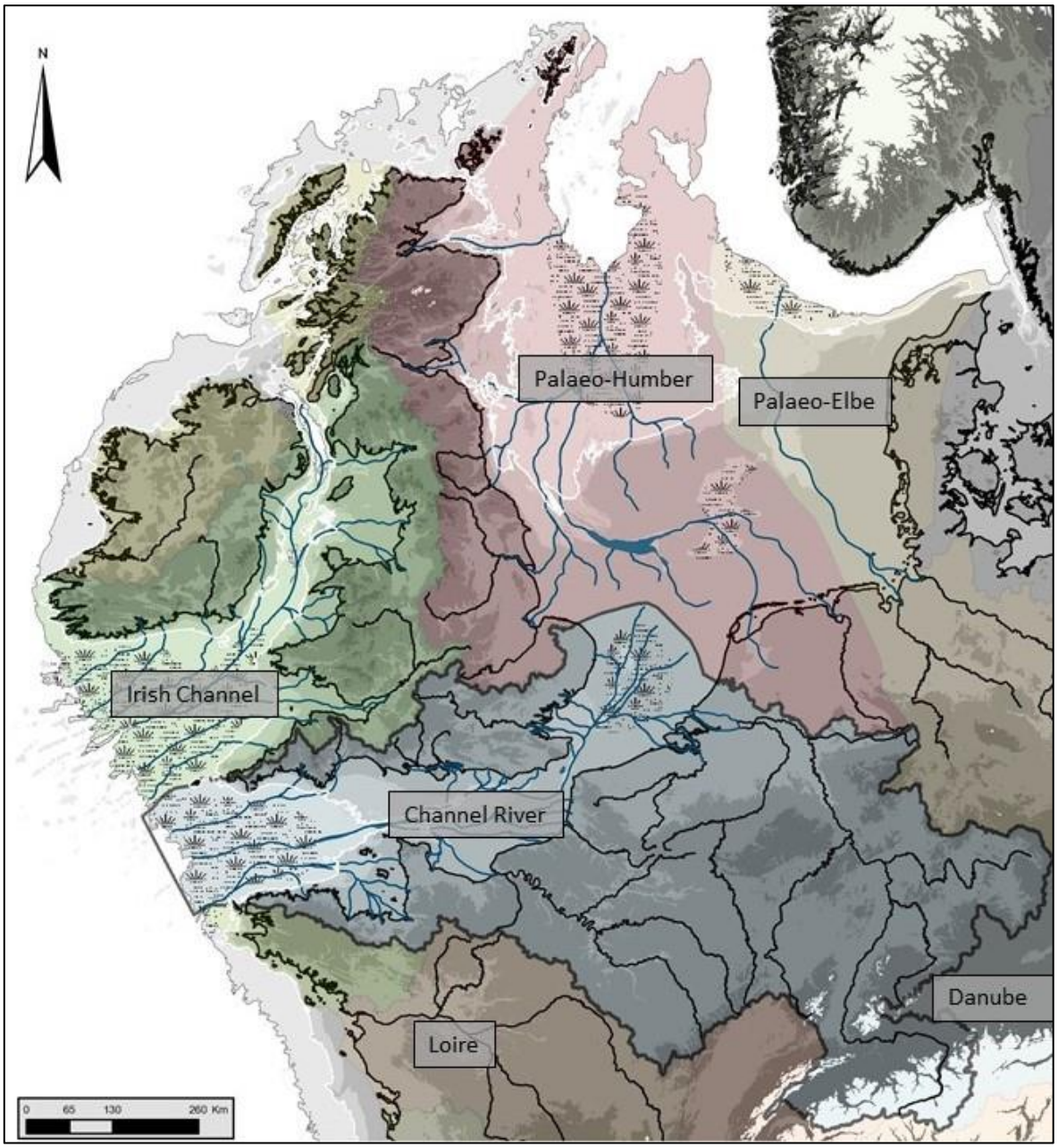


Figure 5.1 Late Glacial Channel River Basin: Relationship with neighbouring river basins. (Source: Author. Basemap GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1)

This chapter describes geomorphological and palaeoenvironmental features of both above-ground and currently submerged courses of the LGCRB relative to LG fluvial conditions. It provides context for Chapters 6 and 7 that discuss LG archaeological distributions and dynamics within the LG Channel River Network (LGCRN) and how the evolving river system played a dynamic role in the postglacial landscape following the

LGM. Figure 5.2 shows the above ground tributary catchments of the Channel River and distribution of the principal LG reference sites. Figure 5.3 shows the LGCRB in relation to the geology of Northwest Europe.

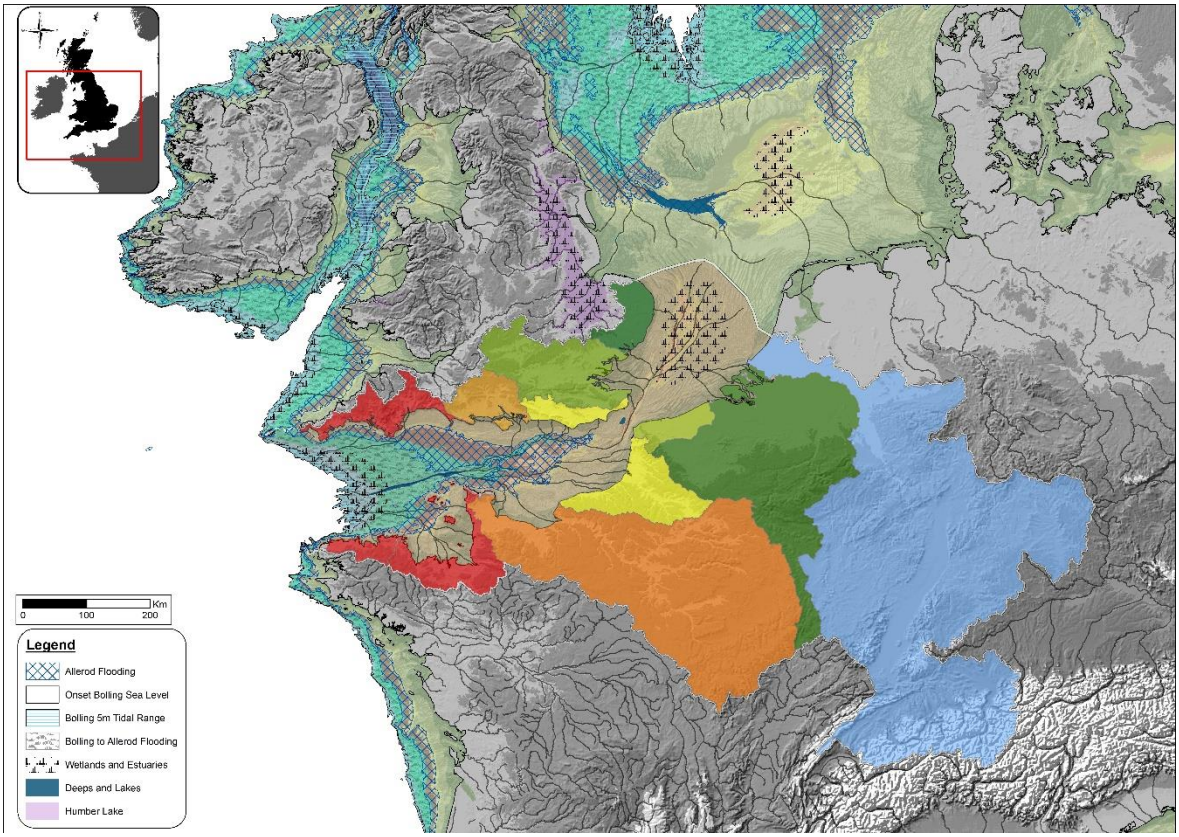


Figure 5.2 Catchment of the Late Glacial Channel River Basin (LGCRB) at the onset of the Bølling. Subdivision of the LG Channel River Basin: Blue = Paleo-Rhine catchment; South bank: Green = Scheldt and Meuse; Yellow= Somme; Orange = Seine; Red = northern Brittany and Channel Islands; North Bank: Dark Green = Stour; Light Green = Thames; Orange = Palaeo-Solent; Red = Devon and Cornwall catchments; Yellow = Weald and South Downs tributaries. (Source: Author. Basemap EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

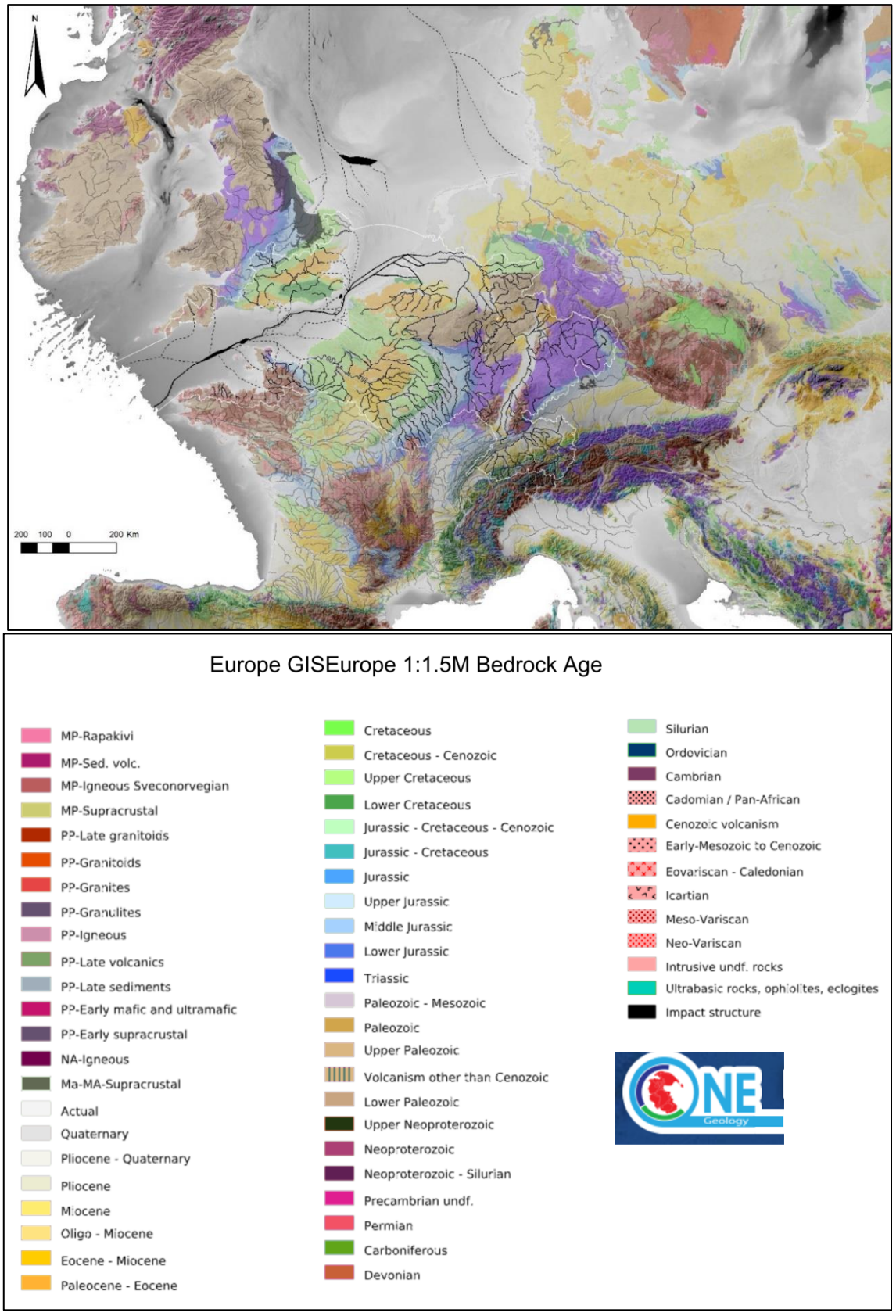


Figure 5.3 Late Glacial Channel River Basin. (Source: Author. Colonisation of Britain database, Basemap GEBCO18, OneGeology http://portal.onegeology.org/ layer, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1)

5.1 LG Channel River Basin, Watersheds and Catchments; topography and major fluvial divisions

The LGCRB can be divided into two principal sections: the Palaeo-Rhine watershed and the Channel River watershed. The LG Palaeo-Rhine flowed south to north following a pre-existing valley system, that continues to be used by the present Rhine River. The Channel River, a continuation of the Palaeo-Rhines' course, flowed east to west following a network of valleys formed during periods of low sea-levels (Gibbard 2007a; Gupta *et al.* 2017). Figure 5.4 shows the catchment of the LGCRB at the onset of the Bolling (GI-1e). The entire course of the LGCRB could be termed the Palaeo-Rhine, as this was the main course of the network, however for continuity with previous research the term Channel River is used in this thesis to refer to the now submerged LG river course from the Dover Strait to the Atlantic Western Approaches (Antoine *et al.* 2003c; Coles 1998; Gibbard & Lautridou 2003).

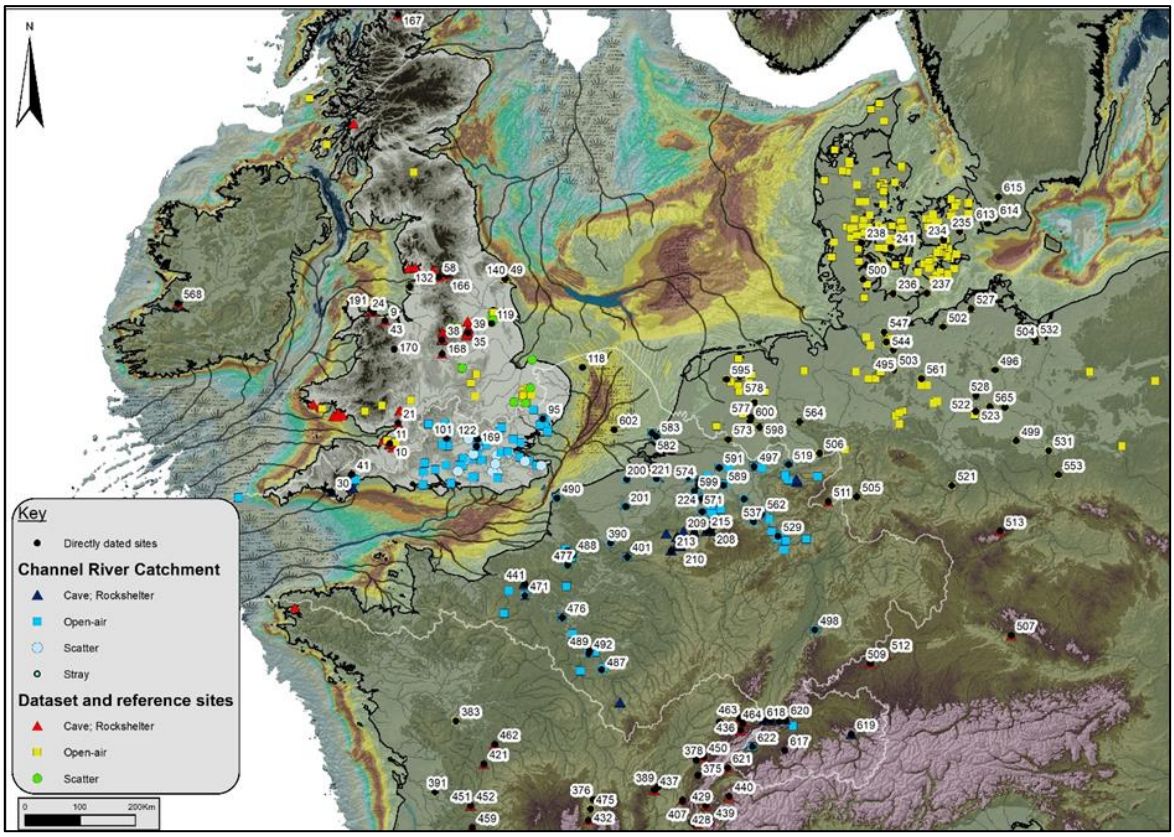


Figure 5.4 The Late Glacial Channel River network and LG reference sites. (Source: Author. Basemap OS TOPO 50, EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1)

The Palaeo-Rhine's principal tributaries were the Palaeo-Vecht, -Meuse, -Scheldt and -Thames, and their region of confluence was the now submerged region of the Southern Bight. This is where the Palaeo-Rhine changed direction for a westerly course towards the Atlantic, and the beginning of the Channel River region starting at the Straights of Dover. The change of direction being initially forced by the extent of the LGM European Ice Mass (Coles 1998; Toucanne *et al.* 2009a; 2010; 2015). The Southern Bight remains one of the least understood features of the CRC because a thick cover of Holocene deposits now masks the local topography of the river network (Bridgland 2003; Collier *et al.* 2015; 2015; D'Olier 1975; D'Olier & Maddrell 1970; Gibbard 1995; 2007a; Hijma *et al.* 2012; Mellett 2012; Wallinga *et al.* 2004). Figure 5.5 shows the area of the Palaeo-Rhine and the Southern Bight.

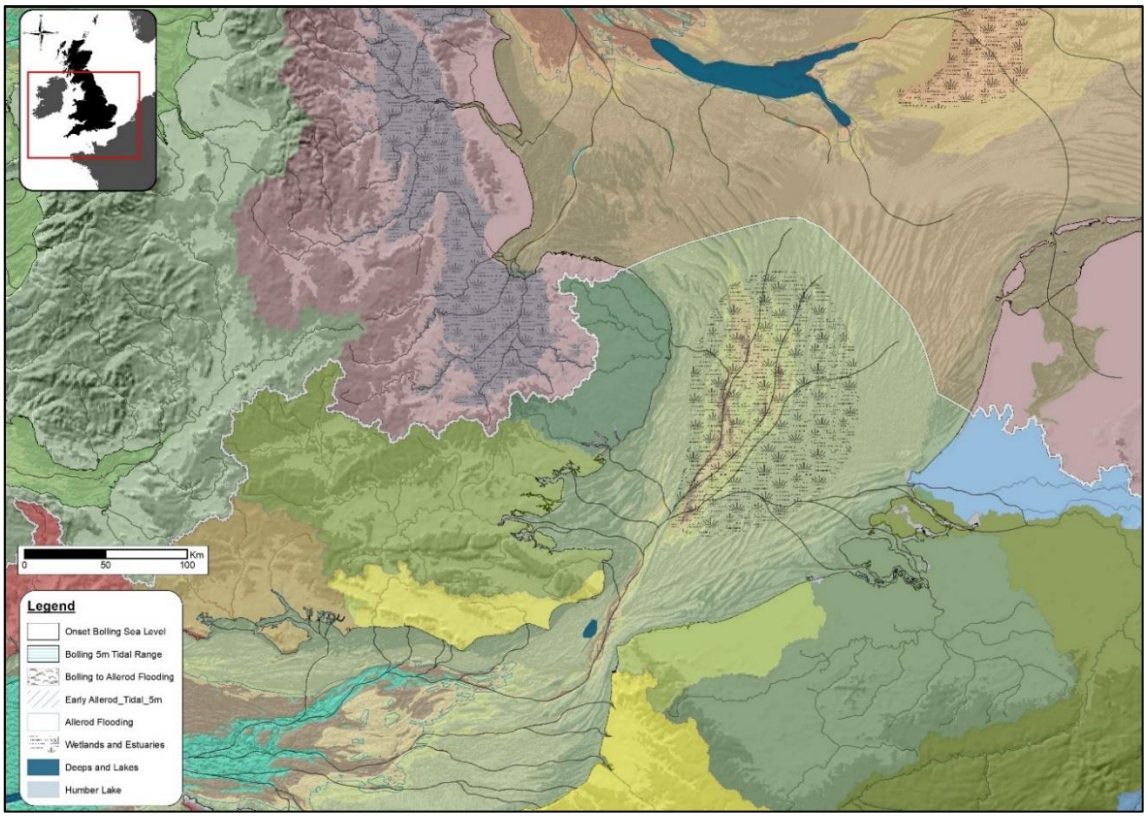


Figure 5.5 Interfluve between England and the Netherlands and axial valley wetland. The interfluve (white line) between the Channel River Basin and the Palaeo-Humber basin (red) marks a potential continuous LG dryland crossing. This interfluve in the Southern Bight is an estimation, as the submerged features are either eroded or submerged by massive sands. (Source: Author. Basemap EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1)

The Channel River's trunk valleys (palaeovalleys) and sections of its tributary fluvial valleys are today submerged by the current 'English Channel' or 'Manche' in French (Antoine *et al.* 2003b; Gibbard & Lautridou 2003). The modern Channel /Manche region is a narrow funnel-shaped stretch of water between England and France (Antoine *et al.* 2003b; Coles 1998; Gibbard & Lautridou 2003). Its course is 520km long, and it is 30km wide at the Dover Strait in the east and 160km wide at its western end (Gibbard & Lautridou 2003, 195). This east-west submerged stretch of the CRC had general north to south and south to north oriented tributary valleys originating from current England and France respectively. The central trunk valleys joined the Atlantic somewhere between Brittany and Cornwall at the onset of the LG (Antoine *et al.* 2003b).

The western deltaic region of the CRC was affected by rapidly rising sea-levels following the LGM, leading to the development of an encroaching deltaic zone gradually shifting eastwards (Antoine *et al.* 2003b; Coles 1998; Toucanne *et al.* 2010). At the onset of the LG mean sea-levels were c. 90m lower than today (Shennan *et al.* 2006), and somewhere around -45m at the onset of the Holocene (Lambeck et al. 2014), although this may vary regionally due to local uplift (Kiden *et al.* 2002; Lericolais 1997; Wallinga *et al.* 2004). Figure 5.6 shows the geomorphological toponymy and principle tributaries referred to in the text. Table 5-1 presents estimates of the proportion of the CRC regions now above water level.

Table 5-1 Percentage of regions above ground and submerged (preliminary estimates).

River	Confluence Area with main course	% Above water
Rhine	Main course	50%
Vecht	Southern North Sea	60-70%
Meuse	Southern North Sea	90-100%
Scheldt	Southern North Sea	90-100%
Thames	Southern North Sea	90-100%
Somme	South Palaeovalley	70-80%
Seine	South Palaeovalley	70-80%
Stour (Kent)	North Palaeovalley	60-70%
Arun	North Palaeovalley	80%
Chichester and Langston Harbours; Palaeo-Solent	North Palaeovalley	70%
Test; Palaeo-Solent	North Palaeovalley	90-95%
Avon; Palaeo-Solent	North Palaeovalley	90-95%
Frome; Palaeo-Solent	North Palaeovalley	90-95%
Palaeo-Solent	North Palaeovalley	60-70%
SW England	North Palaeovalley? Estuary	40-50%
Brittany	South Palaeovalley	40-50%
Brittany	Parallel to the Channel River	40-50%

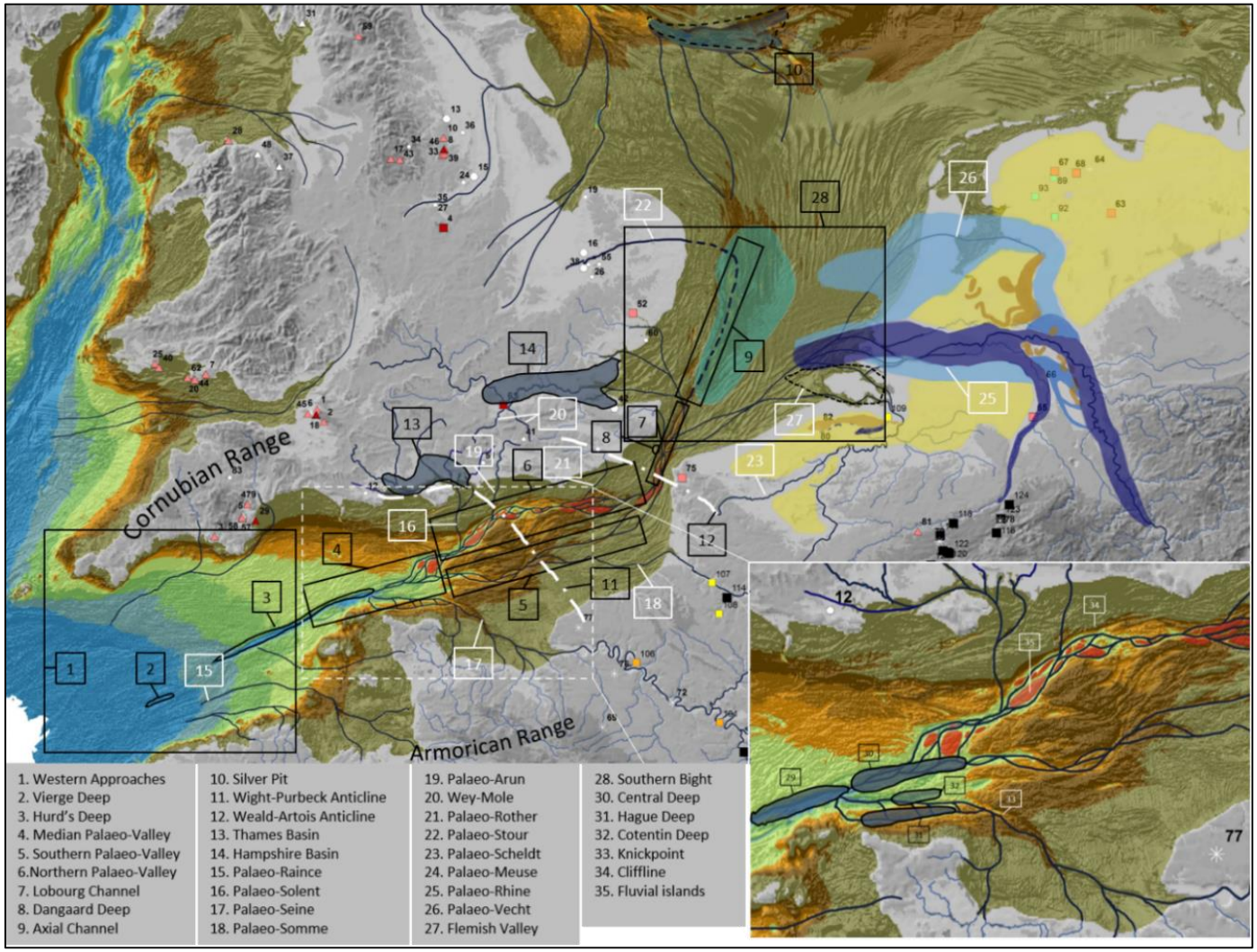


Figure 5.6 *Late Glacial Channel River Basin: Key topographic features, tributaries and sites. (Source: Author. Basemap EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1)*

5.1.1 GCRC Upper course: The Palaeo-Rhine

The Palaeo-Rhine is considered the upper course of CRC. It is the largest course feeding the Channel River with a catchment comprising 180,000 km^2 and running for 1300 km (Busschers *et al.* 2007; van Balen *et al.* 2010). During the early stages of its course it was mainly glacially-fed from its sources in the Alps (Erkens *et al.* 2009). The main course was guided by a series of tectonic graben[27] from before the LG up until today (Erkens *et al.* 2009; Gabriel *et al.* 2013; Przyrowski & Schäfer 2015). The valley systems guiding the LG course of the river are now mainly above ground, although covered by a thick mantle of Holocene deposits in its upper and lower reaches (Busschers *et al.* 2005; Erkens 2009; Erkens *et al.* 2009; Przyrowski & Schäfer 2015). Late Glacial palaeochannels are preserved in today's Rhine deltaic regions but are deeply buried under thick Holocene deposits and are not easily mappable or accessible (Hijma *et al.* 2009; 2012; Tebbens *et al.* 1999). This thesis uses the existing division of the course of the Palaeo-Rhine into Upper, Middle and Lower sections based on local physiological characteristics (Erkens 2009). Figure 5.7 shows the subdivisions of the Palaeo-Rhine.

[27] A depression guided by fault lines and tectonic compression.

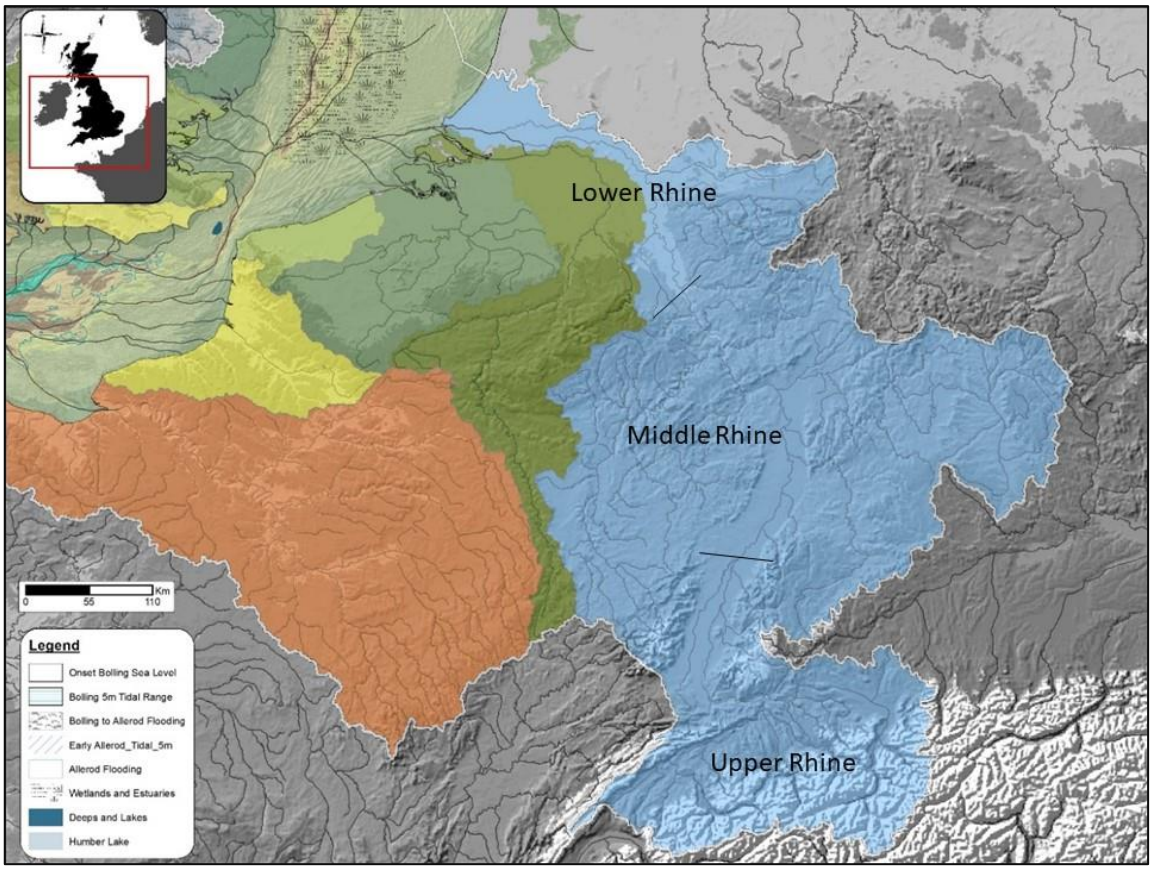


Figure 5.7 Subdivisions of the Palaeo-Rhine. (Source: Author. Basemap EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

5.1.1.1 Upper Palaeo-Rhine

The source of the Palaeo-Rhine is in the region of the Alps of modern Switzerland and Germany (Erkens *et al.* 2009). It is initially a deep-cut river system with little evidence for surviving LG deposits other than the lowest terrace of a continuous series of stacked terraces preserved due to regional uplift (Erkens 2009). The main channels are the result of high-energy systems and have not retained soft sediment deposits dating to the LGM and LG. In the main graben series, the Upper region is dominated by a thick mantle of Holocene deposits rendering the interpretation of palaeochannels complex (Erkens 2009; Gabriel *et al.* 2013). Fluvial terraces are the main source of information for the course and

flow of the palaeoriver in this region (Boenigk & Frechen 2006; Dambeck & Thiemeyer 2002; Erkens 2009).

5.1.1.2 Middle Palaeo-Rhine

The transition from Upper to Middle Palaeo-Rhine is located south of the Neuwied Basin in the Rhineland and is characterised by steep gradients and extensive downcutting to a main valley system confined within multiple grabens. In the Middle Palaeo-Rhine deposits representing LGM and LG sedimentation are accessible and well-preserved (Busschers *et al.* 2007). Most of the palaeo-fluvial record for this river section is reconstructed from fluvial terraces, although there is some evidence for fine sediment palaeochannel deposits, notably towards the gorge region below the Neuwied Basin (Baales 2006; Busschers *et al.* 2007; Erkens 2009).

The Neuwied Basin is one of the most prominent topographic features of the Middle Palaeo-Rhine. It is a graben where the river course extends into an extensive floodplain before being constrained into a narrow gorge and opening into the Lower Palaeo-Rhine (Baales 2006; Baales & Street 1996; Erkens *et al.* 2009). The junction of the floodplain with the gorge is where some of the most significant archaeological and palaeo-environmental sites are located, with numerous examples of high-resolution Magdalenian and Federmesser sites (see Chapter 3) and a unique landscape preserved by the ash deposits of the Allerød-age Laacher See eruption dated to the end of the Allerød (12,916 cal BP or 200 varve counts (years) before the onset of the Younger Dryas in Greenland ice cores) (Baales *et al.* 2002b; Baales & Street 1996; Litt *et al.* 2003). The subsequent erosion and redeposition of these ash deposits towards the end of the LG is well-represented in

fluvial sequences below the Neuwied Basin gorge and provides a horizon marker for Allerød fluvial deposits and the interpretation of associated fluvial dynamics in the Lower Palaeo-Rhine (Baales 2006; Baales *et al.* 2002a; Litt *et al.* 2003).

5.1.1.3 Lower Palaeo-Rhine

The Lower Palaeo-Rhine has a relatively low-relief topography (Busschers *et al.* 2007) and is today a deltaic complex. During the LG it would have been the region of multiple confluences of major tributaries joining the Palaeo-Rhine in the 'Flemish Valley' (Figure 5.6) (Busschers *et al.* 2007; Hijma *et al.* 2009; Huisink 1999; van Balen *et al.* 2010). Many of the LG palaeochannels have been preserved, notably those of the Palaeo-Scheldt and Palaeo-Meuse, enabling a significant reconstruction of the course and character of the Lower Palaeo-Rhine (Bohncke & Vandenberghe 1991; Busschers *et al.* 2007; Hijma *et al.* 2009; Huisink 1999; Kasse *et al.* 2005; van Balen *et al.* 2010; Vandenberghe 1995; 2002). The Lower Palaeo-Rhine appears to have consisted of two main channels throughout the LG and remained confined to its channels rather than anastomosing (interconnecting) or forming braided channels (Busschers *et al.* 2007; Hijma *et al.* 2009; Huisink 1999).

5.1.2 CRC Upper course: The Southern Bight (confluence zone)

The Southern Bight is today the southwestern embayment of the North Sea. During the LG it was the region of the confluence of the Palaeo-Rhine, Thames, Meuse, Scheldt and Vecht where the CRC changed course through the Ardennes fold into the now submerged entrance of the Channel River (Bridgland 2003; D'Olier 1975; Hijma *et al.* 2012). It was one of the most significant topographic features along the LGCRN system, especially with

regard to Southeast England (Coles 1998; Gibbard 2007a). Unfortunately, this key region remains one of the least understood parts of the CRC due to the combination of erosion caused by sea-level rise and the development of significant Holocene deposits from the Rhine and Thames deltas which have sealed this part of the course from bathymetric exploration of submarine topography (Bridgland 2003; Fitch 2011; Hijma *et al.* 2009; Lambeck *et al.* 2014). Seismic studies have revealed a complex series of palaeovalleys in this area, but their chronology and relationship with the CRC remains unclear (Bridgland 2003; D'Olier 1975; Huisink 1999).

A key question is whether there was a dryland passage along the northern banks (interfluve with the Palaeo-Humber catchment) of the Palaeo-Rhine and the Palaeo-Thames during this period, or if it was an extensive wetland zone. Significant palaeoriver channels have been recognised draining from this region into the Greater Silver Pit Lake of the North Sea (Fitch 2011)(Figure 5.6), that indicates the possible existence of a wetland zone around this low-lying region of the axial channel. It is the hypothesis used in this thesis that fluvial activity in the Southern Bight would have been strongly seasonal and that the region would have formed one of the most important intermittent routes for human groups to move into the British peninsula during the LG (Cohen *et al.* 2012; Hijma *et al.* 2012). The interfluve with the palaeo-Humber was the only dryland passage connecting mainland Europe to Britain without needing to cross a major waterbody (Channel River or other major rivers when crossing Doggerland) (Figure 5.8).

5.1.2.1 Axial Valley and Lobourg Channel

The Axial Valley (Figure 5.8) was the main valley before the Dover Strait, traversing the Southern Bight, and the area of confluence between the Palaeo-Rhine and Palaeo-Thames (Bridgland & D'Olier 1995; D'Olier 1975; D'Olier & Maddrell 1970). It was created by successive high-energy river flows following the development of the Dover Strait during the Anglian glaciation (MIS 12) (Collier *et al.* 2015; Gibbard 2007b; Gupta *et al.* 2017). The Axial Valley continues into the Lobourg Channel (Figure 5.8) after traversing the Artois syncline through the Dover Strait (Collier *et al.* 2015; Hijma *et al.* 2012, 31). Both valley systems were created prior to the LG, and the subsequent courses are recognised based on deeply buried LGM and LG sand and gravel deposits: Laacher See pumice within gravel deposits from the Palaeo-Rhine, and Shepperton gravel and sands from the Palaeo-Thames are indications of LG activity (Bridgland & D'Olier 1995; Hijma *et al.* 2012).

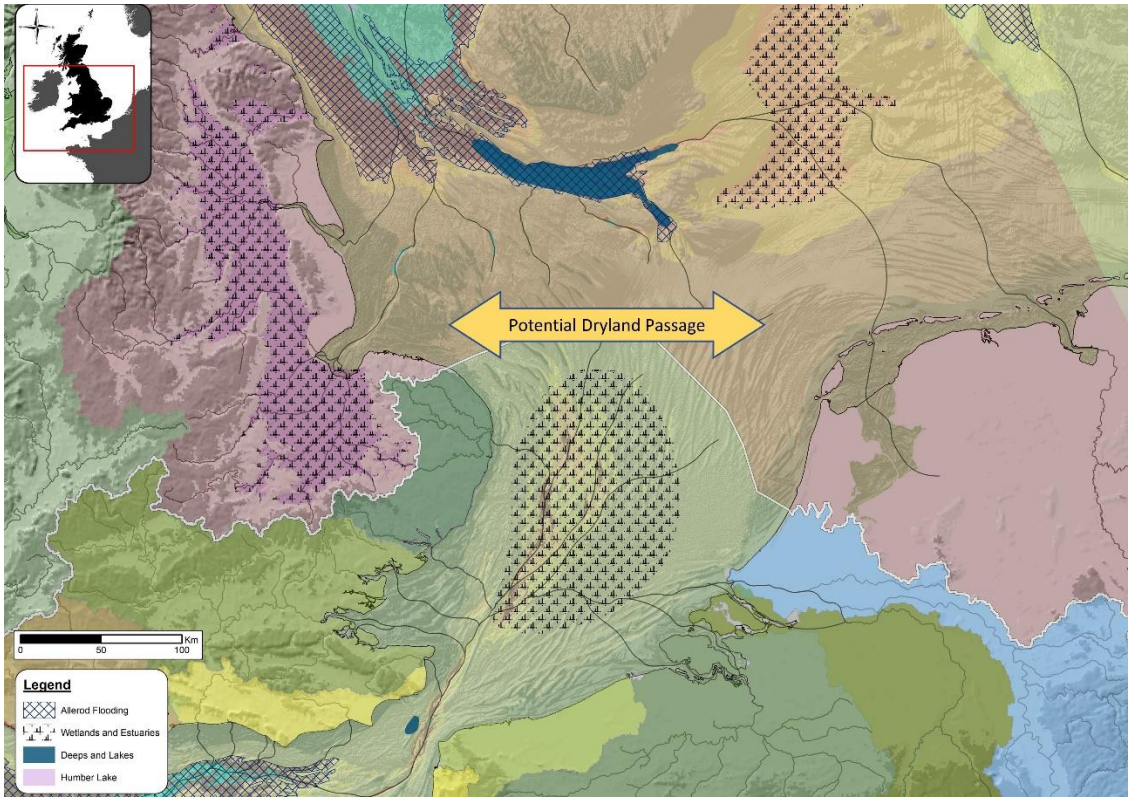


Figure 5.8 Interfluve between England and the Netherlands and axial valley wetland. This would be a possible dryland route (Source: Author. Basemap EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

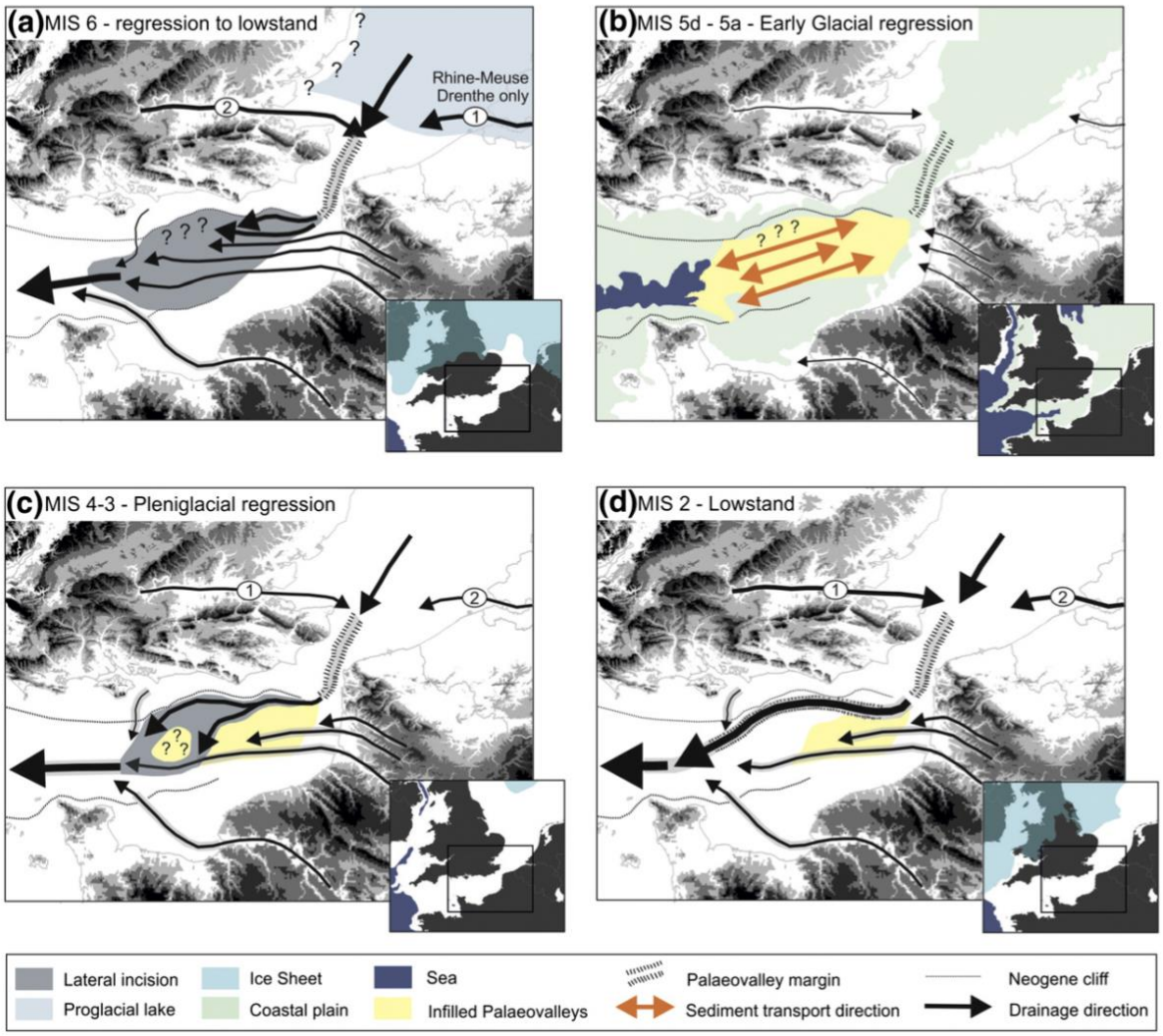


Figure 5.9 Palaeogeography and drainage configurations in the eastern English Channel during*; (a) MIS 6; (b) MIS 5d–5a; (c) MIS 4–3, and: (d) MIS 2. Black arrows show the direction of drainage and the thickness is proportional to discharge with thicker lines indicating higher discharges. The extent of the MIS 6 proglacial lake is based on Busschers et al. (2008) and Murton and Murton (2012). The position of the Rhine–Meuse (1) is taken from Busschers et al. (2008) and the position of the Thames (2) from Bridgland and D'Olier (1995). Ice margins are taken from Ehlers and Gibbard (2004). Shoreline locations are based on global relative sea-level history (Waelbroeck* et al. *2002) and the bathymetry of the continental shelf. (from Mellett et al. 2013: 92)*

The generation of the Dover Strait was complex and appears to have been initiated by the breaching of an extensive proglacial lake at the end of the Anglian glaciation around 450k years ago (Figure 5.9) (Collier *et al.* 2015; Gibbard 1995; 2007b; Gibbard & Cohen 2015; Gupta *et al.* 2017; Mellett *et al.* 2013, 20; Smith 1985). Subsequent glacial events

continued to scour this region, with the development of pronounced drop-pools[28], and the Lobourg Channel deeply-incised valley system (Collier *et al.* 2015). The latest significant scouring took place following the post-LGM glacial melts, identified through a series of eroded fluvial islands linking the main course to the North Palaeovalley (Collier *et al.* 2015). Dated sediments confirm the final Pleistocene and LG age of these channels (Table 5-2) (Collier *et al.* 2015; Mellett *et al.* 2013).

Table 5-2 OSL dates within the Northern Palaeovalley after Mellett et al. 2012.

Diagnostic characteristics	Depositional environment	Core	Depth (m OD)	Sample code	OSL age (ka)
Lateral progradation of inclined seismic reflectors. Matrix supported gravels interbedded with silty fine sands	Fluvial (bar)	VCN4c	-53.2	LV402	17.1 +- 0.8
	Fluvial (bar)	VCN4d	-52.7	LV403	15.8 +- 0.9
	Fluvial (bar)	VCN4d	-53.4	LV411	16.8 +- 0.7
Progradation of inclined seismic reflectors downslope. Very poorly sorted clayey silty sandy gravels	Terrestrial (periglacial slope)	VCL1a	-53.1	LV451	17.9 +- 0.7

5.*1.2.2 Palaeo-Meuse valley*

The Palaeo-Meuse had its catchment in the Franco-Belgian Ardennes range. It initially flowed west-east before taking a northern course through the lowlands to join the Palaeo-Rhine at a confluence in the 'Flemish Valley' near the current Meuse delta (Busschers *et al.* 2007; van Balen *et al.* 2010). The course covered two important archaeological zones: the karstic Cretaceous limestone region containing numerous cave sites; and the deeply sedimented Lowlands with a complex distribution of ridges, buried channels, and palaeosol deposits sealed by coversands that contain rich LG open-air site

[28] Characteristic erosion features created by falling water at the base of cliff-lines and waterfalls.

and paleoenvironmental sequence (Cohen 2003; Crombé & Robinson 2017; de Bie & Caspar 2000; Rensink 2012).

5.1.2.3 Palaeo-Scheldt valley

The Palaeo-Scheldt followed a general east-west course from a source north of the Palaeo-Meuse in the Belgian lowlands and to the west of the Palaeo-Rhine delta. The course was parallel to the lowland course of the Palaeo-Meuse and had a relatively low topography. Most of the course is today overland, but the LG confluence with the Palaeo-Rhine is now submerged in the 'Flemish Valley' (Bogemans *et al.* 2011; Collier *et al.* 2015). Recent research has demonstrated evidence for numerous buried LG palaeochannels associated with this river and local paleoenvironmental sequences (Bogemans *et al.* 2011; Crombé & Robinson 2017).

The Moervaart palaeolake was the most notable of the wetlands and palaeolakes of the Lowlands in Palaeo-Scheldt valley. Numerous LG archaeological sites have been found associated with the area, and the palaeolake has provided one of the richest LG palaeo-environmental sequences for the region (Bos *et al.* 2017; Crombé *et al.* 2011b; Crombé & Robinson 2017). This sequence provides a high-resolution record of the transition from Bølling to Early Allerød, a period of significant archaeological change (Barton 2009; Bos *et al.* 2017; Collins *et al.* 2006; Parker & Goudie 2007; Preece & Bridgland 2012). The Moervaart palaeolake also provides a proxy for available ground-water and standing-water bodies in Southeast England (Bos et al. 2017).

5.1.2.4 Palaeo-Stour (Suffolk) valley

The Palaeo-Stour (Suffolk) was the northernmost of a series of small tributaries of the CRC with sources in East Anglia. Its source was in the chalk uplands and it flowed northwest to southeast to join the main Axial Channel in the Southern Bight (Bridgland 2006; D'Olier 1975). It was significant during the LG as the northeast boundary of the CRC fluvial system where the Palaeo-Rhine turned westward to become the Channel River. It would therefore have represented the western edge of a dryland passage to the British peninsula without the need to cross major watercourses.

5.1.2.5 Palaeo-Thames valley

The Palaeo-Thames flowed in a general southeast direction and was the largest tributary joining the Palaeo-Rhine system from the north (Bridgland & D'Olier 1995; Cohen *et al.* 2014; Coles 1998; Gibbard 1995; 2007a; Gibbard *et al.* 1988; Gibbard & Cohen 2015; Smith 1989; 1985). Its confluence with the Palaeo-Rhine appears to have been located somewhere before the Artois syncline and upstream from the Lobourg Channel. However, the confluence is poorly understood as the terrain is buried by Holocene alluvium (Bridgland & D'Olier 1995; Hijma *et al.* 2012).

Fluvial terrace deposits provide palaeoenvironmental evidence for the Upper Thames (Bridgland 1994; Gibbard 1985; Gibbard & Allen 1994). Rare LG deposits are found in the Middle Thames and occasionally in deep stratigraphic positions in the Lower Thames under thickly developed Holocene sediments (Aalto *et al.* 1984; Bridgland & D'Olier 1995; Bridgland 2003; Bryant 1983a; 1983b; Collins 1994; Collins *et al.* 2006; Gibbard & Allen

1994; Parker & Goudie 2007; Rose 1995). Most LG data comes from its tributary rivers such as the Colne, Kennet, Lea and Wey. The archaeological evidence for LG human occupation of the Lower Thames terraces and floodplain is discussed in Chapter 6. Figure 5.10 shows the principle divisions of the Palaeo-Thames.

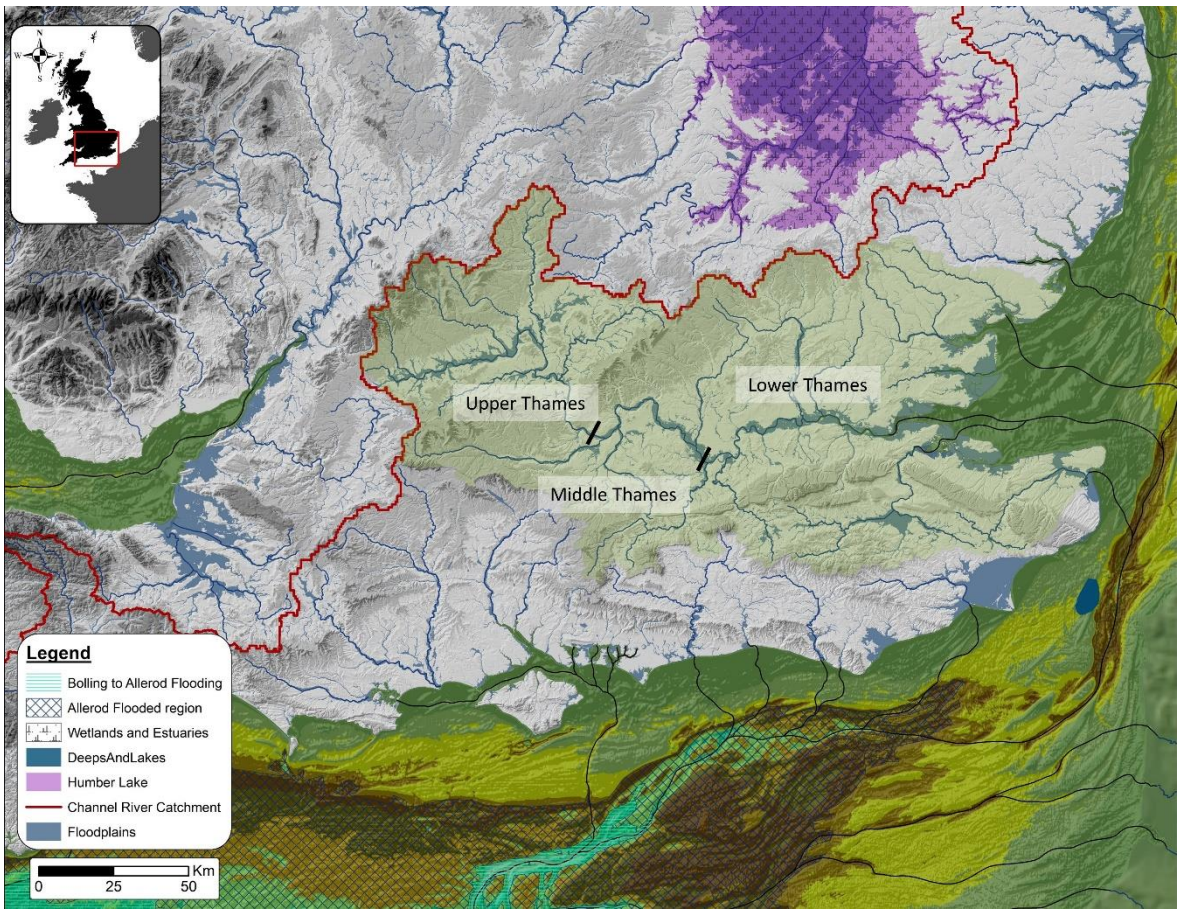


Figure 5.10 Divisions of the Thames. (Source: Author. Basemap OS TOPO 50, EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1)

5.1.3 CRC Lower course: The Channel River

The Channel River refers to the fluvial sections of the palaeocourse of the CRC to the west of the Artois syncline (Antoine *et al.* 2003b; Auffret & Colbeaux 1977; Auffret & Alduc 1977; Collier *et al.* 2015; Gibbard 2007a; Gupta *et al.* 2007; Smith 1989; Smith *et al.*

1975). The trunk valleys guiding the Channel River course are today totally submerged with only extensive sections of its tributaries found above ground. Three major divisions of the submerged course of the Channel River are recognised: The Eastern, Central and Western Provinces (Curry & Smith 1975). This section discusses the Eastern and Central Provinces with the Northern, Southern and Median Palaeovalleys, and the Western Province with the tidal reaches of the river system. Figure 5.6 illustrates the location of the major regions and palaeovalleys of the Channel River.

The topographic elements of the CRC that can be distinguished at present in the current Channel/Manche region are the former river valleys, the large-scale geomorphic features constraining the rivers, rather than the actual palaeochannels of the river courses within those valleys. The original palaeochannels are either eroded by or deeply buried by Holocene deposits and cannot be directly traced without significant coring (Bridgland & D'Olier 1995; Lericolais *et al.* 2003). This thesis recognises that identification of river valleys allows for large-scale modelling (using GIS) of the potential courses of the CRC (Antoine *et al.* 2003b; Lericolais *et al.* 2003) and provides sufficient geographic information to consider human and animal dynamics in relation to this network.

5.1.3.1 The Channel River Eastern and Central Provinces

The Channel River is constrained when passing through the Artois syncline, and high-energy post-glaciation events carved out numerous deep gorges through the syncline and in the adjoining North Palaeovalley (Antoine *et al.* 2003b; Auffret & Alduc 1977; Gupta *et al.* 2017; Smith 1985). This submerged region is mapped by bathymetry (Antoine *et al.*

2003b; Auffret *et al.* 1980; Auffret & Alduc 1977; Evans 1990; Gibbard 1995; Gibbard & Lautridou 2003; Hamilton 1979; Kellaway *et al.* 1975; Lautridou *et al.* 1999; Smith 1989; Smith *et al.* 1975); and by seismic surveys (Bourillet & Lericolais 2003; Evans 1990; Hamilton & Smith 1972; Lericolais *et al.* 1996; Lericolais 1997). The course can be mapped as most of the main valleys of the CRC are topographically significant and only partially filled since the LGM (Antoine *et al.* 2003b; Gibbard *et al.* 1988; Gibbard & Cohen 2015; Lericolais 1997; Mellett *et al.* 2013; Smith 1985; Velegrakis 2000).

Recent high-resolution sonar scans have identified fluvial erosion features linked to high-energy flows (Collier *et al.* 2015; Gupta *et al.* 2007; 2017; Lericolais *et al.* 2003). Deep-sea coring has enabled the characterisation and dating of the alluvial (Lericolais *et al.* 2003; Toucanne *et al.* 2009b) and tidal deposits (Eynaud et al. 2012; Furze et al. 2014; Lericolais et al. 2003; Marsset et al. 1999; Ménot et al. 2006; Reynaud et al. 2003; Scourse et al. 2009b). Some of the most notable features are deep erosional troughs ('deeps') created by successive high-energy flows following glacial melts into waterfall drop pools (Antoine *et al.* 2003b; Collier *et al.* 2015; Gibbard 1995; Gupta *et al.* 2017; Lericolais *et al.* 2003; Smith 1985); The most significant were created following the Anglian glaciation around 450,000 years ago (Gupta *et al.* 2017) and the LGM (Ménot *et al.* 2006; Toucanne *et al.* 2009b; 2015).

The largest of the 'deeps' are the Lobourg Channel and Fosse Dangeard (Figure 5.6). The origin of the Lobourg Channel is linked to the development of a proglacial lake which subsequently burst with extreme energy (Collier *et al.* 2015; Gibbard 1995; Gibbard *et al.* 1988; Gibbard & Cohen 2015; Gibbard & Lautridou 2003; Gupta *et al.* 2017). However, an

alternate model based on valley-fill sedimentation and scarp morphology has recently been proposed that suggests a more regular erosion model with a pulsating Channel River system creating the current valley (Mellett *et al.* 2013). Currently the most parsimonious interpretation of the formation dynamics of the North Palaeovalley is for an initial megaflood carving of the valleys, followed by periods of infilling during low sea-stands, partially eroded away by tidal scouring during sea-level rise events (Collier *et al.* 2015, 202; Mellett *et al.* 2013, 94).

5.1.3.1.1 The North Palaeovalley of the Channel River

The Northern Palaeovalley is the main course of the Channel River at the onset of the LG; (Antoine *et al.* 2003b; Collier *et al.* 2015; Gupta *et al.* 2007; Mellett *et al.* 2012; 2013). It has a low gradient and is marked by a steep scarp topography, notably along its northern flanks dominated by cliffs (Gibbard & Lautridou 2003; Gupta *et al.* 2007). Flow would have been initially accelerated in the constrained Artois syncline (Collier et al. 2015), and then run in palaeochannels within broad and steep-sided valleys. Bathymetry shows these valleys as pronounced topographic features, with tributaries such as the Palaeo-Arun and Palaeo-Solent joining the North Palaeovalley over what are now submerged hanging valleys that in the LG would have been considerable seasonal, if not perennial, waterfalls (Gibbard *et al.* 1988; Gupta *et al.* 2017; Mellett *et al.* 2013). The steepest scarp is found between Kent and Devon and this topographic step would have potentially presented an imposing barrier to migrating fauna and humans during the LG (Gibbard & Lautridou 2003). The North Palaeovalley appears to be devoid of LG sediments probably due to later

erosion phases combined with the effects of tidal scouring and sea-level rise (Gupta et al. 2007; Lericolais et al. 2003).

The centre of the Northern Palaeovalley is marked by well-developed Mesa-like formations[29] carved out of the bedrock by mega-floods (post-Anglian and/or post-LGM) (Collier *et al.* 2015; Gupta *et al.* 2007). These would have created a dramatic landscape with potential mosaic biodiversity between the wetter regions of the local floodplain and the dryer exposed scarp faces. In this respect the Drumheller Channel landscape (Figure 5.11) in the continental region of Washington State (USA) may serve as a useful comparison for the CRC (Bretz 1969; Mellett *et al.* 2013). It also contains isolated mesa-like islands and a rich-variety of hydrological environments and associated biomes (Tiner 2003). There is a complex relation with precipitation in this currently semi-arid region, whereby in dry periods a series of isolated pools and biomes are formed, and when linked in more humid periods create a network of ecozones, termed 'cyclical wetlands' that are attractive to local and regional fauna (Tiner 2003, 502).

[29] Isolated bedrock features carved out on either side by high-energy fluvial flows.





Figure 5.11 Channelled Scablands, Drumheller Channels, eastern Washington. Photos: Joe Becker.

Further west the Northern Palaeovalley broadened into a region with less-pronounced topography and marked by multiple valleys (Antoine *et al.* 2003b; Brown *et al.* 2015; Evans 1990; Gibbard *et al.* 1988; Hamilton 1979); . This low-relief topography extended until the Northern and Southern Palaeovalleys merged to take a common course with the Median Palaeovalley (Somme and Seine Rivers). The course continued to flow into the deepest feature of the Channel River region (Hurd's Deep) (Lericolais *et al.* 2003) and then out towards the Atlantic (Bourillet & Lericolais 2003; Hamilton & Smith 1972; Lautridou *et al.* 1999; Lericolais *et al.* 1996; 2003). This situation continued throughout the first half of the LG until Hurd's Deep and eventually the Seine was absorbed by the rising sea level (Lambeck *et al.* 2014).

The principal tributaries feeding the Channel River from sources in Southeast England were intricately linked to the local bedrock, and hydrology was dominated by the two main factors of scarp slope topography and bedrock porosity. The principal tributaries flowing off the Southeast English chalklands and Downs were the rivers Palaeo-Stour (Kent), -Rother and -Arun, and the tributaries of the Palaeo-Solent the rivers Palaeo-Test, -Frome and -Avon as well as the water courses linked to Chichester and Langstone harbours (Allen & Gibbard 1993; Gibbard 2007a; Gibbard & Allen 1994; Gupta *et al.* 2007; Velegrakis 2000). These chalkland tributaries mark the southern limits of the thesis study area and will be discussed at the end of this chapter. Figure 5.6 shows the location of the Southeast English tributaries of the Channel River.

5.1.3.1.2 The South Palaeovalley of the Channel River

The South and Median Palaeovalleys were marked by major tributaries draining from the Paris Basin, and had a less accentuated carved relief than the North Palaeovalley (Antoine *et al.* 2000b; 2003b; 2007; Gibbard & Lautridou 2003; Lautridou *et al.* 1999; Lericolais *et al.* 2003).

LG sedimentary deposits from the South Palaeovalley have been cut by the North Palaeovalley, perhaps demonstrating a hierarchy of flows (Lericolais *et al.* 2003). Alternatively, this may represent short-term seasonal variation depending on the rate of flow, with peak flows probably occurring from spring until early summer and possibly activating both palaeovalley courses below the Artois Gap (Vandenberghe & Woo 2002; Woo 2012b). It could also represent different extents of seasonal flow, with the North Palaeovalley course flowing for a longer period – this system falling into the category of anabranching (divided flow) or plural[30] systems described for large river channel patterns (Ashworth & Lewin 2012; Lewin & Ashworth 2014). The CRC may therefore have switched from a main channel fed by the Palaeo-Rhine system, to the Channel River system with seasonal variations (Lericolais *et al.* 2003; 2003).

The tributaries of the Pas-De-Calais and Palaeo-Somme flowed into the Median Palaeovalley and subsequently joined the South Palaeovalley with the Palaeo-Seine a little upriver from its confluence with the North Palaeovalley (Antoine *et al.* 2003b; Auffret *et al.* 1980; Auffret & Colbeaux 1977; Auffret & Larsonneur 1971; Auffret & Alduc 1977;

[30] Complex large river systems with functionally different and dynamically variable parts.

Lericolais *et al.* 2003; Pastre *et al.* 2003). The Palaeo-Somme catchment drained the low-lying eastern edges of the Paris Basin chalklands. The Palaeo-Seine catchment was the second largest drainage system following the Palaeo-Rhine. Both Somme and Seine tributaries flowed through a similar bedrock geology, although there are distinct regional variations in the fluvial regimes (Antoine *et al.* 2003b; 2007; Lericolais *et al.* 2003; Pastre *et al.* 2000; 2003).

This region with its lower-lying topography would probably have provided significant seasonal variation in resources, it also offered a more regularly inclined topography, without any major barriers as with the cliff lines along the Southeast English coast. Figure 5.12 shows the southern tributaries of the Channel River.

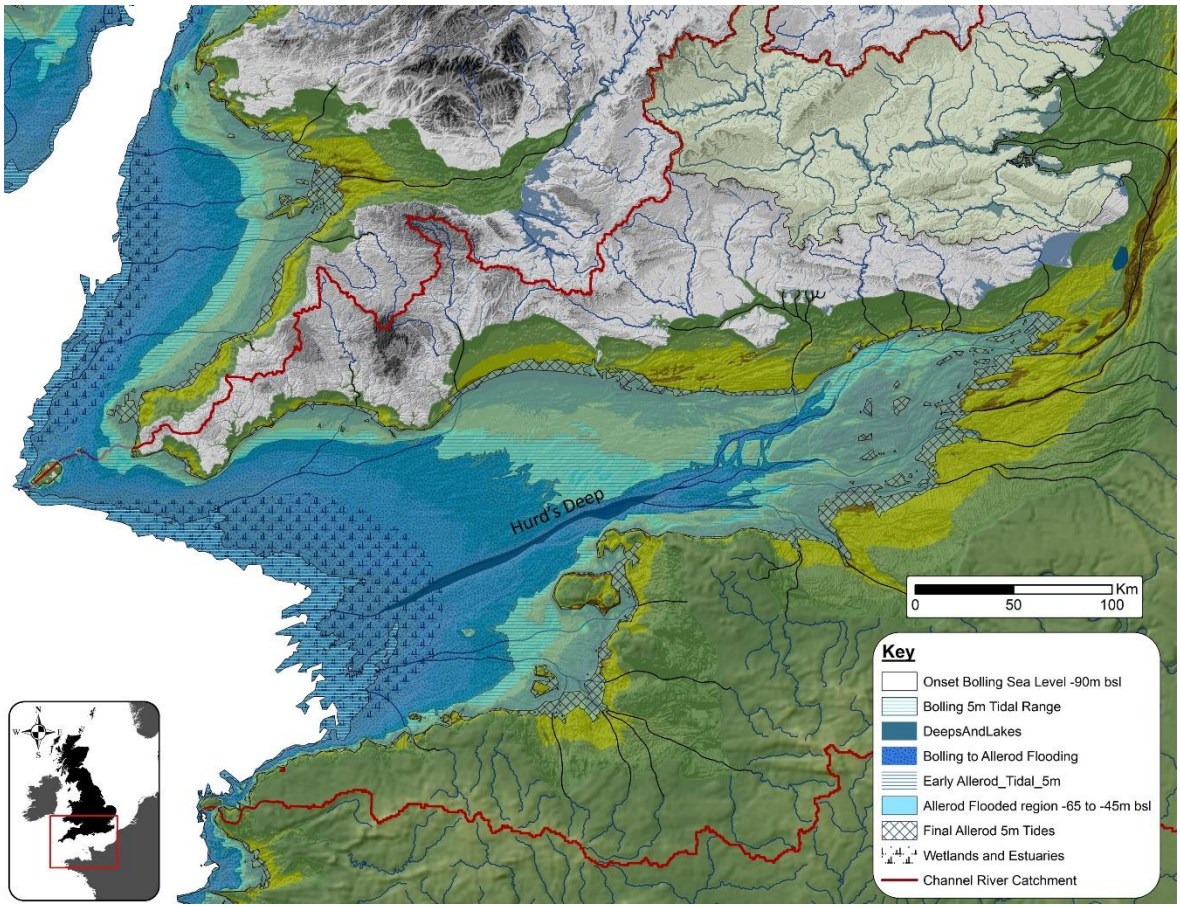


Figure 5.12 Modelled tidal zones. (Source: Author. Basemap OS TOPO 50, EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1)

5.1.4.1 The Channel River Western Province

The Western Province of the Channel River represents an evolving estuarine zone throughout the LG with multiple channels joining the basin from Southwest England and northwest France but not necessarily confluencing, and instead potentially joining the Atlantic independently. This model is based on records of a complex sedimentary dynamic seen in the composition of the Celtic fans off the continental shelf and recorded in boreholes from the western extent of Hurd's Deep (Lericolais *et al.* 1996; 2003; Mellett *et al.* 2012; 2013; Toucanne *et al.* 2010). It also has a less-marked submarine topography than the other Provinces due to planation processes caused by eustatic sea-levels and tidal activity (Antoine *et al.* 2003b; Lericolais *et al.* 2003). During periods of low sea-level,

some of the channels east of Hurd's Deep also appeared not to join the Channel River as tributaries (Bourillet & Lericolais 2003).

The rivers joining the Channel River in this region had reduced sedimentary signatures compared to the major tributaries to the east. This was in large part due to their having smaller catchment areas and thus not generating the same cumulative energy for down-cutting and for creating a marked topography. Many of these rivers flowed from areas of igneous and metamorphic bedrock (Brittany and Cornwall) that are much harder than the sedimentary bedrocks of the Eastern and Median Provinces and less susceptible to accumulating deep sequences of fine erosional deposits (Basell *et al.* 2011; Brown *et al.* 2015). The region is also closest to the Atlantic and most subject to extensive erosion due to sea-level rise during the LG (Bates *et al.* 2003; Conneller *et al.* 2016; Lericolais *et al.* 2003; Scourse 1996; Scourse *et al.* 2009b).

The situation remains unclear as the course of these rivers cannot be traced currently, mainly due to the planation by sea-level rise and tidal erosion of their lower stretches (Lautridou *et al.* 1999; Lericolais *et al.* 1996; Lericolais 1997). The situation remains unclear however as the course of these rivers cannot currently be traced, this is mainly due to the planation by sea-level rise and tidal erosion of their lower stretches.

The framework for characterising the low-relief western regions of the Channel River is based on current knowledge of several topographic features, notably the linear tidal sand ridges (LTSR). These sand ridges are a series of fossil glacially- and fluvially-derived aligned sedimentary bars that provide information on the rate of deglaciation, oceanic currents

and tidal ranges, and sea-level rise (Marsset *et al.* 1999; Reynaud *et al.* 2003; Scourse *et al.* 2009b; Uehara *et al.* 2006; Ward *et al.* 2016).

Further west, over the edge of the continental shelf, a series of deltaic fans of both the Channel River and Irish Sea Ice Stream are separated by a series of canyons (Bourillet *et al.* 2003; 2006; Bourillet & Lericolais 2003; Scourse *et al.* 2009b). These deposits provide information on the principal rivers feeding the Channel River system, notably the change of course of the Elbe shifting towards the North Sea after the LGM, as well as rates of flow for the earlier parts of the LG (Toucanne *et al.* 2010; 2015). Subsequent deltaic deposits are absent further east, except for a pocket within the western extent of Hurd's Deep (Lericolais *et al.* 1996; 2003). This is probably due to the erosion and redeposition of LTSR deposits and planation events during sea-level rise (Lericolais *et al.* 2003; Scourse *et al.* 2009b).

5.1.4.1.1 Hurd's Deep

The most significant landscape feature in the Western Province of the Channel River is a substantial submarine fissure known as Hurd's Deep that was accentuated and carved out by mega-floods (Collier *et al.* 2015) (Figure 5.12). It is 180m deep and is partially infilled with Holocene sediments (Hamilton & Smith 1972; Lericolais *et al.* 1996; 2003). The confluence of Northern and Southern Palaeovalleys occurred either at the eastern extremity of Hurd's Deep or slightly further upstream. It would have combined into a single valley system the flows of the Palaeo-Rhine and southern English tributaries (north) with the Palaeo-Somme-Seine tributaries (South). As such this may have been a region of seasonally extremely high-energy flow with the potential to cause extensive seasonal

flooding of the Deltaic zone and around Hurd's Deep. The main fluvial valley of the Channel River terminated with Hurd's Deep. The outflow west of Hurd's Deep is difficult to follow as there is little in the way of submarine topography.

During the early stages of the LG (GI-1e to c) Hurd's Deep was probably an inland freshwater lake, comparable to Canadian post-glacial inland lakes or to the isolated Baltic Sea. It would also have had water courses flowing out of it to join the Atlantic Ocean. This inland lake may well have had its own specific local environment due to its size. During the following main period of sea-level rise the lake would have gradually come under the influence of the maritime regime, eventually becoming more brackish and partially flooded by tidal influence, before being completely submerged during the Allerød (Coles 1998; Sturt *et al.* 2013). This would have produced a unique environment with a dynamic water body, and a biodiversity attractive to both people and animals in the region. This hypothesis is partly borne out by the presence of unique adaptations of marine algae flora dating to the LGM and LG (Provan & Bennett 2008).

In Chapter 7, it is proposed that Hurd's Deep probably played a significant role for both animals and people around the development of Channel River estuarine environments during the later stages of the LG and may help explain the presence of Federmesser activity as far southwest as the Isles of Scilly in Britain (Berridge & Roberts 1986; Scourse 1991) and Early Azilian elements in Brittany and possibly the south of England (Naudinot 2013; Naudinot *et al.* 2017a).

5.1.4.1.2 Metamorphic and igneous tributaries

The regions of Northwest France (especially Brittany) and Southwest England (Cornwall and parts of Devon) are located on the Armorican and Cornubian geological massifs, areas of ancient igneous and metamorphic bedrocks with layers of sedimentary Tertiary deposits (Antoine *et al.* 2003b; Evans 1990). The geology of these areas had a significant impact on the drainage regimes and erosive/depositional dynamics of the LG river systems flowing from them into the Channel River (Antoine *et al.* 2003b; Brown *et al.* 2015). In these regions the hard bedrock resulted in laterally constrained downcutting of river channels, pronounced river valleys, and less-developed floodplain stratigraphy with soft sediments preserving LG deposits. Rare pockets of LG fluvial deposits survive in the pre-LG valley terraces, and lenses of loess deposits provide local palaeoenvironmental archives as well as potential LG archaeological horizons combined with cave sites (Antoine *et al.* 2003b; Basell *et al.* 2011; Berridge & Roberts 1986; Brown *et al.* 2015; Coutard *et al.* 2006; Lautridou *et al.* 1999; Marchand *et al.* 2004; Naudinot *et al.* 2017a).

5.1.4.1.3 The Western Channel floodplain basin

The Channel River floodplain would have been at its broadest in the now submerged region between Cornwall and Brittany. The main channels were probably constrained to the central part of the basin, with the Western tributaries representing an extensive wetland landscape at least seasonally, and especially with the advent of sea-level rise. The Western deltaic-estuarine zone could be expected to be composed of a mosaic of local environments with a significant biodiversity, and rich in resources such as drift-wood and marine resources (see Chapters 6 and 7). It would thus have been a region of

attraction to mammals and human groups if their primary focus was large mammal hunting - focussing on both migrating animal herds in the early LG and (perhaps even more) on small groups of sedentary animals in the second half of the period. Furthermore, the exposure to westerly winds would have been beneficial during the spring and summer months to mitigate insects (see section 7.2.6).

Spring-lines and other water sources within this environment would have been key factors in both fluvial and human dynamics. Spring-fed systems would have been the only perennial flowing rivers, and the environment may have been arid any distance from them. These springs would be strong poles of attraction for both faunal and human populations. Significant parallels may be drawn with the Fennoscandian and Canadian Shields that are composed of hard non-porous bedrocks (Buttle *et al.* 2012; Woo 2012b).

5.1.4.1.4 Tidal Zone

Modelling of the tidal impact of the Channel River in the Western Province can be approximated to between 5 and 10m above and below mean sea-level based on modern tidal regimes (Conneller *et al.* 2016; Reynaud *et al.* 2003; Scourse *et al.* 2009b; Uehara *et al.* 2006) (Figure 5.12). This is a significant variation in a region with a relatively low topography and slope, and would imply dramatic changes when associated with sea-level rise. These figures need to be combined with estimates of eustatic lift in the region, which may have been in the range of 5-10m (Sturt *et al.* 2013). The combination of a high-tide of 5-10m and an eustatic uplift of 5-10m would have a significant impact on modelling the tidal and estuarine zone in relation to mean sea-levels, of up to 10-20m difference (Shennan *et al.* 2006; Sturt *et al.* 2013). The modelling of this region is therefore complex

and needs to be a focus for future research. This is especially true for understanding human activity in the area as the tidal action would have had significant impact on the palaeoriver systems and their local dynamics.

5.2 Late Glacial Channel River dynamics and regional case studies

This section discusses the main reference sections and derived fluvial regimes for the LG Channel River Network (CRC) from Southern Bight to Hurd's Deep (Figure 5.13). This provides a context for the landscape approach to LG human dynamics in the Channel River region developed in Chapters 6 and 7. The section starts with a description of generalised LG river dynamics and then provides case studies for the Palaeo-Rhine-Meuse-Scheldt and Paris Basin regions, as these provide the best correlations for Southeast England. The section concludes with a discussion of Southeast England.

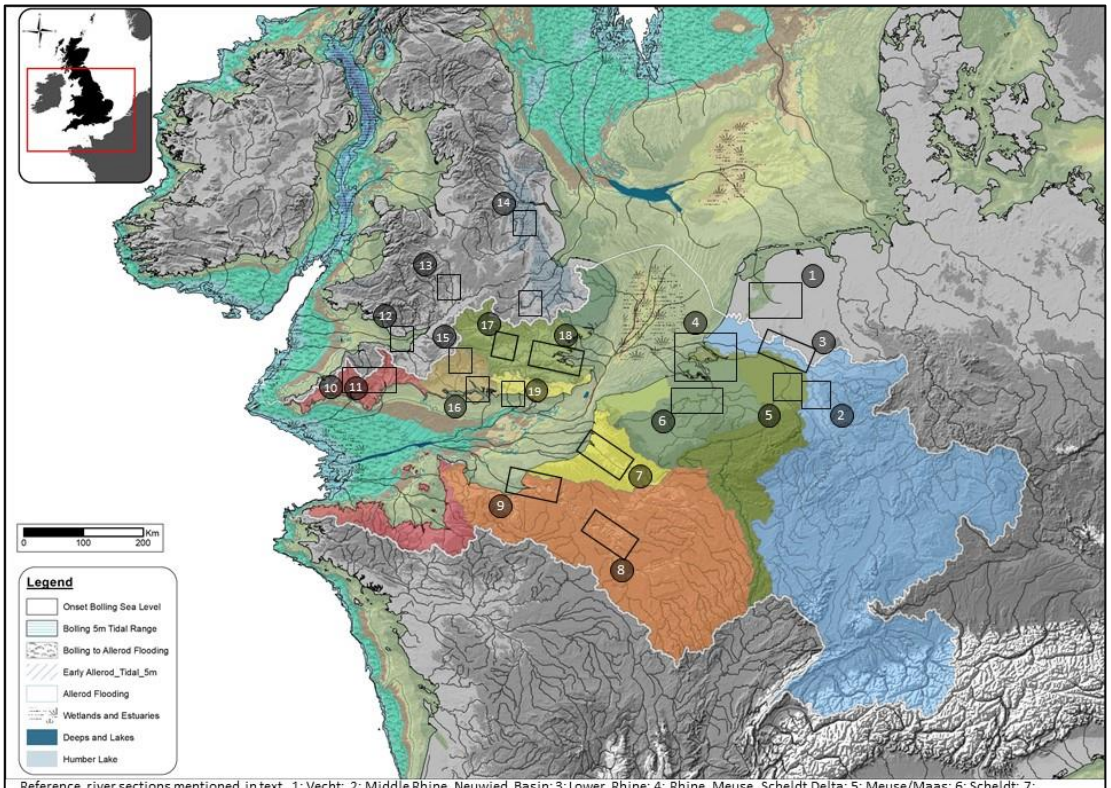


Figure 5.13 Regional reference sites. (Source: Author. Basemap OS TOPO 50, EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1)

5.2.1 Late Glacial Channel River fluvial dynamics

Late Glacial fluvial dynamics of Northwest Europe are closely associated with major climatic shifts. The traditional models based on sedimentary records of glacial and periglacial river systems indicate seasonal high-energy influence (e.g. spring melts) with little soil and vegetational development generating wandering braided channels, while more temperate rivers in vegetated areas have more stable banks and single channel meandering river systems (Bridgland *et al.* 2004; Vandenberghe 2008; Vandenberghe & Woo 2002).

This model is still valid for many LG river systems; however, it is now apparent that other types of river forms, morphologies and regimes are found in periglacial and temperate environments. This complexity is linked to a combination of factors relating to local geology, topographic morphology, ground stability, energy inputs, and time necessary to adapt to new conditions (Vandenberghe & Woo 2002). This recognition led to the development of the 'non-linearity model' by Vandenberghe (Vandenberghe 1995; 2001; 2003; 2008) arguing that most river forms and dynamics can be found in all environments and even along the course of an individual river course (Vandenberghe 1995; 2008; Vandenberghe & Woo 2002). This new model has in turn led to the investigation of local factors impacting LG river systems (Vandenberghe 1995; 2008) which can be combined with the impact of glacio-isostatic uplift/subsidence (Bridgland *et al.* 2004; Hijma *et al.* 2009; Maddy *et al.* 2001; Sturt *et al.* 2013; Westaway *et al.* 2006; Westaway & Bridgland 2010; 2011a; 2011b) and bulge effects (Busschers *et al.* 2007) on river courses and incision/aggradation dynamics.

The prevalent – but not universal – pattern for LG river systems was developed for several regions of the Channel River network: The Palaeo-Rhine (Hijma *et al.* 2009; Huisink 1999; Kasse *et al.* 2005; Vandenberghe 1995); Paris Basin (Antoine 1997b; Antoine *et al.* 2003c; 2007; Pastre *et al.* 2000); and Palaeo-Thames and -Solent (Allen & Gibbard 1993; Bridgland 1994; Brown 1997; Bryant 1983a; Gibbard 1985; 1994; Gibbard & Allen 1994; Lewin & Gibbard 2010; Rose 1995; West 1980; West *et al.* 1960). These syntheses provide general trends for the regions and also highlight local variations e.g. (Antoine *et al.* 2007; Busschers *et al.* 2007; Vandenberghe & Woo 2002).

The following section summarises the general trend for river system development in the CRC during the Oldest Dryas at the end of the LGM (GS-2a) and the three main climatic phases of the LG: GI-1e-d (Bølling and Older Dryas); GI-1c-a (Allerød); and GS-1 (Younger Dryas). The variations and idiosyncrasies of individual river development are discussed in the case study sections.

5.2.1.1 GS-2a (Oldest Dryas): Braided Channels

The Oldest Dryas (GS-2a) was a phase of accentuated cold and aridity at the end of the LGM. During this time braided river systems were prevalent throughout Northwest Europe. The rivers had a bedload dominated sedimentary system, with seasonal high energy flows linked to nival[31] input, and an active permafrost layer. The absence of soil development during this period combined with frozen ground led to rapid runoff that was seasonally accentuated by nival and glacial melts (Antoine *et al.* 2003b; Catt 1985; Lewin

[31] Relating to snow cover.

& Gibbard 2010; Vandenberghe 2008; Vandenberghe & Woo 2002). The combination of bedload dominated sedimentation with frozen subsoils led to lateral mobility of the channels and large fluvial systems (Church 1974; 1972; Vandenberghe & Woo 2002).

5.2.1.2 GI-1e-d (Bølling and Older Dryas): Braided and transitional channels

Most of Northwest European rivers on sedimentary bedrock appear to have continued as braided channel systems throughout the Bølling (Hijma *et al.* 2012; Lewin & Gibbard 2010; van Huissteden & Kasse 2001; Van Huissteden 1990; Vandenberghe 2001). Reasons proposed to explain the lack of change in river dynamics include the absence of vegetation and soil development to stabilise the channel banks; continued cold winters maintaining a sub-soil frozen horizon; and strong seasonal runoff with both nival and ground-surface inputs with higher atmospheric precipitation than GS-2a (Vandenberghe & Woo 2002; Woo 1976; Woo & Marsh 2005).

A 'Transitional Channel' form is identified in some rivers dating to this period (Vandenberghe 2001; Vandenberghe & Woo 2002). This is where a river takes a near anabranching form with seasonal braided and single channel behaviour. It is interpreted as resulting from a time-lag in the response of the fluvial systems to climatic change, and the need for sufficient time to make the transition from a classic braided system to a meandering system (Kasse *et al.* 2005; Kasse 2014; Vandenberghe & Woo 2002). It is proposed that it might take several centuries for river channels to re-establish themselves following a climatic transition. This would correspond with the timeframe of the Bølling and Older Dryas, both relatively short periods which would not enable a complete

transition from one type of channel to the other (Kasse *et al.* 2005; Vandenberghe & Woo 2002). The transition from one system to another appears to be related to two major factors: arriving at a threshold where the transition is initiated and a sufficient time for the transition to be completed (Vandenberghe & Woo 2002).

5.2.1.3 GI-1c-a (Allerød): Meandering single Channels

Many of the braided Channel River systems had completed the transition to meandering channels by the onset of the Allerød. These were principally single channel systems with occasional multi-Channel Rivers, some of which might have been seasonal (Antoine *et al.* 2003b; Briant *et al.* 2005; Gao *et al.* 2007; Vandenberghe 2001; 2003). The change of river system is generally associated with multiple factors such as vegetation, soil development, bank stabilisation, variations in atmospheric precipitation, nival feed, and sea-level (Antoine *et al.* 2003c; Vandenberghe & Woo 2002).

This development marks a major transition in fluvial types and dynamics as meandering channels are generally erosive and down-cutting leading to a more constrained and deeper fluvial system. River activity, concentrated into single channel meandering rivers with developed main channels, generates a different landscape dynamic, encouraging the development of riparian[32] vegetation and creating a more extended period of flow (Brown 1997). Meandering channels under high water levels are susceptible to extensive flooding with the creation of levees and associated high erosion cutting off meanders and creating oxbow lakes.

[32] The interface between land and a river or stream.

Although this was the general trend, some rivers, such as the Palaeo-Thames, did not appear to completely develop into a meandering channel during the Allerød (Gibbard 1985; 1994). This factor raises questions concerning river behaviour and the processes and dynamics involved in climate forcing scenarios versus local dynamics (Lewin & Gibbard 2010; Vandenberghe 2003).

5.2.1.4 GS-1 (Younger Dryas): Meander to multi-channel or braided channels

Following the rapid onset of cooler conditions in the Younger Dryas there was a marked change in fluvial channels across most of Northern Europe back towards a braided channel system (Vandenberghe 2003; Vandenberghe & Woo 2002). Some channels did not make the complete transition to braided systems and this appear to be linked to factors such as the short time span of the intensive cold and dry phases, and surviving established vegetation stabilising river banks throughout this period; and the presence of soil cover (Vandenberghe 2001; 2003; Vandenberghe & Woo 2002). Overall, this was a phase of downcutting and erosion in most river systems, and although lateral erosion may have been accentuated by the presence of permafrost, it is mostly considered discontinuous during this period (Bertran *et al.* 2014; Collins *et al.* 2006; Frampton *et al.* 2011; French 2008; 2010; Harris *et al.* 2009; Isarin & Renssen 1999; James 2004; Matsuoka 2011; Murton & Belshaw 2011; Murton & Lautridou 2003; Renssen & Isarin 2001a; Van Vliet-Lanoë 1998; Vandenberghe & Pissart 1993; Vandenberghe *et al.* 2014; Younger 1989). The Younger Dryas has the most significant amount of LG preservation of archaeological records on the flood plain, probably as they have not undergone the

extreme erosion of previous phases. However, there are few Younger Dryas fluvial reference sections intact for the SE England.

5.2.2 Regional case studies

There appears to be a correlation between regions with good fluvial sedimentary coverage and LG archaeological signatures in Northwest Europe (Antoine *et al.* 2007; Crombé & Robinson 2017), The main LG sedimentation depositional bodies with substantial archaeological and palaeoenvironmental records can be broadly categorised into:

- wetlands (marshes, moors);
- lacustrine environments;
- aeolian deposits (loess and coversands); and
- fluvial environments (floodplains, channel cut-offs, oxbow lakes, mid-channel bars).

The first two categories may be considered as static poles of attraction (sedimentary traps). However, the aeolian and fluvial deposits were created by dynamic and mobile processes covering large regions. Aeolian deposits are created under specific conditions with dry, high energy winds transporting fine sedimentary material grading from fine sands to clays (Antoine *et al.* 1999; 2003a; Catt 1985). Fluvial deposits are more widespread and are produced near continuously by river flow in the major river systems when aggrading (but also with significant hiatuses due to erosional dynamics), although conditioned by local topography, environment and seasonality (Lewin & Gibbard 2010). The choice of the scale of analysis is essential here, as sequences provide information at a local scale that may vary in detail. But at a larger scale these sequences can be combined to provide an overall model of network or system dynamics. This is the objective of this section. The CRC can therefore be considered as an over-arching dynamic

palaeoenvironmental network of integrated records over a large region influencing and 'guiding' human behaviour (Coles 1998b).

The detailed fluvial development and palaeoenvironmental record from the entire CRC is beyond the scope of this thesis that concerns the LG archaeology of Southeast England and its relationship with the Channel River from a palaeo-geographic perspective. Discussion here focusses on three river systems that impact on the research area and provide sedimentary data in association with LG archaeological records. The three study areas are:

1. The Palaeo-Rhine-Meuse-Scheldt confluence. The region with the best record for LG fluvial activity in relation to the main course/flow of the Channel River (Baales & Street 1996; Bogemans *et al.* 2011; Bos *et al.* 2017; Crombé *et al.* 2011b).
2. The Palaeo-Somme and -Seine catchments. These are the most significant tributaries of the Channel River system after the Palaeo-Rhine and share a similar lithology with Southeast England (Coudret & Fagnart 2006b; Fagnart 1984).
3. Southeast England.

All these regions have rich records relevant to both open-air archaeological and LG fluvial dynamics within the Channel River system (Allen & Gibbard 1993; Antoine *et al.* 2003b; Collins 1994; Gibbard & Lewin 2002; Hijma *et al.* 2012; Preece & Bridgland 2012; van Huissteden & Kasse 2001; Van Huissteden 1990; Vandenberghe 2008). The following case studies introduce the main 'reference sections' along these river systems and discuss how they have contributed to characterising LG fluvial dynamics in the area and also to the

climatic and seasonal dynamics which may have played a part in human land-use strategies.

5.2.2.1 Regional case study 1: The Palaeo-Rhine-Meuse-Scheldt confluence

The Palaeo-Rhine-Meuse-Scheldt confluence region is of prime importance in understanding the CRC both as it has a deep stratigraphic record with LG sequences, and as it records the regime of the Palaeo-Rhine, the main course of the Channel River system (Hijma *et al.* 2009). The Palaeo-Meuse and Palaeo-Scheldt are major tributaries of the Palaeo-Rhine and their fluvial records share and complement data from the main river channel. This region has undergone extensive research and has produced some of the best records for LG fluvial activity, including from well-preserved palaeo-meanders of the Palaeo-Scheldt. In addition, the Laacher See ash deposits provide a unique high-resolution record of the Late Allerød fluvial regime and a precise stratigraphic marker (Baales 2006; Hijma *et al.* 2009). The region also has interstitial aeolian and tephra deposits that provide significant palaeoenvironmental and dating records (Busschers *et al.* 2007; Dambeck & Thiemeyer 2002).

As discussed previously, it is now accepted that there are multiple endogenous and exogenous factors influencing river courses, flow and eventual channel mode that are not directly climate related, combined with others that are (Vandenberghe 2003). For the Palaeo-Rhine-Meuse-Scheldt confluence region such non-climate related factors include:

- the development of the Rhine Rift System, a series of graben in the Upper Palaeo-Rhine that guided fluvial activity in the early part of the river course (Busschers *et al.* 2007; Erkens *et al.* 2009).

- the presence of a 5-10m high glacio-isostatic topographic bulge in what is now the northern Netherlands, that would have influenced the erosional behaviour of the Lower Palaeo-Rhine course and confluence with the Palaeo-Meuse and led to a general uplift trend and stacking of sediments (Busschers *et al.* 2007; Cohen 2003).
- structured dune formation in the Palaeo-Meuse region that indicates significant shifts of wind intensity and direction and information about atmospheric circulation (Renssen & Bogaart 2003).

5.2.2.1.1 GS-2a (Oldest Dryas): Palaeo-Rhine-Meuse-Scheldt confluence

During the final phase of the LGM the Palaeo-Rhine-Meuse-Scheldt confluence region was an extensive floodplain occupied by multiple seasonally shifting braided channels. The main controlling factors were extremely seasonal high-energy flows during spring and summer, linked to insolation (solar radiation) and a combination of the melting of the active permafrost layer, nival discharge from accumulated snow, surface ice break up and glacial-melt upstream. The Oldest Dryas is considered as being more arid than the full LGM (about 22-19 ka BP) with a clear decrease in channel activity and the deposition of significant aeolian deposits in the region (Busschers *et al.* 2007). A decrease in fluvial activity is also noted by the abandonment of some of the tributaries during this period. This period remains a time of erosion, with significant channel downcutting (Busschers *et al.* 2007).

The Oldest Dryas terrace deposits along the course of the Palaeo-Meuse and -Scheldt are sealed by extensive coversand dunes indicating an intense cold and dry phase before the rapid warming of the Bølling (Crombé & Robinson 2017; Huisink 2000; Vandenberghe 2002). Some of these aeolian deposits contain well-dated profiles in relation to fluvial deposits.

5.2.2.1.2 GI-1e-d (Bølling and Older Dryas): Palaeo-Rhine-Meuse-Scheldt confluence

The onset of the Late Glacial Interstadial (LGI) is abrupt in the palaeoclimatic record (Anderson *et al.* 2007; Lowe & Walker 2014) However, the main river systems in the Palaeo-Rhine-Meuse-Scheldt confluence do not appear to have reacted to the change immediately. Both Palaeo-Meuse and Palaeo-Scheldt appear to have remained as braided systems until around the mid-Bølling when they began to change to 'transitional channel' anabranching (divided flow) before meandering systems (Bogemans *et al.* 2011; Busschers *et al.* 2007; Huisink 1999; 2000; Vandenberghe 1995; 2003). The change is marked in the sedimentary records by the deposition of finer material in some channels indicating the onset of an aggradation phase(Busschers *et al.* 2007). This transitional phase appears to be absent in the Palaeo-Rhine trunk valley (Huisink 2000).

The delay in response to climatic warming may be related to a time-lag before the rivers reached the threshold necessary for the transition, or until the local river banks were stabilised by vegetation and soil development (Busschers *et al.* 2007). During this period, slope stability in the region was low and the vegetation remained park-steppe-type, with the development of shrubs and grasses inductive to runoff. There is also the possibility of

remnants of rapidly degrading permafrost (Busschers *et al.* 2007). Although generally low, precipitation-levels were rising with significant snowfall in winter providing nival input into the spring-summer river flow (Renssen *et al.* 2007; Renssen & Bogaart 2003). Some of the other Palaeo-Rhine tributaries remained braided throughout this period (Kasse *et al.* 1995; 2005).

5.2.2.1.3 GI-1c-a (Allerød): Palaeo-Rhine-Meuse-Scheldt confluence

The fluvial transition from braided to developed meandering single-channel systems was made throughout the Palaeo-Rhine-Meuse-Scheldt system by the onset of the Allerød (Bogemans *et al.* 2011; Kasse *et al.* 2000; Meylemans *et al.* 2013; Vandenberghe 2008). In particular, the Palaeo-Scheldt river has exceptionally preserved migrating meander systems with well-developed point bars (Bogemans *et al.* 2011; Kiden 2001). The extensive size of these well dated palaeo-meanders have led to an estimation of a flow rate at between 3-5 times that of the present river (Kiden 2001).

The Allerød cooler climate and higher precipitation levels, combined with the absence of permafrost and cryoclastic (frost-split) colluvial input, allowed for the development of soils, and provided time for vegetation to colonise the region and stabilise riverbanks, reducing slope erosion and sedimentary input (Vandenberghe & Woo 2002). The palaeorivers had a pronounced seasonal character, freezing in winter, and significant output during the spring and summer. The early summer would have seen substantial ice breakup periods and perhaps significant ice-damming in some regions (Vandenberghe & Woo 2002). During this period sedimentation is fine-grained and there is significant

development of levees and overbank flooding (Busschers *et al.* 2007; Vandenberghe & Woo 2002). The development of woodland during this period created the right conditions for the settlement of beavers, a major impact on river systems, controlling erosion and creating extensive wetland development and flooding along secondary courses (Coles 2001; Collins *et al.* 2006; 2015) . An important difference between the Rhine and the other tributaries to the network is that the Rhine was glacially fed and would most likely have its peak flow later in the season during mid and late summer.

5.2.2.1.4 GS-1 (Younger Dryas): Palaeo-Rhine-Meuse-Scheldt confluence

During the Younger Dryas the records of fluvial and aeolian deposits from the Palaeo-Rhine-Meuse-Scheldt confluence complement each other and provide a tight chronological framework for the transition from continental temperate to arctic environments in the region (Hoek 1997; 2001; Huisink 1999; 2000; Kasse *et al.* 2005; Tebbens *et al.* 1999; Vandenberghe 1995). A second 'transitional channel' phase was identified in all of the fluvial systems, that initiates almost immediately with the onset of arctic conditions (Huisink 2000; Vandenberghe 1995; 2008).

The seasonality of river flow is accentuated with the re-establishment of permafrost and extreme cold arid winters (Huisink 2000; van Huissteden & Kasse 2001; Van Huissteden 1990). This is combined with the development of aeolian deposits in the form of dune systems that seal both Allerød and Bølling deposits (Crombé & Robinson 2017; Huisink 2000; Tebbens *et al.* 1999). Due to the lack of lateral erosion usually associated with these high-energy flows (e.g. wandering braided channels) there appears to be a period of

incision and the development of anabranching channels seasonally during the strongest flows in spring-summer (Huisink 2000; Kasse *et al.* 2005; Vandenberghe 1995). There is a lag in the response to climate change within these tributaries, and the most important factor causing this appears to be the extent of vegetation cover.

Vegetation maintains a certain bank stability and withholds run-off, reducing to an extent the intensity of flow input, but also constraining the flow (Huisink 1999; 2000; Kasse *et al.* 2005; van Huissteden & Kasse 2001; Vandenberghe 1995; 2008; Vandenberghe & Woo 2002). After the onset of the Younger Dryas there was a gradual reduction of vegetation which appears to be directly correlated with the development of 'transitional' near braided river systems with anabranching channels or multiple meandering channels maintaining bank stability (Huisink 2000; van Huissteden & Kasse 2001; Vandenberghe 2008). The vegetation threshold therefore appears to be the main factor in reducing run-off and preserving bank stability (Brown 1997; Lewin & Gibbard 2010; Simmonds 2017; Woo 2012b). Some riparian vegetation was maintained throughout the Younger Dryas, and this may be a factor in the rapid transition back to meandering river systems at the onset of the Holocene (Vandenberghe 2008; Vandenberghe & Woo 2002).

5.2.2.2 Regional case study 2: Paris Basin tributaries (Palaeo-Somme and Palaeo-Seine)

The Paris Basin is a large Cretaceous bedrock sedimentary basin, consisting primarily of flint-bearing chalk (Antoine *et al.* 2007). Two major tributaries of the Channel River originated in and flowed through this basin: the Palaeo-Somme with its main trunk oriented southeast to northwest; and the Palaeo-Seine with its main trunk oriented

south-southeast to north-northwest (Pastre *et al.* 2000). The Palaeo-Somme, although one of the principle catchments of the Channel River, is dwarfed by the Palaeo-Seine that is the second largest tributary of the CRC after the Palaeo-Rhine (Antoine *et al.* 2003b; 2007; 2007; Auffret & Larsonneur 1971; Gibbard *et al.* 1988; Lautridou *et al.* 1999; Lefebvre *et al.* 1994; Lericolais *et al.* 1996; 2003; Pastre *et al.* 2000). The difference in size of these two fluvial systems may be reflected in their LG dynamic with variances in catchment and flow. The varied bedrock of the more extensive Palaeo-Seine catchment compared to the chalk bedrock of the Palaeo-Somme system may also have had an important impact on fluvial trends especially regarding sedimentary inputs during phases of climatic and vegetational deterioration for degrading chalk valleys (Antoine *et al.* 2007). Both river systems have extensively researched LG deposits, and are the closest comparisons for the Southeast England chalk river systems that are the focus of this thesis

The Palaeo-Somme LG fluvial system is characterised in detail, and is arguably the most detailed fluvial record available for the LG in the region (Antoine *et al.* 2007; Lefebvre *et al.* 1994; Limondin-Lozouet *et al.* 2002; Ponel *et al.* 2005). Furthermore, the chalk bedrock and geographic proximity make it directly relevant to SE England. The Palaeo-Somme's fluvial sediments are both coarse- and fine-grained calcareous clayey-silt periglacial deposits and fine-grained and organic temperate deposits. These are complemented by several rich palaeoenvironmental datasets: loess, pollen, palaeo-botanical, malacofaunal (terrestrial and aquatic molluscs), and chironomids (nonbiting midges), as well as by extensive dated LG archaeological contexts (Antoine *et al.* 2007; Coudret & Fagnart 2006b). These detailed palaeoenvironmental sequences and unique preservation makes

the Palaeo-Somme the type sequence for the LG of Northeast France (Antoine *et al.* 2007), and arguably the most complete continuous sequence for Northwest Europe during this period.

The Palaeo-Seine has been sub-divided into Lower, Middle and Upper sections (Antoine *et al.* 2007), with different characteristics in the three courses related to localised catchment conditions as well as to tectonic and fault variations (Antoine *et al.* 2007; Chaussé 2003; Pastre *et al.* 2000; 2003; Vandenberghe 2008). Most of the Palaeo-Seine tributaries flow through the Paris Basin Cretaceous Chalk-dominated deposits (Antoine *et al.* 2007; Pastre *et al.* 2000; Ponel *et al.* 2005). The Upper to Middle Seine tributaries (e.g. rivers Marne and Oise) incise into Cretaceous Chalks and Tertiary limestones, clays and sands (comparable to the Weald deposits of Southeast England) (Pastre *et al.* 2003, 2177). Some of the southern tributaries, notably the river Yonne, have their source within the igneous and metamorphic bedrock regions of the Massif Central (Antoine *et al.* 2007; Chaussé 2003; Pastre *et al.* 2000), and have different fluvial dynamics from the rest of the system during the LG (Antoine *et al.* 2007).

The Paris Basin palaeoenvironmental records are dispersed, with a concentration of well-preserved sequences at the confluence of the Palaeo-Seine and Palaeo-Yonne (Bodu 1995; 2003; Chaussé 2003; Debout *et al.* 2012; Roblin-Jouve *et al.* 2016), and some high-resolution sequences on the Palaeo-Oise confluence (Ponel *et al.* 2005). There is a high frequency of LG archaeological sites, notably around the confluence with the Palaeo-Yonne and further north along the trunk channel and its tributaries (Brézillon & Leroi-Gourhan 1966; Debout *et al.* 2012; Julien & Karlin 2015). However, to date, the high-

resolution palaeoenvironmental sequences are not in direct association with the archaeological sites, with many questions unresolved regarding chronology and local environments (Chaussé 2003; Debout *et al.* 2012; Pastre *et al.* 2003). This contrasts with the Palaeo-Somme where direct associations have been made between high-resolution palaeoenvironmental sequences and LG archaeological sites (Antoine *et al.* 2007; Coudret & Fagnart 2006b; Ponel *et al.* 2005).

5.2.3.2.1 GS-2a (Oldest Dryas): Paris Basin

Similar to the rest of Northwest Europe, during the periglacial conditions of the Older Dryas the Paris Basin rivers were laterally-eroding aggrading braided channels with high energy seasonal run-offs and relatively broad active floodplains (Antoine *et al.* 2007).

The Palaeo-Seine system extended over a large fluvial valley with high seasonal flows, and the catchment was fed by runoff and nival inputs during this period (Antoine *et al.* 2007). The lower tributaries, with sources in the Massif Central, had clear mineralogical markers revealing input and river regime during this period; e.g. the Etigny beds along the Palaeo-Yonne (Antoine *et al.* 2007; Chaussé 2003). There are also signs of potential tectonic deformation influencing the river flow to the west of the Palaeo-Yonne valley due to the uplift of the Senonian plateau (Chaussé 2003, 62). There appear to be substantially less windblown deposits associated with the Palaeo-Seine system in comparison the Palaeo-Somme and Lower Palaeo-Rhine systems, and this may be linked with its location in the Paris Basin and the dominant winds of the time (Antoine 2002; Antoine *et al.* 2003a).

The transition from Oldest Dryas to Bølling is not well-dated for the Palaeo-Seine although some clear deep LG transitional depositional sequences of sands and silts have been identified along the Palaeo-Oise tributary that are associated with a seasonal flooding regime (Pastre *et al.* 2003, 2178). These sediments have been dated by TL/OSL to 16-15 ka BP (Antoine *et al.* 1999; Pastre *et al.* 2003, 2178). They have been compared with sediments associated with and sealing Magdalenian deposits at the site of Étiolles in the Palaeo-Yonne system (Pastre *et al.* 2003, 2179), and this has led to some debate over the dating of Magdalenian occupation for the region (Debout et al. 2012; see Chapter 3).

The Palaeo-Somme system has some differences compared to the Palaeo-Rhine, notably that the porous chalk bedrock became highly-degraded under periglacial conditions and provided significant colluvial input to the river system in the form of flint-rich chalk (Lefebvre *et al.* 1994; Limondin-Lozouet *et al.* 2002). The chalk was quickly displaced downstream by high-energy seasonal flow leaving a flint bedload that was gradually worked into coarse sands and gravels, with fine calcareous lenses containing well-preserved molluscan faunas (Antoine *et al.* 2007; Limondin-Lozouet *et al.* 2002; Limondin-Lozouet & Preece 2014). The cold dry conditions and strong winds of this phase also led to the development of loess cover in the region, which was also redeposited by colluvial and fluvial deposits within the river valley (Antoine 1997a; Antoine *et al.* 2003a; 2003c; 2007).

5.2.3.2.2 GI-1e-d (Bølling and Older Dryas): Paris Basin

For the Paris Basin palaeorivers, the Bølling was marked by a transition in the braided channel fluvial systems, from multi-channels to a reduced number of active channels downcutting within the braided floodplain (Antoine 1997b; Antoine *et al.* 2000a; 2003c; 2007; Lautridou *et al.* 1999; Lefebvre *et al.* 1994; Pastre *et al.* 2003; Roblin-Jouve 1984).

A detailed palaeoenvironmental record for this period is provided by deposits from the site of Conty in the Palaeo-Somme system. Here there were five active channels during this period, which may be related to the higher flow regime at the confluence. This is comparable to the Scheldt-Maas-Vecht 'Transitional Channel' network, marked by a concentration of flow but an absence of vegetation for maintaining channels leading to an anabranching (divided flow) fluvial system (Vandenberghe 1995; 2008). At Conty, the incision action was clear, with Bølling channels cutting through hydromorphic-loess layers sealing the LGM braided channel sands and gravels (Antoine 1997b, 36). Shortly after the onset of the Bølling at Conty, the abandoned channels from the previous braided system as well as the newly active channels were rapidly infilled and humic peat deposits began to form (Ponel *et al.* 2005, 2450). The peats developed in two phases, a lower amorphous peat followed by a woody peat that developed around 12,370 to 12,300 BP (Ponel *et al.* 2005, 2450). With the return of cold condition in the Older Dryas, there was a sharp transition from peat formation to colluvial minerogenic deposits (Ponel *et al.* 2005, 2450).

With the Bølling climatic amelioration of warm summers and cold winters there was also a development of localised pooling and backwaters in the Palaeo-Somme catchment. This

was possibly associated with thermokarst (permafrost degradation), and with localised grassland and shrub development, albeit with minimal soil development (Limondin-Lozouet *et al.* 2002). The high porosity of the chalk bedrock led to increased colluvial activity and sedimentation (Limondin-Lozouet 2002), and loess continued to be deposited during the winters, at least in the early Bølling (Antoine *et al.* 2003a).

The Bølling transition was slightly different for the Palaeo-Seine Paris Basin rivers and for the Massif Central fed tributaries (Antoine *et al.* 2007). For this river system there was a transition to an anabranching (divided flow) multiple-channel network, similar to most river systems across Northwest Europe (Antoine *et al.* 2007; Vandenberghe 2008). The large meandering system of the trunk channel was fed by atmospheric precipitation (snow and rainfall), with a marked seasonality: stronger spring-early summer flows, decreasing towards the end of summer-autumn, before being frozen during winter. Similar to the Palaeo-Somme there was also a degradation of Oldest Dryas permafrost and the development of local thermokarst wetlands.

5.2.3.2.3 GI-1c-a (Allerød): Paris Basin

During the Allerød climatic factors combined with the development of vegetation, and renewed nival and run-off fed fluvial regimes led to the Palaeo-Somme developing a single channelled meandering system with seasonal overbank flooding (Antoine 1997b; Antoine *et al.* 2000b, 200; Limondin-Lozouet *et al.* 2002). The main channel was infilled with organic silts (Antoine 1997a, 39), and organic deposits and peats developed in areas of cut-off channels, overbank flooding and oxbow lakes (Antoine 1997a, 39). Loess is not

deposited during this period (Antoine *et al.* 2003a, 2016). At Conty, the Allerød is marked by overbank flooding and infilling of the alluvial valley from this single channelled meandering river course (Ponel *et al.* 2005, 2450). These Allerød deposits indicate a tripartite fluvial sequence; two organic deposits correlating with humid warm phases (GI-1c and GI-1a), separated by a small minerogenic lens indicating a cold phase (GI-1b) (Ponel *et al.* 2005, 2452). The lower organic deposits are representative of the *Betula* (birch) phase of the early Allerød (Ponel *et al.* 2005, 2450), and the upper organic deposit is a humic peat with indications of Pine forests and a more open forested landscape (Ponel *et al.* 2005, 2450).

Palaeo-Somme river flow was more regular throughout the Allerød, with seasonal flooding in spring-early summer associated with ice-break and snow melts, but also fed throughout the summer and early autumn by nival melts and a higher pluvio-atmospheric regime. Although it is considered as a period of relative stability with soil formation, there are indications of minerogenic run-off within alluvial deposits, indicating active erosion from the banks, as well as in floodplain deposits, indicating slope scarp input (Antoine 1997b). Numerous archaeological occupations dating to this period are also found on the lower terraces of the Palaeo-Somme overlooking the floodplain in direct relation to the meandering channel system and floodplain (Coudret & Fagnart 1997, 2006).

The Palaeo-Seine also stabilised into a meandering channel system during the Allerød (Antoine *et al.* 2007; Pastre *et al.* 2000). The onset of this period in the Paris Basin was accompanied by the development of shrubs and open birch forests (Figure 1.7, Figure 1.4 see section 1.1), followed by the development of birch-pine forests (Antoine *et al.* 2007;

Chaussé 2003; Pastre *et al.* 2000) and soil formation (Fedoroff & Goldberg 1982) The Palaeo-Seine developed into a meandering single channel system with vegetation helping to consolidate the banks, limit lateral erosion, reduce runoff intensity, and facilitate ground absorption of precipitation (Antoine *et al.* 2007). Strong seasonal river flow combined with Allerød overbank flooding is interpreted as the cause for the development of the fine lenses of overbank flooding at Pincevent. The flooding was perhaps due to nival inputs.

At the onset of the LG the Palaeo-Seine was a tributary of the Channel River, but with the rise of sea-levels during the Allerød its estuary was engulfed, and the river system was separated from its confluence with the Palaeo-Somme and Hurd's Deep. The Palaeo-Seine became an independent fluvial system cut off from the main Channel River network and developed a deltaic sedimentation regime in its lower course (Pastre *et al.* 2000). This could have an impact on human and animal dynamics along the riparian corridors by cutting off access to the Channel River floodplain.

5.2.3.3.4 GS-1 (Younger Dryas): Paris Basin

In the Paris Basin, the sudden onset of the cold and dry Younger Dryas period saw the fluvial networks transformed with the development of thick and homogeneous calcareous minerogenic deposits of overbank flooding from the initial large meandering main channel courses (Antoine 1997a, 39). The transition was initially associated with a down-cutting of the channels before the lateral expansion of the braided system (Antoine *et al.* 2007; Pastre *et al.* 2000). The downcutting apparently resulting from riparian vegetation initially impeding lateral erosion and aggradation and encouraging high-energy

seasonal flows to be confined to the river bed (Antoine *et al.* 2007). The transformation is recorded in the associated palaeoenvironmental assemblages from both the Palaeo-Somme and Palaeo-Seine, with a clear reduction in arboreal cover and a malacofaunal assemblage indicative of cold tundra environments at this time (Limondin-Lozouet 2011; Limondin-Lozouet *et al.* 2002; Limondin-Lozouet & Preece 2014; Pastre *et al.* 2000). This differs from the transition from single to multi-channelled systems identified around the Rhine-Meuse-Scheldt confluence.

The onset of the Younger Dryas at Conty (Palaeo-Somme) was marked by an erosional contact with the pine-dominated Allerød deposits, indicating a period of downcutting (Ponel *et al.* 2005, 2450). This was followed by a thick sequence of minerogenic calcareous overbank flood deposits (Ponel *et al.* 2005, 2450). The calcareous deposits eventually covering the whole floodplain under a regime of seasonal flooding. The source material was derived from weathering of chalk bedrock washed into the channels during the spring-summer thaws (Ponel *et al.* 2005, 2450).

Similarly, in the Palaeo-Seine system the Younger Dryas onset is indicated by significant sedimentary destabilisation, and by extensive calcareous-silt channel infills and overbank flooding deposits (Antoine 1997a; Pastre *et al.* 2000; 2003). This accompanied a change in fluvial dynamics, with a rapid change from meandering to multiple channel systems; this transitioned towards a fully braided system (Antoine *et al.* 2007; Vandenberghe 2002).

5.2.2.3 Regional case study 3: Southeast England (Thames and Hampshire Basins)

Southeast England has the most developed sedimentary archive in Britain in relation to the Channel River network (Rose 1995). It also contains extensive loess deposits (Antoine *et al.* 2003a; Catt 1979; 1985; 2008; Kemp *et al.* 1993) and a series of hydrologically related dry-valleys in the chalk scarps with palaeoenvironmental records combining dryland and hydrological indicators for the LG (Kerney *et al.* 1963; Parker & Goudie 2007; Preece & Bridgland 2012). The local bedrock is dominated by Cretaceous Chalk and Tertiary fine sand, silt and clay beds (Branch & Green 2004; Bryant 1983b; Green *et al.* 2013; Macphail & Scaife 1987; Rose 1995) all of which are soft sediments suitable for the development of thick alluvial sequences (Brown 1997). The overall trend for southern British lowland LG river systems appears to be similar to the comparable Northern European sequences, with some local variations due to deposit type (aggradation/erosion) and the sizes of river courses. The most informative sequences are all from medium size tributaries and stretches of river courses.

This case study focusses on the two main fluvial systems in the region: the Palaeo-Thames to the north (Thames Basin) and the Palaeo-Solent to the west (Hampshire Basin) of the Weald (Figure 5.14). These are two of the most studied river systems in Britain and provide detailed palaeoenvironmental records for the LG, with tributaries (Rivers Colne, Lea, Kennet, Wey and Avon) providing corroborative LG sequences (Allison *et al.* 1952; Bates 2016; Bryant 1983b; Chartres 1980; Cheetham 1975; Collins 1994; 1994; Collins *et al.* 2006; Coope 1982; Dyer 1975; Gibbard & Hall 1982; Gibbard & Lewin 2002; Gibbard 1985; Godwin 1964; Grant *et al.* 2014; Green *et al.* 2013; Jones 2013; Rose 1995). The Palaeo-

Thames joined the Palaeo-Rhine before the Straits of Dover (Bridgland & D'Olier 1995; Bridgland 1994; 2006; Bridgland *et al.* 1993; Busschers *et al.* 2007; Collier *et al.* 2015; D'Olier 1975; D'Olier & Maddrell 1970; Gibbard 2007a, 201520152; Gupta *et al.* 2017; Hijma *et al.* 2009; 2012; Mellett 2012; Mellett *et al.* 2012; Smith 1989; 1985). The Palaeo-Solent was the largest tributary of the Channel River Northern Palaeovalley. Most of the medium-sized tributary river courses in this region drain from the Weald both north (Kennet, Wey, Mole, Darenth and Medway rivers) and to the south (Rother, Ouse, Adur, Cuckmere and Arun-Rother rivers)(Bellamy 1995). Not all of the smaller river systems have preserved or published LG sedimentary records (Bellamy 1995; Rose 1995). Where appropriate reference is also made to other southern English Rivers with important Late Glacial sequences (e.g. the Gipping, Nene and Great Ouse rivers in Eastern England)(Briant *et al.* 2005; Brown 1997, 193–99; Gao *et al.* 2007; 2000; Gao 1997; Rose *et al.* 1980). The case study provides the regional context for the core thesis study area.

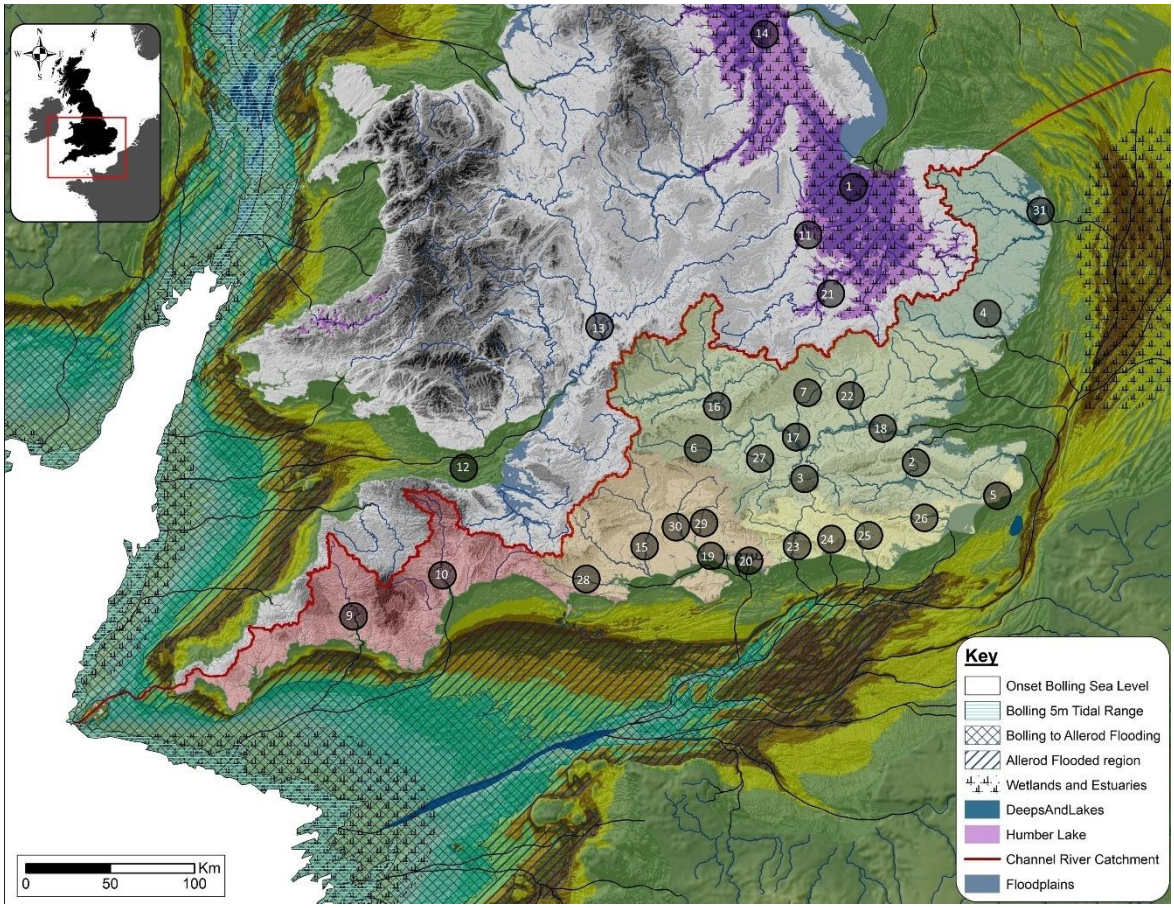


Figure 5.14 Fluvial and associated environmental records for SE England. Reference fluvial deposits mentioned in the text. 1: Humber Lake, 2: River Medway, 3: Rivers Wey and Mole 4: River Gipping, 5: Holywell Coombe, 6: River Kennet 7: River Colne 8: River Arun, 9: River Axe, 10: River Exe, 11: River Nene 12: Severn Estuary; 13: Severn; 14: River Trent; 15: Bournemouth Avon; 16: Upper Thames; 17: Middle Thames; 18: Lower Thames and Estuary; 19: The Solent, 20: Chichester Harbour, 21: River Great Ouse, 22: River Lea;, 23: River Arun, 24: River Cuckmere, 25: River Ouse, 26: River Rother, 27: River Blackwater, 28: River Frome, 29: River Test, 30: River Itchen, 31: River Stour (Source: Author. Basemap OS TOPO 50, EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

5.2.2.3.1 The Thames Catchment

The course of the present River Thames runs for over 345 kms, and is the second longest river in Britain (by only a few kilometres) after the River Severn. The Thames is conventionally divided into four sections based on geomorphological and geological characteristics: Upper, Middle, Lower and Tidal (Bridgland 1994; Gibbard 1985; Goudie 1993). The Upper Thames flows from its source to the confluence with the River Windrush at Newbridge. The Middle Thames runs to the confluence of the River Kennet in

Reading. The Lower Thames runs to the upper tidal limit of the Thames at Teddington weir. Today's tidal Thames runs from Teddington onwards, however this stretch would not have been tidal during the LG and would have extended further into the Southern Bight to join the Paleo-Rhine immediately upriver of the Straits of Dover and the Channel River section.

Two types of fluvial sedimentary records can be associated with the LG in the Thames catchment: extensive gravel and sand beds; and fine silt-clay and organic deposits. Whereas the gravel and sand beds provide a sense of the high intensity flow of this system, they are erosional and high energy, and are representative of the latest event within the sequence potentially masking a fluctuating seasonality. The finer deposits not only provide information on the local fluvial dynamics, but also often contain evidence of the local environment (organic material, phytoliths, pollen, mollusca, malacofauna). The latter also have potential for *in situ* archaeological deposits as they are deposited under low energy conditions (e.g. slow flow rates, over bank flooding, cut-off channels).

There are two principle reference sections for LG gravel and sand deposits in the Middle Thames at Shepperton (GS-2a and LG) and Kempton Park (LGM to LG). These Gravel Groups contain coarse sands and gravels indicative of a braided nival fed fluvial system. Fine sedimentary deposits for the main course of the Thames have been identified in the Upper Thames at Thrupp House Farm, Abingdon (Aalto *et al.* 1984). These are mid-channel organic deposits preserved within a fine silt sedimentation forming within a depression on top of a gravel surface. These were subsequently sealed by sands and gravels consistent with a nival regime. The dating and palaeoenvironmental dataset

(pollen, coleoptera, mollusca) indicate a pre- or early Bølling deposit, with a close to full glacial assemblage and are consistent with dates associated with the Shepperton Gravel beds in the Colne and Kennet valleys (Aalto *et al.* 1984, 77). They indicates presence of short grass/shrub cold environment at the onset of the Bølling, with a very strong wetland signature of marsh and aquatic communities, that might be tied to a thermokarstic (degrading permafrost) environment.

Sedimentary and palaeo-environmental data has also been found in Woolhampton Formation deposits from the Middle Thames near Reading, at the Newbridge to River Kennet confluence. These deposits represent one of the most continuous LG sequences in England, and the channel fills provide excellent preservation of macro-organic material directly dated to the LG and sealed by Younger Dryas deposits (Collins 1994). The Kennet valley sequence is of particular importance as it demonstrates an expansive floodplain with wetland potential during the LG. As a southern tributary of the Thames it is also relevant for the interpretation of the River Wey and Mole sequences. Significant sequences of LG sands and fine sediments have also been identified for both northern and southern tributaries of the Thames, including the Rivers Colne, Kennet, Lea and Wey. Complimentary wetland datasets can also inform on local hydrological dynamics. The boreholes made for the development of the Jubilee underground line in East London recovered an important sequence of LG organic deposits (Sidell *et al.* 2000). A more recent series of boreholes near Brockhill and at Elstead Heath have recovered an important sequence of LG organic deposits from wetlands associated with the Wey fluvial system (Simmonds 2017).

5.2.2.3.2 The Palaeo-Solent Catchment

The Palaeo-Solent is arguable the fluvial system the most affected by the submergence of palaeochannels with the rise of sea levels during the LG in the region. It is also the most important tributary to the Northern Palaeovalley trunk of the Channel River system. Nearly half of the fluvial system was submerged. The most important tributaries of the Palaeo-Solent catchment today exposed above ground are the Bournemouth Avon, Test, and Frome rivers. Today adjacent regions of Langston and Chichester Harbour used to be catchments for tributaries to the Palaeo-Solent. The fluvial system on the Isle of Wight would also be a series of tributaries to the Palaeo-Solent.

Continuous LG sequences are rare in the catchment, with some of the best preservation in the form of organic sequences recovered up-river in the New Forest region from former wetlands (Barber and Brown 1987). Palaeovalley infill from Chichester Harbour might also potentially provide such sequences. Further information on LG fluvial patterns for this catchment is derived from sub-surface topography and geomorphology with associated boreholes. Although the Palaeo-Solent is amongst the most studied palaeo-river systems in Britain, very little has been recovered directly associated with the LG.

5.2.2.3.3 GS-2a (Oldest Dryas): Thames and Hampshire Basins

The records for the cold-dry period of the Oldest Dryas (GS-2a) in this region are two-fold: fluvial sands and gravels, and indirect coversands and loess deposits. This is the phase immediately predating the earliest re-occupation of Britain following the LGM (Jacobi & Higham 2011b). Key sedimentary deposits in the Thames Basin are the Kempton Park

gravel and sands sequence (Gibbard & Lewin 2002), and preserved lenses of fine material with organic residues at Abingdon (Aalto *et al.* 1984) and the Lea Valley (Allison *et al.* 1952; Corcoran *et al.* 2011; Reid 1915; 1949). Equivalent deposits in Hampshire are the Lower Terrace of the River Avon. It is generally assumed that the lowest terraces of southeastern English river systems follow the dynamic of downcutting at the onset of the LG (Bølling) followed by a laterally eroding gravel and sand bedload braided floodplain (Gibbard & Lewin 2002). A similar pattern is recognised in the southern Channel River fluvial tributaries, with the last series of terrace gravels deposited during this period along the Somme, Seine, Scheldt, Meuse and Rhine systems as well as loess deposits (Antoine *et al.* 2003b; 2007). Dated archaeology for the Early Dryas age is sparse and only occurs in the caves of western Britain. There is no direct or indirect evidence associated with fluvial deposits dating to this period other than the local geography, with river systems that had to be traversed or skirted following interfluves to reach these cave sites.

5.2.2.3.4 GI-1e-d (Bølling and Older Dryas): Thames and Hampshire Basins

The onset of LG warming with the Bølling (GI-1e) is not specifically recorded in British LG fluvial records. The gravel and sand deposits of this age are high energy and erosive, and appear to be infilling down-cut channels. The downcutting may be initiated at the beginning of the warming, with the high energy flows released from frozen ground, soon followed by an aggrading laterally eroding gravel sequence (Lewin & Gibbard 2010). The main trunk channels, notably in mid to lower stages of these river courses are therefore unlikely to preserve fine-resolution LG alluvial deposits. Better evidence is available from Thames tributaries and medium-sized fluvial sequences. The Colne Valley has evidence

for preserved LG deposits associated with both the Bølling and Allerød (Gibbard & Hall 1982). The boreholes associated with the Jubilee underground line in London also has signs of this transition with minerogenic alluvial deposits (Sidell *et al.* 2000). The dry valleys in the chalk scarps have indirect evidence for this transition, with indications of marshy standing water during this period (Preece & Bridgland 2012; 1999).

5.2.2.3.5 GI-1c-a (Allerød): Thames and Hampshire Basins

The Palaeo-Thames and Palaeo-Solent gravel beds sequences dominate the main river valleys during the Allerød. It is suspected that these British river courses could have had a transitional anabranching or even a meandering system during this period (compared to other NW European sequences), however there is no direct evidence as yet (Gibbard 2007a). The Allerød remains the period with the richest evidence for LG fluvial activity and groundwater in the form of organic rich deposits within the tributaries and wetlands. These indicate a general stabilisation of the river channels, and transition to a meandering system in the middle and lower reaches of these courses. There is a strong seasonality, and a general cooling trend throughout this period, with rivers freezing-over in winter and fed by relic snow cover in summer (nival fed flows). Spring and early summer were marked by strong ice-breakup dynamics and overbank flooding of the floodplain, as recognised in the Kennet Valley (Collins *et al.* 1996) and the Great Ouse (Gao 1997). Late summer would be a period of significantly lower flow and water levels, although constrained to a single channel system. Within the study this has been best recorded in the Kennet (Collins *et al.* 1996) and Colne (Gibbard & Hall 1982) valleys. The dry-valley colluvial deposits indicate soil formation, and therefore vegetation and

stabilisation (Preece & Bridgland 2012). Wetlands have preserved rich vegetation assemblages indicating the development of arboreal and shrub cover in SE England (Parker & Goudie 2007; Simmonds 2017). These conditions were ideal for the development of beaver activity (section 6.2.3.2) and damming along secondary courses and tributaries in the region (Coles 2006).

5.2.2.3.6 GS-1 (Younger Dryas): Thames and Hampshire Basins

The abrupt transition to the Younger Dryas marks a return to a braided channel system along the main trunk courses of the Palaeo-Thames and Palaeo-Solent as well as its tributaries. There is very little evidence for this period, mostly marked by an erosional interface in the sequences. Fluvial sediments along the Kennet and Colne are marked by a transition to minerogenic floodplain silts towards the end of this period (Collins 1994; Lewis & Rackham 2011). Erosion picks up again within the dry-valley sequences (Preece & Bridgland 2012) indicating the degradation of ground conditions and minerogenic input into the fluvial systems, comparable to the Somme Valley.

5.3 Concluding comments

This chapter has discussed the changing climatic, fluvial and environmental riparian regimes of the CRC and Channel River. The first part considered the scope and extent of the entire LGCRN and noted that significant topographic features of this landscape, now largely submerged, would have had a direct impact on human and animal mobility patterns in the LG. These include features such as trunk valleys, major confluences, cliff lines, wetland zones, palaeo-lakes and marked topographic relief. The second part focused on the CRC tributaries and the sedimentary reference sequences that enable an overview of the fluvial regimes varying under the influence of climatic fluctuations, palaeo-vegetation development, bedrock and seasonality. It also presented a characterisation of the fluvial regimes throughout the LG, with specific reference to three case studies.

The following Chapter 6 integrates the distribution of archaeological sites with this dynamic landscape framework and considers the potential relationships between site locations and fluvial regimes with emphasis on chalk and limestone bedrock of Southeast England. The objective being to present a coherent context for interpreting LG human activity in Southeast England within a larger regional landscape framework.

Research and discussion of the LG fluvial regimes in Northwest Europe has incorporated Arctic and Boreal fluvial analogies. Chapter 7 extends these analogies to consider human and animal mobility in these regions. Based on historical and anthropological data it also

considers the advantages and constraints of specific mobility patterns and resource management in relation to climatic, environmental and fluvial regimes.

Chapter 6 Human interactions with rivers, and the effect of rivers on human mobility systems

"Do people who live with a river also think like a river? Does everyday, and professional engagement with a flowing stream resonate with ways of understanding social and ecological relationships in terms of flows?"

(Krause 2010, iii)

This chapter discusses key physical and environmental components and their potential influence on animal and human mobility around the evolving riparian landscapes of the Lateglacial Channel River (LGCR) system. The discussion focusses on the exposed LGCR valley, a high-relief topographic landscape within a low gradient valley (Collier *et al.* 2015; Collier 2017; Gupta *et al.* 2017). See Chapter 5 for discussion of the LGCR. These LG fluvial components have rarely been used in modelling landscape approaches to mobility, despite being basic topographic and environmental constraints. This chapter takes the innovative approach of considering the environmental and fluvial components together in order to build a landscape framework for modelling Late Glacial human/animal mobility systems and developing further understanding of the significance of LG archaeological site locations.

The analysis aims to provide a more complex and holistic approach than GIS-based least cost path analysis, which evaluates the most efficient path to travel between two locations in terms of time and topography. Instead, the current analysis attempts to polarise and characterise regions with regard to mobility patterns based on multiple sets of data. It considers riparian environments as catalyser, polariser, and as barrier to

mobility for both animal populations and for associated human movements through these landscapes. In essence, the role of rivers within a hunter-gatherer mobility framework is considered as an essential step for distribution analysis of individual archaeological site and find locations within a dynamic landscape, and with resulting inferences for regional interaction and mobility patterns. These ideas and models are further developed in Chapter 7 with reference to the typo-technological archaeological datasets and distributions presented in Chapters 3-4.

Chapter 6 is divided into three sections:

Part I - Direct and indirect archaeological evidence for long-distance mobility and cross-channel movement. This section considers evidence from artefacts, raw materials and animal migration behaviour. Seasonal animal behaviour is considered to have a direct impact on human landscape strategies during the LG.

Part II - Fluvial seasonality, polarity, conduits and barriers. This section considers river systems as influencing human movement and behaviour in relation to topography and rivers. It considers fluvial seasonality, the attraction of rivers for resource availability, rivers as conduits and barriers, and how they may be used to categorise landscapes.

Part III - Technological adaptations and cognitive mapping of fluvial landscapes. This section considers factors relevant to scaling and modelling mobility in LG landscapes. It focusses on variables that significantly affect mobility, and on technologies that can be adapted to these conditions. It also presents different scales of analysis for site distributions, and for potential long-distance movement/exchange.

Part I Archaeological Evidence for LG mobility

6.1 Late Glacial archaeological artefacts indicating long-distance transport for SE England and neighbouring regions: movement or trade

Part I of Chapter 6 examines the direct and indirect archaeological evidence for long-distance scales of mobility and cross channel movement. Many potential sources of material can be identified within the catchment, whereas others are found outside of it, potentially indicating different mobility patterns. Two main themes are examined: (1) the artefactual record with direct sourcing and indirect stylistic-technological traits; (2) the faunal record, which represents the closest evidence for landscape use based on the current knowledge of animal behaviour in relation to landscape features that can be modelled in relation to archaeological distributions in Chapter 7.

6.1.1 Marine evidence, artefacts and shells

The distribution of marine shells and faunal remains are distinct sets of evidence for long-distance transport/trade of goods and movement of people. The Magdalenian sites of Gönnersdorf and Andernach, although preceding the LG, have some of the best evidence for exploitation of marine mammals across the same landscape, with the depictions of seals on stone plaques (Bosinski & Bosinski 2009; Hansen 2006). Evidence of whale bone at the same sites indicate the transportation of this material over 1000 km from either the Southwestern France (Langley & Street 2013), or as argued here, from the mouth of the Channel River. Hurd's Deep would be a closer location for both seals and whales during this period at 600 km (see also section 6.5.3.5 on seals), not outside of the realm of long-distance migrations and along the same river course.

Long-distance movement throughout Northern Europe during the LG is demonstrated by the distribution of marine shells and fossil shells (Eriksen 1996a; Taborin 1993, 54, 93, 151). Questions remain concerning whether these were traded through exchange networks or represent groups circulating throughout the region (Eriksen 1996a; Langley & Street 2013). Similar patterns have been identified in Britain with rare examples in the LG (Barton & Roberts 1996b), and significantly more during the Early Mesolithic (Barton & Roberts 2015).

Contrasting with Bølling human remains in Cheddar Gorge and human remains at Kendrick's Cave, located relatively far inland at the time (c. 55 km to the tidal Irish Channel, Figure 6.1), provides isotopic evidence for a diet that could be enriched by either freshwater or marine resources at a location relatively far inland (Richards *et al.* 2005). This is an indicator of close interactions with either fluvial or marine resources, indicating a certain dynamic within the landscape. However this does not provide direct evidence for long distance mobility on its own. Of interest too is the absence of marine signatures in the human remains at Sun Hole and Gough's Cave in the preceding Bølling, implying different landscape and resource strategies (Richards *et al.* 2000; Stevens *et al.* 2010).

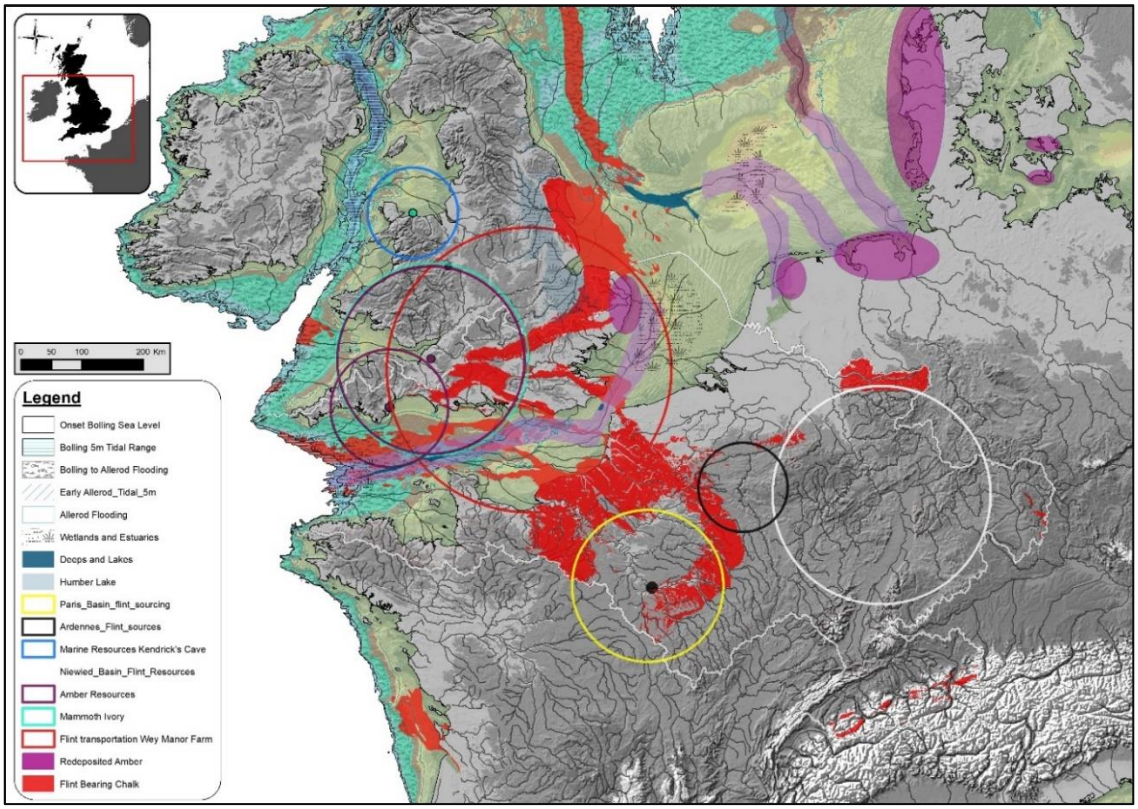


Figure 6.1 LG Estimated distances derived from exotic artefactual resources. The minimal distance of transport (direct or exchange) of flint raw material are presented for the Paris Basin (yellow), the Somme (black), the Niewied Basin (White), and flint sources in the South Downs (red). The estimate for mammoth ivory (light blue) is based on the distance from nearest known contemporary sites of Condover and Gough's Cave and centred on Gough's Cave. The purple circles indicate the closest potential sources of amber to Gough's Cave and Kent's Cavern. The blue circle around Kendrick's Cave indicates the closest tidal zone with potential marine mammals. (Source: Author. Basemap EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1)

6.1.2 Amber

Amber is identified at Gough's Cave, with several pieces recovered and one excavated from the most recent 1986 British Museum excavation within a Creswellian stratigraphic context (Beck 1965; Charles 1989; Currant *et al.* 1989; Jacobi 2004; Pettitt 2012; Tratman 1953). The closest source at the time is the region of Doggerland (Beck 1965; Jacobi 2004), but more specifically likely sourced to the Norfolk coast on the border with the Channel catchment 300 km as a bird flies Figure 6.1, and the most accessible route would be following the North Downs ridgeways (see also section 7.2.5). This again demonstrates

significant distances (Conneller 2007) and a southeast to east connection. There is also another unnoticed potential source for amber, with the material being transported within the Channel River system, carried down river from high standing gravel beds from the Norfolk coast or Doggerland (Figure 6.1). This would reduce the distance travelled to 160 km, and indicate a direct north-south mobility axis and a direct relation with the Channel River. Both models show distances over 150 kilometres.

6.1.3 Flint

Important assemblages with distinct raw materials have been identified in the Neuwied Basin (Baales 2004; Floss 2002); the Belgian Ardennes (Charles 1996; Moreau *et al.* 2016) and the Paris Basin (Antoine *et al.* 2012; Valentin *et al.* 2002), and Brittany (Naudinot 2013; Naudinot *et al.* 2017b; Naudinot & Jacquier 2014). In Britain, the situation is complicated by the very rich flint region of the Southeast, where it is difficult to distinguish flint sources (Pettitt *et al.* 2012; Rockman 2003b). Both macroscopic and chemical analysis (Figure 6.2) have sourced flint material from the Southeast in all of the cave concentrations in Britain: Kent's Cavern, Cheddar Gorge and Creswell Crags (Barton 2010; Barton & Roberts 1996b; Bond 2013; Jacobi 2004; Pettitt *et al.* 2012; Rockman 2003b). The majority of this source is found within the Channel River catchment of SE England (Figure 6.1 and Figure 6.3).



Figure 6.2 Raw material movements from source to site for Farndon Fields, Bradgate Park and Wey Manor Farm. Arrows from flint locales to sites indicate relative contribution and confidence of source region to tested site assemblages, with black representing highest contribution and light grey lowest contribution. Transparent arrows indicate findings from the pilot study. Base map drawn by Mitch Levine. (Pettitt et al. 2012).

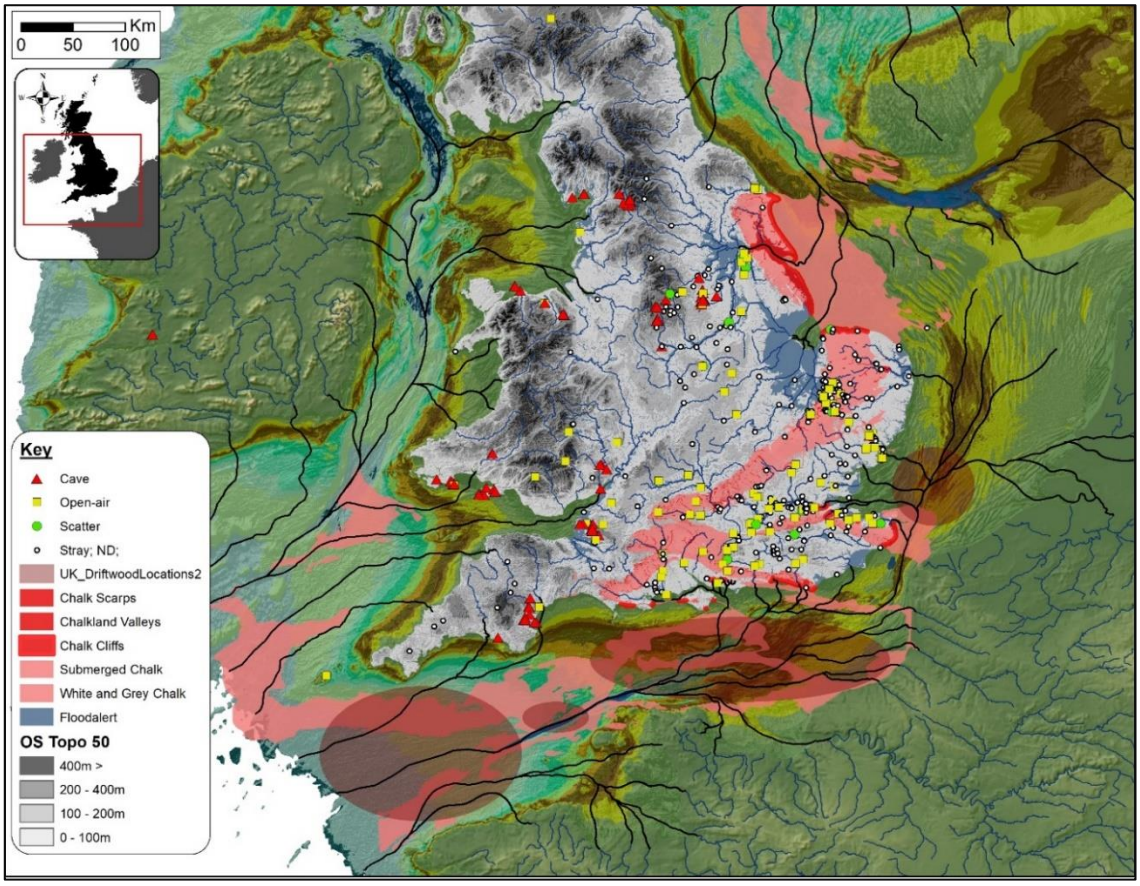


Figure 6.3 Flint sources around Southeast England and the Channel River. (Source: Author. Basemap EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1)

Another source, frequent around Creswell Crags, is presumed to be in Doggerland, possibly derived from submerged sources or glacial till and indicating an eastward movement (Conneller 2007; Pettitt *et al.* 2012). Further north in Scotland, Allerød raw material resources appear to indicate coastal connections (Ballin *et al.* 2010).

This highlights three regions through/from which movement is clearly identified: The Southeast, Doggerland and around the Scottish coast. For the Southeast these provide direct evidence of distances travelled of materials that are comparable to the distances identified in Northern Europe (Rensink 1995). This also brings all groups into proximity of the Channel River Network to the south.

6.1.4 Worked Mammoth ivory and Reindeer antler

Bølling and Allerød mammoth and reindeer organic material associated to lithic assemblages have only been recovered from cave sites. There is no evidence for the direct hunting of either woolly mammoth or reindeer in British LG cave assemblages, but a small collection of c. 20 highly worked and in some cases decorated objects made from mammoth ivory (King Arthur's Cave, Gough's Cave, Kent's Cavern, and Pin Hole) and reindeer antler (Jacobi 2004). However, stylistically Magdalenian-styled artefacts made from mammoth ivory (sagaie) (Figure 6.4) and reindeer antler (*Bâton percé,* Figure 6.5, barbed points, Figure 6.6) have been found in association with Creswellian assemblages (Bello *et al.* 2017; Burkitt 1932; Currant *et al.* 1989; Julien 1982; Langley 2015; 2017; Lucas *et al.* 2019; Pétillon 2016), and direct dating has confirmed their age (Charles 1989; Currant & Jacobi 2011; Jacobi 2004; Jacobi & Higham 2009b) (Figure 6.1).

These artefacts indicate at least two important elements in reference to mobility and distances. Firstly, they have direct parallels with the Paris Basin and Belgian Ardennes Magdalenian material stylistically, as well as material from SW France, indicating a possible north-south axis of cultural connectivity following the LGM (Charles 1989; Garrod 1926; Jacobi 2004).

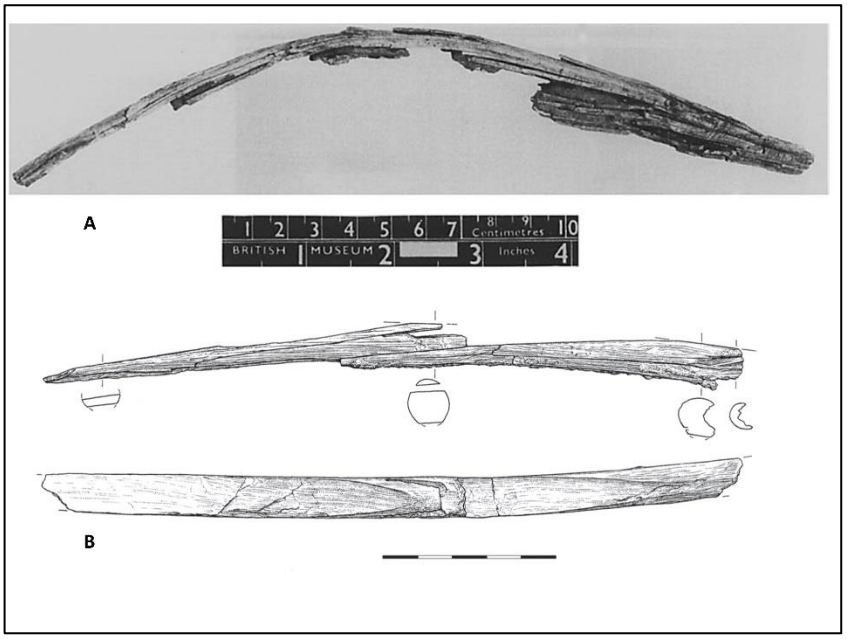


Figure 6.4 English Late Glacial mammoth ivory artefacts. ***A****: Part of the mammoth ivory weapon head ('sagaie') from Gough's Cave, conserved at the British Museum (Currant et al. 1989); B: rod (baguette) from Kent's Cavern made from mammoth (Mammuthus primigenius) ivory and with scooped end, perhaps a foreshaft. Torquay Museum. (Jacobi and Higham 2009: 143).*



Figure 6.5 Engraved artefacts from Gough's Cave. 'bâton percé'' made from reindeer (Rangifer tarandus) antler (PAE 7782), front and rear views; (D) fragment of 'bâton percé'' made from reindeer antler (PAE 7783), front and rear views. (Bello et al. 2017: 5)

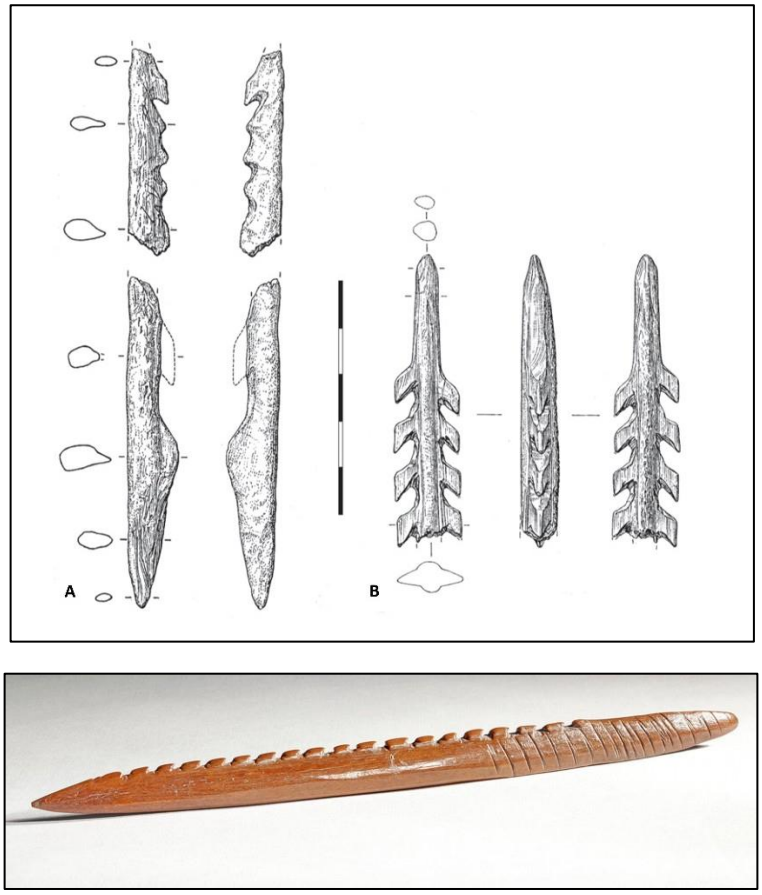


Figure 6.6 English Late Glacial barbed points. ***Upper****: Directly dated Bølling Creswellian uni-and bi-serial barbed points from Kent's Cavern of the same design and style as Magdalenian barbed points (Garrod 1926, Jacobi and Higham 2009: 142).* ***Lower****: Late Allerød[33] uni-serial barbed point made of red deer antler recovered in 1932 by the Colinda fishing vessel and dating to the Allerød of a Federmesser design, this is a good marker of the use of this submerged landscape. Length of specimen is 219 mm. Found at Leman and Ower Banks, Doggerland, currently submerged in the North Sea (Bailey et al. 2020).*

Secondly, the origins of these materials are still in question as neither mammoth or reindeer open-air kill sites have been identified in Britain dating to this earlier part of the LG, and there are no cut marks indicating consumption of the faunal remains in the cave sites (Barton & Roberts 1996b; Currant *et al.* 1989; Jacobi 2004). As these faunas are often associated on the Mammoth Steppe, this is presumed to be their origin, and a hypothesis for the Northern European plain and the region of Doggerland was put

[33] Dated to the Allerød (OxA-1950, 11,740±150BP; 95%: 14,013 to 13,312 cal BP with the IntCal 20 curve), (Bonsall & Smith 1990).

forwards, but very few LG finds have been recovered from the North Sea (Amkreutz *et al.* 2018; Coles 1998; Gaffney *et al.* 2009; Housley 1991; Peeters & Momber 2014; Pettitt 2012; van der Plicht *et al.* 2016), albeit the Lehman and Owen bank harpoon (Figure 6.6) indicates Allerød activity ((Bailey *et al.* 2020; Burkitt 1932). The possibility of a north-south axis crossing the Channel River could also be envisaged as LG reindeer artefacts are identified at Kent's Cavern, and the closest contemporary mammoth remains (Table 6-1) to that site are either located directly north (Condover, Shropshire) or south (Paris Basin) (Lister 1991; 2009; Stuart *et al.* 2004; Stuart 2005). This question will only truly be answered by ancient DNA linking these artefacts to specific mammoth and reindeer populations, or by isotopic evidence (e.g. indicating freshwater consumption patterns) identifying the regional groups they are associated with (Drucker *et al.* 2012; 2011; 2018; Stevens *et al.* 2008; 2010).

Table 6-1 Directly dated Late Glacial mammoth in Britain and Northern France

Lab no.	Radiocarbon age	1s	Median calibrated age	2s	Calibrated age 95% range	Material	Site	Reference
OxA-12019	12135	55	13989	74	14 126-13 836	bone	Etiolles, NE France	Stuart & Lister, in prep. (date replaces Ly-1351)
OxA-20129	12230	50	14088	81	14239-13940	Adult tusk	Condover	Lister 2009
OxA-12018	12235	75	14105	148	14487-13 865	bone	Buisson Campin a Verberie	Stuart & Lister, in prep.
OxA-1462	12320	120	14323	248	14877-13947	tusk	Robin Hood's Cave, Derbyshire	Lister 1991
OxA-19903	12375	50	14361	175	14747-14101	Juvenile cranium	Condover, England	Lister 2009
OxA-1204	12460	160	14541	283	15079-14035	calcaneum	Pin Hole Cave, Derbyshire	Lister 1991
OxA-17846	12470	55	14549	193	14914-14207	tusk	Gough's Cave, Cheddar	R. Jacobi 2008 (date replaces OxA-1890)
OxA-12020	12800	65	15115	131	15418-14881	tooth	Marolles-sur-Seine, France	Stuart & Lister, in prep.

6.1.5 Conclusions and Techno-typological distances

The assessment of the LG archaeological evidence in Britain for mobility and range in section 6.1 has highlighted that large-scale mobility was integral to the landscape occupation strategies, most probably through direct mobility rather than exchange (Figure 6.1). A potential indication of mobility, is suggested in the use of either marine resources or freshwater, to the extent that they represent a high enough proportion of the Allerød diet to be represented isotopically (section 6.1.1), although these resources might also be found locally, and therefore this should be considered with caution. Specific raw materials such as amber indicate a source most likely within the Channel River catchment, currently off the coast of Norfolk, and in close proximity to the interfluve providing a relative dryland passage with mainland Europe (section 6.1.2). This indicates a southern and eastward origins of this resource. It is not self-evident that this was derived directly and not through a trade network, however the transportation of pre-prepared flint blocks from a nearby region suggests individual transport over long distances, at least during the Bølling (Jacobi 2004, Barton 2010). This is further complemented by the laser-ablation results sourcing flint raw material, most of which is provenanced from Southeast England, and managed for long-distance transportation by core preparation and reduction (section 6.1.3). The longest direct route is from sources near the Wey catchment to locations in Yorkshire, and this is the most compelling evidence for nearly 250 km. Finally, the worked mammoth and reindeer material, with an absence of either animal present as butchered in British cave sites, indicate a probable seasonal variation-mobility towards regions of the tundra-steppe rich in migrating herds. These are recognised archaeologically in the Paris Basin and Northern Europe, and could once again be an

indication of an eastward or south-eastward mobility pattern (section 6.1.4). These ranges are summarised in Table 6.1, and average around 250 km. There is clearly a general trend towards the south and southeast.

This trend can be further exemplified when considering the techno-typological characteristics described in Chapters 3 and 4 and their contemporary parallels in Northern Europe. Multiple sites on mainland Europe bear very similar technological and typological characteristics that would encourage the consideration of some sort of link (Barton 2009). These range in average from 250 to 450 km away (see map; table 6.2) may be considered as minimum extents. There may be a pattern of longer distances during the Bølling up to 500km, and more localised distances up to 250 km in the Allerød. Most importantly is that these indirect archaeological links for the vast majority indicate movement across the Channel River system. When taking all of this evidence together a south/southeast to north dynamic begins to emerge, and the Channel River is most likely traversed or skirted throughout this period (Figure 6.7). The ranges adopted here are up to 250km for raw material procurement and 1000 km for trade networks (Figure 6.8). Mobility and distance are further considered in section 6.8.5, and ethnographic examples are considered in section 6.8.5.5.

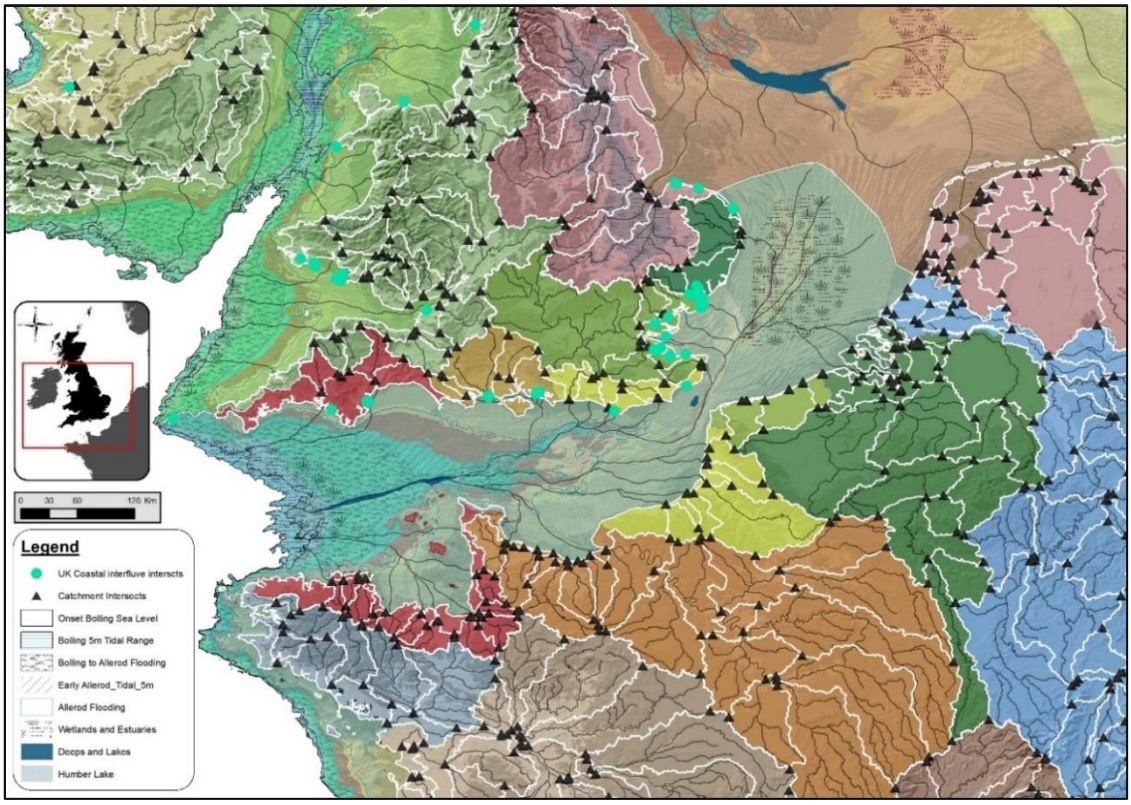


Figure 6.7 Interfluves along the Channel River Network indicating elevated pathways. The white lines represent the interfluves, and therefore elevated land between regions. The black triangles indicate the junction of multiple high ridges, and therefore strategic locations for views and access to multiple river catchments. The light blue circles indicate where interfluves are cut by the British coastline, and therefore indicating locations with good viewpoints over now submerged landscapes. This is modelled so as to explore potential strategic landscape locations. Hengistbury Head stands out. (Source: Author. Basemap EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1)

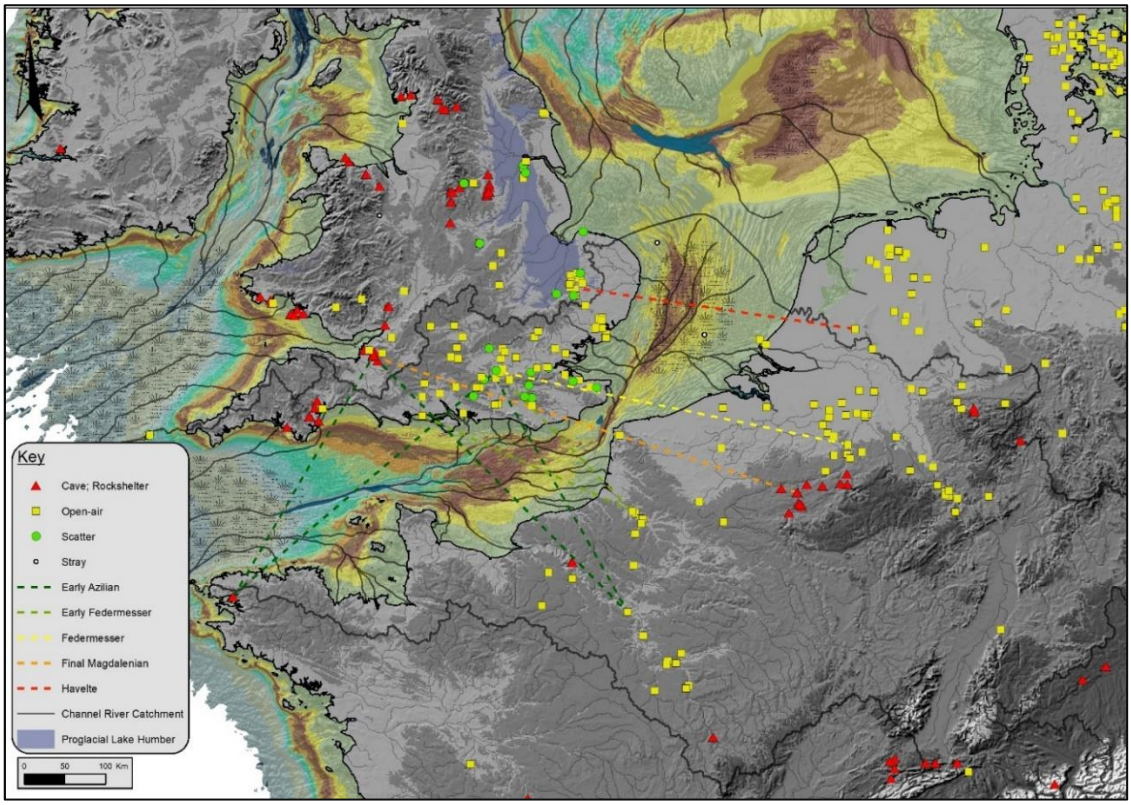


Figure 6.8 Technological and typological parallels between the UK and Europe , based on the techno-typological parallels described in Chapters 3 and 4. (Source: Author. Basemap EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

The theme of landscape use will be further developed in the following sections. With the faunal evidence providing insights on the local landscape strategies and dynamics in section 6.2. Part II will examine the impact and constraints of fluvial seasonality on mobility. And in Part III the technological adaptations are taken into consideration when assessing different regional ranges, scales and interactions around the Channel River system.

Table 6-2 LG Artefactual scales

Material	Distance (min/max distance of comparatives or sources)	Direction	Location	Ref.
Worked ivory and nearest known ivory source	158km /na	S/N	Gough's Cave; Kent's Cavern Min = to Condover Max = to Etiolles/Pincevent	Charles 1989; Currant et al. 1989; Jacobi 2004; Jacobi and Higham 2009
Marine shells				Eriksen 1997, 2002
Fossil shells				Eriksen 1997, 2002
Whale bone and seal depictions	300/1000 km		Gönnersdorf Min = to Channel Estuary Max = to SW Atlantic Coast	Langley and Street; Hansen 2006
Worked antler (stylistic) Magdalenian *Bâton percé*	na/350 km		Kent's; Gough's – Gouy Max = to Gouy	Jacobi 2004; Lucas et al. 2019; Julien 1982
Worked bone/antler (stylistic) Federmesser	na/490 km		Min = Sproughton to Poulton-le-Fylde, Gransmoor, , Leman and Ower Bank Max = Bergkamen, Kettig	Hallam et al. 1973; Wymer et al. 1975; Koojimans 2006; Jacobi et al. 2009 ; Baales et al. 2017 ; Bonsall and Smith 2000 ; Cook and Barton 1986
Marine resources	400 km/na	SE and S	Kendrick's Cave – Min = Irish Channel Delta / Channel River Delta	Richards et al. 2000, 2005, 2006; Stevens et al. 2010; Bocherens and Drucker 2006
Amber	160/400 km	S and E	Gough's Cave and Kent's Cavern Min = Channel River Max = Norfolk Coast	Beck 1965; Charles 1989; Currant et al. 1989; Jacobi 2004; Pettitt 2012; Tratman 1953
Flint (Wey Manor Farm)	/230km	Max N	Max = Yorkshire	Pettitt et al. 2012; Rockman 2003; Rensink 1995

Table 6-3 LG Technocomplex references and scales

Technocomplex	Distance	Direction	Cross Channel	Site
Early Creswellian	560km	SE	Yes	Sun Hole - Marsangy
Late Creswellian	430km	SE	Yes	Etigny-Wey Manor Farm
Havelte	490km	E	Yes	Mildenhall-Oldeholtwolde
Early Federmesser	244km	SE	Yes	Hengistbury Head-Gouy
Allerød Federmesser	250km	SE	Yes	Brockhill - Saleux
Long-Blade	280km	SE	Yes	Avington VI-Le Buhot

6.2 Faunal and human behaviours around rivers and implications for hunting strategies and site locations

6.2.1 Introduction

The absence of faunal remains on British LG open-air sites is a significant gap in our capacity to interpret behavioural relationships with the landscape. Cynegetic strategies strongly influence the choice of site locations (Bignon-Lau 2014; Binford 1980). The closest sites with LG faunal remains are the cave sites in Cheddar Gorge, and the closest open-air sites are in the Paris Basin and Neuwied Basin. These sites are therefore essential elements for the development of a framework assessing potential influences of landscape and choice of site locations.

The faunal assemblages with butchery marks are amongst the best direct evidence for landscape use in the LG. The main reference assemblage at Gough's Cave (Catalogue C) has been used to structure the model of LG fauna throughout the LG (Currant 1991; Currant *et al.* 1989; Currant & Jacobi 2011; Jacobi 2004), employing this specific assemblage to define the Gough's Cave Mammal Assemblage Zone applied to the Bølling in Britain; and used for a diversity of spread out records for the Allerød. The Gough's Cave Assemblage Zone is here applied, in conjunction with the Paris Basin open-air datasets, to assess the faunal indicators of landscape use in relation to the broad dichotomy of open and forested landscapes of the LG and the relation with river systems and mobility. The following chapter will broadly follow this local environmental structure, using the subdivision of Gough's Mammal Assemblage Zone for three distinct environmental landscapes: Bølling, Allerød and Younger Dryas (Figure 6.9).

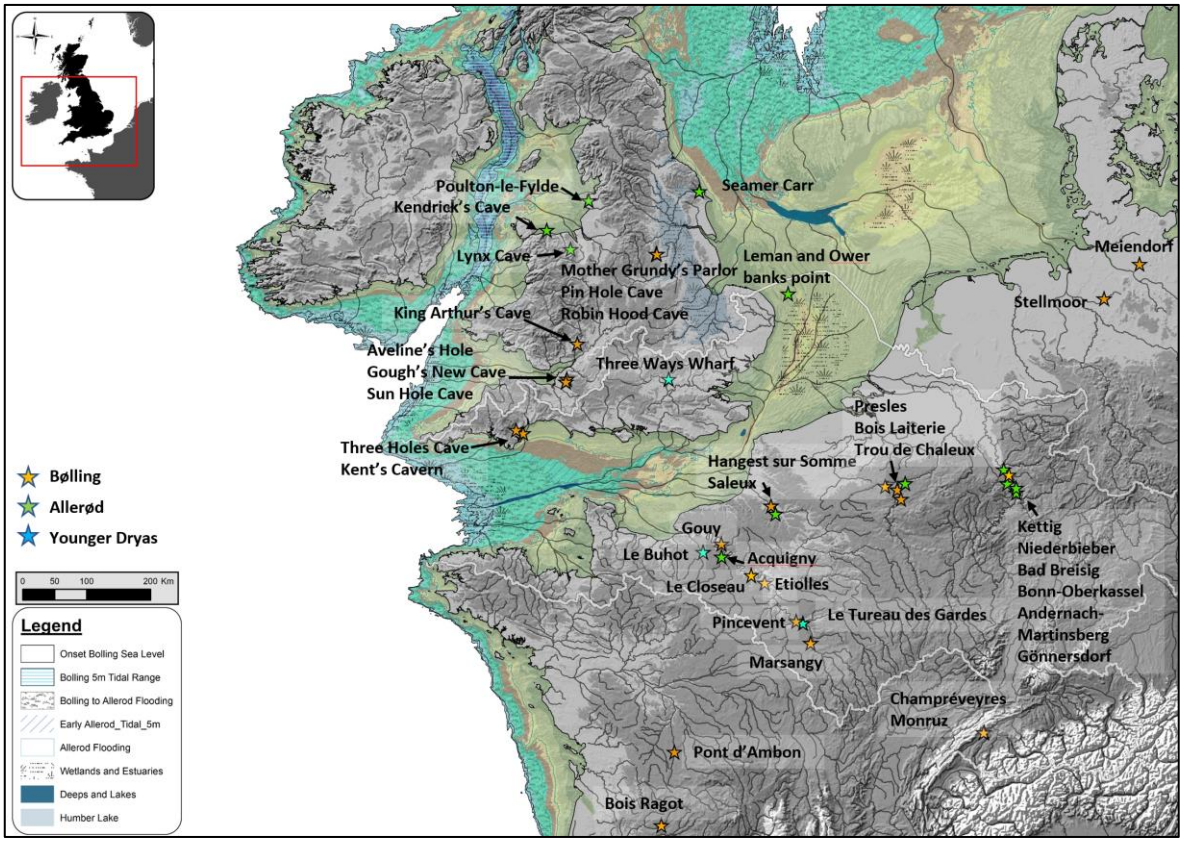


Figure 6.9 Gough's Cave Mammal Assemblage Zone distribution and European references. (Source: Author. Basemap EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

The fauna will be considered proportionately to the amount of spatial information they provide. In the cases of reindeer and horses, the two most important faunal species in the Bølling assemblages, this will be developed in greater detail as they provide essential landscape and mobility insights. The choice of preferential prey (or absence) is indicative of landscape use: horse, red deer, reindeer, mammoth, auroch, elk/moose. Other fauna indicate forms of specialisation such as arctic hare (for furs) (Charles *et al.* 1994) and the appearance of domestic dogs. Others may indicate landscape transformations that would have a direct impact on human mobility and landscape strategies such as aurochs and beavers. The apparent intensification of fishing during the second half of the LG also

suggests a closer relation to wetlands and fluvial systems (Baales *et al.* 2017; Bocherens & Drucker 2006; Brown *et al.* 2017; Gramsch *et al.* 2013; Russ 2010; Van Neer *et al.* 2007) and marine environments (Richards *et al.* 2005; Roselló-Izquierdo *et al.* 2016).

In each section, the emphasis will be on three elements: (1) the information that these records provide on mobility, (2) their relationship to fluvial systems and wetlands; and (3) what this implies for cross-channel or intra channel dynamics. This follows the concepts of 'human niche construction' in relation to riparian corridors following the Magdalenian (Brown *et al.* 2013a; 2013b; Laland 2015; Laland *et al.* 2015; Odling-Smee *et al.* 2003).

6.2.2 Gough's Cave Mammal Assemblage Zone I : Tundra Steppe

Section 6.2.2 covers a selection of mammals from the Gough's Mammal Assemblage Zone (Currant & Jacobi 2011) directly associated with the Tundra-Steppe environment of the Bølling phase of the LG. The aim is to highlight known (and unknown) aspects of their behaviour, and how these can relate to landscape use and inform on site locations. A further two themes throughout the following sections are on the interactions with major river systems, and how these assemblages inform us on mobility patterns and methods.

6.2.2.1 Horses (Equus ferus)

Late Glacial horses (*Equus ferus*), (Bignon *et al.* 2005; Edwards 2014; Montgomery & Provan 2014; Montgomery *et al.* 2014; Yalden 1999) are the predominant faunal species found in the Gough's Cave Assemblage Zone (Currant & Jacobi 2011). Horses are also the earliest dated faunal remains with cut marks directly associated with the human re-

occupation in the British Isles following the LGM (Jacobi & Higham 2011b). British LG faunal assemblages are mostly found in caves, and horses are the most frequent faunal member with traces of human modification in this context (Barton 1999b; Charles 1998b; Currant & Jacobi 2011; Garrod 1926; Jacobi & Higham 2009a; 2011b; Kaagan 2000; Stevens *et al.* 2010; Stevens & Hedges 2004). This is also important, as they are representative of the earliest hunting strategies around these cave sites. This can be contrasted with the bipartite reindeer/horse assemblages of the Paris Basin open-air sites (Bignon 2008). The question remains whether the presence of horses in the LG landscape would have been a pull factor in the initial post-glacial colonisation of this landscape.

Understanding horse behaviour is an important criterion for determining the landscape and mobility strategies (Bignon 2008; Kaagan 2000). The only equids that have had no human influence or domestication that survive as large herds, are African zebras (Bignon 2008; Brown *et al.* 2017; Mitchell 2015). These have extensive migration patterns linked to the rainy seasons in Africa, however, they may not be good comparisons for LG Northern European *Equus ferus* behaviour as the local conditions differ (Ransom & Kaczensky 2016b). Most wild horse data is based on horse behaviour from Mongolia, where there is under a century of re-wilding of horses (Kaczensky *et al.* 2008; Ransom & Kaczensky 2016a), and North America, where there are feral herds of mustangs that may be up to 400 years old (Mitchell 2015). The American Mustangs are arguably the closest examples to truly wild horse herds today. However, their territories are anthropogenically controlled, contained on lands undesirable for agriculture or ranching. For models of behaviour relating to open grasslands and woodlands, horses in Mongolia are considered.

On the tundra-steppe, both mammoth and horse share the same grazing grounds (Guthrie 1990; 2001; Mann *et al.* 2013). As these are found together at Gough's Cave and Kent's Cavern (Currant & Jacobi 2011), it potentially indicates a spatial relationship to the broader landscape (see 6.2.2.3).

The tundra-steppe biome, dentition wear and isotopic records indicate a contrast between grazers (horses, mammoth) and browsers (red deer, elk/moose) (Drucker *et al.* 2017; Mann *et al.* 2013; Stevens *et al.* 2009a; 2010). Of interest here are herds in Yellowstone National Park and some Canadian wild horse groups, as they are maintained in the forest-mountain interfaces, rather than the on grassland plains, and represent another environmental niche that is not as well-known but often associated with horses in the British archaeological record (Girard *et al.* 2013; Kaagan 2000; Mann *et al.* 2013; Ransom & Kaczensky 2016b; Sommer *et al.* 2011; Wockner *et al.* 2004). These modern populations have a clear seasonal migratory behaviour between low valleys and higher altitudes.

In Britain, LG horse faunal remains are mainly associated with areas of upland topography or with mountains on the edge of ecotones (at least for cave sites) (Charles *et al.* 1994; Charles 1996; 1998b; Currant & Jacobi 2001; 2011; Jacobi 2007; Kaagan 2000). This landscape distribution is paralleled in mainland Europe in the Belgian Ardennes caves, but also with a strong association to river valleys and lowlands as in the Paris Basin, Germany and Switzerland (Bignon 2008; Charles 1998b; Leesch & Bullinger 2012; Stevens *et al.*

2010). This provides a signal for seasonal altitudinal variation in grazing territories and contrasts strongly with the long-distance latitudinal migrations of reindeer for spring-summer calving (Drucker *et al.* 2012; 2016b; Friesen 2013; Gordon 2003; 2016; 1988; 1975; Pitul'ko *et al.* 2017; Stevens *et al.* 2010) (see section 6.2.2.2).

The local landscape and locations of British cave sites in regions of marked topography, would likely contain different faunal assemblages than open-air sites, and help explain the dominant horse and red deer component (Barton 1999b; Currant & Jacobi 2011; Jacobi 2004). Very little is known of hunting strategies of wild horse groups. Canadian open-air horse hunting strategies, dating to the same period (Barrón-Ortiz *et al.* 2017; Kooyman *et al.* 2001; Waters *et al.* 2015), made use of topographic natural traps, as used for bison, notably in inter-mountain regions (Friesen 2013; Friesen & Stewart 2004; Frison 2004); this strategy correlates with the location of the cave sites in Britain and their vicinities (Cooper 2012).

Another behavioural facet of horses is their need for a daily intake of water. Whereas in winter they can survive off snow, in summer this has a significant effect on territorial distribution, with a shift towards river systems (Kaczensky *et al.* 2008; Wockner *et al.* 2004). This provides a pattern that can be applied to hunters in the LG summers (Bignon 2008). Horses often only drink in the early mornings and the late evenings, spending most of the hot days at higher elevations, to avoid insects and benefit from the cooler conditions, a similar behaviour to reindeer that used both altitudinal and latitudinal shifts (Kaczensky *et al.* 2008; Wockner *et al.* 2004). Avoiding insects appears to be a significant

pressure on the behaviour of both of these species (see Chapter 7) but is possibly also a key factor affecting human site locations. The behaviour of wild horses, in relation to both altitude and topography and grasslands and seasonality, could reveal significant details on Late Glacial hunting and mobility patterns (Bignon 2008; Kaagan 2000).

A dynamic of integration of elevated regions as dryer environments could be an adaptation to the humidification and paludification (peat formation) of the region throughout the LG (Mann *et al.* 2013, 104). This might play a pull factor for the Creswellian hunter-gatherer groups, or simply an adaptation to the use of the natural cave shelter. In Beringia, isotopes ($\delta^{13}C$ and $\delta^{15}N$) indicate a potential correlation between rising humidification and paludism interpreted as causing a change of vegetation and the decline or even extinction of horse populations (Mann *et al.* 2013). A similar pattern of vegetational transition and decline of horse populations is recognised in Britain and the Northern European record during the second half of the LG (Bignon 2008; Hedges *et al.* 2004; Stevens *et al.* 2009a; Stevens & Hedges 2004). This may be linked to the transition from Creswellian hunting strategies to Federmesser moose and red deer hunting (Jacobi 2004; Kaagan 2000).

The Paris Basin has the closest contemporary LG open-air horse kill sites, and combined horse and reindeer kill sites (Bignon 2007) to SE England. Although locally there is topographic relief, it is not marked by high elevations and mountains (Bignon 2007; 2008). This is comparable geologically and topographically to SE England, and a similar vegetation distribution would be expected. Open-air sites with both horse and reindeer

could therefore be expected in SE England, as found in the Paris Basin unless the Channel River played a role as a barrier reduced or prevented migration northwards. Importantly, there is no evidence that horses have a higher tendency to cross rivers; the opposite appears to be the case (Bignon 2008: 46). This leaves the possibility that horse herds migrated northwards during the winter season when the rivers were frozen and reindeer were in their southern forested range, and spring melts would separate these two groups.

Horses appear reluctant to cross major rivers (Bignon 2008), and therefore the seasonality of the rivers and when it is possible to cross and where potential fording points is of particular importance for modelling horse and associated human spatial and hunting strategies in lowland regions such as SE England. Further DNA analysis of key faunal assemblages may also be able to contribute to understanding of LG horse herd movement and territory by identifying the relationship over larger regions such as the Paris Basin and southern Britain. Ambush hunting would be preferred (Brown et al. 2013: 5; Bignon 2008), notably when they are drinking at the bottom of floodplains, and even more so in late summer (Brown *et al.* 2013b), and these are elements that can help interpret strategic location in the landscape.

A pattern of summer and winter horse hunting in combination with spring and autumn reindeer hunting is not inconceivable (Bignon-Lau 2014; Julien 2006; Julien & Karlin 2014b; Turner 2003; 2006). If this is the case, horses are most likely to be present in the montane regions during winter (less snow cover and frozen ground enabling access to fodder), fitting the pattern of British LG cave sites. This seasonality is also found amongst

Belgian cave assemblages (Charles 1998b; Stevens *et al.* 2010). The evidence points to a local hunting of horses as there are indications of butchering taking place near British LG sites (Jacobi 2004; Jacobi & Higham 2011b).

Horses are the most prevalent large mammal (megafauna) within the extremely rich biotic communities of the Mammoth Steppe (Drucker *et al.* 2018; Guthrie 1990; 2001; Mann *et al.* 2013). This tundra-steppe landscape was present during the Bølling in Britain (Jacobi & Higham 2011b; Kaagan 2000; Lister 2009), and gradually diminishes with the onset of the degradation of frozen ground, and general humidification and paludification intensifying, combined with the development of forestation throughout the Allerød, and related to a significant drop in for horse horses during the Allerød (Bignon-Lau 2014; Guthrie 1982; Kaagan 2000; Mann *et al.* 2013; Yurtsev 2001). However, the mammoths at Condover indicate a likely persistence of the appropriate vegetation (see section 6.2.2.3.).

Hypotheses of Magdalenian domestication of horses based on the interpretation of some elements of Magdalenian art as harnesses reside (Bahn 1980; White *et al.* 1989). At this point the evidence is inconclusive, but should not to be completely dismissed in light of the growing evidence for the domestication of LG dogs in N. Europe and Early Mesolithic harnesses in Siberia (see section 6.2.2.5) (Bahn 1980; 1990; Morey 2014; Pitul'ko & Kasparov 2017; Street *et al.* 2015; White *et al.* 1989).

6.2.2.2 Reindeer (Rangifer tarandus)

Reindeer are a component of the Gough's Cave Mammal Assemblage Zone (Currant & Jacobi 2001; 2011). These are present as artefacts in large numbers in Northern Europe during the Bølling, surprisingly very little evidence exists in Britain, and mostly in the form of crafted tools from cave sites and a total absence of hunting-sites (Jacobi 2004; Jacobi & Higham 2009b; 2009a), but some rock-art at Cathole Cave (Nash *et al.* 2012; Nash 2015). Reindeer are present as artefacts in the mid-Bølling Creswellian at Gough's Cave and Aveline's Hole in the Bølling, and the later Bølling at Kent's Cavern (Jacobi & Higham 2011b), they then disappear from the record until the late Allerød when they reappear in the north, at Victoria Cave (with no anthropogenic modification), but the conditions are forested and cooler in the south (winter refugia?) (Currant & Jacobi 2011). The absence of butchered remains during the Bølling (see dated sites NW England), the early Allerød (Victoria Cave, Kent's Cavern), with a significant number of dates starting in the Younger Dryas (Barclay *et al.* 2017; Conneller & Higham 2015; Jacobi *et al.* 2009; Lewis & Rackham 2011; Lord *et al.* 2007). Furthermore, the landscape becomes more mesic with humidification and paludification during this period, and favourable for reindeer (Mann *et al.* 2013).

The Younger Dryas to Pre-Boreal site of Three Ways Wharf with bone preservation has sedimentary conditions (calcium carbonate rich sediments from chalk erosion) that favour the preservation of bone (Lewis & Rackham 2011). Heavy erosion of chalk scarps during the Younger Dryas will have mobilised these sediments creating areas favourable for bone preservation downstream of chalk rivers (Preece & Bridgland 1999). These

conditions that are absent amongst the earlier Bølling and Allerød open-air sites in either poorly developed soils or on sandy soils unfavourable for bone preservation.

The question remains: why is there a general absence of cut-marked reindeer in British cave sites (although present in the Ardennes cave sites), where assemblages are dominated by horse and red deer (Jacobi & Higham 2011b)?

Reindeer seasonal migrations are predictable, with both a spring and an autumn migration, although the routes may vary (Bignon-Lau 2014; Friesen 2013; Grøn 2005; Smith 1978). Reindeer tend to over-winter in forest environments and migrate towards cooler open-wind exposed regions for summer calving. These migrations can cover hundreds of kilometres. One of the most vulnerable moments is when they swim across open-water bodies such as lakes and rivers (Gordon 2003). This has clearly led to a hunting strategy recognised in North America (Friesen 2013; Smith 1978), Siberia (Grøn 2005), and the Northern European LG record (Aaris-Sørensen *et al.* 2007; Bignon-Lau 2014; Bodu *et al.* 2006a; Bokelmann 1991; Bratlund 2008; 1996; Eriksen 1996b; Gordon 1988; Petersen *et al.* 1996; Sommer *et al.* 2014; Street *et al.* 2006; Zubrow *et al.* 2010). Although considered as a migratory animal, there is evidence of more localised patterns, and some caution is needed (Pitul'ko *et al.* 2015, 143). Some species are restricted to woodland areas, such as the woodland caribou of Canada and woodland reindeer of Finland (Baskin 1986; 2000; Galloway *et al.* 2012; Sommer *et al.* 2014), or use altitudinal migrations such as mountain caribou in the Rockies (Todd *et al.* 2017; Wittmer *et al.*

2005; Yu 2014). The Bølling assemblages from Belgian cave sites could be related to this later type of migration, based on the local topography.

Isotopic evidence indicates the use of different habitats during this period of both woodland and open-ground reindeer foraging (Drucker *et al.* 2016b; 2018; Stevens *et al.* 2010). Within this context the question remains whether the Channel River presented a seasonal barrier for spring and autumn reindeer migration routes, preventing seasonal migrations northwards. Spring-melts could arguably create such a barrier. One route would always be open, crossing the lake at Hurd's Deep (see Chapter 7) (Figure 6.10).

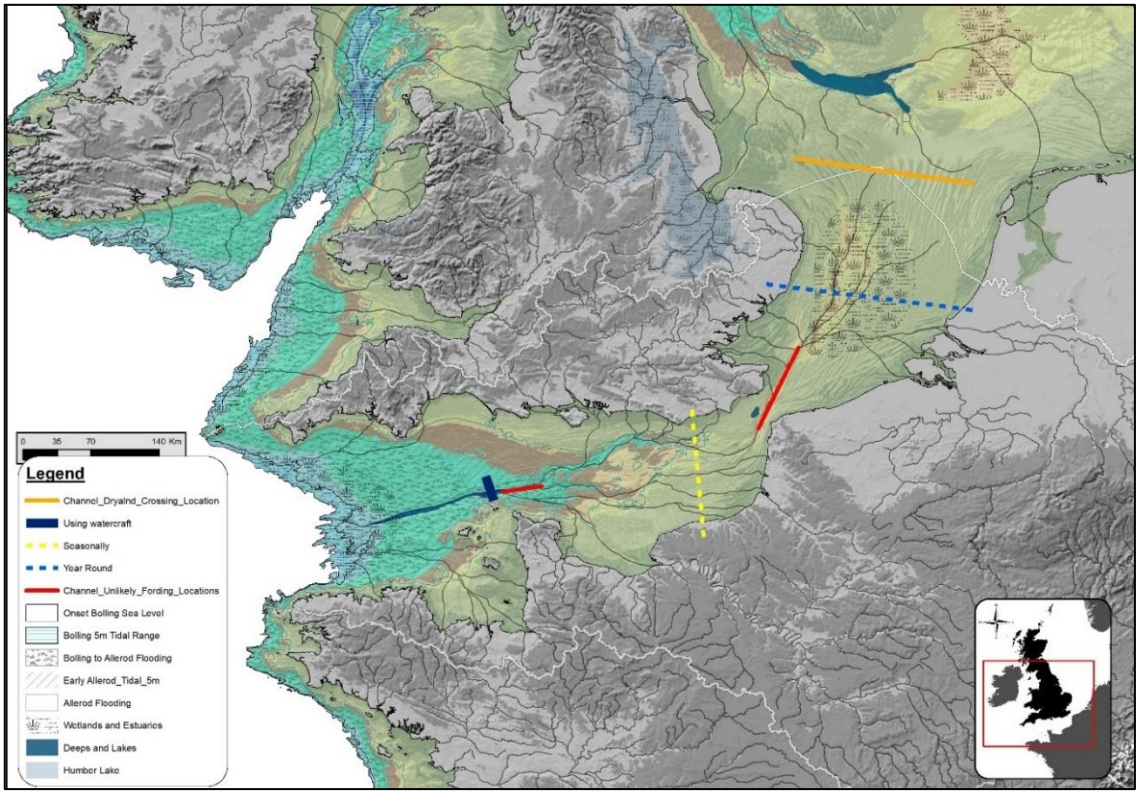


Figure 6.10 Aquatic and dryland crossings of the Late Glacial Channel River. The red lines indicate unlikely crossing points due to significant flow following multiple confluences and constrained channels. The orange line indicates a potential all season dryland crossing along the catchment edge; whereas the blue line indicates a potential crossing of Hurd's deep by boat, most likely a lake at this time and without the effects of strong fluvial currents. The dotted blue and yellow lines indicate potential seasonal crossings, the blue over a potential wetland zone and minor confluences most likely freezing over in winter, and the yellow a potential crossing above numerous confluences. (Source: Author. Basemap EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

Most of the larger assemblages in Northern Europe dating to the Bølling where significant accumulations of reindeer assemblages are found, are open-air sites in vicinity to rivers (Bignon-Lau 2014; Bratlund 1996; Enloe 2001; 1997; Gordon 2016; 1988). Based solely on the absence of organic material on open-air sites in Britain, it would be wrong to completely dismiss this as a hunting strategy as it is so widespread amongst immediate neighbours. Northern Germany has significant reindeer mass kill sites directly associated with rivers (e.g. Stellmoor, (Bratlund 2008; 1996; Rust 1943; Weber 2012). The Paris Basin also has numerous reindeer assemblages (Audouze & Enloe 1991; Bignon-Lau 2014; Enloe & David 1997; Zubrow *et al.* 2010). These reindeer hunting sites are found in close vicinity to rivers, and can be mixed horse-reindeer sites, whereas the horse kill sites with no reindeer can be found on the higher adjacent plateaus (Bignon 2007; Bignon-Lau 2014; Enloe 2001; 1997; 2006).

When ridgelines facilitating movement with good exposure are cut by 'gaps', such as the Wey and Mole Gaps, or the Goring Gap, animals would have to ford the river systems (e.g. Guildford Fire Station). This is also relevant for sites immediately upriver from major confluences, as these are important fording locations (e.g. Wey Manor Farm). Characteristic of these sites is the high proportion of armatures, presumably from retooling. Two open-air sites in SE England fit this model and techno-typologically associated with either the Bølling or the Older Dryas: Wey Manor Farm and Guildford Fire Station. But neither of these sites have very large assemblages indicating 'mass' kill sites.

These sites contrast strongly with Early Federmesser Hengistbury Head and Brockhill sites on elevated ground a distance from the main river systems.

The ethnographic records of North America and Siberia indicate that river and lake crossings are the favoured locations for mass hunting, especially in autumn whilst preparing for winter when animals are at their fattest and have the best skin for clothing (Enloe & David 1997). Two methods are pertinent here, both involve boats and create distinct mass kill assemblages, although they can also be hunted in mass on land (Bratlund 1996; Smith 1978). One is using a spear, and the other bow and arrow technology. These are two technologies that will be discussed in section 6.9.

The actual crossings locations may vary, although preferred locations have been recorded historically and ethnographically (Grøn 2005). There appears to be a tendency for reindeer to cross on a general north-south axis up to and back from summer calving grounds in cooler regions (see Caribou Eater Chipewyan, (Smith 1978), preferentially crossing waterbodies perpendicular to an East-West axis (Friesen & Stewart 2004; Gordon 1988; 1975; Grøn 2005; Smith 1978). These parameters enable the modelling of potential crossing locations for SE England and the Channel River.

Some locations were repeatedly used, and Inuit and Evenki traditionally considered taboo to make noise or leave litter that might spook the skittish reindeer at the crossing (Grøn 2005). Butchering and occupation locations would not be at these crossing locations, but in their vicinity (Binford 1978; 1980; 2002; Friesen & Stewart 2013; Stewart *et al.* 2000). With this strategy, it is important that the herd has already engaged in the crossing

before any sign of human activity, and therefore a north (crossing from south, spring) or south bank (crossing from north, autumn) assemblage would be indicative of seasonality (Grøn 2005). The butchering of the animals would take place near water, as it is necessary for cleaning and processing (Stewart *et al.* 2000). Wey Manor Farm potentially fits this pattern as an autumn site, as could Guildford Fire Station.

Caribou/reindeer migrate just before the spring melts start (to be able to cross rivers) to cooler (further north or elevated) open calving grounds, and just after the winter freezing has started to forested environments for winter fodder (Smith 1978). Both migrations require river and lake crossings. In Canada, they are known to follow raised ground regions to avoid the muskeg/ marshy lowlands in spring and favour good wind exposure to dissuade insects (Gordon 2016). Where these areas of highland intersect east-west oriented rivers would be a strategic hunting location for reindeer and other associated migrating mammals (e.g. Goring Gap; Dover Straits etc.), especially if with elevation and visibility. The North and South Downs would provide an ideal terrain for these migrations. The Avon and Test rivers are the most significant North-South valleys. The east-west oriented river courses, for the study region, are the Channel River and the Thames (Figure 1.2).

Possibly the most important factor is the presence of summer winds. The purpose of the migration is to shift towards cooler and windier climes during the period of calving to dissuade insects. Modelled wind directions indicate predominant south-westerlies during the summer (Figure 6.10). When these are modelled in GIS, the Channel River, Irish

Channel and eastern Doggerland are readily exposed to these winds. Central and eastern England, and western Doggerland are in the wind-shadow, and are therefore less likely locations for migration. This may explain the general absence of reindeer amongst the cave assemblages, as they are not migrating to these regions. It also highlights the importance of the Channel River Basin for both animals and humans during the summer months.

A potential early domestication of reindeer has been proposed based on the interpretation of potential harnesses on Magdalenian art in SW France (Bahn 1980; 1990; Gordon 2016; 1990; Gordon *et al.* 1990; White *et al.* 1989). This remains inconclusive and the depictions less convincing than those associated with horses (see section 6.2.2.3).

There are also issue concerning the concept of following herds of reindeer through the landscape. The ethnographic, historic and archaeological evidence indicates strategic positions of groups along the courses of migration rather than following the migration (Gordon *et al.* 1990). However, with the shift of the polar front northwards during the Bølling and Allerød (e.g. Isarin 1987), there would be a shift northward of the migration patterns that would be followed during the LG if the groups were partly or wholly dependent on this resource (in this case from the Paris Basin towards southern England).

Reindeer distributions are here modelled with two purposes: migration ranges and waterbody traversing locations. Contemporary caribou migration ranges vary from 400-

800 km (Friesen & Stewart 2004). These would have shifted northwards with the onset of the LG and throughout this period with the shifting polar front (see Chapter 7).

6.2.2.3 Woolly Mammoth (Mammuthus primigenus) and Saiga Antelope (Saiga tartarica)

Both woolly mammoth (artefacts) and saiga antelope (unmodified) have been identified within LG cave assemblages and are considered integral to the Gough's Cave Mammal Assemblage Zone (Currant & Jacobi 2001; 2001). Both animals have been directly associated with Steppe-Tundra/Mammoth Steppe faunal assemblages, marked by a cold and arid climate, and a forb dominated vegetation supporting the largest biome on earth at the time (Guthrie 1982; 2001; Rivals *et al.* 2010; Yurtsev 2001). Sedges in Siberian woolly mammoth digestive systems indicate a boggy wetland diet, this would correlate with the Bølling thermokarst and early Allerød environment and dates from Condover (Shropshire), indicating that the LG British lowlands would be good grazing grounds for these large herds.

Mammoth ivory objects have been found both at Gough's Cave and Kent's Cavern in association to Creswellian assemblages (Currant 1991; Jacobi & Higham 2009b; 2011b) and a bone at Pin Hole (Jacobi 2004). As with the reindeer material, apparently the mammoth is contemporary and is not hunted locally, the material was worked elsewhere and transported over a distance to the cave. It was hypothesised that mammoth material has its origins in Doggerland (Pettitt 2012), but there is little direct archaeological LG evidence for their presence, yet there is some direct evidence in the English landscape as

demonstrated by the Condover assemblage (Coope & Lister 1987; Lister 2009). Further research into their landscape distribution is needed.

The six mammoths at Condover date to the LG, although the individual animals were not contemporary with each other (Coope & Lister 1987; Lister 2009). This is indicative of the presence of the 'Mammoth Steppe' vegetation and its associated biodiversity, as mammoth are dependent on the associated vegetation type (forbs) (Guthrie 2001; Lister 2009). Mammoth appear to disappear from the British record with the onset of the Older Dryas (Figure 6.11) (Currant & Jacobi 2011; Jacobi & Higham 2011a; Ukkonen *et al.* 2011). This is the last presence of mammoth in Britain, and coincides with the latest mammoths in Beringia at c.14 k cal BP (Drucker *et al.* 2018; Lister 2009; Mann *et al.* 2013; Stuart *et al.* 2004).

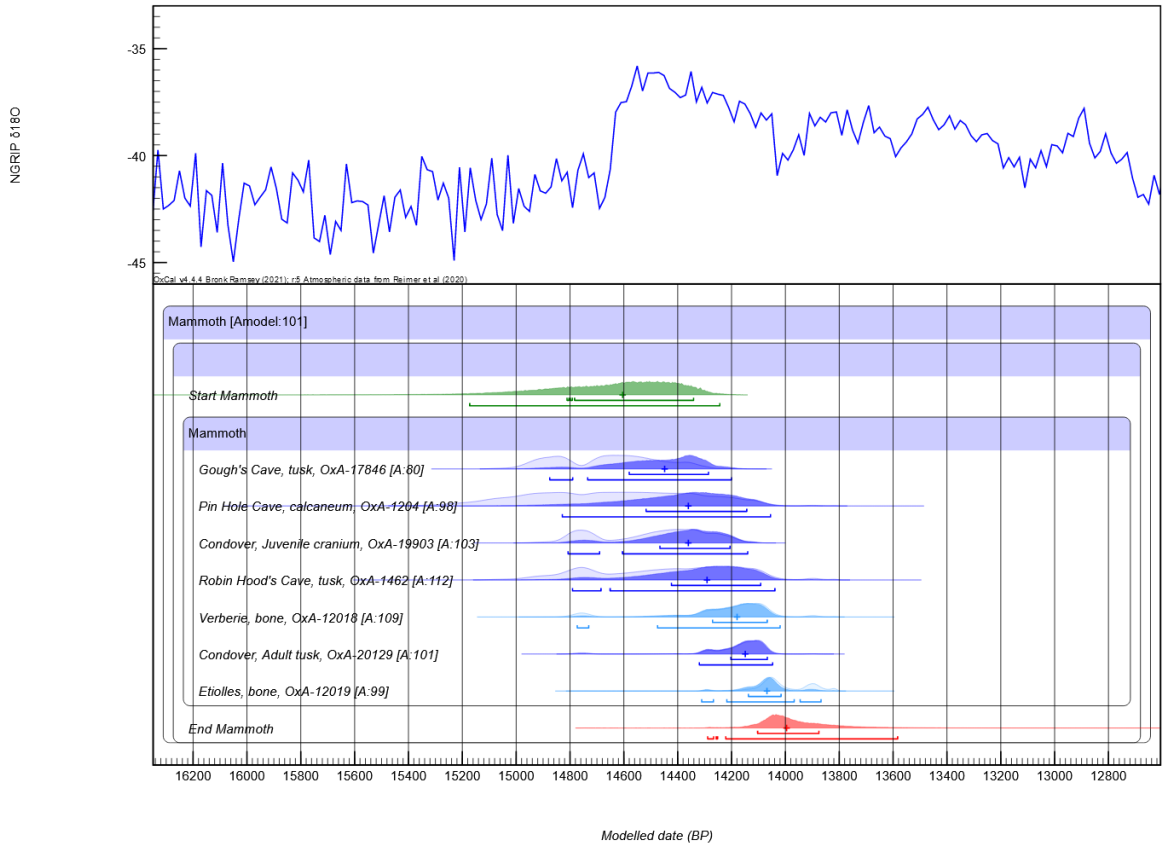


Figure 6.11 Dates for mammoth from Condover and northern France. There is no evidence for mammoths following the onset of the Older Dryas (GI-1d) at around 14100 cal BP. Dates from Lister 2009. Single uniform phase. The Bayesian model confirms the spread of mammoth across the second half of GI-1e (Lister 2009). Modelled in OxCal 4.4 (Bronk Ramsey 2021) using the IntCal20 calibration curve (Reimer et al. 2020). The dates are compared against the NGRIP (GICC05) δ18O record (Andersen et al. 2006; Svensson et al. 2008; 2006).

Often mammoths are dismissed as not having been hunted in LG Europe due to the absence of cut-marked bone. The situation is less conclusive, as it is mostly due to the absence of associated lithics. In most North American mammoth kill sites dating to this period, there is no evidence for cutmarks, but occasionally only a few stone tools in vicinity or associated with the assemblage. This is often interpreted as not needing to cut down to the bone due to the quantity of flesh available (Frison 2004). A technological assessment of Cheddar and Creswell points to Clovis and Folsom points, in their function for bringing down large game, may also be useful.

Saiga antelope is found in small proportions in open-air and cave sites in Britain and Northern Europe (e.g. Sun Hole; Gough's Cave; Soldier's Hole; Pincevent, Belgian Ardennes) (Currant 1987; 1991; Currant & Jacobi 2011; Jacobi 2004; Yalden 1999). Saiga antelope is associated with very dry cold steppe environments and an Older Dryas age is usually presumed, although the Bølling winter conditions could be viable (Currant 1987; Jürgensen *et al.* 2017). Saiga antelope is present in low numbers in all the neighbouring regions of LG site concentrations (Belgian Ardennes and Paris Basin). The presence of Saiga at Gough's Cave is informative as it is often in direct relation to mammoth on the Tundra-Steppe (Currant & Jacobi 2011; Guthrie 1982; Jürgensen *et al.* 2017).

The presence of saiga antelope in English cave sites (Gough's Cave, Sun Hole and Soldier's Hole) and Paris Basin open-air sites dating to the Bølling/Older Dryas is indicative of a much larger landscape distribution than is currently understood for British LG dynamics. The link to major river systems might be considered concerning mammoth distributions, and saiga antelope are a proxy to cold dry winters, when the rivers are frozen over.

6.2.2.4 Arctic (mountain) Hare (Lepus timidus)

Arctic hare (Charles *et al.* 1994; Jacobi 2004; Jacobi & Higham 2011b; Yalden 1999) is a member of the Gough's Cave Mammal Assemblage Zone (Currant & Jacobi 2001; 2011). Found in significant numbers in Creswell Crags at Mother Grundy's Parlour and Robin Hood Cave; and also present Gough's Cave and Kent's Cavern (Charles *et al.* 1994; Currant & Jacobi 2011; Jacobi & Higham 2009b). The site of Robin Hood Cave at Creswell Craggs, with a Bølling Creswellian assemblage, has been interpreted as a hide processing site

preparing furs for winter in either autumn or early winter (Charles *et al.* 1994). This is when the skins are most appropriate for clothing with the development of winter pelts. The cut marks on the faunal remains support this hypothesis (Charles *et al.* 1994). This seasonal framework is a potential indication of mobility strategies for this period, indicating autumn-early winter, as the assemblages do not appear to represent permanent settlement (Charles *et al.* 1994).

6.2.2.5 Wolves (Lupus lupus) and domesticated dogs (Canis familiaris)

Wolves are present in English LG assemblages and are part of the Gough's Mammal Assemblage Zone (Currant *et al.* 1989; Currant & Jacobi 2011). Wolves are of interest as they can be specialist herd hunters and occupy similar ecological niches to humans (Lord *et al.* 2007). Domesticated dog, derived from wolves, has recently been identified at Gough's Cave (Jacobi & Higham 2009a; Parfitt in Currant and Jacobi 2011, 174) and at Kent's Cavern (Jacobi & Higham 2011b, 2324), the remodelling of these dates with the IntCal20 curve as part of this thesis shifts the dates to at least 100-150 years earlier, and places them within the earlier phases of Creswellian (Figure 6.12, Table 6-4). The direct association of domestic dogs with the initial occupation of new territories is striking, as they may be used as transport and/or hunting aids, facilitating this pioneering dynamic. These finds are peri-contemporaneous with the domestic dog burials found, associated with LG human burials at Bonn-Oberkassel (Jacobi & Higham 2009b; 2011b; Janssens *et al.* 2018; Street *et al.* 2015) although there are some arguments for simply another form of wolf (Boudadi-Maligne *et al.* 2018). The Bonn-Oberkassel domesticated dogs, confirmed by DNA analysis (Thalmann *et al.* 2013), are associated with a Late Magdalenian burial and are contemporary with the Creswellian, GI-1e (Janssens *et al.* 2018).

Table 6-4 Dated domestic dogs from Gough's Cave – OxA-13585 (Jacobi and Higham 2009a: 1901) and Kent's Cavern OxA-13588 (Jacobi and Higham 2009b: 146) using OxCal v4.4.2 (Bronk Ramsey 2020) and the IntCal20 calibration curve (Reimer et al. 2020). The results are between 100 and 150 years earlier than the IntCal04 curve used in Jacobi and Higham 2009.

Sample	Element	Pretreatment method	Radiocarbon age BP	$\delta^{13}C$	$\delta^{15}N$	from	to	%
OxA-13585	*Canis cf familiaris*, right dentary (M.49877)	Ultrafiltration	12,440 + 55	-18.5	5.8	14951	14285	95.4
OxA-13588	*Canis* sp. (domestic), left tibia (Pengelly, 1842)	Ultrafiltration	12,470 + 50	-19.3	7.2	14981	14317	95.4

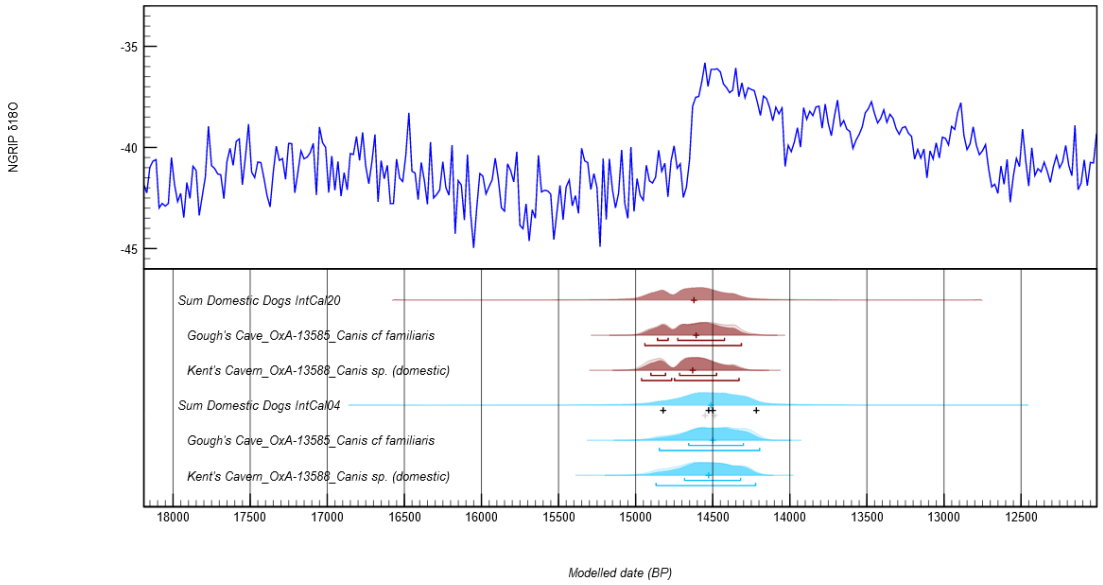


Figure 6.12 Dated domestic dogs, multiplot from Gough's Cave – OxA-13585 (Jacobi and Higham 2009a: 1901) and Kent's Cavern OxA-13588 (Jacobi and Higham 2009b: 146) using OxCal v4.4.2 (Bronk Ramsey 2020) and comparing results from the IntCal20 calibration curve (Reimer et al. 2020, brown) and IntCal04 curve (Reimer et al. 2004, blue). The new curve pushes back the medians of the dates (black crosses) dates by around 150 years.

The ever-growing dataset for the second half of LGM domestic dogs, and specifically the Magdalenian, indicates a significant period of domestication immediately preceding the LG and continuing culturally within the first half. This has recently been demonstrated by ancient DNA (Frantz *et al.* 2016; Morey 2014; Thalmann *et al.* 2013). There is also a presence during the Allerød of domesticated dogs based on an incisor found at Rookery Farm, but with insufficient protein for a direct date (Conneller *et al.* 2009, 1). The presence of fully domestic dogs at Starr Carr in Early Holocene Britain corroborates a preceding domestication and a likely presence throughout the LG (Schulting & Richards 2002; 2009). In arctic Siberia domestic dogs at the Early Holocene site of Zhokhov are associated with the earliest unequivocal evidence for sledges (Pitul'ko & Kasparov 1996; 2017). Batons de commandments, found at both Gough's Cave (with the presence of dog

bones) and Kent's cavern, have also been tentatively associated with sledges (Bahn 1990; Lucas *et al.* 2019).

Both Germonpré *et al.* (2009; 2012) and Street *et al.* (2015) have put forward the possibility of pack dogs, notably in view of the transport of bulky butchered hunted material (e.g. mammoths) and raw material movement as pre-shaped cores respectively. This would also fit Creswellian raw material strategies (Barton et al. 2003; Barton 2010).

The use of dogs assisting in organised hunting is a hypothesis based on their developed olfactive senses (Street *et al.* 2015) and endurance, notably for the difficult hunting of horses (Eriksen 1996a) and moose that can easily be worn down and driven to water over a distance (Pitul'ko & Kasparov 2017, 512), and can also be considered for red deer and megaloceros, but they may also be linked to a prey specialisation (Lupo 2017). This is relevant for both the Bølling and Allerød periods, and the relation of site locations near waterbodies.

The assistance of dogs in the more forested environments developed during the Allerød, where faunal mass is more dispersed than on the Tundra-Steppe (i.e. where their potential use of separating and isolating prey from the main herds should not be omitted), would develop and likely play a major role. One essential aspect of hunting large game with dogs, either as packs or in small numbers, especially if it is in pursuit, is that the animals will go to water the vast majority of the time, and generally aiming for

the largest water body (personal experience). This is directly relevant for site locations and landscape in the following section describing the Allerød faunal assemblage.

6.2.3 Gough's Cave Mammal Assemblage Zone II: Transitioning Steppe-Forested

6.2.3.1 Red Deer (Cervus elaphus)

Red deer, following horses, are the second most represented fauna in British LG cave assemblages (Currant 1986; Currant & Jacobi 2011; Jacobi & Higham 2011b; Lister 1984; Sommer *et al.* 2008). Red deer components of the assemblages appear to date to later in the Bølling and may be associated with the transition from Bølling to Allerød, and can tentatively be associated to the potential Early Azilian bipoints in the assemblage at Gough's Cave, also marking a transition in predominant hunting methods (Currant & Jacobi 2011; Jacobi 2004; Jacobi & Higham 2009a, 1905; 2011b).

Red deer are also associated with the Mammoth Steppe environments across Eurasia and North America (Guthrie 2001; Rivals *et al.* 2010), and continue as the predominant fauna in cave sites throughout the Allerød (Sommer *et al.* 2008), coincident with new occupation dynamic as cave sites in England appear to be less used during the Allerød and have smaller assemblages (Jacobi & Higham 2009a; 2011b). This could relate to the transition in local environments and prey with the development of forestation and the degradation of the Mammoth Steppe. Red deer is only found in southern English and Welsh assemblages, and are absent at Creswell Crags (Currant & Jacobi 2011; Yalden 1999).

The high proportion of red deer in British LG cave sites contrasts significantly with the Magdalenian open-air sites south of the Channel River that are dominated by reindeer and horse during the Bølling (Bignon & Bodu 2006; Jacobi 2004; Jacobi & Higham 2009a).

During the Bølling to Allerød transition, they become more frequent, and are directly associated with the Cepoy-Marsangy Facies and Early Azilian in the Paris Basin (Bignon & Bodu 2006; Lhomme *et al.* 2004; Poplin 1992) and the Allerød Federmesser sites in the Neuwied Basin (Street *et al.* 2006). In Britain red deer are dated to the late Bølling and Allerød, and the presence at Gough's Cave (Jacobi & Higham 2011b). This is also indicative of different landscape strategies that are possibly either seasonal or in direct relation to the higher local topography.

Little is known of Bølling red deer behaviour patterns (Edwards 2014; Lister 1984; Montgomery & Provan 2014; Montgomery *et al.* 2014; Sommer *et al.* 2008). Red deer are often associated with low montane environments but are very adaptable. Contemporary red deer appear to have a short distance but a high altitudinal migration. Red deer provide limited information on mobility at this point, but may be used as a proxy for local environments based on the stable isotopes (Stevens *et al.* 2006; Stevens & O'Connell 2016) and a seasonal signature of presence at locations (Jacobi 2004; Jacobi & Higham 2011b; Rivals *et al.* 2010; Sommer *et al.* 2008).

6.2.3.2 Auroch (Bos primigenius, Allerød)

Aurochs are identified in cave assemblages and dated to the late Bølling onwards (Currant & Jacobi 2011; Jacobi *et al.* 2009). This period is transitioning from an open landscape marked by the absence of forest, into the Allerød, with the development of forestation (Germonpré & Sablin 2002; Jacobi 2004; Naudinot *et al.* 2017a). They are generally associated with open areas within forests, especially river valleys (Fontana 2003; Vuure

2002). Caution is required regarding aurochs as they are often associated with forested environments, however there is clear evidence of a presence within the LG in open environments (Jacobi 2004; Vuure 2002). Although associated with forested environments historically, it was specifically the open flood plains of these forests that was their habitat (Guthrie 1990; Vuure 2002).

In Britain aurochs appear at the transition from the Bølling Arctic steppe to the more humid and wetland-dominated Allerød where they develop (Jacobi 2004; Jacobi & Higham 2009a). The appearance of auroch in the British record during the Bølling is a significant marker of landscape transformation. The auroch is present from the Late Creswellian assemblages onwards. There are also examples of auroch in the Paris Basin contemporary to the Late Creswellian at Marsangy (Schmider 1992; 1979) and a significant site with depicted aurochs and horses on schist plaquettes at the Rocher de l'Impératrice in Brittany, where four aurochs were included within the Late Azilian assemblage (Naudinot *et al.* 2017a). One plaquette has an auroch depicted with what appears to be sun rays around its horns, a potential representation with further symbolic significance (Naudinot *et al.* 2017a). It should be noted that at present it is difficult to distinguish faunal remains of auroch (*Bos primigenus*) and bison species, and that further research using Zoological Mass Spectrometry (ZOOMS) could help secure these identifications (Jacobi 2004). The association with fluvial plains and its recurrence in the British LG record is an indication of the persistent use of these environments.

6.2.4 Gough's Cave Mammal Assemblage Zone III : Woodland

Unlike the reference assemblage at Gough's Cave for the Bølling, there is no single distinct assemblage for the Allerød (Currant & Jacobi 2011). The Allerød period, marked by the development of woodland in the southern half of England, is composed of individual finds. The only site with a diverse assemblage in Britain is Seamer Carr (Conneller 2007; Currant & Jacobi 2011), quite a distance north of SE England. The closest significant assemblages to SE England dating to this period are in the Neuwied Basin (Baales *et al.* 2002b; Street *et al.* 2006), Somme Valley (Fagnart & Coudret 2000b; Naudinot *et al.* 2019) and Le Closeau in the Paris Basin (Bignon & Bodu 2006). An important member of the Allerød (and earlier Bølling) faunal assemblage is the *Megaloceros giganticus*, but little is known of its landscape and spatial behaviour; and it has not been included here.

6.2.3.1 Elk/Moose (Alces alces), Forested Allerød

Moose are large animals that live in small groups for a short period of time during winter and otherwise spread out in the landscape, mature males often living solitary (Yalden 1999). They have a very distinct seasonal behaviour, seeking areas of small short scrub, protected from winds in winter, and often located in valley bottoms, browsing shrubs and foliage (Yalden 1999). Their preferred aestival region are riverine flat-lands as they have a large consumption of aquatic plants in summer (Hall 2008; Montgomery *et al.* 2019; Risenhoover 1987).

There is direct evidence for moose hunting indicating the possible use of bows at Poulton-le-Fylde, High Furlong, during the Allerød, marked by numerous impact wounds on the rib cage and two imbedded barbed points (Baales *et al.* 2017; Barnes *et al.* 1971)(see 7.3). Dogs would be a significant aid in hunting moose (Pitul'ko & Kasparov 2017, 511; Street *et al.* 2015). This is another direct link to hunting strategies around riparian environments.

6.2.3.2 Beaver (Castor fiber)

Possibly one of the most important faunal additions with the onset of the Allerød and tree development, beavers are true landscape engineers (Coles 2000; 2001; 2006; 2008; Collins *et al.* 1996; Worsley 2009). They can also colonise open landscapes immediately ahead of forest development (Tape *et al.* 2018). They live along riparian corridors, along secondary river courses where flow is not too strong. Beaver is recognised on the Rhine in Northern Europe (Baales & Street 1996) and Britain dating to the Allerød and most likely associated to the expansion of willow and birch (Coles 2006, 73). By felling trees annually and creating dams along seasonally frozen rivers, they are a major source for driftwood. Their presence along the Rhine at the onset of the Allerød is of significance, and creates a major source of driftwood downriver (Baales *et al.* 2002b).

In direct relation to the southern English LG landscape, the early presence of beaver in cave assemblages at Kent's Cavern and Gough's Cave marks their presence in the local landscape during the Allerød and Younger Dryas (Coles 2006; 2008; Marr 2016). The evidence for developing vegetation in SE England in the Bølling and Allerød would justify their presence in this region, notably with willow and later birch and hazel (Gramsch *et al.*

2013; Simmonds 2017). This may also be considered in relation to the extensive flooding recognised in the LG Kennet valley (Collins 1994; Collins *et al.* 2006). A similar situation could be envisaged along smaller tributaries and further upstream of major river courses such as the Thames and Palaeo-Solent (Figure 6.13). The presence of beavers would lead to the development of extensive wetlands as well as facilitating the upstream migration of anadromous spawning fish like salmon (Bouwes *et al.* 2016; Mitchell & Cunjak 2007).

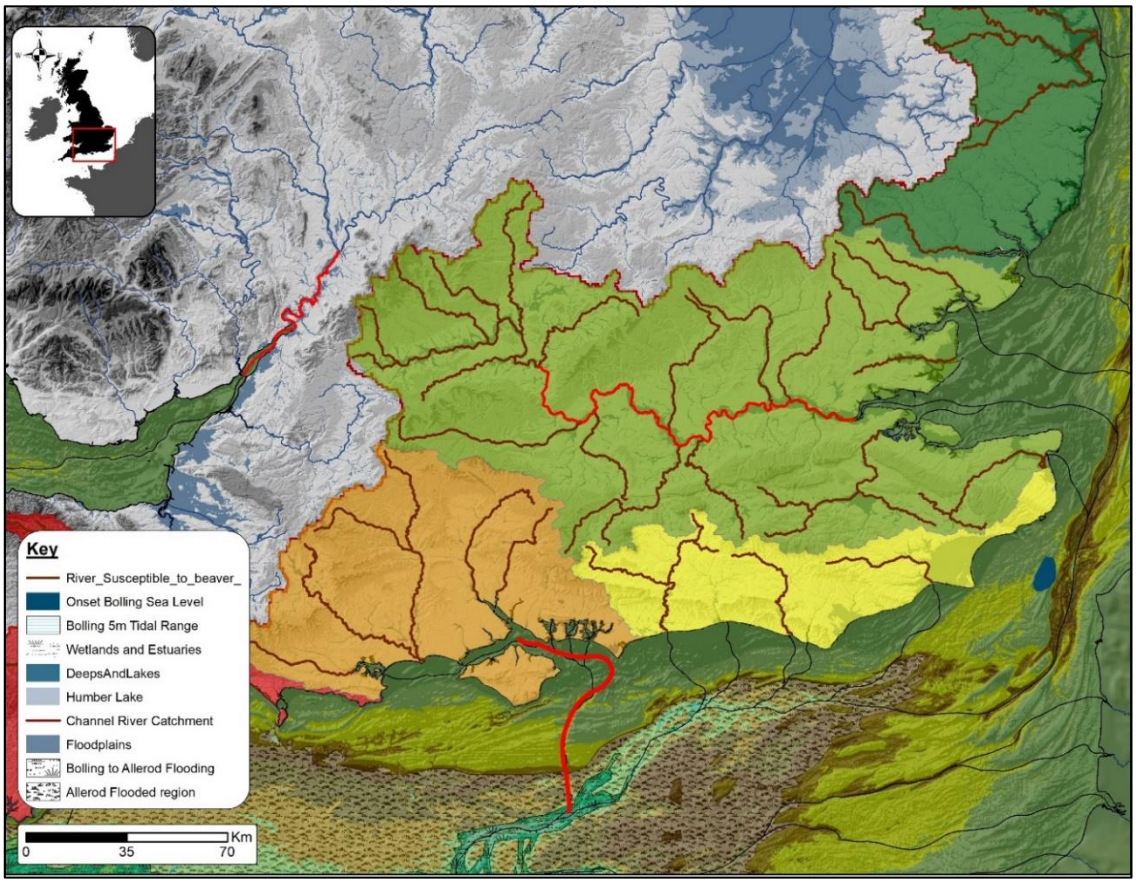


Figure 6.13 Areas of SE England and Channel susceptible to beaver dams as they are on low relief and minor confluences with limited flow (brown), and rivers unlikely to be dammed due too high a flow (red). (Source: Author. Basemap EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

Although not indicative of movement or mobility, they would create rich and diverse local vegetation and faunal environments (watering hole, fish and bird species as well as

aquatic plants attracting moose and vegetation diversity) (Brown *et al.* 2013b; 2017; Coles 2006). These are ideal locations for seasonal occupation (e.g. Star Carr, North Yorkshire). The presence of beaver, and isolation of stretches of river which would be amenable to damming, are areas that can be considered as poles of attraction for human groups, as well as sources of driftwood.

6.2.3.3 Fish: Atlantic Salmon (Salmo salar) and European eels (Anguilla anguilla)

Both salmon and eels use fluvial systems for spawning and development, and are known from LG Europe and Britain (Brown *et al.* 2013b; Russ 2010). English rivers have been suggested to be salmon-rich during the Mesolithic (Barton *et al.* 1995; Brown *et al.* 2013b; Russ 2010), but there is no distinct isotopic evidence for their consumption thus far as signatures can mix with other marine resources (Schulting 2013). Direct evidence of anthropogenically derived fish remains (brown trout, burbot and greyling) has been identified in the neighbouring Belgian Final Magdalenian Cave of Bois Laiterie (Van Neer *et al.* 2007), but no isotopic evidence for significant salmon consumption from either Belgium (Polet *et al.* 2020) or Germany (Drucker *et al.* 2016b) has been identified. There are Magdalenian depictions of fluvial fauna, notably salmon and eels, indicating a likely seasonal familiarity and possible consumption (Brown *et al.* 2013b; Cleyet-Merle 1987; Langley & Street 2013).

The Channel River system would be suitable for Salmonidae migrations during the Bølling (Kettle *et al.* 2011). This would likely develop during the Allerød with the combination of the migration of the Channel Estuary eastwards and the presence of beaver ponding, the

latter has been demonstrated to have a significant increase in salmon presence and spawning (Bouwes *et al.* 2016). The presence of these resources is another factor for considering the Channel River tributaries as significant poles of resources during the summer and especially the late summer and autumn (Figure 6.14).

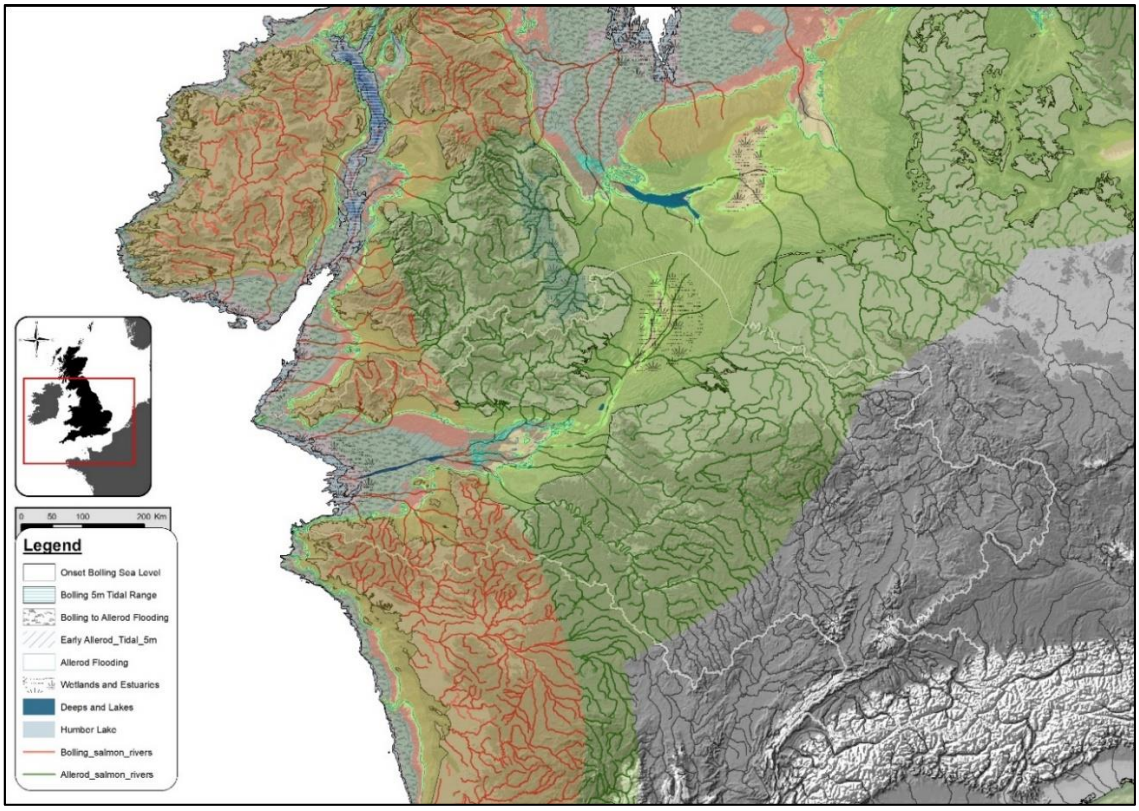


Figure 6.14 Progression of Late Glacial salmon migration routes with rising sea levels. The potential is based on the estimated migration distance (up to 400km for Atlantic Salmon[34]) from the shoreline in the Bølling (red) and Allerød (green and red), respectively. (Source: Author. Basemap EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

Fish remains are generally rare and in small numbers for this period in Northern Europe (Russ 2010). Fish remains are found in the Neuwied valley (Baales *et al.* 2017). Evidence for the use of freshwater and marine resources from artefacts (Eriksen 1996b; 1996a;

[34] https://www.fws.gov/fisheries/fishmigration/atlantic_salmon.html

Langley & Street 2013) and isotopes (Richards *et al.* 2005) is now available throughout the LG, but the geographic preservation is patchy. A very rich early Mesolithic record of fishing and marine resources tends to corroborate the practice that developed during preceding periods (Amkreutz *et al.* 2018; van der Plicht *et al.* 2016). Taphonomic issues and the absence of preserved organic material remain a problem for earlier sites, as well a potential seasonality as represented in the historic and ethnographic records.

Although geographically distant, the Pyrenean refugia following the LGM, currently has the richest evidence for fish consumption. This region is also considered as the source of the migration north of the first colonisers of NW Europe following the LGM, and does have strong parallels in its technological and cultural inhabitants: Magdalenian and Azilian. There is evidence for intensive fishing starting in the Magdalenian and throughout the Azilian, mostly around estuarine regions, in Cantabria (Roselló-Izquierdo *et al.* 2016). There is a clear diversification of fish and marine species consumed during the Late Magdalenian (Roselló-Izquierdo *et al.* 2016). This region may have also been a refugia for aquatic species with the shift southwards of the polar front, followed by a recolonization of northern waters as the front shifted northwards during the LG (Gomez et al. 2007; Kettle *et al.* 2008; 2011). The general consumption of aquatic resources could be been more systematic in NW Europe than SW Europe based on human stable isotope readings, and freshwater resources being the mainstay (Drucker *et al.* 2016a). The Late Glacial human remains dating to the Allerød/Younger Dryas at Rhünda, within the Palaeo-Rhine catchment, indicates a high consumption of freshwater resources (Salmonidae excluded) (Drucker *et al.* 2016a). The high trophic level of pike corelates with high nitrogen isotopes

(Drucker *et al.* 2016b, 694). There is evidence of the use of freshwater resources derived from isotopes associated with assemblages in the Belgian Ardennes during the Magdalenian, and the Azilian site of Pont d'Ambon (Drucker *et al.* 2016a).

There appears to be a dominance of salmon fishing in the Late Magdalenian/ early LG that subsequently switches to a dominance of pike in the Allerød Federmesser of the Northern European Plain (Cziesla 2004). The latter pike could be associated with the finds of Federmesser (Neuwied Basin) and Azilian fishhooks (e.g. Pont d'Aubon; Bois Ragot) (Cziesla 2004; Gramsch *et al.* 2013). Both eels and Salmonidae are present in the register of Magdalenian mobile art (Brown *et al.* 2013b; 2017). Upper Palaeolithic fish remains at Trou de Chaleux indicate the consumption of seasonal migrating Salmonidae in the Palaeo-Rhine tributaries (Van Neer *et al.* 2007). The same can therefore tentatively be applied to the Channel River and southern England.

During the LGM it appears that the Channel River, notably around the region of Hurd's Deep, would have been the northern most extent of Atlantic Salmon (Kettle *et al.* 2011, 194) and a refugia for other northern marine fauna (Provan *et al.* 2005; Gomez et al. 2007). With the shifting of the polar front northwards during the LG, it opens up the landscape to LG fish migrations, notably salmon and eels.

The hypothesis that some of the barbed bone/antler points were parts of leisters (Christensen *et al.* 2016; Grønnow 2012; Pettitt 2012), in some cases very possibly linked to eel fishing, with several examples dating to the Allerød (Baales *et al.* 2017; Brown *et al.*

2017; Cziesla 2004; Petillon *et al.* 2009). The earliest fish hooks in NW Europe date to the Allerød and are associated with the Federmesser technocomplex (Baales *et al.* 2017; Gramsch *et al.* 2013) and may have been developed earlier in the LG or Magdalenian as double pointed gorges as are found at Gönnersdorf and Andernach in the Neuwied Basin along the Palaeo-Rhine (Cziesla 2004). Not only is this a strong link to fluvial environments, but also another technological development taking place before the Mesolithic where there is more archaeological evidence. A similar argument for the early development of bows and boats will be discussed in sections 6.7.2 and 6.7.4 respectively.

In Britain, isotopic analysis of human remains from the Allerød-age Federmesser-associated burial at Kendrick's Cave suggests consumption of either marine mammals (Richards *et al.* 2005; 2006; Stevens *et al.* 2010) or fish (Bocherens & Drucker 2006; Drucker *et al.* 2016a). Freshwater birds are not mentioned, although they are significant in the ethnographic records of North America, could these perhaps have an impact on the interpretation depending on bird types, notably migrating birds such as geese (Dark 2003; Schulting 2013; Schulting & Richards 2002; 2009)?

6.2.5 Conclusions for the faunal mobility and fluvial associations

Deriving landscape, mobility and behavioural patterns from the British Bølling records is a challenge as the evidence is scarce and restricted to specific landscape contexts, cave sites. The rare early Bølling fauna assemblages are dominated by horse, and isotopic readings from human remains supporting a meat rich diet. However, the diversity of the fauna recognised in the transformed tools that have been recovered in materials not local

to the cave locations (reindeer and mammoth) indicates a more extensive landscape use and mobility system. This corresponds to both the archaeological artefactual and techno-typological evidence presented in the earlier sections of this chapter. The evidence from the southern banks of the LGCR, the Paris Basin, provides the best comparative evidence for SE England. These landscape models are currently the best template for SE England, with both horse and reindeer playing mixed and seasonal roles in the economy, and occupations concentrated along river valley floodplains and near important confluences. However, the potential absence of reindeer in this region, and the indications for long-distance mobility contrasting with the localised models proposed for the Paris Basin Magdalenian hints towards a potential variation. Either reindeer did cross this region, a distance from the cave sites, or there is a more specialised hunting activity focussing on horses. Our current understanding of wild horse behaviour does not enable a seasonal or behavioural modelling within the region. Of particular interest is however, the late Bølling/Older Dryas evidence associated with a more diverse economy in the Paris Basin at sites like Marsangy and Le Closeau (niveau inférieur) with a more diverse faunal assemblage. This would correspond better to the open-air techno-complexes recognised in SE England and associated with the Bølling/Older Dryas, and the Late Creswellian.

The faunal evidence for the Allerød is also limited, and mostly from cave assemblages with rare isolated finds in the landscape such as the moose at Poulton-le-Fylde. This, combined with the richer open-air distribution of artefacts, suggests a more widespread use of the landscape, with a transition from predominantly herd hunting to more diverse and isolated resources. There also appears to be a broader diet, with a higher

consumption of marine resources in the isotopic analysis of human remains at Kendrick's cave, and the fish remains[35] at Pin Hole Cave, Creswell Craggs, although not directly linked to human occupation, who might also support this diet (Russ 2010, 23). This is reinforced by the recovery of the earliest fish hooks in Northern Europe. This broader landscape dynamic and intensification of aquatic resources agrees with the Northern European records both along the southern tributaries and up-river of the LGCR. The importance of the expanding LGCR estuary and embayment would be a significant concentration of resources in this region combined with the fluvial resources and broader use of the landscape, implying a good location for aggregation sites.

The faunal assemblages support a broad dichotomy of landscape mobility and use in the LG, following the palaeoenvironmental divide between Bølling and the Allerød. There appears to be a period of transition, following the process recognised in the Paris Basin archaeological assemblages termed 'Azilianization'. This provides yet another set of evidence for transformations in mobility and landscape strategies that have a direct impact on our models of landscape use within the Channel River catchment and SE England. The following section will examine the role played by the river systems within this dynamic landscape and focus on the role rivers played in structuring the landscape and directly influencing mobility and landscape use.

[35] Russ 2010, 23: " […] pike, grayling and cyprinid remains, but also perch (Perca sp.), European chub (Squalius cephalus), salmon or trout (Salmo sp.) and flounder (Platichthys flesus)". The European flounder is an interesting addition as it is marine. Is this an indication of bird activity? The accumulation agents for these finds remain unknown (Russ 2010, 277).

Part II Fluvial Seasonality, Polarity, Conduits and Barriers

Following from the discussion in Chapter 5 on the topography and seasonal flow of the LGCR, this part of Chapter 6 considers the role played by rivers structuring and seasonally transforming the landscape and how it is used by people.

The following section is divided into five subsections:

- Sub-section **6.3** examines the physical geographic structuring of the landscape, with an emphasis on climatic transitions and seasonality of rivers.
- Sub-sections **6.4** and **6.5** consider the structural dichotomy of rivers playing roles as both barriers dividing the landscape and as poles of attraction for resources.
- Sub-section **6.6** summarises above in a framework for the Late Glacial.
- The framework is applied in sub-section **6.7** that examines the archaeological record in relation to the climatic and seasonal variations of river systems.

6.3 Physical divisions around the Channel River Network

6.3.1 Flow: seasonality, main courses and tributaries

As discussed in Chapter 5, the Northern Channel was the main course of the LGCR (Collier *et al.* 2015; Gupta *et al.* 2017), contrasting a west to east flow pattern with its major tributaries that can be subdivided by both catchment size and their location either north or south of the Northern-Channel. The location and size of the catchments would be reflected in the seasonal flow, broadly grouped into three categories: (1) the main trunk valley, (2) south to north flowing and (3) north to south flowing tributaries (see Chapter 5).

During winter the LGCRN would be frozen over, as compared to rivers under similar conditions in North American (e.g. Mackenzie) and Siberian (e.g. Lena, Yana) rivers (Woo 1976; 2012a; Yang *et al.* 2015). The periods of thawing and spring breaks, outflow of the permafrost active layer, glacial input, the type of precipitation (snow/rain), summer nival input, and vegetation are the most influential factors on the fluvial dynamics of these LG rivers (Vandenberghe & Woo 2002; Woo 2012a).

South to north flowing tributaries were affected by spring thawing overspill creating a different dynamic to north to south flowing rivers that break-up following the latitudinal gradient. Not only is the periglacial environment more developed to the north, but the south to north flow of tributaries produces a very specific spring-melt flow regime with thawing commencing at the headwaters and evolving down river (see for example the Lena; Costard & Gautier 2007; Gautier *et al.* 2003). In both cases the ice-break would

create significant ice and log dams, and peak towards extreme high flows during the spring and early summer months.

Assessing LG flooding regimes is difficult as records are sparse. The Paris Basin has good signs of large-scale flooding events notably around the LG sites of Pincevent and Verberie with large-scale low energy flooding (Orliac 1994; Pastre *et al.* 2000; Roblin-Jouve 1984). Other major tributaries such as the Meuse-Maas (Busschers *et al.* 2007; Mol *et al.* 2000), Vecht (Huisink 2000), Scheldt (Bogemans & Vandenberghe 2011; Storme *et al.* 2017) and the Niers Rhine (Busschers *et al.* 2005) have preserved fluvial sediments dating to GI-2e indicating an increased seasonal flow following GS-2a south of the Channel. In Britain, the sedimentary record from the Great Ouse indicates a strong spring break most likely followed by persistent nival input (Gao *et al.* 2007), the Thames appears to maintain a braided system.

Smaller tributaries flowing through carbonate rich bedrocks and sediments had significant slope destabilisation during colder periods, with both flow and pooling as indicated from molluscan data from the Somme (Antoine *et al.* 2003c; Limondin-Lozouet 2011) and SE English dry valleys such as Holywell Combe), that would have been active at the time.

Another source for seasonal groundwater conditions are lacustrine regions either feeding into or adjacent to the LGCR, such as the Belgian Moervaart Palaeolake (Bos *et al.* 2018; Crombé & Robinson 2017) and wetland deposits of SE England (Parker & Robinson 2003; Parker & Goudie 2007; Simmonds 2017). These register an intense groundwater regime

during the Bølling, with significant seasonal flow followed by a drying up, most likely linked to late summer/early autumn slowing down of runoff water.

Low vegetation and the absence of soil development during the Bølling (see chapter 5), lead to intense seasonal runoff. Questions of intensity and type of precipitation remain, otherwise most courses could be considered as falling relatively low towards the end of summer unless glacially fed such as the Rhine and the Northern Course of the LGCR. Rate and intensity of flow from glacially fed courses remain unknown. Permafrost, or a thermokarst/degrading-permafrost terrain could also add significant additional flow to the fluvial regime, notably during the early Bolling (Antoine 1997b; Brown 1997). Direct rainfall would create rapid swelling of channels due to the absence of soils (e.g. such as arroyo's and wadi's in arid environments today) whereas nival input may also be high if there were heavy snowfall and relatively short summer days (Briant *et al.* 2005; Gao *et al.* 2007). This rhythmic seasonality would have been an important factor in the timing and choice of routes during the early LG. The expected outcome would be potential higher mobility during the winter over frozen landscapes and late summer after the ice breaks have receded.

During the Allerød, with the onset of vegetation leading to bank stabilisation, combined with the intensification of atmospheric precipitation (snow and rain), there is every reason to assume a continuous flow from spring until the winter freeze-up (Gao *et al.* 2007; Gao 1997).

The transformation of channel structures from braided to single channel meandering between the Late Bølling and the Allerød can also be considered as a restructuring of the mobility axes. The flow and depth of riverbeds would be high energy during spring break-up, followed by a continuous deep channel flow during the late summer period that would be very susceptible to rainfall and surface runoff. These deeply incised single channelled systems have a more regular and deep-water flow, becoming perennial barriers unless adaptive techniques are used (e.g. boats), or pathways shift further up river to shallower natural fording locations.

6.4 When rivers act as barriers; impeding or reducing movement

Rivers can act as barriers when they are too large to cross, too deep or have dangerous high flows. The size, depth and rate of flow/dimension of river courses are significant factors in whether a river is a barrier or a conduit (Vandenberghe & Woo 2002; Woo 2012a). These factors may vary based on dimensions, structure of the river course, and seasonally. River courses can also be both barriers and conduits.

A very broad deep flowing river can be hazardous to cross, and would require extra planning, strategies and/or technologies (e.g. watercraft). Rivers such as the Rhine during the Roman period were noted as physical barriers (e.g. the *Limes*). Although it is possible to cross by swimming, the use of boats was a requisite for regular river crossings unless moving far up-river to fording locations, otherwise these rivers would represent natural barriers. The same may be considered for the Missouri River in North America, where in its upper reaches, although a broad and swift river, Mandan and Lakota tribes frequently crossed it and transported heavy loads downriver using water craft (bullboats, similar in design to the European coracle) (Bowes 2008; Hornell 1946)(Figure 6.15). The broad river remained a significant natural barrier to migrating herds and seasonally slowing movement across it rather than completely impeding it (except in winter).



Figure 6.15 A Mandan Village with bullboats on the Missouri (Painting by Karl Bodmer) (Bowes 2008: 7)

Local topography can transform a river into a barrier created by a combination of geology and structure when the river course narrows constraining and intensifying flow (e.g. gorges). Natural choke points such as the Straits of Dover would be areas of intensification of flow. Sharp variations in topographic elevation such as past knickpoints, geological faulting or past shorelines may result in cliff lines and waterfalls as found along the northern bank of the north Channel.

6.4.1 Braided Rivers

Rivers with braided channels predominate during the Bølling (Chapter 5). They are marked by very strong seasonal variation. The active channel during peak flow can be very broad and erodes laterally. It is also of extremely high energy following ice break-up.

This is amplified by strong winters and deep freezing of riverbeds, as the release is abrupt and can last up to one to two months when the river is a true physical barrier.

6.4.2 Meandering Rivers

Meandering deep single Channel River systems develop during the Allerød in NW Europe (Chapter 5). There is a significant variation in depth and rate of flow between the upper and the lower course. As with braided channels, these may represent natural barriers along the trunk and principal tributaries of the LGCR, notably in the mid and lower river sections. As with braided rivers, the spring ice break-up (usually around a month) is a period when the larger rivers become particularly hazardous and represent physical barriers.

6.4.3 Importance of "crossing" large rivers: fording

Fording rivers is linked mostly to intensity and/or depth of flow. The locations may vary significantly based on seasonality and on channel type (braided/meandering). In both cases the shallowest locations are either upstream where the floodplain is broadest and not constrained by local topography, or seasonal with lowering of the water levels (Figure 6.10).

Braided rivers have a drop in flow towards the end of summer (unless glacially fed) shifting potential fording locations significantly down river. Braided rivers also tend to restrict flow to fewer deeper channels or even a single channel when the floodplain is constrained. This also has an impact on animal fording locations such as reindeer crossing (Smith 1978). For single Channel Rivers, the same may apply for smaller courses if there is

not a significant amount of precipitation during the summer months or nival input maintaining a high flow. In the case of deep single channel meandering rivers, the fording locations shift from further upriver during the early summer months (but this period is also usually associated with extensive flooding and breaking of the river banks creating an extensive shallow wetland) and may shift downstream as the river levels drop. Beavers would have an important impact on medium and small courses in this type of environment.

For SE England the larger palaeo-river courses (Thames and Solent) have been sub-divided into upper, middle and lower sections to map potential fording regions and eliminate unlikely areas (e.g. the Gaps through the chalk downs). This topographic division was the first step in modelling mobility patterns for these river systems. It can thereafter be combined with seasonal modelling and flooding patterns to determine most likely terrains facilitating access.

6.5 Rivers as corridors; enabling and facilitating movement

6.5.1 Open Environments (GI-1e-d, Bølling / Older Dryas)

The onset of the Late Glacial is marked by a transition from arctic tundra environments to thermokarst grassland environments with very little soil development (Atkinson *et al.* 1987; Catt 1979). Rivers historically facilitate movement through arctic and sub-arctic open landscapes: tundra, park-tundra and plains. Tundra "barren-land" environments are marked by a strong bipartite seasonal fluctuation (long winters and short summers), and the use of rivers in traversing them has proven to be an important strategy in the historic and ethnographic records (Aporta 2003; Hearne 1795).

6.5.1.1 Spring-summer

This wetland topography would be seasonally flooded, notably during spring to summer melts and high water (Vandenberghe & Woo 2002; Woo 2012a), leading any mobility to be reduced to on the water (water vessels) or on higher ground avoiding wetlands (marshes, pooling, muskeg) and river floodplains (Figure 6.16). During summer months a boat and/or river routes are historically an option to facilitate movement (Figure 6.11).

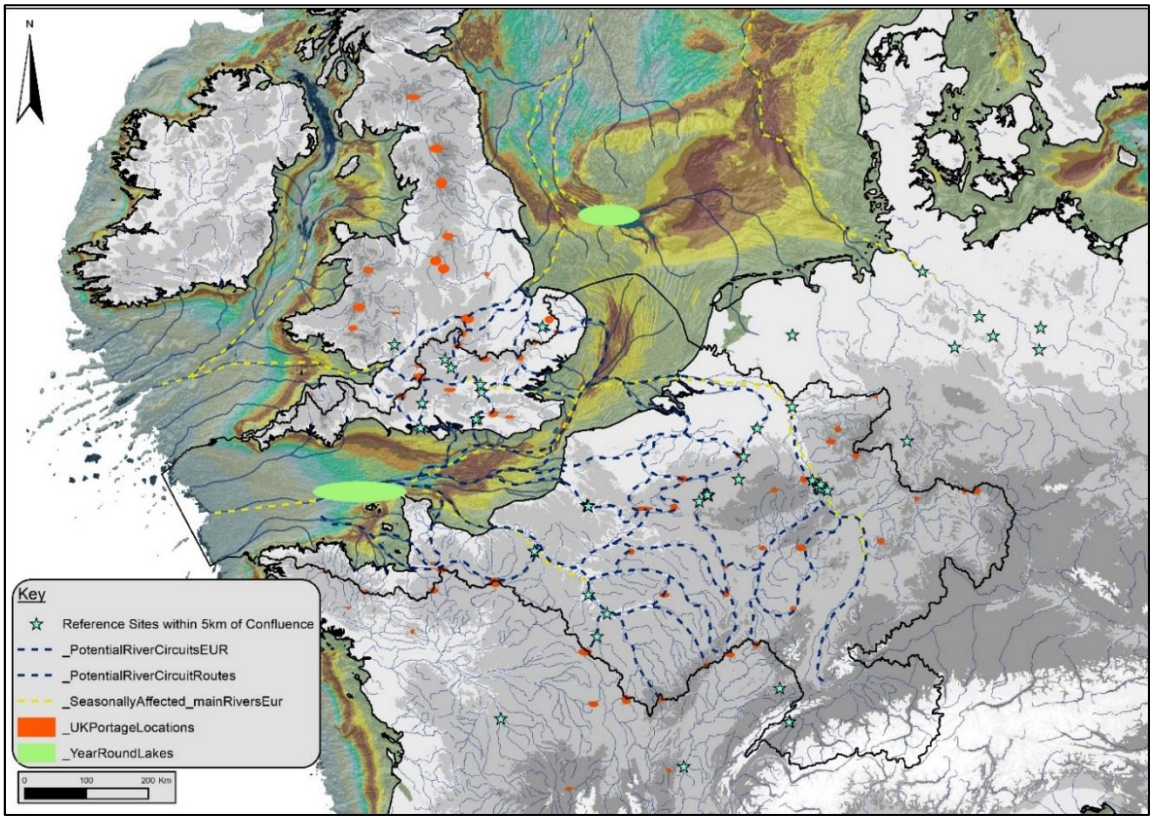


Figure 6.16 Potential navigation routes and portage locations. The estimation of the routes is based on the main tributaries and courses within each catchment. The modelled portage locations (indicated in orange) are based on the nearest connectivity between catchments. (Source: Author. Basemap EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

Throughout the pleniglacial, temperatures rarely rose above freezing, possibly limited to short periods of the day during summer months. Temperatures would have seasonally been high enough to melt the active layer in permafrost regions (Atkinson *et al.* 1987; Catt 1979). During the Bølling the conditions were marked by a discontinuous permafrost moving into a degradation or thawing of the thermokarst as the LG advanced (Isarin 1997). This would create a very specific wetland environment (comparable to muskeg with no soils), difficult to traverse, with uneven ground, significant pooling and little in the way of topographic markers (Hearne 1795; Woo 2012a). In the case of standing melt water floods, pooling would be constantly shifting, and permanent routes would be absent in the lowlands and floodplains (Hearne 1795). Due to north wind exposure in

Britain, there would most likely be a differential thawing between the North Sea region and the Channel River region. This would provoke a differential spring thawing and flow pattern, with an initial western spring melt and thawing followed by the eastern region. This could hypothetically lead to distinct mobility patterns shifting from east (Doggerland) to west (England-Wales) following initial thawing. Owing to the absence of arboreal vegetation resources, a reliance on large herds creating migration corridors (Gordon 1975), as these landscapes provided the necessary resources (Blinnikov *et al.* 2011; Gordon 1975; Guthrie 1982; 2001; Zimov *et al.* 2012). These animal routes would be a significant factor determining mobility patterns through these open landscapes (Gordon 1975).

6.5.1.2 Winter

Rivers are historically the preferred route facilitating movement during the winter in tundra environments (Aporta 2009). When there is snow-cover, the uneven landscape quickly becomes treacherous, with low visibility and with snow drifts masking irregularities in the terrain. In contrast, rivers and lakes are, when frozen, relatively flat, and can be distinguished within the uniform snow-covered landscape as snow drifts are preferentially blown-off iced surfaces. These surfaces also facilitate the use of drawn equipment such as sledges, travois and toboggans (see below). Being located on a frozen river provides a topographic location, as the river systems are continuous landscape features. Finally, in these open environments, the scant vegetation is mostly concentrated around riparian and lacustrine systems, enabling access to rare resources such as shrubs (dwarf willow; dwarf birch) for fire and retooling (Hearne 1795; Pitul'ko & Kasparov

1996), as well as attracting fauna as food use, hide material and fuel (Guthrie 2001). Some forms of bedrock and surface geology favour the formation of vegetated patches, such as sandy deposits, sandstone bedrock and loess formation. The advantage of sandy surfaces is that they are well drained in summer if found in elevated positions and can provide non-waterlogged environments for occupation as well as vegetation with roots reaching the aquifer. This is recognised as a preferential site location in the ethnographic record (Hearne 1795; Jarvenpa 1979; Jarvenpa & Brumbach 1988).

6.5.2 Vegetated environment

Regions with dense vegetation can impede mobility (notably dense undergrowth) or visibility (of the horizon and/or waypoints) (Figure 1.4). This is well documented amongst mobile groups in boreal-taiga forested regions (Jarvenpa & Brumbach 1988). These conditions are applicable to the second half of the Allerød in SE England with its open-forested environments and development of shrubs, especially along riparian corridors (Preece & Bridgland 1999; Simmonds 2017; Walker *et al.* 2012). In these regions, river systems create natural topographic corridors, funnelling movement along the course, banks and terraces (Aporta 2003; 2005; Aporta *et al.* 2014; Smith 1978). Potentially, understanding mammoth landscape behaviour would help enhance the modelling of migration behaviours and large herd movement as they are considered as trail blazers.

The shared and repeated use of animal pathways can provide a significant opening of vegetated landscapes in direct relation to primary resources (Taylor 1994, 4–6). When considering the assemblages of large mammals from the Bølling and the Allerød, they

would have very different impacts and path-building systems within the landscape. The Bølling assemblages mentioned above indicate that human interaction was primarily with mammal herd groups (mammoth, horse, reindeer) and some smaller specialist fauna (arctic hare, arctic fox) most likely for furs. During the Allerød with the advance of shrub vegetation and forestation, the 'natural' pathways would change as the main faunal groups were transitioning. The faunal assemblages are mainly represented by auroch (*Bos primigenius)*, red deer (*Cervus elaphus)*, elk (*Alces alces)* and rare equids for large mammals and some smaller fauna, such as beaver (*Castor fiber)* (Coles 2006) and indirectly with isotopic analysis potentially aquatic resources or marine mammals (Richards *et al.* 2005).

Often the pathways around riparian environments are developed according to access to water and constructed by multiple species repetitive use creating open pathways (e.g. some trailblazers, and others following the established route). Historically mobile groups identify and follow the most suitable of these paths to traverse the land (and settle in regions above the floodplain with relatively flat ground for camp locations). In this case, the river is not the path from spring breakup to autumn freeze-up, but the pole of attraction for animals creating paths.

An alternative route through closed environments is on the actual waterways. When the river is very shallow (e.g. summer in Bølling braided river context, notably secondary and minor tributaries), this can be simply walking along the riverbed. With more depth of flow there is the possibility of using watercraft (e.g. a meandering river). This can be

determined by the catchment size and slope (Chapter 7). Both factors are today mapped by canoeists when planning a course along a river, identifying flow, knickpoints, and rapids based on topographic maps. Sections of navigable river courses can therefore potentially be modelled. For the Late Glacial, this model is applicable during the Allerød with the development of meandering single channel courses. When navigating rivers, movement is mostly downstream, however, going upstream is also common, especially around larger courses and estuarine regions. This could also be a rapid colonising dynamic. Transport of watercraft over short distances and between interfluves is a possibility (portage) as well as local construction of watercraft when needed.

The river consequently plays the role of a converging path-maker, a landscape marker for orientation and a centre for resources. There is always a sense of orientation (direction of flow) within the course of the river in even the densest vegetation and flattest landscape (Aporta 2005). Ethnographic data suggest that the larger the river, the more significant role it plays in the mental mapping of the landscape (Aporta 2003; Aporta *et al.* 2014; Bennett *et al.* 2016; Cogos *et al.* 2017).

6.5.3 Rivers as contrasting features in the landscape: resources

Rivers, estuaries and wetlands are arguably the most important resource poles in the LG landscape. The LGCR being the largest geomorphological feature in LG northwestern Europe, not only had structurally defining topography guiding fauna and humans alike, but also constitutes a zone of attraction for both fauna and humans with the resources it

provides. The following section describes some of the most important resources that can be mapped in the landscape.

6.5.3.1 Water

Water is an essential element for occupation and when processing large scale hunts of herd animals, notably the spring and autumn migrations of reindeer recorded in other regions of Late Glacial Northern Europe. There appears to be an absence within British Cave assemblages (the vast majority of faunal assemblages for the LG in Britain), and the question remains whether this reflects the landscape (Jacobi 2004). There is also a strong possibility that these are not on the migration routes that would focus on the regions most exposed to summer Atlantic westerly predominant winds in the LGCR valley and the Irish Channel.

6.5.3.2 Vegetation

Rivers concentrate vegetation in both open tundra and closed forested environments and are ecotones. In arctic environments resources are extremely sparse, and river systems sustain woody shrubs essential for firewood, tools and nourishment if they produce berries (Turner *et al.* 2003). Furthermore, they attract fauna. During the Bølling colonising plants would have initially concentrated along river systems, not only because of access to water but also due to the distribution by animals who would regularly access water (birds, herbivores, omnivores) disseminating seeds via their faeces, creating a concentration and variety of resources within a very open and barren landscape.

When considering fuel in cold regions, although there are many different types of fuels available, such as herbivore dung and bones, wood from shrubs would be the most efficient combustible for higher temperatures (Pitul'ko & Kasparov 1996). Wood is also important for tool and receptacle making for mobile groups, but in regions supporting large faunal herds, bone, ivory and antler can be used instead (Pitul'ko *et al.* 2017). There are also food and medicinal properties in shrubs and plants growing in wetland and riparian environments, such as willow and birch fungus that are present during the Bølling (Simmonds 2017). Comparatively, in open-forested environments, the clearings made by river systems can lead to lighter and diverse vegetation.

6.5.3.3 Minerals

The rivers erode and transport mineral raw material. This would be even more substantial with seasonal extremes in water flow, causing large fresh erosions and deposits which would be accessible during periods of low water. The access to mineral raw materials (e.g. flint, sandstone, hematite) would also be affected in cold poorly vegetated environments by colluvial slope erosion of flint bearing chalk's susceptible to freeze-thaw erosion (French 2010; Preece & Bridgland 1999). The freshly exposed scarp faces and erosion of the base of scarp sediments into river systems would both expose primary sources of flint and redistribute and sort the material during high waters providing easy access to flint blocks in secondary context during low waters (end of summer and autumn). In the region of SE England, with Cretaceous flint-rich Chalk dominated geology (Aliyu 2016; Mortimore 2011) combined with Tertiary sandstone beds, riverbeds and exposed scarps would provide significant resources for frequently used raw materials

(flint, sandstone blocks, pyrite). This fits both the Creswellian and Early Federmesser lithic procurement strategies of large blocks for the curation of cores for transport and the production of long blades (Barton 2010; Barton *et al.* 2003).

Within more vegetated forested environments where there is less bedrock and soil exposure, river systems provide access to large quantities of redeposited (secondary context) raw material in both the river banks and the sand and gravel bars, ideal locations for sourcing flint nodules. The selection of river cobbles as cores is apparent in the Allerød Federmesser lithic procurement strategies, where many of the smaller cobbles used for lithic production are clearly derived from river courses (Barton 2010; Barton & Roberts 1996b). These would be mostly exposed in late summer as well as winter along the edges of the floodplain, on exposed mid-channel bars and abandoned braided channel bars before the onset of significant soil formation. The region of SE England would therefore represent a major acquisition area for crafting and processing mineral resources (flint, sandstone, haematite).

6.5.3.4 Driftwood

This resource can be indispensable in regions lacking in wooden raw materials / resources (Alix 2004). Very little is known of Late Palaeolithic wooden resource use in NW Europe due to very poor preservation. In the subsequent Early Holocene, Mesolithic wood use preservation is much better, and it is very clear that it played a central role in tool design and production (Taylor *et al.* 2018a). The Palaeo-Rhine course during the Late Glacial would travel through southern wooded environments absent in the northern UK during

the Bølling. The change of course of the Paleo-Rhine and its tributaries preceding the entrance into the Channel-River region, followed by the narrowing and splitting of the river course, would have been locations for the deposit of significant amounts of driftwood transported from further south by rivers. Westward, Hurd's Deep and the confluence of the North Channel and South Channel and the Seine (see Chapter 5), would also be a region of significant driftwood deposition (Figure 6.17). And finally, the advancing estuarine shoreline at the western end of the Channel River would have been a region of significant driftwood accumulation.

Throughout the Allerød the quantities of driftwood would be very significant, with the presence and development of beaver dams and their eventual demolition and flushing downstream with the high energy spring ice breaks. There is significant evidence for beavers around the Palaeo-Rhine in the Neuwied Basin during the Allerød (Baales *et al.* 2002b) and in southern Britain (Coles 2006), and potentially an even earlier Bølling presence. Sedimentary deposits in the Kennet Valley indicate pooling and lacustrine deposits possibly linked to the development of beaver dams during the Allerød (Collins *et al.* 1996; 1996). Species of wood absent in Britain at the time travelling from further south would have been transported by flow in vicinity. This could also be one of the major factors for site locations, at least seasonally, and especially during the Bølling when wood would be a scarce resource (Alix 2005; Alix & Brewster 2004). During the Allerød, with the transformation of hunting technologies towards the more frequent use of the bow and the possible use of watercraft, driftwood and wood sources would represent an important additional resource (Alix 2004; Grønnow 2012; Walls 2010). This must be one of the most overlooked resources that can be modelled. Downriver regions of

confluences and major shifts in river orientation would be major regions for the accumulation of driftwood. Examples include the Southern Bight before entering the Channel Region, broader floodplains following restrictions of the course such as the Northern Channel following the Straights of Dover, and the region of confluence of the Southern and Northern Channels before Hurd's deep.

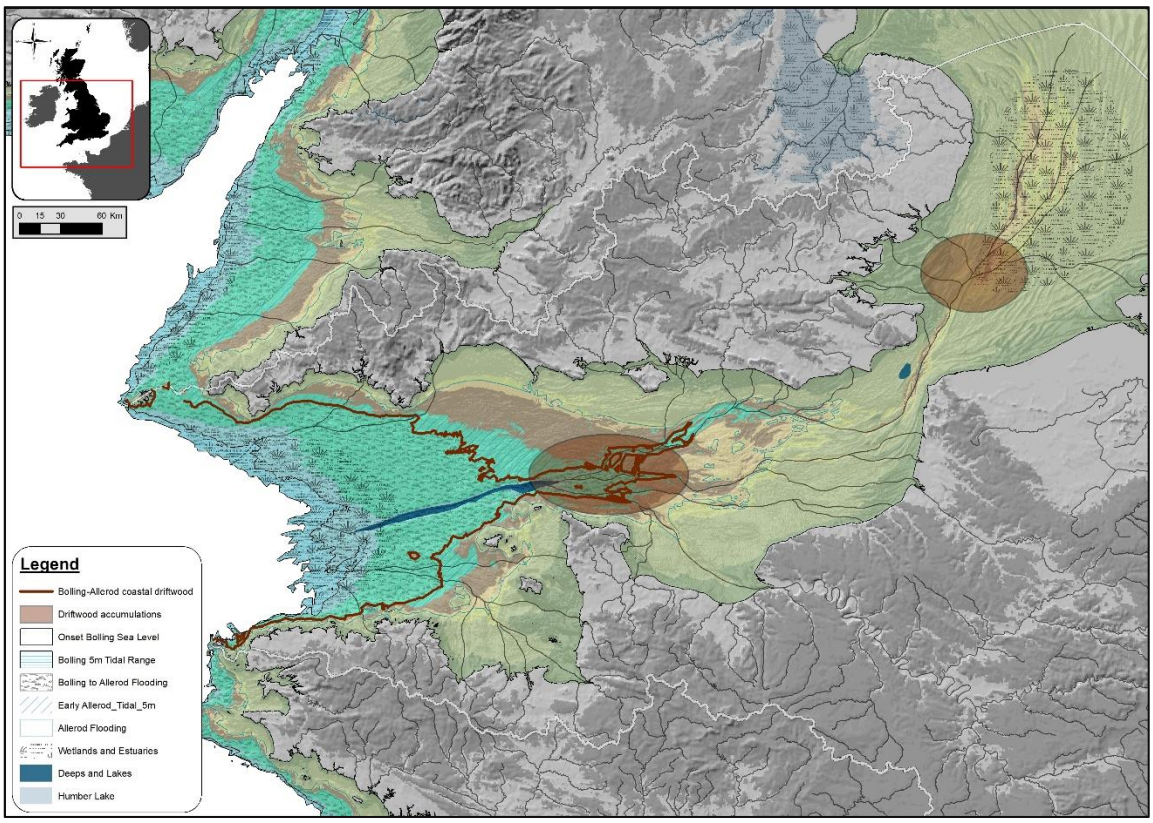


Figure 6.17 Late Glacial Driftwood distribution. (Source: Author. Basemap EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

6.5.3.5 Lakes and wetland environments fed by rivers

These provide complex habitats with notably the development of fish, which attract many other species. These ecotone 'edge' regions are often focussed upon by hunter gatherer groups (Turner *et al.* 2003). There are inland lakes and waterbodies that would develop,

and significant regions along the Channel River such as Hurd's Deep and the Southern Bight that may have represented important wetland zones. The pro-glacial lake in the Fenlands, Lake Pickering (Murton & Murton 2012), and Hurd's Deep, could represent an even more significant location during both the Bølling and the Early to Mid Allerød, with sheltered refugia for marine mammals such as seals, or during the Allerød when it falls under the influence of brackish and marine environments, an ideal location for these types of marine mammals.

The Magdalenian use of these resources is supported by the anatomically specific depictions of different types of seals (2 to 3 different species) on stone plaques at Gönnersdorf (Figure 6.18), which would have been several hundred miles inland at the time (Hansen 2006). This is supported by the records of Late Glacial seals around the North Atlantic and Baltic Basin (ringed seal, *Phoca hispida*; Grey seals, *Halichoerus gyprus*; Harp seals and the arctic bearded seal, *Erignathus barbatus*) (Schmölcke 2008; Sommer & Benecke 2003). There may also be some isotopic indications for the consumption of marine mammals at some of the Allerød occupations, notably the human remains from Kendrick's Cave, well within the mobility catchment area of mobile hunter-gatherer groups (Schulting & Richards 2009). The consumption of mammoth (Frison 2004) and/or fresh water fish may be yet other options for these higher nitrogen isotope levels (Bocherens & Drucker 2006; Drucker *et al.* 2016b; 2017), as there is evidence for their presence in the landscape at Condover (Lister 2009). If it were confirmed that it is marine mammals, this would be another indication for a very high mobility system covering

hundreds of miles, as well as the possible movement upriver of major channels of marine resources.

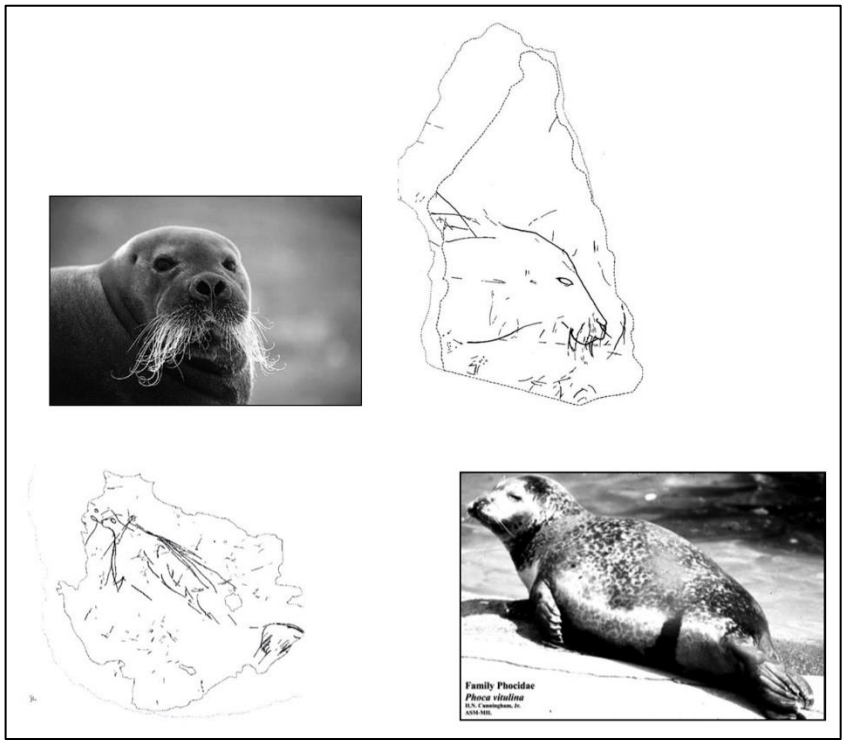


Figure 6.18 Engravings of seals at the Magdalenian site of Gönnersdorf , and identification of associated species: upper: Bearded Seal (Erignathus barbaus), Lower: Harbour seal (Phoca vitulina). (After Hansen 2006)

Salmon has rarely been discussed as a potential food resource during the Bølling in Britain, although it is a known for the adjacent continental Magdalenian and there is evidence for fish consumption in Britain during the Allerød (see section 6.2.2.3). Salmon runs require a river with a perennial channel leading to the sea, a feature known for the trunk valley and main tributaries of the Channel River system. As such these rivers can be assumed to have been potential salmon rivers (see Chapter 7). Salmon runs in rivers have a strong seasonal association (autumn) but may also be present during the summer (Hendry & Cragg-Hine 2003; Lindberg 2011).

These are only a few of the resources that can be discussed pertaining to the central gravitational landscape role of river systems in the LG. There is not the space here to expand further on the topic, but there is certainly scope for future investigation on this theme.

6.5.3.6 Vegetation, raw materials and gravitational regions around the Channel River Network

The development of vegetation creates bank stabilisation, soil development, and leads to structural changes such as single channel meandering rivers. It also implies restructuring of landscape resources that attract animals around riparian environments. This will be faster along south to north oriented river systems, as the flow direction would carry seeds etc. Otherwise, it is birds and fauna using the newly vegetated riparian corridors that augment the cycle of seeding and vegetation development.

The role of the Northern Channel is prominent within this framework, as it would be working as both a barrier/limit for the south to north accumulation of seeds and plants flowing from downstream southern tributaries, but also a region of intensive vegetational development due to high seasonal flooding and stranding of this vegetational material on the northern bank. Once it has taken hold on the northern bank it is up to animals (birds, mammals etc.) to initiate the propagation northwards through the newly developing soils along the south to north flowing tributaries. Wetland regions would probably be areas of rapid development attracting migrating animals (Simmonds 2017). These animal and

vegetal resources are also primary resources for the human population, and riparian corridors are therefore attractive as resource catchments, and mobility thoroughfares.

6.6 Part II conclusions

This section considered the role played by rivers in structuring the landscape seasonally and through resources. The physical conditions of the rivers (timing and extent of frozen, flooding, and flowing rivers) have a direct seasonal impact on population (human and animal) dynamics and mobility systems. There is also a climatic scale that influences the broader structure and dynamics of rivers throughout the LGI, with a clear division between the Bølling and the Allerød. The impact of both of these factors, climatic and seasonality, on river systems has a direct impact on the human use of landscape for occupation and resource acquisition. Many of the most important resources (water, vegetation, mineral, driftwood, lakes and wetlands) are directly synched to river and groundwater dynamics.

The physical landscape around the rivers also play an important role, notably in regard to large scale seasonal factors such as wind chill or exposure to ward off insects, opposed seasonally and in the landscape (higher or lower elevation, orientation of river valleys) both of which are arguably the most important factors in parallel with energy resources to survive in arctic and sub-boreal landscape based on historic and contemporary anthropology and history.

Four conclusions can be drawn for the fluvial impact on landscape structure and use for modelling mobility:

- Frozen winter rivers are the most reliable and constant routes into a landscape (especially when sheltered from dominant cold winds).

- Wind is arguably the most important factor in combination with river valley topography and orientation impacting on both mobility in both seasonal cold and warm conditions.
- Rivers function as distinct features in the landscape for resource accessibility in both winter and summer.
- Although this study focusses on the importance of the LGCR and its role when considering open-air LG archaeology in SE England, the importance of adjacent regions of the Irish Channel and Doggerland would be similar.

Following the description of archaeological evidence around the LGCR for mobility and landscape use (Chapter 6, Part I), and the role played by the LGI fluvial dynamics in structuring the landscape (Chapter 6, Part II), the following section will focus on the different technologies recognised in the archaeological record that would have a direct impact on mobility dynamics and scales in the LG, and landscape use in SE England.

Part III Evidence for Technological Adaptations to Fluvial Landscapes and the Mapping of territories

Having defined and characterised our current understanding of site distributions in SE England and its neighbouring regions based on techno-typological characteristics (Chapters 3 and 4), and characterised the main faunal groups recognised as LG resources in relation to the fluvial landscape, arguably the most important pull factor for these mobile groups (sections 6.1, 6.2). Starting from the material available, lithics scatters, it is necessary to spiral outwards to other sources that may provide insight into the archaeological record. The modes of mobility will be considered in the final part of this chapter. This is to assess the scales used when interpreting the archaeological record for this period, and to provide insight into potential new aspects of the lithics toolkit that could be over-emphasising the butchering and hunting function in the LG.

6.7 Technological adaptations associated with Fluvial Environments

The recurrent challenge of taphonomic biases within the British LG archaeological record is linked to the absence of preservation of organic material on open-air sites. This poor 'visibility' arguably leads to an over-cautious underestimation of behavioural dynamics, a phenomenon that has recently been termed the 'Schöningen effect' in light of Middle Palaeolithic wooden finds (Conard *et al.* 2015). The European LG open-air sites that preserve organic materials (bone, antler and ivory) have a near total absence of the preservation of wooden and hide/tendon material. The latter arguably composed the most important proportion of Upper Palaeolithic materials used in the fabrication of tools and equipment, based on comparison with analogous hunter-gatherer groups now inhabiting arctic and sub-arctic regions.

The thesis will take the position that LG hunter-gatherer groups have access to the technological adaptive abilities identified earlier in the archaeological record, and with a broader pan-Eurasian perspective (with boats and bows in particular), postulate that groups would adapt these techniques and crafts if the local environment was suited for their use. Emphasis is also made upon the regions of southern Europe, where Magdalenian LGM refugia are recognised prior to the colonising of Northern Europe during the LG (Fu *et al.* 2016; Gamble *et al.* 2006; Naudinot *et al.* 2017b; Straus 1996). These refugia have more sites with better preservation, informing on the skills and tools that used by migrating groups northwards. Additionally, by drawing upon records of available vegetal resources and recorded composite technologies recognised as optimal for the environments defined for the LG, to examine the criteria of different hunting

strategies and scales of mobility in relation to river systems that have been modelled in the past for this period.

The thesis focusses on the availability of resources in the fluvial landscape as predictable poles of attraction. This perspective is buffered by the appearance in the record of many of the technologies discussed here in a very developed state immediately subsequent to the LG in the Early Mesolithic, when the taphonomic conditions for wooden material preservation are available.

Preboreal Early Mesolithic directly dated sites with good organic preservation provide ample evidence of use of wood-based technologies. They also provide the first direct archaeological records for likely paddles and the suggested use of boats (Star Carr, Duvensee, Pesse) whereas arrows date to as early as the Younger Dryas/Pre-Boreal transition and associated to the Ahrensburgian (Stellmoor) (Ballin 2017; Bang - Andersen 2012; Bjerck 2017; Dunkley 2014; Erič 2014; Glørstad 2013; 2016; Mcgrail 1998; 1998; Meadows et al. 2018; Mithen *et al.* 2015; Rowley-Conwy 2017). These two technologies combined with means for movement over snow or frozen ground (sledges, snowshoes and skis) are significant as they would have a direct impact on our modelling of speed and distance of colonising and hunter-gatherer ranges within the region. It is possible that these have been largely underestimated, especially when considering the ranges of historic and ethnographic accounts of mobile hunter-gatherer groups in both North America and Eurasian Siberia.

The aim of this thesis is to evaluate potential mobility patterns and routes throughout the Late Glacial Channel River catchment landscape leading to the development of the British LG record as a holistic system at both regional and local scales. This is to position the lithic scatters of SE England within a broader context. When evidence leans towards a shift in technology based on environmental conditions such as types of rivers, local vegetation or behaviours and availability of recognised faunal resources, the parsimonious answer may be the usage of either boats and/or bows. Use of these technologies has already been suggested by many researchers (Baales & Street 1996; Barton *et al.* 1992; Eriksen 1996b; Fagnart 1988; Jacobi 2004; Riede 2009; 2010; Sano *et al.* 2016; Valentin 2008a; Weber 2009), but they are rarely included in discussion of large-scale LG mobility patterns. The thesis hypothesises that the presence of domestic dogs combined with evidence for long-distance transport of raw materials may imply a more dynamic use of frozen fluvial landscapes and hails the consideration of the use of animals of burden and sleds/sleighs (Eriksen 1996b; Rensink 1995; Street *et al.* 2015).

The argument is presented that these technologies are intricately linked to the evolution of LG fluvial systems and their distinct riparian vegetation and role in the landscape as described in sections above. This further enhances the potential role of the Channel River Network as a major physical and resource artery for mobility in northwestern Europe during the LG. The following section concludes that the Channel River Network ostensibly functioned as a living and seasonally rhythmic LG map of the region for hunter-gatherers living within its catchment, creating zones of exchange and encounter, resources, and dynamic avenues into the landscape around this centripetal feature.

This section focusses on five themes, with emphasis on bow technology as it has the best direct archaeological evidence and implies potential use of other technologies:

- resource availability;
- implications for landscape use of bow technology (hunting strategies, lithic management, forestation, links to other technologies);
- implications for landscape use of techniques to adapt mobility in specific environmental conditions (dogs and sleds);
- implications for landscape use of boats and watercraft; and
- how these technologies impact interpretation of British Late Glacial open-air lithic scatters.

6.7.1 Resource Requirements and Availability

6.7.1.1 Tundra and arctic environments

The adaptation to arctic environments by modern humans had been developing for over 25,000 years by the onset of the LG (Pitul'ko *et al.* 2017), with mobile strategies on water and snow developed in multiple regions at a truly global scale throughout this time (Siberia; Japan; Beringia; Australia; Cyprus; North and South America). It would appear more parsimonious to accept that these adaptive techniques would be commonly used if the conditions were optimal.

Resource availability is an initial step when considering the use of composite technologies such as boats and bows. Whereas in the Bølling north of the Channel River, the absence

of arboreal cover leads to a reliance on stone, faunal (including bone, antler and ivory found in large quantities amongst the Tundra-Steppe herds), and hide technologies (Pitul'ko *et al.* 2017; 2015). Animal and mineral resources are the main focus for local technologies in these environments.

There is an important source of wood in the form of driftwood along the Channel River's North Channel, transported by rivers flowing northwards from regions further south with developing arboreal stands (see section 6.2).

The best analogies available to these types of terrain are currently found in the ethnographic and historic records of tundra/arctic steppe regions of Siberia and North America (see section 6.2). The Inuit often combine a coastal and interior resource mosaic, marked by seasonal rhythms (Binford 1978; 1980; 2001; Kelly 1995). Skin craft such as kayaks and umiaks, historically used for sea and occasionally freshwater mobility are used during the summer and built using a combination of driftwood and skins (Adney *et al.* 2014; Alix & Brewster 2004; Arima 1987; Rasmussen 1926). When considering the isotopic signatures indicating the consumption of a proportion of marine resources (that could be entirely provided by salmon) of the Allerød skeleton at Kendrick's cave, relatively far from the coast, this form of mobile system is not to be ruled out (Richards *et al.* 2005). Although the Creswellian skeletons from Cheddar Gorge do not have an isotopic marine signature, if the origins of this group are from southern Magdalenian refugia, there was probably a marine component when accessible as well. Historically Inuit inland mobility is

mostly during winter, and relied upon two technologies, snowshoes and sleds (often made using driftwood materials recycled from summer watercraft).

Within these regions it is the seasonal access to resources that directs the how and when, that can be modelled for the LG. Collection and construction are focussed around spring and autumn with access to driftwood and the processing of materials gathered from hunted migrating herds. This is when most important crafting and construction activities would take place. This coincides with a significant transition in seasonal mobility patterns. These technologies are pivotal in this seasonal rhythm and adaptation. A review of archaeological sites with this type of seasonal resolution (e.g. Paris and Neuwied Basins) would be a useful future project.

Driftwood is a major resource in all arctic environments (Alix 2012a), and arguable the most neglected resource in the LG archaeological record due to the absence of preservation and visibility. However, the distribution of driftwood can be predicted along the Channel River and the Atlantic coast. The most important deposits would be major poles of attraction in summer, with lower water levels and winter for fuel (Alix 2005; 2012b; Alix & Brewster 2004).

6.7.1.2 Importance and sources of driftwood and the forest edge

Areas of important fluvial expansion and calm waters such as lakes or floodplains (Hurd's Deep in the LGCR), or the floodplains of the LGCR reaches with low gradients, would also be regions of driftwood accumulation. Large amounts of driftwood would be available

after seasonal flooding, such as early spring floods. With receding waters in late summer, autumn and winter this resource could be abundant in strategic locations.

Driftwood is a resource made available by south to north flowing tributaries as the vegetation expansion shifts from southern refugia into more northern zones during the Bølling and especially the Allerød. Once trees are established along the southern riparian corridors (Rhine and Seine), this resource would be available at both the confluence of the Thames (from the Rhine), along the Channel River and additionally with the confluence of the Seine and Atlantic. The earliest appearance of specific tree types along the Rhine and the Seine during the Bølling is the best indication of the availability of these types of wood as driftwood for crafting in Southern England.

During the Bølling and Allerød, beaver dam flooding also provides an important resource of standing cured wood by drowning trees at the base (personal observation in Alberta, Montana and Quebec, 2017).

During the Allerød, with the development of birch and pine forests in southern England, the wooden resource collection patterns would change. There is access to both greenwood, driftwood and with the establishment of meandering rivers probably different and increasing modes of transport and mobility requiring wood. This is likely expressed in hunting and raw material management, and subsequently in the lithics assemblages. There was most likely a prolific use of wood, with birch, pine and hazel available (Simmonds 2017) as well as other wood types from further south in the form of

driftwood. Birch, spruce and pine are traditional boat making materials present in this landscape. Hazel can be used to create frames for coracle like craft (e.g. bullboats, historic and personal experimentation). Although birch and pine are not associated with modern bow making, hazel can be used, and composite bows of birch and pine have historic and ethnographic antecedents (Insulander 2002; Lepola 2015), and willow was used in the Mesolithic at Star Carr (Taylor *et al.* 2018a) to create bows with less poundage. The Nunamiut Inuit traditionally used spruce with sinew backings (Rausch 1951). Furthermore, other materials such as antler, bone and tendons are also available and recognised in the ethnographic record as bow-making materials in regions sparse in wood resources (Bergman & McEwen 1997; Cattelain 1997; Clark 1963; Grønnow 2012; Hamilton 1970; Murdoch 1890; 1890) (see section 6.7.2). The environmental transitions are accompanied by technological adaptations that must be reflected in the lithic toolkit but have not been recognised yet.

The abundance of driftwood may also be an incentive to move into the Channel region during winter, as it would be a ready resource for fuelling fires whilst taking advantage of the rivers, resource convergence and strategic topography of the Channel River Network valleys. This usage of driftwood resources has also been recognised in the Mesolithic Siberian archaeological record at Zhokov, where driftwood was methodically used (Pitul'ko *et al.* 2015; Pitul'ko & Kasparov 1996). The Channel River valley was a resource-rich (flint, wood and fauna) region, protected from the harshest northern winds, and most likely concentrating human activity, at least during the winter months if not throughout the year in northwestern Europe. Furthermore, important wetland

environments (e.g. cut-off channels, deep water lakes such as Hurd's Deep, estuarine environments, etc.) would make this a year-round resource rich location of interest.

A misrepresentation of a sudden transition to woodworking with the development of adzes and axes in the Mesolithic is possible. This could be more a focus on chopping rather than splitting techniques rather than a complete revolution in the materials used. This is not necessarily linked to the intensity of wood usage, but more to the techniques of wood transformation. Technologically, the LG inherits the Magdalenian techniques of splitting and edging/grooving techniques focussing on preform blanks of organic material and optimising integrated properties (following the grain) to optimise a rare resource, as opposed to shaping tools to the immediate need that develops in the Mesolithic with the abundance of green woodland, following an inherent form as opposed to carving a form (Grønnow 2012; Pitul'ko & Kasparov 1996; Taylor *et al.* 2018a; Walls 2010). Possibly more intensively used during the Mesolithic, but not necessarily a sudden apparition of its more frequent use (e.g. consider arctic and forest groups of North America, both use wood but with different techniques and intensities). This represents more a local environmental adaptation. The methods of splitting and grooving are still recognised in traditional forms of bow and boat making in arctic and subarctic environments, as they optimise the use properties of organic raw materials available. The question remains: what are the woodworking tools in the LG lithics assemblages that may have survived in the landscape? When considering which tools would be appropriate for woodworking amongst the LG assemblages, the tools identified for working other hard organic materials such as for antler would appear to be appropriate for driftwood. However there

is little to no trace of woodworking usewear amongst these tool types in the LG (Jacquier 2015), bearing in mind that it also remains very difficult to identify this type of wear and to distinguish it (Jacquier 2015). Additionally, the historic evidence for driftwood working amongst arctic habitants, indicates the use of a variety of tool types and materials (metal, stone, bone and ivory) used for splitting (Alix 2012a; Walls 2010) rather than chopping and carving as found with greenwood (Taylor *et al.* 2018a). This distinction means that the question remains unanswered, other than that the current evidence is only extremely rare amongst LG stone tool assemblages. Earlier hypothesis that LG sites with high proportions of burins might be interpreted as wood working sites (e.g. Mills 2013) are therefore inadequate and the evidence currently indicates the contrary, that burins were mostly associated with antler or on hard materials (Barton 1986; Jacquier 2015). The Late Glacial usewear analyses carried out up until now in northern France only indicate a rare potential usage for splitting wood on a few tools (end-scraper, blades and burins) that show traces of use as chisels or wedges; however, it remains very difficult to distinguish microwear traces from bone/antler work (Jacquier 2015, 212–13). Another rare example of lithics used for LG vegetal/woodwork is found further afield on Federmesser and Swiderian material from Poland (Sobkowiak-Tabaka & Kufel-Diakowska 2019). I could not find any examples of experimentation on cured wood (e.g. driftwood) compared to greenwood that would have very different characteristics, and this might be worthy of further investigation as well as the use of different types of wooden hammers, cured, green and fire hardened, although a soft organic hammer has been considered at La Fosse as there were no clear percussion impact traces (Jacquier 2015, 212). For the same time period, YD/Early Holocene transition, usewear analysis at Three Ways Wharf indicates a

dominant use on wood (Lewis & Rackham 2011), however this remains contested due to the methodology used at the time (Jacquier 2015, 384). Comparative usewear is very frequent on wood and vegetal remains dating to the Mesolithic (Guéret 2013), accompanied by preservation of wooden tools for the same period (Taylor *et al.* 2018b). The Late Glacial usewear analysis from Pont d'Ambon does however indicate use of truncated blades for woodwork (and on fish), and one large blade for a sawing action (Moss & Célérier 1983). As with the LG/Holocene transition and the Mesolithic, it appears that the few lithics directly associated with woodwork are used in a scraping fashion (e.g. debarking, or scraping) (Guéret 2013; Jacquier 2015; Moss & Célérier 1983). This is paralleled in the ethnographic record where most splitting woodwork is carried out with bone and ivory tools (Grønnow 2012; Walls 2010).

6.7.2 The Bow, hunting strategies, local environments and bow technologies

Bow technology may be the best indication for a significant change in the use of wood as an available and transformed raw material. This has many implications for other methods that could significantly impact mobile groups through the landscape such as boats as they share the same concepts and use the same properties of wood (grain, tensile properties). It is also directly linked to different hunting methods and differential landscape use. If the use of bow technology is recognised in the LG record (Barton 1992; Barton & Bergman 1982; Dev & Riede 2012; Jacobi 2004; Meadows *et al.* 2018; Moss & Célérier 1983; Naudinot 2009; Rots *et al.* 2003; Sano 2009; 2012; Sano *et al.* 2016; Weber 2009), and numerous sites with stone artefacts (shaft smoothers) likely used for arrow shaft production (Moreau *et al.* 2015; Naudinot 2009; Riede 2012). For these reasons the

evidence for the 'intensification' of bow use in the archaeological record will be examined in greater detail.

Although much of the literature on the development of the bow has focussed on archaeological evidence, as it should be, perhaps more focus could also be made on the local environments (Dev & Riede 2012; Riede 2009; 2010; Weber 2009) that lead to the development of bow technology as an optimal hunting strategy (Barton & Bergman 1982; Cattelain 1997; Cattelain *et al.* 2002; Edinborough 2005). One of the major arguments for the transition to the bow in the archaeological record has focussed on the presence and absence of spear throwers, the presumed predominant predecessor and hunting equipment used for mass herd hunting before the 'age' of the bow (Cattelain 1997; Cattelain *et al.* 2002; Pétillon *et al.* 2011). It is now becoming more evident that both technologies, at least for a while, coexisted (Cattelain 1997; Dev & Riede 2012; Pétillon *et al.* 2011; Valentin 2008a). The most ubiquitous archaeological evidence remains the actual projectile points (mostly stone but also bone and antler), and analysis of dimensions (Figure 6.19) and impact criteria have been amongst the clearest indicators of a transition in projectile technologies in the Northern European LG record (Cattelain 1997; Dev & Riede 2012; Pargeter 2007; Rots 2016; Rots *et al.* 2003; Sano 2012; Sano *et al.* 2016; Shea 2006; Shea & Sisk 2010).

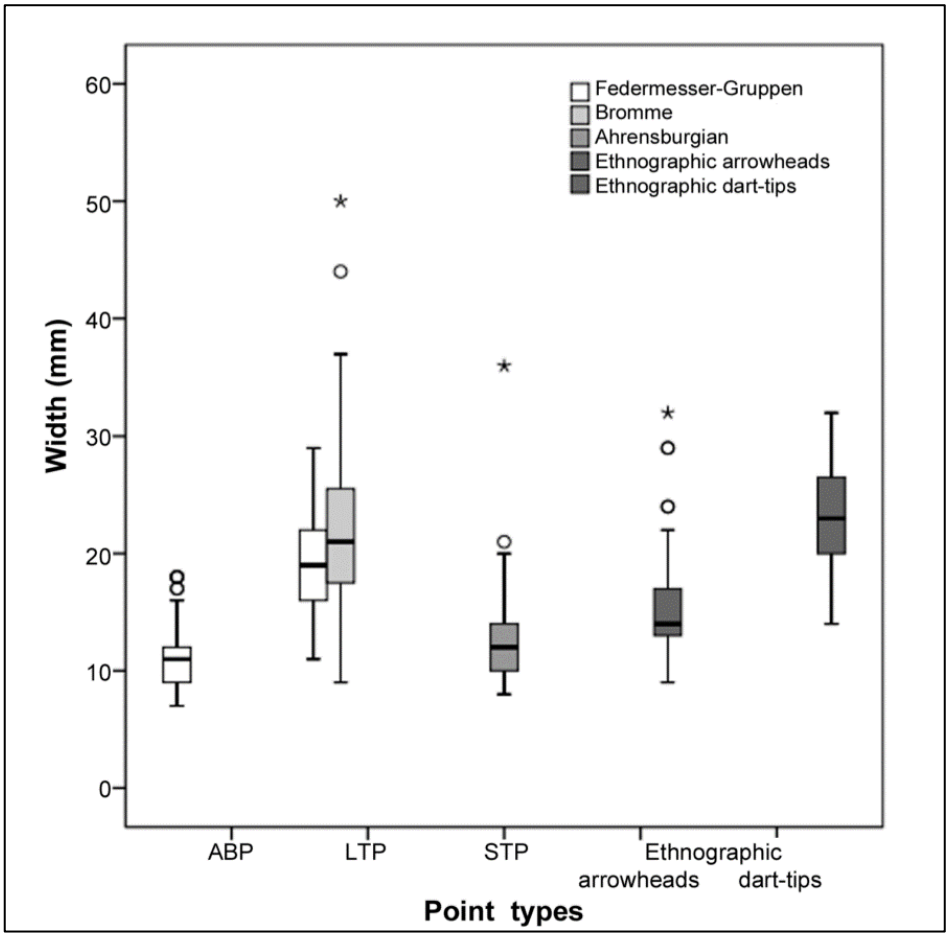


Figure 6.19 Box-and-whisker plot showing the maximal width measurements for points : arch-backed points (ABP) of the Federmesser-Gruppen (NABP= 138), large tanged points (LTP) from Federmesser-Gruppen contexts (NLTP= 41), large tanged points of the Bromme culture (NBromme= 244), and the small tanged points (STP) of the Ahrensburgian culture (NAhrensburgian= 147). (Dev and Riede 2012: 44).

The record in Europe based on projectile points indicates a transition within the LG from predominance of spear thrower to bow technologies (Barton & Bergman 1982; Dev & Riede 2012; Leroi-Gourhan 1983; Rots *et al.* 2003; 2005; Sano 2009). This section examines how the context for technologies involved in the creation of the bow, directly links to the local environment and resources. Also considered is the important role that river systems might play in the development or transition to a preference for this type of technology during periods of the Late Glacial. This technology would also have a direct impact on the assessment of lithics assemblages.

The arrows found at Stellmoor are the earliest irrefutable evidence for the use of the bow in NW Europe (Rust 1943; Weber 2012). These finds are associated with the late Ahrensburgian technocomplex and date to the last phase of the Younger Dryas (Meadows *et al.* 2018; Riede 2009; 2010; Weber 2009; 2012). These are technologically advanced composite arrows with foreshaft, and made of *Pinus* sp. (Meadows *et al.* 2018; Weber 2009). These faunal assemblages are also very strong indirect evidence of hunting practices using bow technology, they are mass reindeer kill sites, near river crossings, and the faunal remains bear the traces of multiple impact marks indicative of group strategies (Bratlund 1991; 1994; 1996). Some inland Inuit such as the Nunamiut hunted caribou with both spear and bow (Figure 6.20)(Rausch 1951).

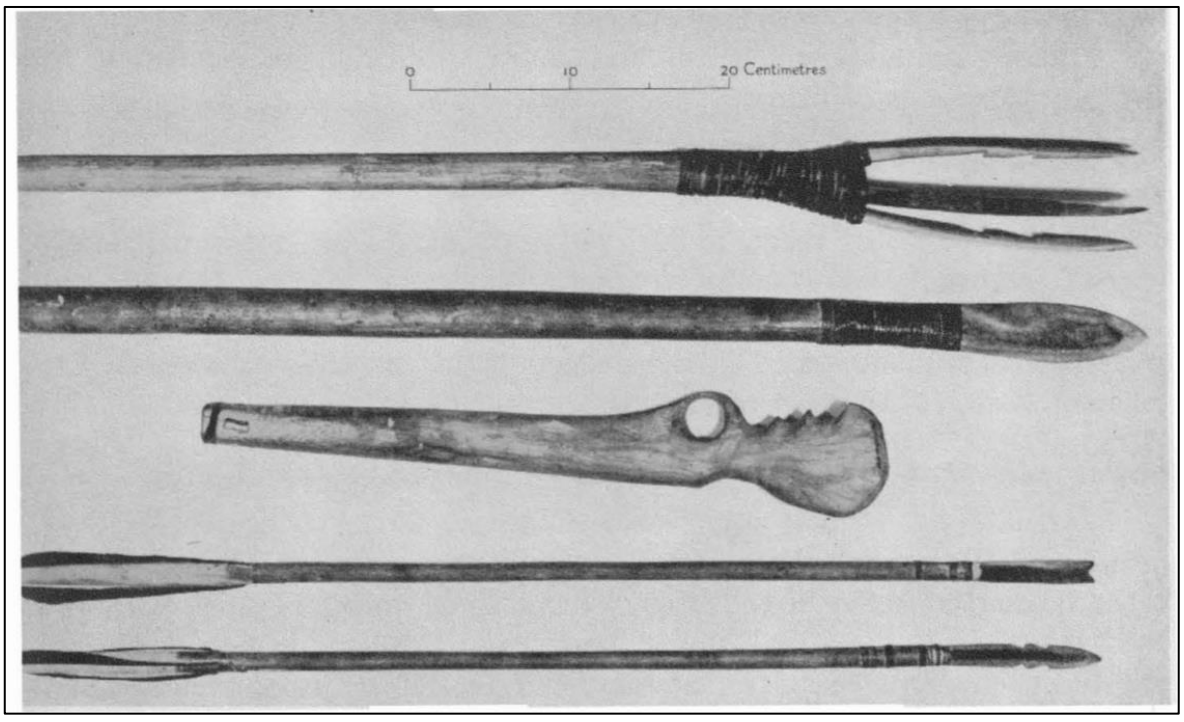


Figure 6.20 Nunamiut hunting weapons : three-pronged throwing spear; spear for swimming caribou; throwing stick; bird arrow (uchulick); caribou arrow (natkulik). (Rausch 1951: 163). N.b. the presence of both spear and arrows for hunting caribou. The bow was the principal weapon used for hunting ambushed caribou crossing rivers by the Nunamiut, and the spear is used for hunting caribou from kayaks, often in lakes (Rausch 1951: 163, 191).

Other earlier LG indirect evidence dating to the Allerød (Gillespie *et al.* 1985) is recognised on projectile points. Two antler harpoon points were recovered embedded in a Eurasian elk/moose (*Alces alces*), one in the shoulder blade and the other in the hind limb, at Poulton-le-Fylde, and based on dimensions have been interpreted as a spear or arrow projectile (due to its small size) associated with the bow (Barnes *et al.* 1971; Mason 1894) or barbs for a leister (Pettitt *et al.* 2017), and due to the large size of the complete dart the evidence for the use of a bow from Poulton-le-Fylde remains indeterminate. The use of a bow would be in accordance with the hunting strategies associated with isolated fauna such as elk as well as mass herd reindeer hunting associated with spear-thrower hunting (Barton 1999b; Churchill 1993; Rausch 1951). Another isolated small barbed point found in Gransmoor and dated to the Allerød has also been interpreted as a possible arrow projectile tip (Figure 6.21) (Baales *et al.* 2017; Sheldrick *et al.* 1997). A possibility is the hafting of a leister-like fitting onto arrows as in some Inuit examples for bird hunting when they are smaller barbs (Figure 6.20). The latter had some residue at the base interpreted as a mastic for hafting, which contained traces of pine mastic and bees wax which was later dismissed as a contaminant (Sheldrick *et al.* 1997). A very similar barbed point dated to the Allerød and made from bone was discovered in Germany at Bergkamen-Oberaden, with a basal mastic comprised of a mix of pine resin and bees-wax (Baales *et al.* 2017). Grooved sandstone blocks found on Allerød age sites throughout the region are interpreted as possible arrow shaft smoothers (as the grooves would be too thin for spear thrower dart shafts) and could provide further evidence for the bow during this period (Moreau *et al.* 2015; Riede 2012).

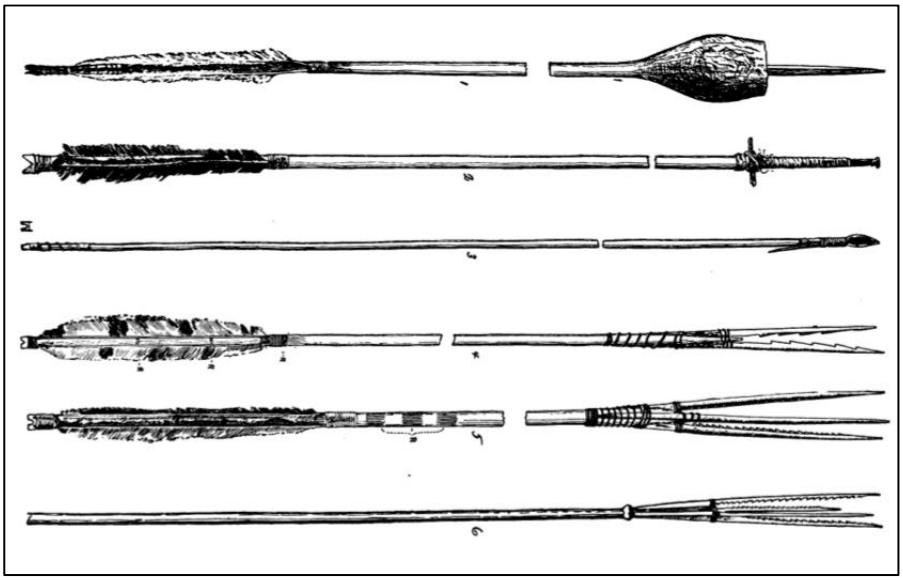


Figure 6.21 Examples of Inuit arrows with barbs (Masson 1894: 155)

Earlier still, there appears to be indirect evidence for bow use in the Bølling, and early Allerød, recognised in the production of small retouched microliths, backed Federmesser/Azilian points, Cheddar and Creswell points (Barton & Bergman 1982; Rots *et al.* 2003; 2005; Sano 2012; Valentin *et al.* 2006; Valentin 2006b). These would be suited for projectile points and have impact fractures (spin-offs) associated with bow ballistic dynamics (Sano *et al.* 2016). These are contemporary with spear-thrower technologies, as indicated by the composite dart tip using backed bladelets (absent in the British Creswellian) recovered at Pincevent (Leroi-Gourhan 1983), and the impact marks on the fauna at the same site. Further south, there are numerous Magdalenian cave sites with better preservation of diagnostic bone and antler points, absent in the British assemblages (Cattelain *et al.* 2002; Langley *et al.* 2016; Pétillon *et al.* 2011).

The earliest bow staves date to the Early Mesolithic, and were recovered at Holmegård in Denmark, and indicate a well-developed bow stave technology dating to around 9,500 cal

BP (Barton & Bergman 1982; Bergman & McEwen 1997; Cattelain *et al.* 2002; Edinborough 2005). These early bow staves were made from elm; perhaps Wych Elm (*Ulmus glabra*) that grows in montane and moist environments, typically in river valleys.

Bow technology requires both bow staves and arrows, both of which are composite and can include materials such as tendons, gut, resins, feathers, stone, and bees-wax (Barton & Bergman 1982; Bergman & McEwen 1997; Cattelain 1997; Clark *et al.* 1974; Hamm & Baker 2000; Laubin 1991; Pope 1923; Soar 2009). What is of importance here, is the explicit knowledge required of both tensile strength and flexion behaviours of wooden raw materials used in creating both bow staves and arrows. These are already very advanced by the time of production of the Stellmoor arrows and the Holmegård bow. These same technologies of woodworking, understanding grain, understanding the properties of wood (e.g. hardness, tensile strength, flexibility) are what are required for the construction of high poundage bows for hunting. The same materials used in the construction of bows and arrows are used in the construction of bark and skin boats (Adney 1983; Luukkanen 2009; Walls 2010).

The example of the elk at Poulton-le-Fylde, if it was a bow, would necessitate an evolved bow technology, as this would be necessary to take down such a large mammal (Barton & Bergman 1982), needing a certain bow poundage to penetrate, and therefore advanced understanding of wood properties mentioned above. It is still not known what type of staves were used for the Stellmoor bows, the arrows are made of pine (Rust 1943; Weber 2009, 121), and there would have been other woods available. Although pine

wood is not considered as a good bow-wood in modern experimental circles (Hamm & Baker 2000), a specific technique for encouraging hard wood for the production of bows traditionally used in Scandinavia and Siberia, still persisted until recently: the malming method (Alm 1936; Insulander 1997; 2002; Lepola 2015). This consists of cutting around the base of a tree several years before it is felled, to encourage the growth of bow-performant woods (Lepola 2015). Another method in these regions is to combine the lower side of spruce limbs and birch to create a stave with the appropriate qualities and poundage for large mammal hunting (Insulander 1997; 2002; Lepola 2015). Both methods require an in-depth knowledge of wood properties. There is also evidence of possible use of willow for bows, but they would not be very powerful and so unlikely for big game (Grønnow 2012; Taylor *et al.* 2018b). The additional use of bone and antler could be used to augment the power as composite bows (Grønnow 2012; Hamilton 1970). There is also the possibility of composite bows made from weaker woods and reinforced with either antler or horn or even tendons (Bergman & McEwen 1997; Hamilton 1970), many of which are found in regions poor in wooden materials, ethnographically and historically. It is common knowledge amongst bowyers that the hardest part of making bow and hunting material is the making of good arrows (Alix *et al.* 2012; Allely & Hamm 2002; Ames *et al.* 2010; Clark *et al.* 1974; Grønnow 2012; Mason *et al.* 1891). The sophisticated well-made Stellmoor arrows demonstrate a highly advanced skill.

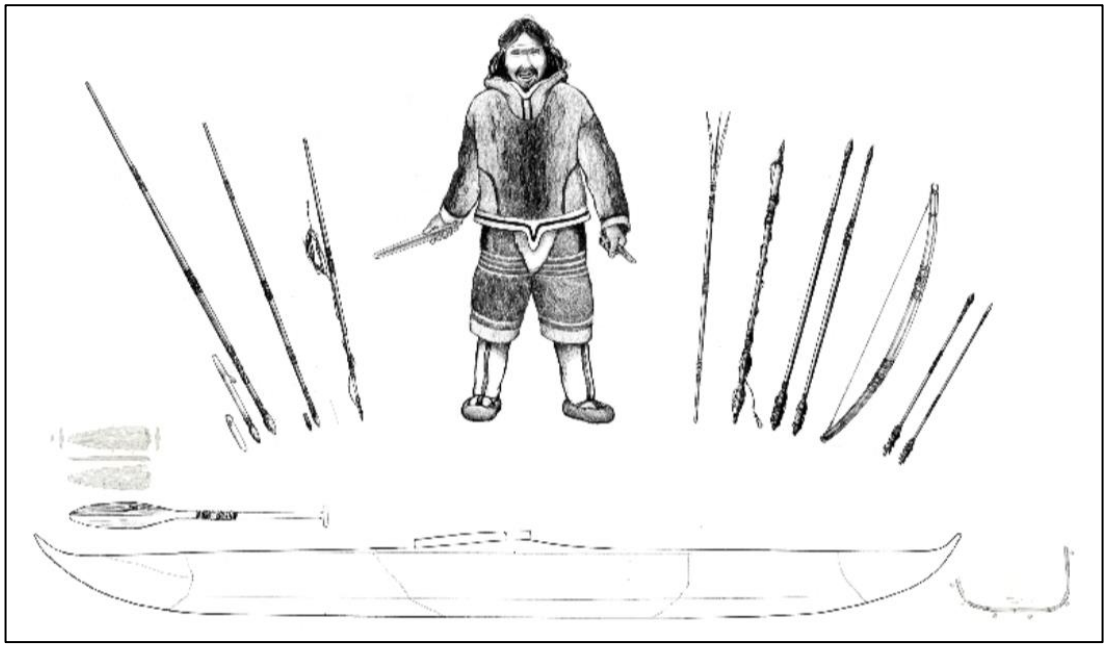


Figure 6.22 A Saqqaq hunter with his hunting toolkit. This schematic reconstruction is based on the archaeological analyses. To the left of the hunter, a heavy lance and a light lance with different kinds of heads are shown as well as a toggling harpoon for seal hunting through breathing holes. In his hands the hunter holds an atlatl and a knife. To the right, one sees a three-pronged bird spear, a harpoon for open-water sealing, two kinds of light darts, a reinforced bow, and two calibers of arrows. Below, finds from Qeqertasussuk—a fragment of a paddle and a frame—suggest that the Saqqaq hunter possessed kayak-like vessels (drawing: Nuka K. Godtfredsen, National Museum of Denmark), (Grønnow 2012, 45). N.b. the presence of both light darts and arrows for hunting reindeer, and the leister is considered as a bird spear. Seal was the main staple food of the Saqqaq hunter, and caribou was regularly hunted. Driftwood was the main raw material used for the wooden elements.

Bow technology implies different types of hunting strategies as opposed to the predominant spear-throwing strategies identified for the Magdalenian. Whereas the spear-throwing strategies are mostly associated with herd hunting assemblages and usually group hunting, the bow can be either individual or group hunting and can isolate individual and seasonally more gregarious prey, much of which is associated with Allerød assemblages (e.g. red deer, elk, auroch, roe deer). This is also relevant for the Creswellian, as it remains unclear what form of weapon was used as there is an absence of the straight backed bladelets and bone points that are associated with spear-throwers in the Magdalenian (Cattelain 1997; Knecht 1997; Leroi-Gourhan 1983; Petillon *et al.* 2009).

Whereas for mass herd hunting, groups have to logistically cover a large area, and be highly mobile, as the herds move across regions, in the case of sparsely forested isolated animal hunting, camps are usually quite mobile, at least seasonally, to avoid depletion locally, as there is less biomass (Barton 1999b; Friesen & Stewart 2004; Gordon 1975; Grøn 2005; Smith 1978).

The development of bow technology throughout the LG marks an important transition from the principal Magdalenian spear thrower technology. This is also most likely linked to a variation in prey choice, an important landscape strategy. This has multiple implications on both the nature of lithic scatters and spatial distribution in the Bølling and the Allerød.

The relationship with the important resource of wood would also be transformed during this period, and the Channel River would play a central role for this resource. With the advance of the forest edge up to central England during the Late Allerød, new distribution patterns would also be expected, notably with concentrations around the forest edge zone, or in regions further south. Sites such as Seamer K and Farndon, are of particular interest as they are north of the Forest edge, and it would be interesting to compare the lithic scatters with sites further south along these lines.

6.7.3 Dogs, sleds and toboggans

Other means of transport such as sleds are now directly identified as soon as the Early Mesolithic at Zhokov in Siberia, and early skis at Vis II in European Russia (Burov 2008; Huntford 2009) and in China (Tacon *et al.* 2016). In the ethnographic record these are built of a combination of driftwood and animal sinew or rawhide (Hearne 1795; Rasmussen 1926).

The earliest archaeological example of snowshoes was found in the Alps near the location of the mummified remains of Otzi and dated to the Neolithic/Bronze age. Dated to the same period are depictions on Scandinavian rock art at Alta (Gjerde 2010, 2018) illustrating bows, boats and snowshoes. It is recognised based on archaeology and ancient DNA (Fu *et al.* 2016; Reich 2018) that the Neolithic and Bronze Age marked a period of intensive migration into Europe, so many of these technologies could have been introduced from elsewhere at the time. However, an earlier use seems plausible considering the amount of arctic experience accumulated during the Palaeolithic, and the archaeological evidence from Siberia (Pitul'ko 1999; Pitul'ko *et al.* 2015).

The transportation of large nodules of raw material as well as large faunal remains accumulated in LG cave sites may be an indication of the usage of other means of transport such as dogs and sledges and skis. Both sledges and skis have been identified at the Mesolithic site of Vis I (where there are many other organic artefacts such as bows) and possibly earlier in Siberia where evidence for domestic dogs and sleds in the Early Holocene in the high arctic at Zhokhov Island, Russia (Pitul'ko & Kasparov 1996; 2017, also

see Clark 1955; Bonsall 2017). This has already been highlighted as a possibility by researchers (Barton 2010; Jacobi 2004; Street *et al.* 2015). This hypothesis is further supported for the Magdalenian by recent identification of multiple sites with domestic dogs (Morey 2014; Street *et al.* 2015; Thalmann *et al.* 2013; Thalmann & Perri 2019).

For LG northwestern Europe the presence in Bølling may be supported by the recent evidence of domestic dogs in Creswellian cave sites (Gough's Cave and Kent's Cavern) (Currant & Jacobi 2011; Jacobi & Higham 2009b). For the Allerød, a site in Germany (Bonn-Oberkassel, (Janssens *et al.* 2018; Street *et al.* 2015) has clear evidence for domestic dogs and the concept of sledges and animals of burden is more probable due to their large size (Pitul'ko & Kasparov 2017). The English Allerød Federmesser site Rookery Farm, has a canine identified as domesticated dog (Conneller *et al.* 2009),

The use of dogs and sledges would have a significant effect on the mobility strategies and ranges used by these hunter gatherers (Ameen *et al.* 2019; Pitul'ko & Kasparov 2017). It is noted that frozen rivers are the ideal routes for the use of sledges in winter, with distances travelled significantly amplified.

6.7.4 Boats

Development of the Channel River estuary and the Irish Channel estuary would have been two very important resource rich regions for southern England and would favour the use of watercraft to optimise mobility for resources during the LG.

One of the conceptions often found in the history of boats and watercraft is that boats are developed in maritime environments and somehow this technology shifts to inland adaptions through waterways (Dunkley 2014; Hornell 1946; Johnstone 2013; Mcgrail 1998). Is it possible that these developments were coeval and/or even developed inland and thereafter adopted for coastal environments?

The importance of boat technology resides in the scale of spring to autumn mobility and landscape strategies. River flow direction and gradient has a direct impact for interpreting potential site occupation locations and mobility patterns. When combined with dominant winds, this can be used as a framework to explore larger regional connections and relations between Southeast England and neighbouring regions of Northern Europe within the LGCR catchment.

The following section will examine the direct and indirect archaeological evidence, the open-air distributions and sites in relation to river systems, the fluvial criteria when considering boats as a regular means of transport, and the link between boat technology (and its direct relation to bow technologies) and LG and riparian environments.

6.7.4.1 Archaeological evidence for early boats

The earliest direct evidence for boats in Northern Europe dates to the Early Mesolithic. Paddles recovered from Star Carr and Pesse (Bjerck 2009; Ellmers 1984; Glørstad 2013; Rowley-Conwy 2017). The earliest dated is currently at the very onset of the Mesolithic at Star Carr, and is associated with potential birch bark canoes (Rowley-Conwy 2017). The

first boats discovered thus far date to the Middle Mesolithic and are dug-out canoes from Duvensee.

It can be hypothesised that early indirect archaeological evidence for boats may also be found in site locations. This was highlighted in Scandinavia where multiple locations on shorelines have been dated to the Younger Dryas and Early Mesolithic (Bang - Andersen 2012; Bang-Andersen 2013; Bjerck 2017; 2009; Breivik 2014; Breivik *et al.* 2018; Glørstad 2013). There is also indirect evidence for the use of boats during the Younger Dryas in Scotland, with the presence of Ahrensburgian projectile points on Islands, leading to the hypothesis of a potential northern seafaring route (Ballin 2017; Ballin & Saville 2003; Mithen *et al.* 2015). This can tentatively be pushed back to within the Older Dryas or early Allerød with the identification of Later Hamburgian Havelte points in Scotland (Ballin *et al.* 2010; Saville & Ballin 2009).

Another aspect potentially reinforcing this hypothesis of Ahrensburgian use of boats is in the lance impacts on reindeer in the NE German and Danish Ahrensburgian bone assemblages (Bratlund 1996; Brown 1967; Petersen 2009; Petersen *et al.* 1996; Petersen & Johansen 1991; Tromnau 1987). There appear to be numerous animals with impacts from above which would fit with hunting during river crossings[36] (Grøn 2005). The local vegetation and the nature of the finds related to these environments indicate either skin or bark boats (Luukkanen 2009). This is in parallel with the Early Mesolithic where there is dense birch and pine forestation, and evidence for the use of bark containers and bark

[36] Short documentary on the Netsilik Inuit spear hunting caribou https://www.nfb.ca/film/at_caribou_crossing_place_pt_2/

rolls (Rowley-Conwy 2017). With the subsequent Mesolithic, regions with well-developed dense deciduous forests are where clear evidence for dug-out canoes is found. This is also the period where axes and adzes become prominent in the lithic records. One would expect less evidence of skin and bark boats, as taphonomically they are less likely to be preserved, and require different tools to dug-out canoes consistent with denser organic material. As for bows, the high proportion of some tool types (e.g. burins) might be associated with scraping woodwork as identified in some of the rare identified woodworking usewear. Although there is no evidence for "lames machurée" having been used for woodworking, it might be that the side with percussions identified as being made mostly mineral and occasionally bone contact (Jacquier 2015), could be the edges percussed for splitting wood on the opposed side without leaving recognisable traces.

6.7.4.2 Fluvial Criteria for the use of boats

There are certain criteria necessary for the use of water-craft, and these may be divided into three main categories: fluvial, lacustrine and marine. This section will initially focus on fluvial characteristics as they would play a major impact on site distributions around the LGCR and of SE England and are transferable to lacustrine environments. For the use of boats, water courses also need to have a minimum depth and flow (20cm for bark canoes; Frank Wolf, personal communication; personal observation).

LG river systems can be divided into two principle types: braided rivers or meandering rivers. Large extensive braided rivers will have significant flow, seasonally prohibiting the use of boats, but they die down quickly becoming very shallow. During the summer

months it may be too shallow for boats, due to a lack of flow. On the other hand, larger braided river systems, when reducing flow after the spring breaks often abandon many of the secondary channels and recede to a single channel system following the talweg of the main course. The lower courses of these rivers often have well developed single channel systems during these low flow months. If the river system is developed enough this would permit the use of boats (e.g., Mackenzie River, Lena River).

With regards to the Channel River, this would be the scenario during the Bølling in the western extent of the Channel River system, with navigable talwegs (deepest channel) during some months of the year, from late summer to autumn. The LGCR and its larger tributaries would fit this pattern. This may also be expanded to the major tributaries such as the Seine, Avon, Thames, Meuse and Scheldt. The flow in smaller tributaries is harder to estimate and less likely.

Many of these larger rivers have strong flows towards the estuary rendering movement up-river challenging. If the stretch of river is under tidal influence this can facilitate movement in both directions. This was the case for the lower reaches of the Channel River for most of the Late Glacial, although how far the tide went up the river system is not known, the intensity of tides has been demonstrated to be significant (Conneller *et al.* 2016; Uehara *et al.* 2006). Taking into account elevation and palaeo-tidal studies, a tide of 5-10m is proposed (Conneller *et al.* 2016; Scourse *et al.* 2009a; Uehara *et al.* 2006). This can be projected to model a potential tidal range. It is also possible to go upriver along

large river systems following the eddies along the banks that create circular currents that may be used.

The second major type of river system, the meandering river, has mostly a developed single channel system providing both flow and depth facilitating navigation. There would be a steady flow for several months a year, notably summer and autumn, and the depths of the main channels of the principle courses such as the Thames, the Seine, the Meuse, the Solent and the Rhine and some larger secondary tributaries, would only be traversable using boats.

Smaller courses would have the flow to support navigation but have the additional hazards of beaver dams and deadfall which could make the journeys more challenging but can also facilitate on smaller tributaries with continuous ponding. This is where looking at the long tradition of Canadian canoeing through Boreal and subarctic environments, the methods used by explorer canoeists today (on canoe routes which are not managed) to assess the navigability of a course of river. These same methods can be applied to the modelling of navigable rivers in the Late Glacial.

Factors used by modern canoeist to plan routes are the restriction and extension of lateral slope (floodplain) indicating the hardness of bedrock and lateral erosion (gorges vs. flat rivers), the general gradient over a course of a stretch of river indicating rate of flow; and important changes in bedrock and erosion (in some cases due to changing sea levels) along the axis creating knick-points and past cliff-lines where there are often

waterfalls or significant hazards. When these factors are assessed, there is the factor of input to flow that is considered from a local meteorological perspective which can only be generalised for broad blocks of the Late Glacial at this point (Renssen & Isarin 2001b). Assessing these factors can enable the tracing of navigable routes, and regions that must either be detoured (portage, carrying the boat around a hazard) or avoided completely due to rapids (gorges). Another factor is navigated orientation of rivers. Only specific river courses can be travelled in both directions, the broader the course the easier the movement upriver using lateral counter currents (eddies).

Using river flow momentum not only accelerates your movement at a regular pace with less effort (except for rapids), but also provides a means to transport much larger quantities of materials. More provisions can be transported reducing unpredictable hazardous situations and energy, leading to a more flexible and efficient solution. The Mandan villagers and Pawnee plain bison hunters are a good example of using the Missouri to transport heavy loads in corracles ('bull boats') after hunts planned upriver (Lewis *et al.* 2003; Weltfish 1977). Another advantage is that you are within one of the richest ecotones for food and raw materials in the landscape (Turner *et al.* 2003) (Sections 6.1 and 6.2). Anyone who has travelled by canoe will have remarked how close you get to fauna, big or small, without flight, as animals do not appear to consider people in canoes as threats. One might argue for a learnt behaviour; however, this was the same over hundreds of years of historic records in regions where this was practiced in Canada (Hearne 1795; Nisbet 2011) and Siberia (Frost 2012).

When hunting large mobile herds on the plains, both the Pawnee and the Lakota would preferably hunt up-river following the herds, to be able to float the large quantities of butchered bison downriver to the camps using bullboats, a local form of coracle, made with hunted bison skins wrapped around a wooden frame and transported for winter storage. This leads to the questions: is there a potential for up-river / down-river relationship of LG sites? Where are the Spring/ early summer sites located?

6.7.4.3 Boat construction materials?

These may be divided into physical components, and technological components. There are three types of early or temporary boat-craft that have been identified (Arnold *et al.* 2015; Hornell 1946; Johnstone 2013): skin, bark, and dug-out boats. These three types of craft, at least in the historic and ethnographic records, are very much environmentally determined, more than chronologically determined. However, dug-out canoes have a strong taphonomic bias for preservation and have provided the earliest archaeological boats thus far (Bjerck 2009; Rowley-Conwy 2017). All three require access to wood for the structure, although there are examples of skin-frame boats using bone and ivory components. Whereas the dug-out canoe requires mature trees and techniques for extracting large amounts of wood (e.g. fire, adzes), the skin and bark boats require secondary materials.

For birch bark constructions (less so for cedar or elm barks used in temperate environments), require cold winters for a thick functional bark. This is a reason why they are not found in later periods of the Holocene in NW Europe. Both skin boats and bark

boats also vary from extremely simple craft, to an in-depth knowledge of wood working, compression and tensile properties; the same properties that are found in bow construction. Another requirement for both skin and bark craft is the access to binding materials, such as tendons, cordage from vegetal materials (e.g. willow), which have been demonstrated to be present throughout the Upper Palaeolithic. A final pre-requirement for both skin and bark is the capacity to process these materials.

There is evidence for the processing of skins, throughout the Upper Palaeolithic and Late Glacial, notably the indirect evidence of use-wear analysis on stone tools (Keeley 1987; Moss 1983; Naudinot & Jacquier 2014; Rots *et al.* 2011) but no direct evidence for woodworking.

Adzes and axes would only be needed during the production of dug outs and even then, with the use of fire, and the presence of beavers felling large trees, this is not a pre-requirement for felling. For both skin and bark boats wood frames, axes are unnecessary, and it is splitting techniques that would be required. The same goes for the production of bows. Many of the skin boats can be made with young shoots, such as willows used for Plains bull boats, and Irish, Welsh, and Scottish coracles and corraughs, as well as badaikas in Siberia, and Arctic kayaks (Adney 1983; Luukkanen 2009).

Consider this from a chrono-environmental perspective, skin boats would be possible during the Bølling with access to driftwood, whereas during the Allerød, skin boats, bark boats and potentially dug-outs would be optimal with the presence of both driftwood

pine and spruce and local thick-barked cold adapted birch (Alix & Brewster 2004; Walls 2010). Dug outs would be the least likely with these materials due to the nature of both wood types available.

Having established a potential for the use of boats, especially around major river systems, the following questions relate to what impact they would have on mobility patterns? Can the use of boats, at least seasonally, enable us to model different land-use patterns and mobility systems? And what impact could this have on the distribution of sites in southern England, linked to the largest river system in NW Europe?

Knowledge of the properties of materials and for both use and construction of hides or bark vessels is very apparent in periods preceding the LG (birch tar, working wood), during the LG in the treatment of skins for clothing (needles, tent rings) and in the subsequent Early Mesolithic birch-bark containers.

Where are the spring/early summer sites located? These would be when watercraft are built if used. A combination of environmental (forestation, wind direction), fluvial dynamics (navigable routes, driftwood deposits), and strategic locations (confluences, ridges) are here combined to assess the most likely locations for sites with a direct relation to the use of watercraft. The spring and early summer locations would most likely be related to proximity to necessary materials if this type of transport was used.

6.7.4.4 What can open-air sites and lithic assemblages tell us?

Stone tool productions and lithic scatters in the Bølling open landscape are most often interpreted as “retooling”, “butchery” or “base-camp” sites. Advances in, and more widespread applications of use-wear analyses demonstrate that a large proportion of these lithic assemblages are associated with materials such as bone and hides (de Bie & Caspar 2000; Donahue & Evans 2013; Jacquier & Naudinot 2009; Moss 1983; 1987; Moss & Newcomer 1982)(Rots *et al.* 2011). Going beyond potential clothing and structures, skin processing would also be a technological attribute when considering the construction of watercraft.

Although there is no direct evidence for the use of boats at LG sites along the Somme and the Seine in the Paris Basin, the site distributions indicate a very close spatial relation to the river systems, interpreted as processing and hunting sites. This may be extended on sites along the Seine to potential migration dynamics. Most of the Seine and Somme sites are related to gravel extractions, and are preserved in exceptional preservation contexts for the LG, however this is probably a bias towards fluvial deposition conditions that have favoured their preservation. The sites do however present a settlement and activity link to the fluvial contexts by the choice of location. The main issue remains preservation biases, as the LGI taphonomic conditions do not favour the preservation of organic vegetal remains as in the following Mesolithic where direct evidence is abundant. This does not intrinsically imply the use of boats, but they remain a possibility.

6.7.5 Conclusions: open-air lithics assemblages in SE England

The hypothetical framework developed in this chapter proposes a preferential use of river-systems in LG open landscapes in both winter and summer, as the course provides a spatial reference and the surface is more regular for movement in winter, especially with sledges (Aporta 2009; Hearne 1795; Stewart *et al.* 2000).

The above questions about rivers, boats and bow technology are derived from questions regarding the open-air lithics assemblages of SE England. One of the issues with the interpretation of these assemblages is the absence of organic materials and reducing their analysis to simply typo-technological characterisation of stone tools and comparisons. By placing lithic assemblages within a broader dynamic, it is possible to place site locations and tool production within this contextualised landscape. Going beyond a characterisation of assemblages within the formal needs of butchering sites and hide processing sites, it is worth contemplating the working of other materials within a mobile system, for mobility purposes and habitation purposes. This also provides a framework to start considering links and divisions across a much broader geographic region, integrating seasonal behavioural patterns and hunting strategies, and not only looking for the bow and the spear-thrower, but also for the boat, fish trap and fish processing.

Some of these site locations indicate repeated occupations along river systems (Hengistbury Head and Nea Farm; Wey Manor Farm and Guildford Fire Station), and in some cases potentially site specialisation. In the case of the Brockhill site, although a

surface scatter, it has a substantial number of burins (generally usewear analysis indicate that burins are mostly used for antler and bone work), demonstrating a specifically purposed activity (Mills 2013). Whether this is indicative of a more domestic occupation, the proximity of water facilitating the fabrication of antler/bone tools, or their use for other activities in vicinity to a wetland environment remains an open question (Mills 2013; Simmonds 2017).

6.8 Rivers used for the cognitive structuring of landscapes: the role of rivers in Mapping Arctic and Boreal regions

The same significant division between open and closed environments: arctic opposed to boreal-taiga landscapes, will be applied here. These are two extremes, and in both cases river systems are arguably the optimal (for different reasons) and the likely means used to map these regions.

The aim of this section is to develop an insight into how SE English landscapes 'may plausibly' be colonised (as per questions proposed by Gamble et al. 2004), and applying the evolving resolution of the archaeological datasets to this region. The aim is to hypothesise on the dynamics of re-colonisation of Northern Europe following the LGM and identify the mechanisms and processes of colonisation. A geographic and mobility approach is attempted here. By working out the processes of colonisation, and highlighting the corridors of access to southern England, the high and dryland or riparian corridors, our perception of spatial relations of the archaeological record can take a new shape.

6.8.1 Mapping Arctic environments

Aporta describes three major topographic mapping features for arctic environments:

- coasts and inlets (notably when viewed from the sea);
- mountains and visible peaks (visibility over long distances, way points); and
- river systems (can be followed in low and high visibility and enable a continuous spatial situation).

Often the two major factors limiting orientation and navigation in open landscapes are low visibility due to weather conditions and visibility of topographic features which is further reduced by snow cover in winter.

6.8.2 Mapping Forested environments

References to navigation through forested environments, notably in the Canadian Boreal forests will be used here. The sources are historic, ethnographic and archaeological; similar models have been described for the Siberian Taiga (Grøn 2006). All three sources appear to indicate the importance of river systems through these closed forest environments.

In Canada there is a lot of evidence in both historic (mostly fur traders) and ethnographic accounts (mostly 20th century) of river systems being the dominant mapping element within Boreal forested zones (e.g. Hearne 1795; Gordon 1988, and contained references). The same is for Siberia in the Middle Ages (Luukkonen 2009). The specific constraint for forest mobility systems is visibility, without the visibility of pronounced topographic features the river systems become essential, not only as continuous spatial markers but also giving a sense of direction according to the flow (e.g. up and down river).

When considering larger territories (similar to Creswellian and Azilian/Federmesser scales), river systems take on an even more important role. They are the main features expanding continuously over long distances in the absence of mountain ranges, or in between elevations when montane, and linking multiple geomorphological landscapes.

6.8.3 Confluences and aggregations

The confluences of major river systems have also been recorded archaeologically and historically as conducive to seasonal aggregation sites amongst mobile groups with seasonal resource variations (Smith 1978). This is in a large part due to sub-groups splitting up and following different tributaries seasonally and regrouping where there is a common junction, most often a large confluence (Binford 1978).

6.8.4 Mapping the Late Glacial Channel River

> "We found [our way] better without maps! [laughter] We didn't need any. What will you do with a map when you have the ponds, and the sunlight? And the rivers… The brooks flow from west to east. And the trees thrive towards the sun." [a woman, Sirges community] (Cogos *et al.* 2017).

This leads to the provocative idea of presenting the Channel River network as the heart of a Palaeolithic map of northwestern Europe. Southeast England would be a central northern region within this mapped landscape.

If one rotates the cartesian map of Northern Europe to consider the Channel River system as the main orientation, starting in altitude and flowing towards the base of the cognitive map, the world system takes on a very different aspect. This is simply anecdotal at this point as it has no direct impact on the interpretation of the archaeological record and would need further consideration of what it might imply, or how it might affect the interpretation of the archaeological record, notably a recolonization movement from

south to north (Gamble et al. 2006). The important point is that major river systems are recognised as strong cognitive mapping markers within forested territories.

6.8.5 Mapping SE England

Southeast England is a region of relatively low topography. This same low topography is found on Doggerland and the North European Plains as well as northern France. Chapter 5 discussed the important role played by catchment topography and river dynamics on landscapes, and this chapter highlighted landscape dynamics and use. To conclude this chapter, these themes are applied to the SE English landscape. Chapter 7 will focus more fully on the site distributions within this framework and the links with Northern Europe.

The LG archaeological record for SE England is solely based on lithic scatters and haematite. The lithic finds and assemblages can be coarsely sub-divided chronologically based on techno-typological traits to brackets ranging from 200 to 400-year periods (Chapter 4). It is important to relate this to the actual quantity of all the lithic assemblages, these could quite easily be created by one small group over one year of intermittent flint production. So, the resolution is an indication of presence at points in time rather than a developed picture of continuous presence. Only two sites show strong enough parallels to be considered as contemporaneous based on the knapping: Hengistbury Head and Nea Farm (Barton *et al.* 2009). Our understanding of human behaviour and relations of these sites is consequently very limited.

6.8.5.1 Lithic resources

Flint is a ubiquitous resource in this region. The sourcing and choice of this material undergoes significant transitions during the LGI (see Chapter 4; Barton 2010). During the Bølling access to primary large blocks of high-quality material, pre-prepared before transport can be interpreted as a strategy for high mobility. This is emphasised by the direct sourcing of material from the region of Salisbury Plain (Figure 1.3) travelling as far North as the Pennines and the Yorkshire coast (Pettitt *et al.* 2012). Whereas in the Allerød, the strategy appears to be more focussed on local material, with a significant proportion of river rolled blocks (Barton 2010). These could either be from active riverbeds or past fluvial terraces. Both share typo-technological traits over long distances and are indicative of a high level of mobility (see chapters 3 and 4).

The sources for flint can be divided into primary and secondary sources. The availability would change significantly between the Bølling and the Allerød with the development of soils and vegetation during the latter in the region. The primary sources are the chalk Downs of SE England, and erosive fluvial features such as the gaps (valleys varved by rivers perpendicular to the chalk folds) would expose flint bearing scarps. Furthermore, bedrock instability due to freeze thaw action would expose large amounts of flint as colluvium (Preece & Bridgland 1999), facilitating the recovery of large high-quality flint blocks. No flint extraction locations are known for the Creswellian during the Bølling, but many of the Long-Blade sites during and following the Younger Dryas have been interpreted as flint extraction and preparation sites (Barton 2010). The Bølling would therefore favour locations with freshly exposed scarps and immediately down-river of the

colluvium. During the Allerød, the river beds would be the most accessible sources for flint, and this would be more accessible in late summer with low water levels.

All of the local large and medium fluvial systems in the region would have significant access to raw material during the Bølling. The Allerød would probably focus on secondary tributaries and exposed scarps. Other resources are predicted without direct evidence (see above). There would be a substantial area of driftwood immediately south of SE England. It would be an important resource in spring/summer for building materials and important all year round as a fuel for fire.

6.8.5.2 Fauna behaviour and mobility

Chapter 6 discussed the importance of the limited faunal records peripheral to SE England, and how they can inform on landscape and mobility patterns. Two factors for determining seasonal movement can be modelled: elevation and dominant wind direction. Southeast England is adjacent to the main course of the LGCR Northern Channel. The region of the Paris Basin on the opposite flank of the Channel valley has good faunal preservation within its open-air sites, with reindeer and horse as the dominant species for the Bølling. Unfortunately, it is not possible to model horse landscape behaviour at the moment. Reindeer appear to have some strong behavioural patterns during the spring and autumn calving migrations. They tend to migrate to regions with wind exposure and cooler regions northwards (or in altitude in montane regions) to dissuade insects during calving. They also tend to follow high ground for exposure during spring and autumn. Both of these can be modelled. For the Bølling the

ideal summer calving location would be the Channel Estuary and Irish Channel where there is strong exposure to dominant south-westerly winds and rich floodplains. If heading further north across the Channel, SE England would potentially be on the route. The ridges and important river crossings on this path are viable for both reindeer and humans alike.

SE England is a favourable location for overwintering for both humans and animals, as it is protected from the predominant North winds, and its link to the LGCR valley resources. It would also be more sheltered in winter from Atlantic storm tracts moving up the LGCR valley from the Atlantic.

6.8.5.3 Fluvial seasonality and movement

There is a relative rich dataset on LG rivers for SE England (see Chapter 5). The Thames and the Palaeo-Solent were the most important courses in SE England at the time. During winter and summer, they both would be poles for resources and movement linking directly to the LGCR system. The water flow in this region joins the LGCR and creates a circuit that could be followed in winter and summer (Figure 6.16). During the Allerød with the development of light forest and beavers, the secondary tributaries such as the Kennet, Test, Wey and Mole, would be particularly attractive environments with damming and vegetational development and rich ecotonal peripheries.

Directly south of the region the abrupt transition to the relatively flat LGCR North Channel floodplain would also provide an important resource. A certain landscape dynamic can be

envisaged with seasonal circuits in both summer and winter. During spring, the whole region would be isolated with spring melts damming and preventing eastern, southern, western and northern movement. The ridges to the northwest between the Thames and Palaeo-Solent catchment would be the only exit and access.

6.8.5.4 Technologies impacting on mobility

Applying the concepts of mobility developed in Chapter 6 brings in three elements: sledge, boats and on foot. The general low-lying aspect of the terrain would be appropriate for both on foot and/or sledges in winter. The frozen water-courses are ideal throughways. The ridges would be avoided due to the effects of windchill, and the exposed major valleys are most likely abandoned for a preferential use of secondary sheltered valleys, especially when protected from the north winds.

The spring to autumn months would see a near complete reversal of this pattern. There would be a preferential use of major river systems, for wind exposure and resources. The tributaries would also play important roles. Mobility could focus on both ridges and valleys. Whereas the largest rivers and most important tributaries should be relatively free of beaver activity, and open for watercraft if used.

6.8.5.5 Ethnographic and historic records for mobility, seasonality, territory and scales

There are no environments or groups of people today that can be directly compared to Late Glacial hunter-gatherer groups. The Barren Lands/Tundra and Boreal/Taiga regions are here considered as best approximative analogies for the Late Glacial Bølling and Late

Allerød. More specifically, Boreal/Taiga open-forest fringe would be more appropriate as dense forest was not fully developed during the LG. Grassland Plains were also considered as an analogy for the Bølling open grassland landscapes with warm summers, however during the Bølling there was no soil development. All of the sources discussed below are of independent highly evolved hunter-gatherer groups, that use adaptive techniques and methods to adapt to current environments. The objective of this section is to examine if there are some aspects of modern and historic hunter-gatherer adaptive strategies to very specialised environments that might help inform at a broad scale some of the physical constraints and necessities when living in these regions, the nature of the uses of rivers, and mobility systems/techniques adaptations that would be relevant to all groups living within these environments.

The arctic and sub-arctic, especially the North American regions (published in English), and a less accessible Siberian arctic/sub-arctic literature, have an immense corpus of published ethnographic and historic work on First Nations and indigenous peoples living in these regions (Binford 2001). One of the aims of the thesis was to focus on three themes within this corpus, river systems, scale of territories and mobility. What soon became a challenge whilst carrying out the research was to find descriptions of hunter-gatherer groups that were settled inland without diets reliant on marine resources (based on the known isotopic records for LG Northern Europe), and descriptions of seasonal mobility patterns of economies that were not totally dependent on fur trading exchange systems. This often required going back to texts predating or at the onset of the most recent colonisations of North America (Hearne 1958; Thwaites 1900) and Siberia (Fedorova *et al.* 2010; Frost 2012). Another specific environmental constraint when

considering the literature was open-woodland forest records as analogies to the LG. Finding information on traditional mobility patterns, landscape use and usage of river systems was surprising scarce along the tundra edge and inland (Binford 1978). The recent historical and archaeological records were therefore required to explore these regions (Binford 1978; Friesen & Stewart 2004; Gordon 1975; Smith 1978). When examining the potential datasets for North America (Binford 2001; Kelly 1995; 2013), large swathes of the corpus were immediately dismissed: all of the Alaskan, Canadian and Greenland coastal Inuit did not fit the desired non-marine diets, as were the Pacific and Eastern coast hunter-gatherer groups. I was very surprised to realise that very few inland hunter-gatherer groups were described, and fewer still had survived the transition to fur trading economies. Along the forest edge and open-forest region only archaeological records were available (Friesen & Stewart 2004; Friesen 2004). The objective being to contrast the role played by rivers on mobility and territory, I therefore examined records from within the forested boreal environment to contrast with the barren land open environment (Brumbach & Jarvenpa 1989; Jarvenpa 1979). Finally research on orientation, mobility and territoriality of the Inuit was most helpful (Aporta 2005; 2009; Aporta *et al.* 2014) when considering open non-arboreal LG landscape use and the role of rivers within them.

The Siberian records, of which a large portion is not as accessible due to my lack of fluency with the Russian language, focussed on early explorer and geographic descriptions of the pre-trans Siberian railway river network (Czaplicka 1914; Fedorova *et al.* 2010; Frost 2012) and accounts of inland groups that have transitioned from hunter to nomadic reindeer herder economies (Grøn *et al.* 2008; Grøn 2005; Jordan 2008; 2012).

The latter also had the advantage of being expressed in territoriality, mobility and focussed strongly around river systems (Grøn 2006), and applied to the Hamburgian archaeological record (Grøn 2005).

The sources have been listed by themes around local landscape environments, mobility patterns and around river systems in Table 6-5. The aim has been to contrast open-forested when possible, but often forested against barren land arctic and sub-arctic environments. These are developed in relation to the archaeological evidence in chapters 6 and 7. In the following section I will briefly highlight three of the these: traversing the landscape, scales and strategies; territories around river systems; Seasonal migrations in relation to reindeer hunting.

Traversing the landscape, scales and strategies

The ethnographic sources have been useful in two regards when considering travelling and scales in arctic/sub-arctic and Boreal environments and around river systems:
The scales and distances of networks and routes around fluvial systems
And the optimal methods (boat, following forest edge, etc.) and techniques (sled, snow shoe, dog travois, etc.) for traversing these specialised landscapes. These combined help structure an approach to the LG archaeological landscape, taking into account landscape constraints and potential scales of analysis.

The Bering expedition of 1725-1730 is of particular interest (and similar parallels can be found in the 1805-1809 Lewis and Clark Expedition in North America) as it highlights an important network of fluvial systems predating the development of the Trans-Siberian

railway (1891-1916) and follows a network of traditional routes. Most of Siberia could be crossed using fluvial routes, which was the traditional form moving through the wooded Taiga landscape during the summer seasons. This network had only been lightly impacted upon by the influence of fur traders at the time of the Bering expedition. When examining the map (Figure *6.23*), itself only representing the main landscape features of mountains and rivers, the importance of rivers whilst moving in across this region is apparent.



Figure 6.23 Map of Bering's Expedition. Blue: fluvial route, brown: terrestrial portages.

Another example is that of Samuel Hearne's expedition to find the source of copper north across the barren lands to the arctic ocean. After two very unsuccessful attempts that demonstrate the specialised skills needed to traverse these different types of terrain, Hearne is guided by a local Chipewyan from the Boreal forest through the tundra open-woodland and the Barren Land to the region settled by Inuit on the Arctic Ocean (Hearne

1958). This is also unmapped territory for the fur traders, and although guided by fur collectors, much of the expedition reflects traditional pre-fur trade routes and landscape logistics.

So as to traverse the treacherous muskeg barren lands, the method was to follow the forest edge from Churchill during winter leaving in December 1770. The forest provided constant resources as many animals take refuge here during the winter months as there is more food available. Following the forest edge, they can therefore move westwards to position themselves upriver from their destination and not be isolated in the barren lands low on supplies. They made it in time for the spring caribou hunt and could restock. This could also be modelled for the LG, and accentuates the importance of the forest edge/ open woodland present in southern Britain during the Allerød.

The following strategy was to wait for the ice-break to take place in spring and stock up on the necessary materials for bark canoes. After quickly building these temporary craft they follow the river to the coast which they reached by July, in six months. The distance covered is over 1000km, with 500km in the canoe. Hearne is also the first to record in detail, the indigenous methods and techniques for adapted to traversing this landscape, and sets out to employ them. This is particularly interesting as it goes beyond the traditional ethnographic scales of mobility applied to LG hunter-gatherers.

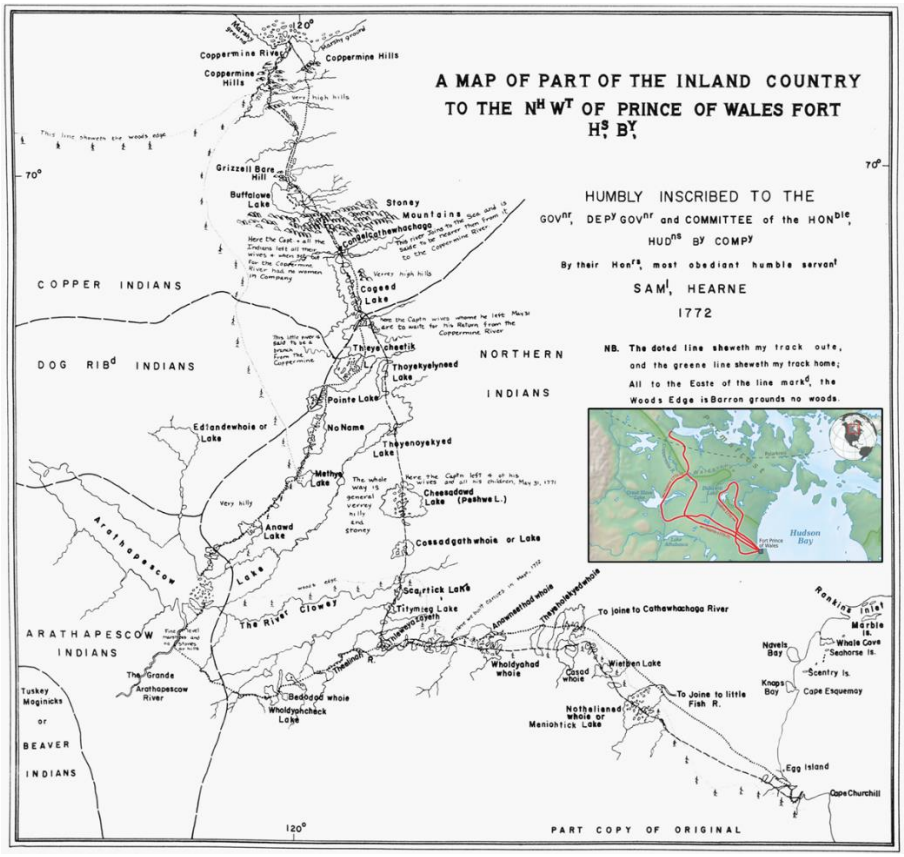


Figure 6.24 Samuel Hearne, 1772 map , 3 attempts were made, the final (successful) attempt guided by Matonabbee follows the forest edge for shelter and food before descending the river following spring ice break-up.

Territories around river systems

> "Evenk territories are conceived not as 'land areas' but as 'rivers with their adjacent hunting grounds'"
>
> (Grøn et al. 2008: 74).

The concept of movement and territories open and forested regions is also very much centred around major river catchments. This is recognised in both open barren land contexts (Aporta 2003; 2005) and in more open-forested environments such as the Gwich'in around the mouth of the MacKenzie River (Figure *6.25*)(Aporta *et al.* 2014). River systems form both territorial boundaries and the major arteries and routes. They are literally the topographic cognitive maps (Grøn *et al.* 2008).

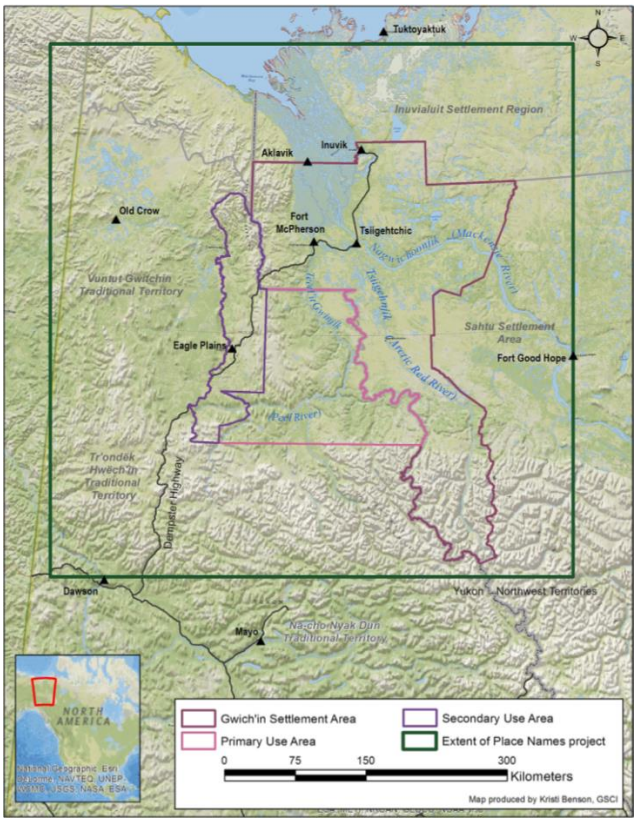


Figure 6.25 Map of the Gwich'in Settlement Region (GSR) defined by the 1992 Gwich'in Comprehensive Land Claim Agreement. The GSR is composed of the Gwich'in Settlement Area in the NWT and Primary Use and Secondary Use areas in the Yukon – Trans-boundary areas shared with neighbouring Aboriginal groups. The area within the square indicates the extent of Gwich'in traditional land use and the place names recorded in the Gwich'in Place Names Atlas. (Aporta 2014: 234). River valleys mark important routes and territorial markers The scale of the traditional territory is also much larger than scales modelled for European prehistoric models of hunter-gatherer movement.

"Even if the settlements are on the banks of lakes, they are conceptually related to the river system feeding and draining the lakes." (Grøn et al. 2008: 68).

Of particular interest to archaeologists has been Binford's ethno-archaeological work with the Nunamiut (Binford 1978; 1980). These are interesting scales of analysis to consider for LG Northern Europe, especially as the Nunamiut are one of the few non-marine dominant groups whose landscape knowledge has been recorded (Binford 2001). It is also interesting as the territories are very much focused around major fluvial systems (Figure *6.26*). Furthermore the scales for yearly and generational scales of landscape are

illustrated (Figure 6.26, Figure 6.27). This is the scale that has been used when considering mobility and distances whilst considering SE England (Figure 6.28) and its relation to the Channel River catchment, 100, 250 and 1000km based on Binford's recordings of Nunamiut territorial usage (Chapter 7).

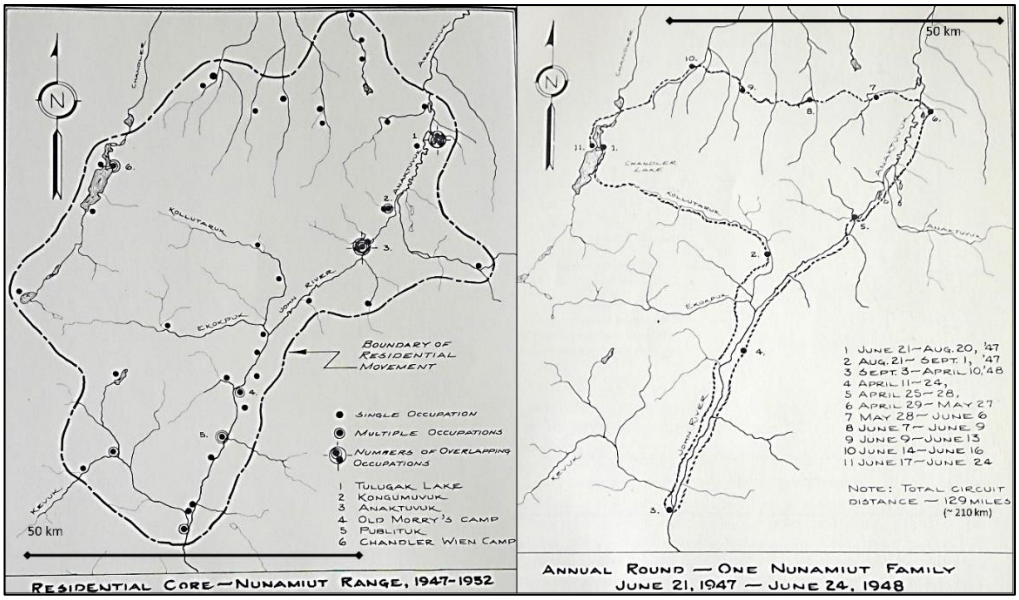


Figure 6.26 Locations of the sites occupied by one Nunamiut family during an annual round of settlement in 1947-8. (Binford 1978: 111-112).

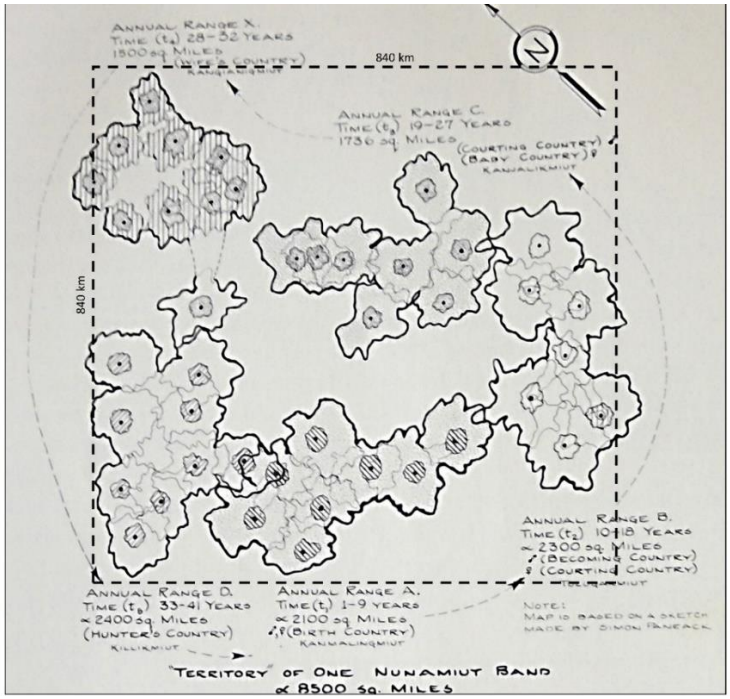


Figure 6.27 Idealised model of Nunamiut land use during one person's lifetime , based on interviews with Eskimo informants (Binford 1978: 115).

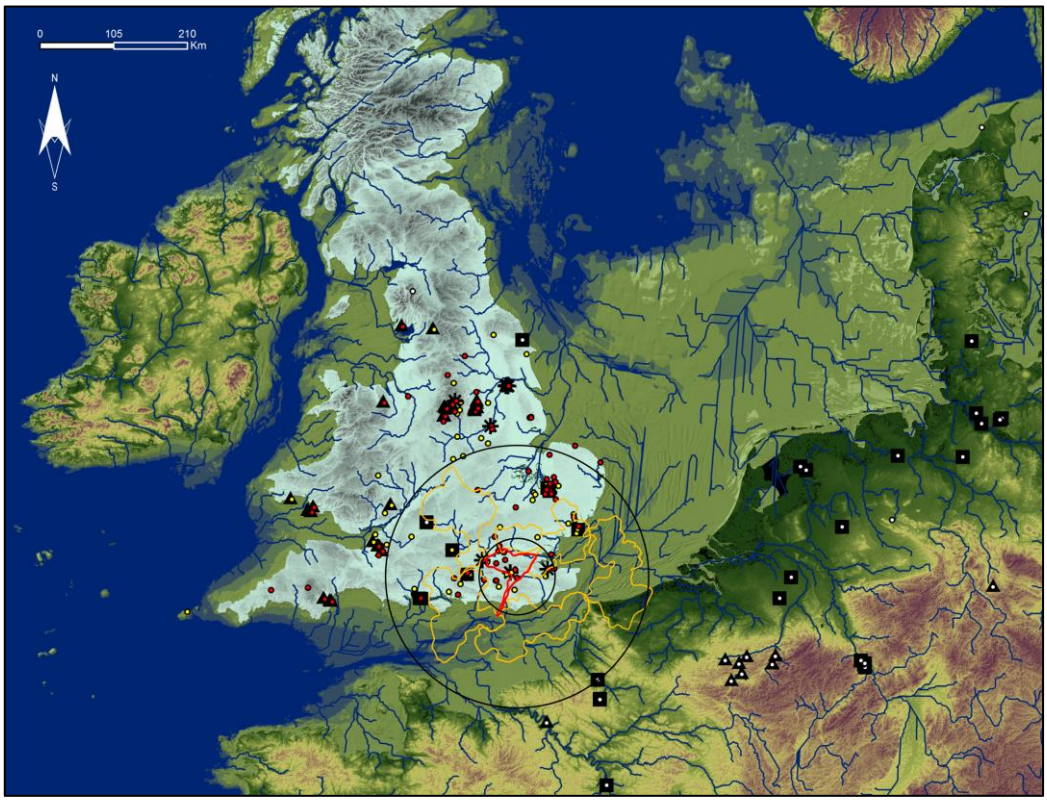


Figure 6.28 An example of a Nunamiut annual (red) and lifetime (orange) land use round (Binford 1978, Figure 6.25, Figure 6.26) superimposed over SE England and the Channel river. The annual rounds would be relative to the region, and the lifetime coverage would take into account both sides of the Channel River. The concentration of LG sites in SE England are within the annual scale. (Source: author. Basemaps GEBCO18 and EMODnet17)

Seasonal migrations in relation to reindeer hunting.

> "Toward the end of winter, the caribou again concentrate near the treeline, in preparation for the northward migration that generally occurs in May-June, while the northern lakes and rivers still have hard, thick ice" (Smith 1978: 71)

The importance of caribou/reindeer seasonal migration in the open sub-arctic to arctic landscape and on the forest edge is central to nearly all of the communities in North America and Siberia (Friesen 2004; Gordon 2003; Grøn 2005). Although not recognised in Britain, there is little doubt of the proximity of large reindeer herds in the Paris Basin. What remains unclear is whether the Channel River was a barrier preventing reindeer from migrating further northwards. Distances implied both in Siberia and Canada would bring southern England into the region of migrating reindeer from the forest edge throughout the Late Glacial (Figure *6.29*, Figure *6.31*). The contrast of Inuit and Dene hunting and settlement patterns, both in relation to caribou migrations is also of particular interest when considering LG territories (Figure *6.29*). The modelling of Evenki reindeer hunters on river catchments as territorial markers, and concentrated movements seasonally of groups to ambush or intercept the migration herd has been modelled for the Hamburgian (Figure *6.31*, Figure *6.32*). All these elements combined help justify the use of river catchments and major tributaries as appropriate landscape divisions and scales of analysis.

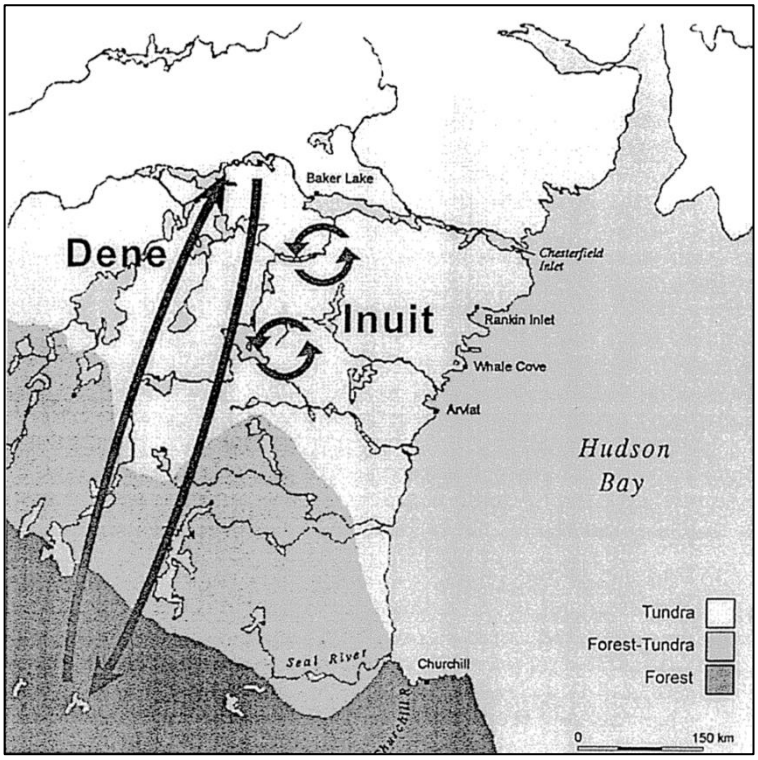


Figure 6.29 Schematic comparison of mobility patterns for eighteenth century Dene and Late Nineteenth century Inuit (Friesen 2004: 312). The forest is used for overwintering and the baren lands for summer herd hunting as for the Evenki in Siberia (see Grøn 2005). The Inuit seasonal round does not involve long-distance migration.

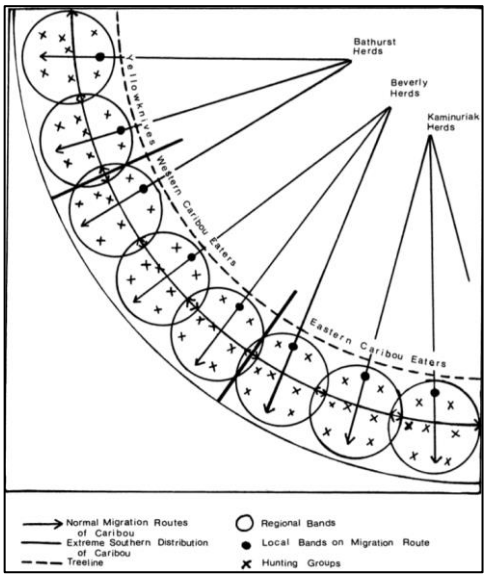


Figure 6.30 Schematic Representation of Caribou Eater Caribou Hunting Strategy (Smith 1978: 84).

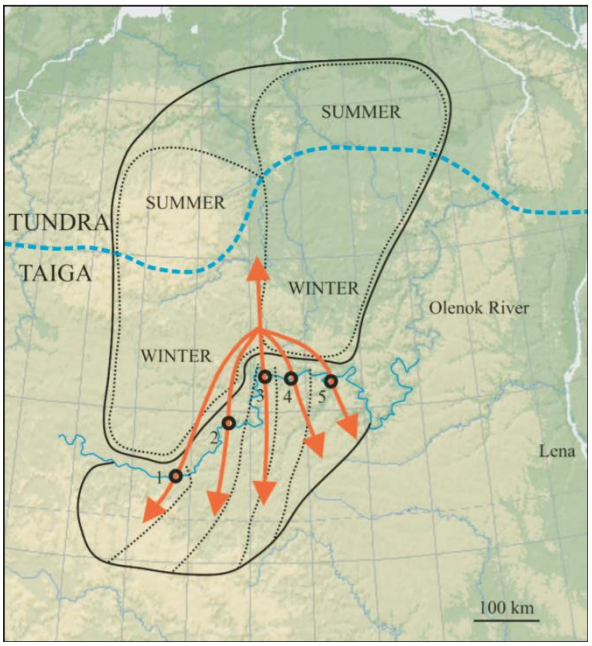


Figure 6.31 Map showing 1) the area with Evenk hunter-gatherers south of the Olenok River, their assembly sites at the taiga-sites (black circles) and a suggested organisation of this area into five clan-territories, 2) the area with Evenk large-scale pastoralists north of the Olenok River with two clan-territories from the early 20th century, 3) the border (broken blue line) between taiga and tundra (including 'forest tundra', 'mountain tundra', and 'arctic tundra'), 4) the annual movements of the clans within their territories: the hunter-gatherers with northern positions near their assembly sites in winter and southern positions in summer, and the pastoralists with southern positions in the taiga in winter and northern positions in the tundra in summer, 5) the route of the migrating reindeer as they branch out and cross the river in exactly the places where the tiga-sites are located – except site no 3 where the villages of Olenok and Harielak were built by the Communists in 1936. (Grøn et al. 2005:9)

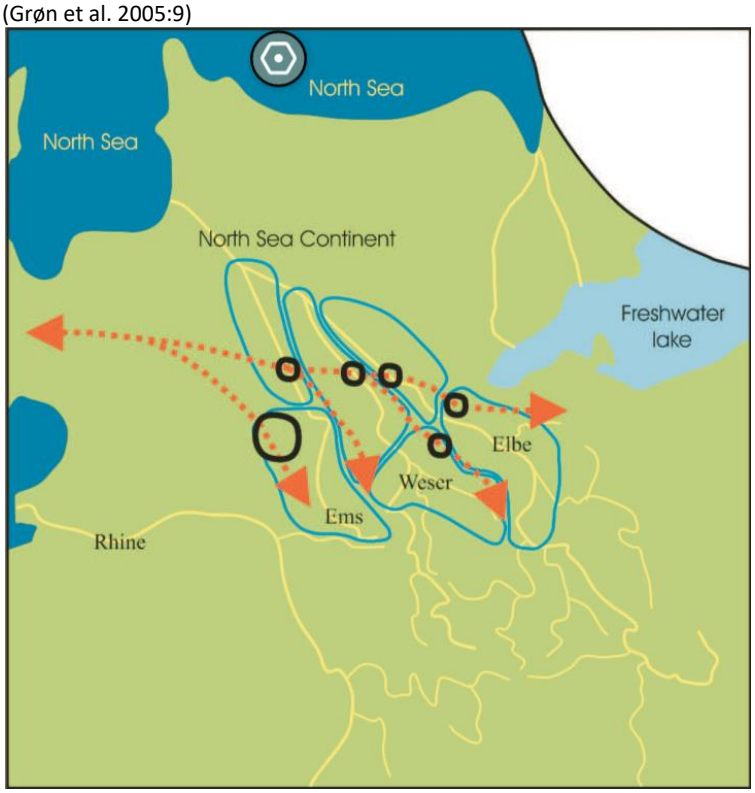


Figure 6.32 A reconstruction of the landscape of the Hamburgian Culture and a suggested territorial organisation of a part of its territory including assembly/kill-sites (black circles). Based on Bokelmann 1979 and Coles 1998. (Grøn 2005: 19).

Table 6-5 Literature criteria for the arctic and sub-arctic and boreal references

seasonality, river use, and mobility of inland hunter-gatherers. ***Bold: principle references cited within this thesis****.*

Region	H-G group	Tundra/ Barren Lands	Tree line, open-woodland	Forest	Plains	River mobility	Landscape mobility	Seasonality	Fur trade dynamics	Domesticated reindeer	Expedition	Anthropology study	recorded observation	Main Sources
N. America	**Nunamiut**	**X**	**x**	**X**		**X**	**X**	**X**	**X**			**x**	**1940's-1970's**	(Binford 1978; Rausch 1951)
N. America	**Dene/Cree/ Inuit**	**x**	**x**	**x**		**x**	**x**	**x**	**X**		**x**		**1770-1780**	(Hearne 1958)
N. America	**Multiple**	**x**	**x**	**x**		**x**	**x**	**x**	**x**		**x**		**1780-1790's**	(Mackenzie 1802)
N. America	**Multiple**		**x**	**x**	**x**	**x**	**x**	**x**	**x**		**x**	**x**	**1600's**	(Thwaites 1900) **Jesuit Journals**
N. America	**Multiple**			**x**		**x**	**x**	**x**	**x**			**x**	**1970's-**	(Brumbach & Jarvenpa 1989; Jarvenpa 1979; 1998)
N. America	Chipewyan	x	x	x		x	x	x	x			x	1967-1970	(Smith 1978)
N. America	Chipewyan	x	x	x		x	x	x	x			x		(Gordon 2016; 1975)
N. America	**Plains**				**x**	**x**	**x**	**x**			**x**		**1803-1806**	(Lewis *et al.* 2003) **Lewis and Clark journals**
N. America	multiple				x		x	x						(Denig 1975)
N. America	**Pawnee**				**x**	**x**	**x**	**x**				**x**		(Weltfish 1977)
N. America	Kutchin		X	X		X	X	X	X			X	1970's	(Nelson 1980)
N. America	Multiple											x	1970's	(Brody 1981; 2002)
N. America		X	x			x	x	x			x		1846-1847	(Rae 2012) John Rae Journals
N. America	Multiple		x	x	x	x	x	x	x		X		1784-1812	(Nisbet 2011) David Thompson, Journals

N. America	**Dene, Inuit**	**X**	**X**	**X**		**X**	**X**	**X**				**X**		(Friesen 2016; 2013; Friesen & Stewart 2004)
N. America	**Inuit**	**x**	**x**			**x**	**x**	**x**				**x**	**1980-**	(Aporta 2005; 2009; Aporta *et al.* 2014)
N. America and Siberia	**Inuit**	**x**	**x**			**x**	**x**					**x**	**1980-**	(Fortescue 1988; Fortescue & Fortescue 2011)
N. America	**Inuit**	**x**	**x**			**x**	**x**	**x**				**x**	**1980-**	(Alix 2012a)
N. America	**Multiple**	**X**	**X**	**X**	**X**		**X**	**x**	**x**			**X**	**Multiple**	(Kelly 1995; 2013)
N. America	**Multiple**	**x**	**x**	**x**	**x**		**x**	**x**	**x**			**x**	**Multiple**	(Binford 1980; 2001)
N. America	**Multiple**	**x**	**x**	**x**		**x**		**x**	**x**			**x**	**1880's**	(Adney 1983)
N. America	Multiple		x	x			x	x				x		(Oswalt 1972)
N. America	Multiple	x	x	x	x	x	x	x						(Newell 1997b; 1997a; Newell & Constandse-Westermann 1996)
N. America	Multiple													(Tanner 1979)
N. America	Chipewyan		x	x	x	x	x	x				x		(Lovis *et al.* 2006; Lovis & Donahue 2011)
Siberia	Multiple	x	x	x	x	x	x	x			x		1914-1915	(Czaplicka 1914)
Siberia	Multiple	x	x	x	x	x	x	x			x		1725-1730	(Fedorova *et al.* 2010; Frost 2012) Bering journals
Siberia	**Evenk**		**x**	**x**	**x**	**x**	**x**	**x**		**x**		**x**	**1980's-**	(Grøn 2006; Grøn 2012)
Siberia	**Ket, Khanty,**	**x**	**x**	**x**	**x**	**x**	**x**	**x**		**x**		**x**	**1980's-**	(Jordan 2004; 2008; 2010)
Siberia	**Multiple**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**Multiple**	(Armstrong 1963)

6.8.5.6 Cognitive mapping of Southeast England

The LGCR is a very favourable resource rich region, with accommodating topography for settlement. Southeast England represents an important node within this extensive network. It is the link between the North Sea reaches of Doggerland and the North European Plain and the north bank of the LGCR. This location in such a flint-rich region, with local diversity and seasonal shelter between important karstic systems to the west, north and south-east is at the centre of the LG cognitive mapping of the LGCR system. Immediately east are the important confluences of the Rhine and Thames, and to the southeast the major confluences of the Palaeo-Solent and the Somme and Seine towards Hurd's Deep.

The fact that all of the local river systems flow into the LGCR, directly to the south or indirectly via the Thames or Palaeo-Solent creates an intrinsic tie with this river network, a constant loop back to the LGCR when heading in all directions. It is also on the southern border of the only dryland route across the LGCR catchment and links the two largest rivers flowing from north to south and east (the Palaeo-Solent and Thames respectively), structuring the landscape and funnelling movement by its direction of flow.

The seasonal dynamics of the fluvial system and poles of attractive resources that fluctuate with this embed the LG archaeology (with all signs of high mobility) within a very dynamic landscape. The cognitive map of the region can be summarised in sense of flow, resources and prominent topography (ridges, viewpoints and cliffs). SE England is therefore an important node in this very rich and diverse catchment.

The following Chapter 7 will examine how the landscape and fluvial theory applies to the archaeological distribution at local and regional levels around the Channel River catchment.

Chapter 7 Where the wind blows: Contextualising Late Glacial site distributions in relation to landscape dynamics and the Channel River network

Chapter 7 examines the Late Glacial (LG) archaeological distribution of Southeast England by cross-referencing the structural attributes of fluvial systems with the landscape-use models developed in Chapter 6. This framework opposes low-lying, resource-rich floodplains to high and dryer-wind-exposed interfluve ridges, providing a basis for the discussion of LG archaeological distributions, mobility and the position of Southeast England within the LG Channel River Network (LGCRN). This regional study focusses on the distributions around the Wey-Mole and Palaeo-Solent catchments, as these have a significant concentration and diversity of LG open-air signatures.

Chapter 7 is divided into three parts:

- 7.1 examines the archaeological biases affecting the current understanding of LG lithics distribution, taking into account taphonomic and landscape conditions;
- 7.2 highlights Southeast English LG landscape features in relation to occupation and mobility;
- 7.3 considers the archaeological distributions in relation to the geographic and seasonal models developed in Chapters 5 and 6.

7.1 Late Glacial taphonomic and site distribution biases in the archaeological record

This section examines the landscape-dependent biases affecting the current LG archaeological datasets available, using the Colonisation of Britain (CoB) data updated with more recent excavations in the region (Chapters 2, 3 and 4). The distribution is compared with a series of taphonomic factors and specific landscape locations to examine intrinsic biases in the record that directly affect further thematic interpretations of the archaeological distribution. These are presented as a series of maps.

Four themes are developed:

- sedimentary biases;
- organic preservation biases;
- the impact of modern population on the records; and
- ground-surface visibility.

7.1.1 Sedimentary: paleoenvironmental and archaeological preservation biases

Taphonomic biases driven by exposure to erosion and gravity are strongly in favour of alluvial depositional environments capturing and funnelling material derived from higher ground erosion (colluvial) and upstream river erosion deposits. These depositional environments can accumulate significant stratigraphic records several meters in depth, especially in the lower reaches of the fluvial system where deposits are thickest (Figure 7.1). The active riverbeds were not always aggrading; these are also erosive features that rapidly truncate much of the valley floor, leading to reworking. The highest potential for preservation is often in depth or on the edges of the floodplain. The objective is therefore to identify regions with either thick alluvial deposits with potential LG preservation in depth (lower reaches of tributaries) and/or lateral sections that have undergone little active erosion (broad floodplain edges) since the LG (Brown 1997; Lewin & Macklin 2003). Depositional environments with higher rates of sedimentation, such as lowlands and extensive fluvial floodplains, are more likely to provide a better preservation of occupation sites (if the locations were considered favourable in the past). Within these depositional environments, the depth of sediment, protecting the archaeology from ploughing or urban development, can also inhibit site discovery and impede recovery (Figure 7.1).

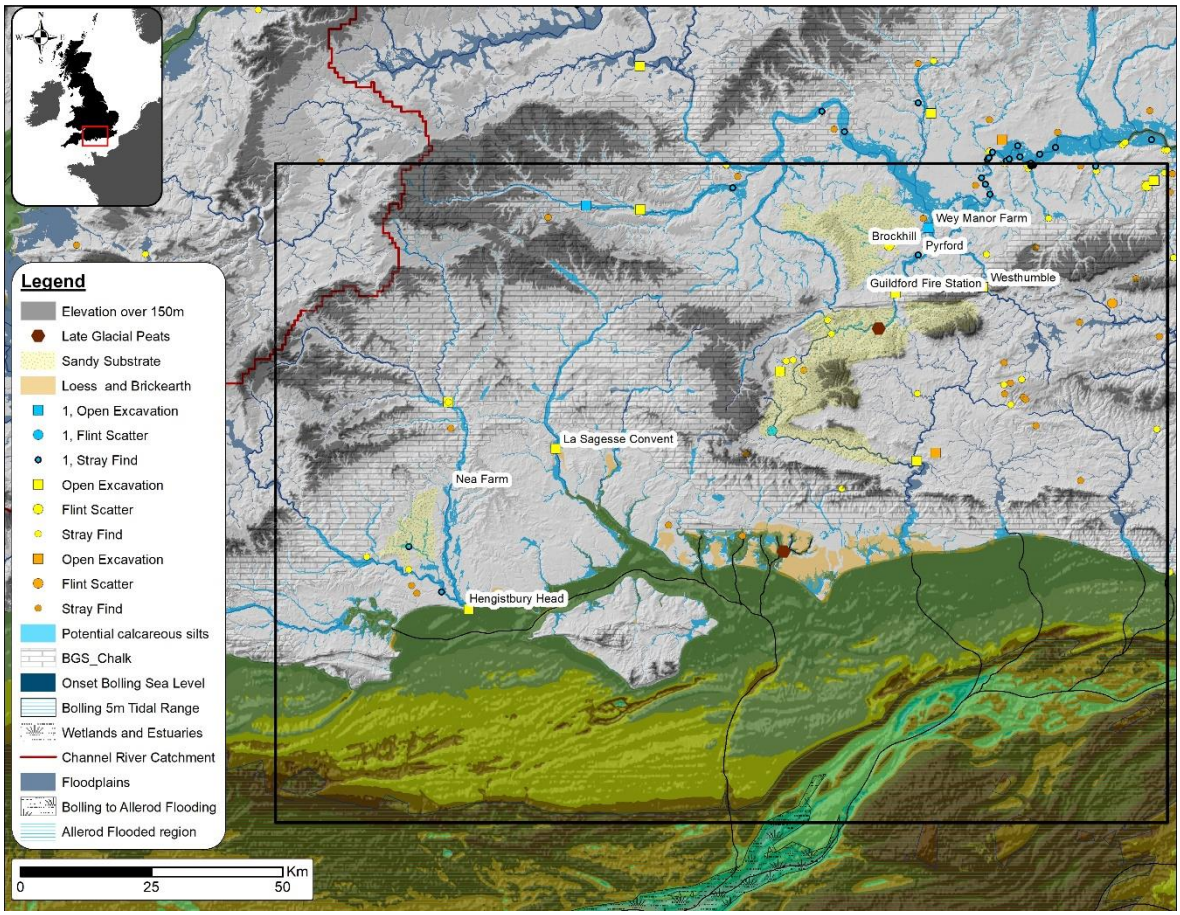


Figure 7.1 Southeast England distributions in relation to alluvium and calcareous silts. (Source: Author. Basemap OS TOPO 50, EMODnet17, GEBCO18, BGS bedrock geology 650k layer, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

This pattern of alluvial plain preservation (sealed and laterally exposed) can be recognised in the LG distribution of Southeast England at multiple excavated sites (Wey Manor Farm, Guildford Fire Station) and scatters (Westhumble, Pyrford) recovered from valley floodplains. Multiple isolated finds are also from within the floodplain (Figure 7.1).

Surface deposits (BGS 625k) like loess and peat developed during the LG. These can create important sedimentary archives, with archaeological potential in regions with unfavourable bedrock conditions (Catt & Staines 1982; Catt 2008; Wintle & Catt 1985) and additional deep sequences on the leeward slope/versants for loess and coversands

(e.g. Kent) (Antoine *et al.* 1999; 2003a; 2009; Lautridou *et al.* 1985). These deposits have been identified in Southeast England with horizons directly dated to the LG (Catt 1985; 2008; Kerney *et al.* 1963; 1980; Kerney 1977; Parker & Goudie 2007). Although LG soils have been identified within these deposits (Chapter 6), no artefacts from these deposits have been recovered so far (Figure 7.1). They do, however, represent sediments with very high potential.

7.1.2 Preservation of organic materials and dating.

Sediment types have different organic preservation potentials (Brown 1997; Lewin & Macklin 2003). Open-air sites in calcareous silts have better bone preservation, as they are alkaline (Paris Basins, Three Ways Wharf) (Chapters 3–4; Figure 7.1). The Late Glacial Interglacial (LGI) open-air sites in the region do not have any organic preservation, as they are either above the floodplain (Hengistbury Head, Nea Farm, Brockhill) or the sediments sealing them (Wey Manor Farm; Guildford Fire Station, La Sagesse Convent, Westhumble) are not as carbonate rich as the subsequent Younger Dryas (YD) deposits (Three Ways Wharf) (Figure 7.1). There is therefore good potential for techno-typological recovery, but less potential for faunal recovery for the LGI in the region, unless recovered from dry valleys dominated by these conditions or colder periods with intense scarp erosion (Older Dryas, Younger Dryas).

Organic preservation in anaerobic wetland deposits have rarely produced LG finds, as these mostly developed during the Holocene. Recent coring in the region has located LG organic sequences in the upper reaches of the Wey Valley (Elstead Heath) and near the

site of Brockhill (Simmonds 2017) (Figure 7.1). These have great potential for high-resolution datable site recovery. When compared with neighbouring regions such as the Somme, the relation between floodplain silts and organic deposits within channels can provide a uniquely high-resolution archaeological record. The floodplain regions around known organic deposits therefore merit further exploration.

7.1.3 Ground visibility (e.g. ploughfield vs. meadow)

Repeated active erosion on higher grounds constantly exposes sites, facilitating discovery by causing deflation, disturbance and erosion (e.g. Hengistbury Head). In light of this dynamic, the absence of LG material on higher grounds is suspect (Figure 7.1). Although there may have been some erosion, a minimum of archaeological presence might be expected in the form of stray finds in Southeast England. The effects of the Younger Dryas in Southeast England included intense scarp erosion under periglacial conditions on chalk bedrock (Preece and Bridgland 1999). This would have caused significant erosion of shallowly buried or surface material during its earliest phases, when periglacial activity was highest. Whether it is an exception or a confirmation of this model, Hengistbury Head and Brockhill are on relatively high locations (Figure 7.1) and both have a significant amount of archaeology dating to the LG, but on sandy subsoils (Figure 7.1. The sandy substrate of these two sites, a similar Tertiary substrate of well drained sandy bedrock, was less affected by periglacial erosion than chalk bedrock, and could be a reason for better preservation. Another possibility is that these locations were preferable due to better drainage (see wetlands below).

Locations with moderate and low slope gradients are preferable for both occupation sites and agricultural activity such as ploughing, leading to more frequent discoveries due to higher visibility of objects churned up and periods of no vegetation for surveying (Figure 7.2). This contrasts with regions used as grazing meadows with poor archaeological visibility, although these are usually on sloped terrain. The majority of isolated finds in the region appear to be derived from a ploughfield context, which indicates potential for future recovery beyond fluvial contexts.

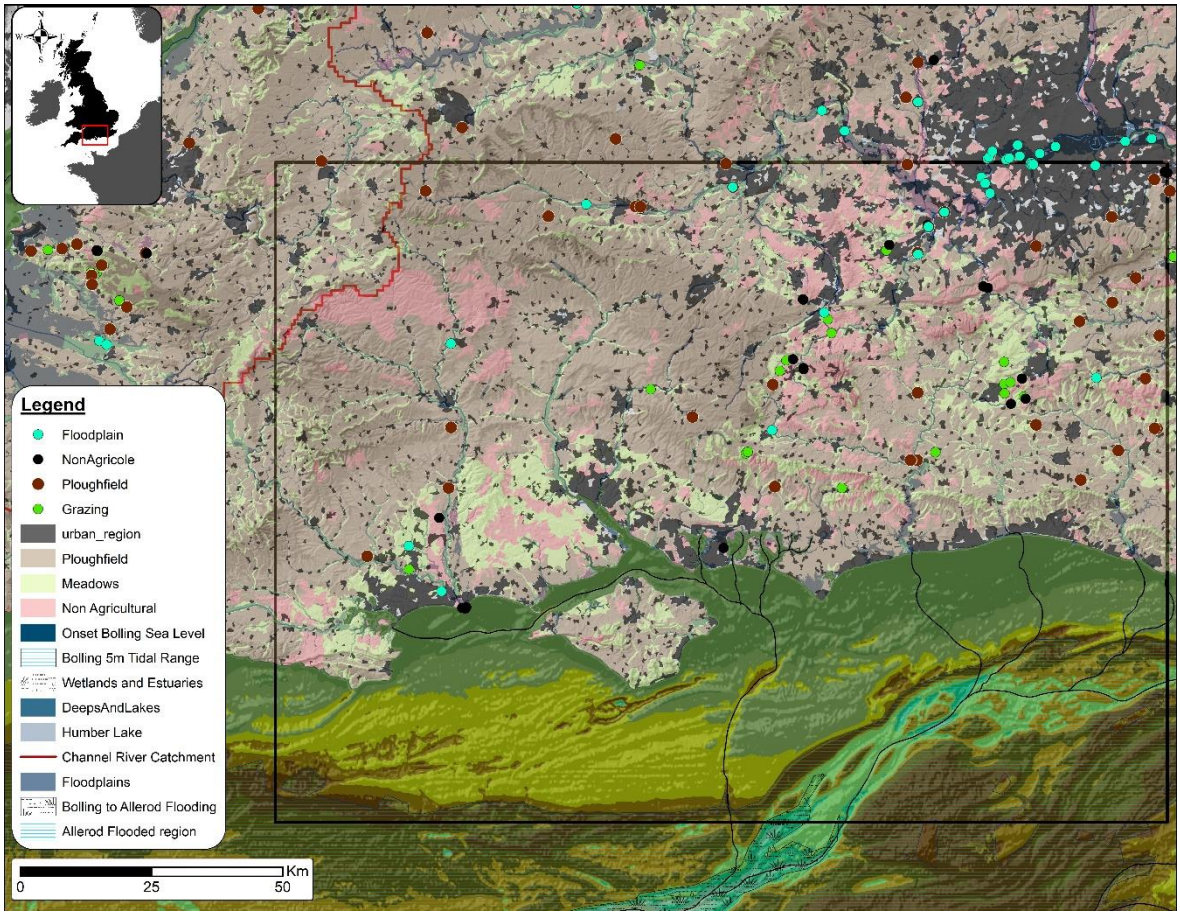


Figure 7.2 Southeast England Map of ploughfield, meadow and fluvial locations. (Source: Author. Basemap OS TOPO 50, EMODnet17, GEBCO18, UK Environmental Agency land use layer, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

7.1.4 Population, pathways and agents

The population density of urban centres combined with the development of contract archaeology creates a bias towards the discovery of sites (Figure 7.3)(Ashton *et al.* 2015; Cooper 2013; Cooper & Green 2015b; Darvill *et al.* 2018). In other words, finds and new sites are more likely to be discovered and collected in the vicinity of cities. University cities, notably those with archaeology departments, would also be expected to have a larger concentration of sites within a local catchment area, and more active and organised groups of archaeologists and archaeological societies. This creates a positive bias in the current evaluation of known site distributions and may indicate relative neglect of larger distributions in less systematically examined regions. This is noticeable in very populated Southeast England, with nearly half of single finds recovered from within 1 km of a settlement. The density of finds grades from dense to sparse when moving – in a south by southwest direction – away from major agglomerations in the northeast (Greater London) (Figure 7.3). This appears to be a recovery bias, as no major changes in ground conditions are apparent, and indicates a considerable region with potential for the discovery of LG sites.

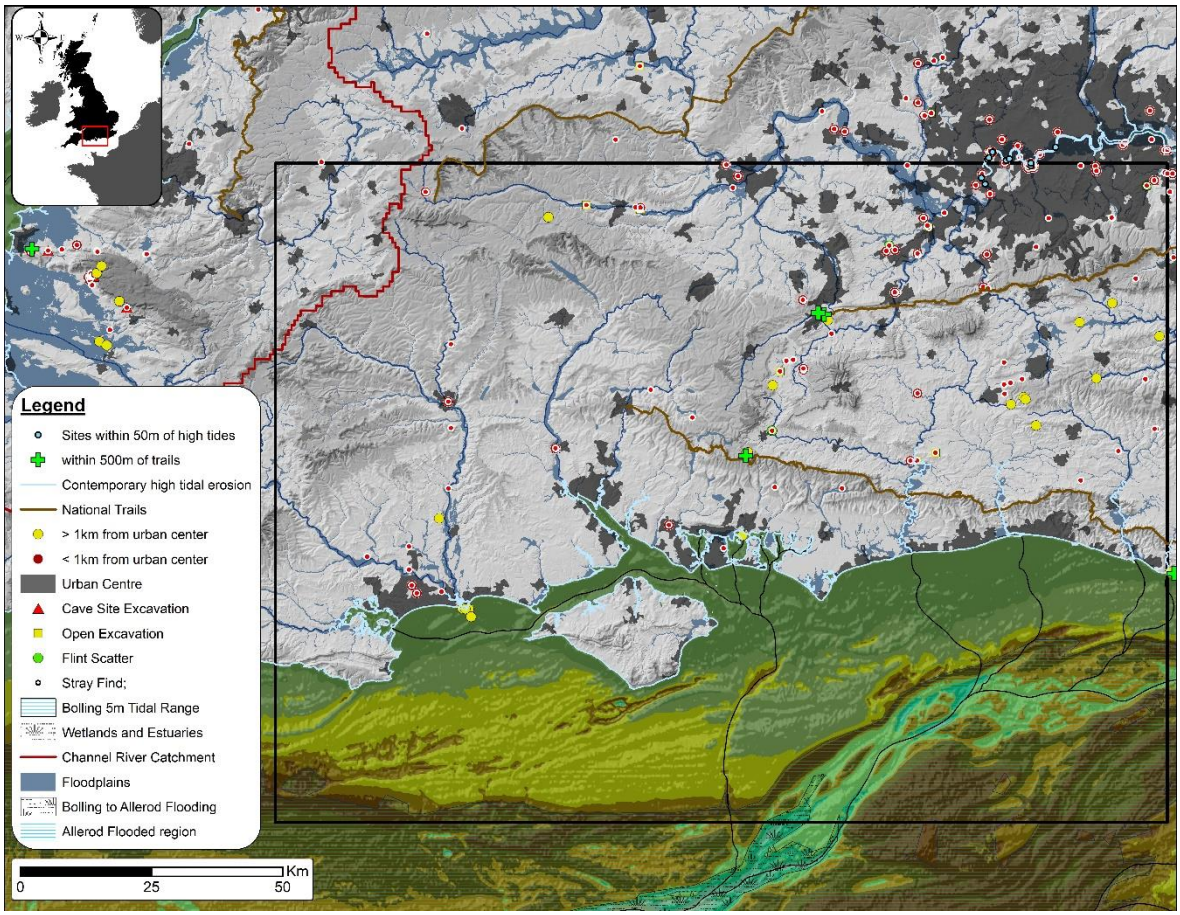


Figure 7.3 Southeast England, urban landscape and public pathways. (Source: Author. Basemap OS TOPO 50, EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

Public footpaths create a bias, as they focus people and "eyes" along specific areas of the landscape and increase the likelihood of discovery. It is therefore difficult to assess whether a relatively greater concentration of sites along a historic pathway is indicative of higher archaeological density or is simply a function of such areas being more commonly frequented by curious wanderers. Ridgeway routes are a good example of this effect, as they tend to be strategic locations developed as public pathways, frequented by hundreds of thousands of walkers every year. The general absence of LG finds on elevated ridges suggests this possibility (Figure 7.3). If affected by YD erosion, further

research into dry valleys would be a possible way to explore whether sites have been eroded and redeposited, this has not yet been recognised.

For Southeast England, a good correlation of site locations with alluvial and well-drained elevated sandy soils and bedrock is apparent (Figure 7.1). It is very likely that the concentration of sites, and of stray finds, around London is linked with it being a major urban centre (Figure 7.2 and 7.3). The concentration of sites and findspots along the tidal Thames is significantly greater (Figure 7.3), although no 'intact' sites have been located in this region. Much of this material has been linked to the Long-Blade technocomplex by item dimensions. However, this is a relatively weak criterion (Chapter 3) and many of these blades could be redeposited LGI assemblages that were sorted by size by the fluvial regime.

7.2 Late Glacial fluvial topography and strategic locations

Section 7.2 focusses on the recognised seasonal logistical dynamics within the LG record (Chapter 6) and their relation to the current LG archaeological distribution in Southeast England. An assessment is made of both potential strategic locations (landscape features) and the possible reasons for recurrent strategic locations using multi-occupation sites in Southeast England (e.g. Hengistbury Head, Brockhill) contrasting with smaller refitting assemblages interpreted as short or single occupation sites (e.g. Nea Farm, Wey Manor Farm, La Sagesse Convent and Guildford Fire Station).

7.2.1 Landscape Resources

Regions on the edge of multiple ecotones are particularly favourable for resources and occupation over longer periods of time. Southeast England has multiple indicators for such environments with LG access to major fluvial systems and wetlands (Figure 7.4). Furthermore, these fluvial systems would have structured mobility throughout the landscape, having been regions of extensive ground water, ample fording locations and many navigable courses (Chapter 6). Floodplain edges are also predictably rich in ecotones. Rising sea levels throughout the LG substantially shaped the most important LGCR ecotone, the edge of the Channel Estuary. These areas also have high potential for organic preservation (Figure 7.4 and 6.6).

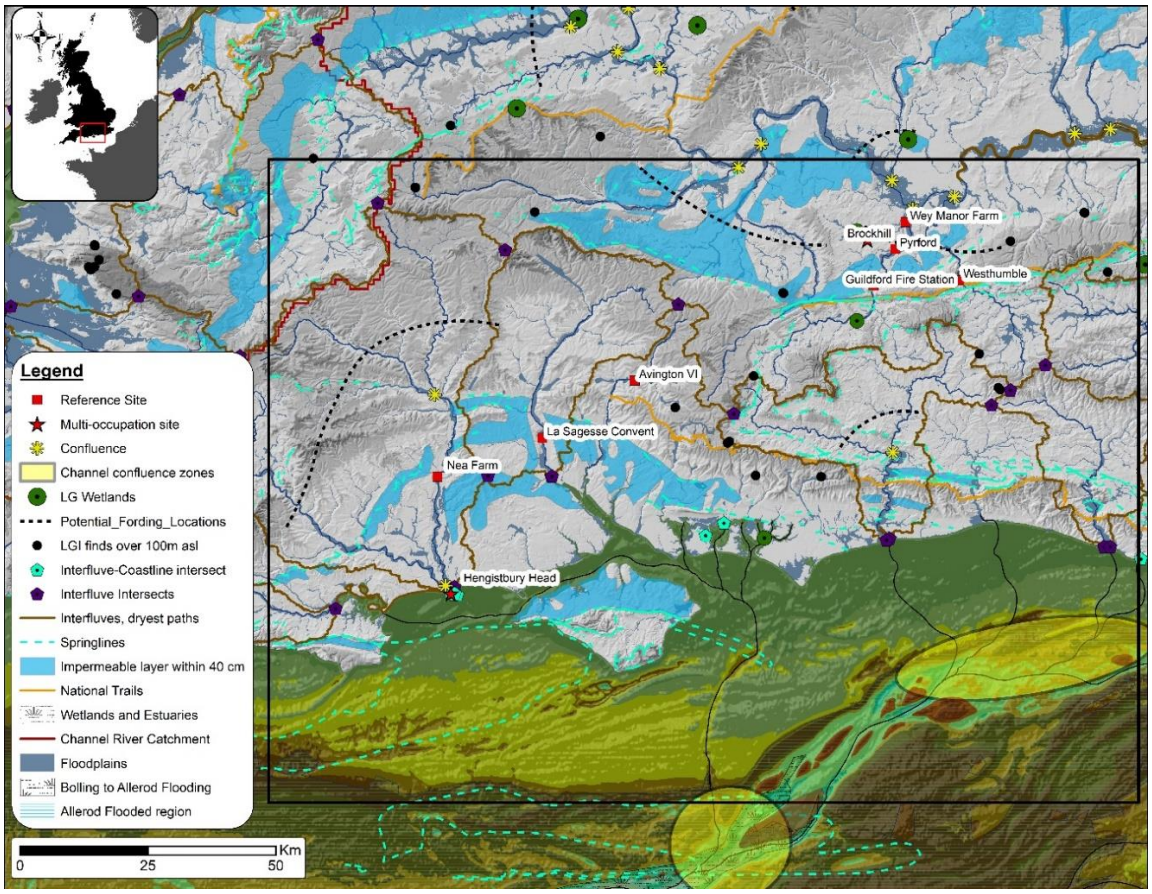


Figure 7.4 SEUK Landscape features. Sites above 50m are indicated as black dots, catchment intersects (meeting of interfluves) are indicated as stars, and light blue when intersecting the coast. (Source: Author. Basemap OS TOPO 50, EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

7.2.2 Network nodes (confluences and interfluves)

Fluvial confluences are recognised as potential aggregation locations (Grøn *et al.* 2008; Grøn 2005; Rausch 1951; Wiessner 1983). They function as both a concentration of resources, with the rich ecology to be expected between two tributaries, and a newly formed larger channel extent (Figure 7.4). From a mobility perspective, they open axes into the landscape. Both Hengistbury Head and Wey Manor Farm are in the vicinity of major confluences, whereas the other sites do not appear to be related to this feature (Figure 7.4). There are also important confluences with the North Valley of the Channel

River immediately south of the region. The multi-occupation site of Hengistbury Head is the only site that fits this model of a potential seasonal aggregation site.

Interfluve nodes – characterised by ridges separating two river catchments – have rarely been explored systematically from an archaeological perspective. On the border of catchments, they are the most elevated locations over two or more valley systems. When truncated by the southern coastline, they also overlooked the LGCR valley (e.g. Hengistbury Head). This indicates the use of elevated ground. The only site on an interfluve is Hengistbury Head (Figure 7.4). There is, however, a small concentration of stray finds on elevated land where several interfluves meet in the centre of the Weald (near Beedings, Figure 7.4 and 1.2). This would be the highest ground in the local area, well exposed, with multiple interfluve pathways leading in all directions. This may also have a seasonal component, as interfluves would be the most exposed to wind (see section on wind below) and are elevated above wet ground conditions, making them favourable during the warmer months.

7.2.3 Waterflow and fording locations

Fording locations can be estimated based on two factors – upriver from major confluence zones (where individual tributaries are less significant) and seasonally in broad lowland floodplains during low water (where flow would be significantly lower) (Chapter 6). During winter this river system would be frozen over. The sites concentrated towards the base of the Wey Valley (Wey Manor Farm, Brockhill, Pyford and Guildford Fire Station)

are all located where the Wey river would have been fordable upriver from its confluence with the Thames.

Moreover, the region is marked by significant areas of impermeable bedrock and spring-lines, most probably leading to seasonally wet ground conditions (Figure 7.4). The fording location here would also link with potential fording locations of the Luddon and Kennet rivers further west, creating a route south of the Thames (Figure 7.4).

River courses are constrained by the narrowing of bedrock or cutting through hills in areas such as the chalk Gaps (e.g. Wey and Mole Gaps) of Southeast England; the constraining and accelerating of fluvial flow means such areas would be unlikely fording locations during higher seasonal flow (Figure 7.4).

Crossings between two catchments (also potential portage locations) could have linked two major routes, if between two sources. Strategic locations would be found at the upriver intersections of major river catchments (Figure 7.4).

7.2.4 Wetlands

Wetlands are very diverse and resource-rich environments. Identifying LG wetlands has been carried out by auguring and coring in Southeast England (Brockhill, Elstead Heath, London Jubilee Line) (Parker & Goudie 2007; Sidell *et al.* 2000; Simmonds 2017). Rivers such as the Bournemouth Avon, the Test, the Wey and the Mole in the study area would have been ideal habitats for beavers during the LG, meaning they were likely sites of expansive ponding and floodplains. This dynamic potentially began before the onset of forestation (Chapter 6) and developed during the Allerød with the onset of birch and pine forestation. This also correlates with the earliest direct evidence of beaver in the British

landscape (Chapter 6) (Coles 2006). The site of Brockhill and numerous find locations along the upper Wey course are in the vicinity of recognised contemporary wetlands. This indicates a potential focus on these resources (Figure 7.4) and may be a seasonal signature, as these regions are particularly rich in spring and summer.

The channel system itself currently does not show any direct evidence of LG wetland zones in the form of recovered sediments, although the region of the Southern Bight (Fitch 2011) and around Hurd's Deep would most likely have been important wetland or lacustrine zones, respectively, in the LG. These would also have been accessible from Southeast England (Chapter 6; Figure 6.16).

Deltaic regions have similar resources to freshwater wetlands, but with an additional marine component and highly variable sedimentation and flow rates. The Channel River delta had a high tidal range over a relatively low gradient landscape. This would potentially be the richest resource environment throughout the year for the whole region, but this fact has often been overlooked. The location of Hengistbury Head, on a prominence opening up to the Channel River and the deltaic region, indicates a likely connection with these regions (Figure 6.16).

7.2.4 Ground conditions

Ground drainage has an important impact on whether the land is suitable for occupation, notably in regard to lowland waterlogging by early spring thaws and early summer flooding (Chapter 5 and Figure 7.6). This can be determined based on bedrock

permeability (Figure 7.4). There are significant parts of the landscape that have shallow impermeable bedrock in the region, yet no site and only one spot find is located on this type of bedrock. There is a relatively narrow corridor of permeable bedrock between the Wey and the Luddon rivers; this contains the most significant concentration of stray finds and is surrounded by impermeable bedrock adjacent to spring-lines. Furthermore, this is a region of well drained sandy bedrock (Figure 7.1). This may also be a seasonal indication of spring–summer activity and avoidance of wet ground conditions.

7.2.5 Elevation: visibility and wind exposure

Elevation and visibility have strategic advantages, the most obvious of which is the ability to monitor activity across the landscape (Figure 7.6). Less obvious, but potentially more important, is a seasonal factor dictated by prevailing wind direction with protection from insects in summer and lee slopes protecting from wind in winter.

7.2.6 Wind

> "Take, for example, the simple mosquito. The wispy insect can't fly in any kind of wind, waiting for the lull to allow its vampiric work. Similarly, we avoid wind when we paddle, working the lee shore as much as possible, and sometimes, like yesterday, unable to work against its power at all." (Wolf 2018, 183-184)

Seasonal winds can be estimated by the location of the polar front and its effect on prevailing winds (Chapter 6). This is important from the perspective of using the wind in summer to protect against insects and avoiding the wind in winter due to chill factor. This is particularly relevant for site locations. As the Channel corridor is in the axis of prevailing

SSW to W winds (Antoine *et al.* 2009; Brauer *et al.* 2008), and its tributaries are mostly perpendicular and sheltered from northern winds, these valleys could have very different seasonal functions. They would be optimal year-round for settlement. This contrasts with northern regions and northeastern Doggerland, which are exposed to northern winds (Chapter 6). With the onset of forestation during the Allerød, the treeline would be an important factor.

The same exposures (north and south) also play a significant seasonal role throughout the LG, with thawing taking place earlier on south-facing exposures, with earlier snow melts feeding the river courses. An earlier thawing of the Hampshire basin could be expected when compared with the Wey-Mole catchment, as both regions contrast significantly with regards to wind exposure (Figure 7.5).

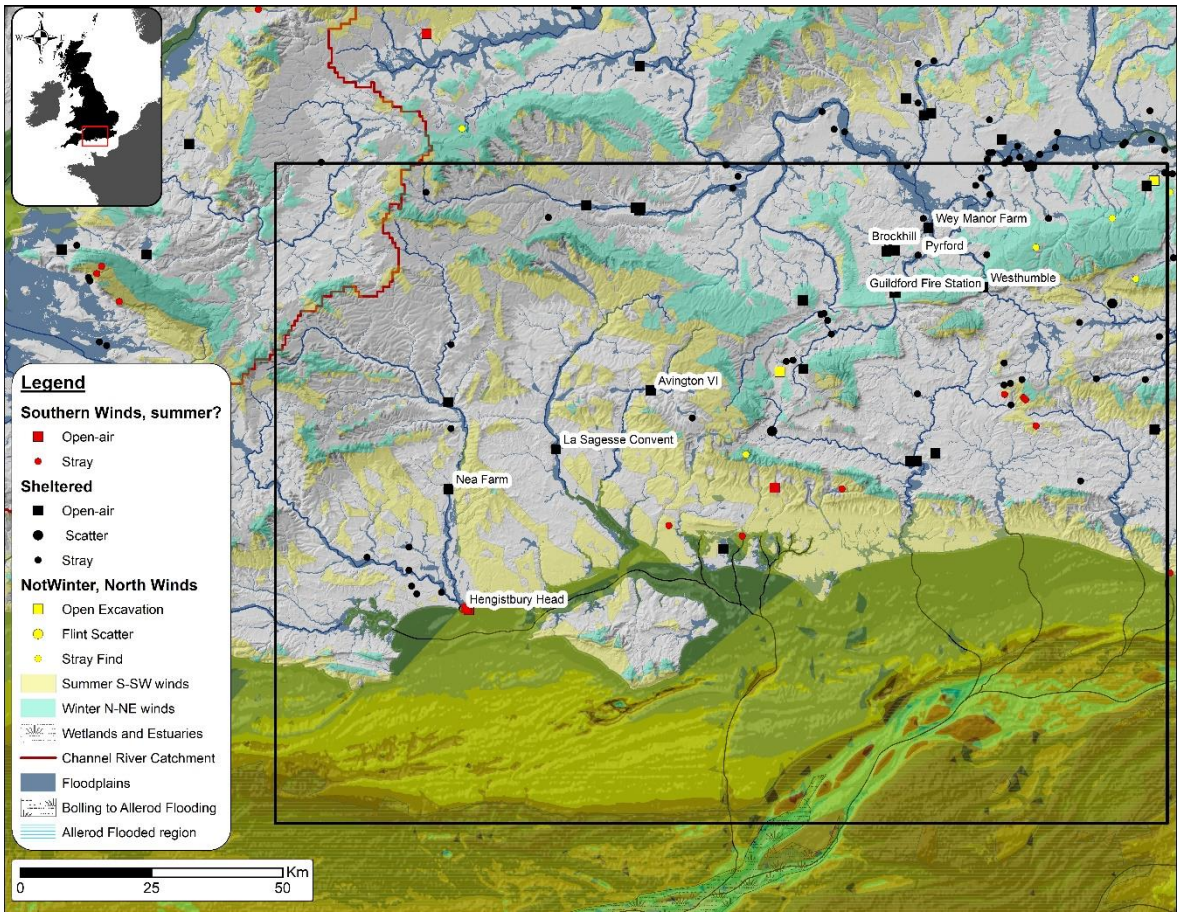


Figure 7.5 SEUK and dominant winds. (Source: Author. Basemap OS TOPO 50, EMODnet17, GEBCO18, borders and rivers European Environmental Agency, projected in ArcGIS 10.6.1).

During winter months, wind chill can be life threatening and occupation sites are unlikely to be exposed to the dominant northern and northeastern winds. Sites in these locations are unlikely to be winter occupations (Figure 7.5). The opposite can be tentatively proposed for spring and summer months, where insects (black flies, midges, mosquitoes) are a significant hazard for both animals and humans (Chapter 6). The coleopteran (beetle) and chironomid (midge) records indicate their very early presence at the onset of the Bølling (Atkinson *et al.* 1987; Coope 1982). Exposure to wind, dominantly western and south-western during these months is sought after, especially for settlements. Valleys oriented to receive the dominant winds, such as the LGCR valley, would be favoured. This

could arguably provide a first seasonal indication for open-air sites that do not have faunal remains in Britain. Hengistbury Head fits this model, as it is very exposed and therefore unlikely to be a winter occupation. Brockhill is on the lee side of an elevation and protected from northern winds; it would fit the wind model not only for winter occupation but for all seasons. The other sites appear to be more focussed on areas not exposed to dominant winds and could therefore be suitable in any season.

7.2.7 Multi-occupation sites and landscape distributions

The sites with indications of multiple occupations (Hengistbury Head and Brockhill) share some common features. Both are on elevated areas in the vicinity of rich wetlands. They also share the feature of being on well-drained sandy bedrocks, which has an effect on ground condition and possibly on local vegetation (Figure 7.1 and 7.4). Hengistbury Head has a clear link to the Channel River, with its location overlooking the valley. Brockhill appears to be in the vicinity of important strategic fording locations – of the Wey to the east and the Loddon to the west (Gibbard 1982). Nea Farm is also on elevated ground, on the lower terrace overlooking the floodplain (Barton *et al.* 2009). It therefore also fits this pattern, which supports a hypothesis of ground conditions. A cluster of stray finds on raised ground in the centre of the Weald merits future investigation.

The common attributes of the other sites are related to their situation *vis-à-vis* river valleys. Although potentially active either in the Bølling or Allerød, these indicate sustained activity within the alluvial floodplains. The locations of Wey Manor Farm, Guilford Fire Station, Pyrford and Westhumble on the floodplain indicate a probable late summer to winter occupation, avoiding flooded and wet ground conditions (Figure 7.4).

The concentration of sites towards the probable fording location of the Wey River could be indicative of mobility and hunting strategies. The distribution of stray finds for the majority follow this pattern within the floodplains. None of these sites appear to be occupation sites and therefore could also be indicative of landscape activity.

The closest comparative with faunal remains and an indication of seasonality are in the Paris Basin Magdalenian and Azilian sites (Bignon & Bodu 2006; Bignon-Lau 2014). Of these only Ville-Saint-Jacques is located on the upper plateau of a hill, whereas the other sites are all in floodplain contexts (Bignon 2007; 2008; 2009). Ville-Saint-Jacques has a mixed faunal assemblage of both horse and reindeer, but the seasonality of the site remains unclear (Bignon 2007). Both Hengistbury Head and Brockhill are considered to be later than the Final Magdalenian of Ville-Saint-Jacques.

7.3 Working towards seasonal models for LG Southeast England

Both Wey Manor Farm and Guildford Fire Station have the potential to be amongst the earliest sites, with multiple traits indicating either late Bølling or Older Dryas (Chapter 4). That they are contemporary to the Hengistbury Head-Nea Farm-Brockhill assemblages remains possible, but Wey Manor Farm varies both technologically and typologically, and Guildford Fire Station is currently being analysed, this remains inconclusive. The model here distinguishes these technocomplexes as open-air Creswellian and Early Federmesser, respectively. These could therefore represent separate occupation episodes, or a seasonal variant (the imminent publication of the Guildford Fire Station analysis may help clarify this question). The sites are both within the floodplain (also in contrast to the Hengistbury-Nea Farm-Brockhill assemblages) and could correlate to the interception of migrating animals.

For the Late Bølling to Early Allerød, the location of Hengistbury Head, combined with the fact of techno-typological characteristics shared with the Paris Basin (Chapters 3 and 4), indicates a close relationship with, and probable traversing of, the Channel River region. Two important factors favour crossing the Channel region: the sites are south of the Thames; and they have close techno-typological traits shared with sites in Somme and Seine River catchments. A dryland passage to the northeast circumventing the Thames remains a possibility, especially with the concentration of similar material on the northeastern margins of the Thames (and LGCR) catchment. This could be essential when considering a floodplain and main course at times potentially stretching over several kilometres width. It is unlikely that the Channel River was crossed from spring to summer, with a possibility from mid to end of summer if using watercraft, and an accessible winter

crossing when the river froze. Hengistbury Head's location indicates a potential summer occupation based on its exposure. The other sites are in valley bases protected from wind exposure and therefore seasonal interpretation is more elusive.

Later Federmesser Allerød evidence is scarcer. However, once again, the site locations are south of the Thames, indicating seasonal access to the Channel River region. The major river systems are unlikely to be barriers, but seasonal barriers. Winter there would always be access if the river courses froze.

What is apparent is that the region would be rich in resources and favourable for occupation. The conditions from a landscape and resource perspective appear to become more favourable with the development of wetlands and the advance of the Channel Estuary. This contradicts site recovery, as there are very few Late Allerød sites, and none of significance. However, there are Allerød sedimentary deposits with potential in the region. Only future excavations will help answer these questions. The current record indicates a relatively short-term, yet wide occupation of this landscape. This corresponds to high mobility and possibly even seasonal occupation.

At the same time, although the technological parallels are maintained, there is distinct typological variation in penknife points during the Allerød (Chapter 4). Could the development of deep, single-channel Allerød rivers feeding the LGCR have created more difficult features to traverse? Or could the LGCR estuary possibly have developed into a more complex passage, limiting cross-Channel movement and cutting off direct traversing of the region, while favouring a shift eastward to the dryland passage further north and wetlands in the Southern Bight region?

The Younger Dryas marks a significant transition from the preceding 2600 years of sparse LG occupation in the region. There is an apparent intensification of fluvial occupation in Southeast England with multiple sites and find locations concentrated in the final phases of this stadial. These sites are concentrated along the floodplains, notably along the Thames (Figure 7.1) (Roberts & Barton 2020).

Chapter 8 Conclusions

This thesis has focussed on Late Glacial (LG) sites in Southeast England and its regional context within the broader landscape of the Channel River Catchment. To develop a framework for a qualitative assessment of a broad variation of LG signatures, with few sites, multiple scatters and extensive single find distributions, it was necessary to re-examine the diagnostic criteria in light of recent developments in Britain and Northern Europe (Chapters 1, 3 and 4). Chapters 3 and 4 focus on defining at multiple chronological, spatial and qualitative scales (lumping and splitting) the LG lithic assemblages' distribution of SE England and its neighbouring regions with relevant reference sites and industries. This involved collating and assessing several large datasets.

Four questions led this research:

- *What resolution of site is suitable as a technocomplex reference site (dating and diagnostic elements) contrasting with what is the lowest signature of a tangible landscape signature (single find to full excavation)? (Chapters 3 and 4)*

It soon became clear that due to the inconsistency and incomplete nature of the datasets that a new structure was needed to investigate landscape use, distinguishing reference sites from large scale spatial signatures so as to have a representative sample by chronozone tranche. Important also was to define the relationships between the industries in Britain and neighbouring countries so as to have the appropriate scale of comparison and analysis within the Channel River catchment framework. This was successfully developed by initially splitting the industries into chronologically and techno-

typologically distinct groups, highlighting the attributes that have been used to define them. This enabled the direct comparison with other industries in Northern Europe that may have better dating / palaeoenvironmental / technological datasets that can feed into the modelling of landscape use and mobility for Southeast England. Subsequent to this, it was possible to group these into broader chronozone groups that could be used at the scale of palaeoenvironmental transitions and chronozones exploring large scale mobility and landscape strategies (Chapters 6 and 7).

This new refined chronological and techno-typological framework with four technocomplexes (with variations in confidence): an Early Creswellian, a Late Creswellian with Azilian traits, an Early Federmesser/Azilian and an Allerød Federmesser technocomplex. Within this framework, it has been possible to identify traits that are relatively diagnostic of specific or groups of technocomplexes.

The role played by a dynamic and environmentally facetted landscape, and the impacts of climate and seasonality on mobility within the Channel River catchment is discussed in Chapters 5 and 6. The fluvial dynamics are complex and would likely play an important role in structuring the landscape for humans and animals. The characterisation of the river systems provides a good basis for modelling human mobility at a seasonal level, within broad climatic phases. These environmental and fluvial transitions appear to coincide broadly with techno-typological adaptations (Chapters 3, 4 and 6). The rivers can be broadly categorised into two groups, braided and meandering (referring to the mid and lower stretches of the courses). The trunk north valley of the Channel River is glacially

fed throughout summer, whereas the tributaries follow a shared pattern in transitioning from braided to meandering systems in the Bølling and Allerød respectively. Furthermore, the rising sea levels and expansion inland of the Channel Estuary is highlighted in the models and would have played a significant role in the landscape.

- *What role did the Channel River play in our understanding of LG site distributions? (Chapters 5 and 6)*

By examining the topography and dynamic transitions of river systems on land and submerged within the Channel River Network, it is possible to build a framework for assessing site locations within a broader dynamic landscape. The rhythm and strategic locations in the landscape become apparent and completely transform our perception of Southeast England with the rest of England and Northern Europe. The region of Southeast England had its southern extent on the banks of the Channel River, and its western and northern extent delimited by the Channel River's two largest northern tributaries, the Palaeo-Solent and Thames respectively. On the banks of a major river that seasonally conditions resources and access, the passage to the north-east is a relatively isolated corridor. The environmental transitions (i.e. the development of open woodland in particular) initiates and develops more in this region than further north in Britain, and proximity to the encroaching and developing estuary provides an exceptionally rich resource. Conversely, it is relatively seasonally isolated by the large river to south and major rivers to the north (Thames) and east (Rhine/Channel River) if without watercraft, or completely connected if watercraft are used. Integrating ethnographic data on landscape use and mobility

technologies enabled a further characterisation of landscape features and seasonal rhythm's respective roles on human mobile strategies.

- *Within the developed landscape framework of the Channel River, can mobility and site distributions be reassessed and integrated into a larger broader landscape discussion? (Chapter 7)*

When integrating the chronozone and palaeoenvironmental characterisation with landscape features and site distributions, mobility, and strategic locations can be questioned for the first time at both local and regional scales. Cross-channel relations between technocomplexes could be explored, and strategic landscape locations highlighted, for Southeast England at both a climatic and seasonal scale. Mobility and resource locations are also integrated into a continuous landscape assessment. This spatial template facilitates the integration of multiple thematic datasets so as to analyse LG site distribution in relation to taphonomy, and features recognised in both ethnographic and historic sources. The distinction between archaeological biases is highlighted and taken into consideration.

A larger scale for mobile systems is also applicable, potentially highlighting some of the inconsistencies and pitfalls of too narrow window on mobile hunter-gatherer groups. The technocomplexes clearly indicate cross-channel activity throughout the LG, and now the question of the nature of this activity through direct mobility or exchange, and probable routes, can begin to be questioned.

- *Can a landscape approach help in our understanding of site distributions and what role does topography play in determining site locations and potential mobility corridors? (Chapter 7)*

The landscape and mobility characterisation of the LG Channel River network in Chapters 5,6 and 7 highlights important seasonal rhythms and topographic features that help structure our interpretation of site locations. As described in Chapters 3 and 4, all of the open-air sites in Southeast England are lacking any direct organic data relating to mobility, site function or broader inter-relation of sites. Within the framework developed here, aspects such as proximity to fluvial systems, the dynamic function, and the important role of elevations and ground conditions are distinguishable, and patterns become apparent. Suggested is the choice of well drained soils for larger Federmesser occupation locations for the few sites recovered so far (Chapter 7).

Attributes that are recognised as essential in the ethnographic and historic record can be applied such as wind direction (sites such as Hengistbury Head that are very exposed can be constrained to spring-summer occupation).

Strategic locations in the landscape are highlighted, and correlations can be made such as the relationship between Kent's Cavern and the Channel River Estuary. The role of large river systems as conduits and barriers is highlighted, with regions such as Hurd's Deep and Silver Pit, significant lakes that could be traversed by migrating herds when the main

river flow would be too high. The same goes for regions where the river is constrained by bedrock topography, increasing flow regimes, and unlikely crossing locations. The locations of major confluences are also significant, not only for the role they play for aggregation sites that is documented archaeologically, ethnographically and historically, but also for fording locations upriver from these locations where subsequent flow intensifies.

Resource rich locations attract both animals and humans and can be distinguished, along the estuarine edge, lakes, wetlands, regions of driftwood deposition, and downcutting exposing raw material. Routes and strategic locations can for the first time be modelled and, in the future, tested.

The objective of this thesis was to examine the pattern of LG distributions in light of a broader landscape approach. For Southeast England, examining the collections at face-value, it soon became apparent that there would be little other than a basic static techno-typological analysis per site. Within this broader landscape context, highlighting the major role played by the Channel River for the first time, these assemblages begin to take on contextual role, beginning to shed light not simply on reduced technical traits on broader behavioural patterns. It also enables the examination of the region as a cohesive set of signatures, that can be tentatively split into chronological patterns.

The re-modelling of dates using the IntCal20 curve significantly refined the overall chronological framework for this period, facilitating the landscape approach and long

distance comparisons. Significant shifts in Late Glacial dates (from 150 to 300 years), as well as a more precise calibration, highlighted the exceptionally early migration (of both people and their domestic dogs) North into lands previously occupied by a peri-glacial landscape. This dating also emphasises the likely lag between the Greenland Ice Core records (GICC05) and the British palaeoenvironmental transition at the onset of the Late Glacial.

The purpose of the research was also to highlight regions for future research and heritage awareness. The patterns recognised in Southeast England (Chapter 7), indicate several regions of interest. The alluvial floodplain has important potential for site recovery. The upper reaches of the Wey a very important wetland sequence at Elstead Heath, which also has potential for high resolution archaeology on its fringes. The repeated use of elevated sandy grounds (Hengistbury Head, Brockhill) indicates that the concentration of stray finds near Beedings, in the central Weald could be significant. The region has potential for more significant Late Glacial sites.

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Volume 2: Catalogues

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Catalogue A: Late Glacial Dates

Catalogue OxCal 4.4 with IntCal20

All of the following plots were modelled in OxCal 4.4 (Bronk Ramsey 2021) using the IntCal20 calibration curve (Reimer *et al.* 2020). All dates are compared against the NGRIP (GICC05) $\delta^{18}O$ record (Andersen *et al.* 2006; Svensson *et al.* 2008; 2006). When regional palaeoenvironmental terms are used (Bølling, Allerød and Younger Dryas), they refer to an adapted framework applied within this thesis taking into account the potential lag of the Greenland ice record in relation to Northern European Late Glacial (LG) temperatures, notably the Bølling (with a warming as early as 15,500 cal BC, Figure A.*3*), up until the onset of the Allerød, where they appear to fall broadly in phase (Blockley *et al.* 2004; 2006).

Here is the description of the methods used:

- "simple plot" (calibration of the dates without modelling);
- "uniform single phase" (a Bayesian model where there is one phase with all of the dates constrained by start and end boundaries determined by the program) (Bronk Ramsey 1998; 2000; 2009a, 343–44; Steier & Rom 2000);
- "overlapping uniform phases" (a Bayesian model with several phases constrained by start and end boundaries, the start boundary of a phase can overlap with the preceding phase up to the preceding start boundary);
- "outlier model" (a model that attributes a 5% chance to a date being an outlier, identifying the outlier and weighting it) (Bronk Ramsey 2009b, 1024);
- "charcoal outlier model" (in this case charcoal samples are attributed a 100% outlier probability (Bronk Ramsey 2009b, 1031), but these dates will only be considered as older, this is to take into account the possibility of older wood being combusted); and
- "KDE model" (Bronk Ramsey 2017) (a non-Bayesian statistical model, best used for large groups of dates and summarising) for more than three dates as described in the methodology section (2.5.1).

The same methods and representations as used in Jacobi and Higham (2011) were applied: "In the absence of contrary stratigraphic data each site model consists simply of a single phase constrained by boundaries. Individual likelihoods are shown by the light-shaded distributions, whilst the darker

outlines represent posterior probability distributions. In each phase, the agreement index values were all >60%, indicating acceptable levels of agreement." (p. 232), with the addition KDE models and of colour, both relatively new features to OxCal 4.4.

All of the figures follow the same formatting dependant on the type of model used: *Table I*.

Table I Formatting of the figures depending on the type of model used.

	Single date (68 & 95%)	68%	95%	Multiple plot (68%)	Curve plot (sigma)	Sum (median)	KDE plot (median)	Agreement index
Simple plot	x	x	x	x	x			
Single uniform Phase		x	x	x	x	x	x	x
Overlapping uniform phases		x	x	x	x	x	x	x
KDE Model		x		x	x		x	x

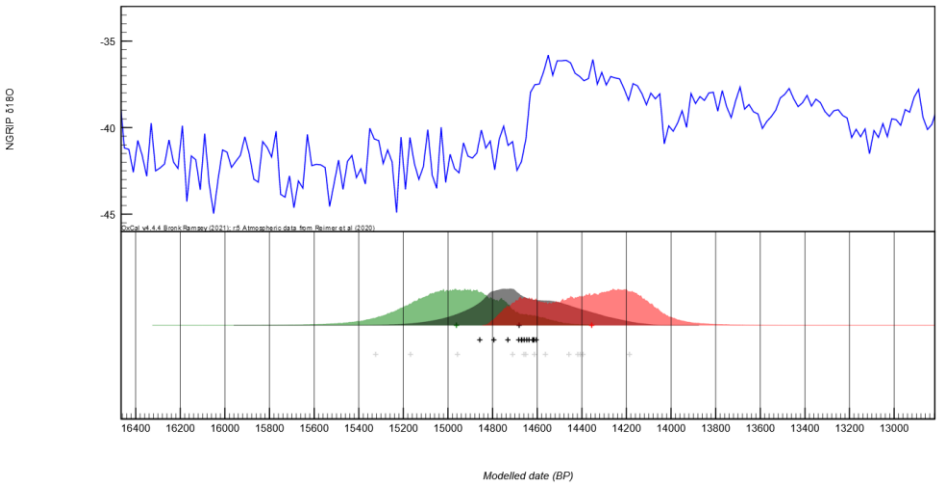


Figure A.1 Example of stacked dates for uniform single phase and overlapping single phase models. The results are summarised as stack plots with start (green) and end (red) boundaries. Light grey crosses indicate medians before modelling and black crosses medians resulting from modelling.

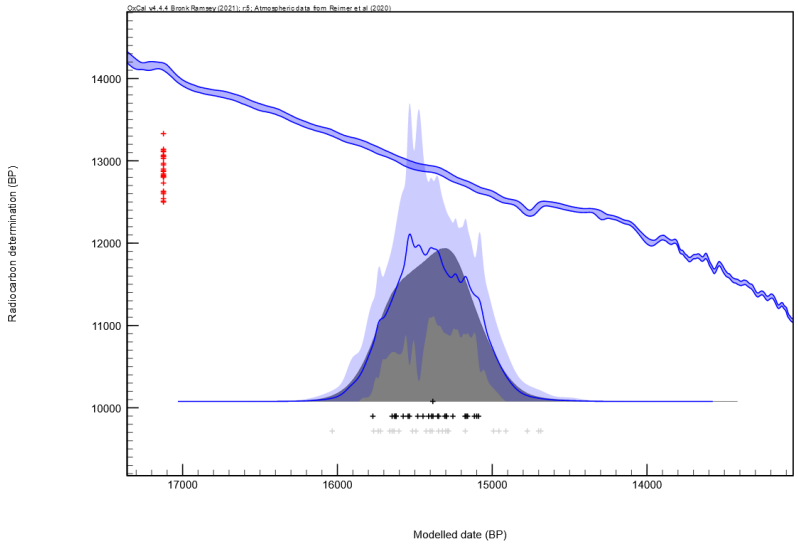


Figure A.2 Example of summed dates from a KDE Model. Light grey crosses indicate medians before modelling and black crosses medians resulting from modelling. Uncalibrated medians are marked as red crosses. The grey fill indicates the probability before modelling, the blue line indicates the cumulated model probability, with the transparent blue fill indicates the variability.

Conventions

The following are appended to the lab number in the projections:

* = cut marked/modified material (bone, antler, ivory)

AF = ultrafiltration pre-treatment (see Jacobi and Higham 2011: 225)[37]

AI = ion-exchange gelatine date (see Jacobi and Higham 2011: 225)

AC = activated charcoal treatment (see Jacobi and Higham 2011: 225)

c = conventional date

= charcoal

[###] = the agreement index

[37] This method is had to be rectified as early applications of the method left traces that contaminated the samples. The series of bone dates at risk are: OxA-9361 to 11851 and 12214 to 12236 (Higham et al. 2007: S2)

Abbreviations for British sites used in the following models:

AH: Aveline's Hole

PXH: Pixie's Hole

SH: Sun Hole

KAC: King Arthur's Cave

GNC: Gough's New Cave

KTC: Kent's Cavern

RHC: Robin Hood Cave

PHC: Pin Hole Cave

MGP: Mother Grundy's Parlour

THC: Three Holes Cave

KDC: Kendrick's Cave

CON: Condover

HF: High Furlong

LC: Lynx Cave

BC: Broken Cavern

SK: Seamer K

Example of date annotation used in this catalogue:

OxCal (formatted by concatenation in Excel): "site abbrev", "area/layer", "excavation", "species", "date code", "preparation" "cut mark" etc., e.g.: "GNC, Area I, NHM 1987-1989, Homo, OxA-17849 *"

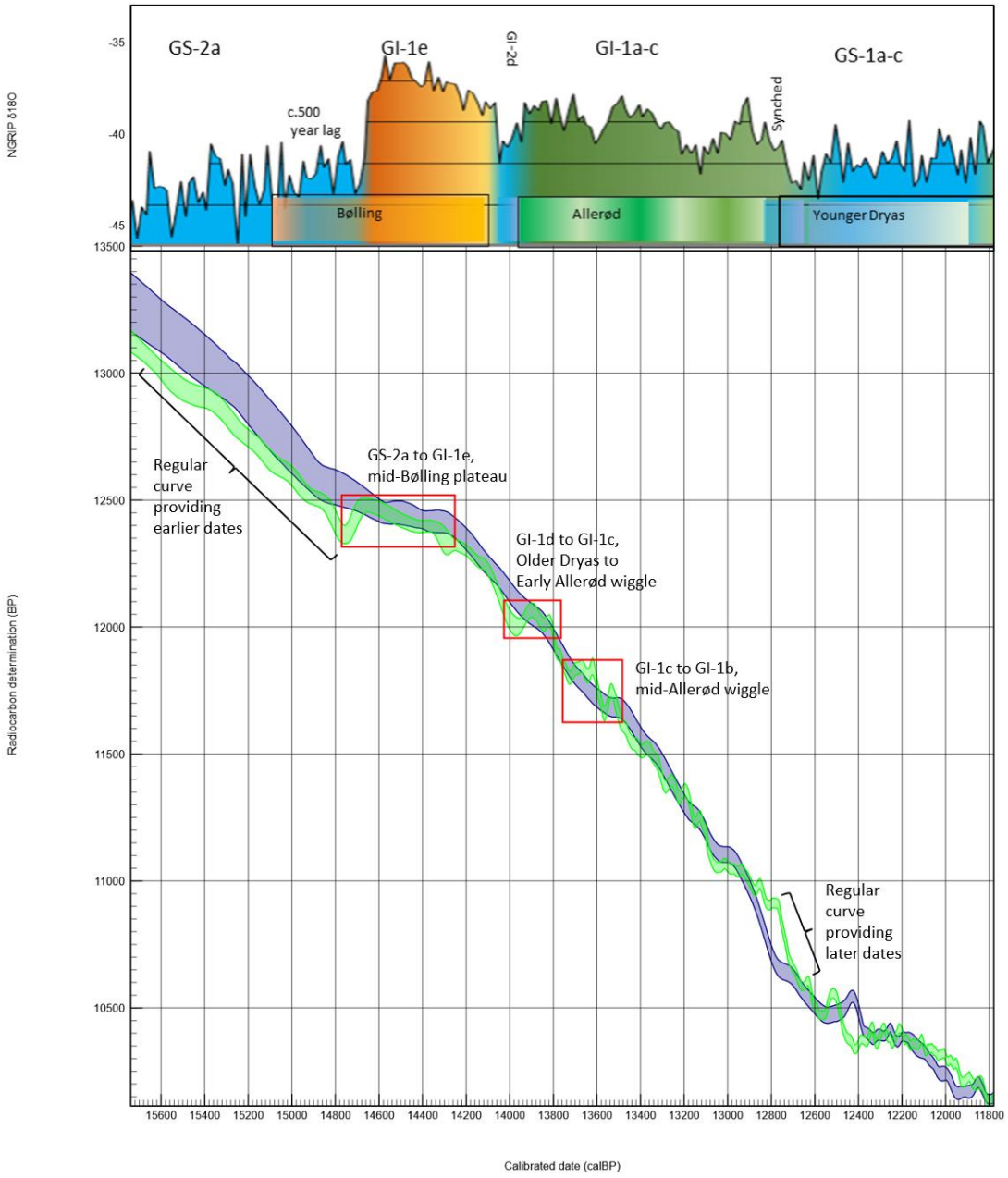


Figure A.3 IntCal04 (blue, Reimer et al. 2004) and IntCal20 (green, Reimer et al. 2020) calibration curves overlapping. The IntCal04 curve was used for the seminal publications (Jacobi and Higham 2009a, 2009b, 2011) dating English and Welsh Late Glacial sites. It has been added in the background of the subsequent British date distributions for comparison with the recent IntCal20 projections. The following dates have undergone quality selection and are here recalibrated and modelled with the most recent IntCal20 curve.

The two curves differ with overall earlier dates when using the IntCal20 curve. Where in some parts the curve has gained precision, in others this has exposed wiggles and plateaus not apparent in earlier curves. The latter part of the Allerød (second half of GI-1a) provides later dates with IntCal20. The most significant plateaus and wiggles referred to in the following captions are at the onset of GI-1e, the transition from GI-1e to GI-1c, and GI-1c to GI-1b. Otherwise, where the InCal20 curve is regular it is more precise than IntCal04. (Source: author).

Mainland Europe

Late Magdalenian

Switzerland: Late Magdalenian Monruz and Champréveyres

Overlapping Uniform Phases

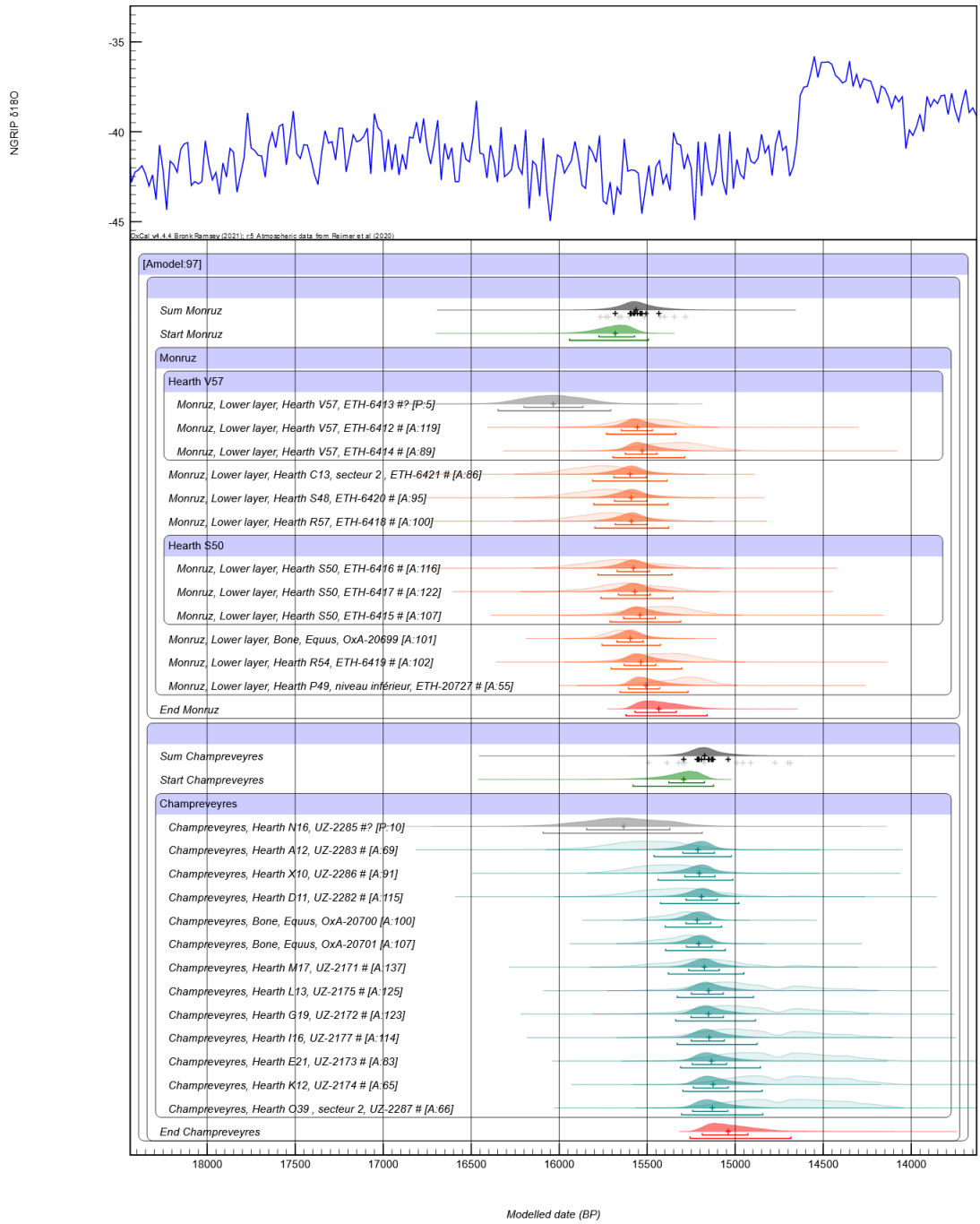


Figure A.4 Swiss Magdalenian, Monruz and Champréveyres, selected dates after Leech 2012 and Debout et al. 2014. Overlapping uniform phases of the two sites (one phase per site). Dates from the same hearth are grouped, as although there are indications of hearth re-use it is most probably to be peri-contemporaneous withing the 14C dating resolution (Leech 2012). Two dates (grey) were treated as outliers as their agreement indexes were low in previous models. When processed with the outliers this significantly improved the model agreement. Amodel: 97% is very good.

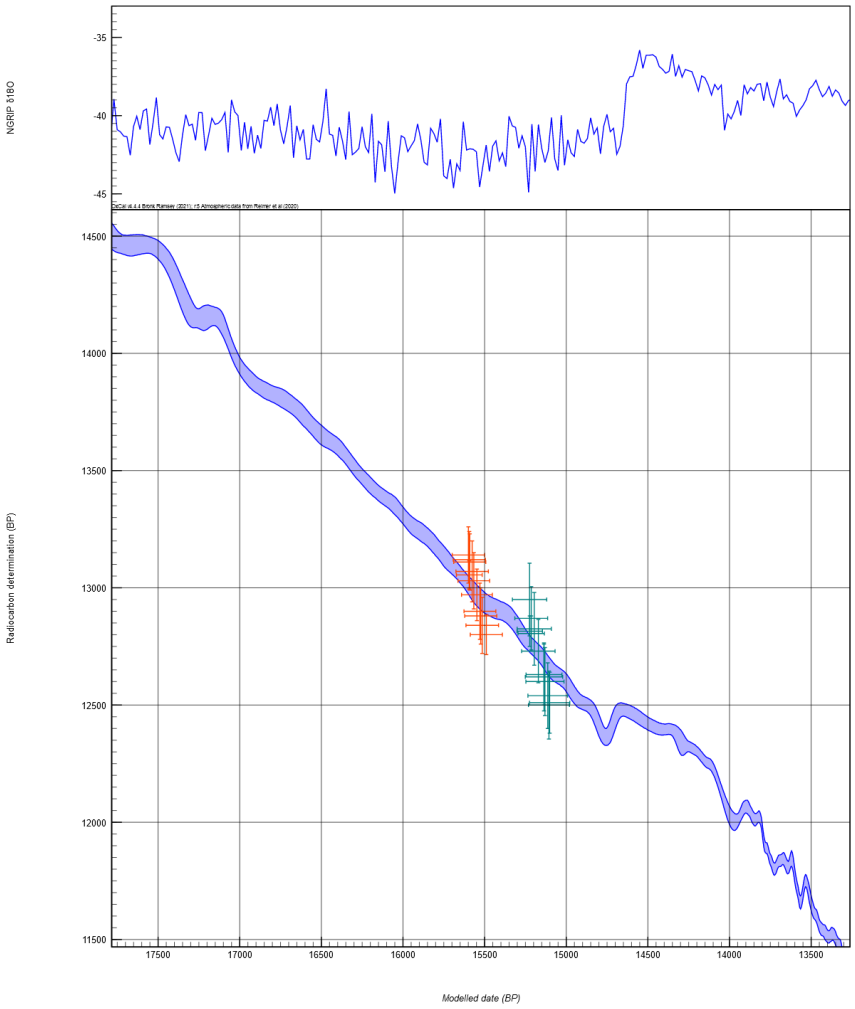


Figure A.5 Swiss Magdalenian, Monruz and Champréveyres, selected dates after Leech 2012 and Debout et al. 2014. Overlapping uniform phases. The dates clearly precede GI-1e, and appear to indicate two distinct occupations towards the end of GS-2a.

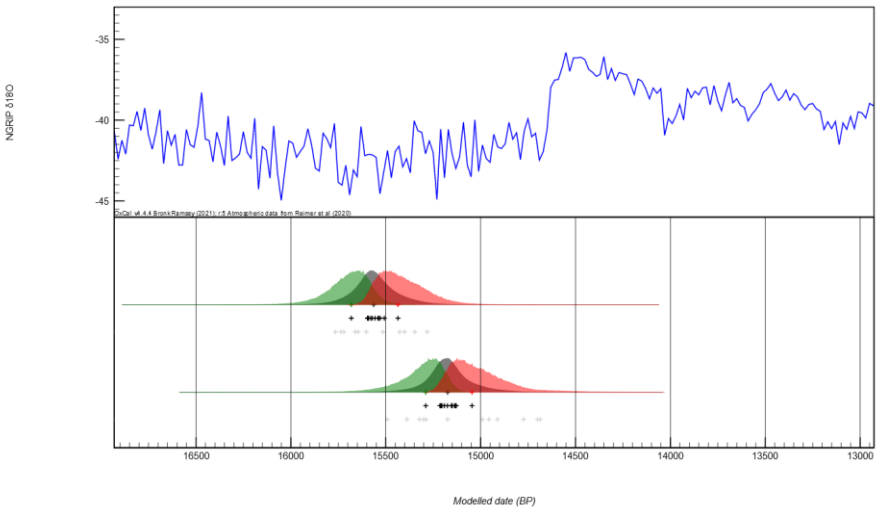


Figure A.6 Swiss Magdalenian, Monruz (top) and Champréveyres (bottom), selected dates after Leech 2012 and Debout et al. 2014. Overlapping uniform phases. The two sites appear to be staggered.

Germany, Neuwied Basin: Late Magdalenian Gönnersdorf and Andernach

Overlapping Uniform Phases

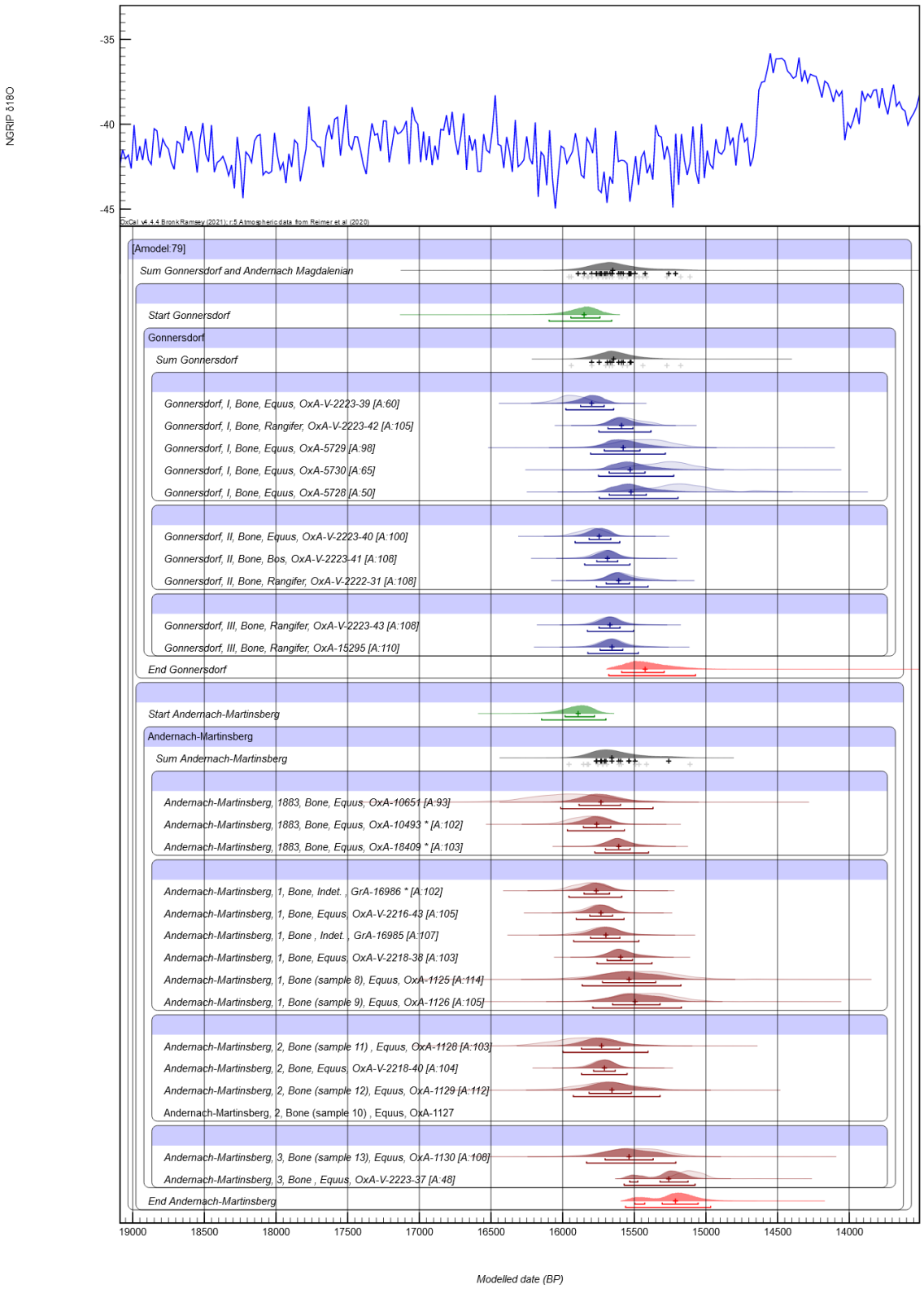


Figure A.7 Late Magdalenian Gönnersdorf and Andernach. Not ordered based on stratigraphic relationships, grouped by excavation area. Data from Stevens et al. 2009. Overlapping uniform phases. Amodel: 79% is acceptable.

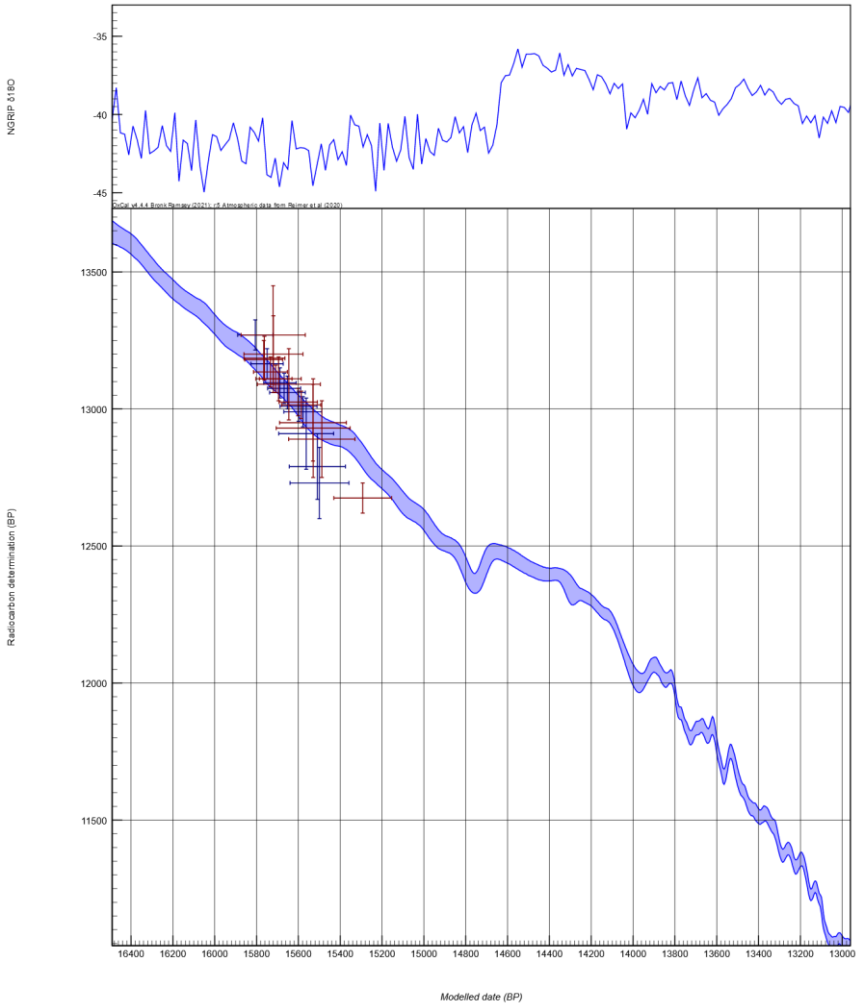


Figure A.8 Late Magdalenian Gönnersdorf and Andernach. Not ordered based on stratigraphic relationships. Data from Stevens et al. 2009, sorted and selected. Overlapping uniform phases. 68.3% probabilities indicated as bars. The dating clearly clusters in GS-2a.

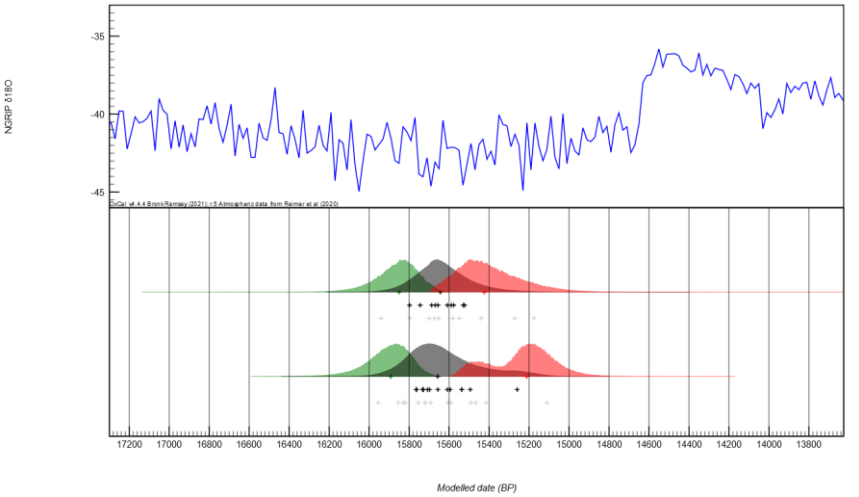


Figure A.9 Late Magdalenian Gönnersdorf (top) and Andernach (bottom). Stacked dates with start (green) and end (red) boundaries. Data from Stevens et al. 2009. The two sites appear to be contemporary.

Belgian Late Magdalenian Cave assemblages

Overlapping Uniform Phases

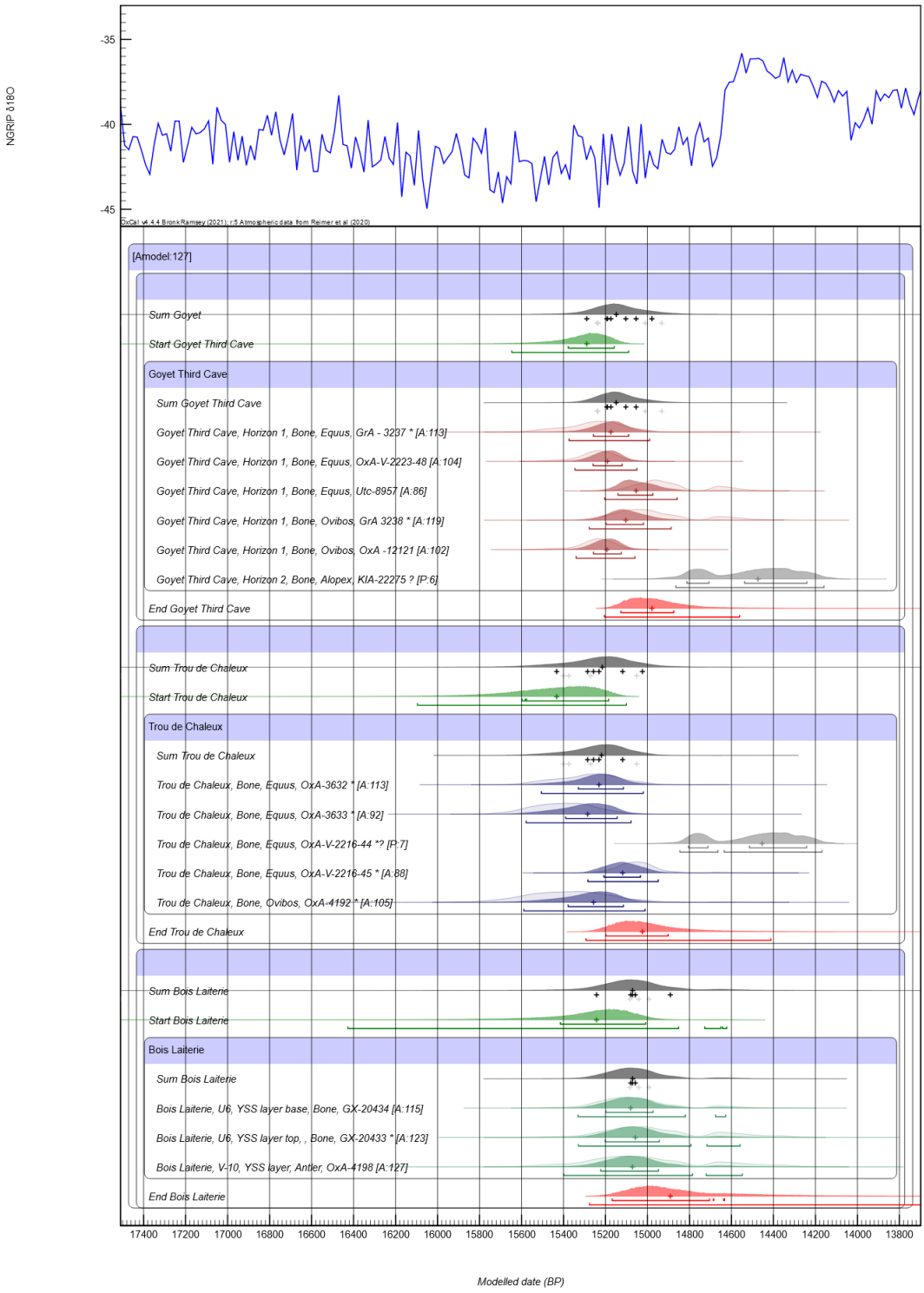


Figure A.10 Belgian Late Magdalenian Cave assemblages. Dates selected from Stevens et al. 2009 and Sano et al. 2011. Overlapping uniform phases. Amodel: 127% is very good. Two dates are considered as outliers (grey).

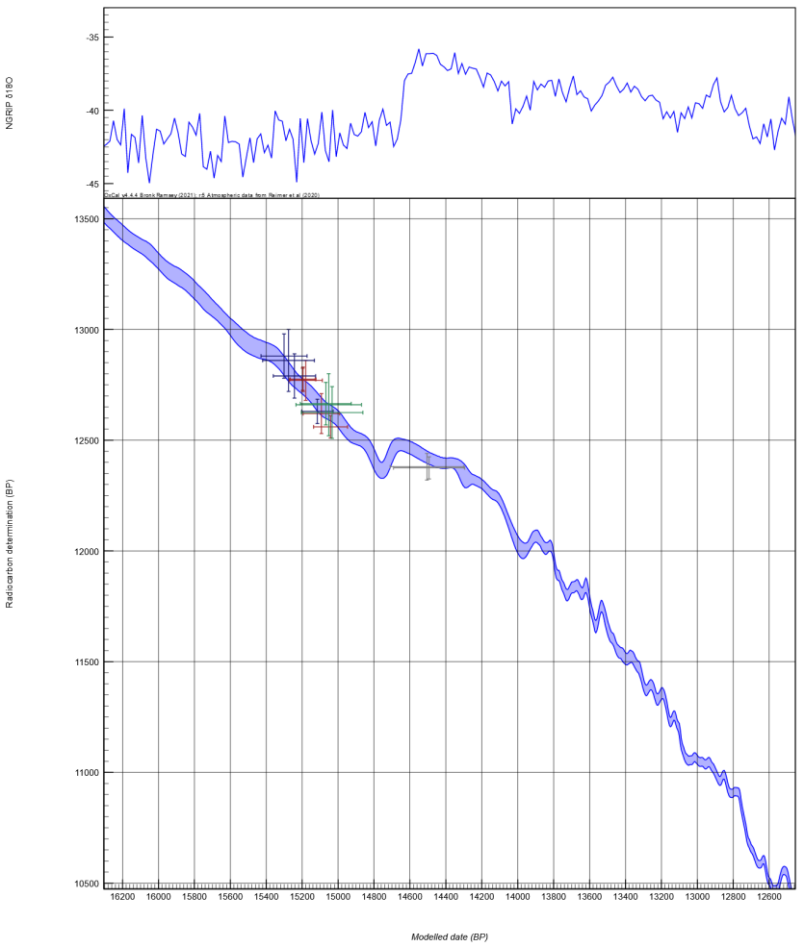


Figure A.11 Belgian Late Magdalenian Cave assemblages. Dates selected from Stevens et al. 2009 and Sano et al. 2011. Overlapping uniform phases. Two dates indicated as outliers (grey). There is a consistent cluster of dates in GS-2a.

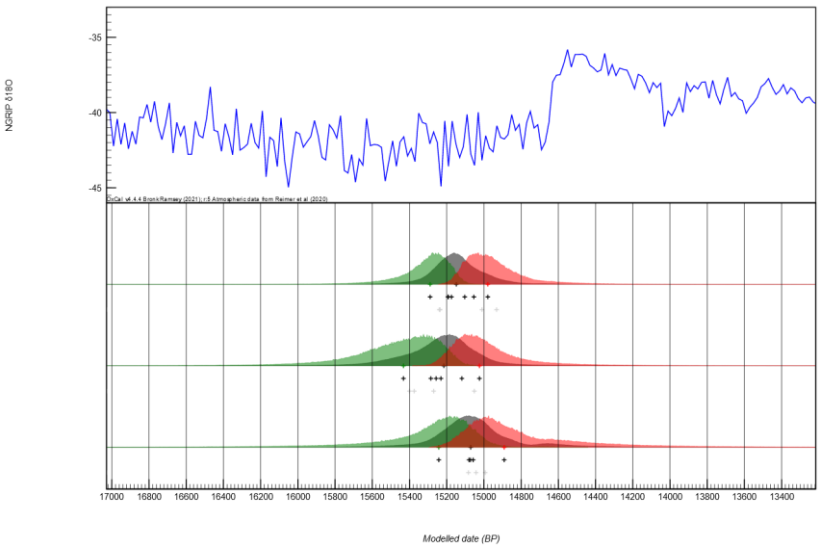


Figure A.12 Belgian Late Magdalenian Cave assemblages. Dates selected from Stevens et al. 2009 and Sano et al. 2011. Overlapping uniform phases. Sum (grey), Start (green) and end (red) Goyet Third Cave (top), Trou de Chaleux (middle) and Bois Laiterie (bottom). The three sites appear to be contemporaneous.

Paris Basin, Late Magdalenian

Overlapping Uniform Sequences

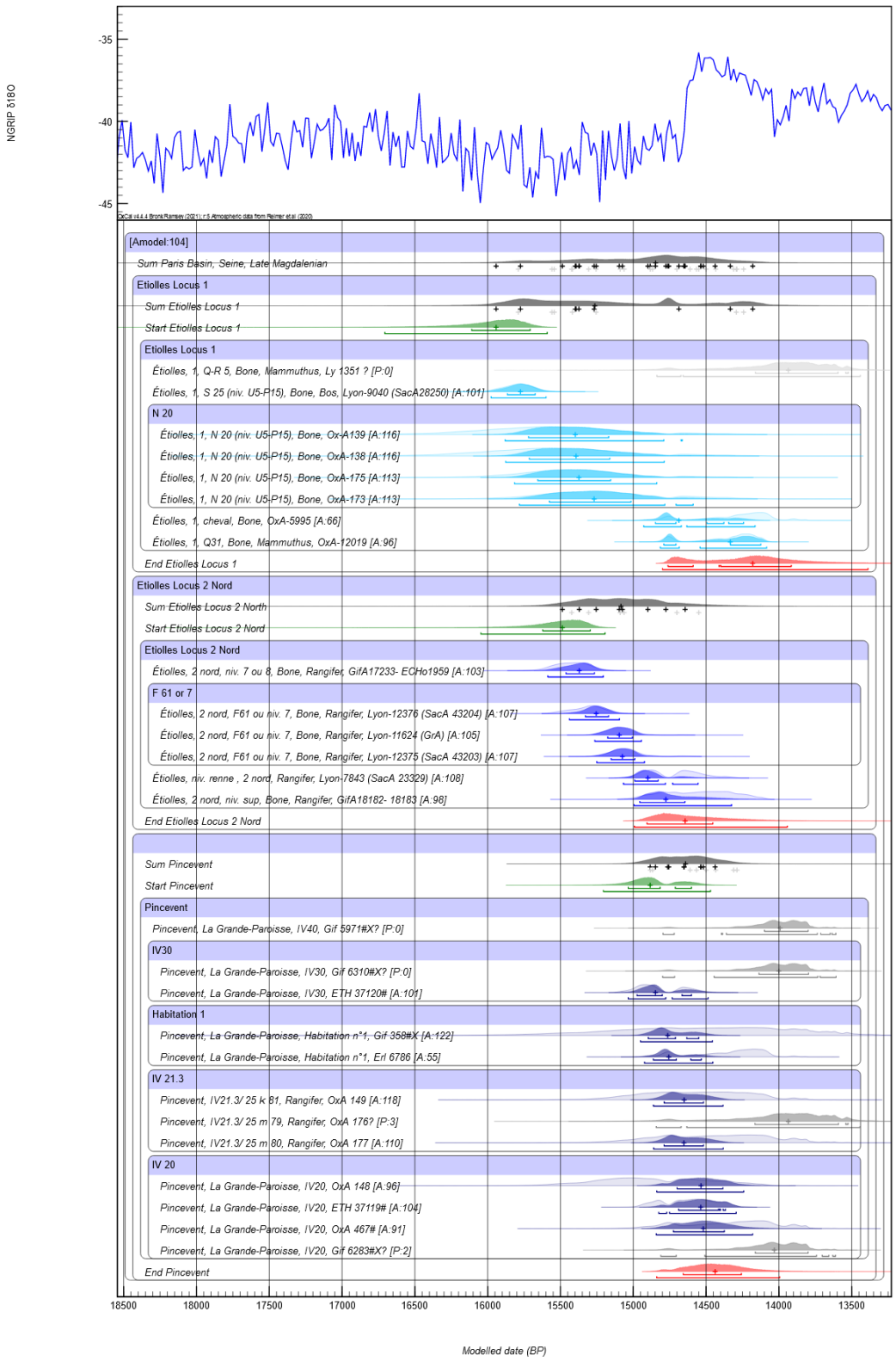


Figure A.13 Seine catchment Late Magdalenian, Etiolles and Pincevent overlapping sequences. Etiolles in stratigraphic order (Roblin-Jouve et al. 2016 and Olive et al .2019) and Pincevent dates in stratigraphic order (Bodu 2004, Debout et al. 2014 and Karlin and Julien 2018). These dates have not undergone isotopic and recent collagen control. Some dates were obvious outliers due to their stratigraphic position, and removed from the model (light grey), two other dates had low agreement index values in previous models and are marked as outliers (light grey). Interestingly, the outlier from Etiolles and the four

from Pincevent all group around the same date (around 14000) and might be considered as an indication of some form of taphonomic alteration/contamination.Amodel:104% is very good. Both sites appear to overlap from GS-2a into GI-1e. Pincevent has a much more concise dating profile whereas Etiolles appears to start earlier and finishes later.

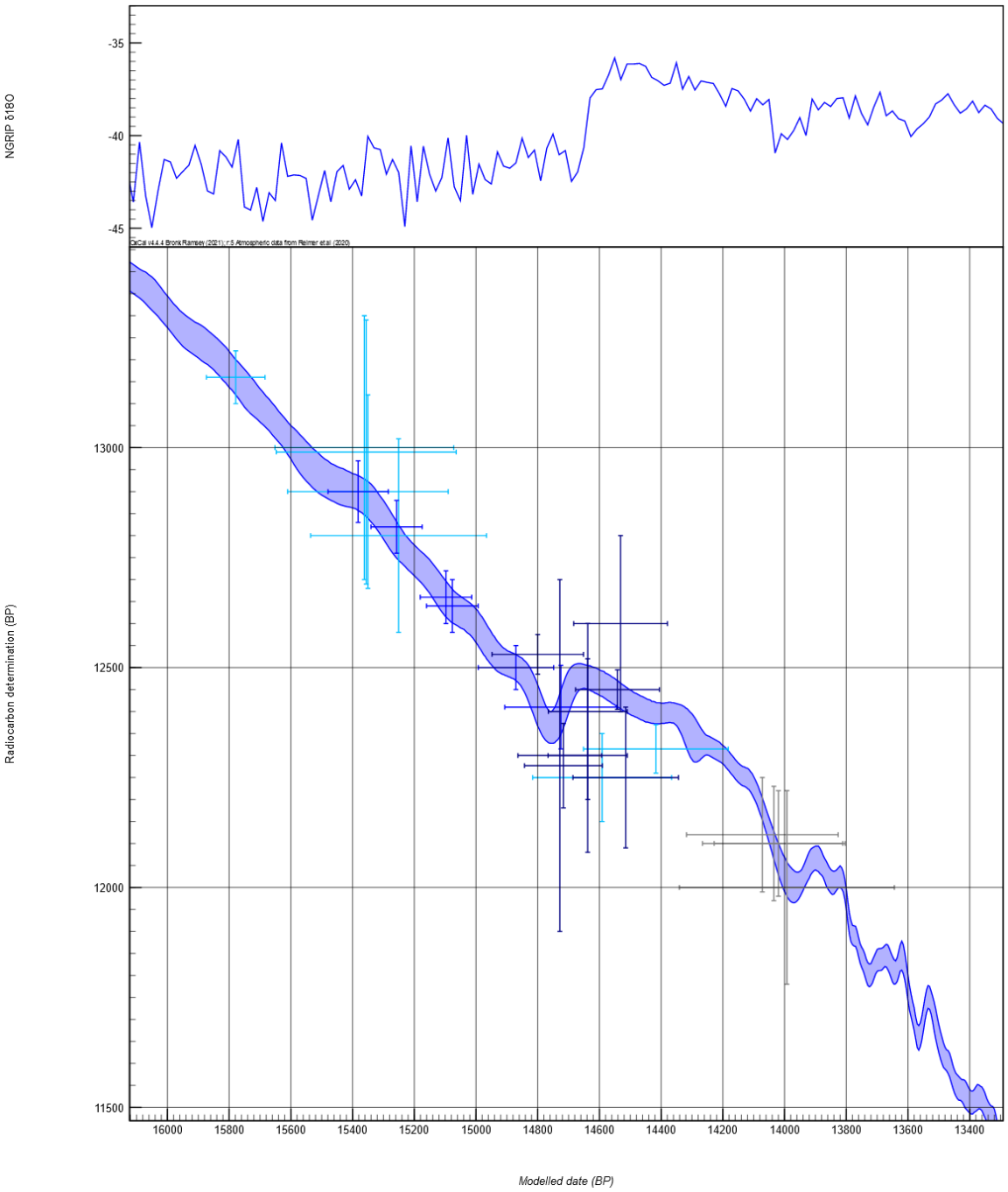


Figure A.14 Seine catchment Late Magdalenian, Etiolles and Pincevent overlapping sequences. Etiolles Locus 1 (light blue), Locus 2 (blue) and Pincevent (Dark blue). Outliers are grey.

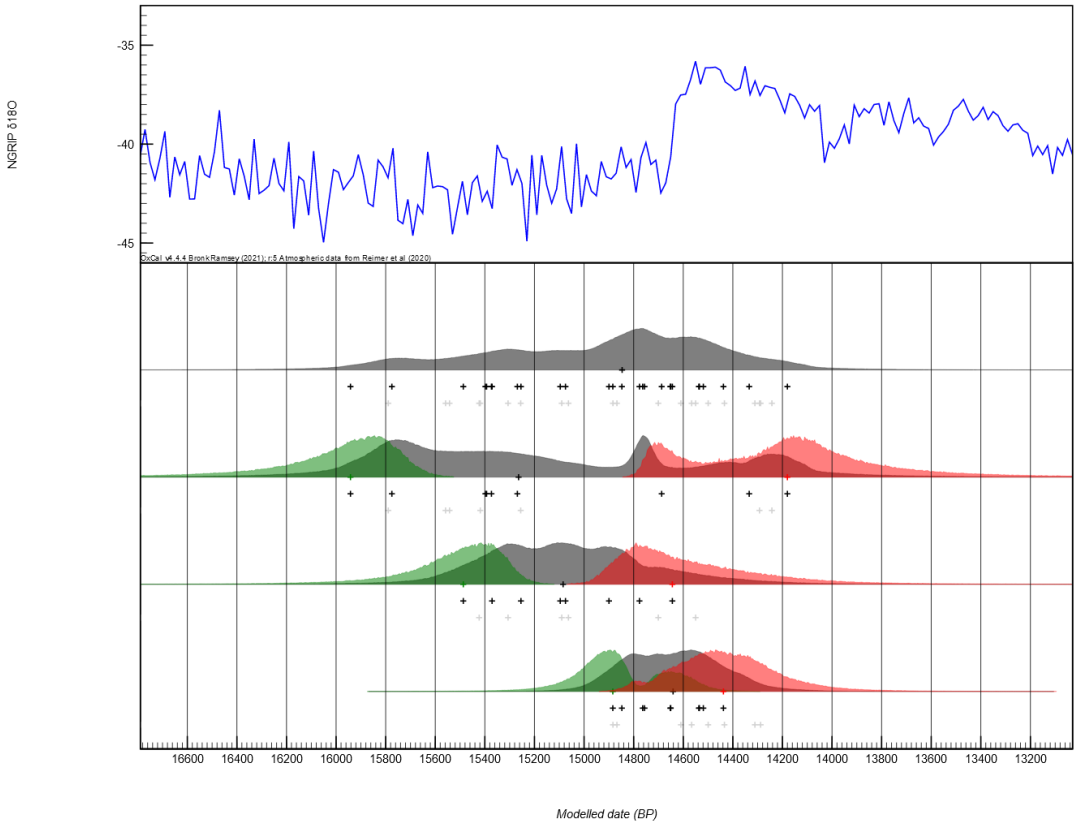


Figure A.15 Sums for Seine catchment Late Magdalenian (top), Etiolles (Locus 1 mid upper, Locus 2, mid lower) and Pincevent (bottom) overlapping sequences.

Etiolles

Overlapping Uniform Sequences

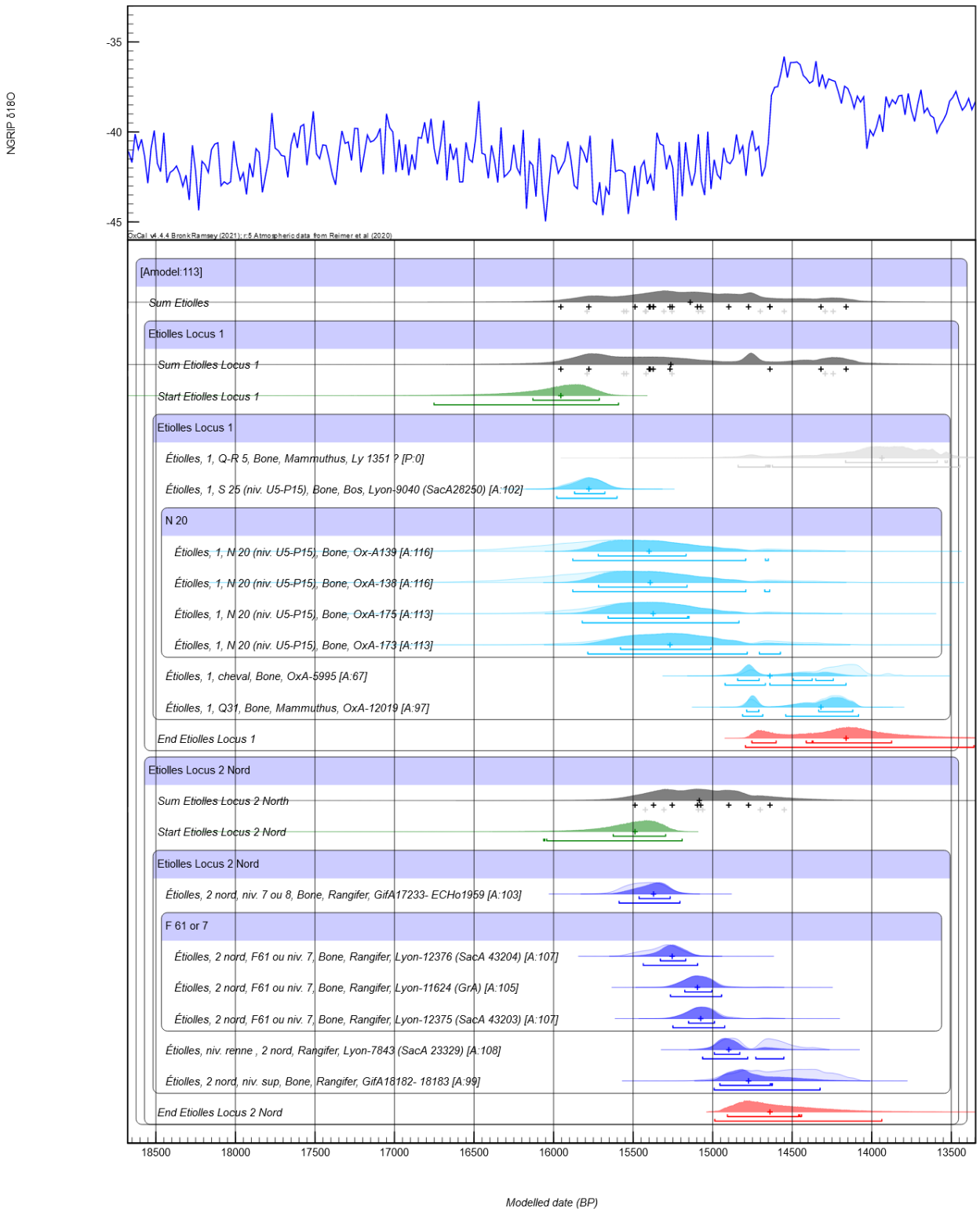


Figure A.16 Etiolles, Paris Basin, selection of recent AMS dates in stratigraphic order. Overlapping uniform sequences. Roblin-Jouve 2016 and Olive 2018. Uniform Sequence. The dates have not undergone verification of collagen and isotopic values. Amodel: 113% is very good. There is one date considered as an outlier at Etiolles (Grey).

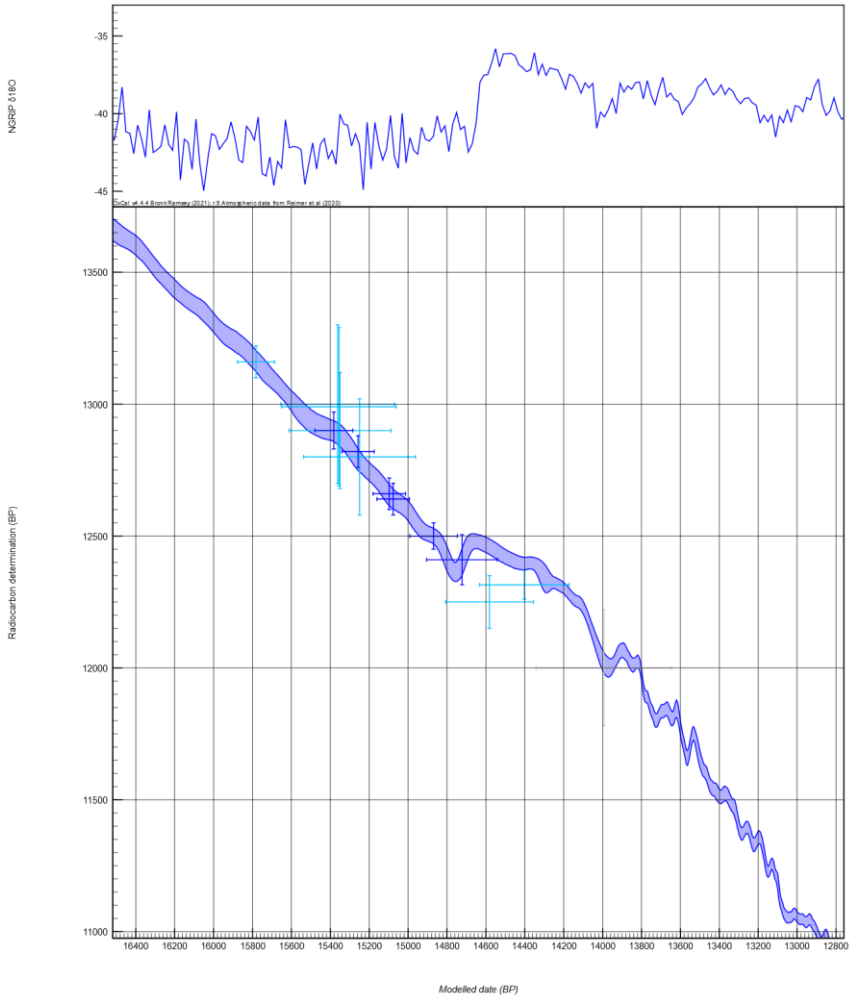


Figure A.17 Paris Basin, Etiolles Locus 1 (light blue) and 2 North (blue), selected dates in stratigraphic order, overlapping uniform sequence. Dates from Roblin-Jouve 2016 and Olive 2018.

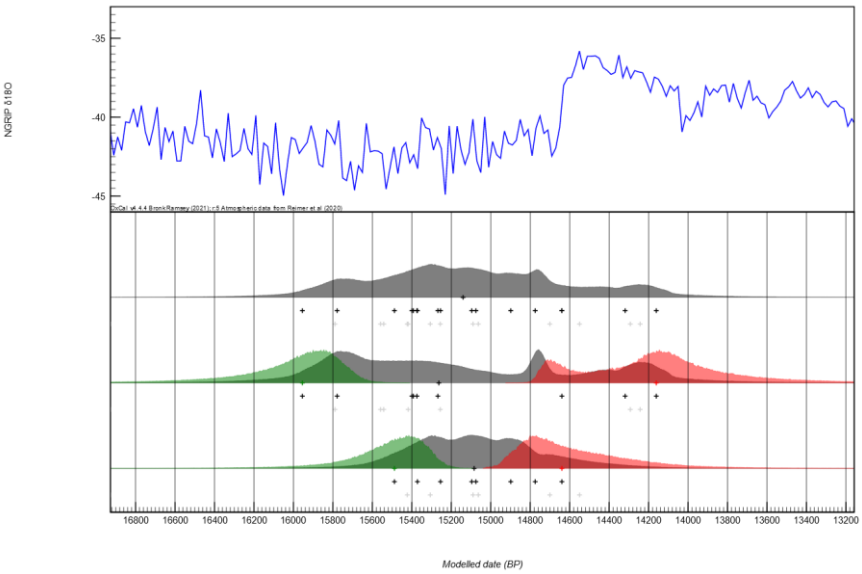


Figure A.18 Paris Basin, Etiolles, selected dates in stratigraphic order. Dates from Roblin-Jouve 2016 and Olive 2018. Sum for Etiolles (top), for Locus 1 (middle) and Locus 2 North (bottom).

Pincevent

Uniform Sequence

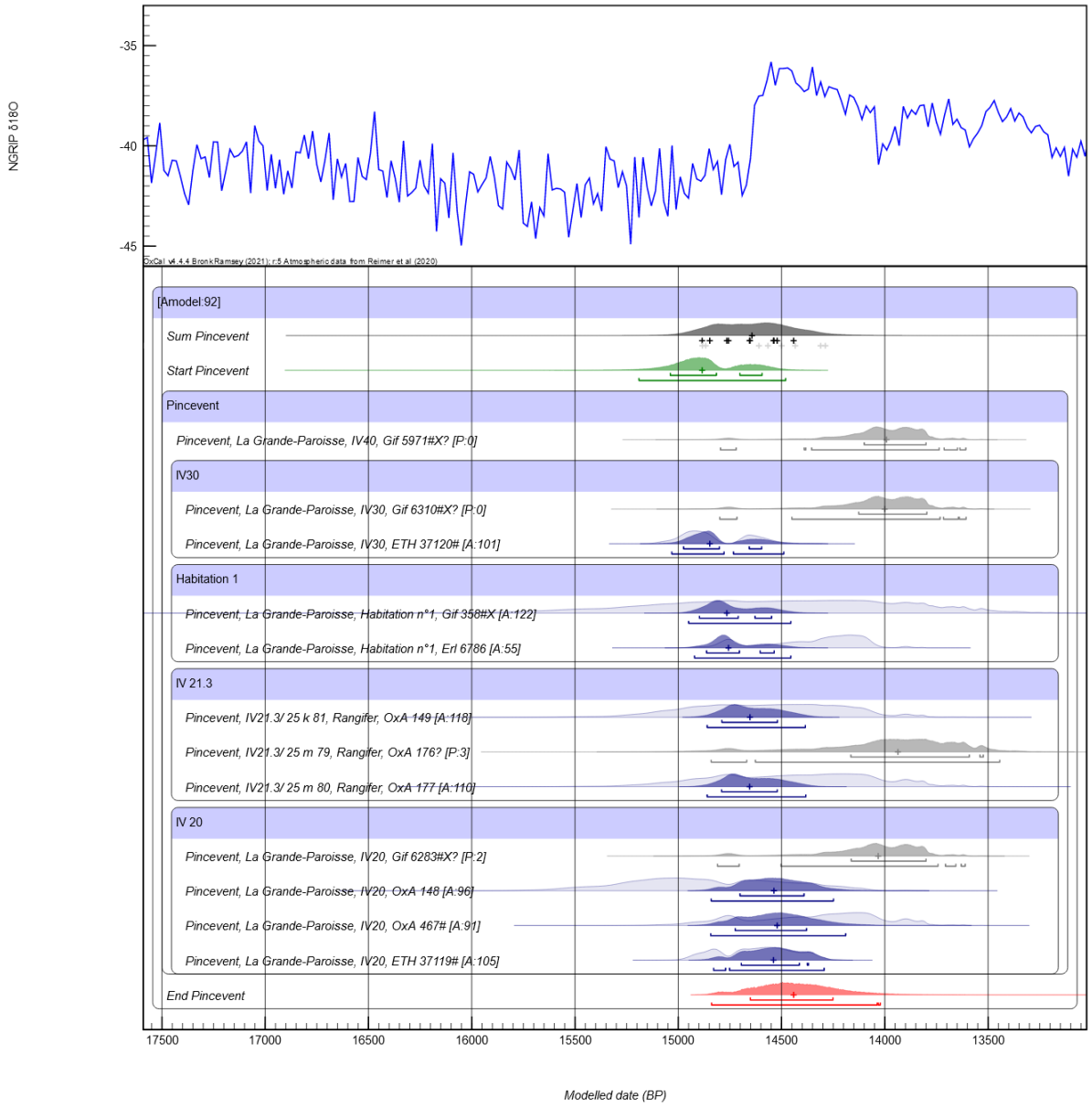


Figure A.19 Selected Pincevent dates in stratigraphic order (Bodu 2004, Debout et al. 2014 and Karlin and Julien 2018). Uniform Sequence with boundaries. Paris Basin, Pincevent. Selection of dates marked as outliers as they had low agreement indices (grey). Amodel: 92% is good.

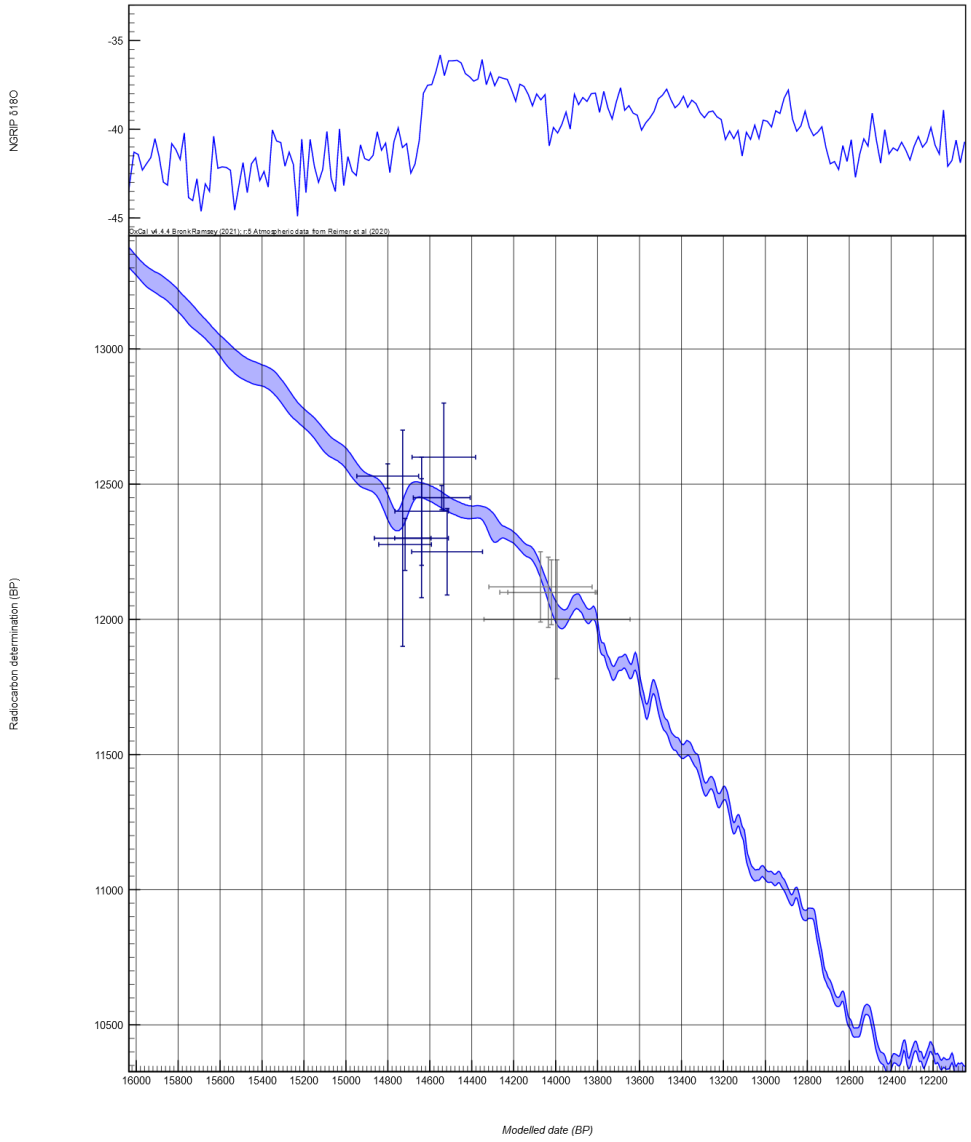


Figure A.20 Paris Basin, Pincevent. Dates selected from Bodu 2004 and Debout et al. 2016. Uniform Sequence. Selection of dates made outliers as they had low agreements (grey).

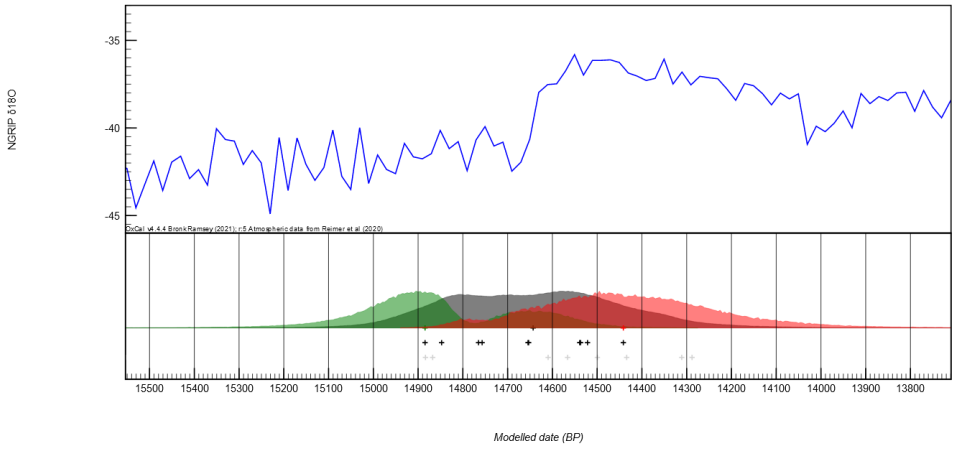


Figure A.21 Paris Basin, Pincevent. Dates selected from Bodu 2004 and Debout et al. 2016. Uniform phase.

Late Magdalenian Cepoy-Marsangy facies

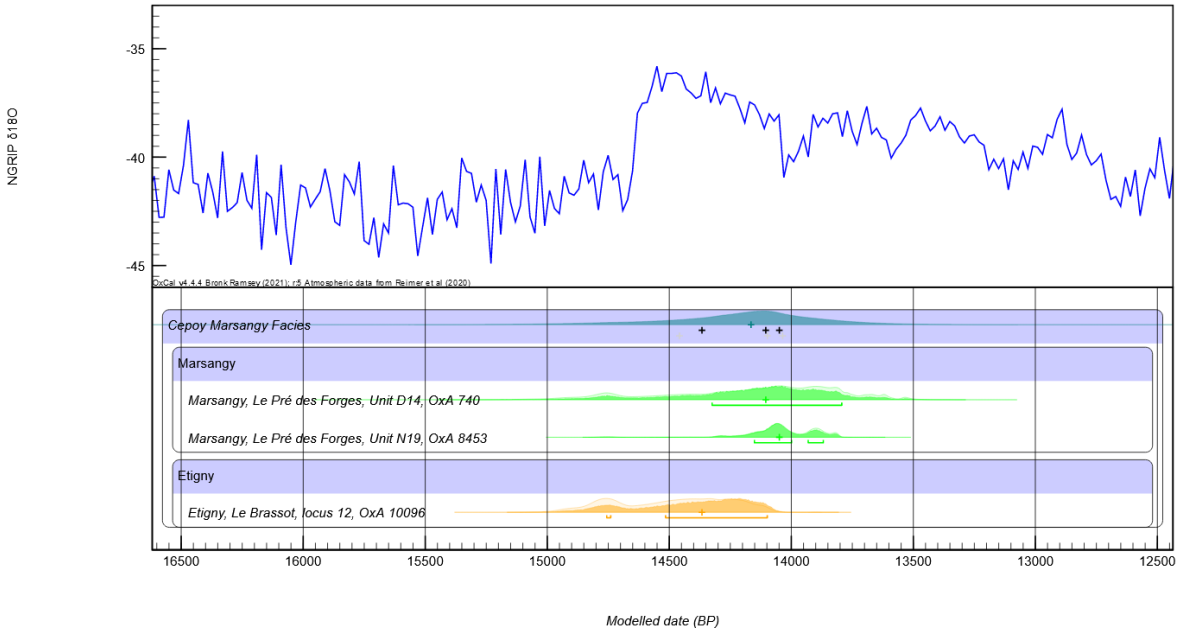


Figure A.22 Marsangy Facies. Dates from Debout et al. 2014. simple plot. Etigny is included here, it has also been associated with the Creswellian on mainland Europe.

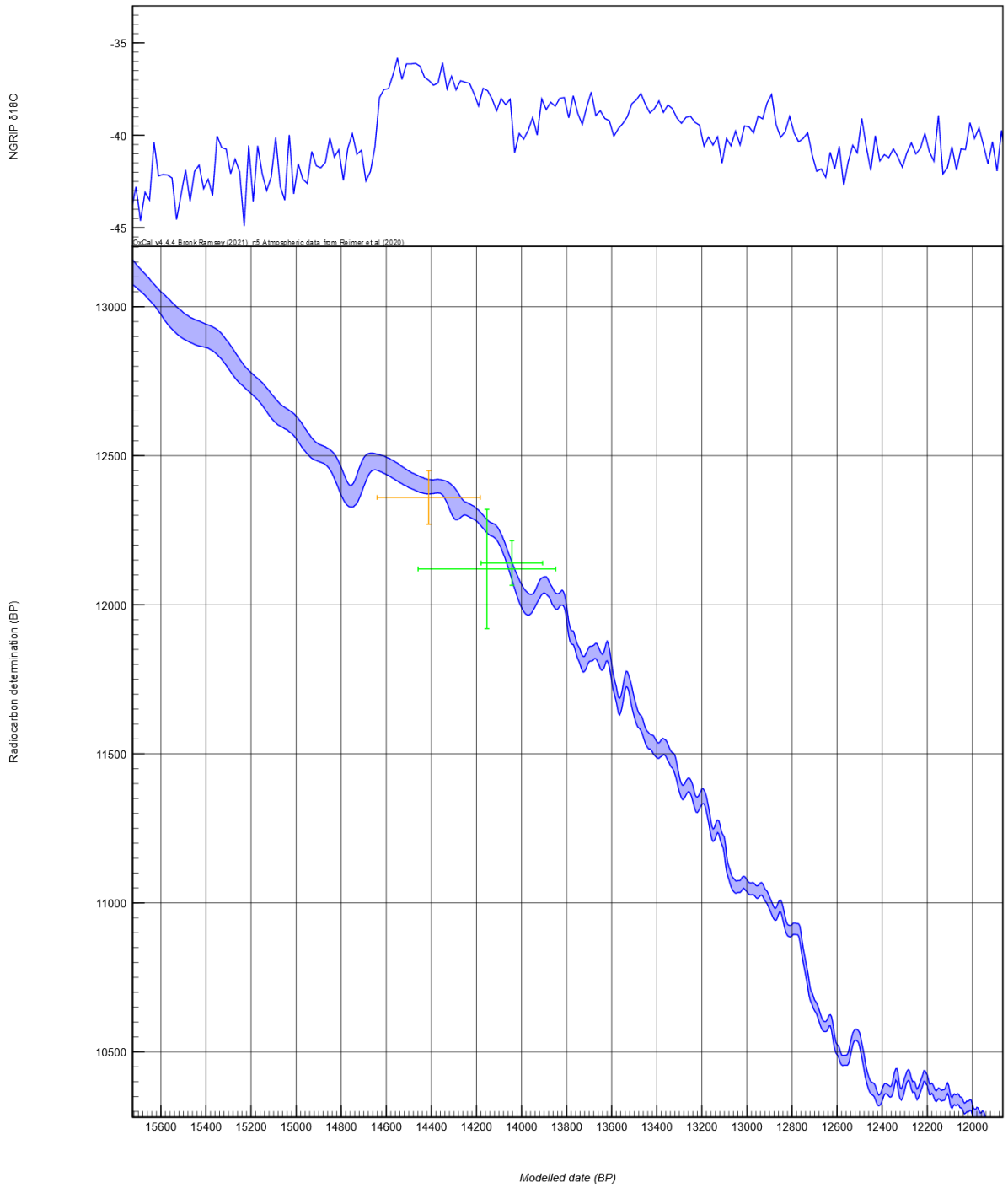


Figure A.23 Marsangy Facies. Dates from Debout et al. 2014. simple plot. Etigny (yellow) is included here, as it has also been associated with the Creswellian on mainland Europe.

Marsangy

Single Uniform Phase

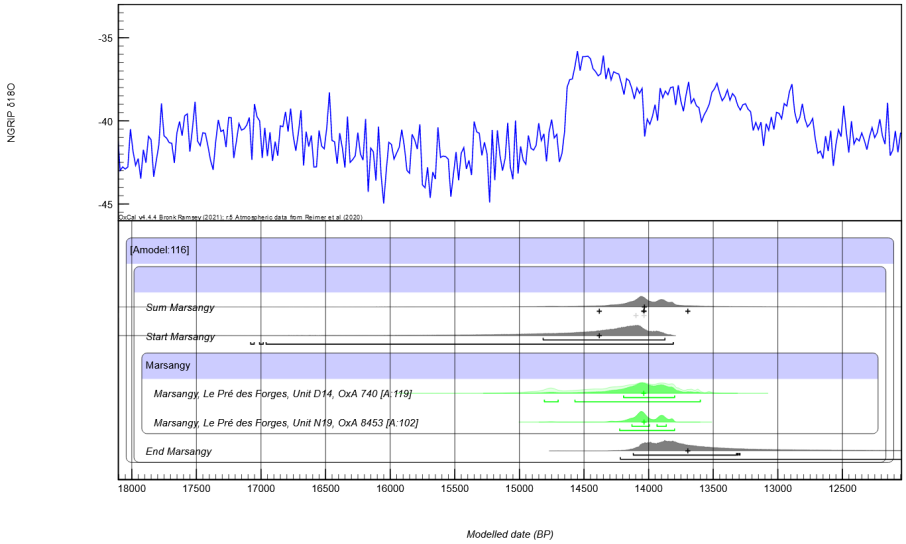


Figure A.24 Marsangy. Debout et al. 2014. Single uniform Phase.

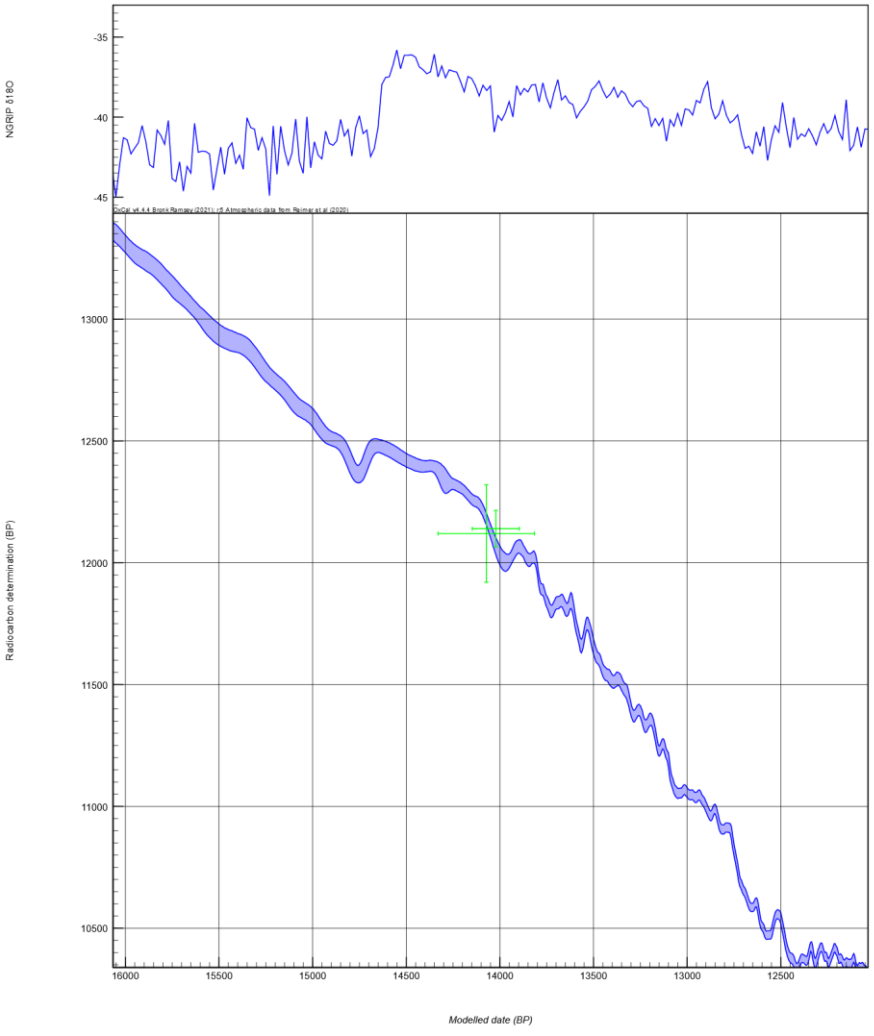


Figure A.25 Marsangy. Debout et al. 2014. Single uniform Phase.

Mainland European Creswellian

Etigny

Etigny has been associated to both the Cepoy-Marsangy facies and the Creswellian (Lhomme et al. 2004, Debout et al. 2012).

Simple Plot

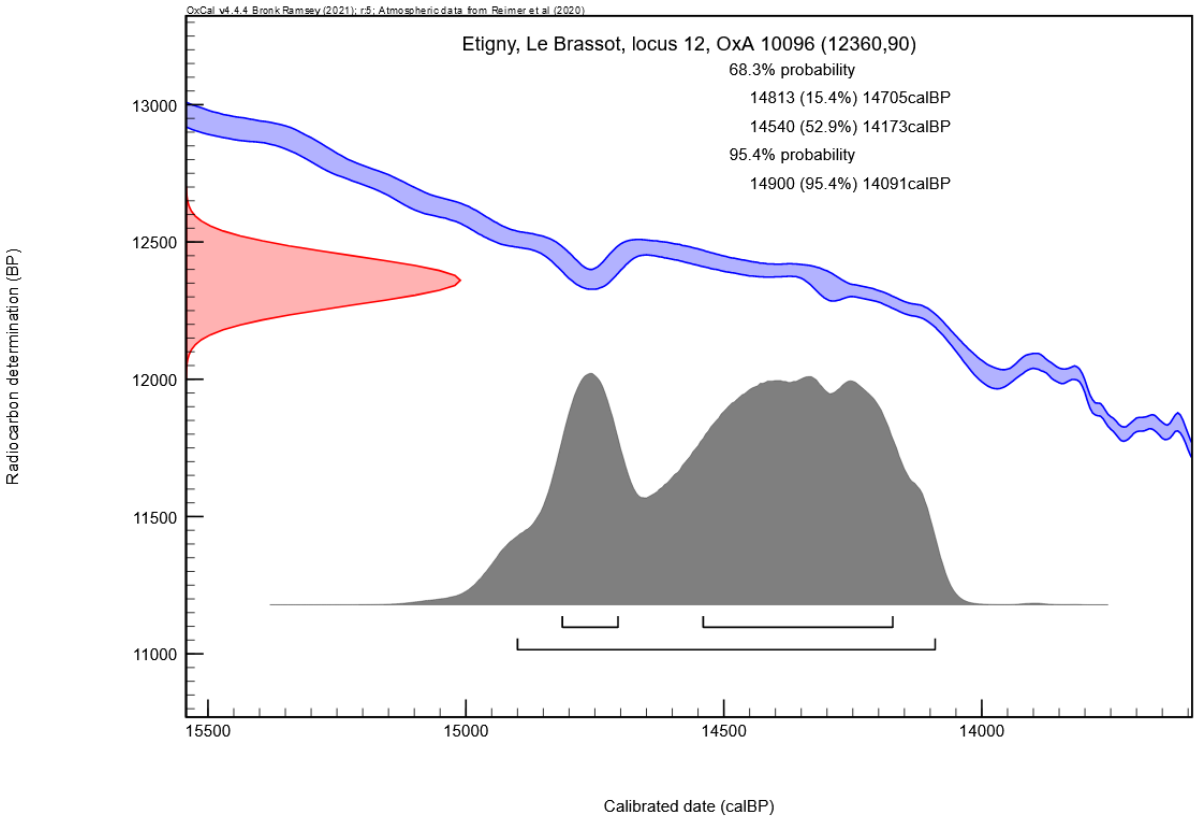


Figure A.26 Etigny, Le Brassot, Locus 12 (Lhomme et al. 2004, Debout et al. 2016). Magdalenian dates from Etigny, Debout et al. 2014. Simple Plot. One date plots within the middle of the early GS-1e plateau but with its highest probability at 1 sigma (68.3%) towards the latter half of GS-1e. This date must be considered with caution as it is within the series of OxA dates with ultrafiltration potentially contaminating the sample (Higham et al. 2007), however in this case the date fits the date of the assumed technocomplex, and not all dates were affected. A redating is essential.

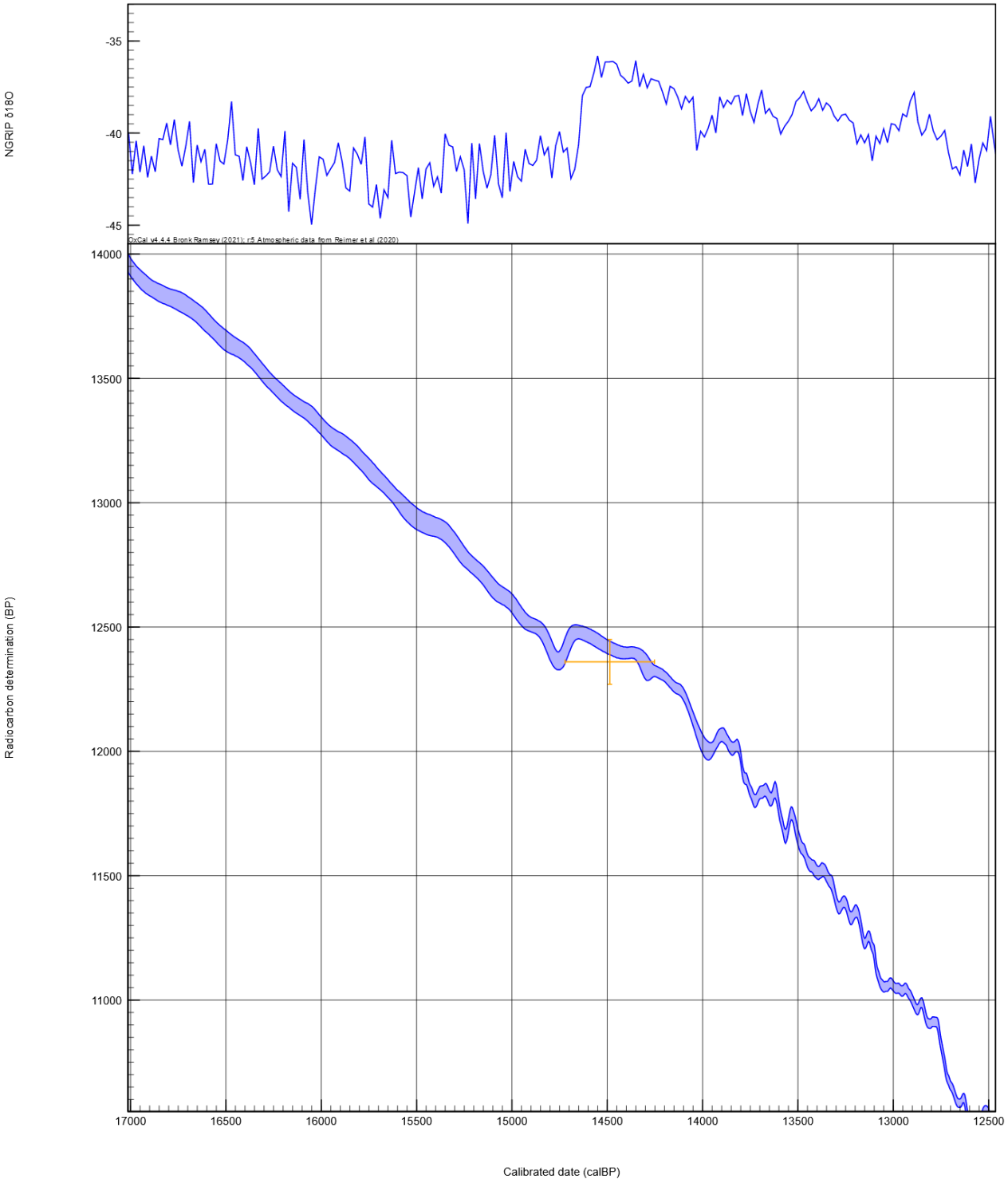


Figure A.27 Etigny, Le Brassot, Locus 12 (Lhomme et al. 2004, Debout et al. 2016). Magdalenian dates from Marsangy, Debout et al. 2014. Simple Plot. Modelled in OxCal 4.4 (Bronk Ramsey 2021) using the IntCal20 calibration curve (Reimer et al. 2020). One date plots within the middle of the early GS-1e plateau but with its highest probability at 1 sigma (68.3%) towards the latter half of GS-1e.

Hamburgian

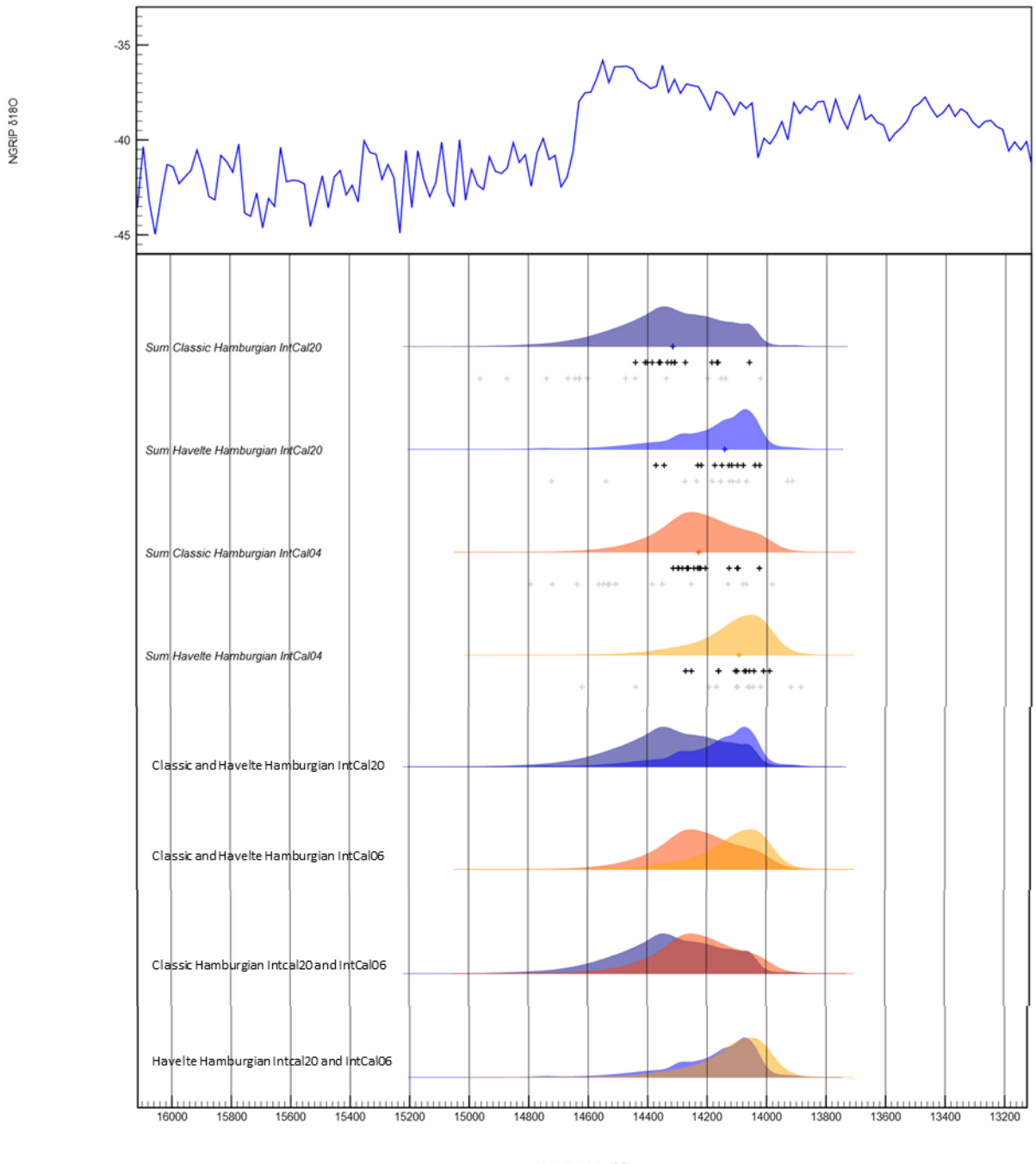


Figure A.28 Classic and Havelte Hamburgian (dates after Webber and Grimm 2009), overlapping uniform phases, comparing IntCal04 and IntCal20 models. There is a marginal change in the dates, with IntCal20 providing earlier dates. Below are the same dates as above, represented for comparison.

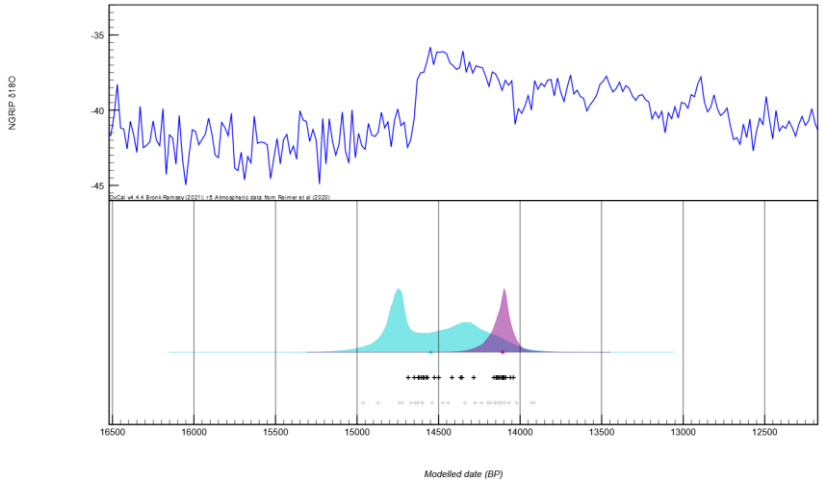


Figure A.29 KDE plot of Classic Hamburgian (light blue) and Havelte Hamburgian (magenta). Dates from Weber and Grimm 2009.

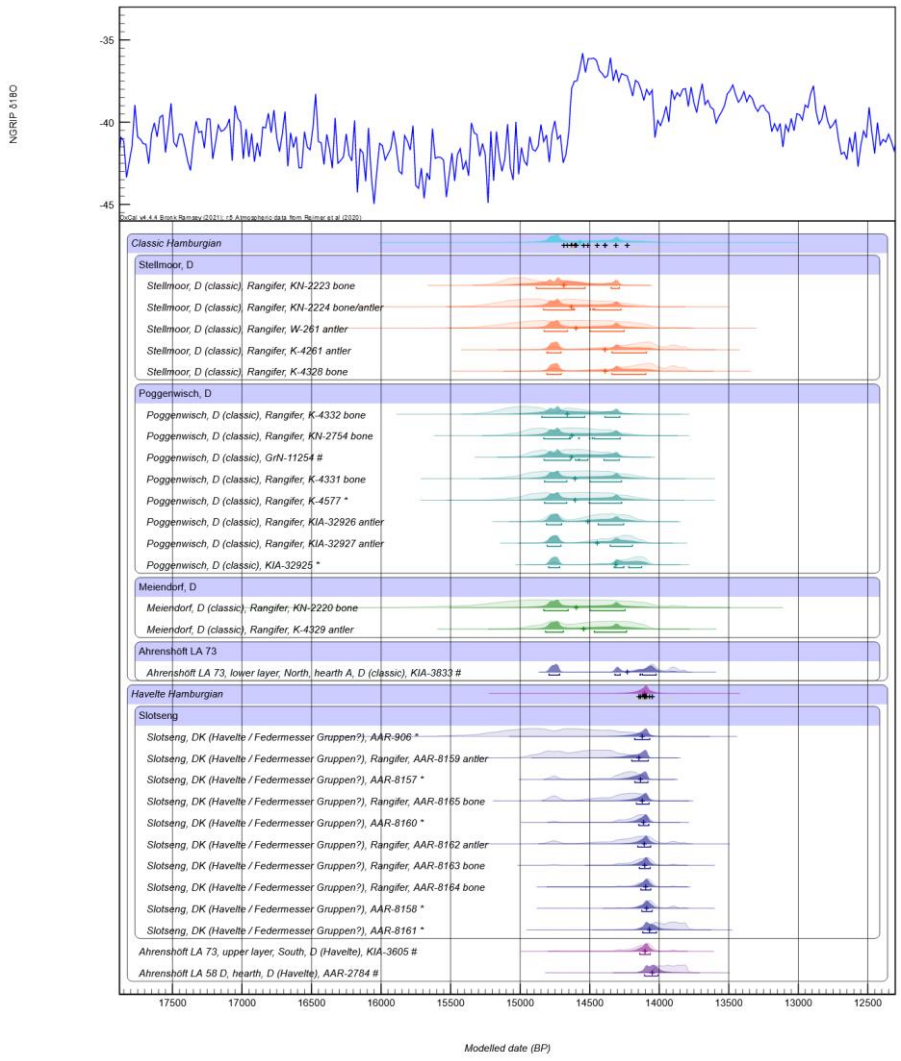


Figure A.30 KDE plot of Classic Hamburgian. Dates from Weber and Grimm 2009. The first two (earliest) dates from Slotseng may be outliers.

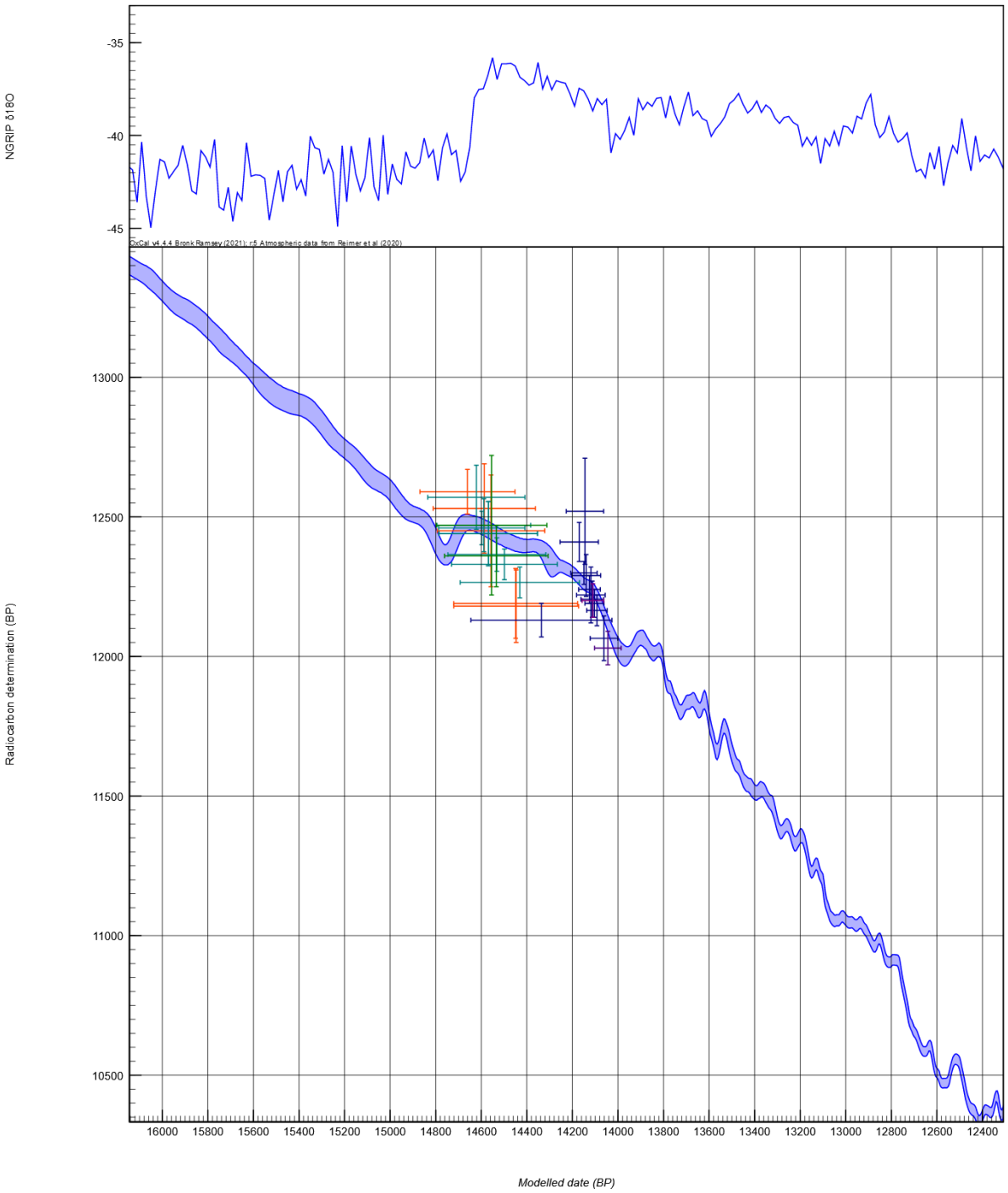


Figure A.31 KDE plot of Classic Hamburgian (GI-1e plateau) (Stellmoor = orange; Poggenwisch = teal; Meiendorf = green; Ahrenshoft LA73 = navy blue) and Havelte Hamburgian (Slotseng = purple; Ahrenshöft La 73 and 56D = magenta) (transition GI-1e to 1d). Dates from Weber and Grimm 2009. The two concentrations of dates are quite distinct. Some of the Havelte dates (Slotseng = purple) could be early Federmesser (see Havelte modelling).

Classic Hamburgian

Single Uniform Phase

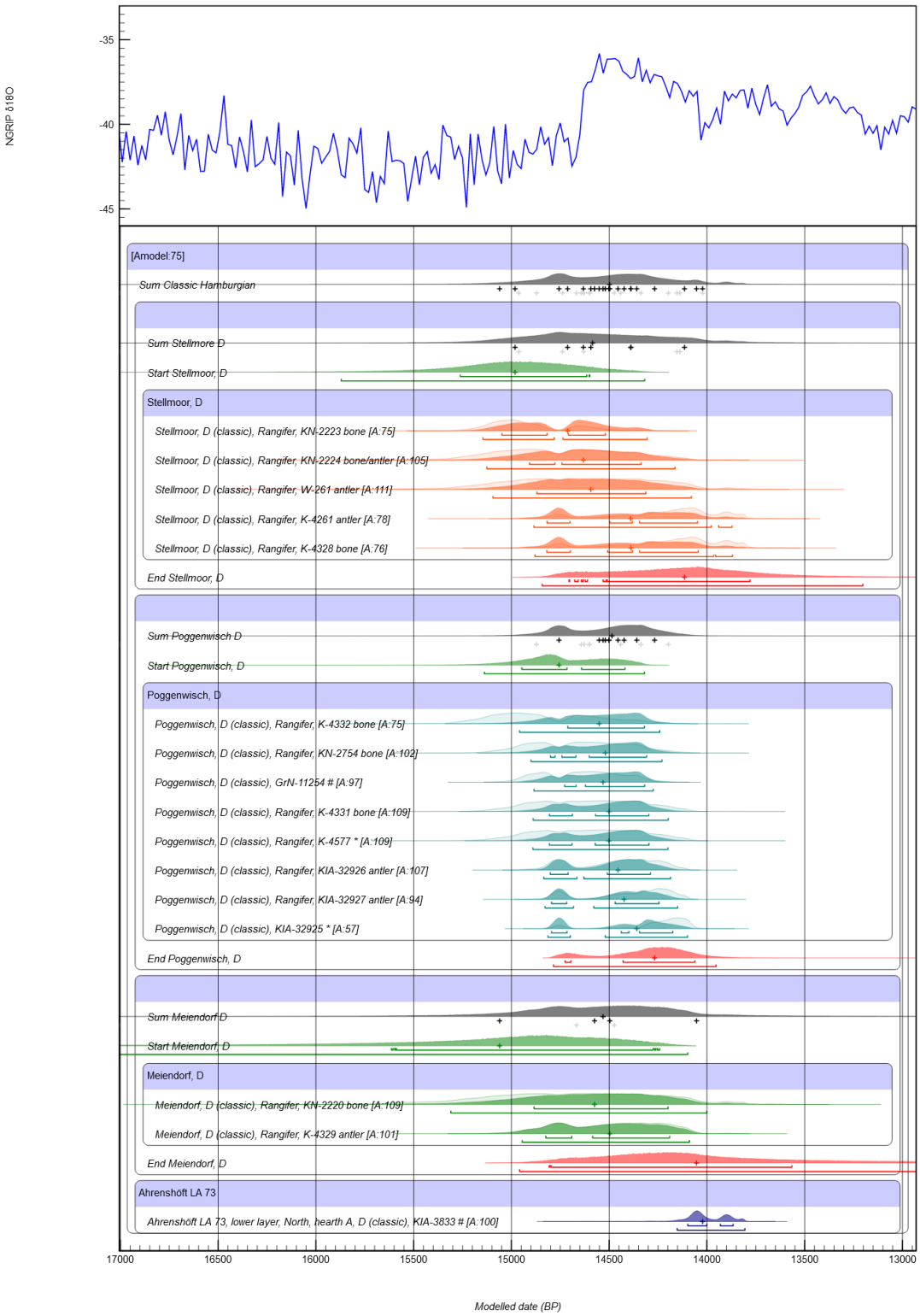


Figure A.32 Classic Hamburgian dates (Weber and Grimm 2009), not in stratigraphic order, subdivided by site. Uniform single phase model.

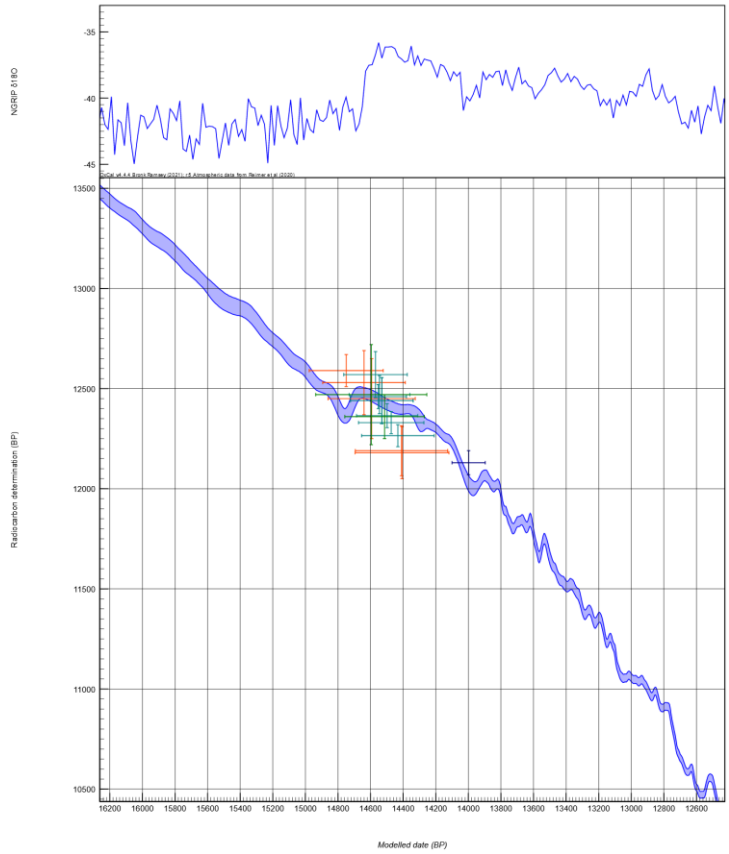


Figure A.33 Classic Hamburgian dates (Weber and Grimm 2009), not in stratigraphic order, subdivided by site. Uniform single phase model. Ahrenshöft LA 73 lower level falls outside of the principle group and overlaps with Havelte Hamburgian (see Havelte below).

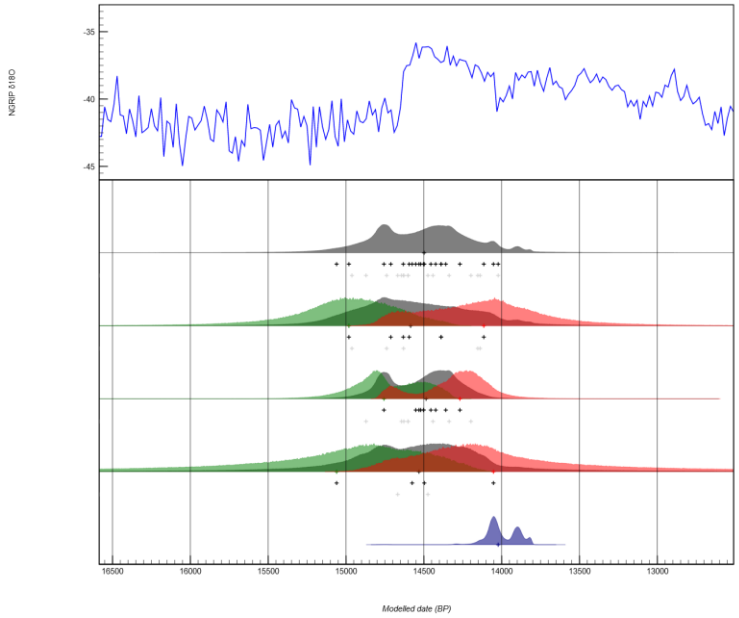


Figure A.34 Classic Hamburgian dates (Weber and Grimm 2009), not in stratigraphic order, subdivided by site. Uniform single phase model. Sum of dates from top to bottom: sum of Classic Hamburgian dates (grey, top), sum of Stellmore Classic Hamburgian dates, sum of Poggenwisch Classic Hamburgian dates, sum of Meiendorf Classic Hamburgian dates, single Ahrenshöft LA 73 date (indigo, bottom).

Havelte Hamburgian

Single Uniform Phase

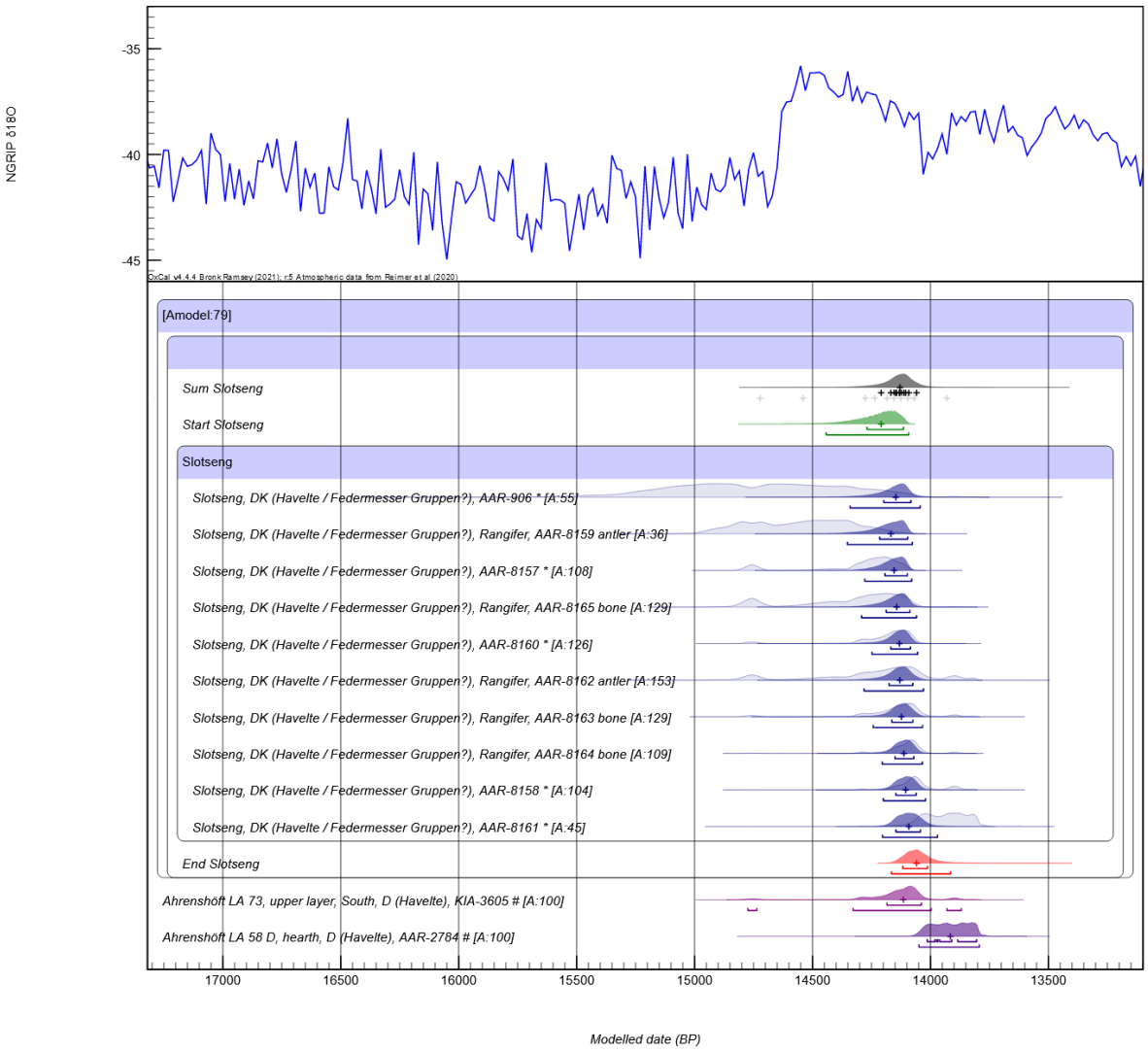


Figure A.35 Havelte Hamburgian dates (after Weber and Grimm 2009), not in stratigraphic order, subdivided by site. Single uniform phase plot. Questions remain to whether the Slotseng dates are Havelte or Federmesser as they are not directly associated to archaeology. The dates with low agreement were kept in this model as they are recovered together in a kettle hole, however there may be a palimpsest.

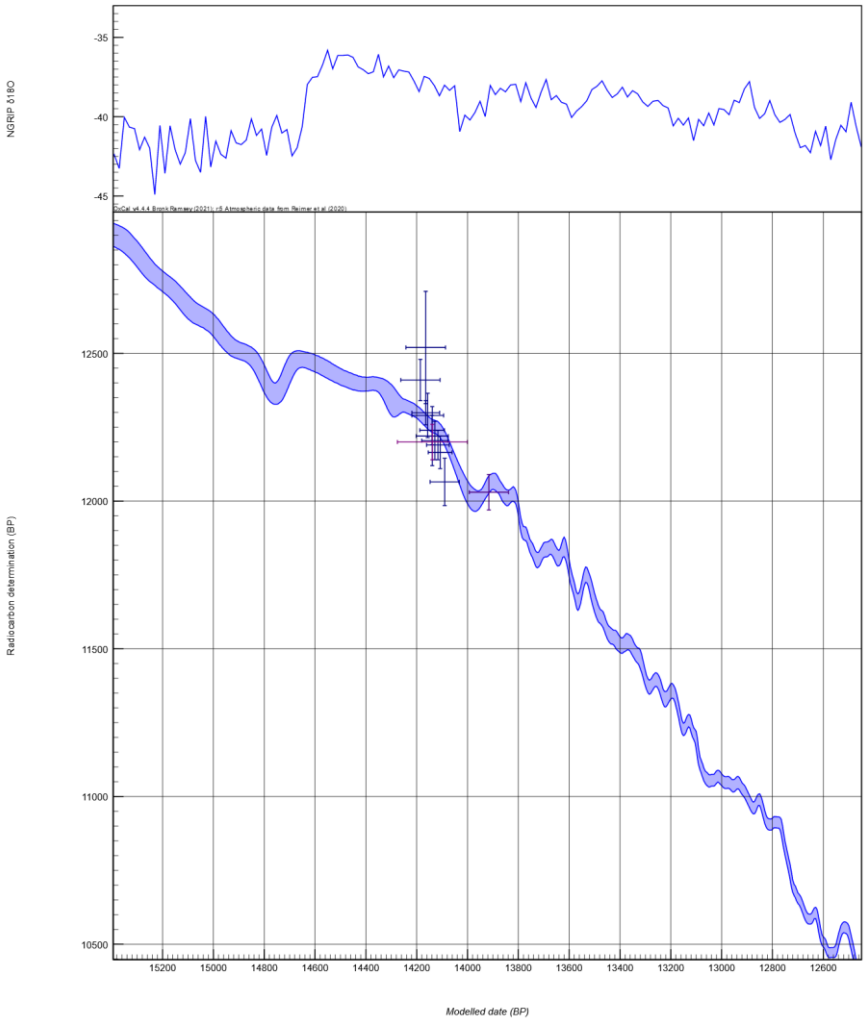


Figure A.36 Havelte Hamburgian dates (after Weber and Grimm 2009), not in stratigraphic order, subdivided by site. Single uniform phase plot.

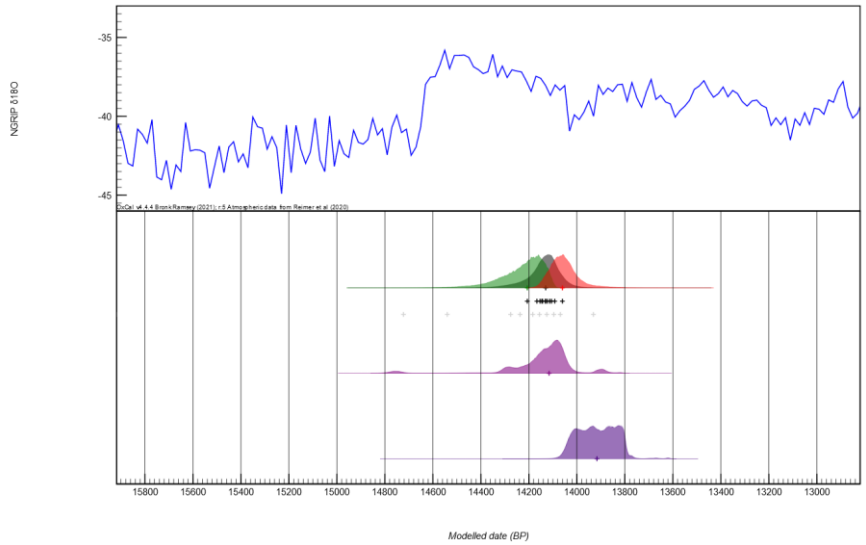


Figure A.37 Havelte Hamburgian dates (after Weber and Grimm 2009), not in stratigraphic order, subdivided by site. Single uniform phase plot. Slotseng (top), Ahrenshöft LA 73 (middle), Ahrenshöft LA 58D (bottom).

Azilian

Early Azilian

Early Azilian, reference sites south and within the Paris Basin

Single Uniform Phase

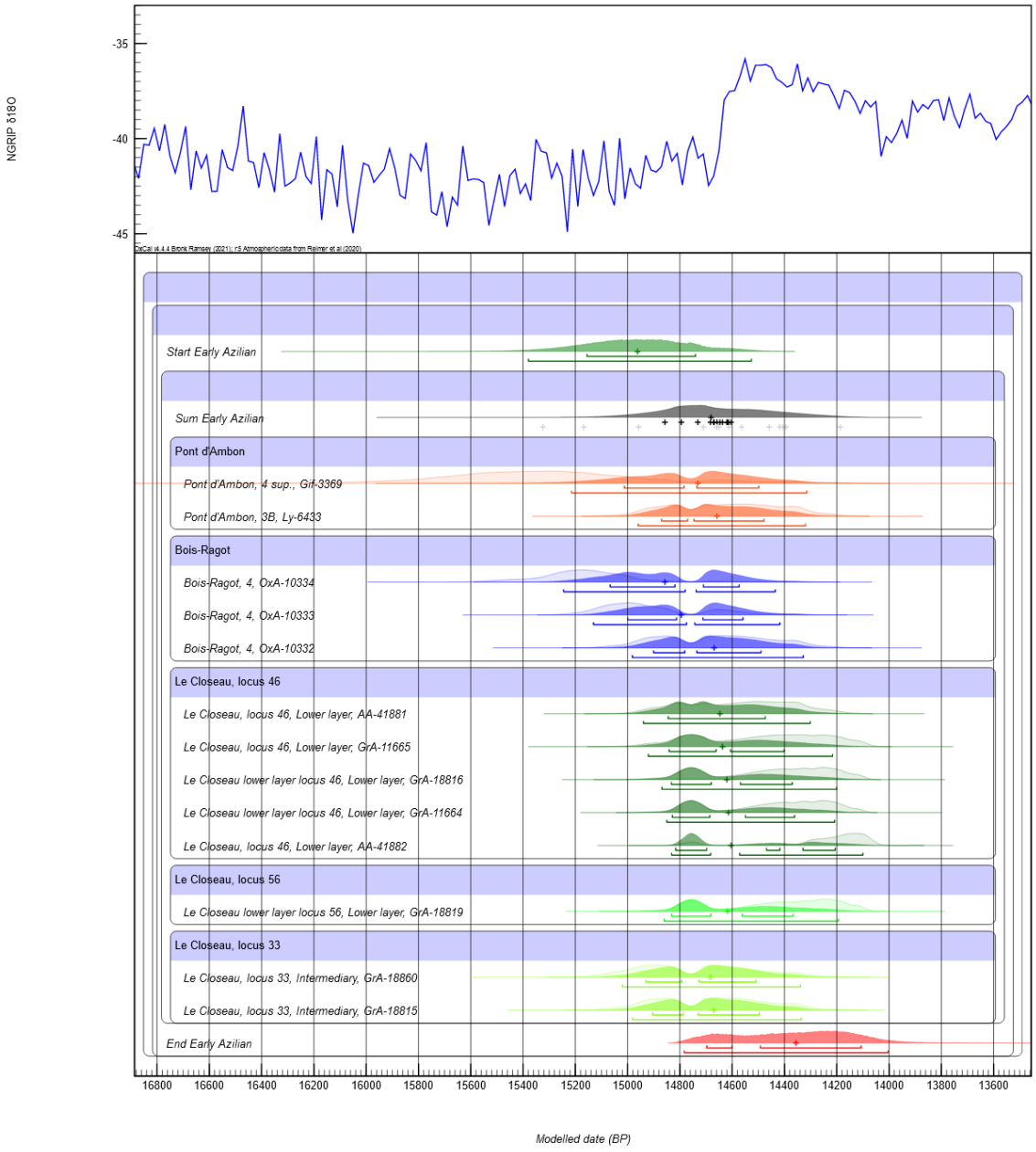


Figure A.38 Early Azilian dates for reference assemblages mentioned in the thesis, dates from Naudinot et al. 2017. Not in stratigraphic order, subdivided by site. Uniform single phase. The Paris Basin dates (Le Closeau) overlap and appear later than sites further south (Bois-Ragot and Pont-d'Ambon). The earliest date from Pont d'Ambon, layer 4, is from the Magdalenian horizon, and the following date in layer 3b marks the Early Azilian (Célérier et al. 1993). Caution is needed with the dates from Bois Ragot as they are part of a series of potentially contaminated dates due to the preparation method applied (Higham et al. 2007), though in this case they appear to be in agreement with the other early Azilian dates shown.

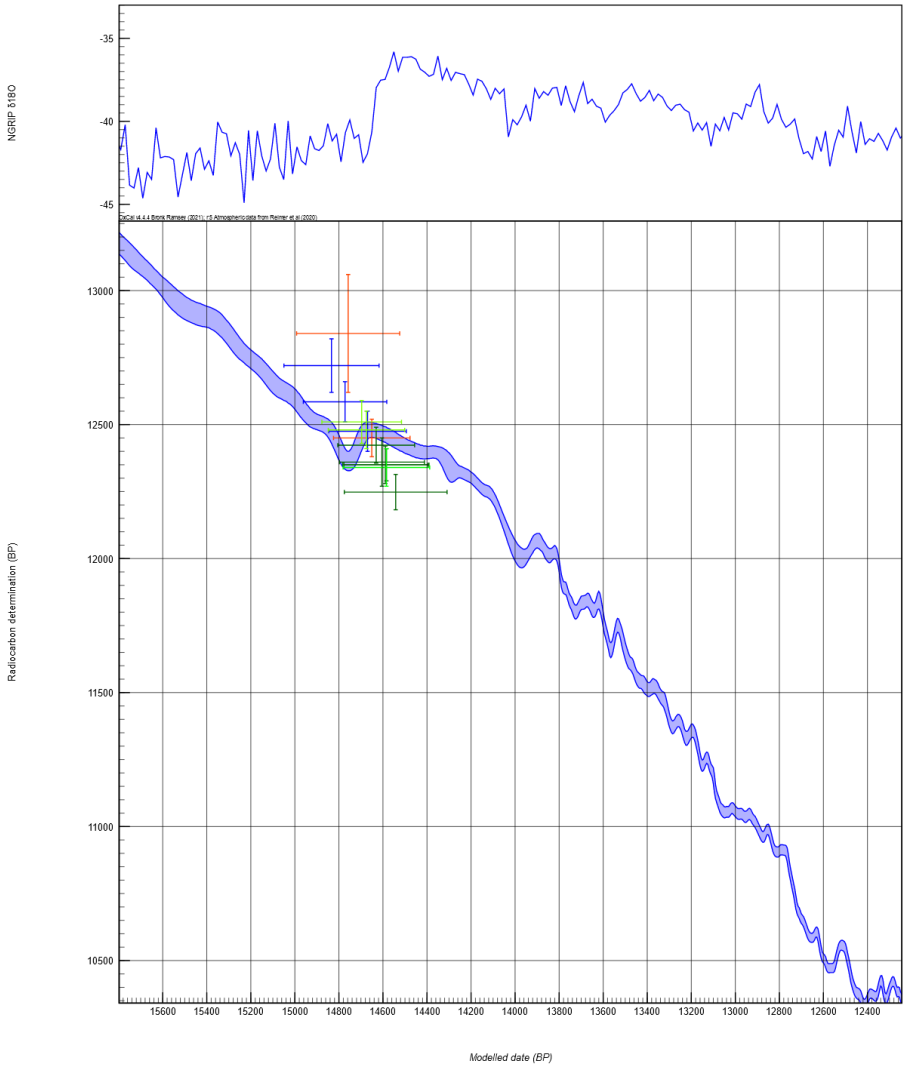


Figure A.39 Early Azilian dates for reference assemblages mentioned in the thesis, dates from Naudinot et al. 2017. Not in stratigraphic order, subdivided by site. Uniform single phase. The Paris Basin dates (Le Closeau) overlap and appear later than sites further south (Bois-Ragot and Pont-d'Ambon).

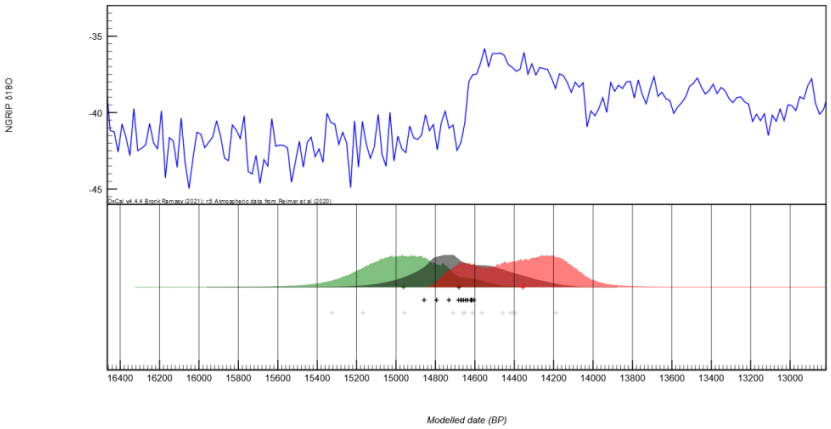


Figure A.40 Early Azilian dates for reference assemblages mentioned in the thesis, dates from Naudinot et al. 2017. Not in stratigraphic order, subdivided by site. Uniform single phase. The Early Azilian dates coincide with the transition from GS-2a to GI-1e.

Paris Basin, Seine Catchment Azilian, La Closeau

Bølling and Allerød

Overlapping Uniform Phases

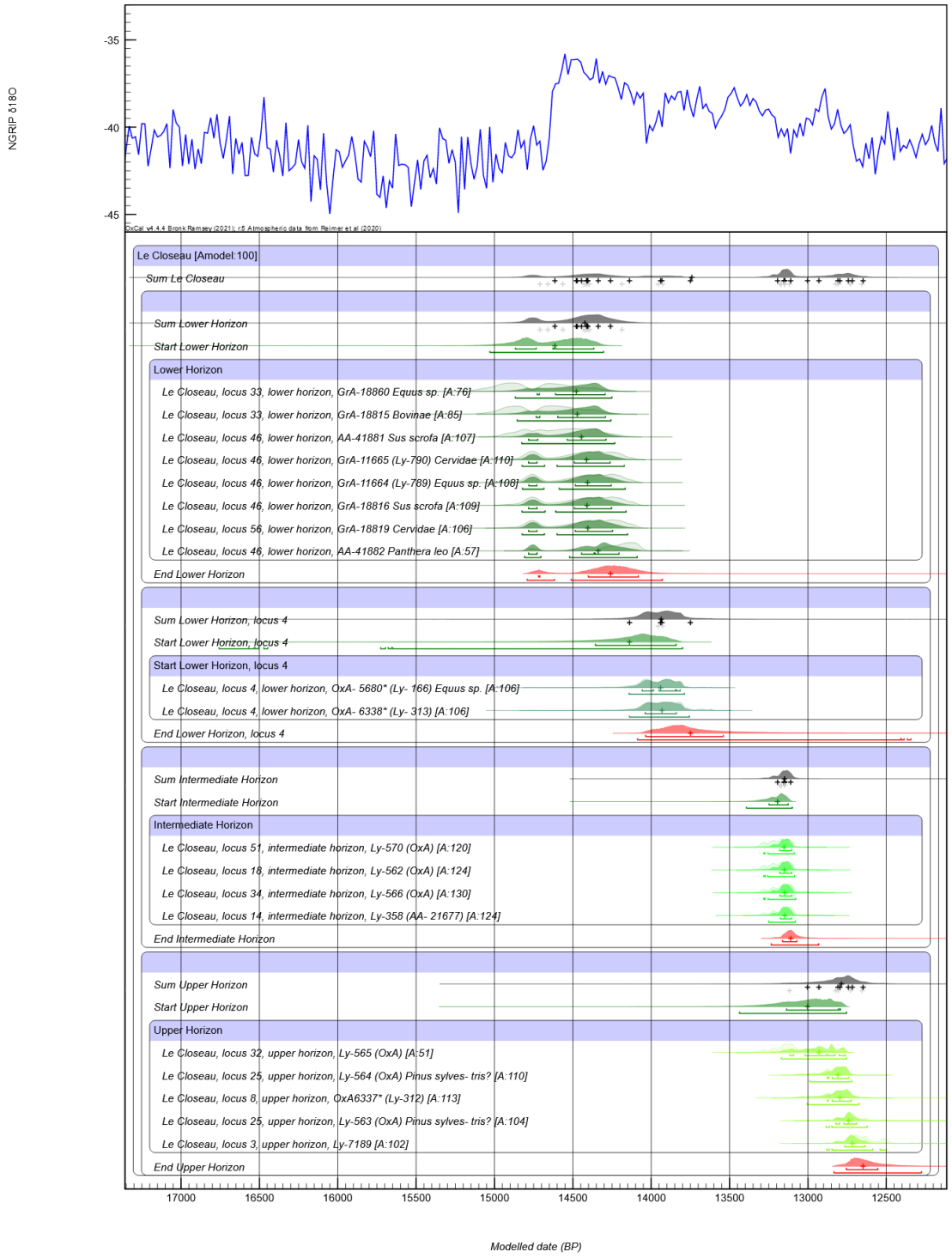


Figure A.41 Le Closeau, Azilian dates, grouped by horizon (Bodu 2004 and Grimm 2013). Not in stratigraphic order, subdivided by locus. Overlapping uniform phases. A distinction and hiatus between the Early Azilian lower horizons and intermediate and upper horizons is apparent.

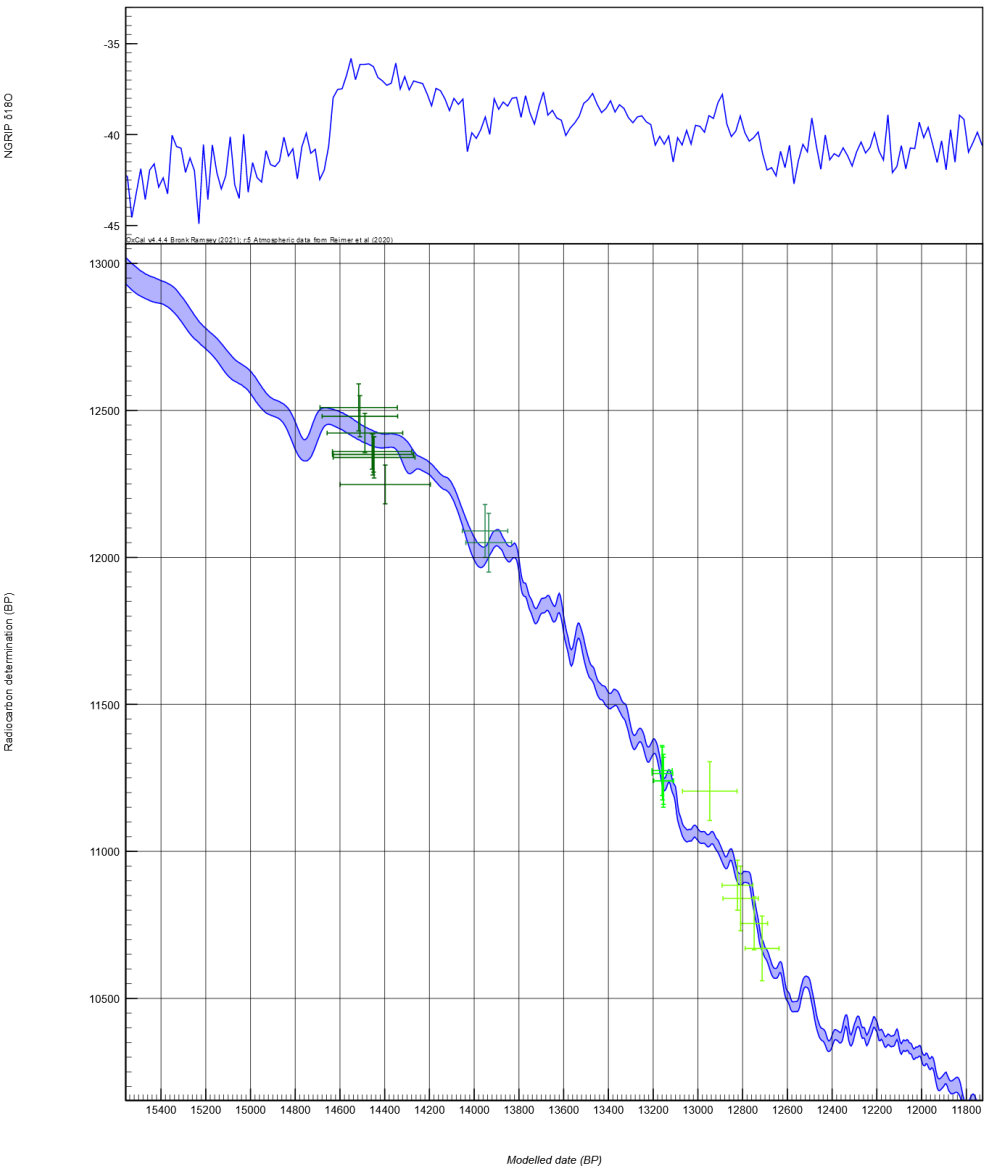


Figure A.42 Le Closeau, Azilian dates, grouped by horizon (Bodu 2004 and Grimm 2013). Not in stratigraphic order, subdivided by locus. Single overlapping phase. Four groups of dates are apparent, lower horizon (Loci 33, 46 and 56) in GI-1e, lower horizon (Locus 4) in GI-1d to GI-1c, intermediate horizon GI-1b, and the upper horizon GI-1a.

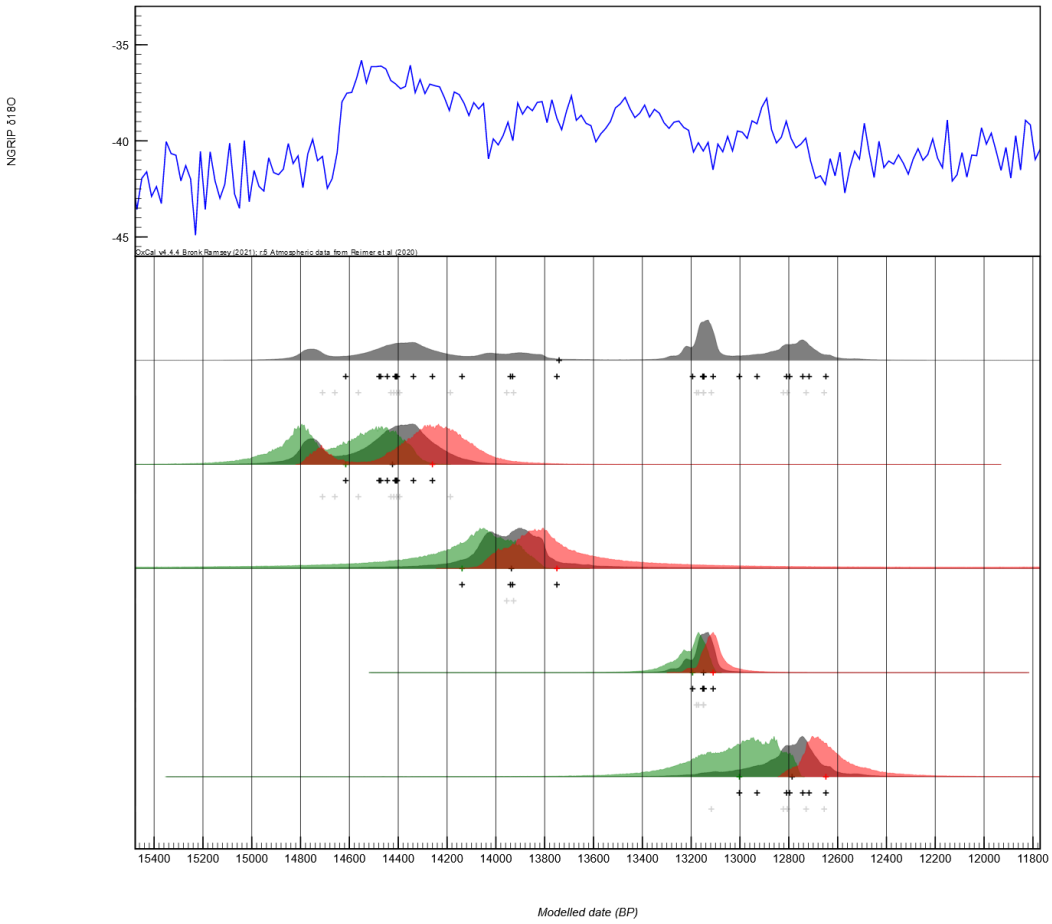


Figure A.43 Le Closeau, Azilian dates, grouped by horizon (Bodu 2004 and Grimm 2013). Not in stratigraphic order, subdivided by locus. Single overlapping phase. Upper level sum of all of the dates (grey), indicates a hiatus in GI-1b. Four groups of dates are apparent from top to bottom: lower horizon (Loci 33, 46 and 56) in GI-1e, lower horizon (Locus 4) in GI-1d to GI-1c, intermediate horizon GI-1b, and the upper horizon GI-1a.

Paris Basin, Seine Catchment Early Azilian, Le Closeau

Single Uniform Phase

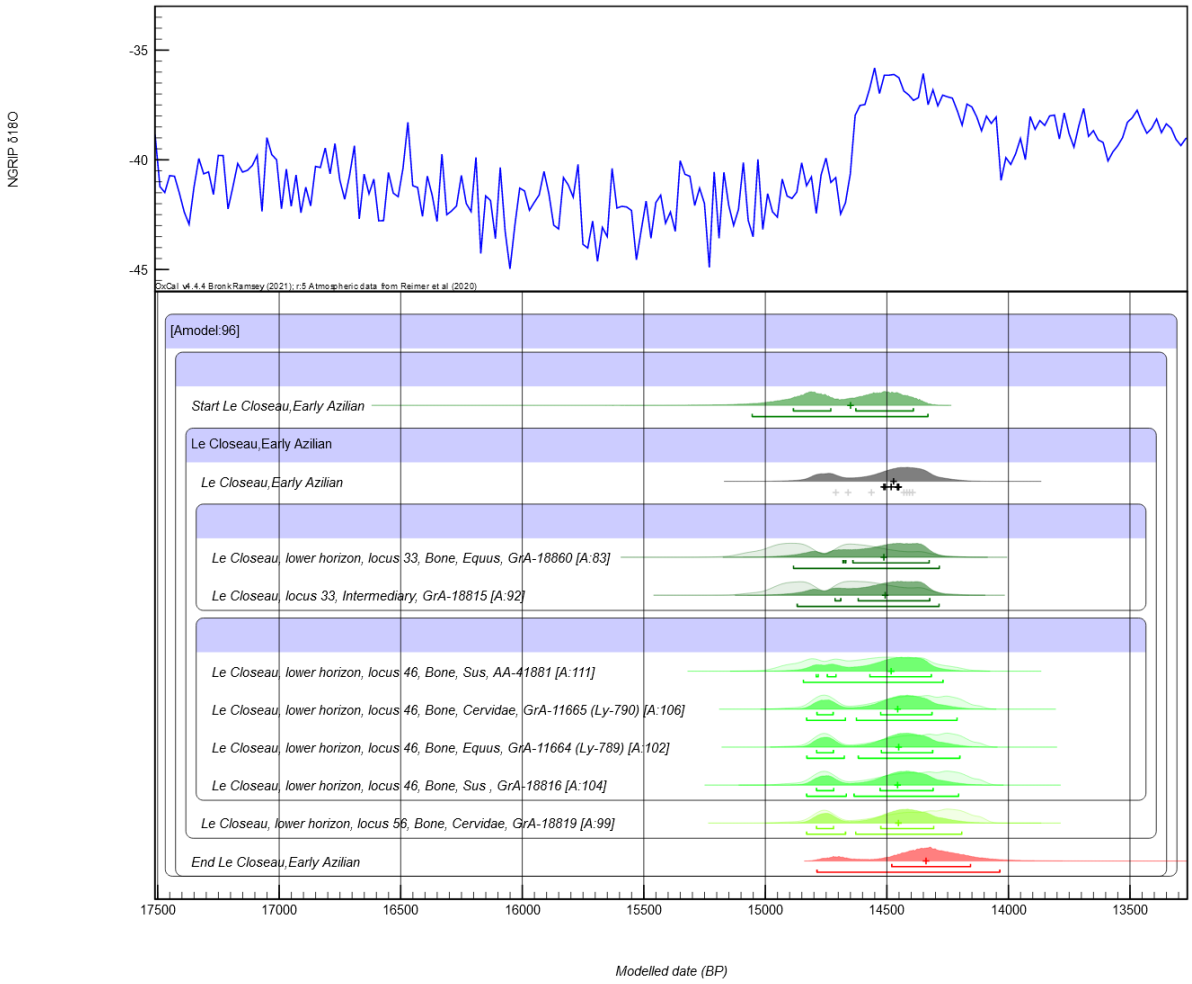


Figure A.44 Le Closeau Early Azilian dates, grouped by area (Bodu 2004, Grimm 2013, Naudinot et al. 2017). Not in stratigraphic order, subdivided by locus. Single Uniform Phase. Amodel: 96% is good.

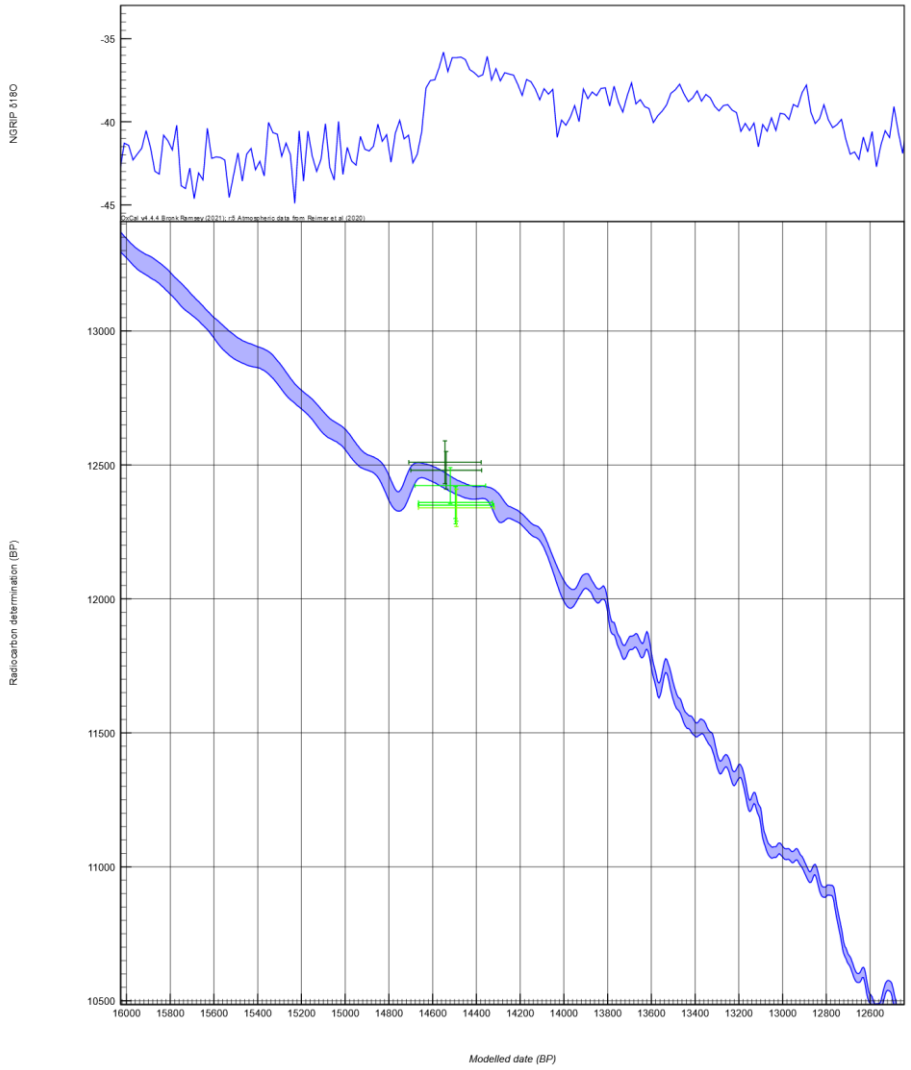


Figure A.45 Le Closeau Early Azilian dates, grouped by area (Bodu 2004, Grimm 2013, Naudinot et al. 2017). Not in stratigraphic order, subdivided by locus. Single Uniform Phase. The dates are tightly clustered on the GI-1e plateau.

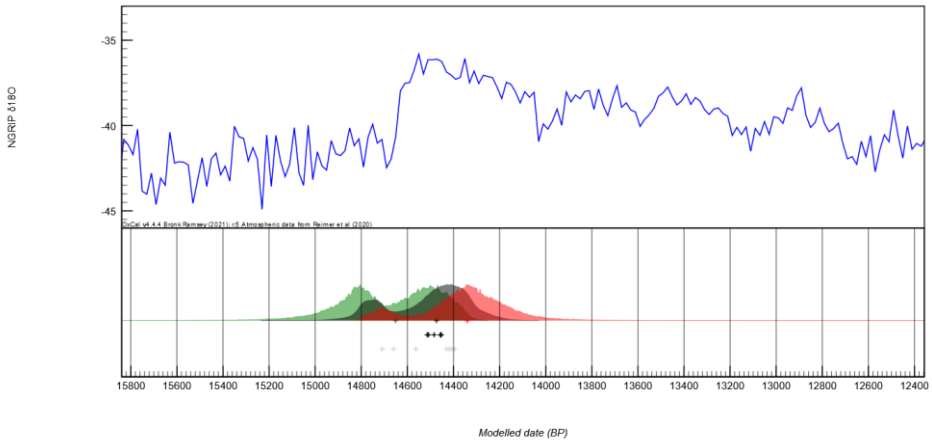


Figure A.46 Le Closeau Early Azilian dates, grouped by area (Bodu 2004, Grimm 2013, Naudinot et al. 2017). Not in stratigraphic order, subdivided by locus. Single Uniform Phase.

Le Closeau, Allerød Azilian

Overlapping Uniform Phases



Figure A.47 Le Closeau, Allerød Azilian dates, grouped by horizon (Bodu 2004 and Grimm 2013). Phases in stratigraphic order, subdivided by locus. Overlapping Uniform Phases.

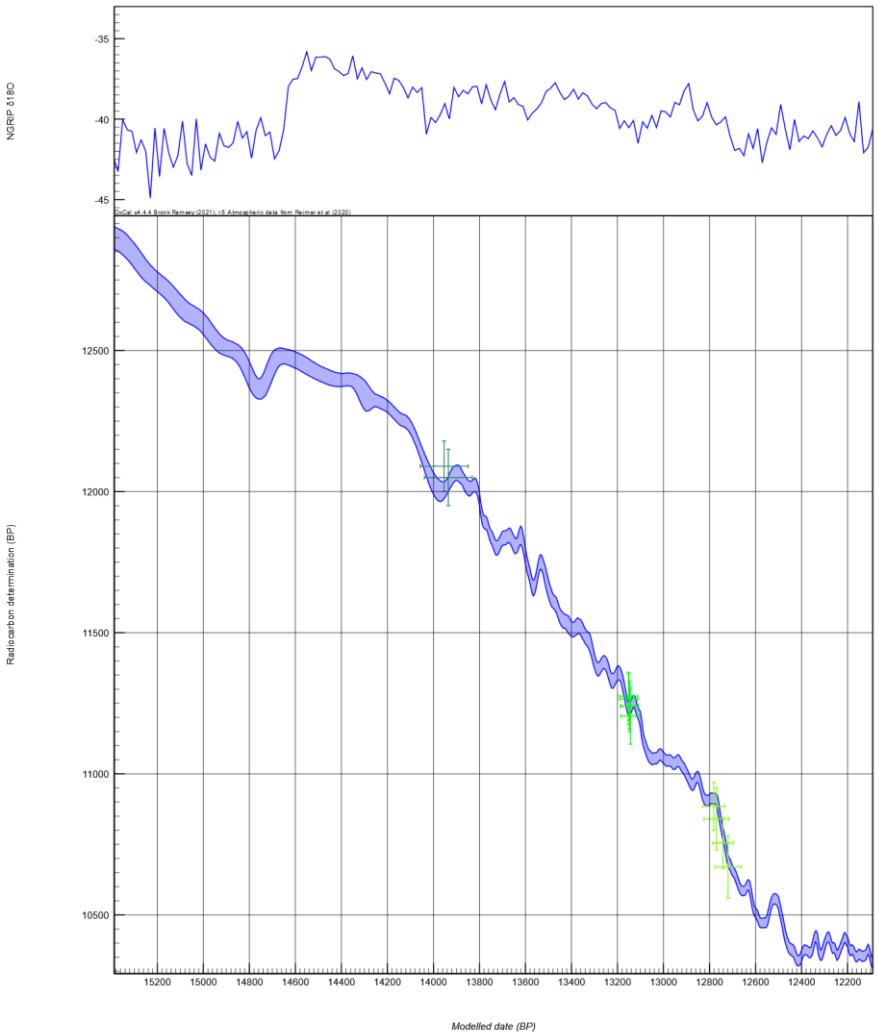


Figure A.48 Le Closeau, Allerød Azilian dates, grouped by horizon (Bodu 2004 and Grimm 2013). Phases in stratigraphic order, subdivided by locus. Overlapping Uniform Phases.

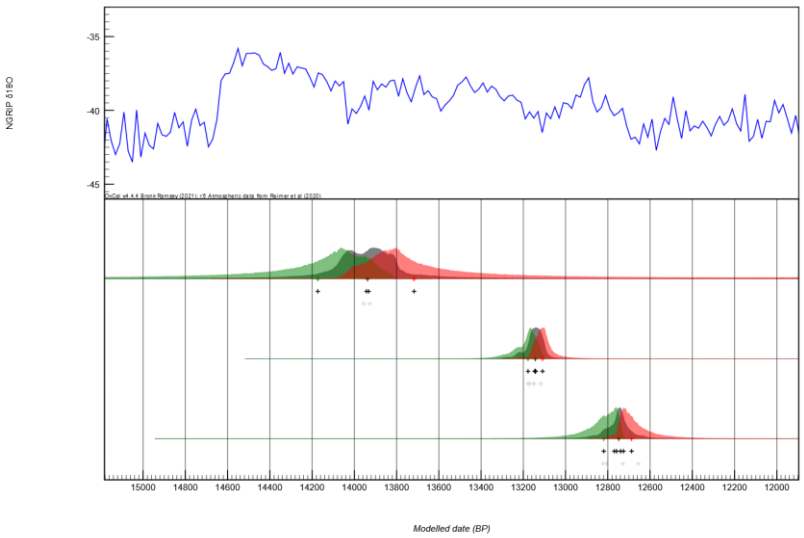


Figure A.49 Le Closeau, Allerød Azilian dates, grouped by horizon (Bodu 2004 and Grimm 2013). Phases in stratigraphic order, subdivided by locus. Overlapping Uniform Phases.

Pincevent Allerød

Simple Plot

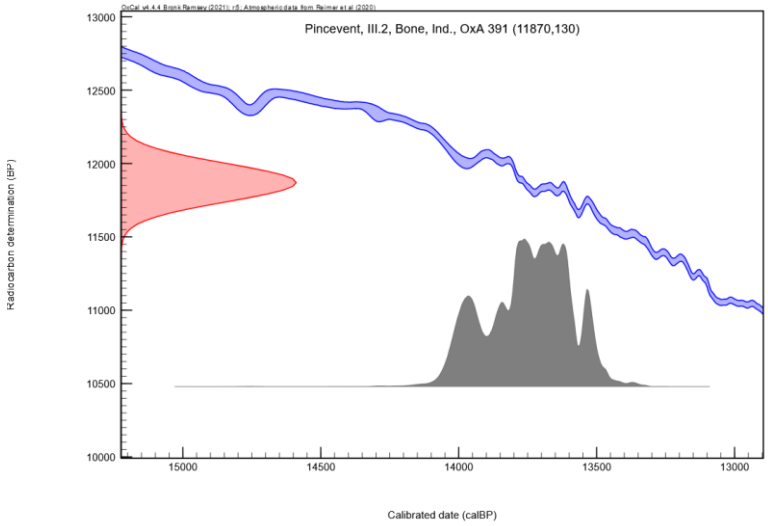


Figure A.50 Paris Basin, Allerød Azilian, Pincevent III.2. Dates from Bodu 2004 and Grimm 2013. Simple Plot.

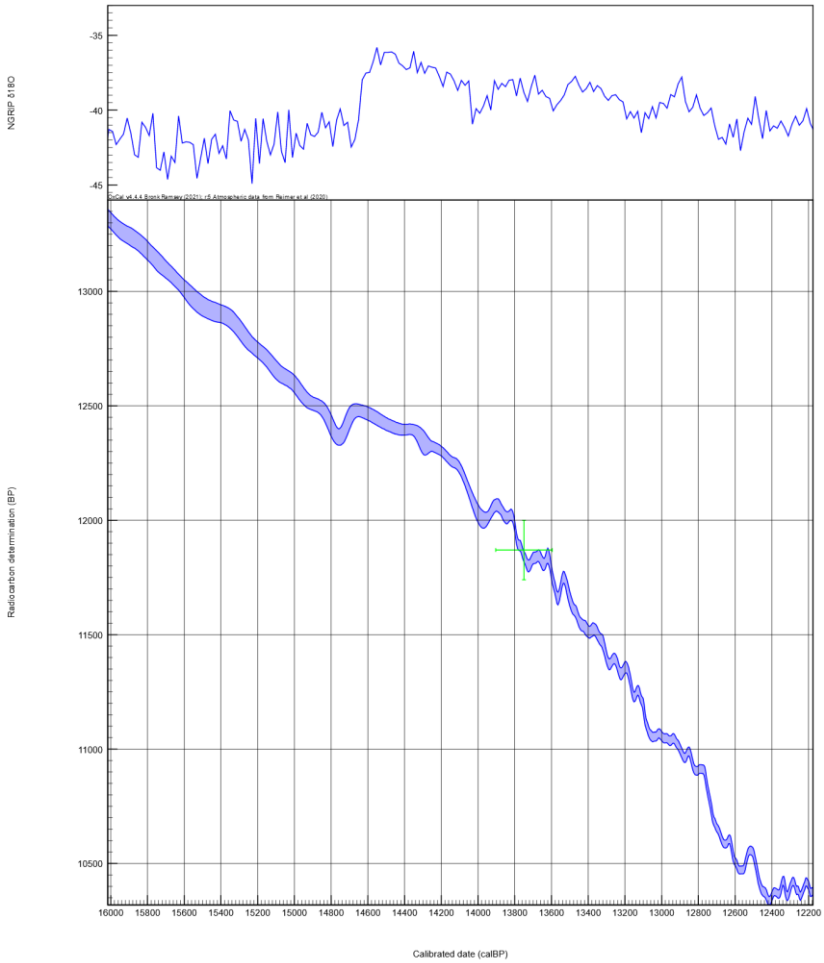


Figure A.51 Paris Basin, Allerød Azilian, Pincevent III.2. Dates from Bodu 2004 and Grimm 2013. Simple Plot.

Federmesser Sites

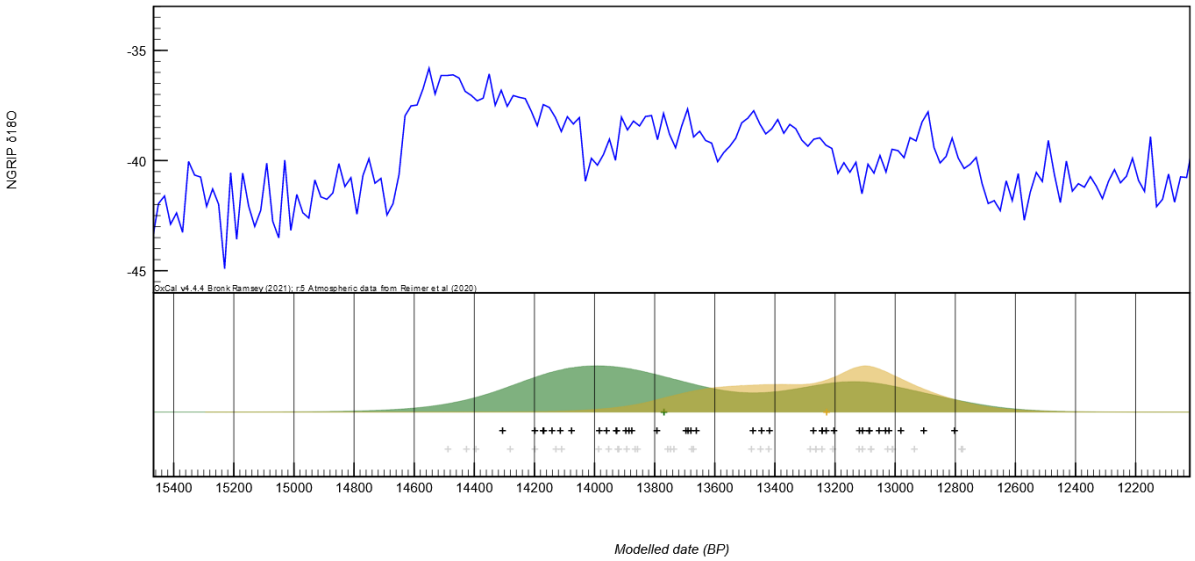


Figure A.52 Stacked plots of dates of German Rhineland Federmesser dates (green) and Paris Basin, Somme catchment Federmesser sites (yellow).

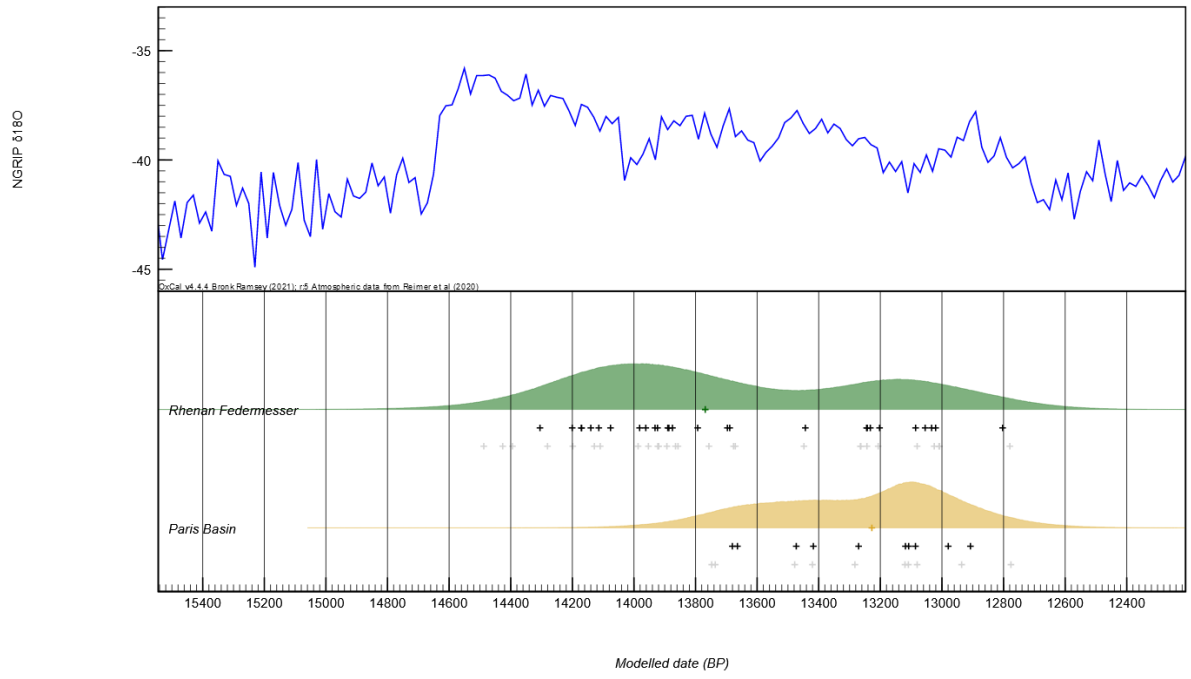


Figure A.53 Stacked plots of dates of German Rhineland Federmesser dates (green) and Paris Basin, Somme catchment Federmesser sites (yellow).

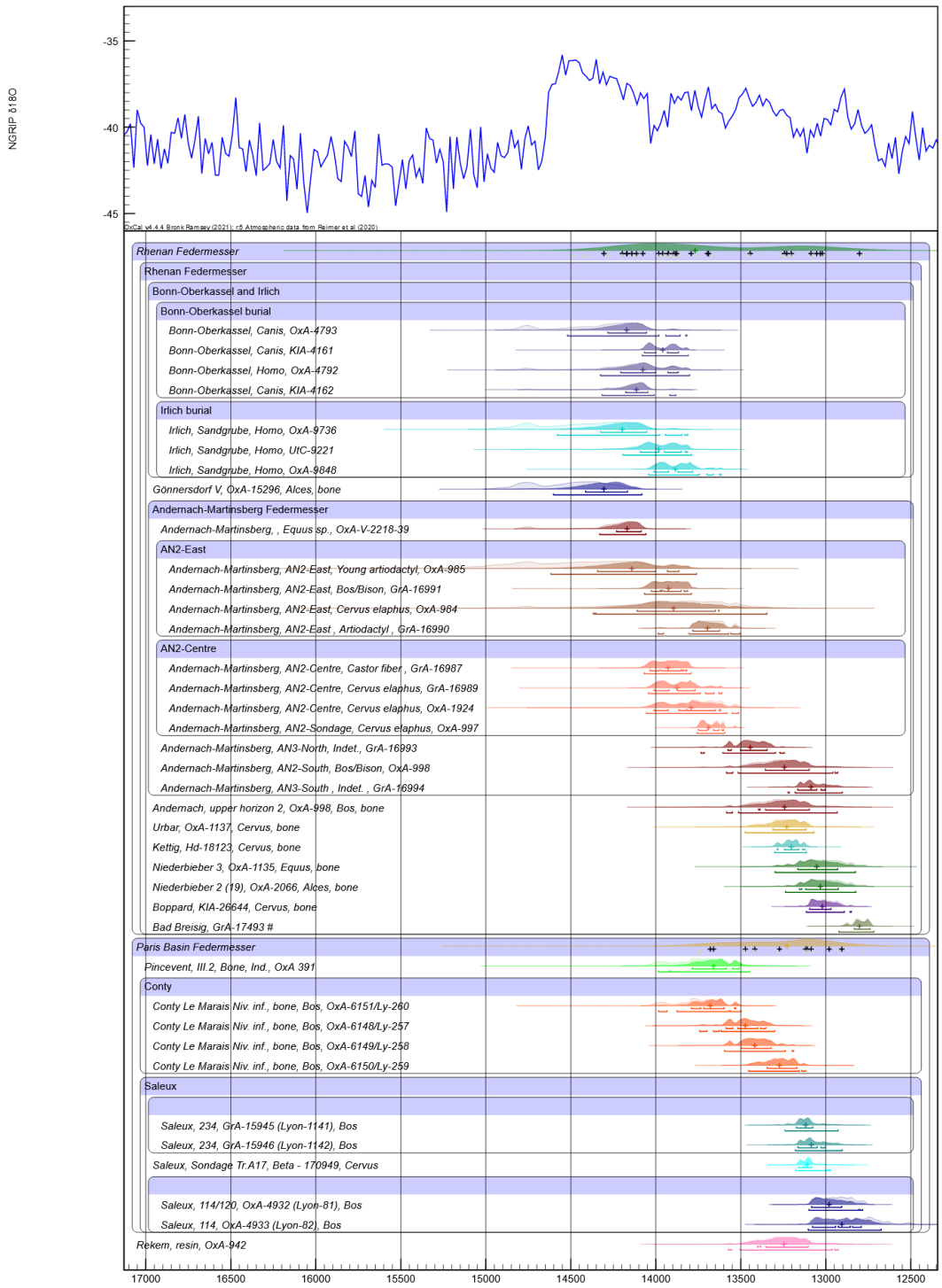


Figure A.54 Dates from Federmesser sites referred to in the thesis dating from the end of GI-1e to GI-1a, grouped as Rhineland Federmesser and Paris Basin, Somme catchment Federmesser. Excavation areas are grouped within sites. There is a significant drop in number of dates around GI-1b.

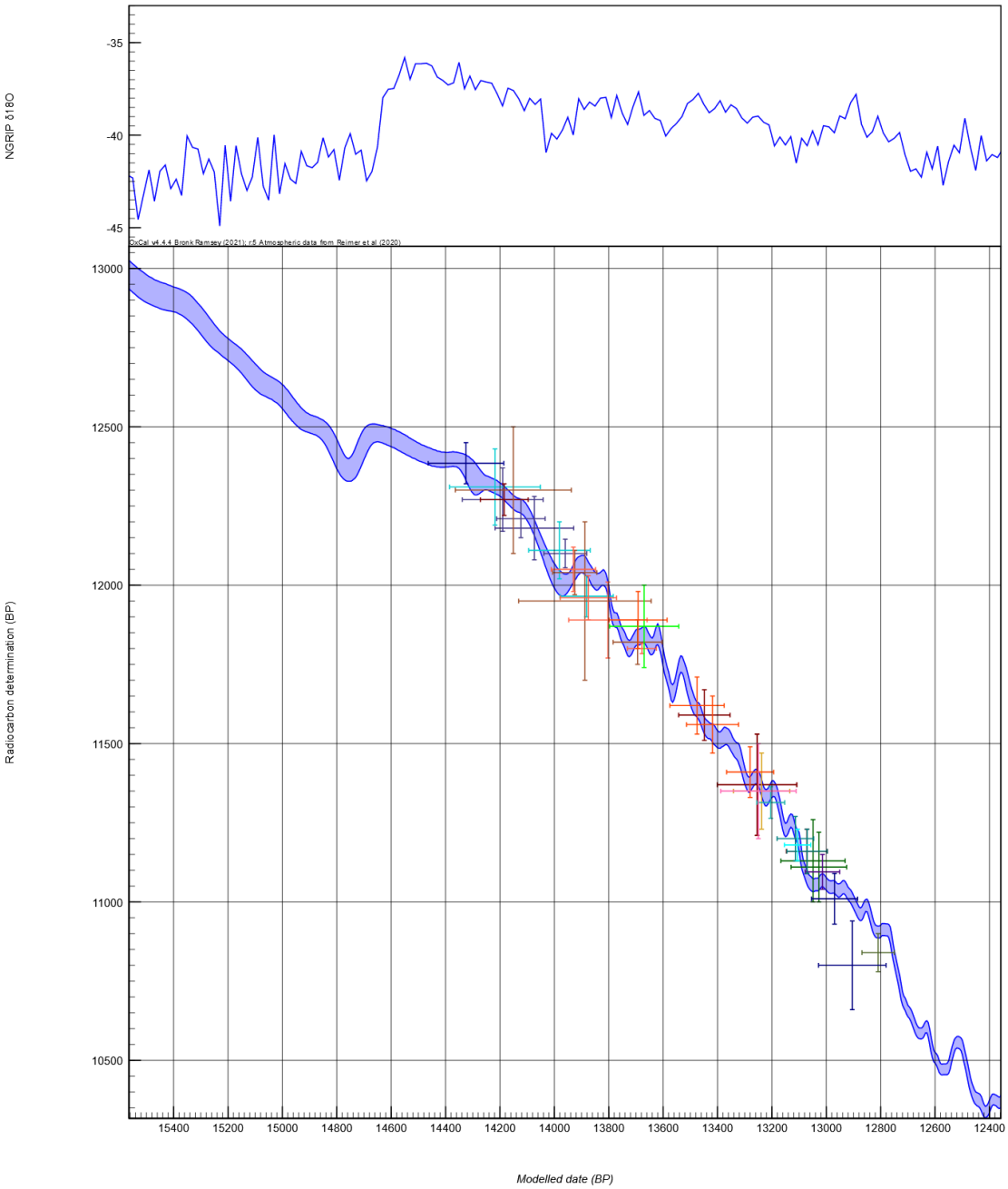


Figure A.55 Dates from Federmesser sites referred to in the thesis dating from the end of GI-1e to GI-1a, grouped as Rhineland Federmesser and Paris Basin, Somme catchment Federmesser. The hiatus around GI-1b is less apparent.

Rhineland Federmesser

Overlapping Uniform Phases

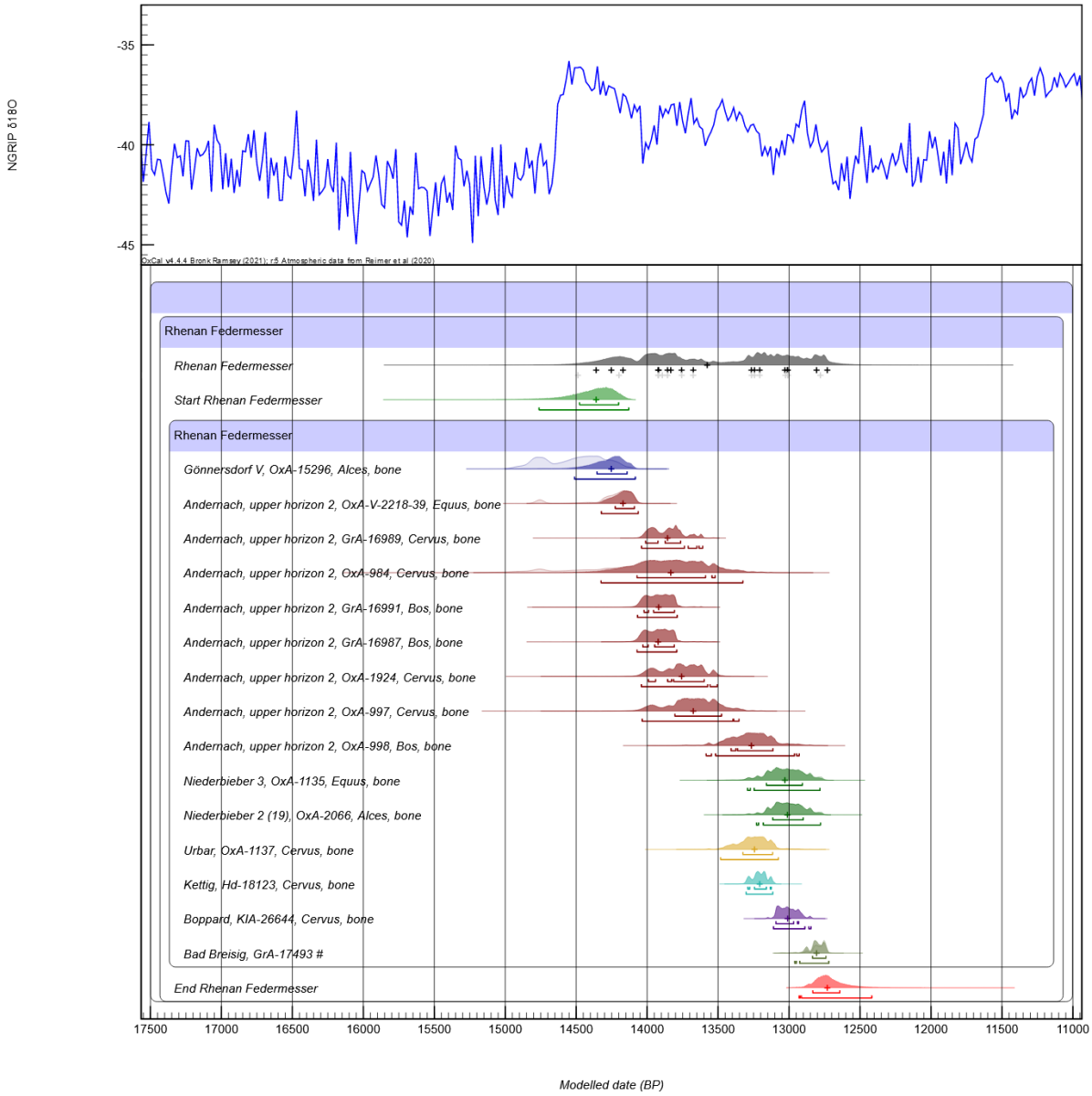


Figure A.56 Rhineland Federmesser. Dates from Stevens et al. 2009 and Grimm 2013. Subdivided by excavation and site. Overlapping uniform phases.

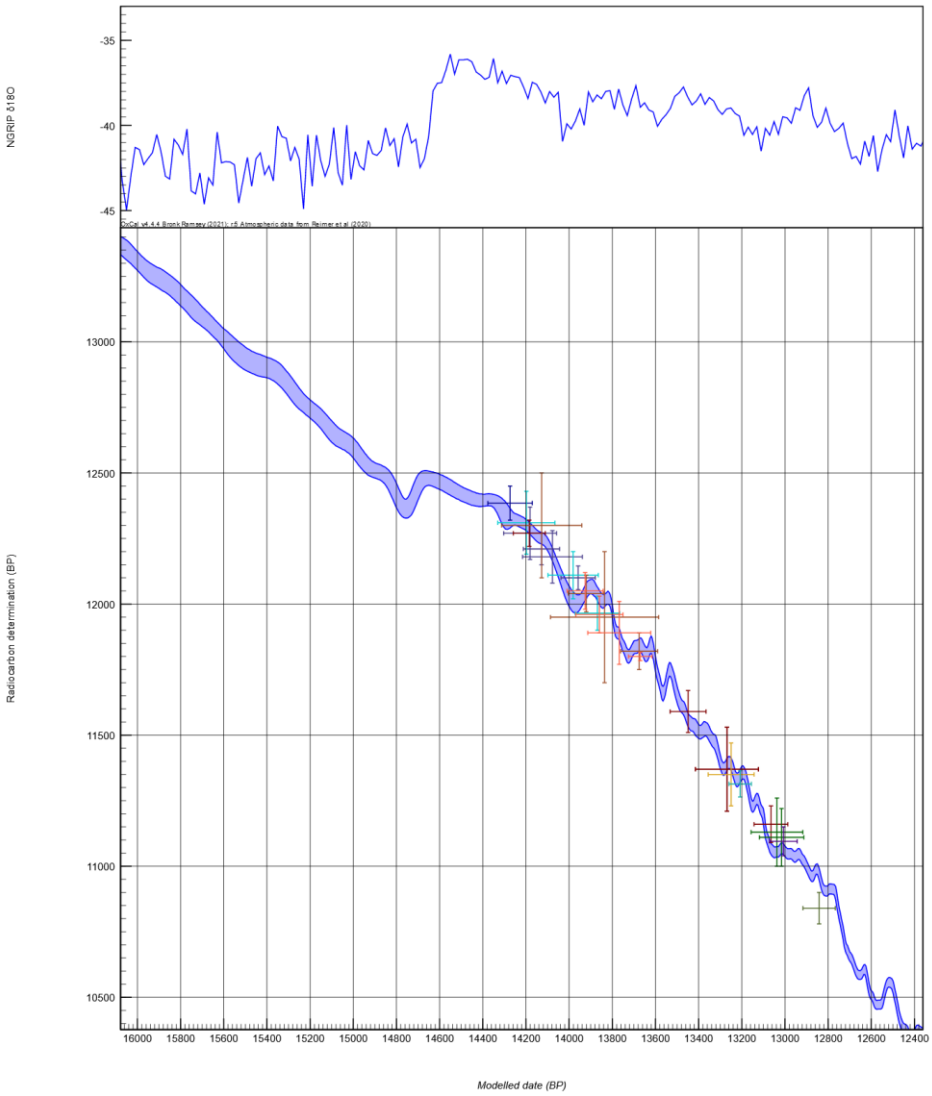


Figure A.57 Rhineland Federmesser. Dates from Stevens et al. 2009 and Grimm 2013. Subdivided by excavation and site. Overlapping uniform phases.

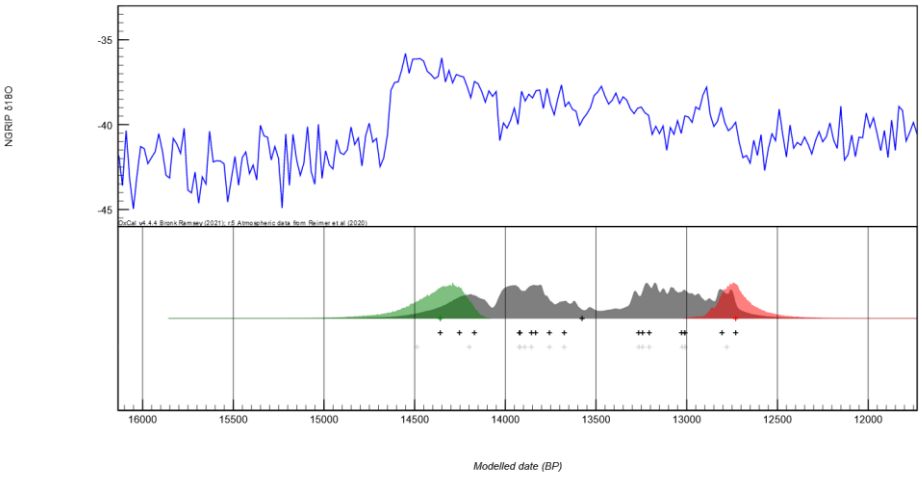


Figure A.58 Rhineland Federmesser. Dates from Stevens et al. 2009 and Grimm 2013. Subdivided by excavation and site. Overlapping uniform phases.

Irlich and Bonn-Oberkassel

Overlapping Uniform Phases

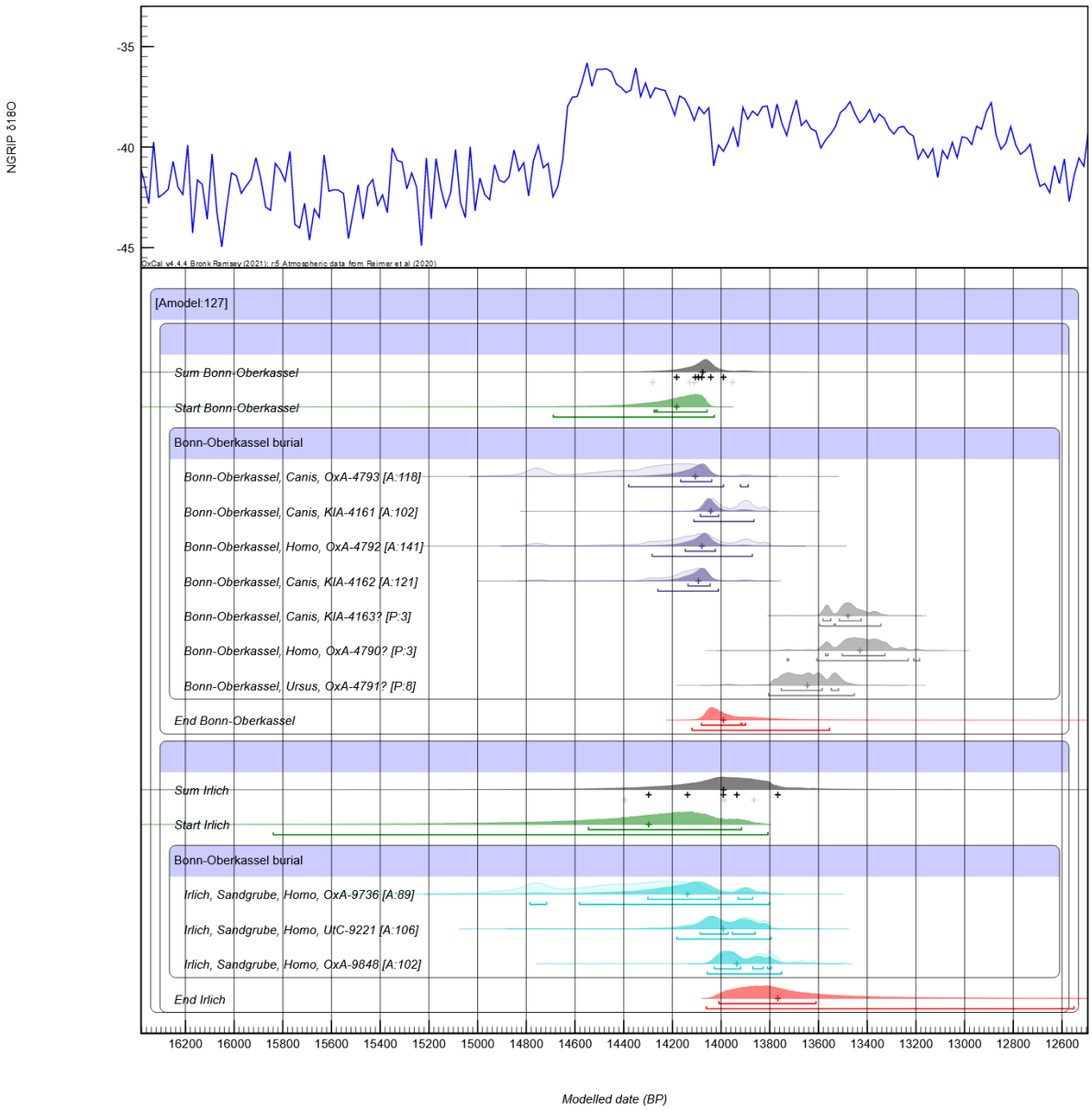


Figure A.59 Irlich and Bonn-Oberkassel burials. Possibly Federmesser, but no associated diagnostic material. Dates from Grimm 2013. Not in stratigraphic order, subdivided by site. Dates in grey are here considered as outliers and may be contaminated, however no contamination was recognised by the laboratory (Street and lab comment in Hedges et al. 1998: 231, Street 1998, Street and Baales 2002). Overlapping Uniform Phases.

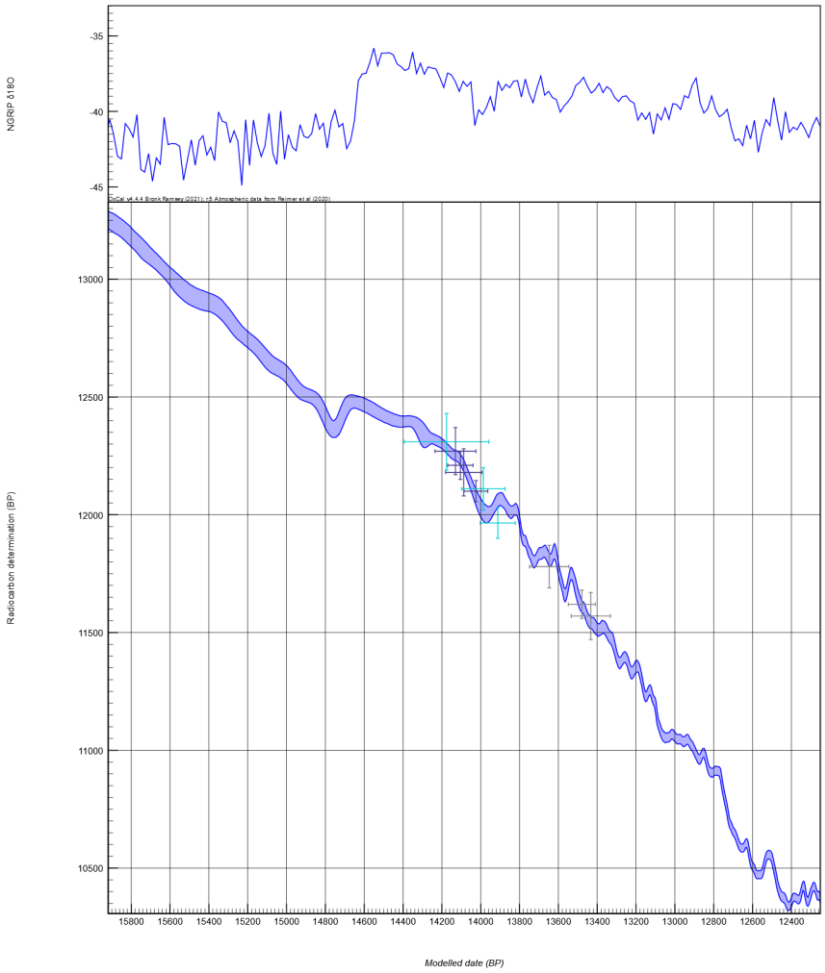


Figure A.60 Figure 0.119 Irlich and Bonn-Oberkassel burials. Possibly Federmesser, but no associated diagnostic material. Dates from Grimm 2013. Not in stratigraphic order, subdivided by site. Grey crosses are considered as outliers and may be contaminated (Street et al. 2006). Overlapping Uniform Phases.

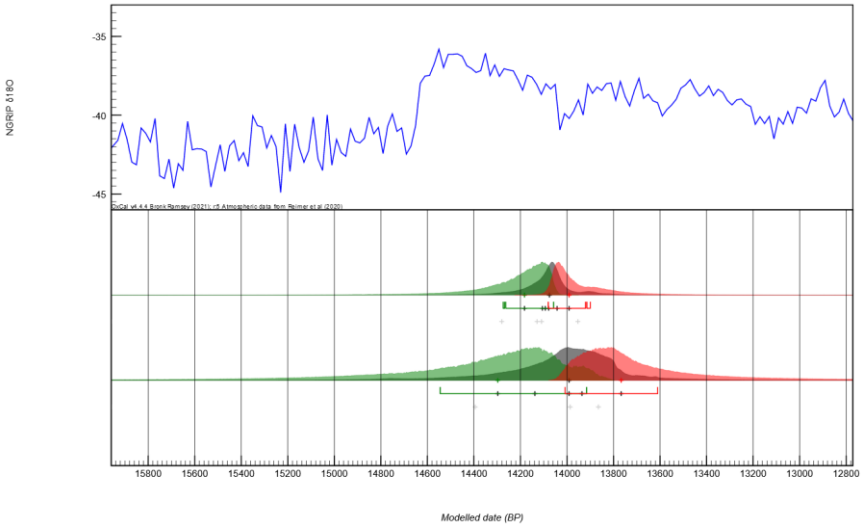


Figure A.61 Irlich (bottom) and Bonn-Oberkassel (top) burials. Possibly Federmesser, but no associated diagnostic material. Dates from Grimm 2013. Not in stratigraphic order, subdivided by site. Overlapping Uniform Phases.

Andernach-Martinsberg Federmesser

Overlapping Uniform Phases

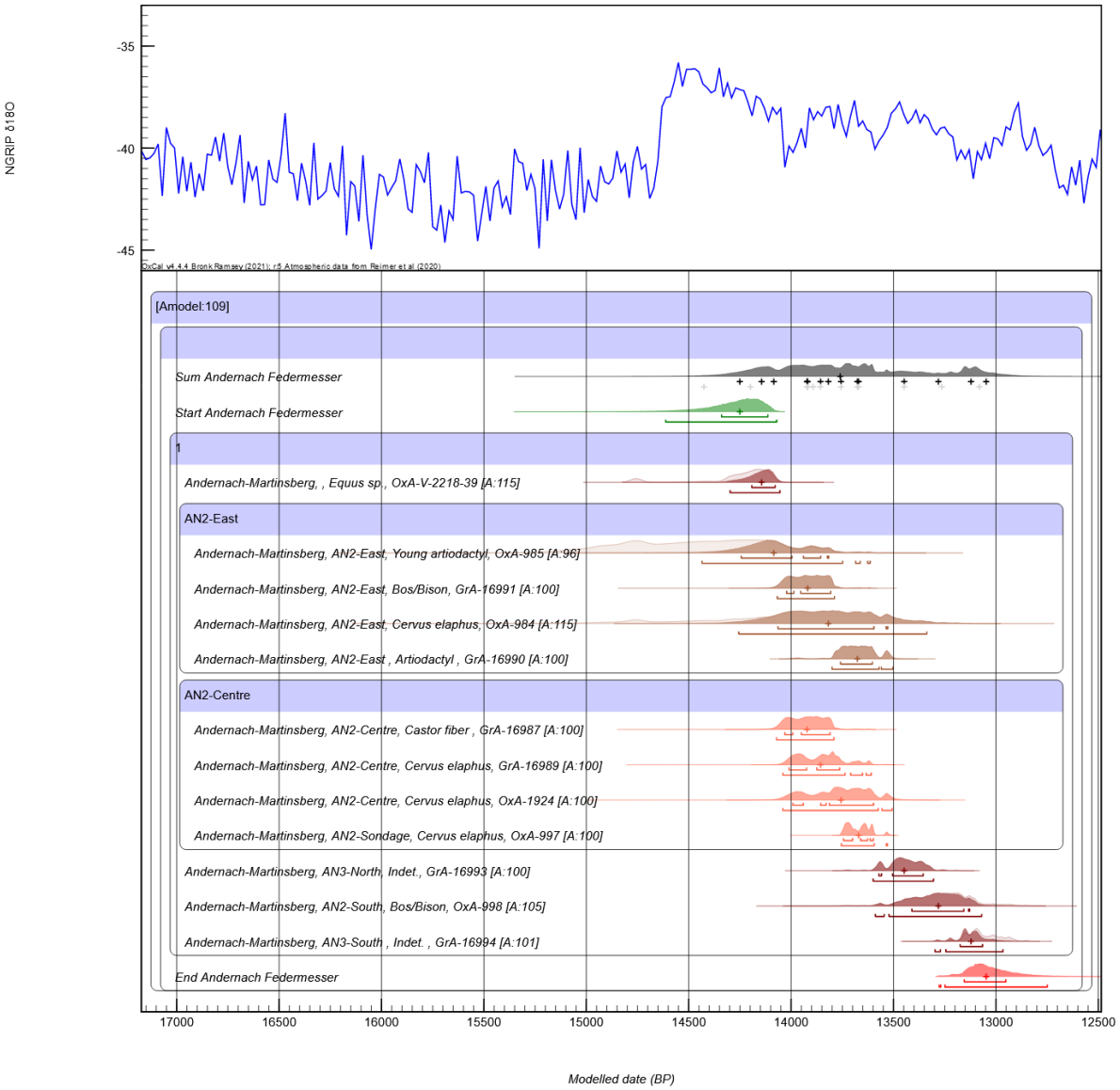


Figure A.62 Andernach-Martinsberg Federmesser. Dates from Stevens et al. 2009. Not in stratigraphic order, subdivided by excavation. Overlapping Uniform Phases.

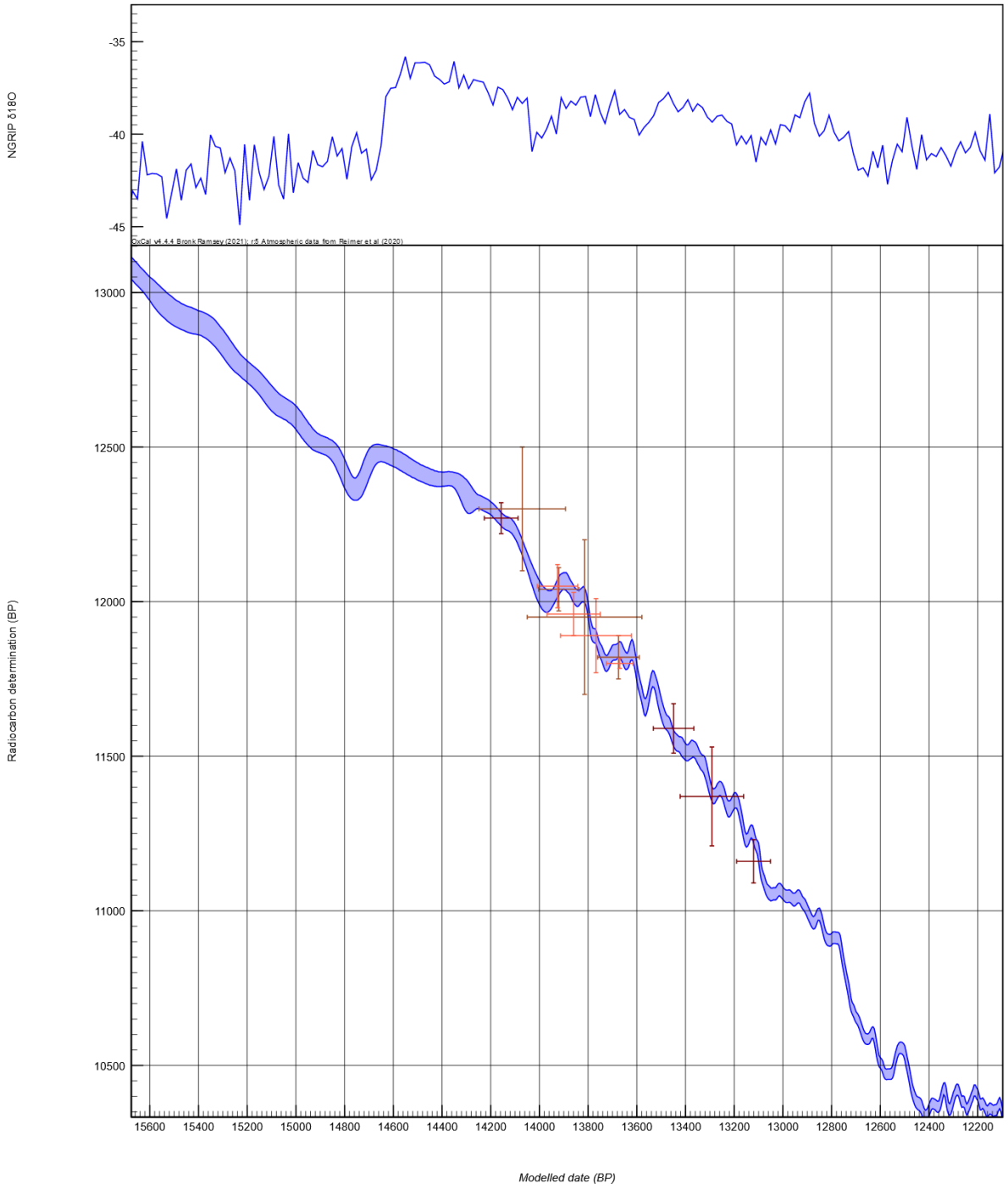


Figure A.63 Andernach-Martinsberg Federmesser. Dates from Stevens et al. 2009. Not in stratigraphic order, subdivided by excavation. Overlapping Uniform Phases.

Rekem

Simple Plot

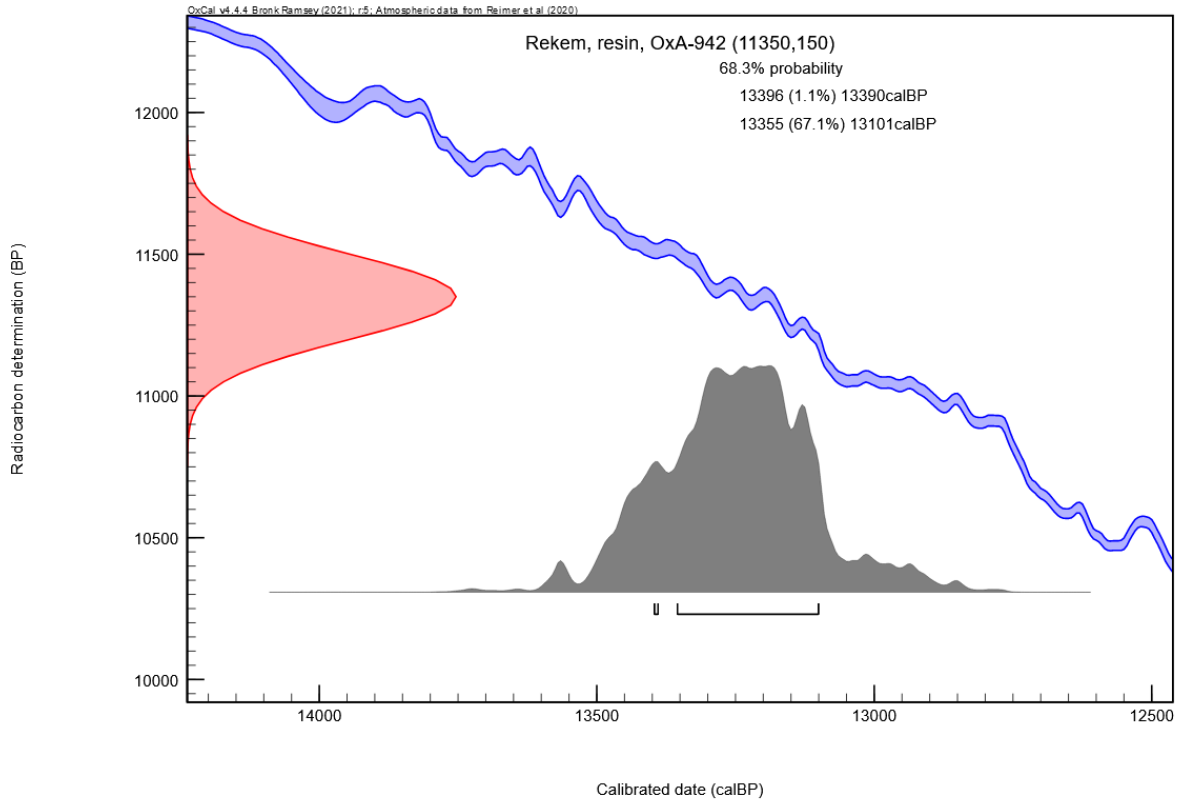


Figure A.64 Rekem, Federmesser. Date Caspar and De Bie 2000. Simple Plot.

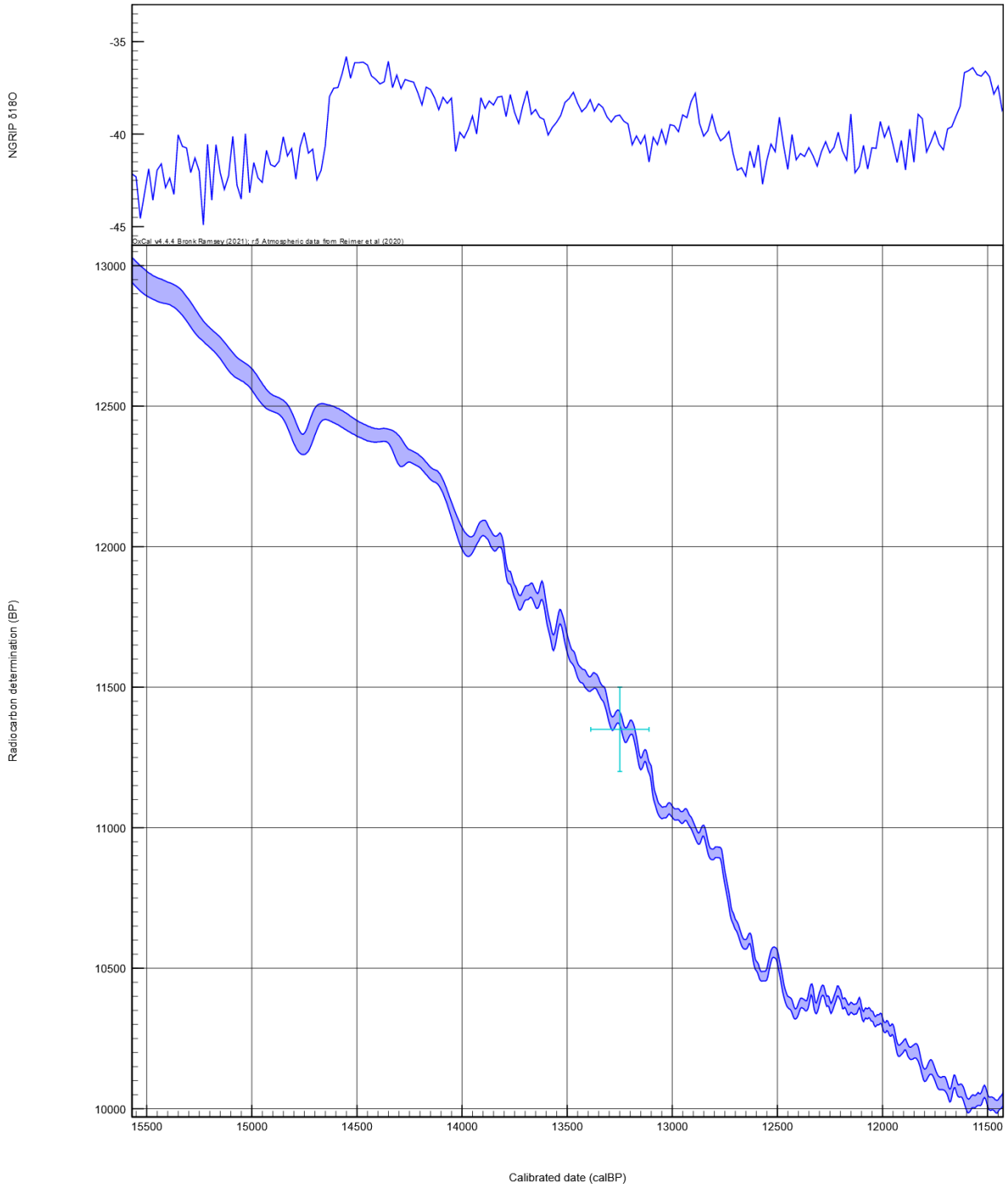


Figure A.65 Rekem, Federmesser. Date Caspar and De Bie 2000. Simple Plot.

Paris Basin, Somme Catchment Federmesser

Overlapping Uniform Phases

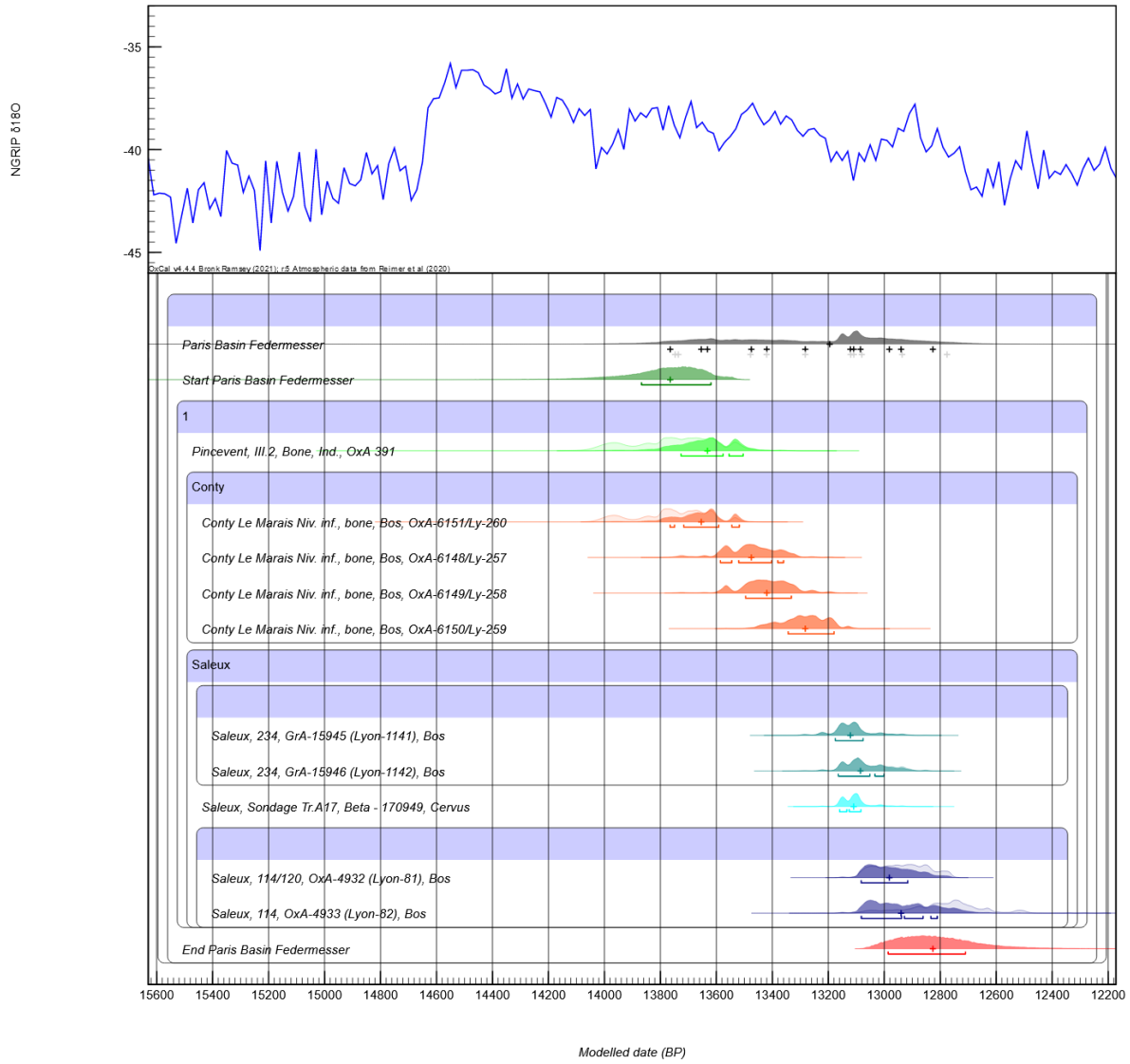


Figure A.66 Paris Basin, Somme Catchment Federmesser. Dates from Coudret and Fagnart 2004 and Grimm 2013. Overlapping uniform phases.

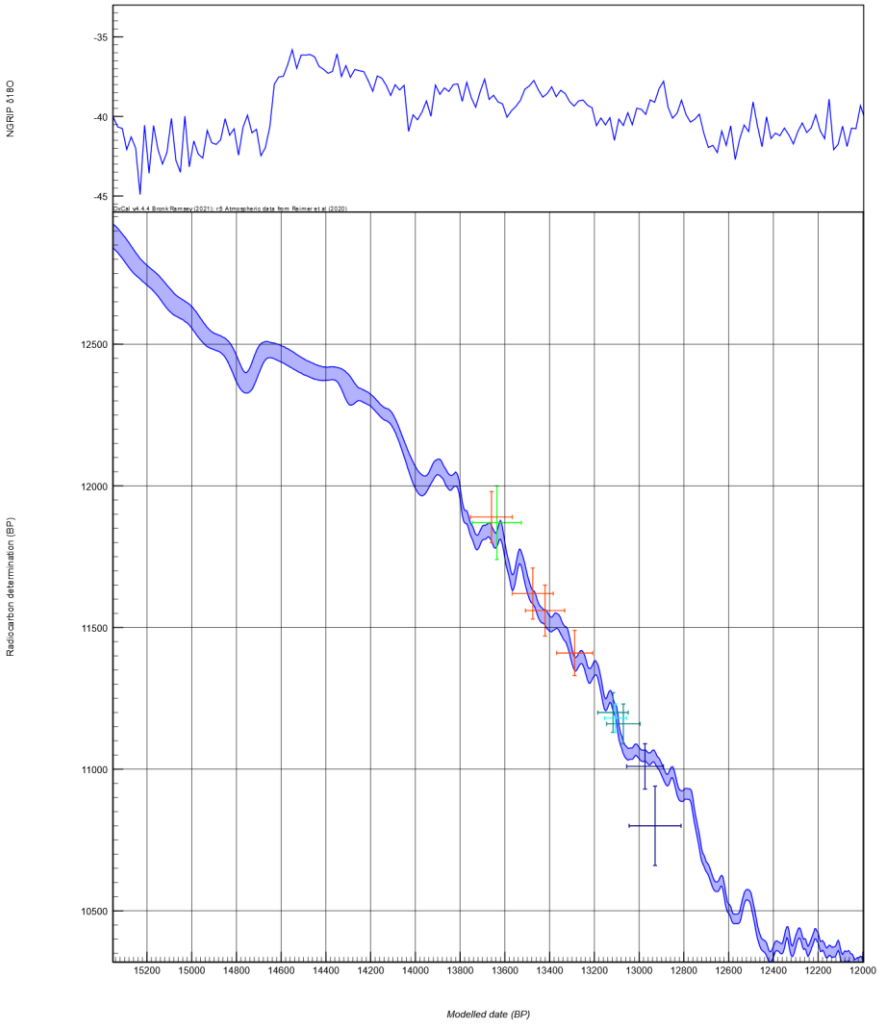


Figure A.67 Paris Basin, Somme Catchment Federmesser. Dates from Coudret and Fagnart 2004 and Grimm 2013. Overlapping uniform phases.

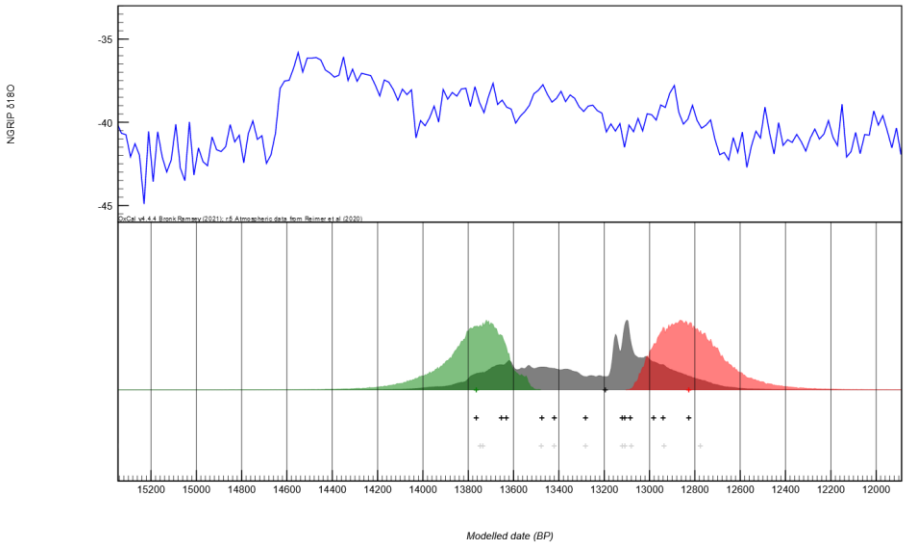


Figure A.68 Paris Basin, Somme Catchment Federmesser. Dates from Coudret and Fagnart 2004 and Grimm 2013. Overlapping uniform phases.

Conty

Single Uniform Phase

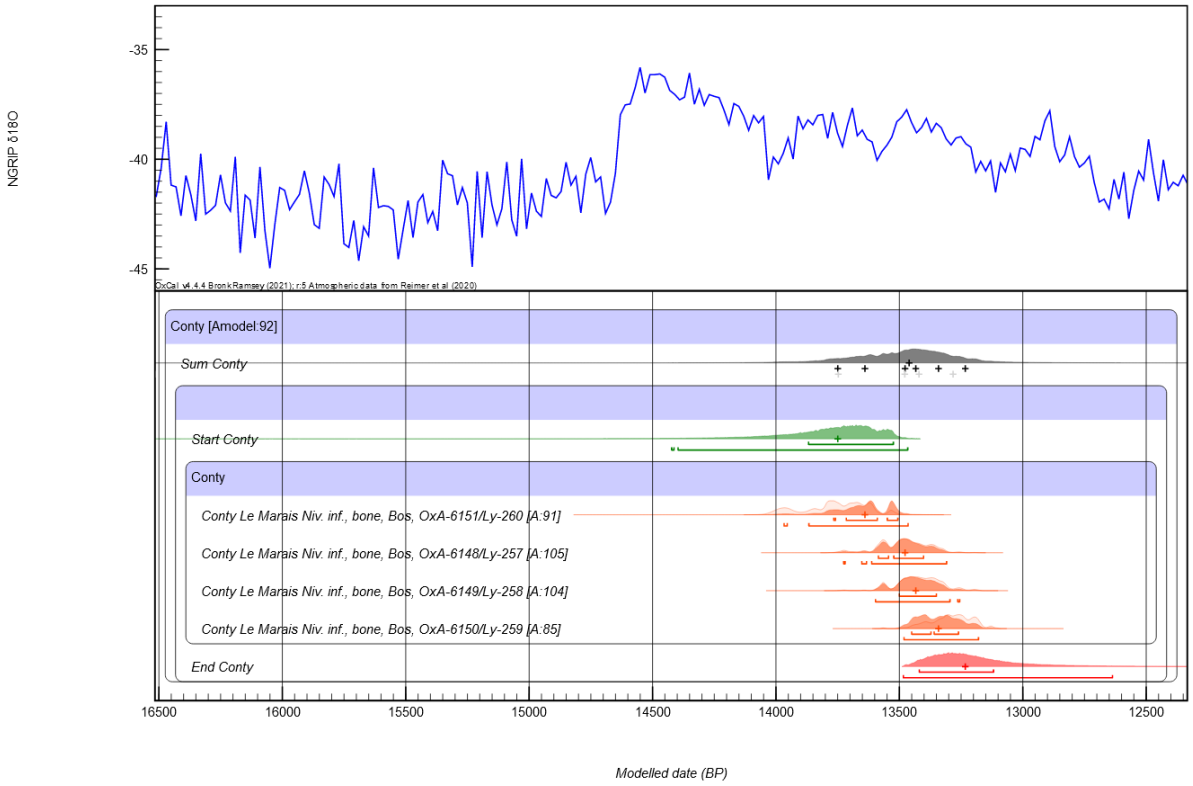


Figure A.69 Lower level dates from Conty associated to the lithic assemblage attributed to the beginning of the later Federmesser (Antoine et al. 2012, Grimm 2013). Single uniform phase. Although the dates are from the same archaeological horizon, the earliest date (OxA-6151) in GI-1c is the best fit with the rest of the stratigraphic and environmental data (Antoine et al. 2012).

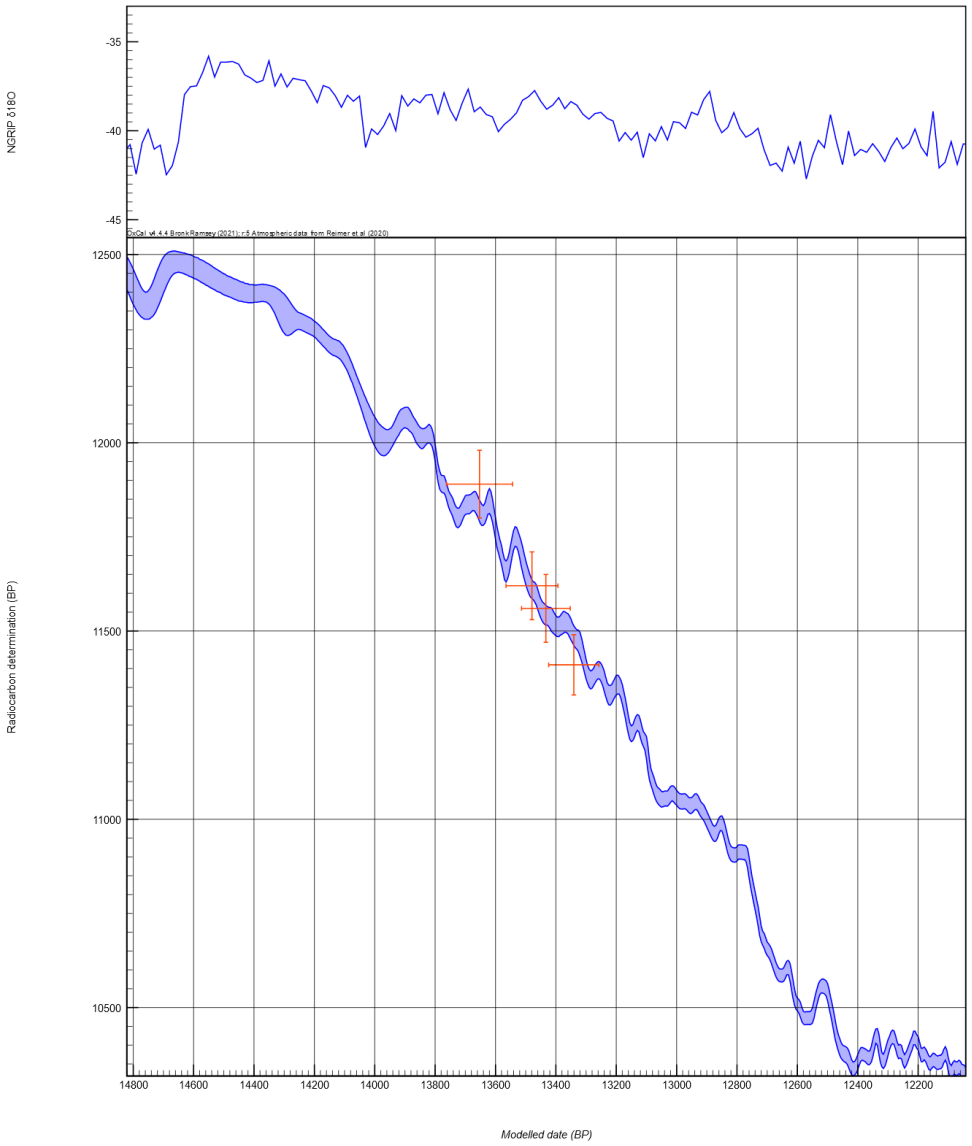


Figure A.70 Lower level dates from Conty associated to the lithic assemblage attributed to the beginning of the later Federmesser (Antoine et al. 2012, Grimm 2013). Uniform phase.

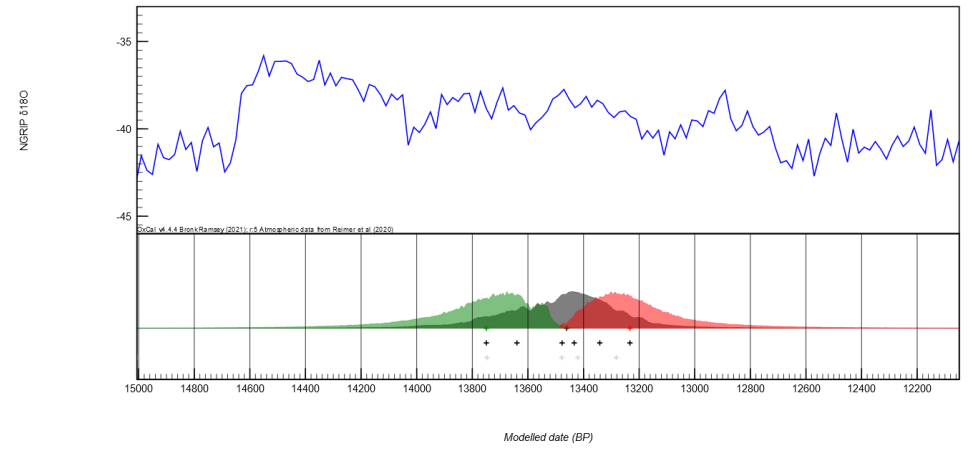


Figure A.71 Lower level dates from Conty associated to the lithic assemblage attributed to the beginning of the later Federmesser (Antoine et al. 2012, Grimm 2013). Uniform phase.

Saleux

Overlapping Uniform Phases

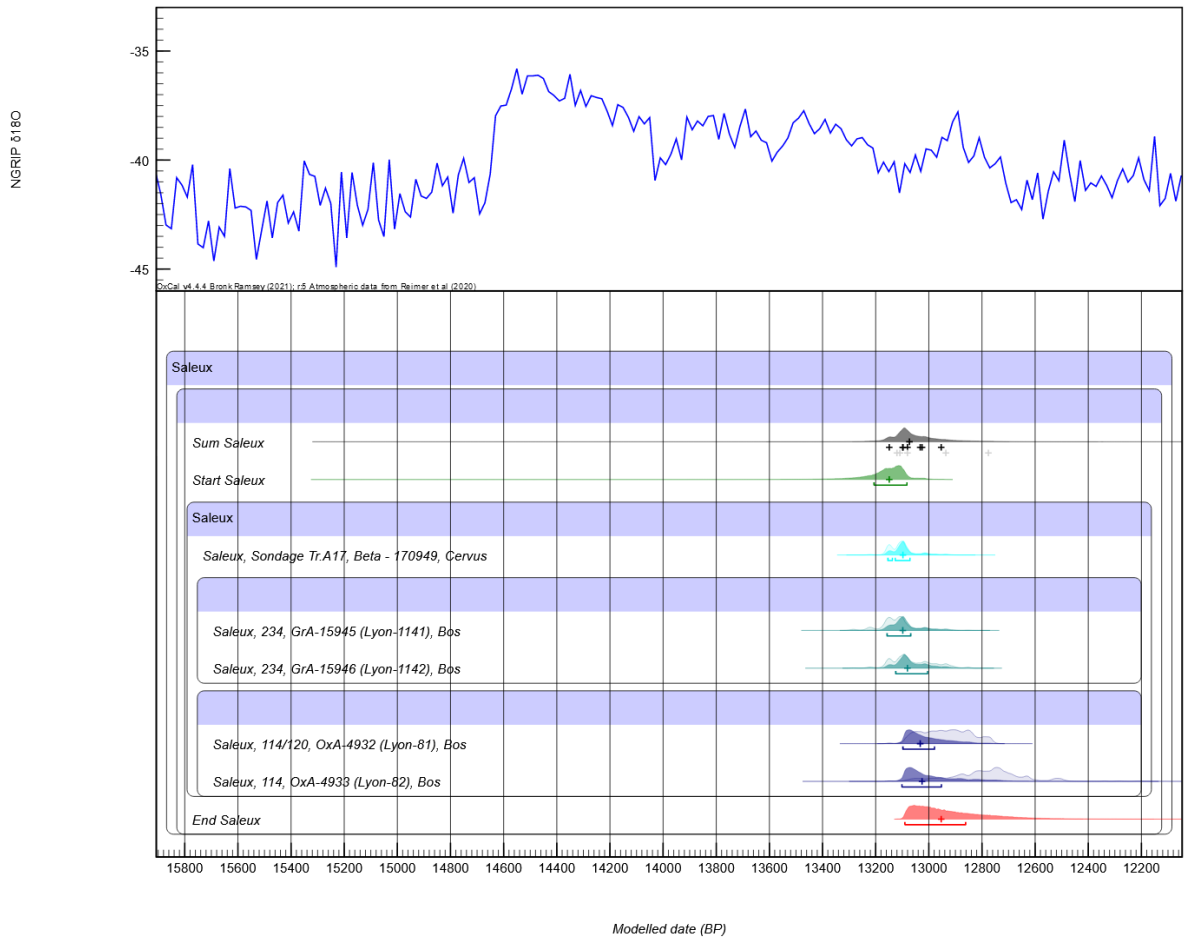


Figure A.72 Paris Basin, Somme Federmesser, Saleux. Dates from Coudret and Fagnart 2004 and Grimm 2013. Overlapping uniform phases.

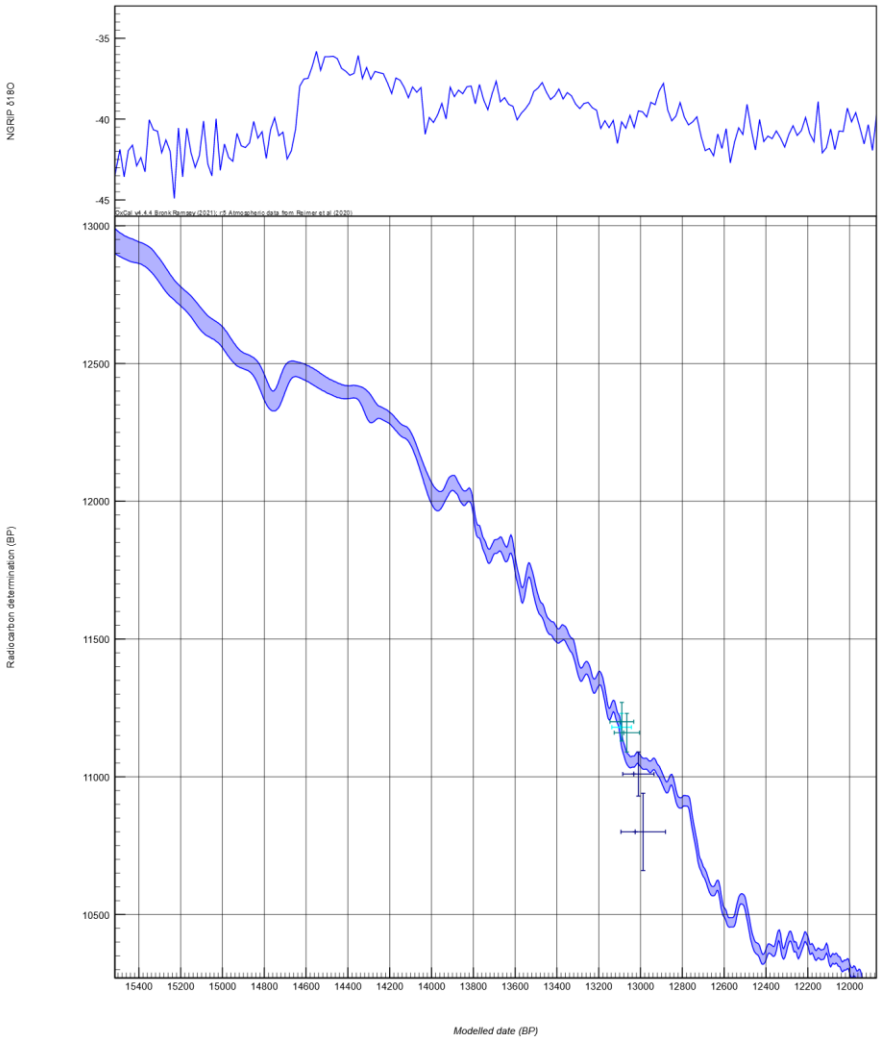


Figure A.73 Paris Basin, Somme Federmesser, Saleux. Dates from Coudret and Fagnart 2004 and Grimm 2013. Overlapping uniform phases.

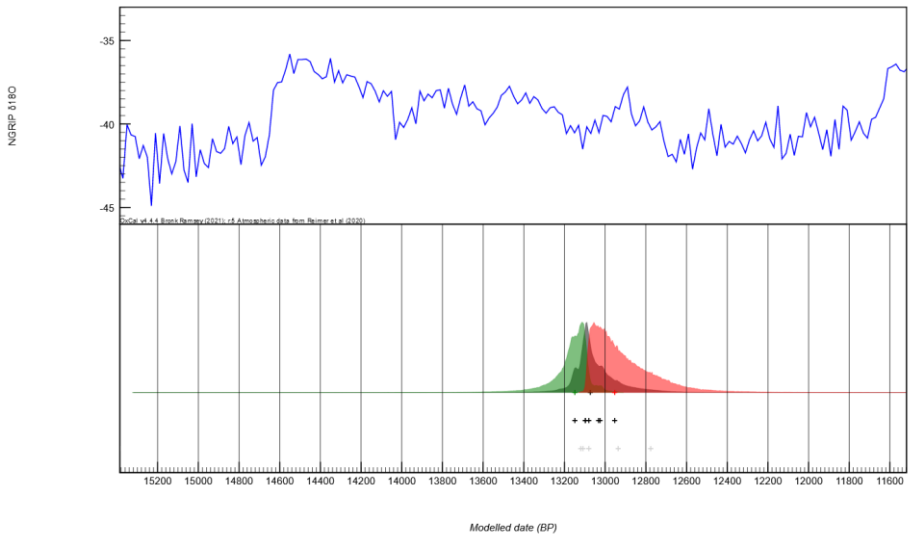


Figure A.74 Paris Basin, Somme Federmesser, Saleux. Dates from Coudret and Fagnart 2004 and Grimm 2013. Overlapping uniform phases.

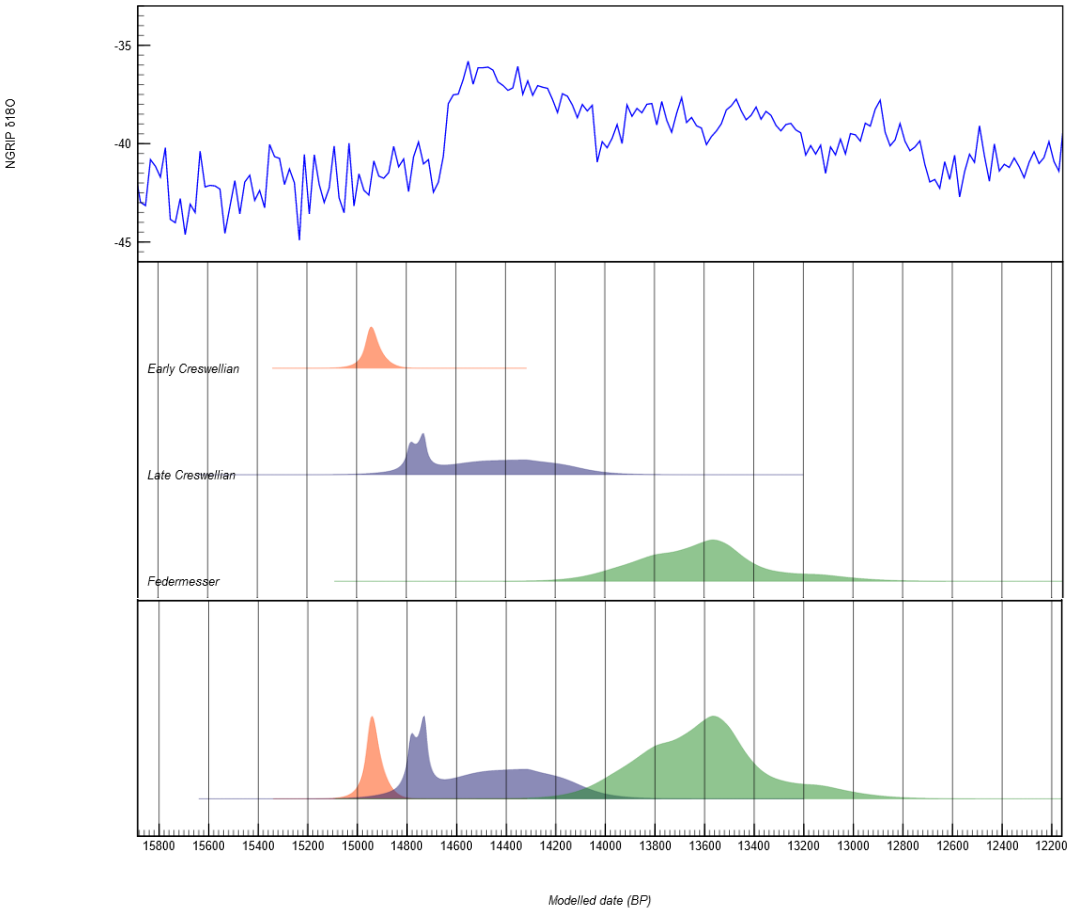


Figure A.75 Stacked KDE models of dates grouped as Early Creswellian, Late Creswellian and Federmesser in this thesis. The Late Creswellian peak appears to be associated to the large wiggle at the transition from GS-2a to GS-1e before the GS-1e plateau.

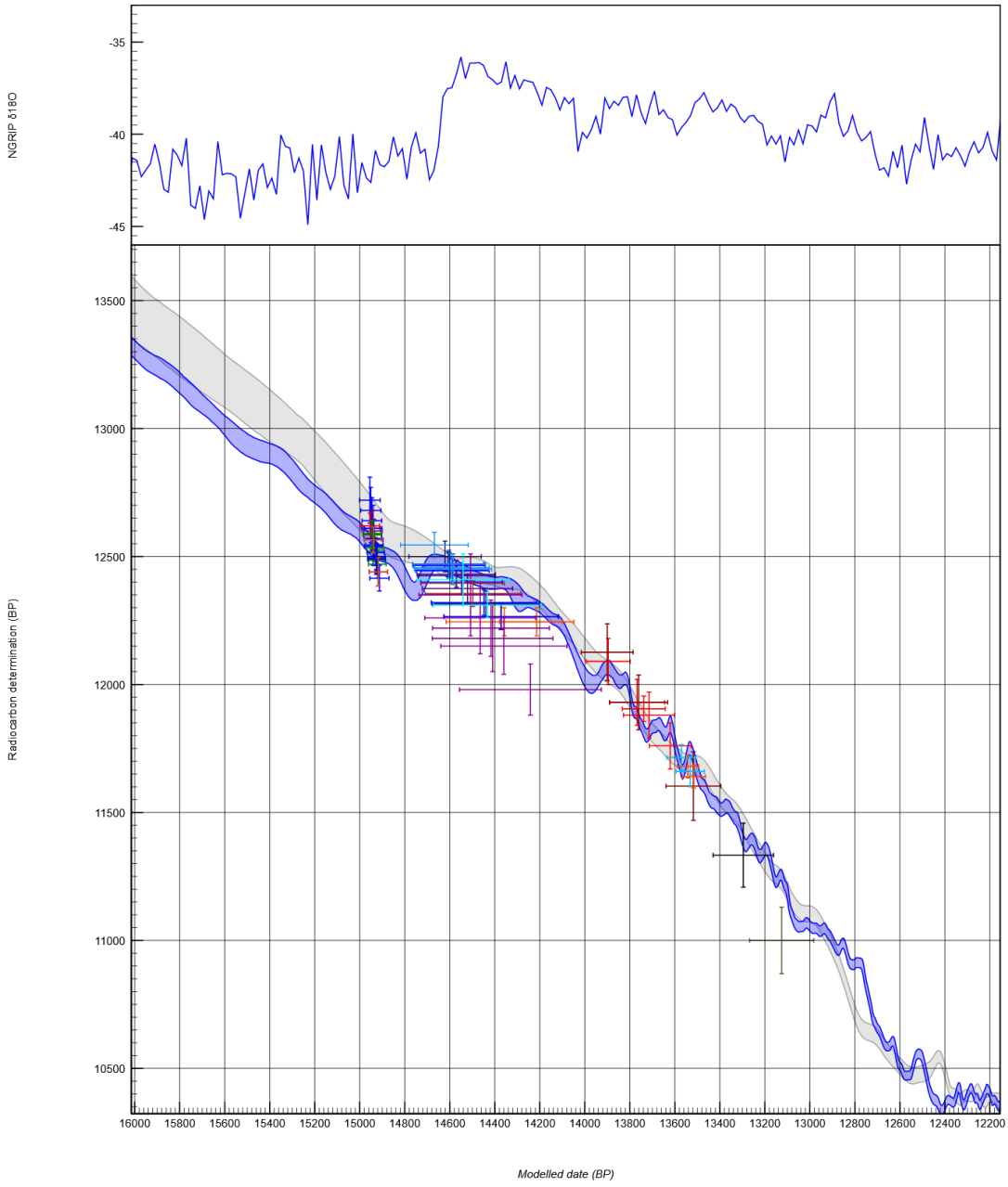


Figure A.76 Cumulated distribution on a curve plot of British Late Glacial dates after KDE modelling by period. The Early Creswellian group is very consistent following 15,000 cal BP, and preceding the onset of GI-1e. The Late Creswellian group is mostly affected by the GS-2a to GS-1e wiggle and plateau, with a concentration between 14,400 and 14,800 cal BP. There is an absence of dates during GI-1d, a significant hiatus. The Allerød dates are mostly in the first half, GI-1c to midway through GI-1b. There is only two dates for the second half of the Allerød.

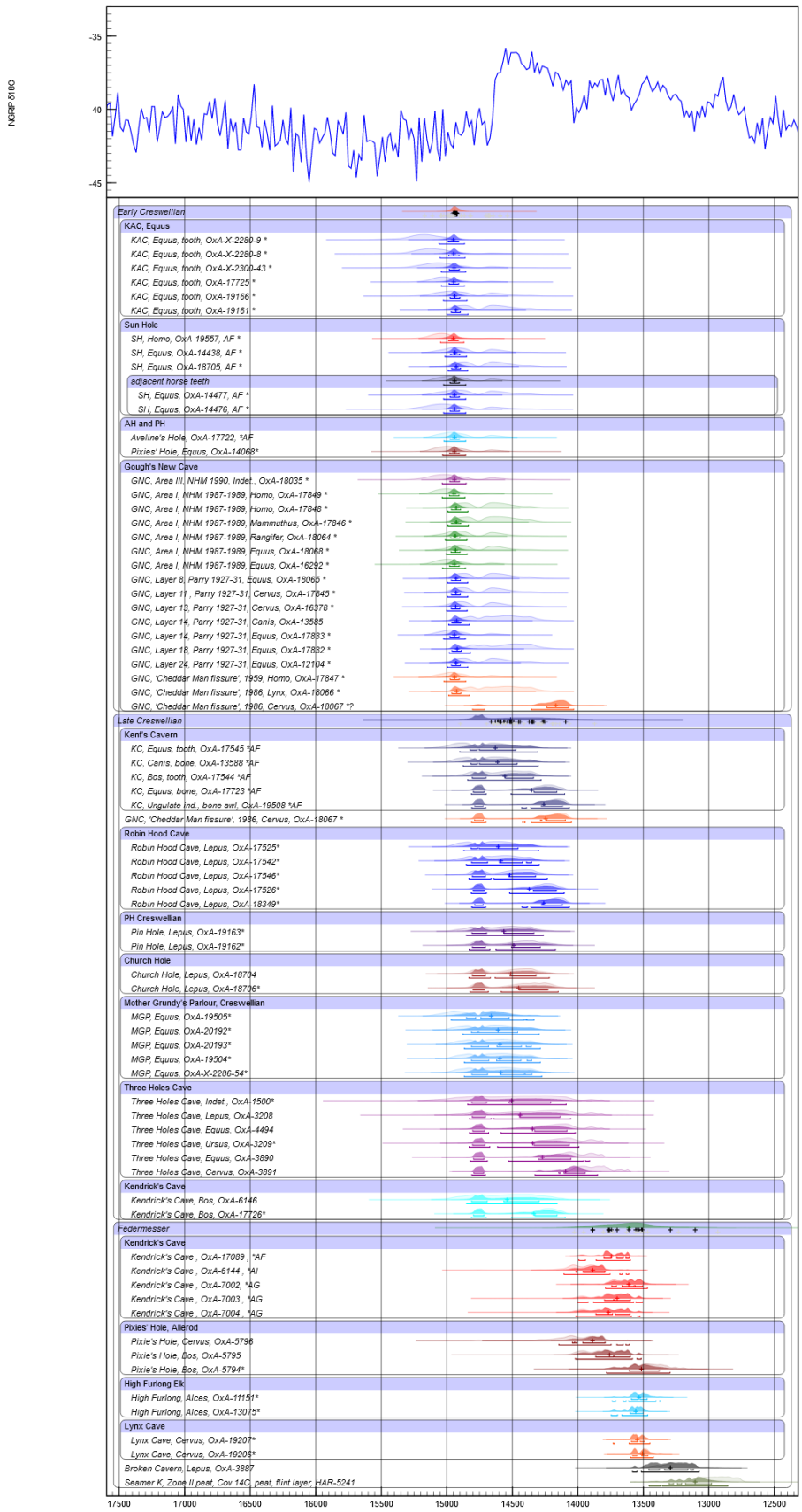


Figure A.77 Cumulated British Late Glacial dates used in this project, divided into three overlapping KDE models (Early Creswellian, Late Creswellian and Allerød Federmesser. The Early Creswellian dates group very tightly, with a high precision segment of the curve. The Later Creswellian is very imprecise due to the GI-1e plateau. The earliest Allerød dates are also affected by the curve.

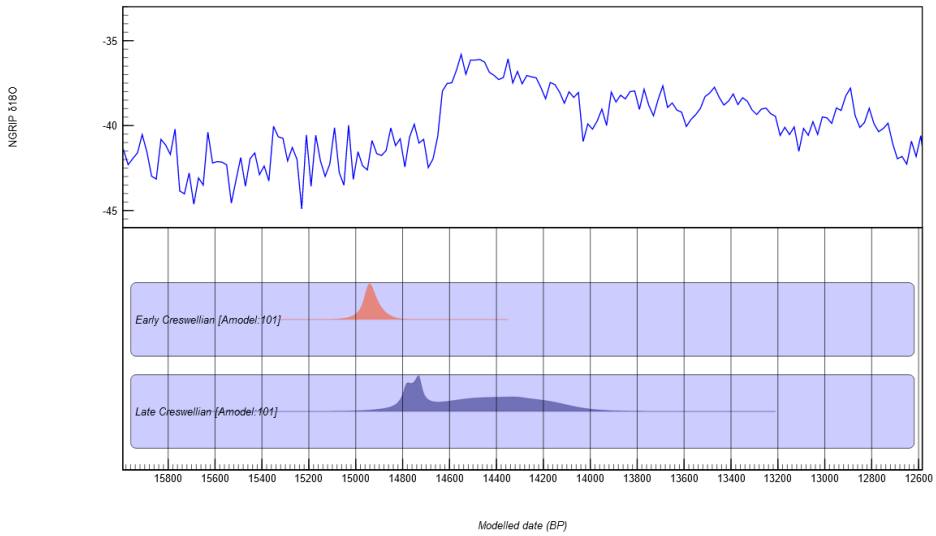


Figure A.78 Cumulated distribution of dates from sites attributed to Early and Late Creswellian based on their different dating and assemblage resolutions. Each group was modelled as separate KDE models. The Early Creswellian group has a very tight dating around 14900 cal BP, possibly coinciding with the onset of the Bølling in Britain. The Late Creswellian group is more dilated, this is mostly due to the presence of a large wiggle (seen here as the cumulation around 14,800 cal BP) and a long plateau from 14,700 to 14,200 cal BP.

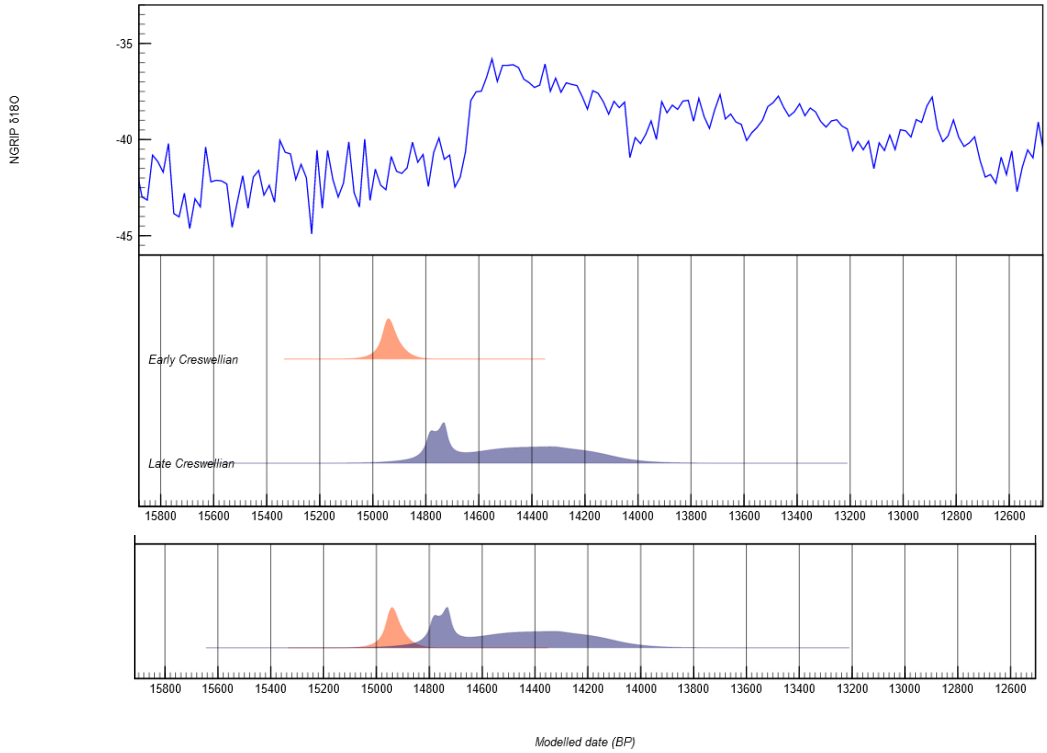


Figure A.79 Cumulated distribution of dates from sites attributed to Early and Late Creswellian based on their different dating and assemblage resolutions. Each group was modelled as separate KDE models. The Early Creswellian group has a very tight dating around 14,900 cal BP, possibly coinciding with the onset of the Bølling in Britain. The Late Creswellian group is more dilated, this is mostly due to the presence of a large wiggle (seen here as the cumulation around 14,800 cal BP) and a long plateau from 14,700 to 14,200 cal BP.

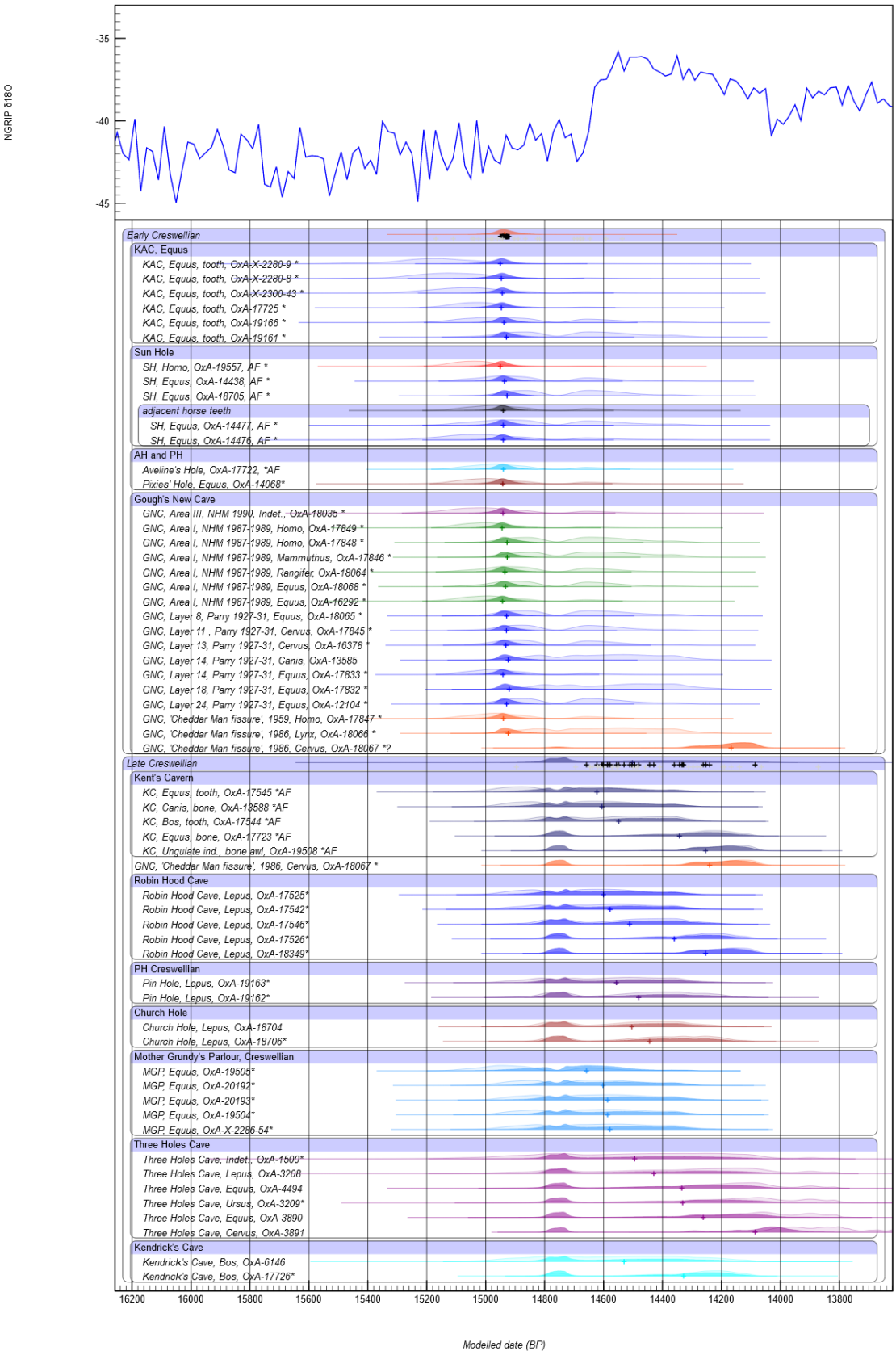


Figure A.80 Cumulated distribution of dates from sites attributed to Early and Late Creswellian based on their different dating and assemblage resolutions. Each group was modelled as separate KDE models. The Early Creswellian group has a very tight dating around 14,900 cal BP, possibly coinciding with the onset of the Bølling in Britain. The Late Creswellian group is more dilated, this is mostly due to the presence of a large wiggle (seen here as the cumulation around 14,800 cal BP) and a long plateau from 14,700 to 14,200 cal BP.

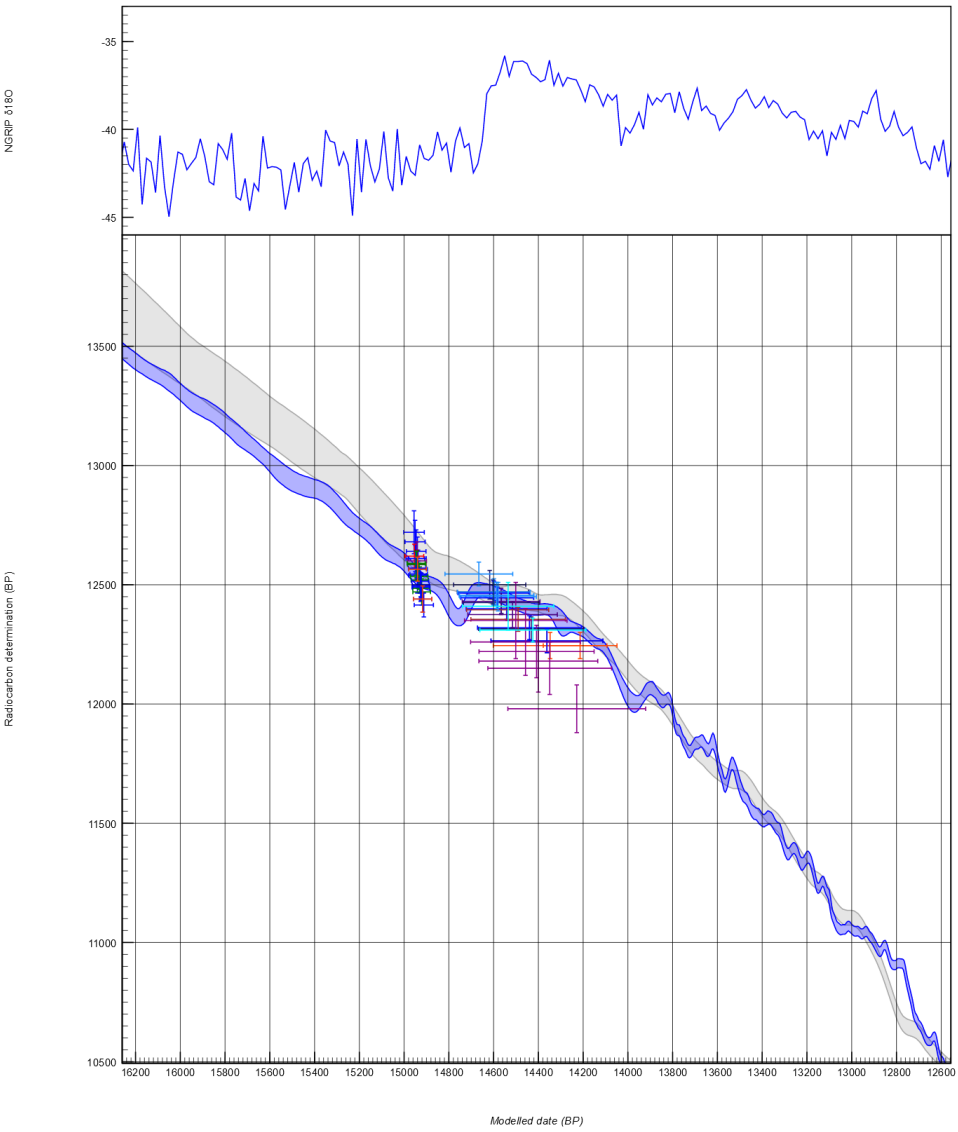


Figure A.81 Cumulated distribution of dates from sites attributed to Early and Late Creswellian based on their different dating and assemblage resolutions. Each group was modelled as separate KDE models. The Early Creswellian group has a very tight dating around 14,900 cal BP, possibly coinciding with the onset of the Bølling in Britain. The Late Creswellian group is more dilated, this is mostly due to the presence of a large wiggle (seen here as the cumulation around 14,800 cal BP) and a long plateau from 14,700 to 14,200 cal BP.

Early Creswellian

Uniform Phase

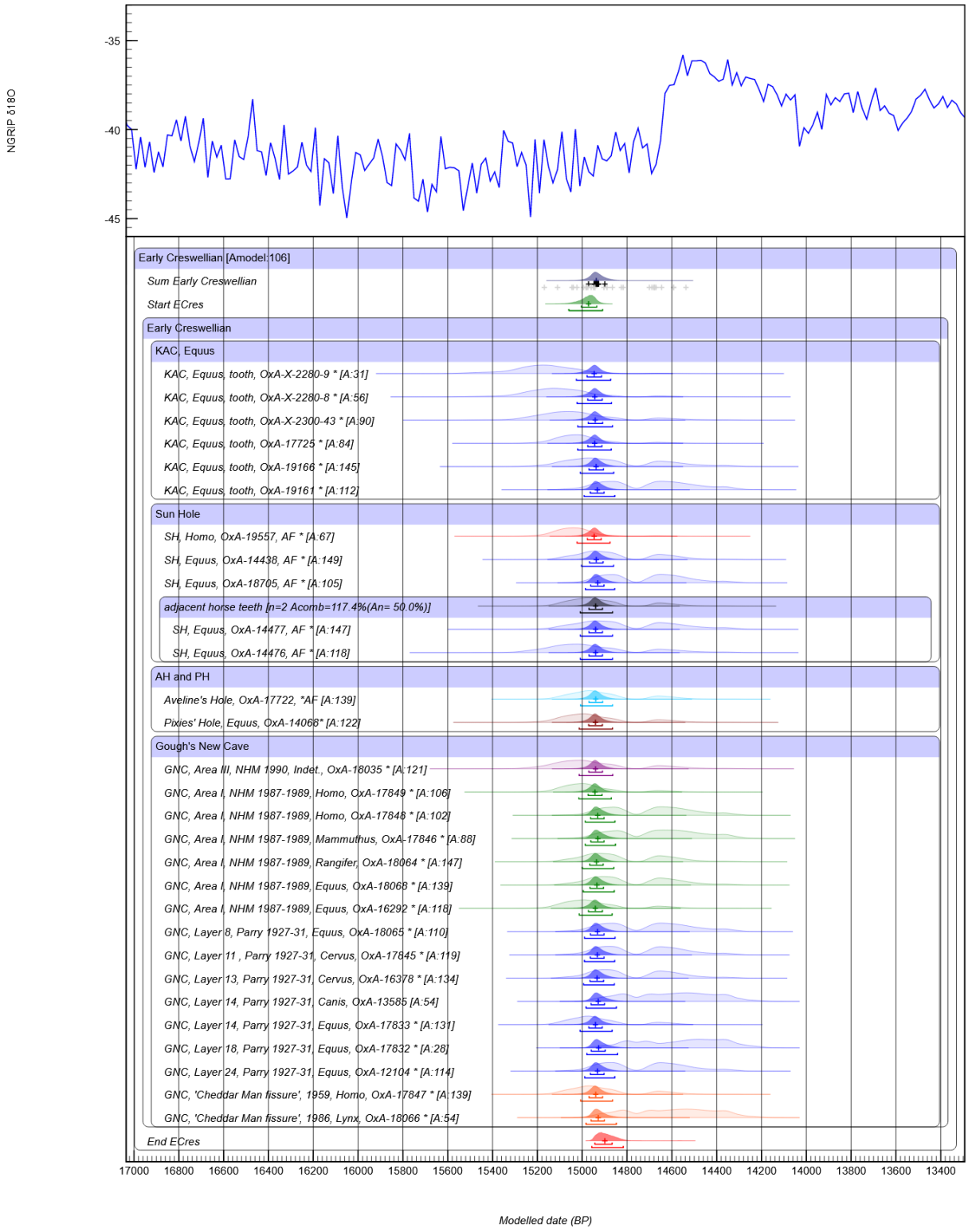


Figure A.82 Early Creswellian. Dates from Jacobi and Higham 2009, 2011. Overlapping uniform phases. There is a very good agreement overall, Amodel: 106, with only the first date from KAC, OxA-X-2280-9 (A: 31%) being overly forced into the model (indicating a probable earlier occurrence). The several of the dates from GNC also have low agreements, notably OxA-17832 (A:28%). Although the overall model agreement is high, there is probably more background variability.

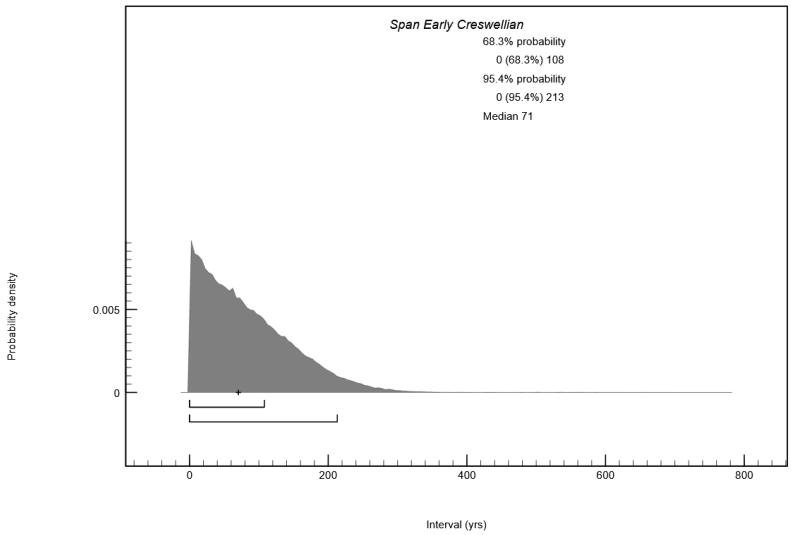


Figure A.83 Early Creswellian. Dates from Jacobi and Higham 2009, 2011. Overlapping uniform phases. Sum Early Creswellian. The cumulated Early Creswellian indicates a potential very short occupation span, less than 108 years at 68% probability within this uniform single phase model.

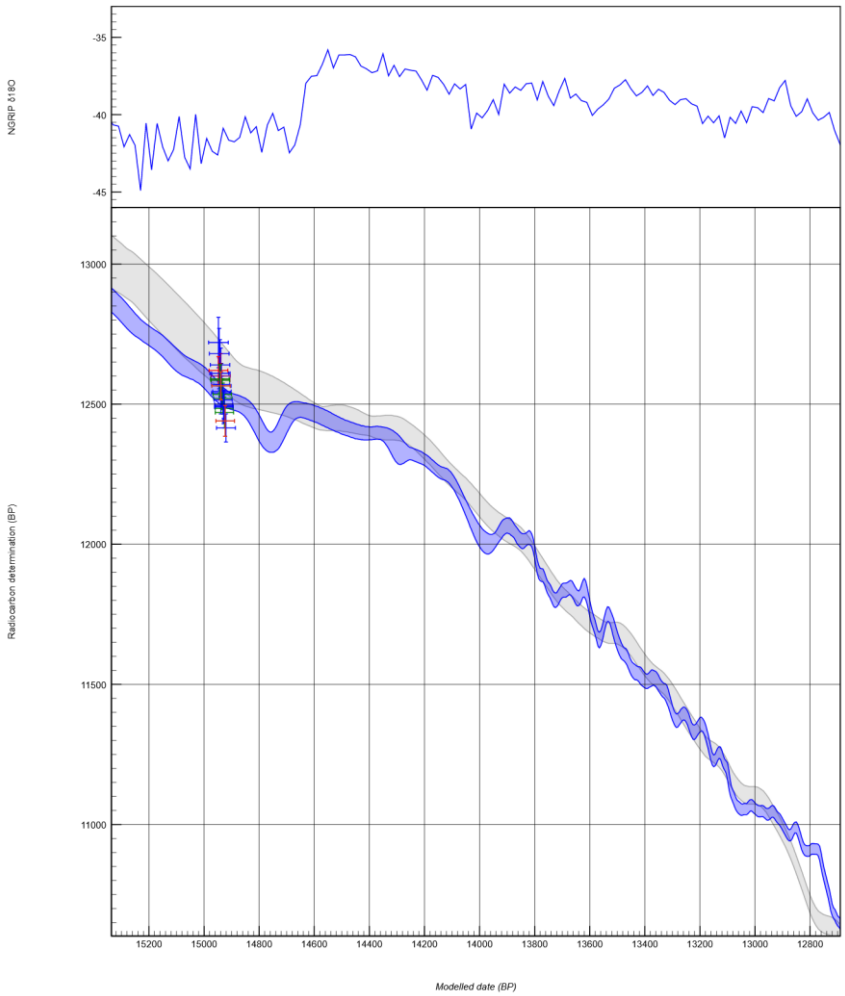


Figure A.84 Early Creswellian. Dates from Jacobi and Higham 2009, 2011. Overlapping uniform phases. IntCal04 (grey) (Reimer et al. 2004) is in the background for reference. The dates are better grouped and earlier than the IntCal04 curve.

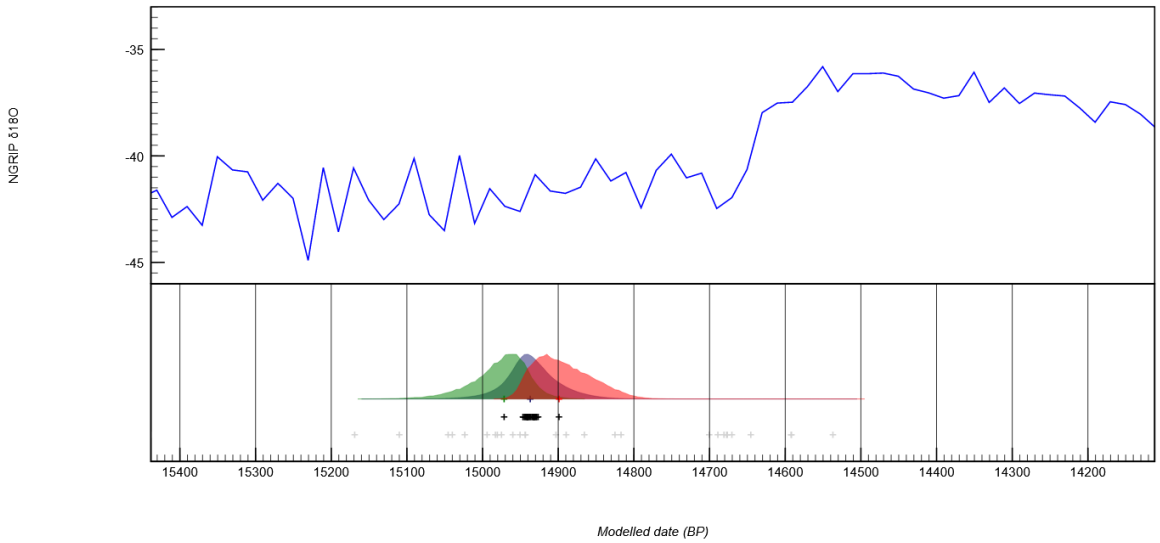


Figure A.85 Early Creswellian. Dates from Jacobi and Higham 2009, 2011. Overlapping uniform phases. Sum Early Creswellian. The onset of the Creswellian is approximately 300 years before the onset of GI-1e.

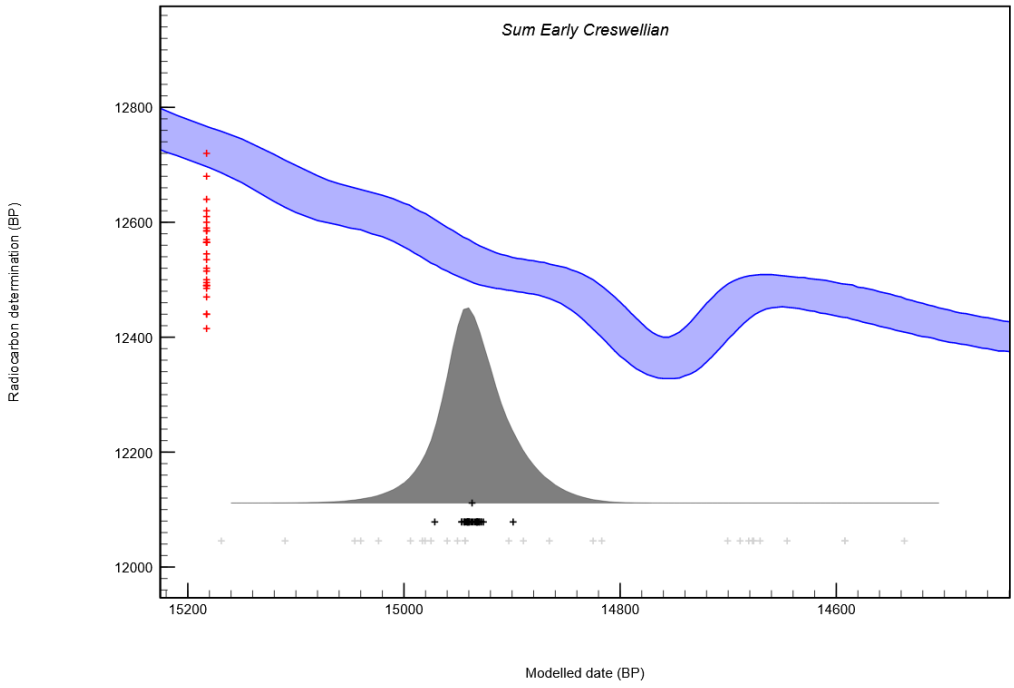


Figure A.86 Early Creswellian. Dates from Jacobi and Higham 2009, 2011. Overlapping uniform phases. Sum Early Creswellian. The Bayesian modelling strongly affects the dating alignment as seen in the medians (crosses, light grey before modelling, black after modelling).

Single KDE

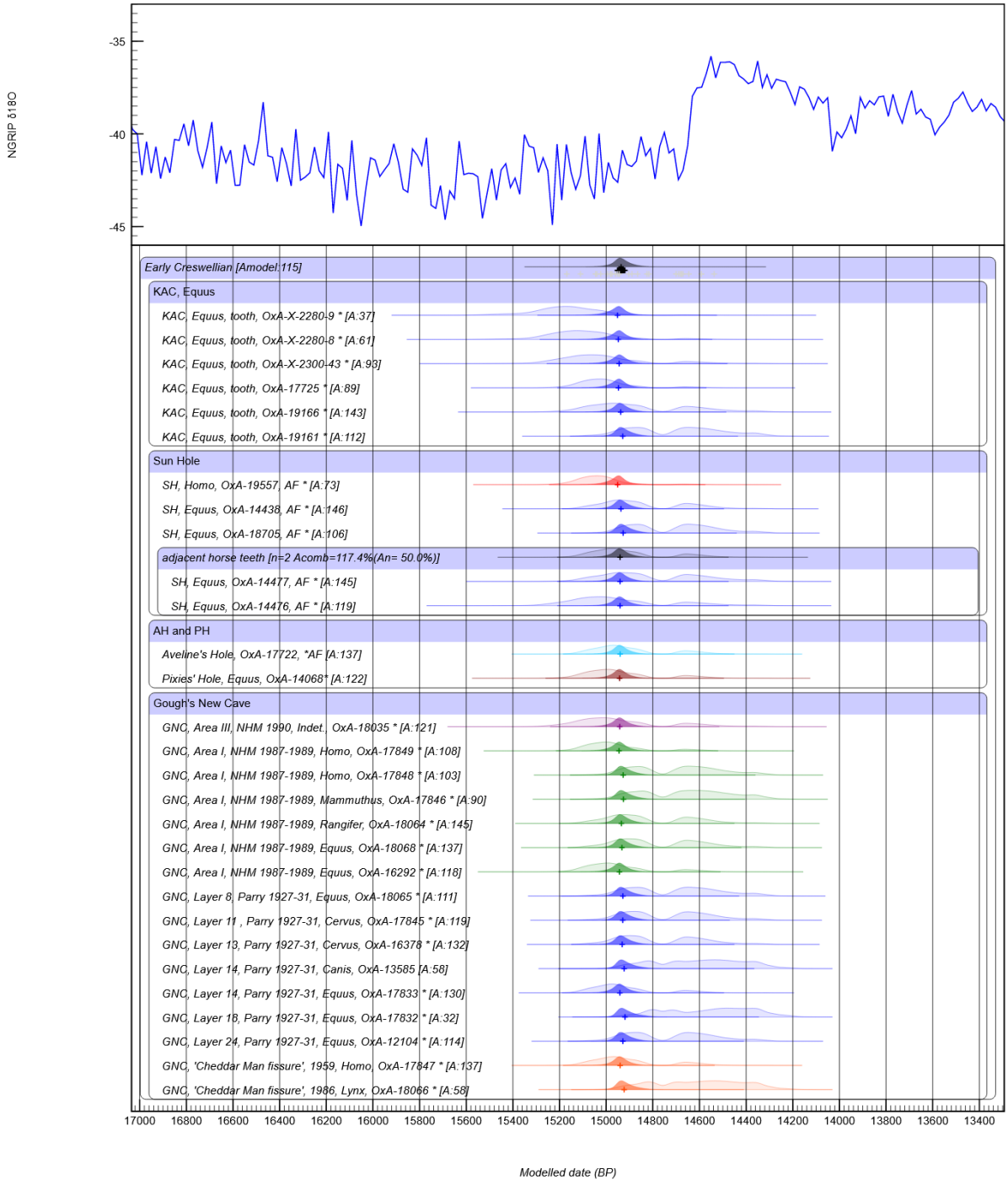


Figure A.87 Early Creswellian. Dates from Jacobi and Higham 2009, 2011. Overlapping uniform phases. Single KDE. The KDE model has a higher Amodel: 115% than the uniform phase model. The dates are also less aligned.

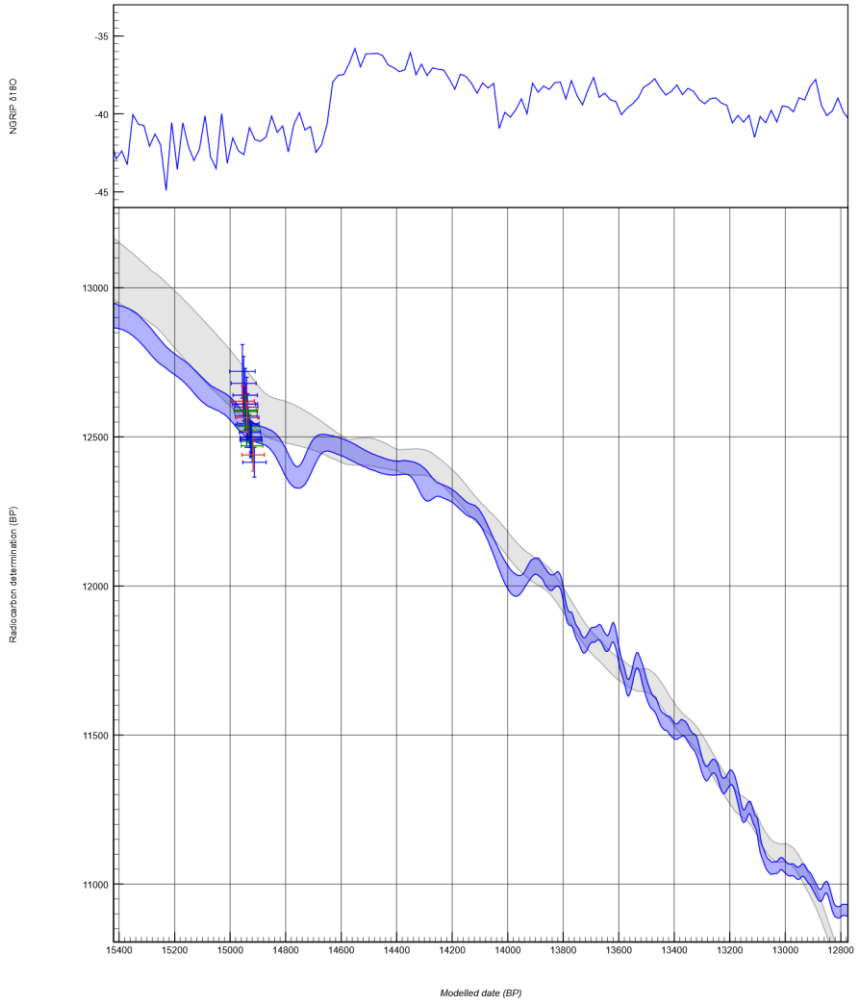


Figure A.88 Early Creswellian. Dates from Jacobi and Higham 2009, 2011. Overlapping uniform phases. Single KDE. These are similar results to the uniform single phase model.

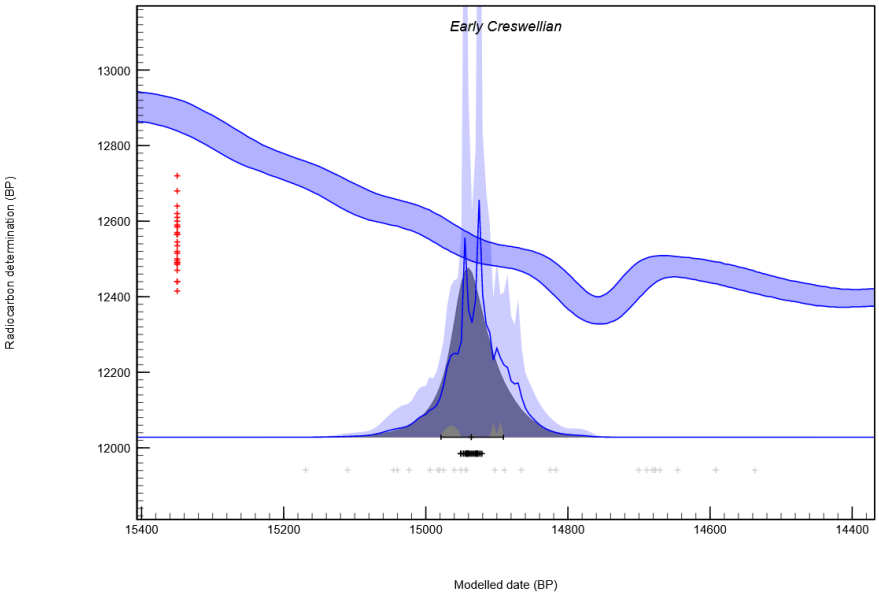


Figure A.89 Early Creswellian. Dates from Jacobi and Higham 2009, 2011. Overlapping uniform phases. Single KDE. These are similar results to the uniform single phase model.

Individual KDE's per site

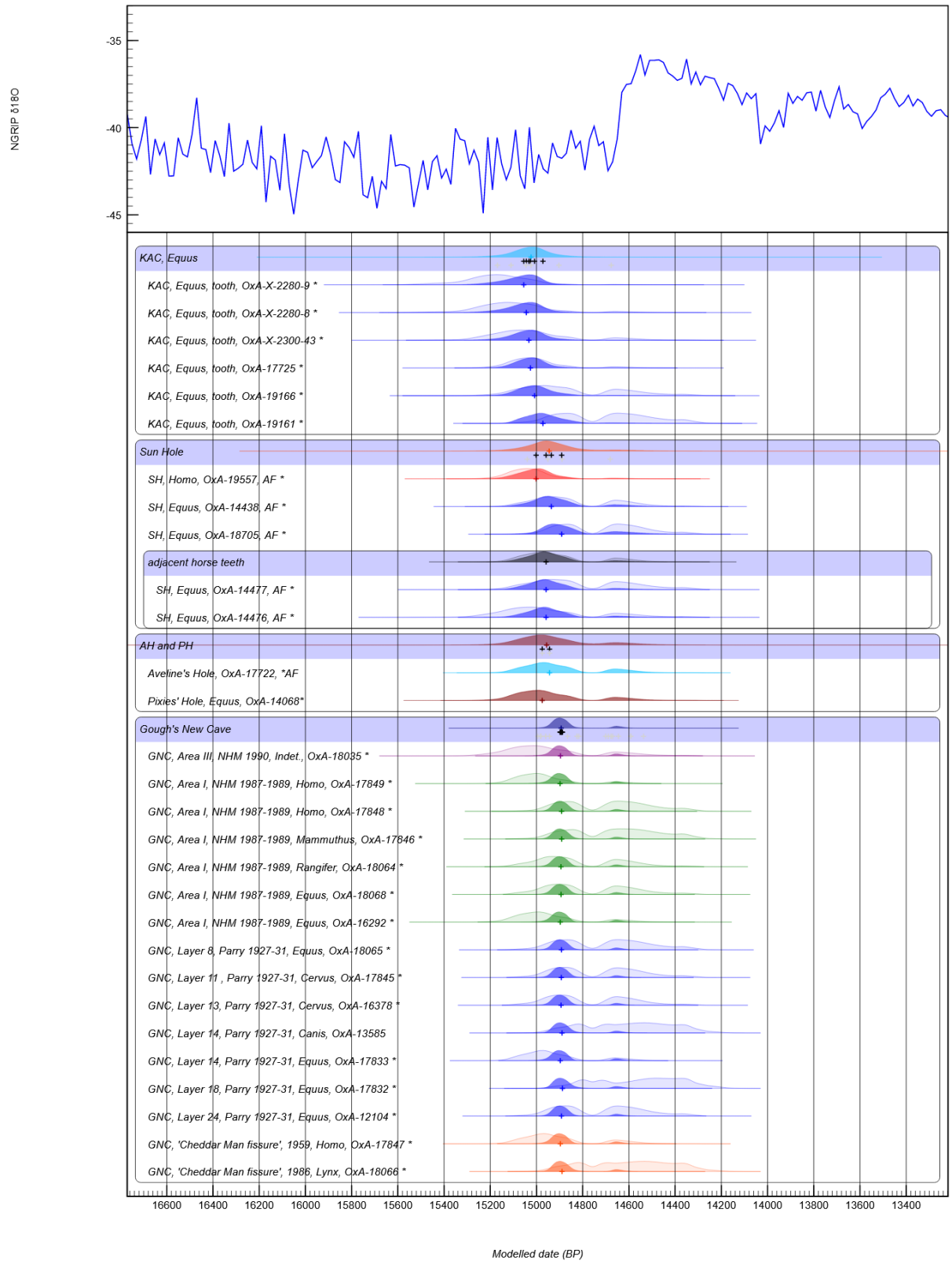


Figure A.90 Early Creswellian. Dates from Jacobi and Higham 2009, 2011. Overlapping uniform phases. Multiple KDEs. Following the low agreements for some of the dates in the overall models, sites were modelled independently, preferring a KDE model as it had a higher agreement. There is a much higher variability, with a potential staggering of the sites from before 15000 cal BP at KAC, and a later phasing at GNC.

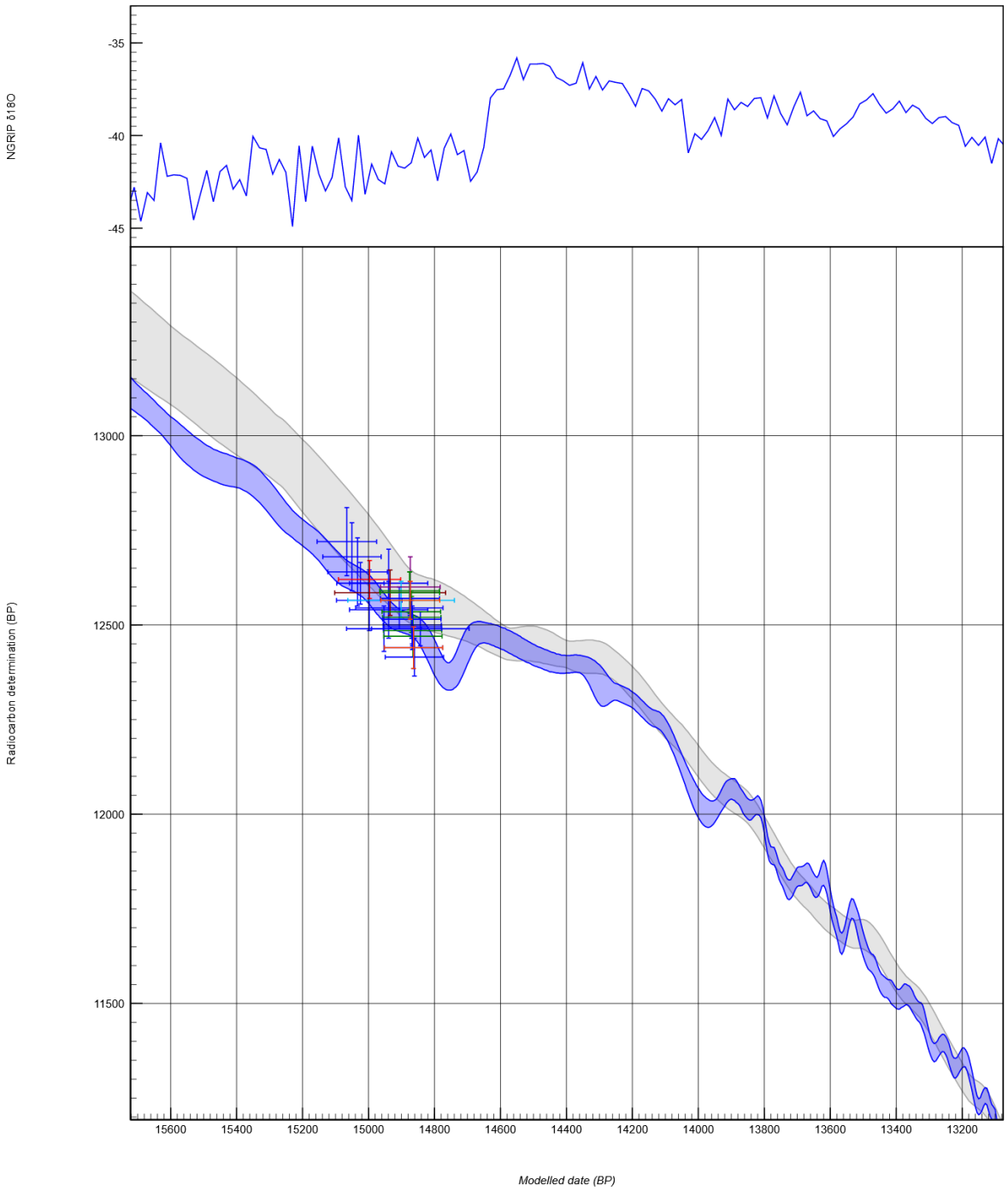


Figure A.91 Early Creswellian. Dates from Jacobi and Higham 2009, 2011. Overlapping uniform phases. Multiple KDEs. When plotted as multiple KDEs, the dates still cluster on a regular section of the curve, however the alignment is less imposed by the model.

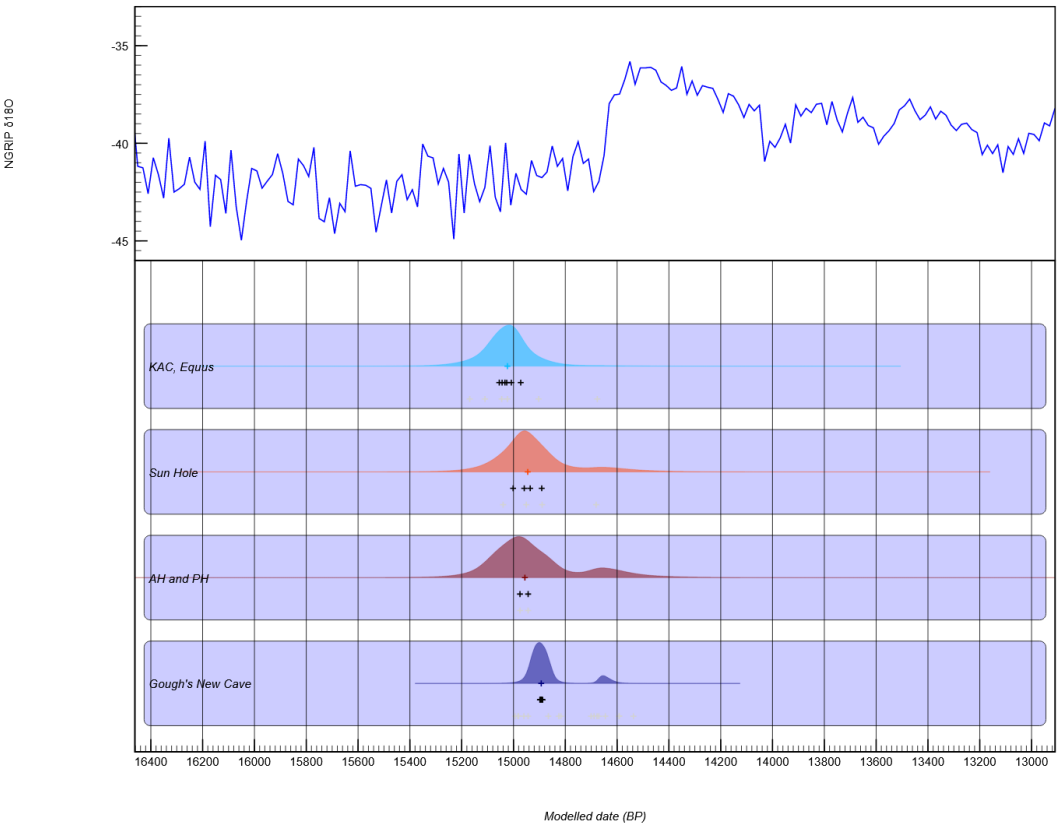


Figure A.92 Early Creswellian. Dates from Jacobi and Higham 2009, 2011. Overlapping KDEs. King Arthur's Cave (KAC) has the earliest series of dates, with the average preceding 15,000 cal BP. This group is closely followed by SH and the individual dates from AH and PH. GNC has a very tight grouping a little later than the earliest three sites.

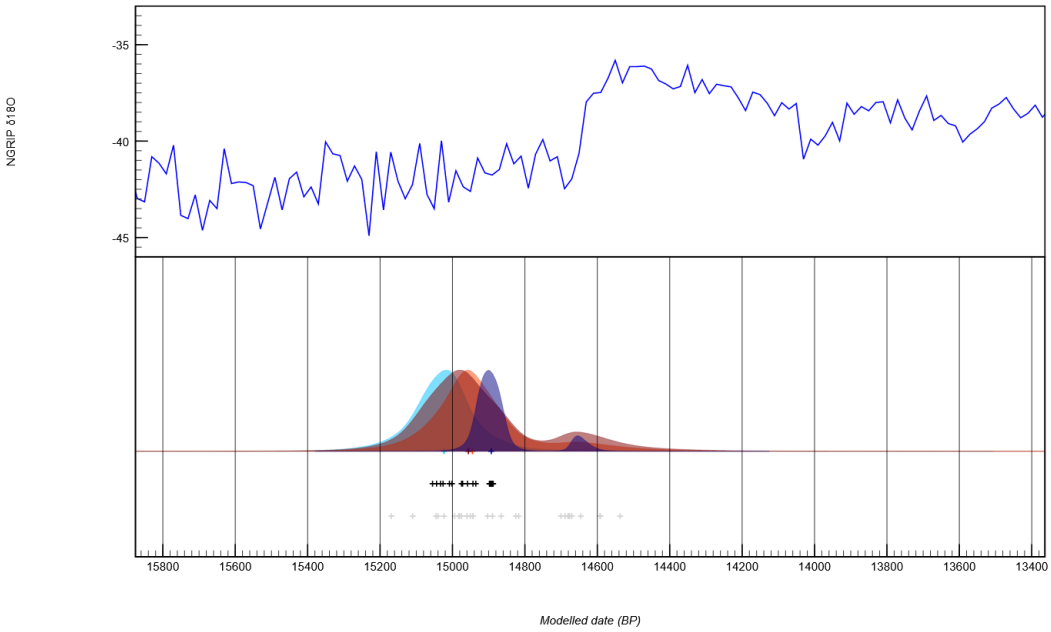


Figure A.93 Early Creswellian. Dates from Jacobi and Higham 2009, 2011. Overlapping KDEs. King Arthur's Cave (KAC) has the earliest series of dates, with the average preceding 15,000 cal BP. This group is closely followed by SH and the individual dates from AH and PH. GNC has a very tight grouping a little later than the earliest three sites.

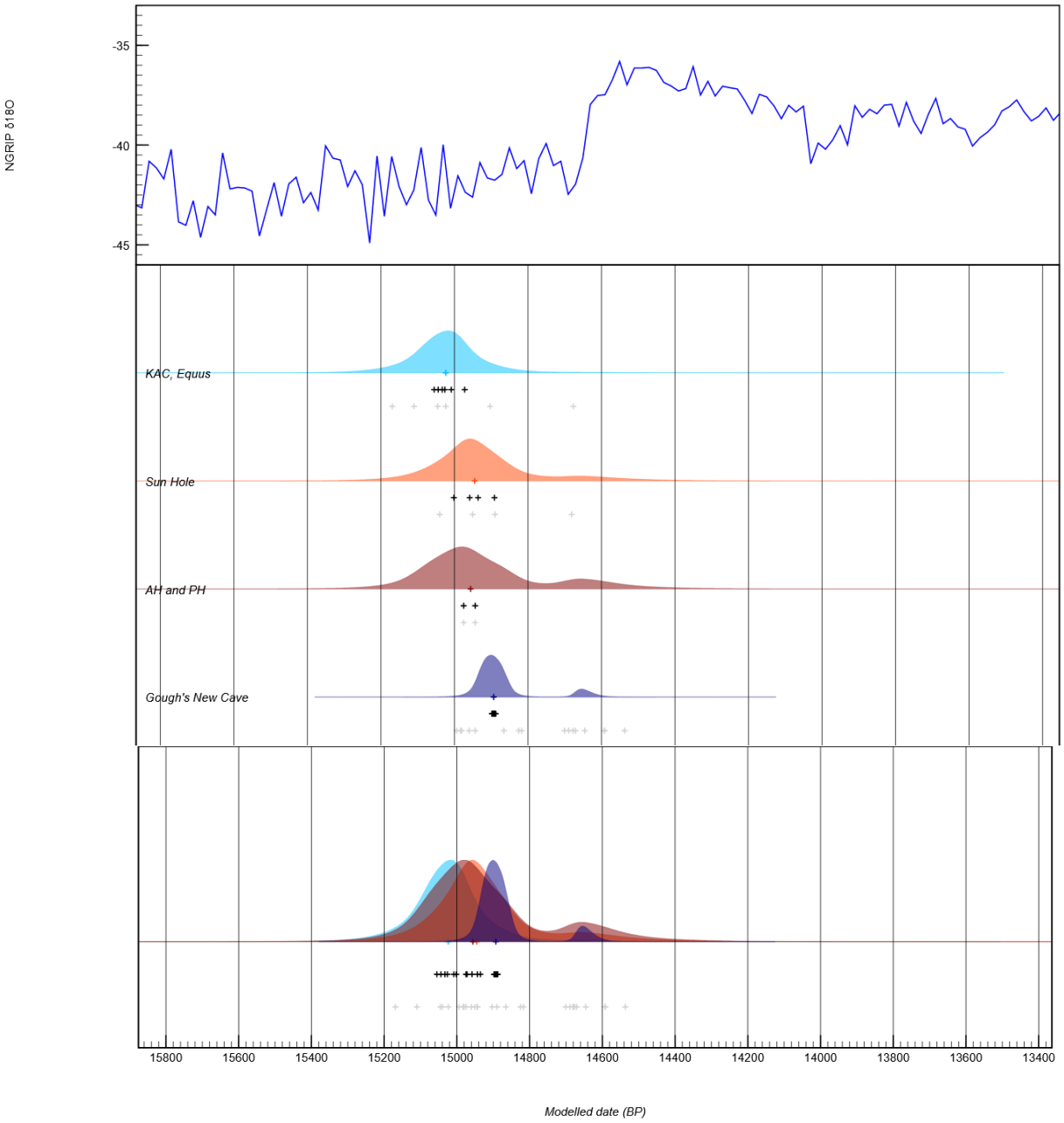


Figure A.94 Early Creswellian. Dates from Jacobi and Higham 2009, 2011. Overlapping uniform phases. Multiple KDEs. Early Creswellian. Dates from Jacobi and Higham 2009, 2011. Overlapping KDEs. King Arthur's Cave (KAC) has the earliest series of dates, with the average preceding 15000 cal BP. This group is closely followed by SH and the individual dates from AH and PH. GNC has a very tight grouping a little later than the earliest three sites.

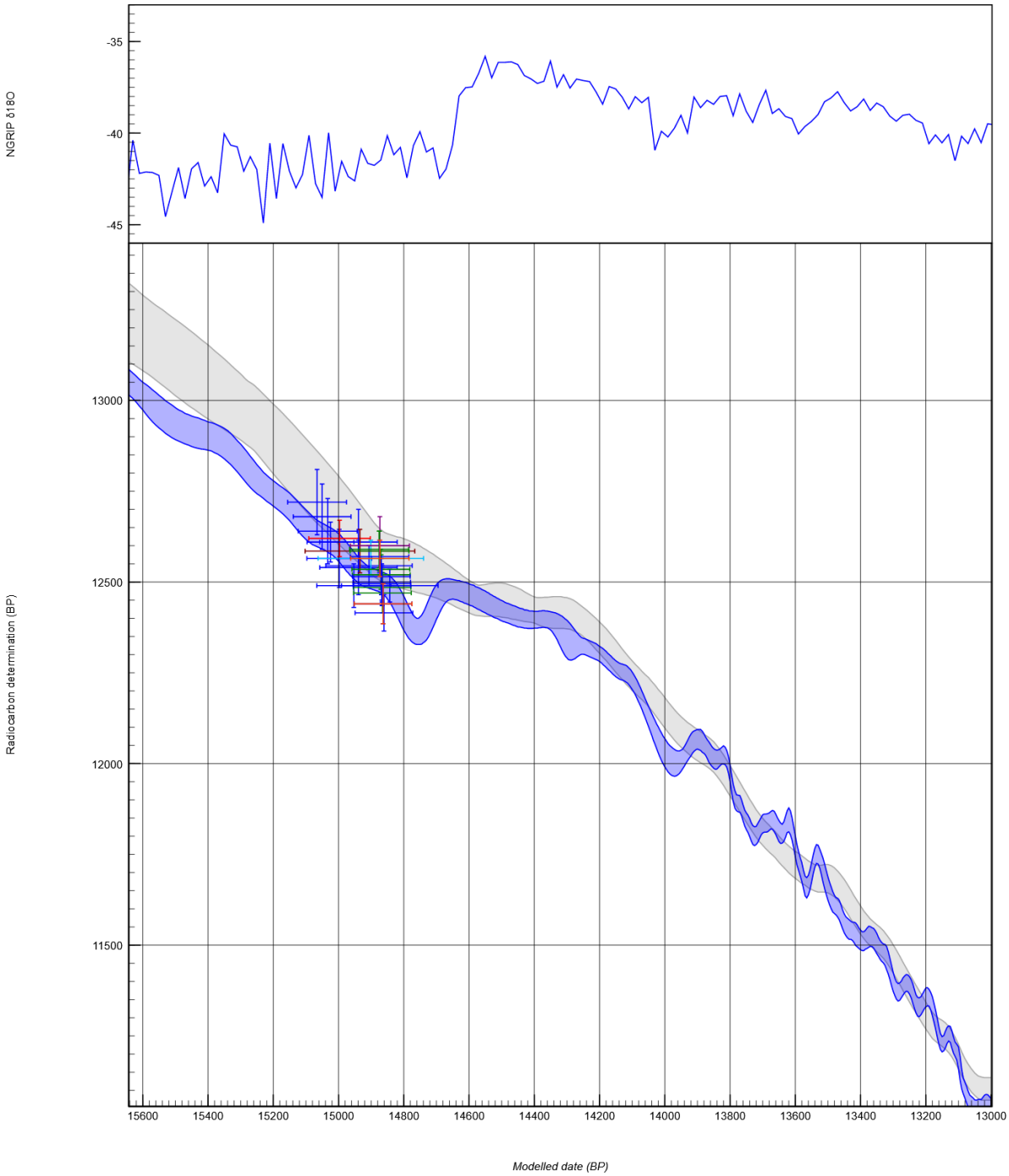


Figure A.95 Early Creswellian. Dates from Jacobi and Higham 2009, 2011. Overlapping uniform phases. Overlapping KDEs.

King Arthur's Cave (KAC)

Overlapping Uniform Phases

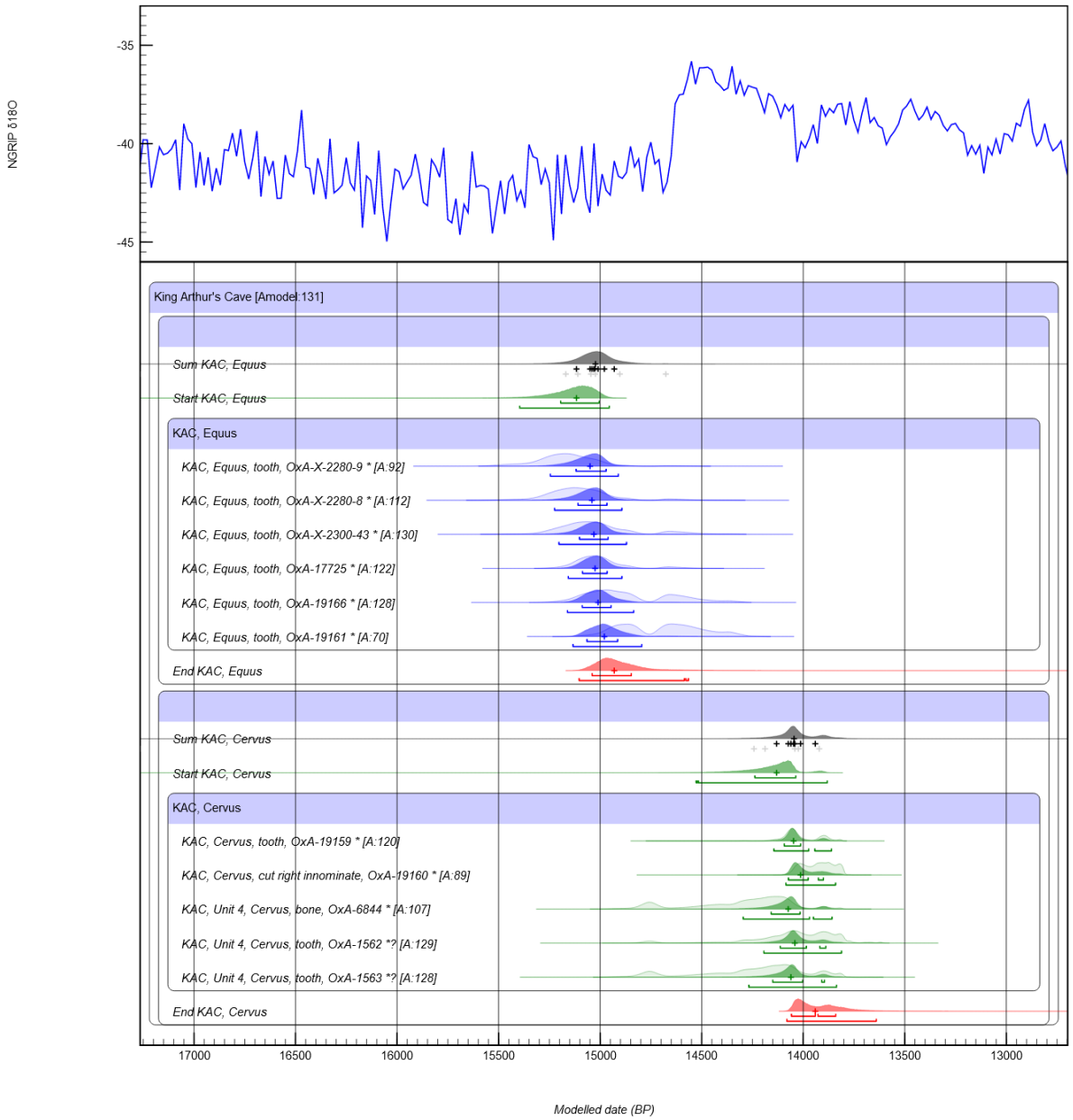


Figure A.96 King Arthur's Cave (KAC). Dates from Jacobi and Higham 2011, Hedges et al. 1987 and Bronk Ramsey et al. 2002. Overlapping uniform phases, no stratigraphic ordering. The two sets of dates are very distinct and homogenous. The earliest dates are on horse (see Jacobi and Higham 2011) whereas the later dates are on Red Deer (Cervus elaphus). Whereas there are no artefacts associated to the earliest dates, the later dates on red deer are associated to Federmesser material (Barton 1996). A pre-Bolling group (assumed Creswellian) and a group grouping towards the transition from GI-1e to 1d. All material is either cut marked or intentionally fractured. Although the Equus material has been modified, no lithics have been found directly in relation to this horizon, however the dates would place it within the Creswellian. The Cervus material was found in relation to the second hearth (OxA-1562 and -1563 Hedges et al. 1987) and a well stratified horizon with a lithic scatter (OxA-6844 Barton 1996, Bronk Ramsey et al. 2002), the dates corroborate a Federmesser interpretation of the lithics techno-typology (Barton 1996, Barton and Roberts 1996). These both need further refining with Bayesian modelling. The three OxA-X dates have lower than accepted collagen weights (<1 wt% collagen) by ORAU (Oxford Research Accelerator Unit), and therefore have this indication (Jacobi and Higham 2011). They are however providing acceptable dates within the model. Amodel: 131% is very good.

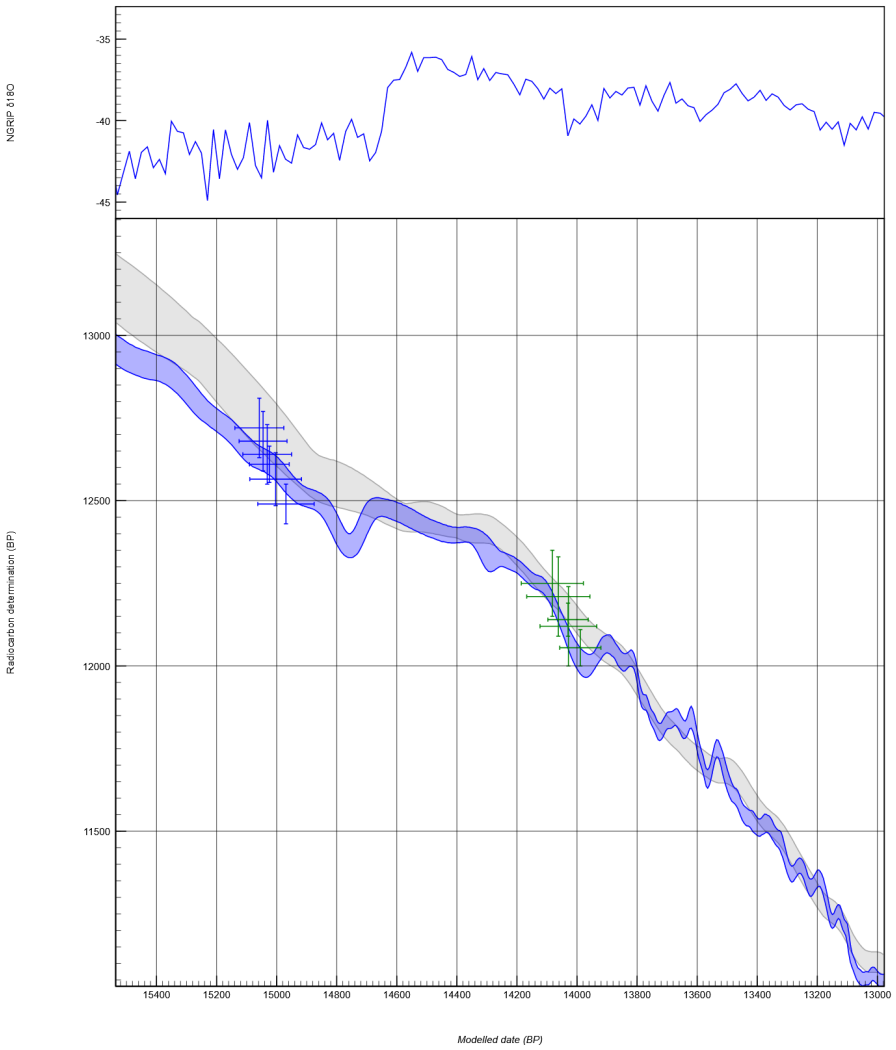


Figure A.97 King Arthur's Cave (KAC). Dates from Jacobi and Higham 2011. Overlapping uniform phases. Both series are on regular parts of the calibration curve. Both have very tight groupings.

Sun Hole (SH)

Overlapping Uniform Phases

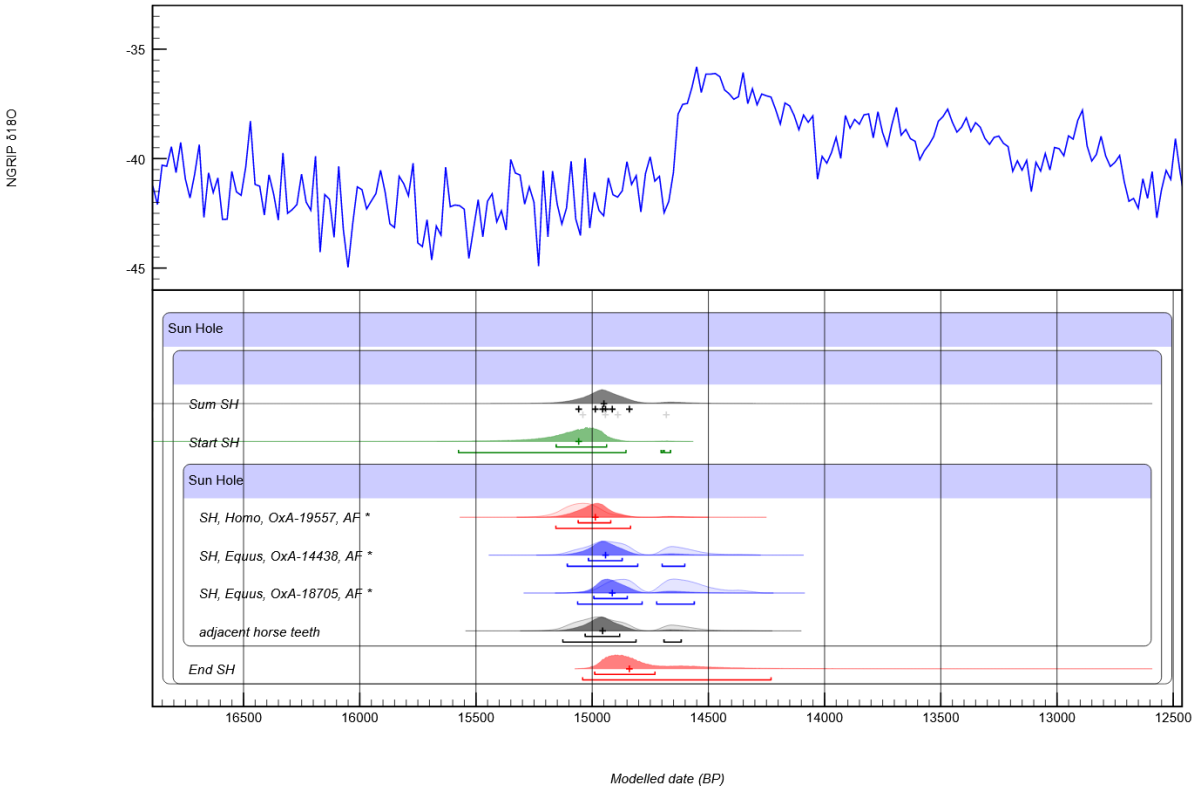


Figure A.98 Sun Hole (SH). Dates from Jacobi and Higham 2011. Single uniform phase. The Sun Hole material is associated to a small Creswellian assemblage, however there is also a Mesolithic presence, but they appear to be distinct (Jacobi and Higham 2011). There is a good agreement of the dates. Human remains are highlighted in red.

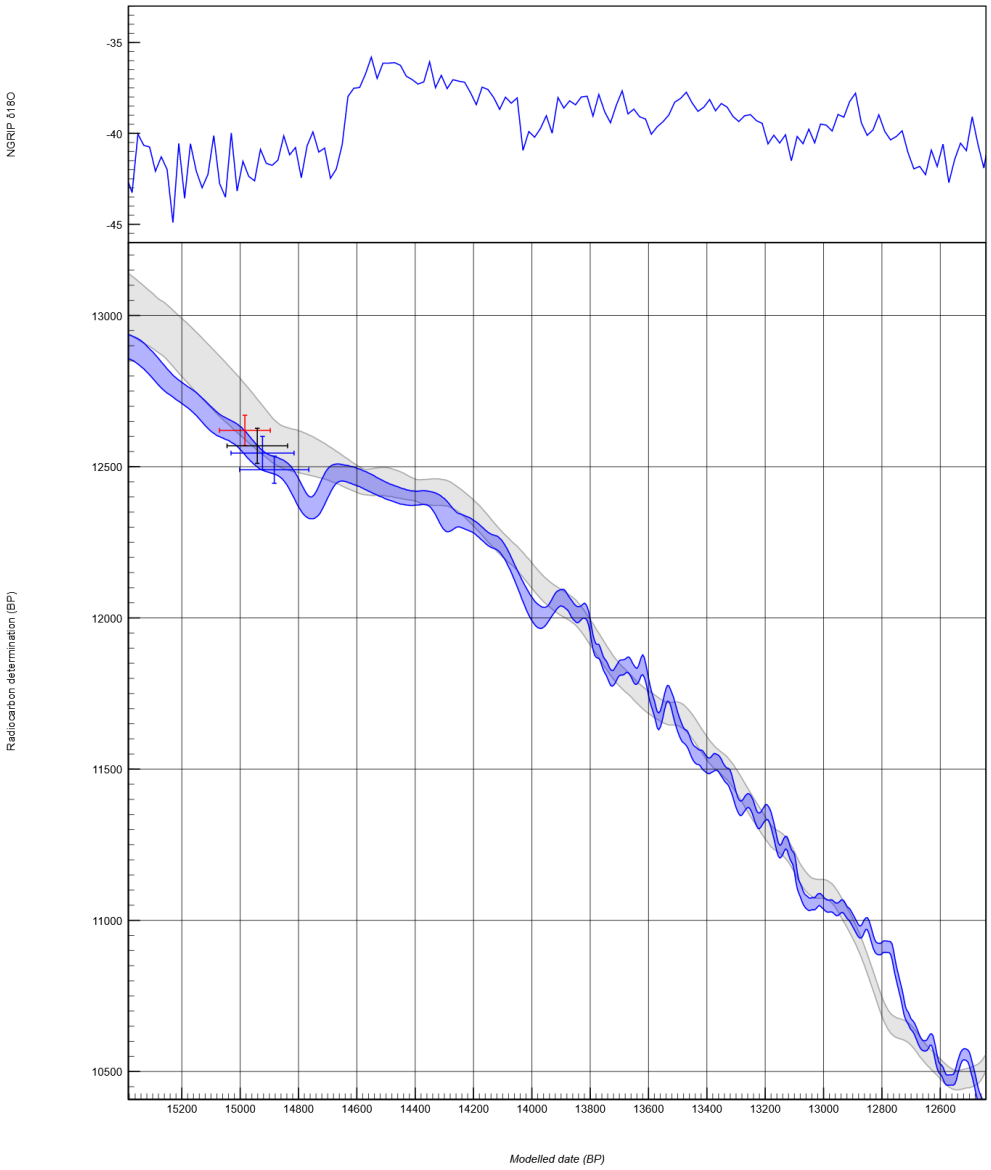


Figure A.99 Sun Hole (SH). Dates from Jacobi and Higham 2011. Single uniform phase. Human remains are highlighted in red.

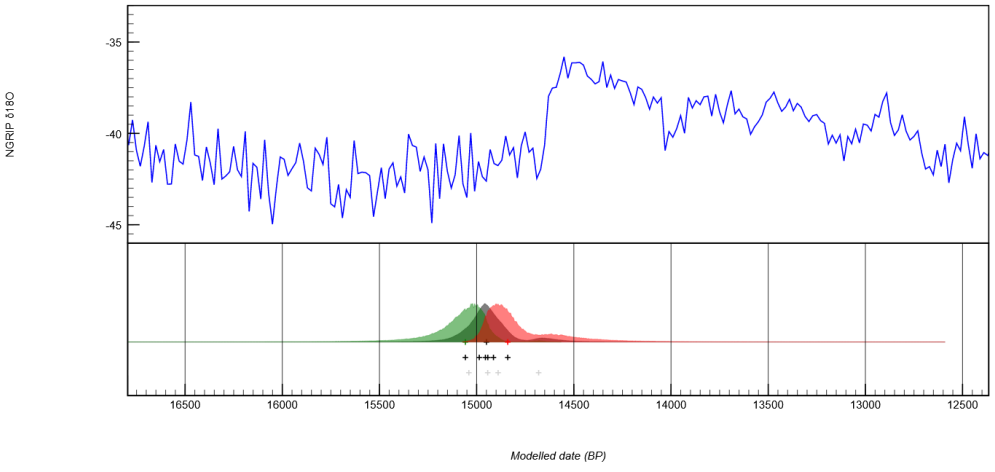


Figure A.100 Sun Hole (SH). Dates from Jacobi and Higham 2011. Single uniform phase.

Aveline's (AH) and Pixies' Holes (PXH)

Overlapping Uniform Phases

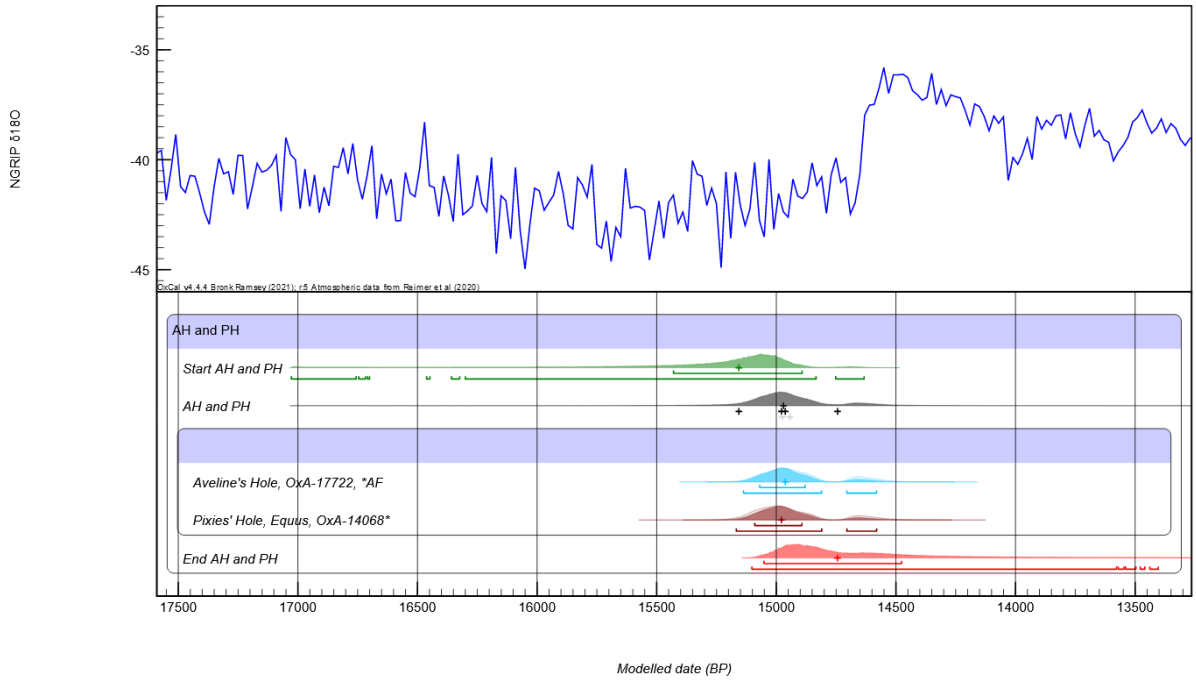


Figure A.101 Aveline's Hole (AH) and Pixie's Hole (PXH) selected early dates. Neither are directly associated to archaeology, but both have cut marks. Dates from Jacobi and Higham 2011. Single uniform phase. N.b. the Equus bone from Pixies' hole is not associated to the excavation and lithics assemblage (Collcutt 1986). These dates are treated separately here. See below for Allerød dates. Of interest is also the early date for red deer (AH). Most of the assemblages from Aveline's Hole were destroyed during the second world war, however several artefacts have been retrieved and associated to the Creswellian (Jacobi 2005). The presence of Cheddar points confirms a Creswellian occupation of the cave (Jacobi 2005). There is also the presence of large curved backed points made on anvil, as illustrated by Garrod 1926, and identical to examples at Gough's Cave. These have been associated to the Creswellian assemblage and the early date (Jacobi 2005), however penknife points were also amongst the assemblage indicating a Federmesser presence. The presence of backed bladelets is a possible indication of an Early Federmesser occupation like Hengistbury Head and Nea Farm that both have bi-points (Jacobi 2005, Barton 2009), however they could also be early Mesolithic (Jacobi 2005). The attribution of the bi-points therefore remains unclear and could be related the early or a later undated occupation. The cheddar points do confirm a Creswellian occupation consistent with this date.

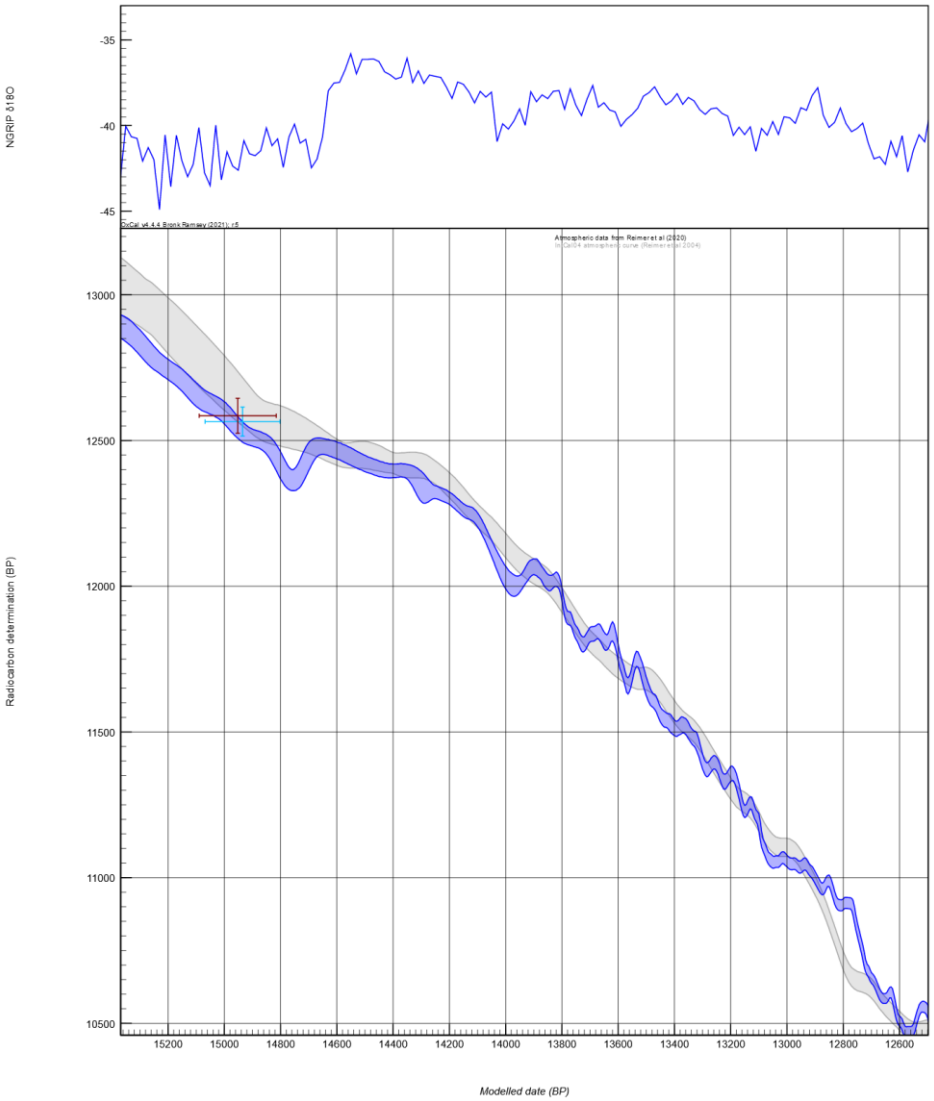


Figure A.102 Aveline's Hole and Pixie's Hole selected early dates. Neither are directly associated to archaeology, but both have cut marks. Dates from Jacobi and Higham 2011. Overlapping uniform phases. IntCal04 (grey, Reimer et al. 2004) in the background as a reference.

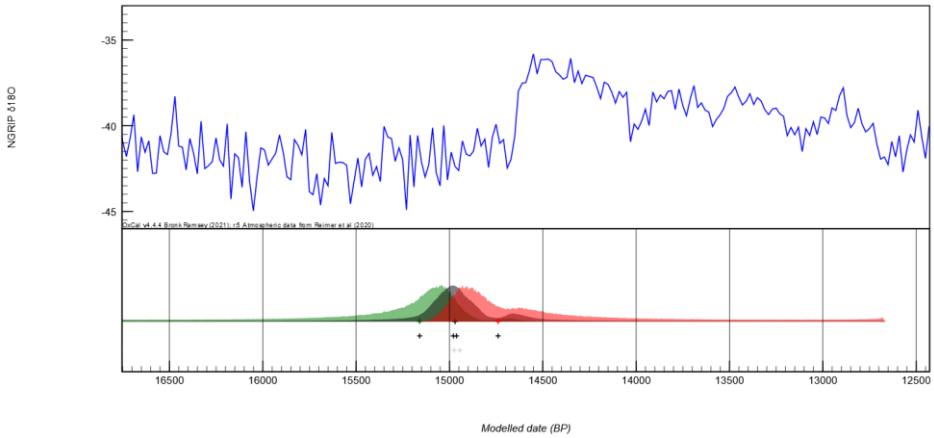


Figure A.103 Aveline's Hole and Pixie's Hole selected early dates. Neither are directly associated to archaeology, but both have cut marks. Dates from Jacobi and Higham 2011. Overlapping uniform phases.

Gough's (New) Cave (GNC)

All of the labelled "Gough's Cave" here are from deposits in Gough's "New" Cave (Collcutt 1985) as opposed to the earlier Gough's "Old" Cave (Irwin 1986).

Single Uniform Phase

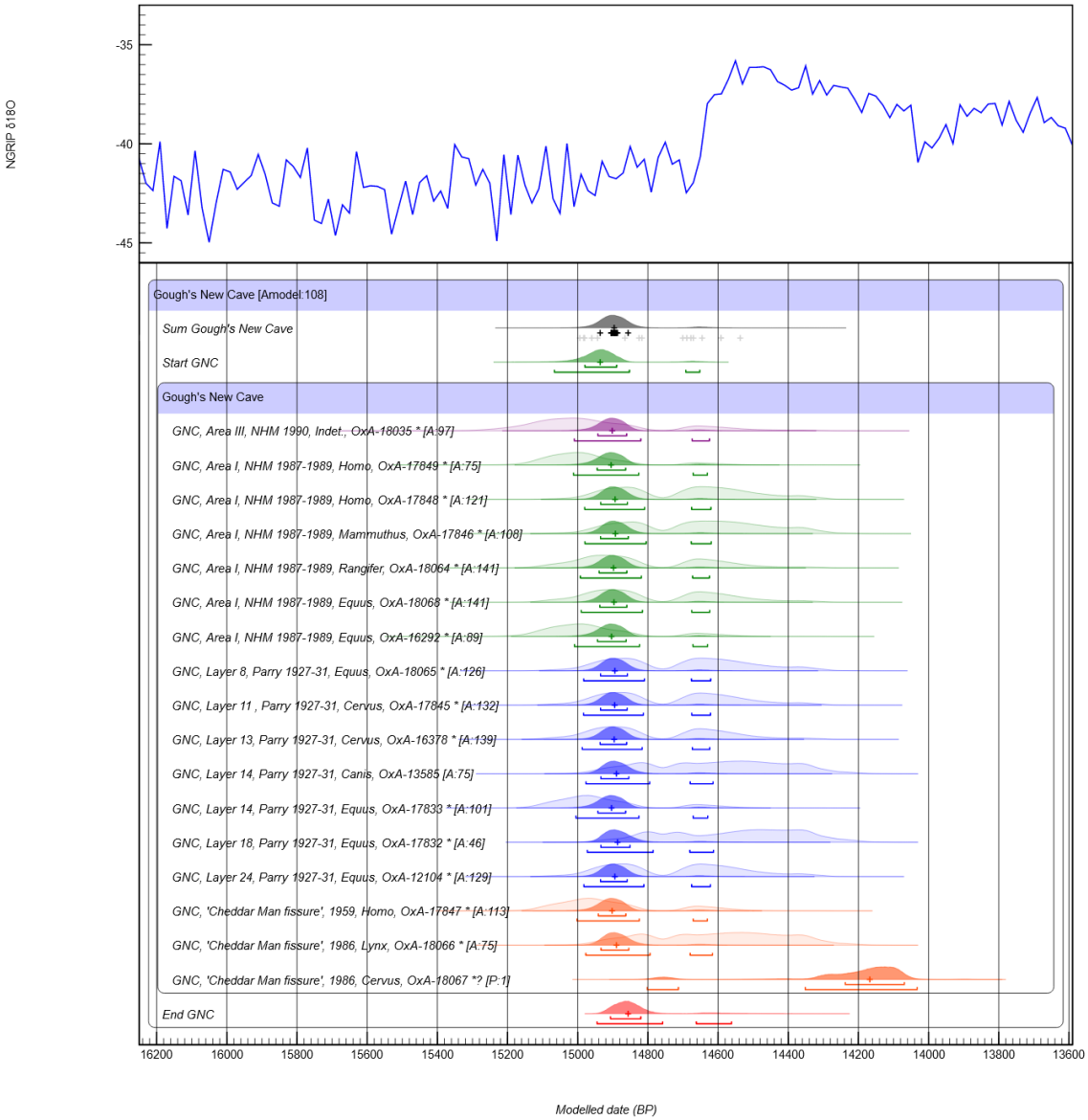


Figure A.104 Gough's (New) Cave (GNC), dates selected based on cut marked and modified material and in stratigraphic order per excavation area (colouring). Dates from Jacobi and Higham 2011. Simple Plot. The NHM (Natural History Museum) excavations were recorded with modern methods, whereas the Parry excavation material was ordered based on past field notes by R. Jacobi (Jacobi and Higham 2009). The most recent date deviates from the group (OxA-18067) and has been identified as an outlier, possibly indicating a later phase of occupation (Jacobi and Higham 2011). This later phase of occupation, potentially Federmessergruppen or Azilian, would help explain the presence of bipoints (Jacobi and Higham 2011: 233-234), however an early date for this material is also a possibility as the Azilian is present in the Paris Basin around this time. The dates have a tight alignment around 14,900 cal BP. OxA-18067 is treated as an outlier. Amodel 108% is very good. The date of OxA-18035 in Area 3 of the 1990 NHM excavation is significant, as it is directly associated to en-éperon knapping characteristics. Amodel: 108% is high.

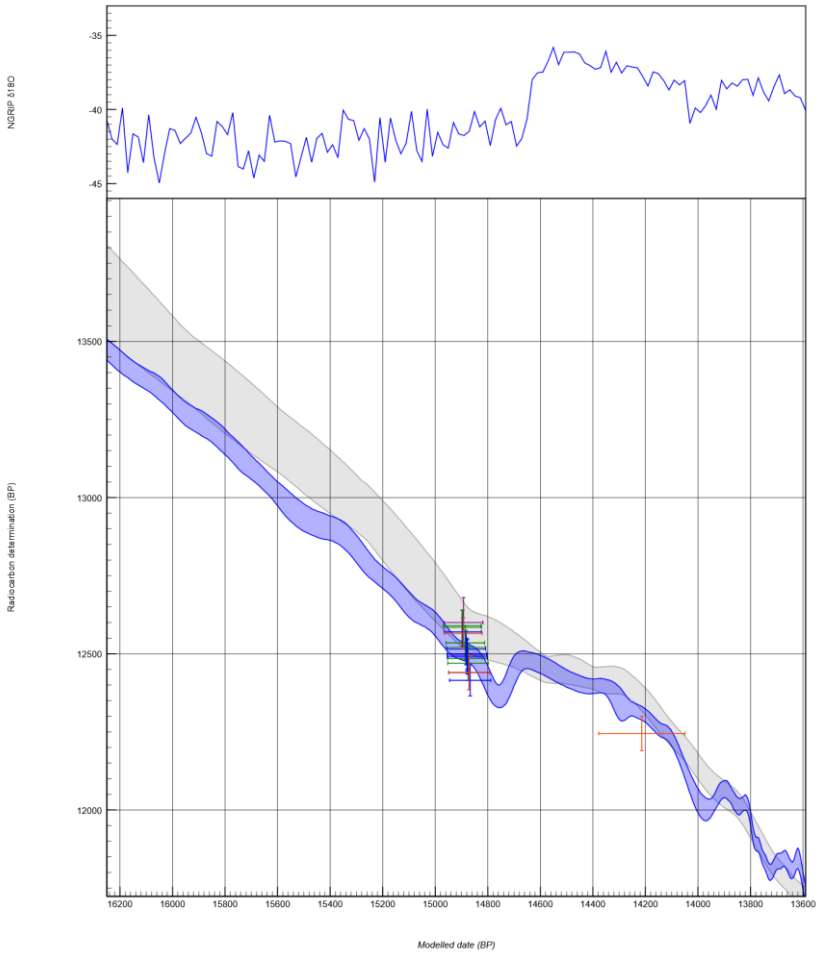


Figure A.105 Gough's (New) Cave (GNC). Dates from Jacobi and Higham 2011. Single uniform phase. The dates cluster around a regular segment of the curve.

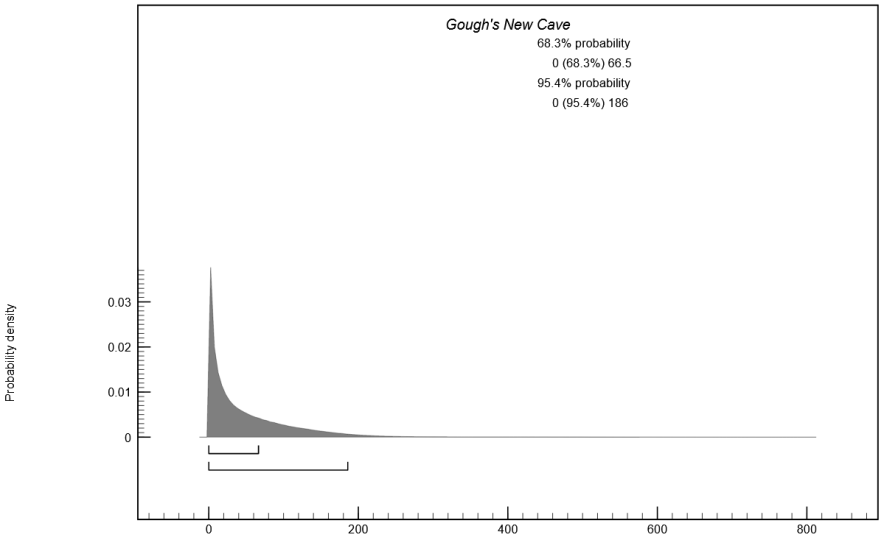


Figure A.106 Gough's New Cave (GNC), dates selected based on cut marks and in stratigraphic order per excavation area (Jacobi and Higham 2011). KDE model per area compared, IntCal20. The span indicates a much shorter duration than when modelled on the IntCal04 curve (Jacobi and Higham 2011), 0-66.5 years at 68.3% with a very sharp peak at the onset, and less than 180 years at 95%. This favours a short window of occupancy of the cave as suggested by Jacobi and Higham 2011.

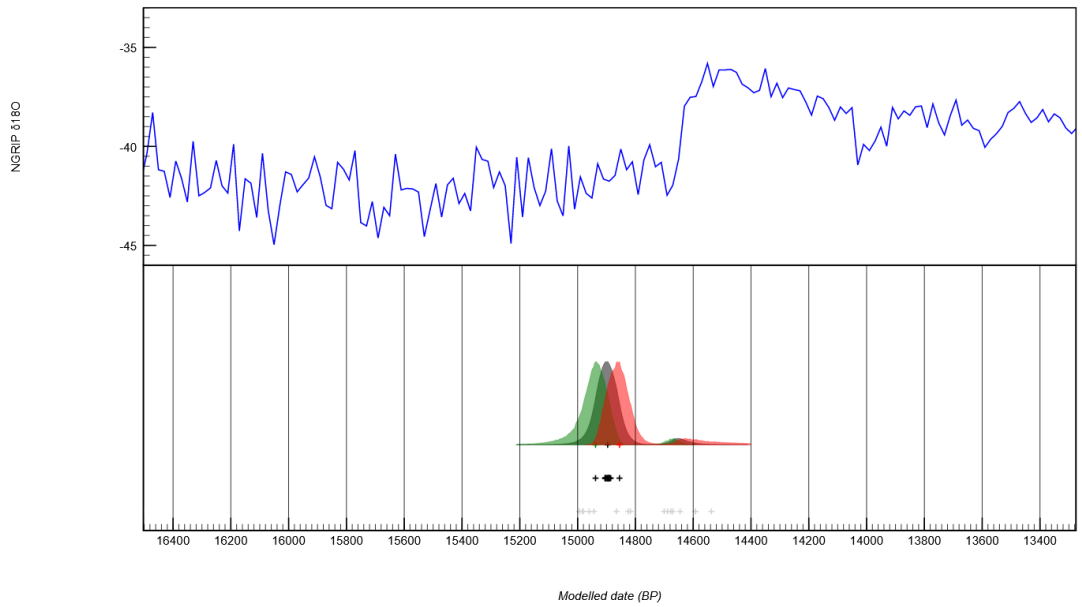


Figure A.107 Gough's (New) Cave (GNC). Dates from Jacobi and Higham 2011. Single uniform phase.

Overlapping Uniform Phases

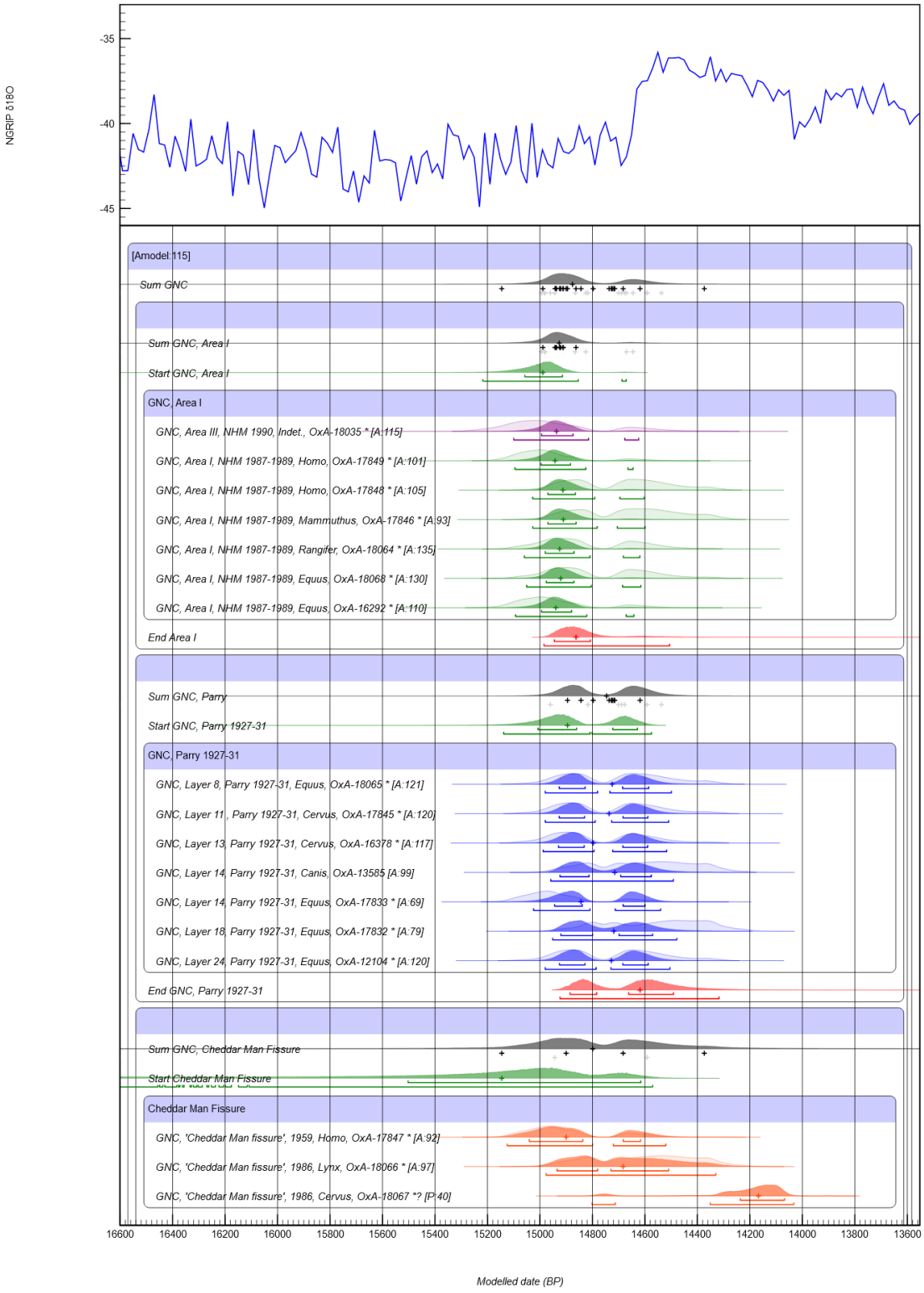


Figure A.108 Gough's (New) Cave (GNC). Dates from Jacobi and Higham 2011. Single uniform phase. OxA-18067 does not fit the model, and has been left as an outlier for reference. It is considered as an indication as a later occupation (Jacobi and Higham 2011). The dates have a tight alignment around 14900 cal BP. OxA-18067 is treated as an outlier. Amodel 108% is very good. The date of OxA-18035 in Area 3 of the 1990 NHM excavation is significant, as it is directly associated to en-éperon knapping characteristics. Amodel: 115% is high and just as valid as a single phase model.

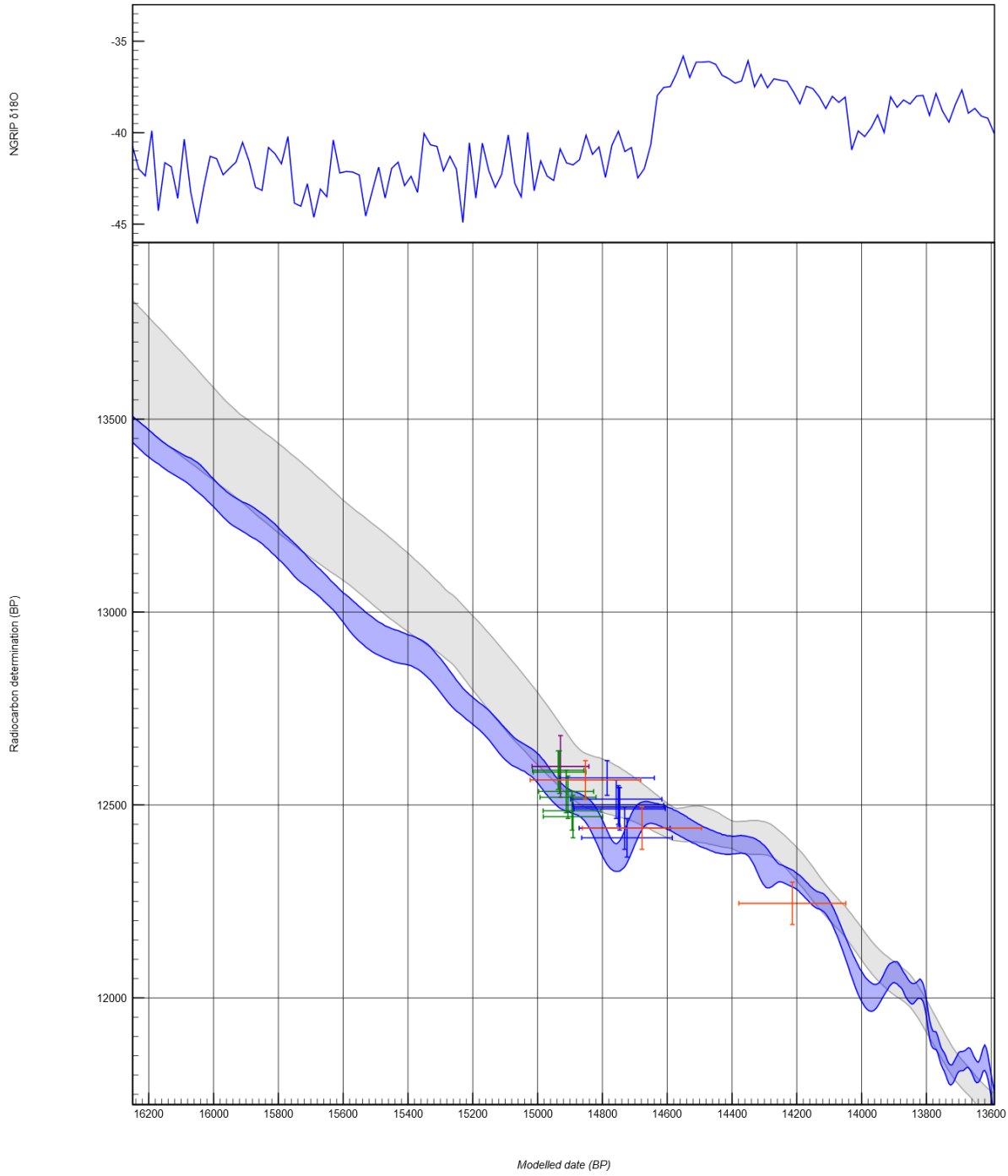


Figure A.109 Gough's (New) Cave (GNC). Dates from Jacobi and Higham 2011. Single uniform phase. OxA-18067 does not fit the model, and has been left as an outlier for reference. The two groups of dates are distinct, one preceding a large wiggle (green) and the latter within the wiggle and at the onset of the GI-1e plateau. With this prior, Gough's Cave would represent multiple Creswellian occupations, transitioning between the earliest (better resolution) group of site (ECres) and the latter group which plots along the GI-1e plateau (LCres).

KDE Model, multi-phase

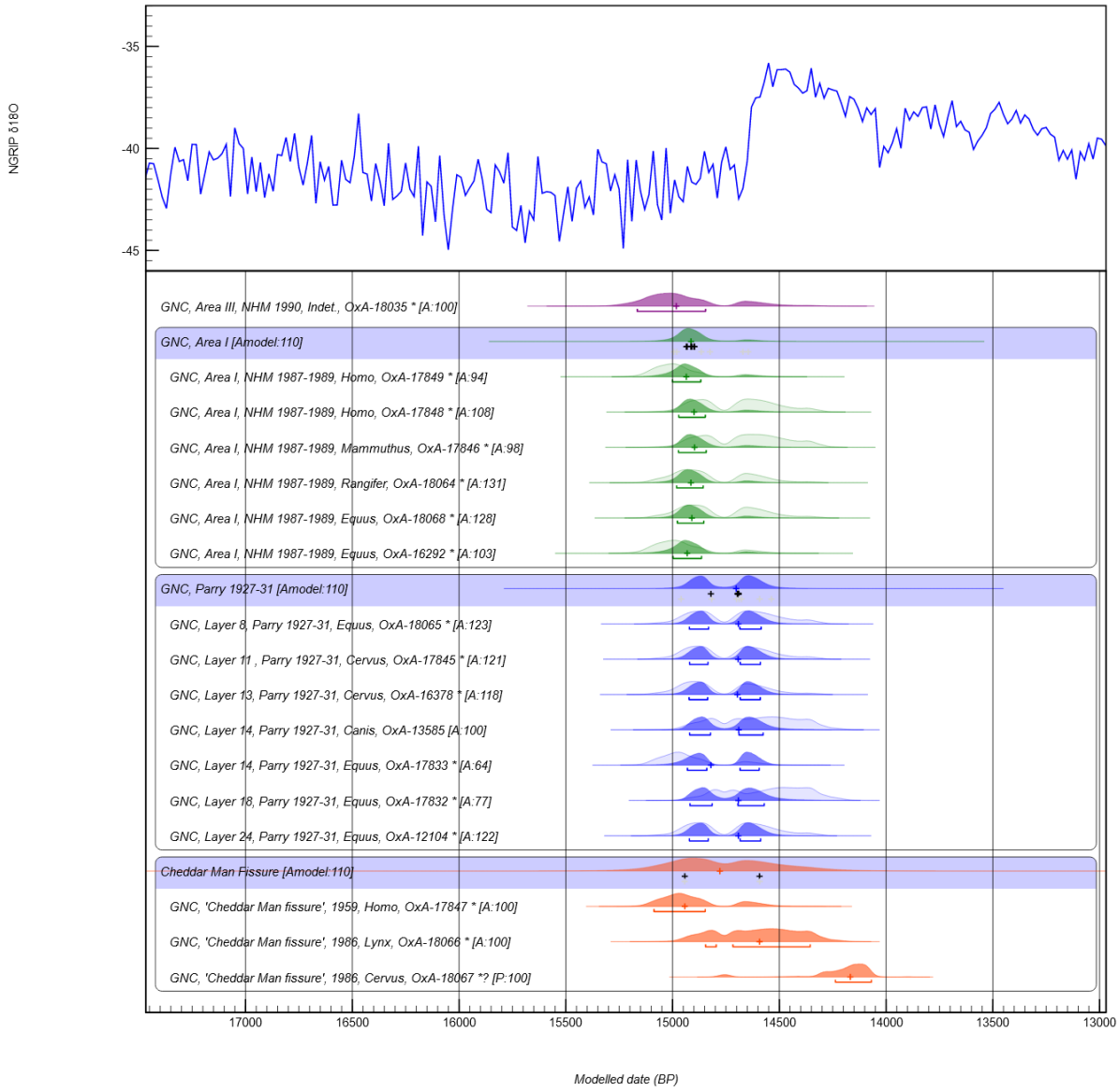


Figure A.110 Gough's (New) Cave (GNC). Dates from Jacobi and Higham 2011. Overlapping KDE models per excavation. This model differs significantly from a single uniform phase model. The NHM excavation material appears to predate the Parry excavation by 200-300 years. The Cheddar Man fissure material falls into three groups, the earliest date on human remains fits with the early NHM results centred around 14,900 cal BP, whereas the lynx would fit better with the later phase. Finally, the red deer is significantly later. Amodel: 100% with no individual dates below acceptable agreement levels.

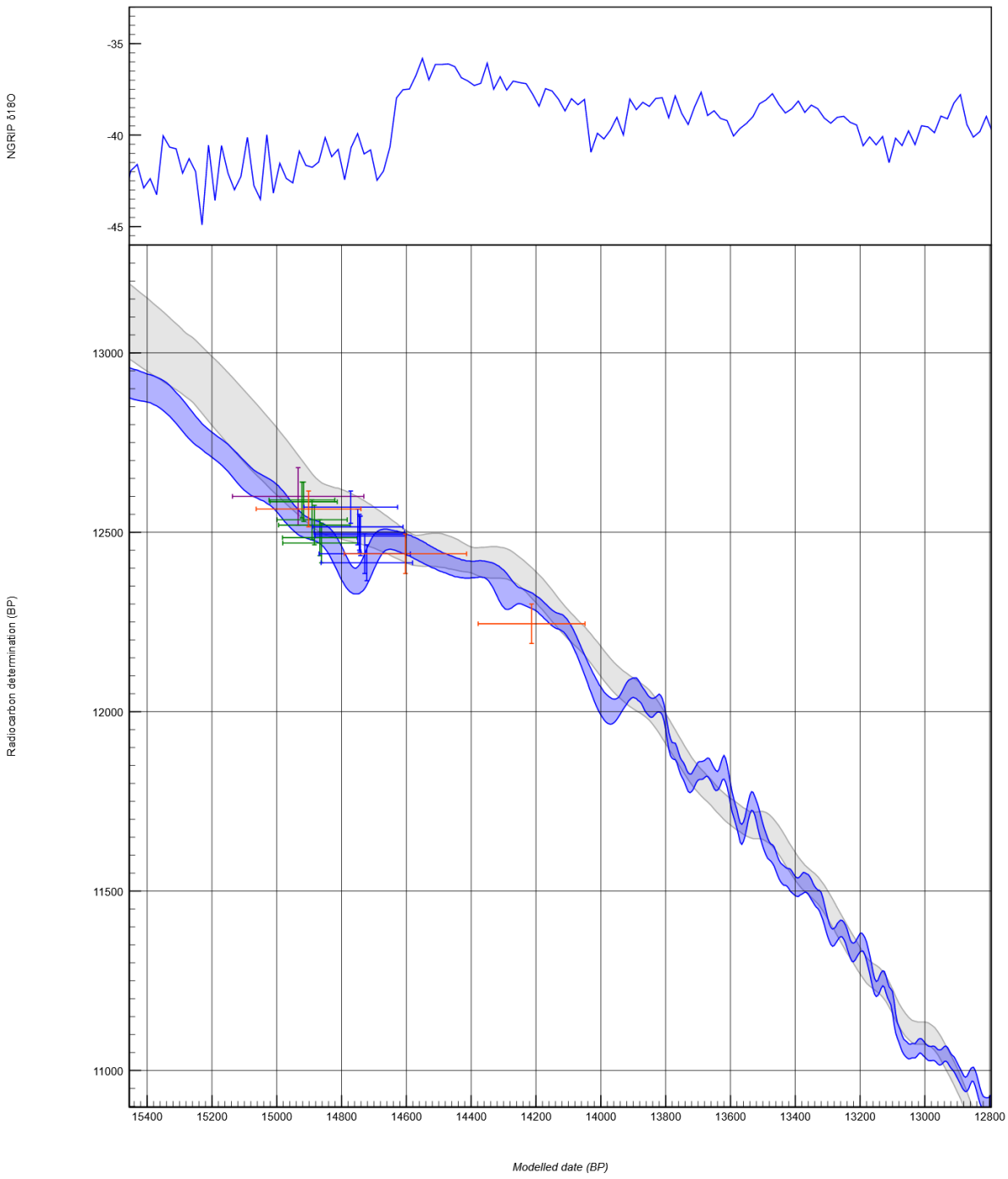


Figure A.111 Gough's (New) Cave (GNC). Dates from Jacobi and Higham 2011. Overlapping KDE models per excavation.

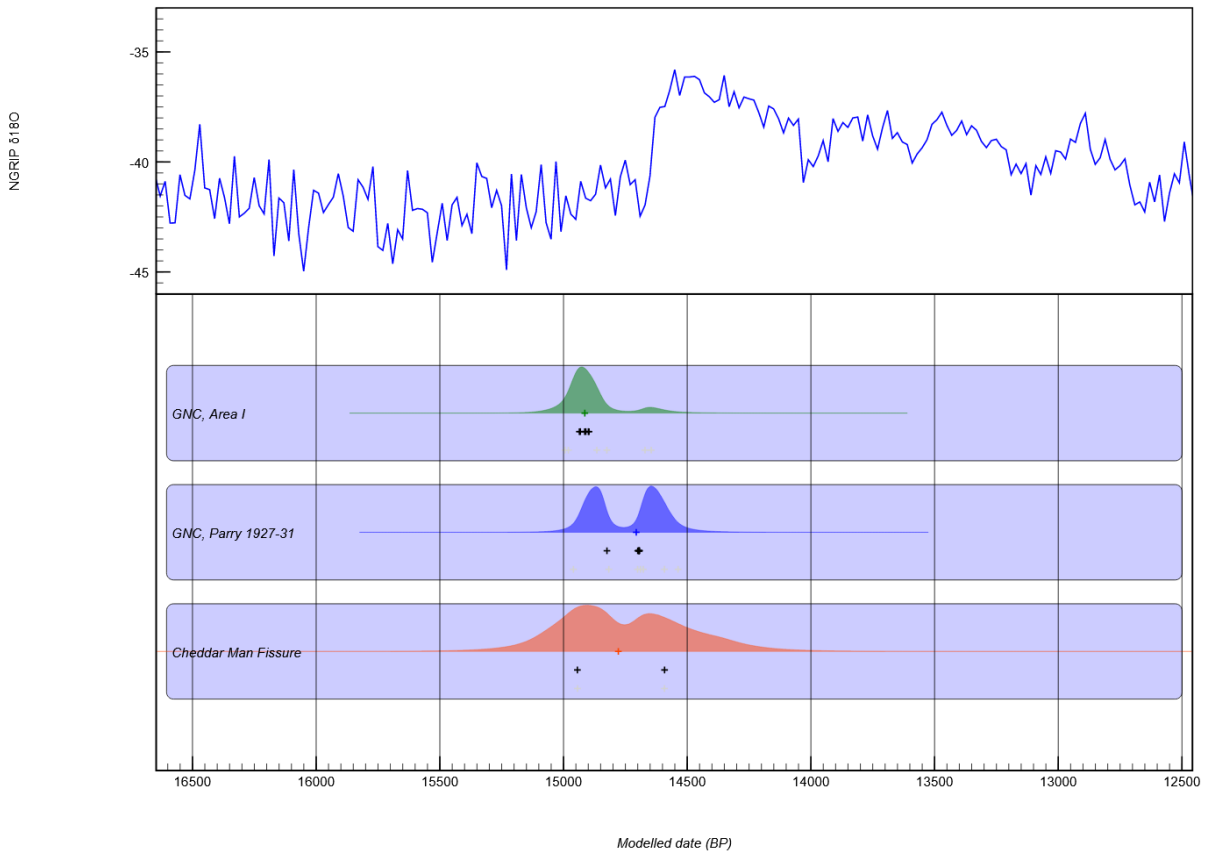


Figure A.112 Gough's (New) Cave (GNC). Dates from Jacobi and Higham 2011. Overlapping KDE models without OxA-18067. The distinct grouping of dates is clear in the KDE models unlike the single uniform phase where the dates are more constrained.

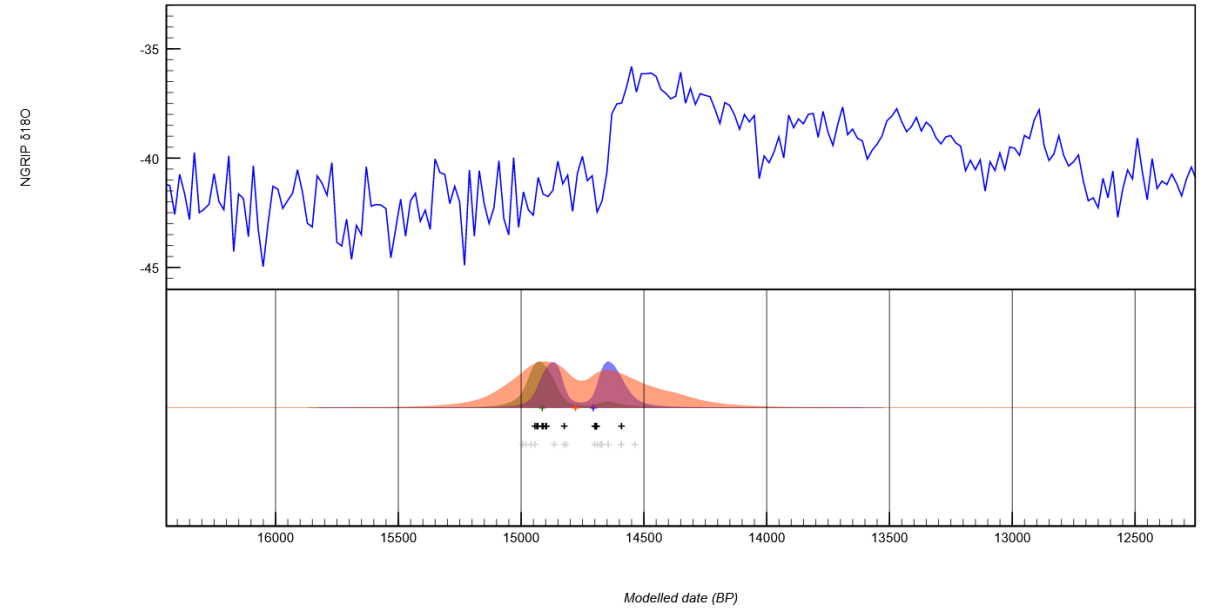


Figure A.113 Gough's (New) Cave (GNC). Dates from Jacobi and Higham 2011. Overlapping KDE models per excavation, stacked results.

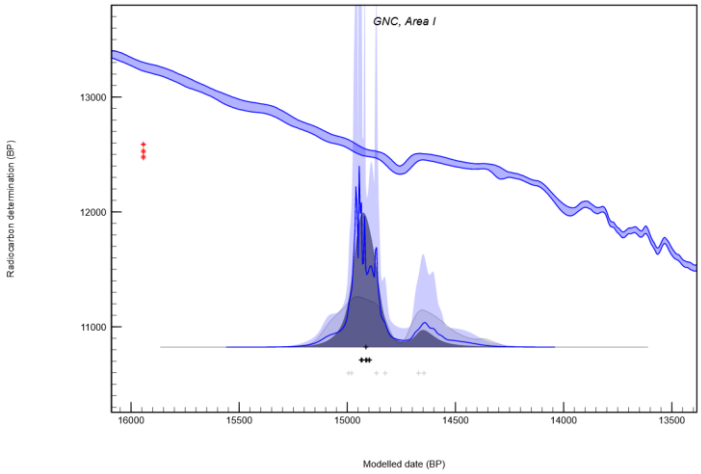


Figure A.114 Gough's (New) Cave (GNC). Dates from Jacobi and Higham 2011. Overlapping KDE model for Area I.

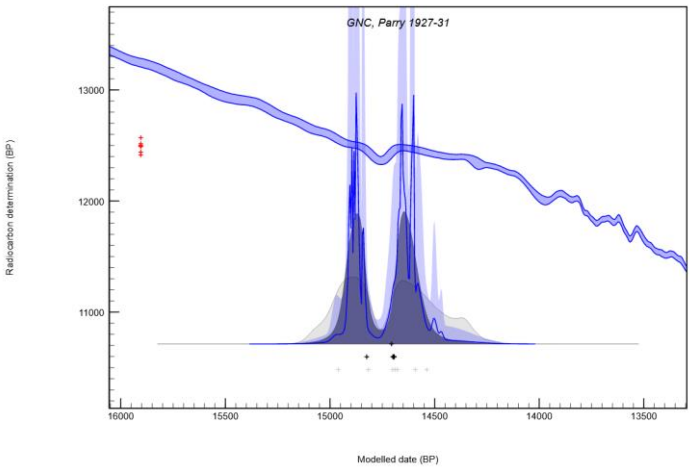


Figure A.115 Gough's (New) Cave (GNC). Dates from Jacobi and Higham 2011. Overlapping KDE model for material recovered from the Parry excavation.

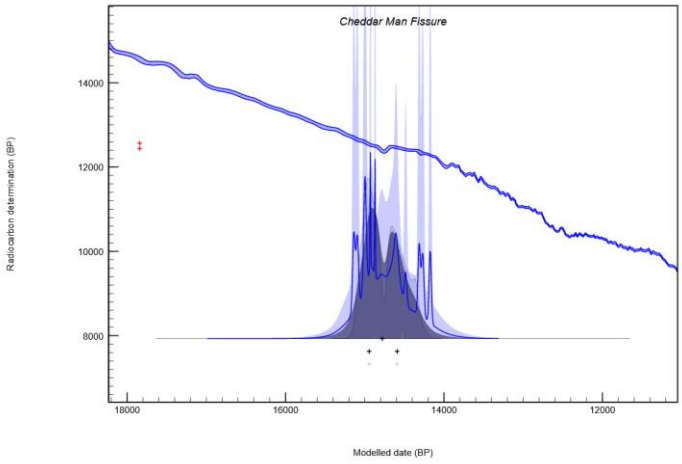


Figure A.116 Gough's (New) Cave (GNC). Dates from Jacobi and Higham 2011. Overlapping KDE model for material recovered from the Cheddar man fissure.

KDE Model, single phase

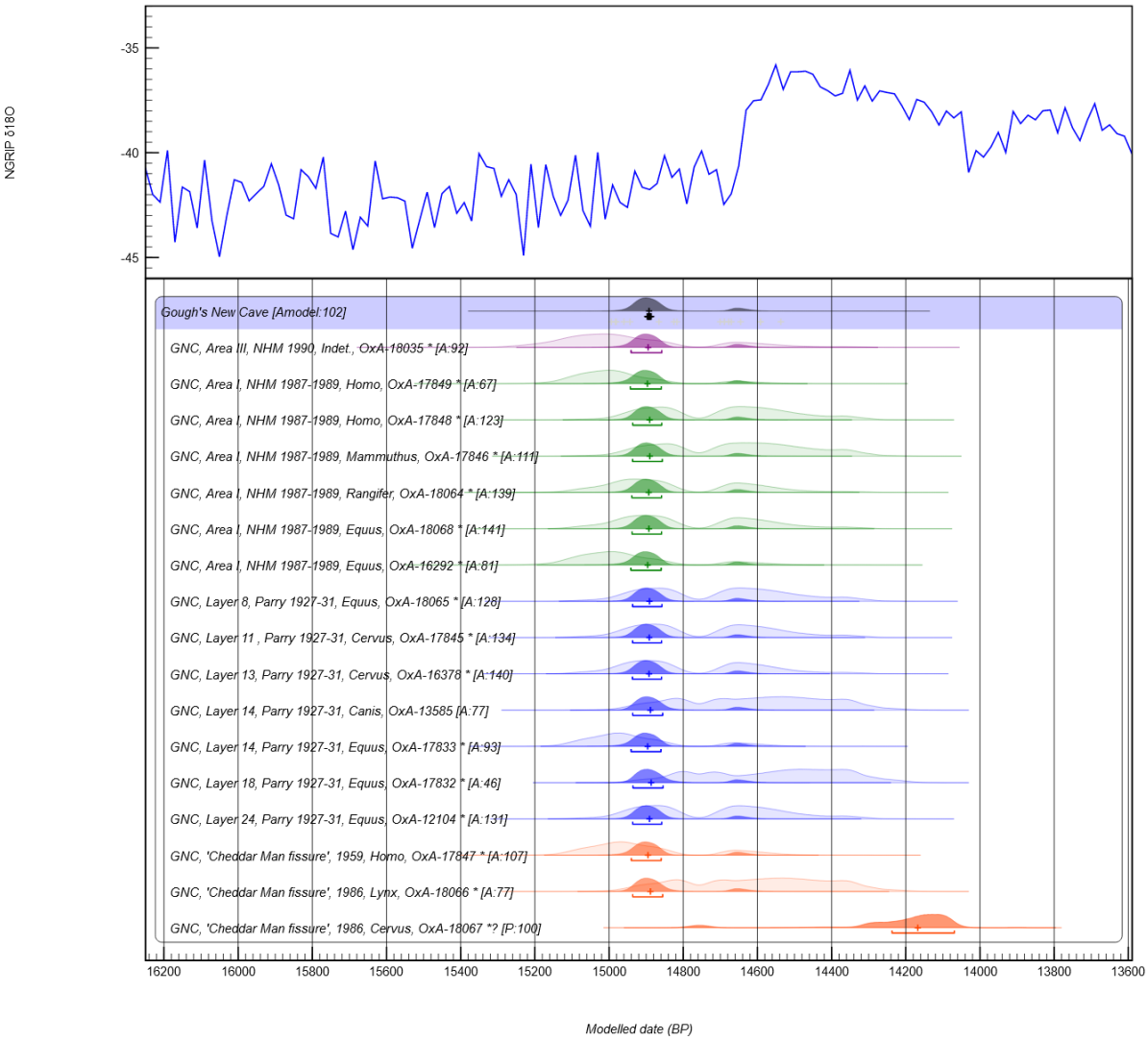


Figure A.117 Gough's (New) Cave (GNC). Dates from Jacobi and Higham 2011. Single phase KDE model. OxA-18067 does not fit the model, and has been left as an outlier for reference. It is considered as an indication as a later occupation and treated as an outlier here, not affecting the modelling of the other dates (Jacobi and Higham 2011). The dates align very well centred on 14,900 cal BP. It is not apparent which model is correct, a single uniform KDE or independent KDEs per excavation, as they both have good agreements. Amodel: 102% is similar to the modelling of individual excavations.

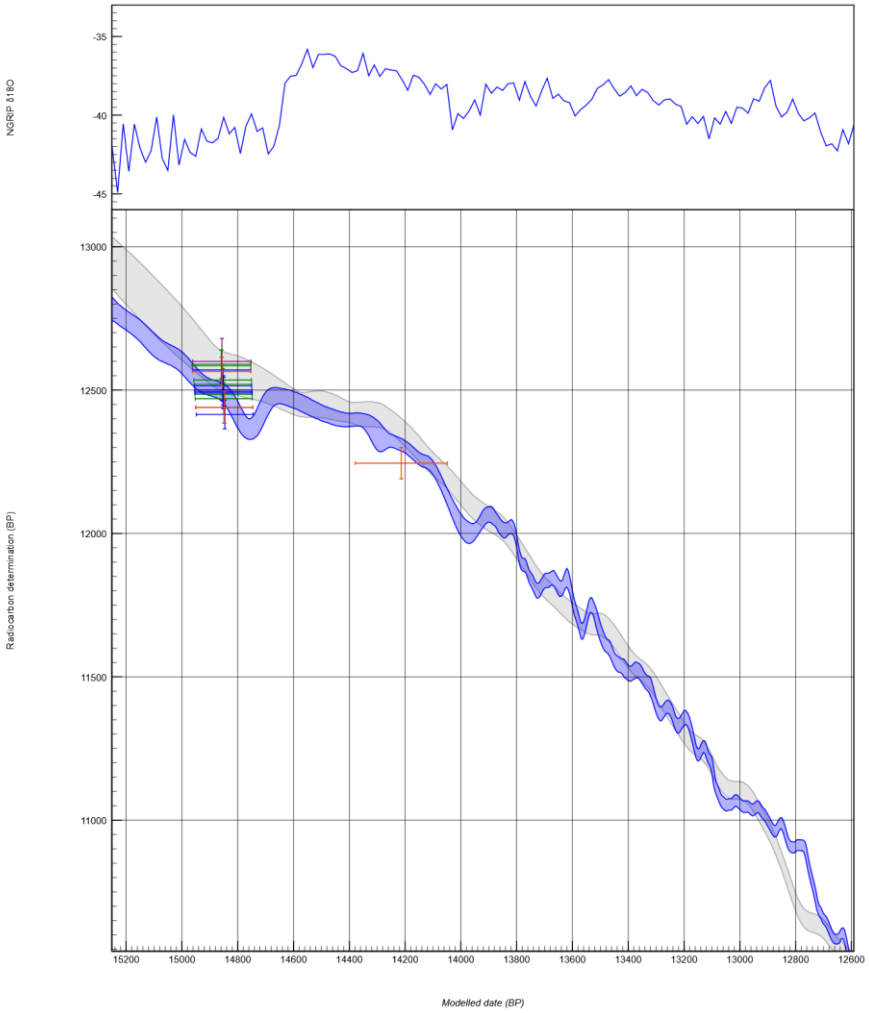


Figure A.118 Gough's (New) Cave (GNC). Dates from Jacobi and Higham 2011. Single phase KDE model. The dates align very tightly on a regular segment of the curve.

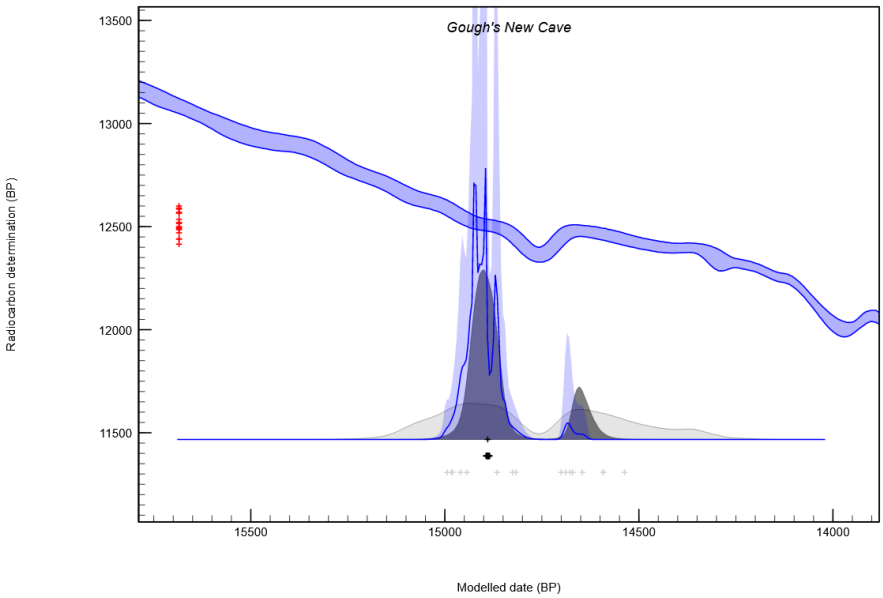


Figure A.119 Gough's (New) Cave (GNC). Dates from Jacobi and Higham 2011. Single phase KDE model.

Later Creswellian

Single KDE

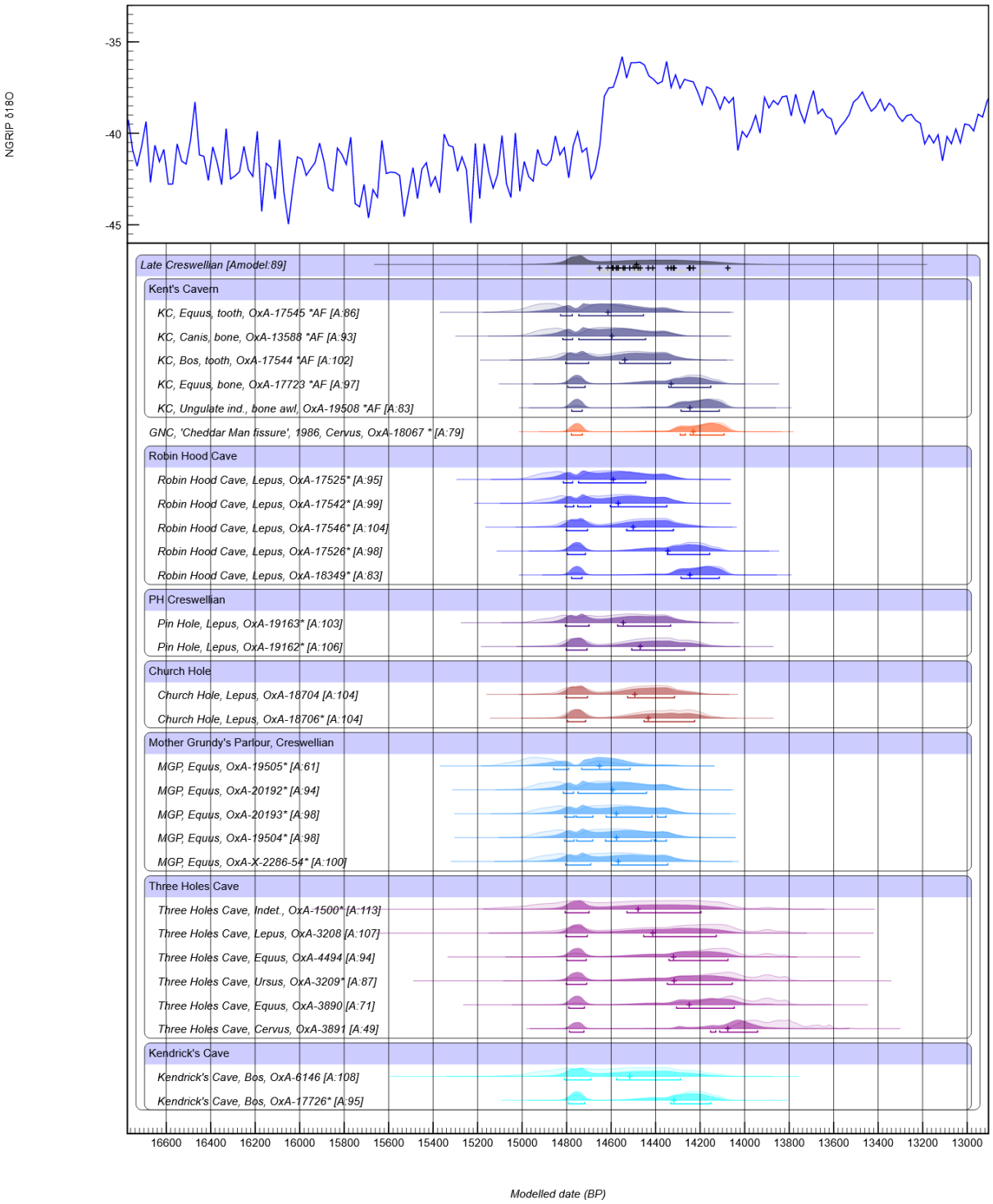


Figure A.120 Single phase KDE model. Selected sites grouped as Late Creswellian as they fall on the GS-2a and Early GI-1e wiggle and plateau. The dating resolution is very different to the Early Creswellian group, as the wiggle and plateau spreads over nearly 700 years. The early excavation and recovery resolution (very little stratigraphy and reliable unmixed assemblages) combined with the dilated dating resolution were the main criteria for separating the Earlier dated assemblages from the Later dated assemblage within this work. The main reference site for these later dated assemblages is Three Holes Cave, the only Creswellian assemblage with both a discreet refitting archaeological horizon and associated dating (Barton and Roberts 1996).

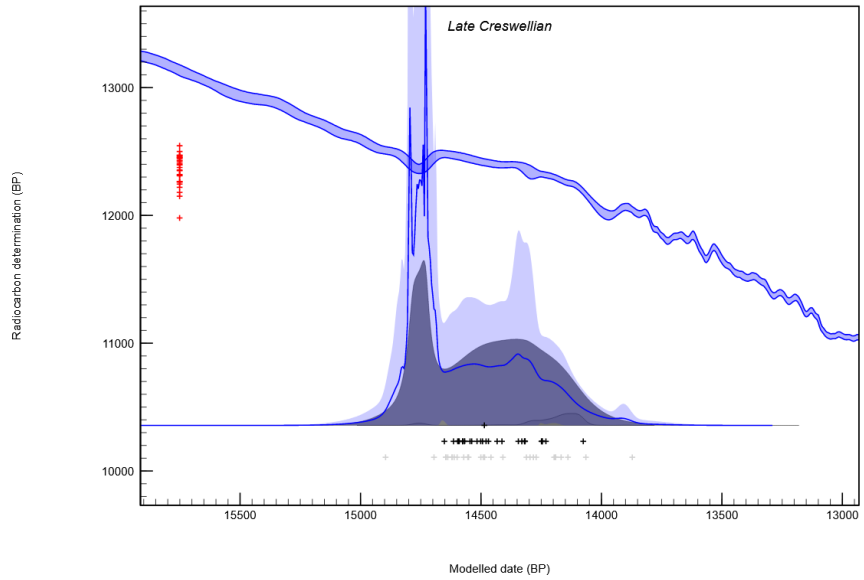


Figure A.121 Cumulated KDE Model for Late Creswellian sites.

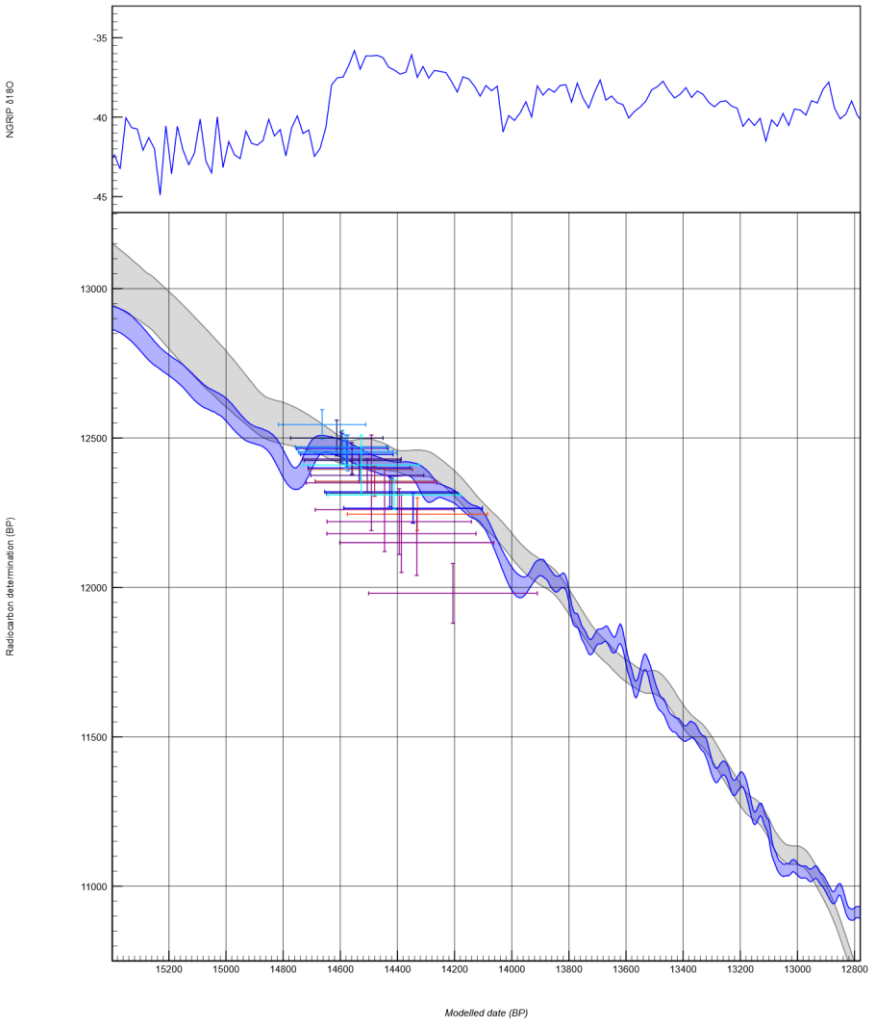


Figure A.122 Cumulated KDE Model for Late Creswellian sites. The dates all overlap with the GI-1e plateau, with a dense cluster at the onset of GI-1e.

Multiple KDE

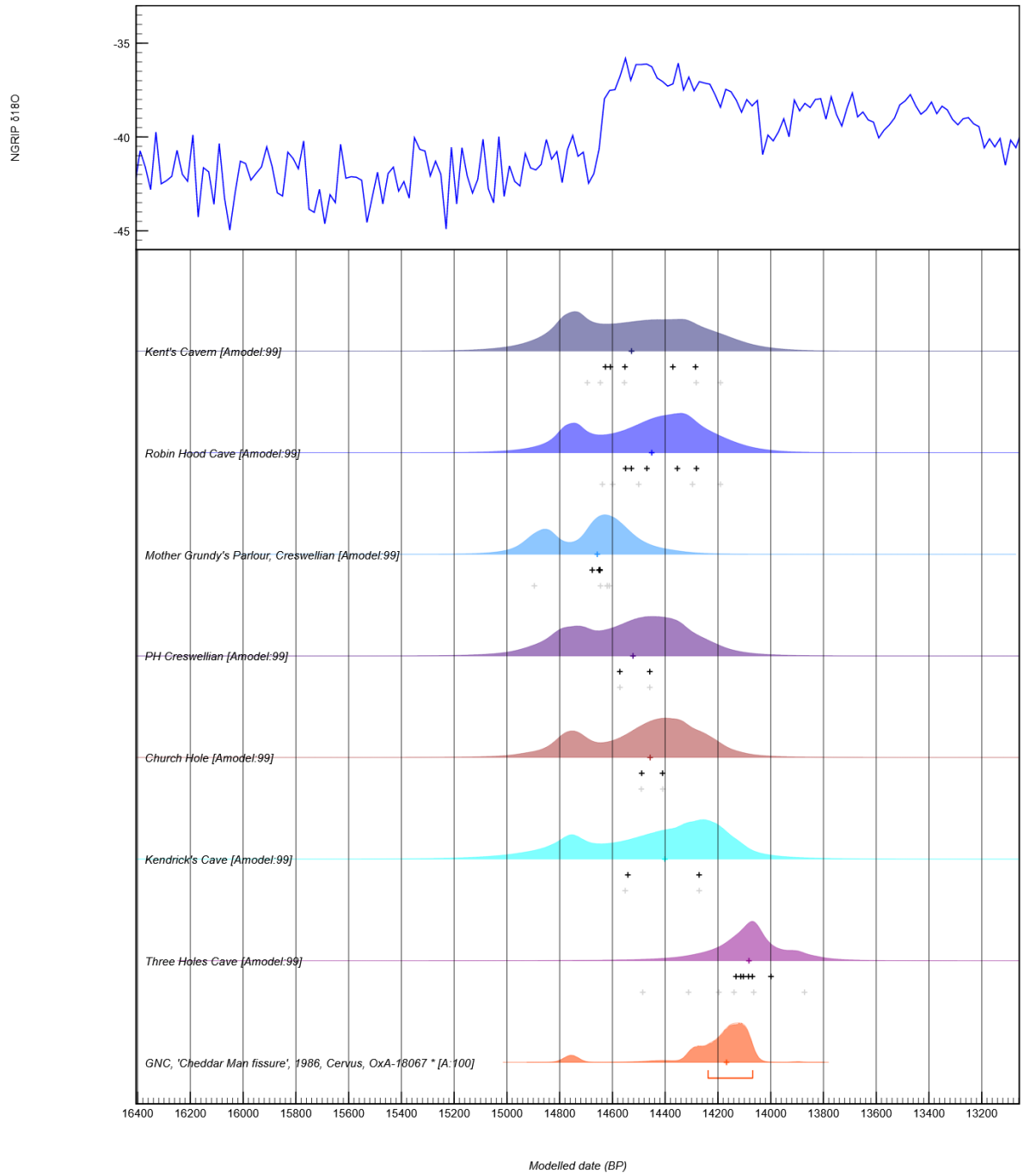


Figure A.123 KDE Model of Late Creswellian sites. Gough's Cave isolated late date (OxA-18067) falls towards the end of this distribution, before Three Holes Cave. Although a Federmesser or Azilian date has been suggested (Jacobi 2005), the possibility of a later Creswellian occupation at Gough's Cave is also possible. The archaeological material from Gough's Cave indicates the presence of both techno-complexes (Jacobi 2000, 2004, Jacobi and Higham 2011). The presence of bi-points could be either associated to an Early Azilian (GS2a-GI-1e) or an Early Federmesser (late GI-1e to GI-1c). The presence of bi-points at Hengistbury Head and Nea Farm favours the presence of the latter, however the presence of bi-points within Early Creswellian assemblages favours an Early Azilian date.

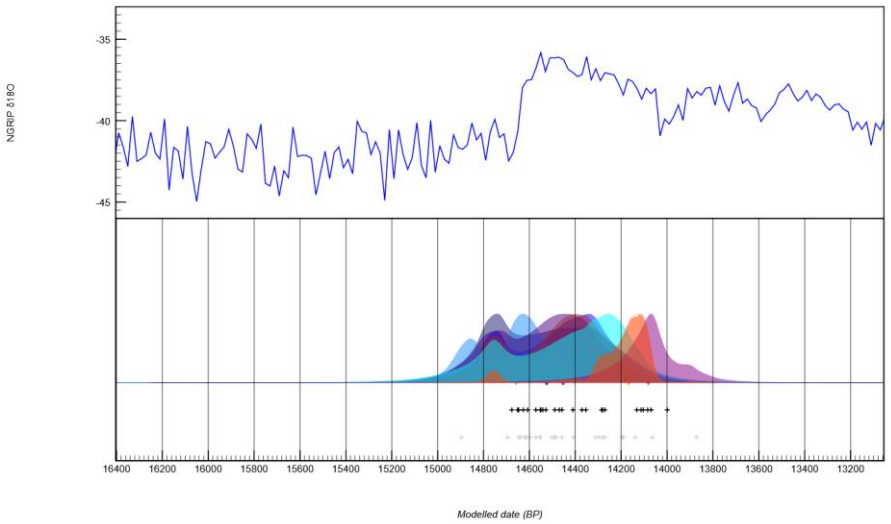


Figure A.124 Stacked distribution of KDE Modelled Late Creswellian dates per site.

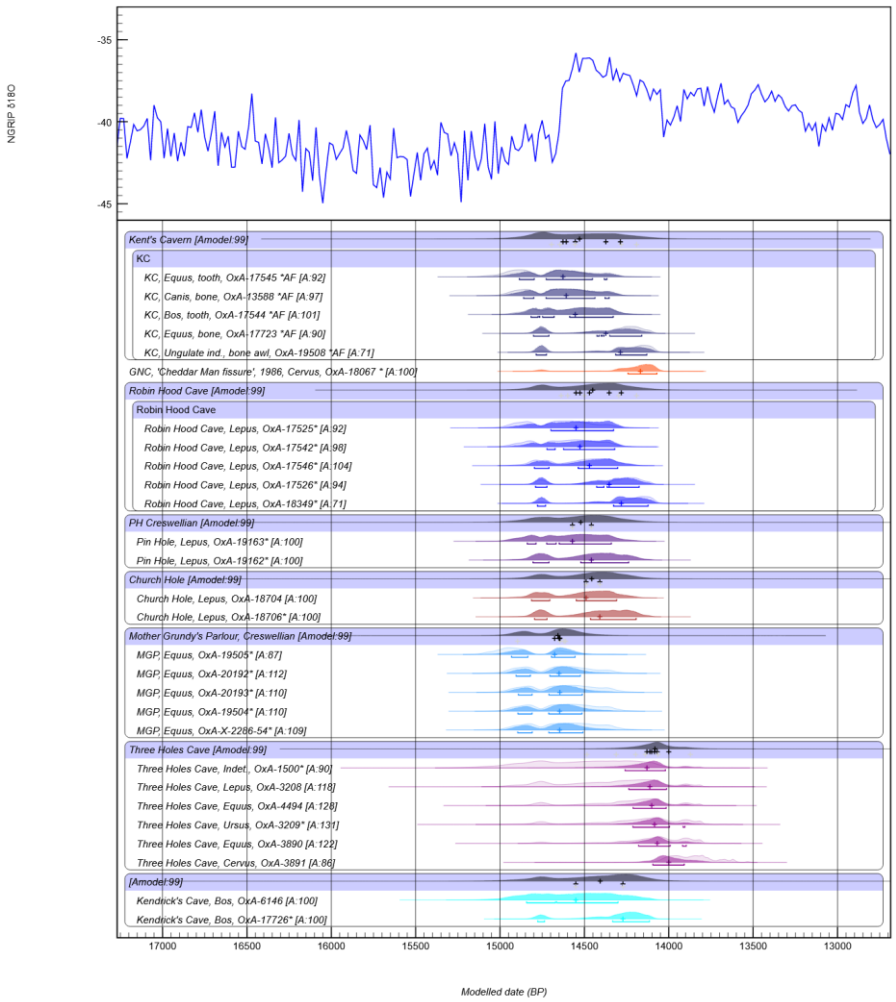


Figure A.125 Compared KDEs modelled per site. Three Holes Cave groups very tightly on a regular section of curve towards the transition from GI-1e to GI-1d. This is the latest dated Creswellian site. The other sites are grouped within the GI-1e plateau.

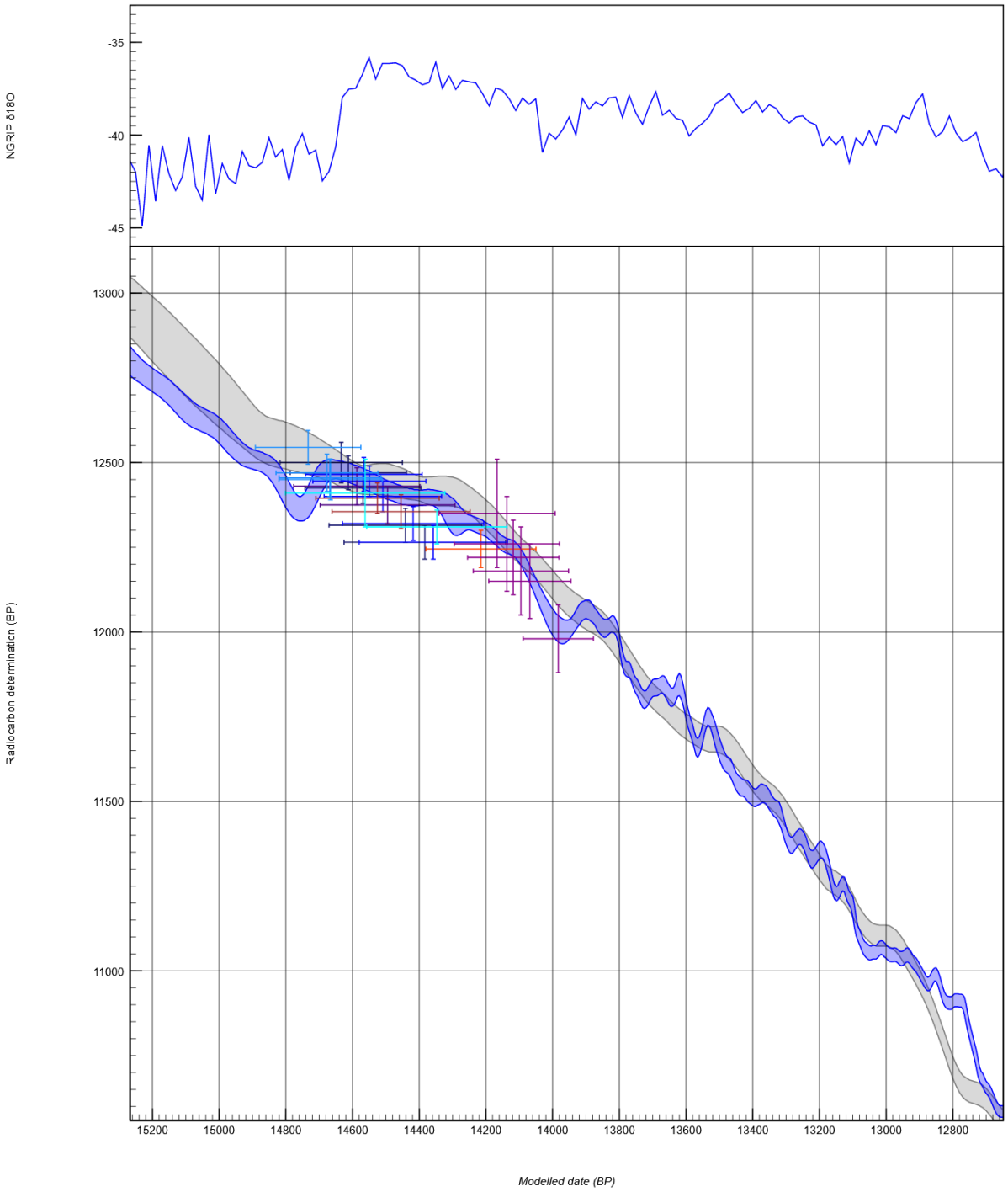


Figure A.126 Compared KDEs modelled per site. Three Holes Cave groups very tightly on a regular section of curve towards the transition from GI-1e to GI-1d. This is the latest dated Creswellian site. The other sites are grouped within the GI-1e plateau.

Kent's Cavern "Black Band" (KC)

Single Uniform Phase

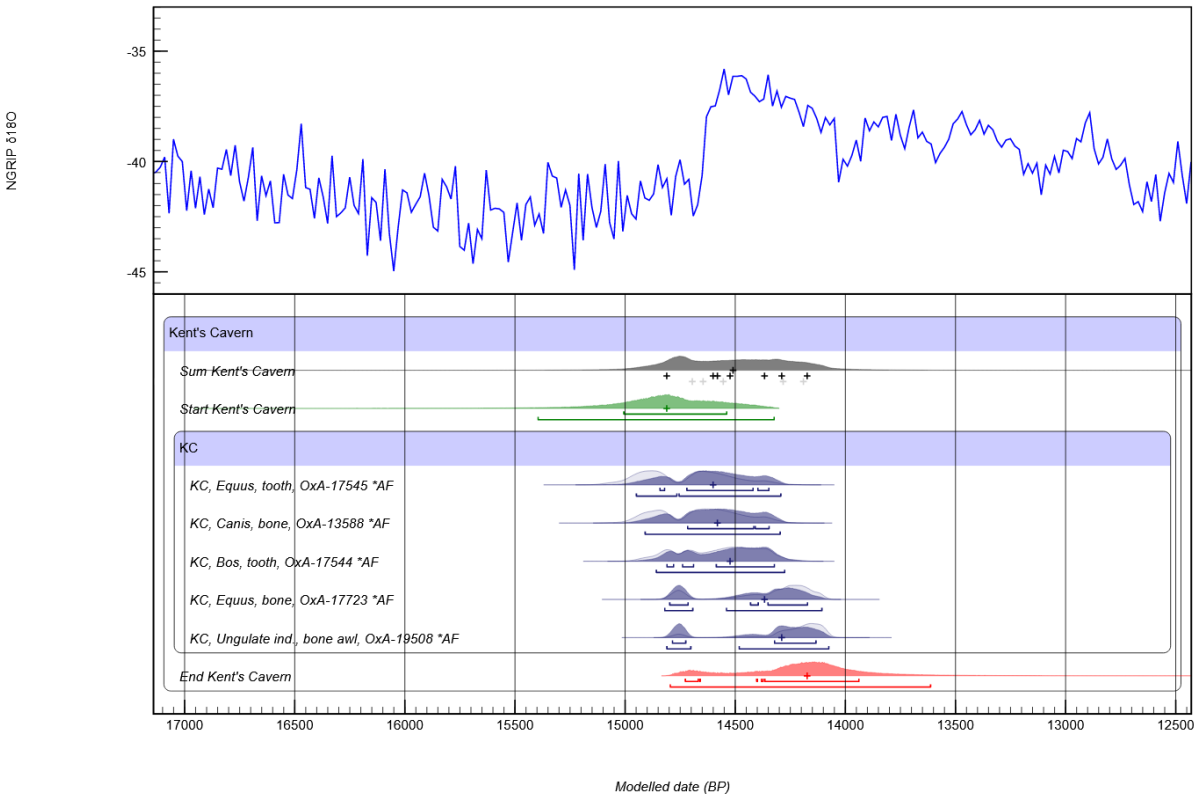


Figure A.127 Kent's Cavern "Black band" (KC). Dates from Jacobi and Higham 2011. Uniform phase. No knowledge of phasing or stratigraphic data (Jacobi and Higham 2009b: 147). There appears to be two groups of dates (as at GNC). When modelled as a single uniform phase (due to the absence of stratigraphic data), the dates have a large spread over GI-1e, but still maintain two groups.

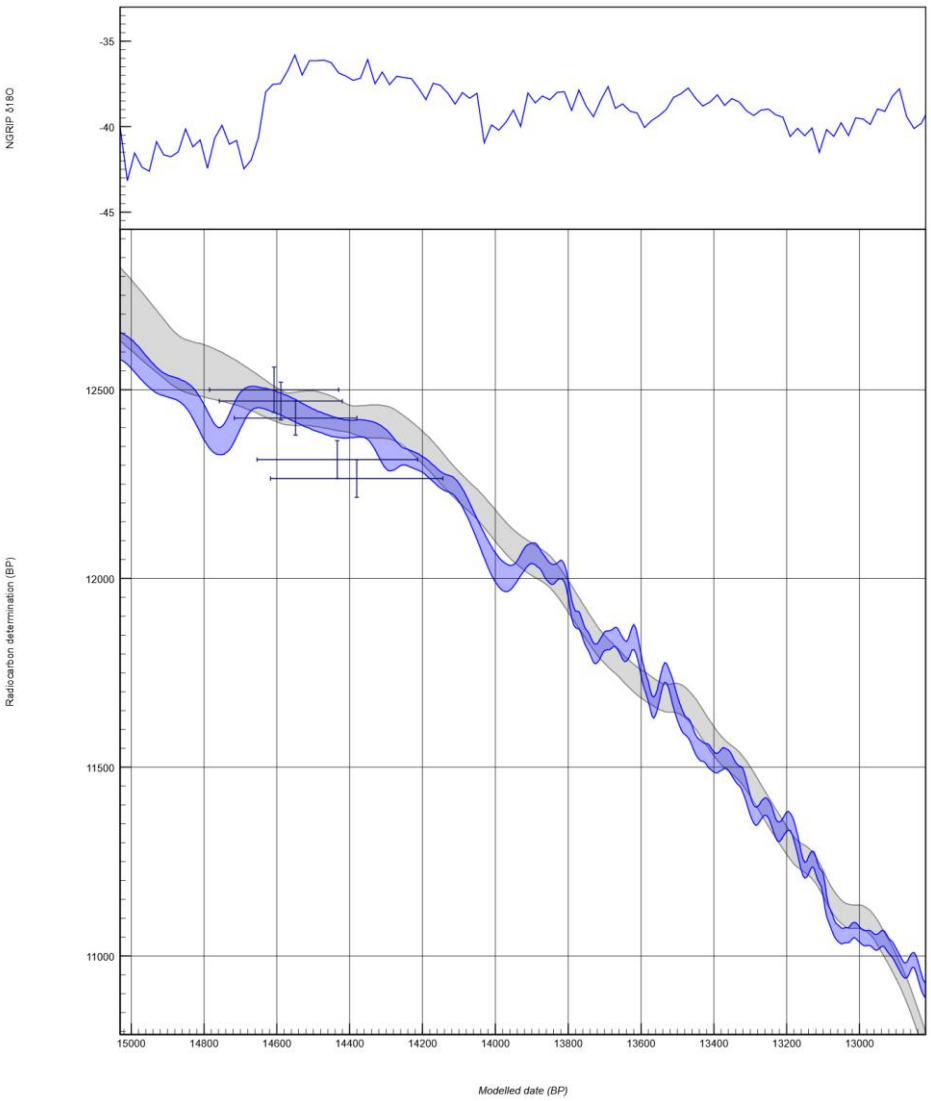


Figure A.128 Kent's Cavern "Black band" (KC). Dates from Jacobi and Higham 2011. Uniform phase. IntCal04 (grey) (Reimer et al. 2004) is in the background for reference. When modelled as a single uniform phase (due to the absence of stratigraphic data), the dates have a large spread over GI-1e, but still maintain two groups.

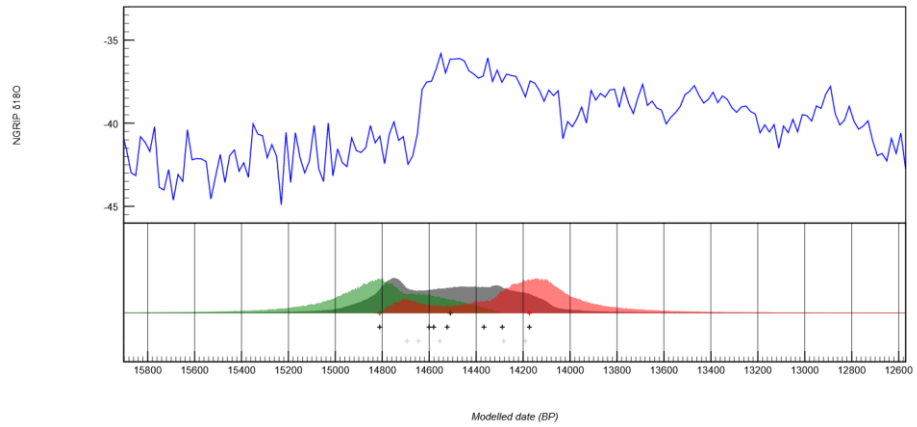


Figure A.129 Kent's Cavern "Black band" (KC). Dates from Jacobi and Higham 2011. Uniform phase.

Overlapping Uniform Phases

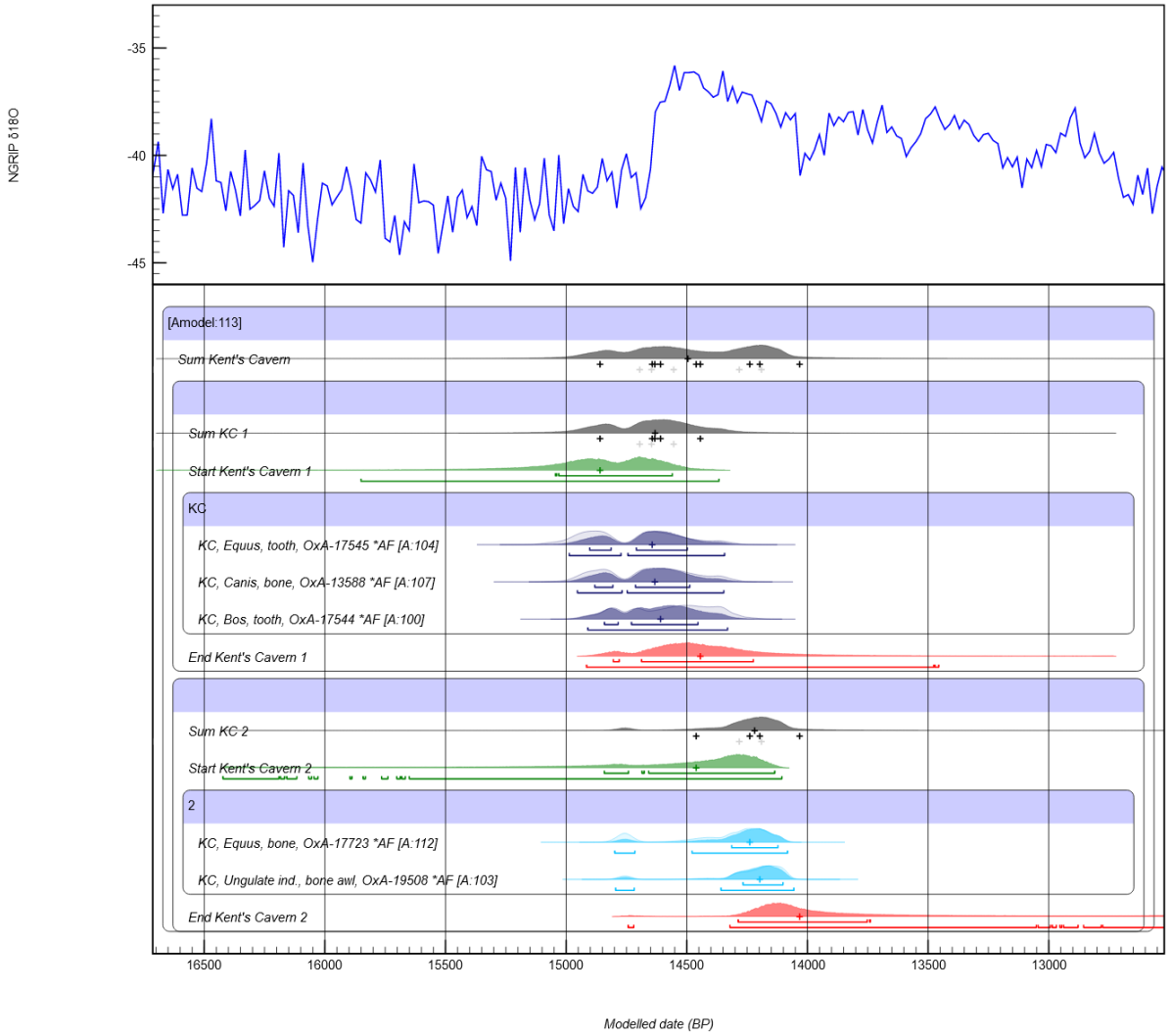


Figure A.130 Kent's Cavern "Black band" (KC). Dates from Jacobi and Higham 2011. Overlapping phases. Due to the absence of stratigraphic data this is tentative. Amodel: 113% is high, significantly higher than the 88% for a single uniform phase.

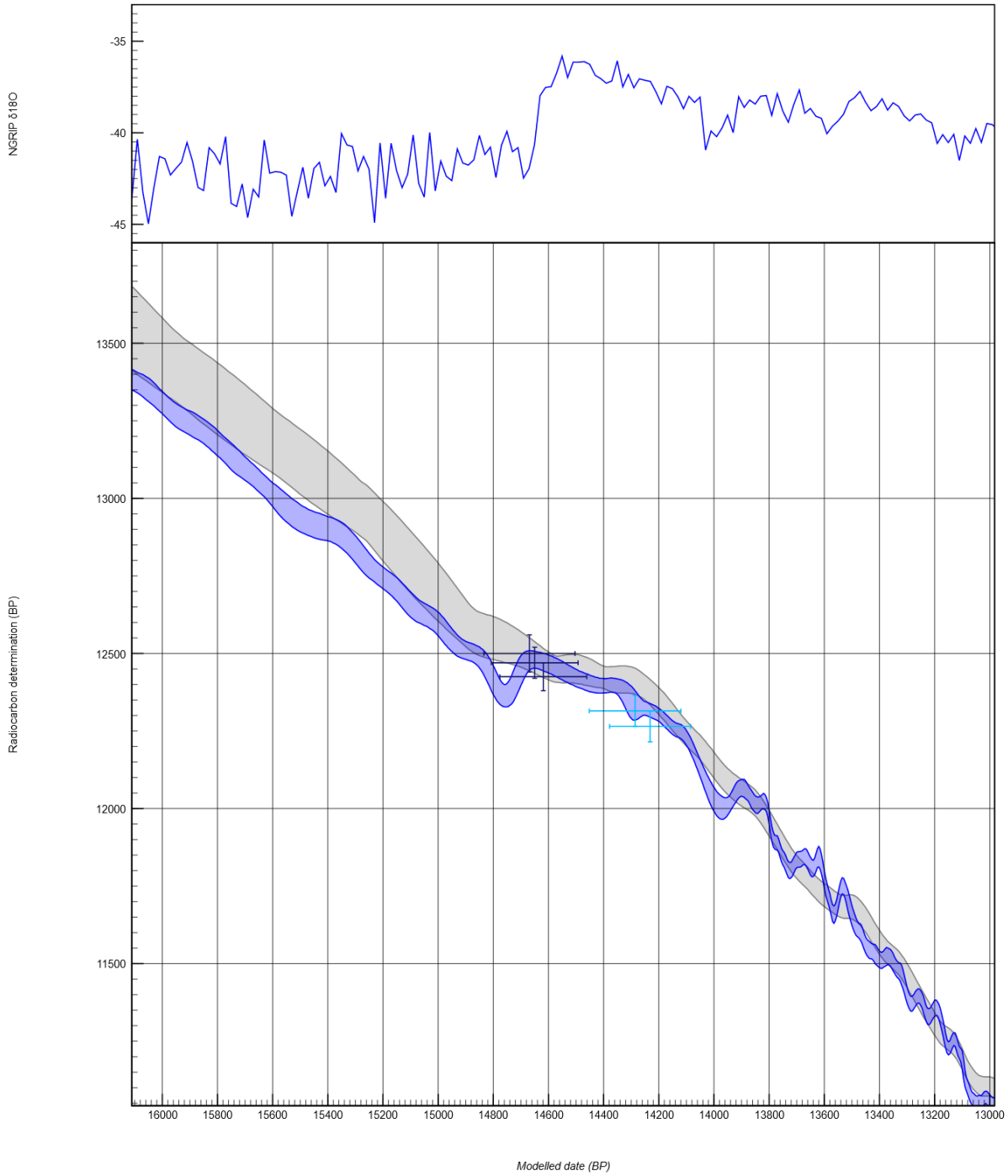


Figure A.131 Kent's Cavern "Black band" (KC). Dates from Jacobi and Higham 2011. Overlapping phases. Due to the absence of stratigraphic data this is tentative. When modelled as two separate phases, the dates cluster at the beginning and end of the GI-1e plateau. This model appears valid but without stratigraphic data it is only speculative.

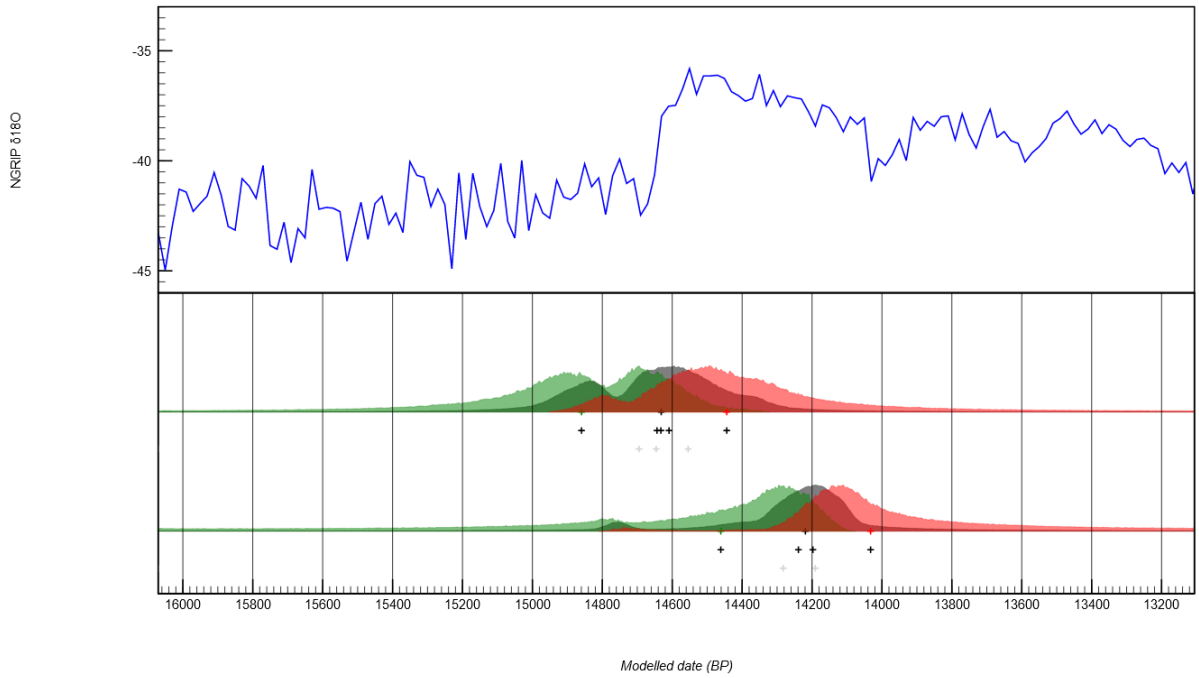


Figure A.132 Kent's Cavern "Black band" (KC). Dates from Jacobi and Higham 2011. Overlapping phases. Due to the absence of stratigraphic data this is tentative. When modelled as two separate phases, the dates cluster at the beginning and end of the GI-1e plateau.

Reproduction of Jacobi and Higham 2009: figure 11 (IntCal04) with IntCal20

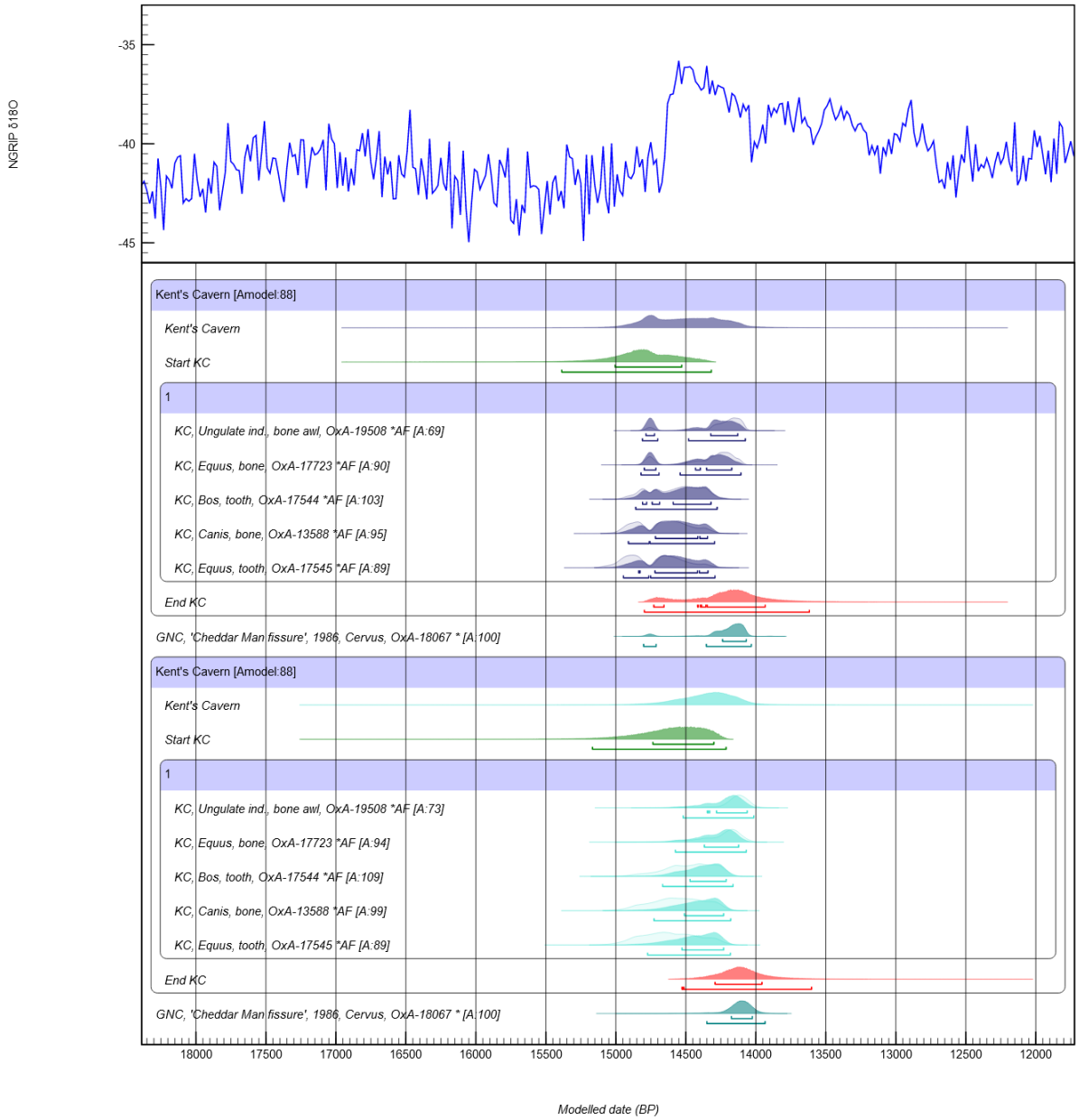


Figure A.133 Kent's Cavern "Black band" (KC). Dates from Jacobi and Higham 2011. Uniform phase. When compared to the IntCal04 model (Jacobi and Higham 2011), the dates are more spread out and less consistent with the isolated date from GNC, although there is still some overlap.

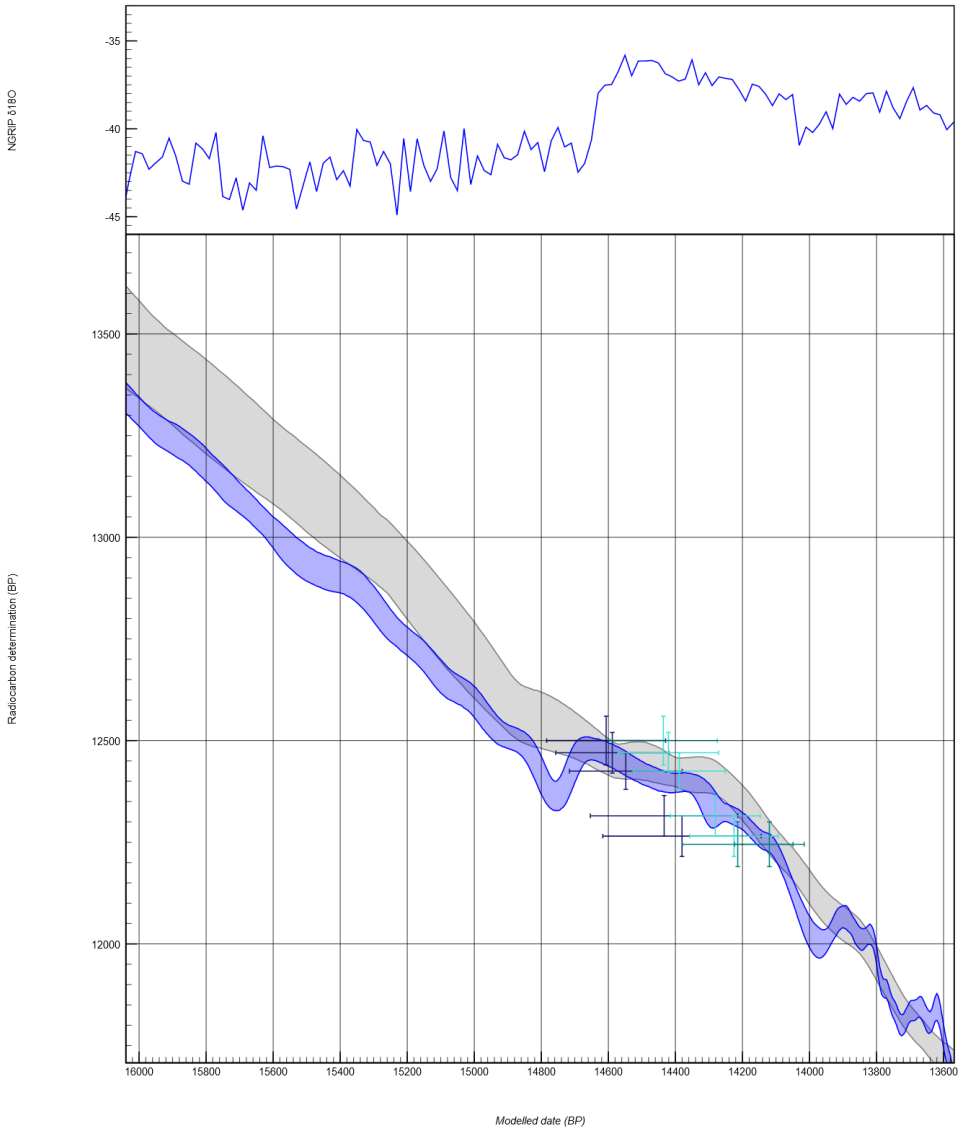


Figure A.134 Kent's Cavern "Black band" (KC). Dates from Jacobi and Higham 2011. Uniform phase.

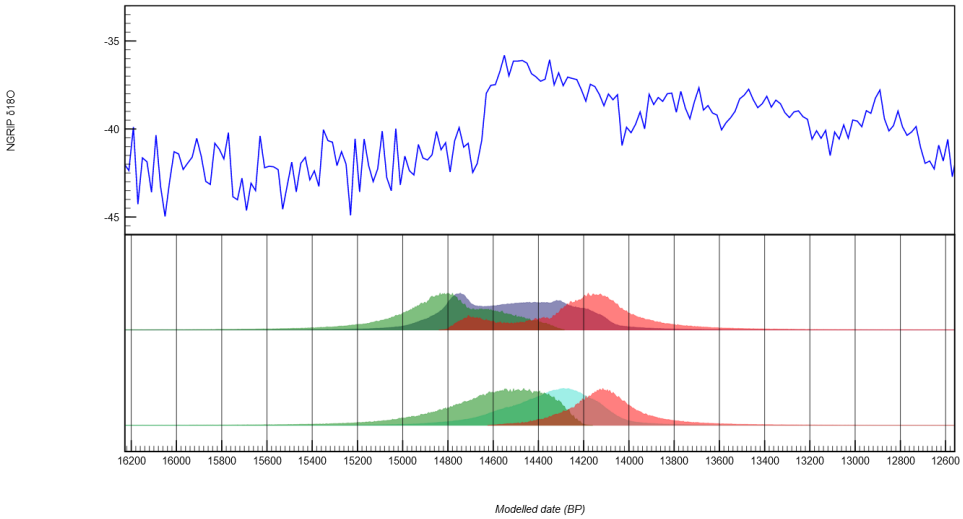


Figure A.135 Kent's Cavern "Black band" (KC). Dates from Jacobi and Higham 2011. Uniform phase.

Robin Hood Cave (RHC)

Single Uniform Phase

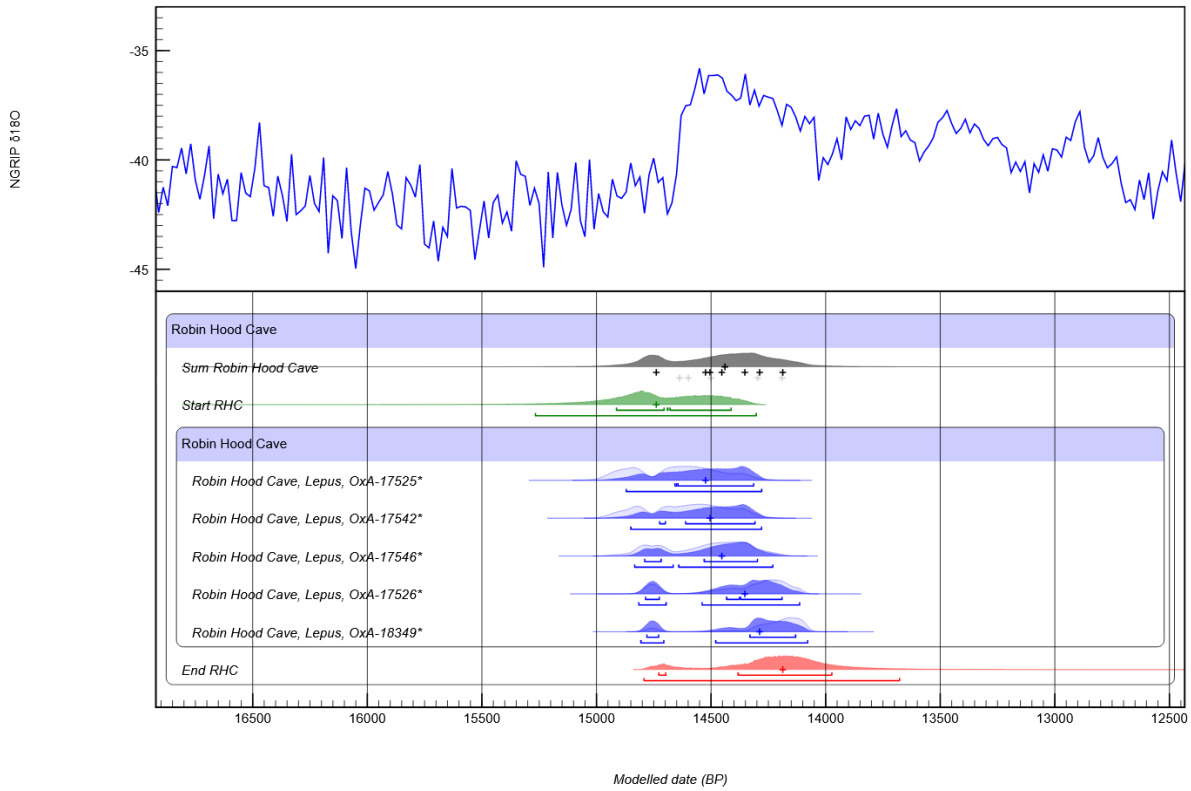


Figure A.136 Rodin Hood Cave (RHC). Dates from Jacobi and Higham 2011. Single uniform phase. The material from RHC is not stratified.

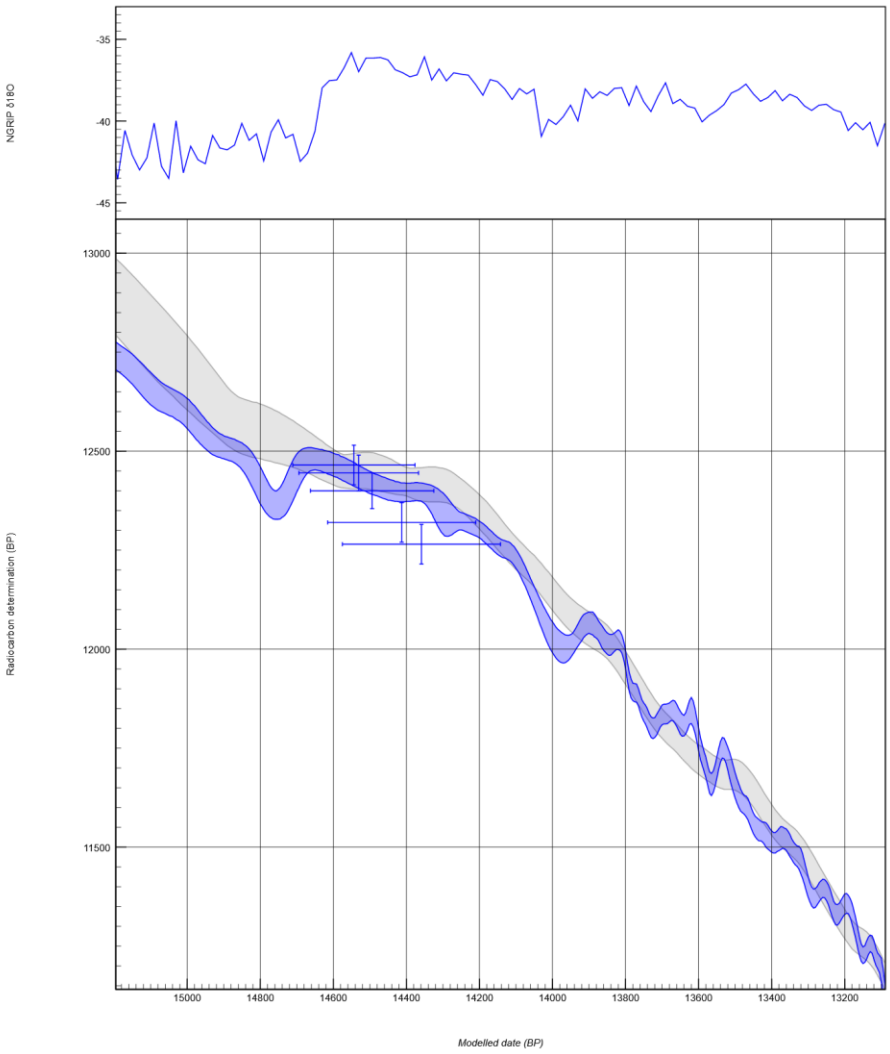


Figure A.137 Rodin Hood Cave (RHC). Dates from Jacobi and Higham 2011. Single uniform phase. IntCal04 (grey) (Reimer et al. 2004) is in the background for reference. The dates cluster with significant overlap.

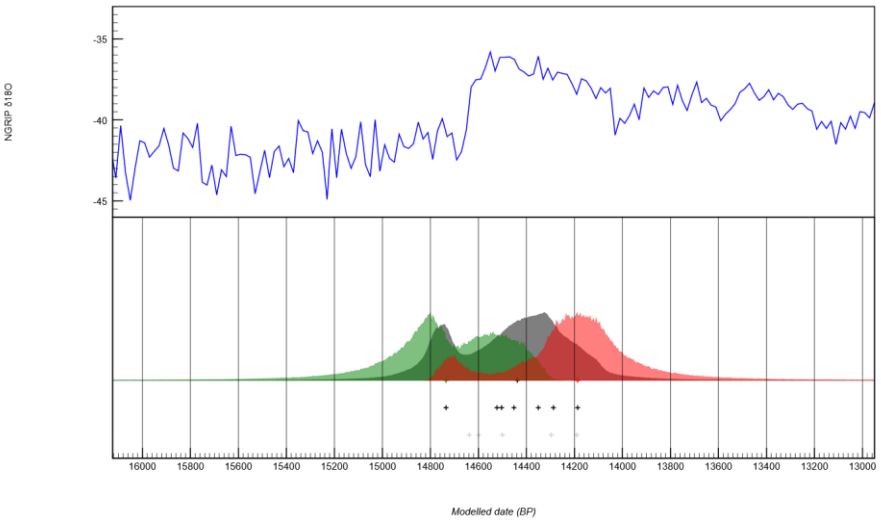


Figure A.138 Rodin Hood Cave (RHC). Dates from Jacobi and Higham 2011. Single uniform phase. Two peaks are distinguishable.

Pin Hole Cave (PH)

Single Uniform Phase

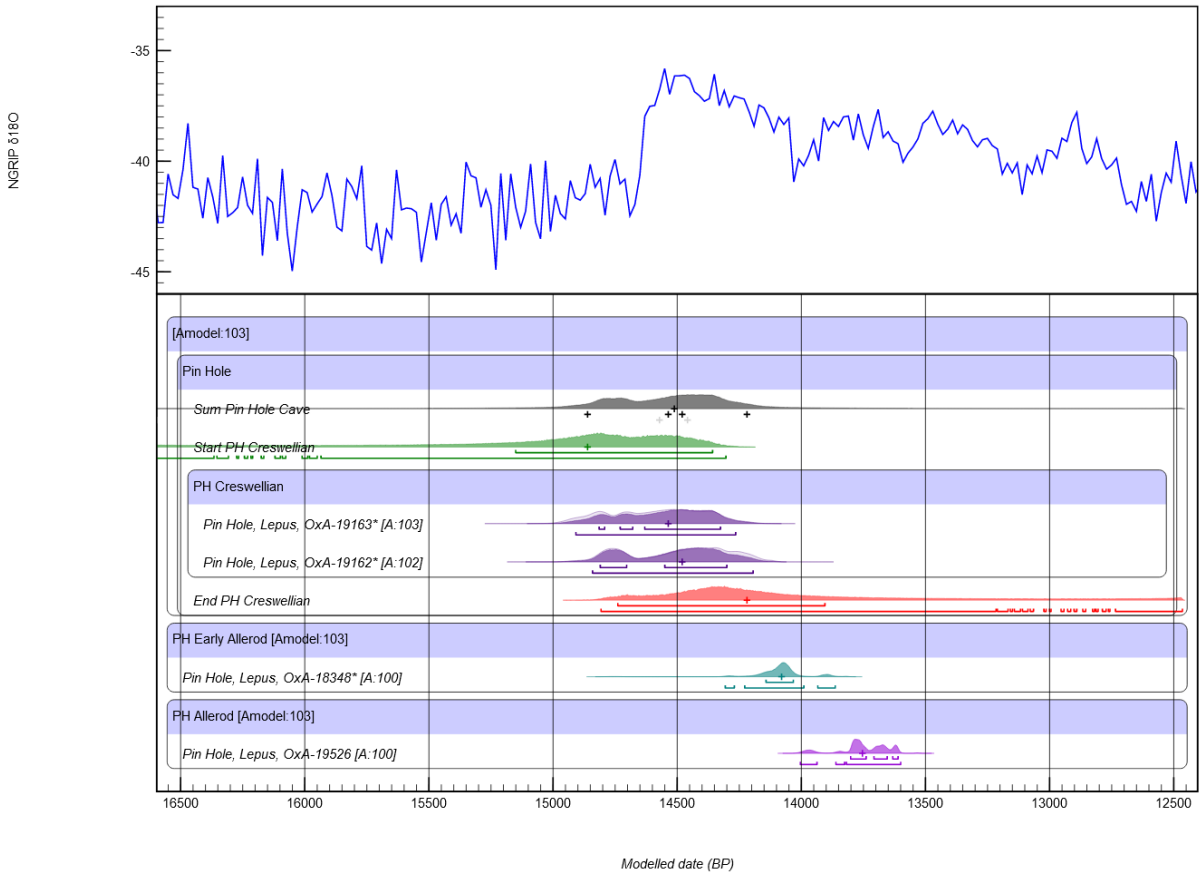


Figure A.139 Pin Hole Cave (PHC). Dates from Jacobi and Higham 2011. Simple Plot. The material was not stratified. There appears to be three distinct phases, GI-1e, GI-1e to GI-1d, and GI-1c. The latter would correspond to a Federmesser occupation.

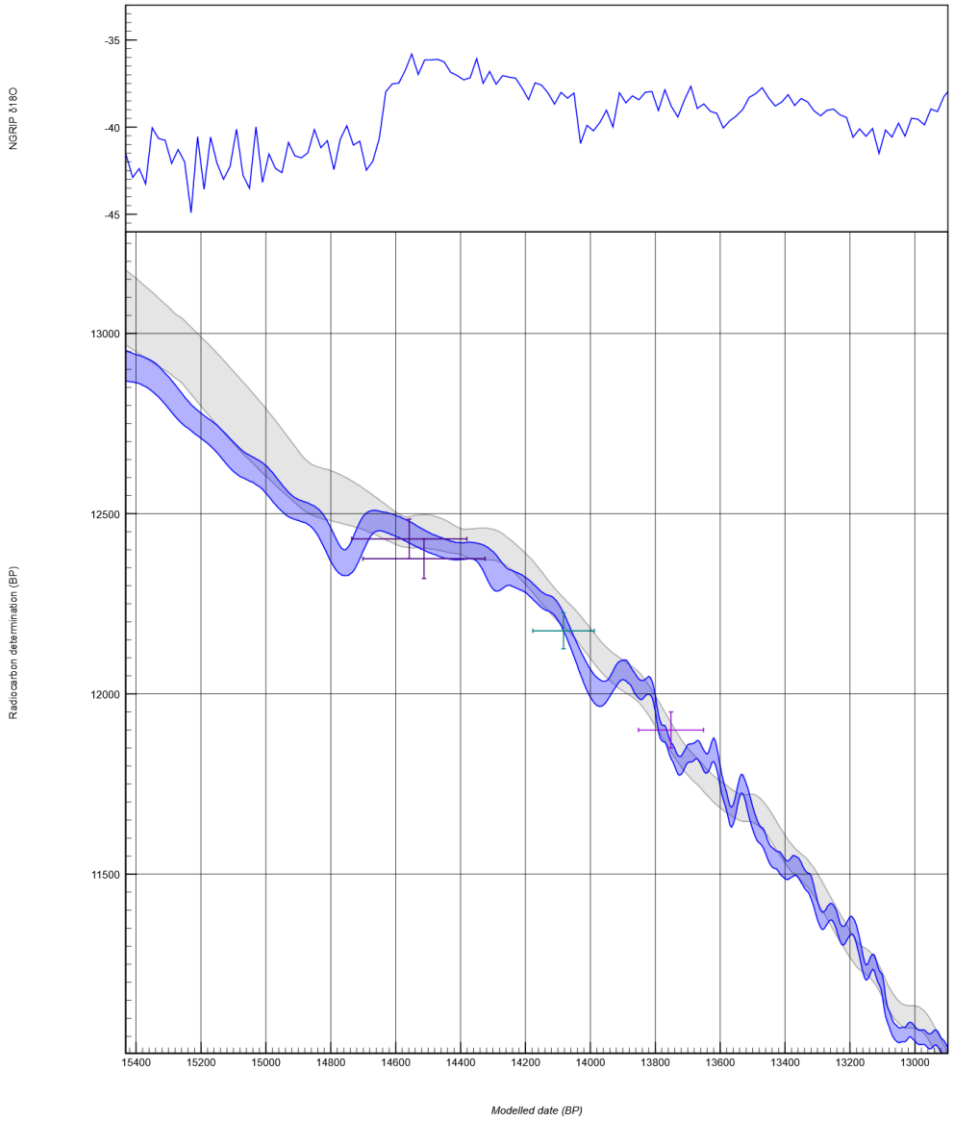


Figure A.140 Pin Hole Cave (PHC). Dates from Jacobi and Higham 2011. Single uniform phase. IntCal04 (grey) (Reimer et al. 2004) is in the background for reference.

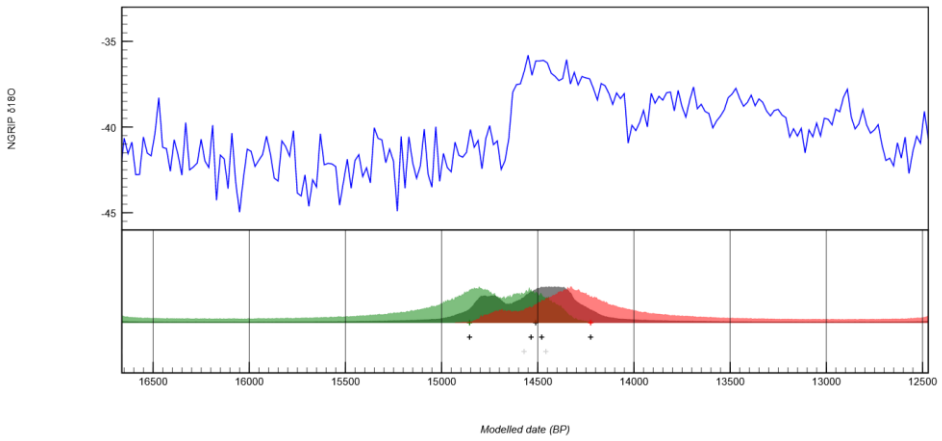


Figure A.141 Pin Hole Cave (PHC). Dates from Jacobi and Higham 2011. Single uniform phase.

Church Hole (CH)

Single Uniform Phase

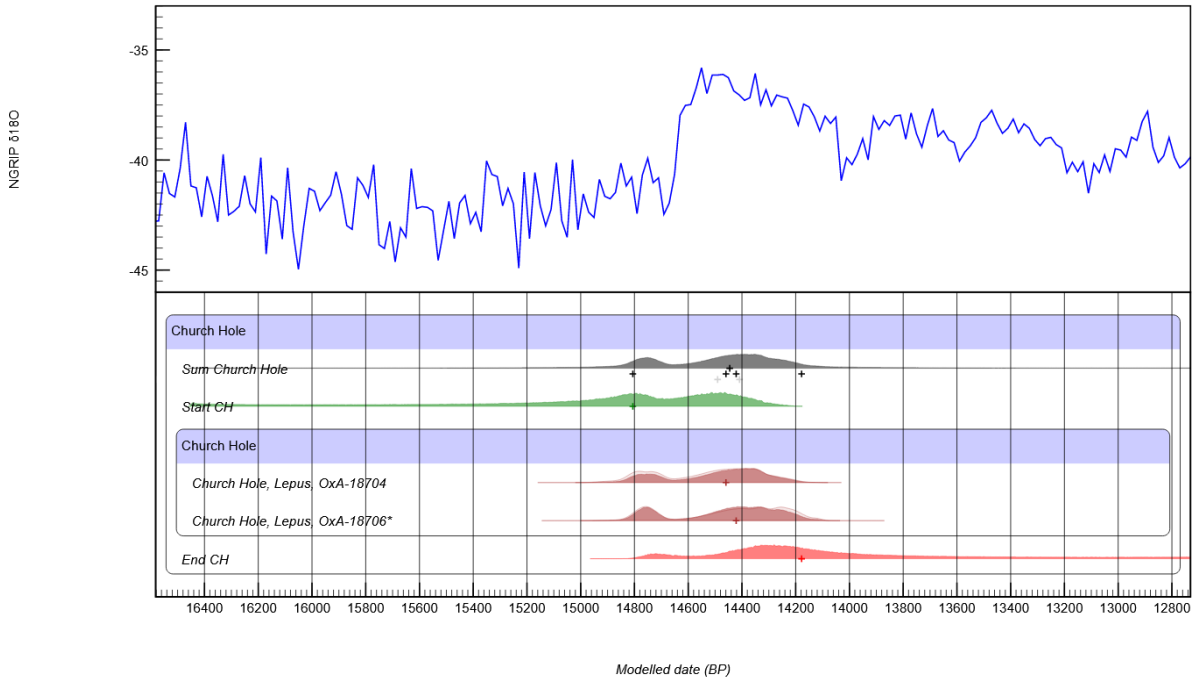


Figure A.142 Church Hole (CH). Dates from Jacobi and Higham 2011. Single uniform phase. The dates fall in the middle of the GI-1e plateau.

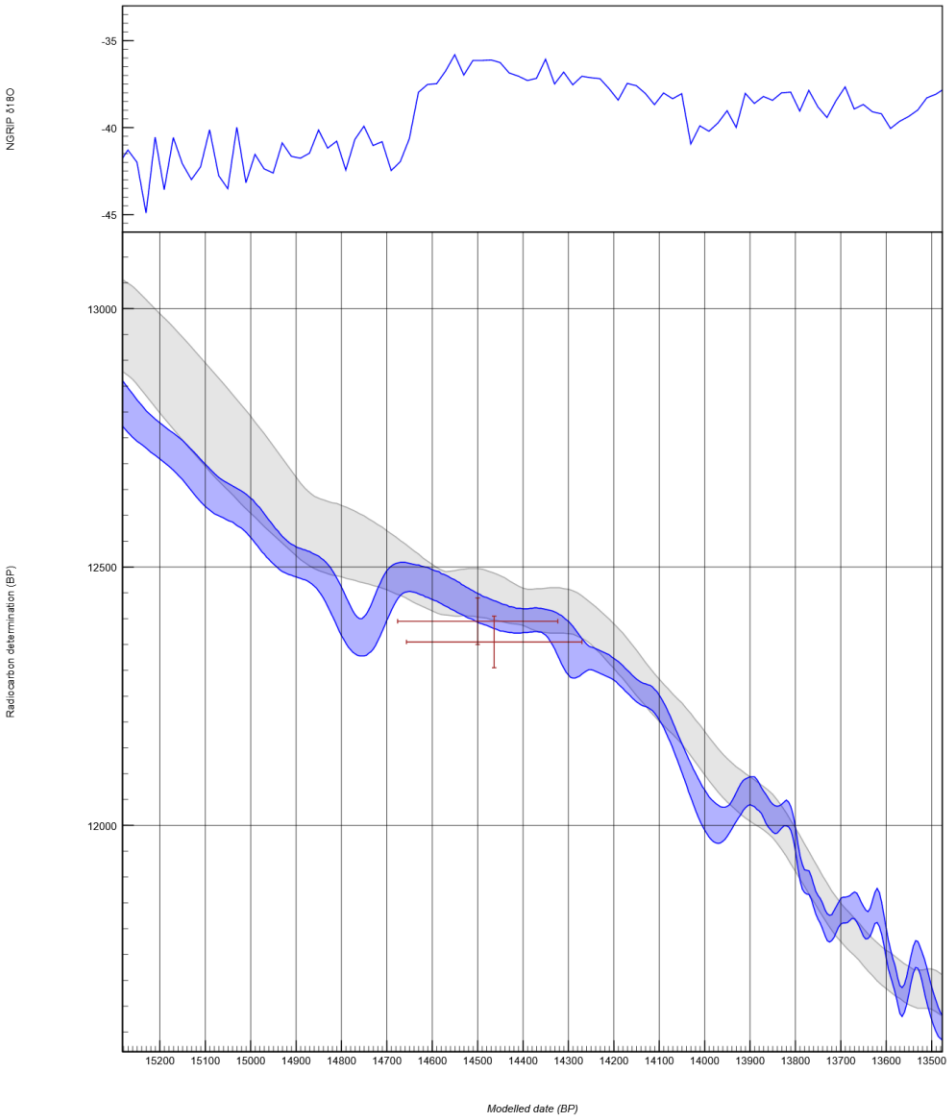


Figure A.143 Church Hole (CH). Dates from Jacobi and Higham 2011. Single uniform phase.

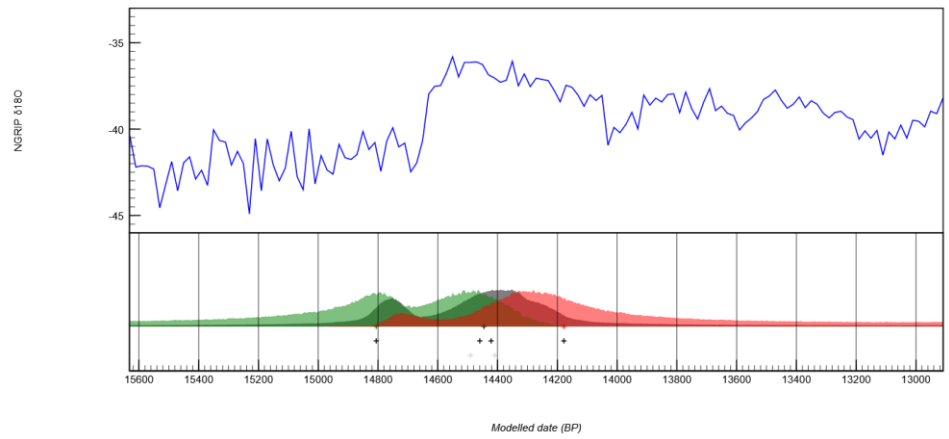


Figure A.144 Church Hole (CH). Dates from Jacobi and Higham 2011. Single uniform phase.

Mother Grundy's Parlour (MGP)

Single uniform phase

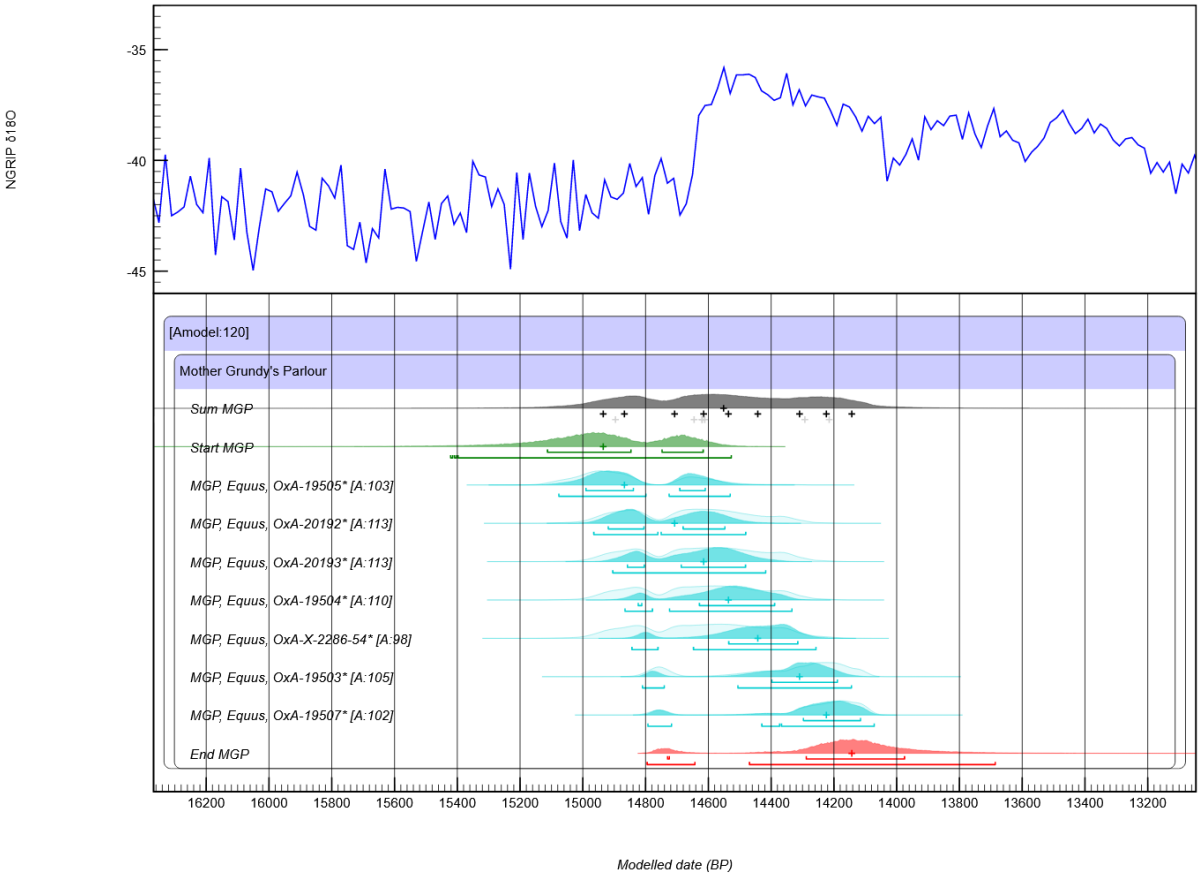


Figure A.145 Mother Grundy's Parlour (MGP). Dates from Jacobi and Higham 2011. Single uniform phase. The single phase appears to spread the dates regularly.

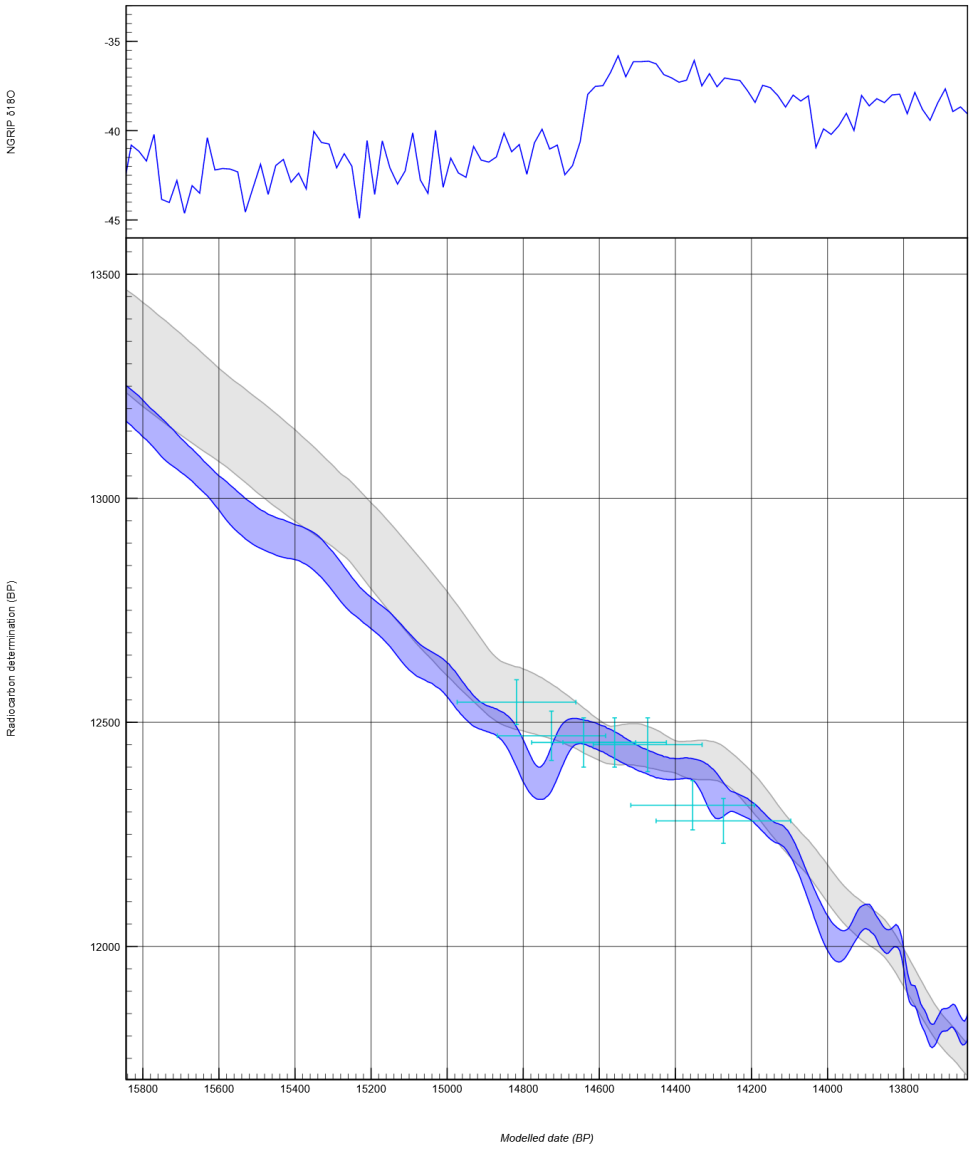


Figure A.146 Mother Grundy's Parlour (MGP). Dates from Jacobi and Higham 2011. Single uniform phase. The two latest dates appear two fall outside of the main cluster.

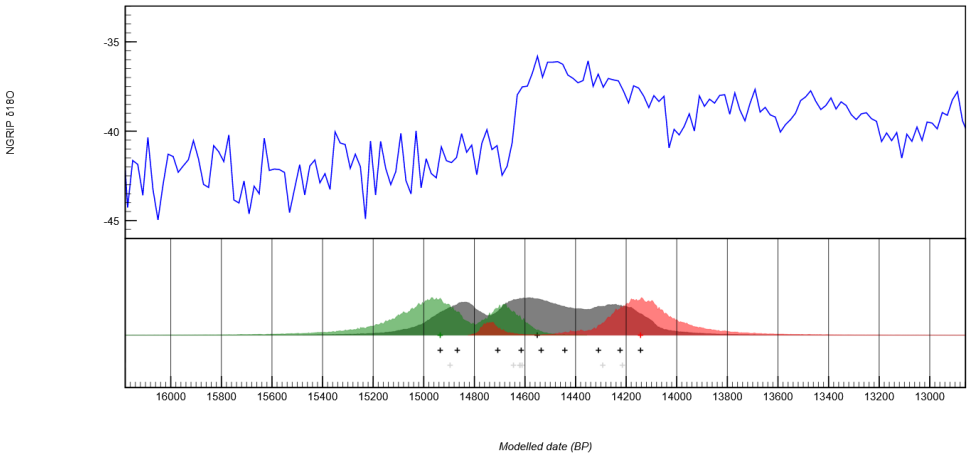


Figure A.147 Mother Grundy's Parlour (MGP). Dates from Jacobi and Higham 2011. Single uniform phase.

Overlapping Uniform Phases

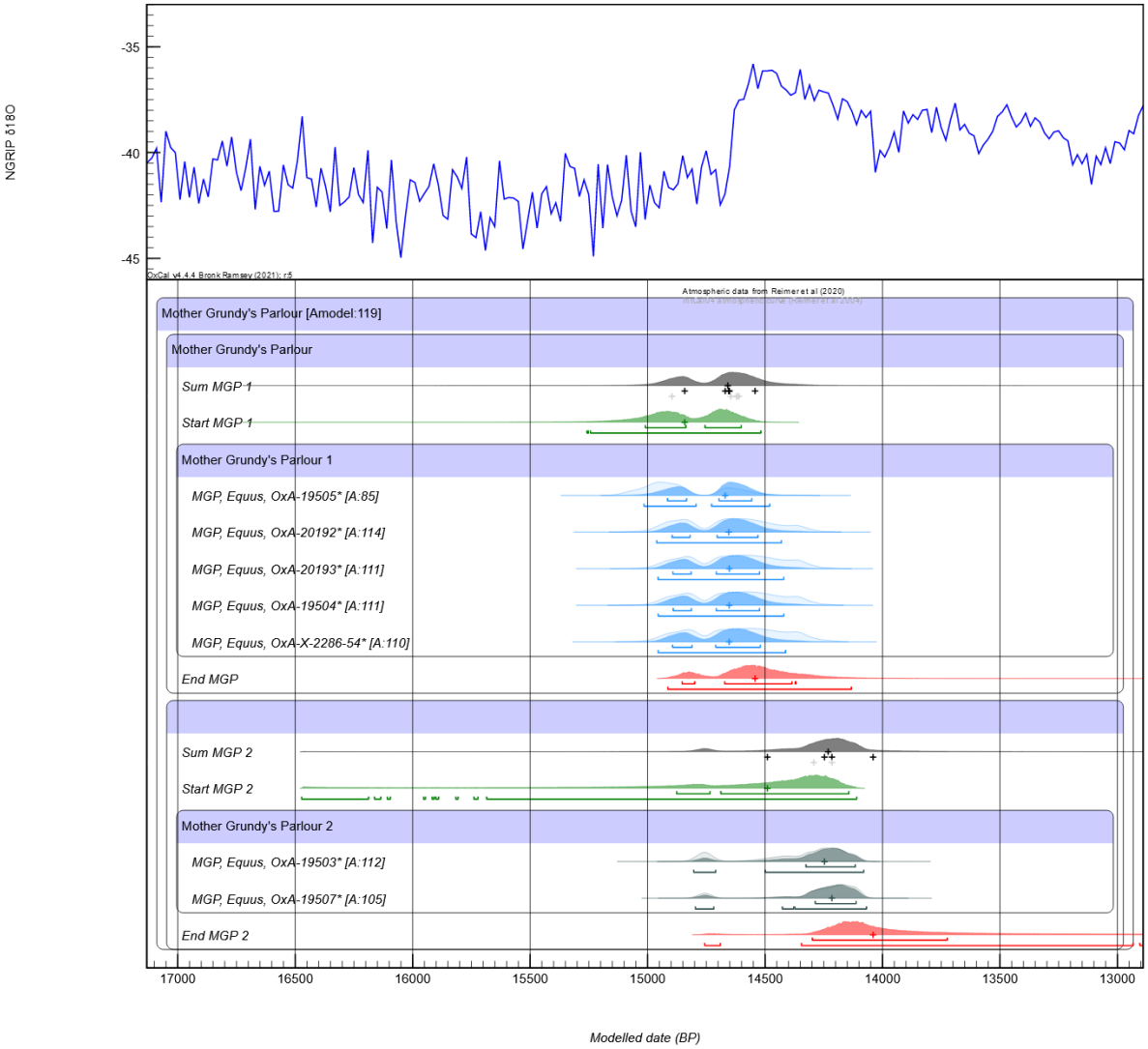


Figure A.148 Mother Grundy's Parlour (MGP). Dates from Jacobi and Higham 2011. Overlapping uniform phases. A second modelling sequence with overlapping phases. Amodel: 119%, is a good agreement. Without supporting stratigraphic data or more dates, this model is only speculative. Similar to Kent's Cavern and Gough's Cave, and less so to Robin Hood Cave, there are two clear clusters of dates at the beginning and the end of the GI-1e plateau.

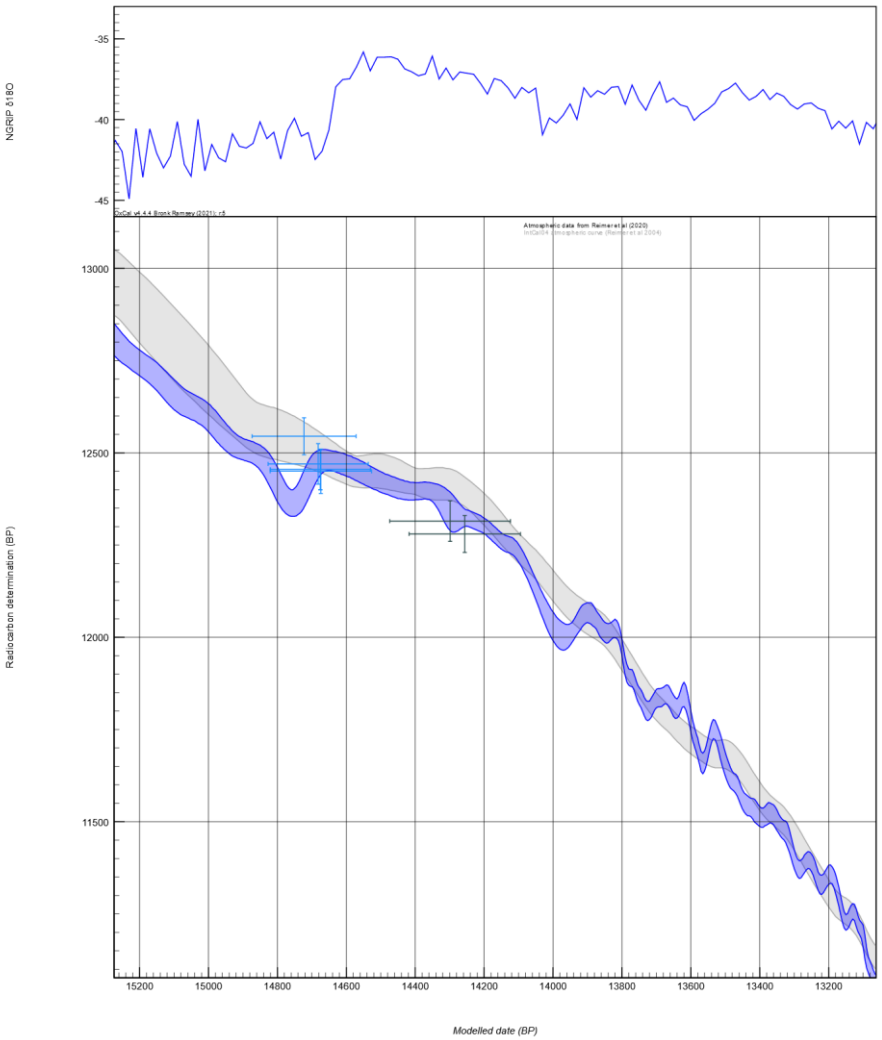


Figure A.149 Mother Grundy's Parlour (MGP). Dates from Jacobi and Higham 2011. Overlapping uniform phases. Two distinct groups are apparent. Both clusters are tighter than in a single phase model.

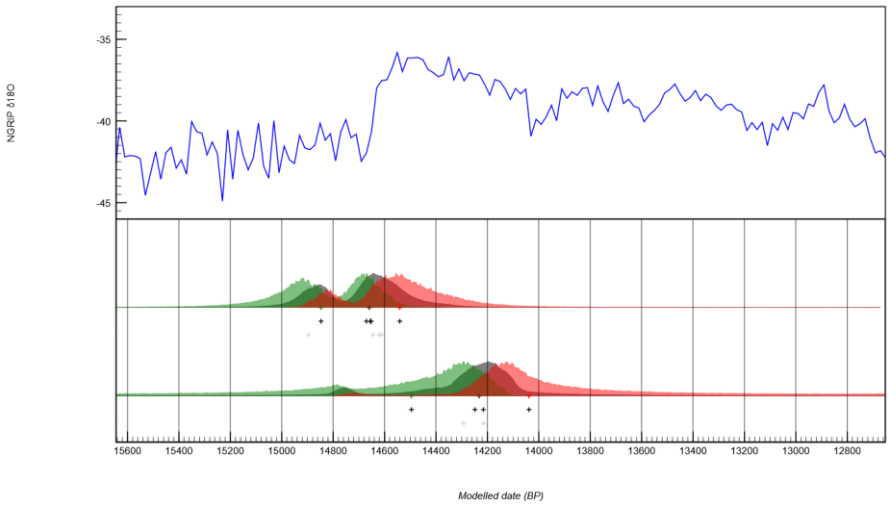


Figure A.150 Mother Grundy's Parlour (MGP). Dates from Jacobi and Higham 2011. Overlapping uniform phases.

KDE Model

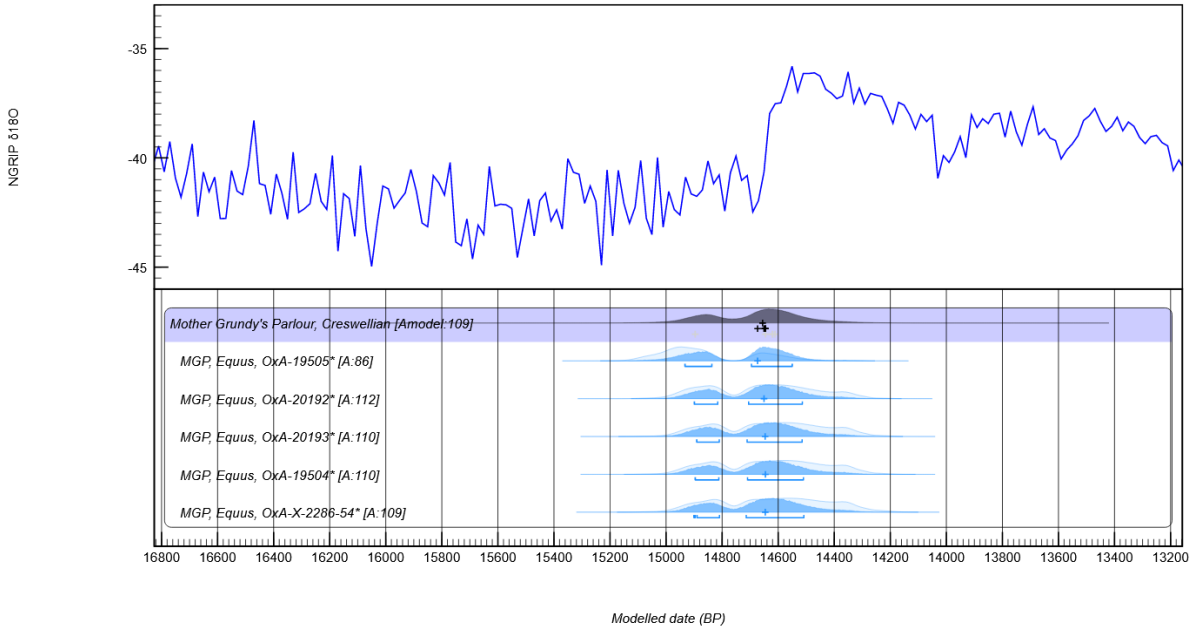


Figure A.151 Mother Grundy's Parlour (MGP). Dates from Jacobi and Higham 2011. KDE model. With the KDE the dates align very well with a high agreement. This contrasts with the overlapping phase model.

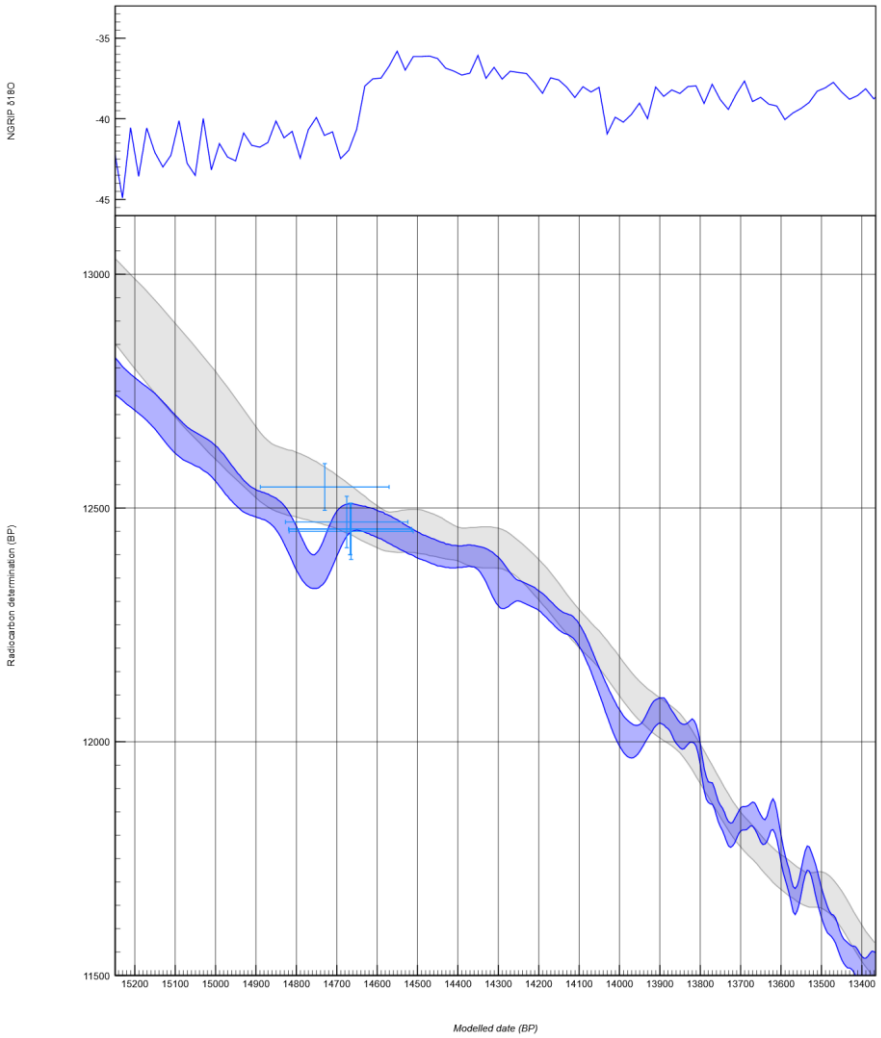


Figure A.152 Mother Grundy's Parlour (MGP). Dates from Jacobi and Higham 2011. KDE model. The dates cluster on the beginning of the GI-1e plateau.

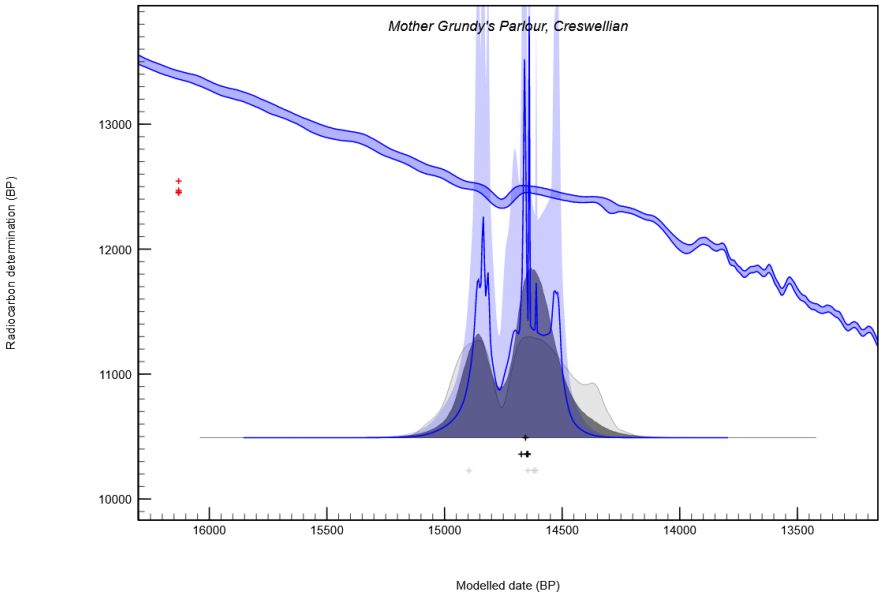


Figure A.153 Mother Grundy's Parlour (MGP). Dates from Jacobi and Higham 2011. KDE model.

Three Holes Cave (THC)

Single Uniform Phase

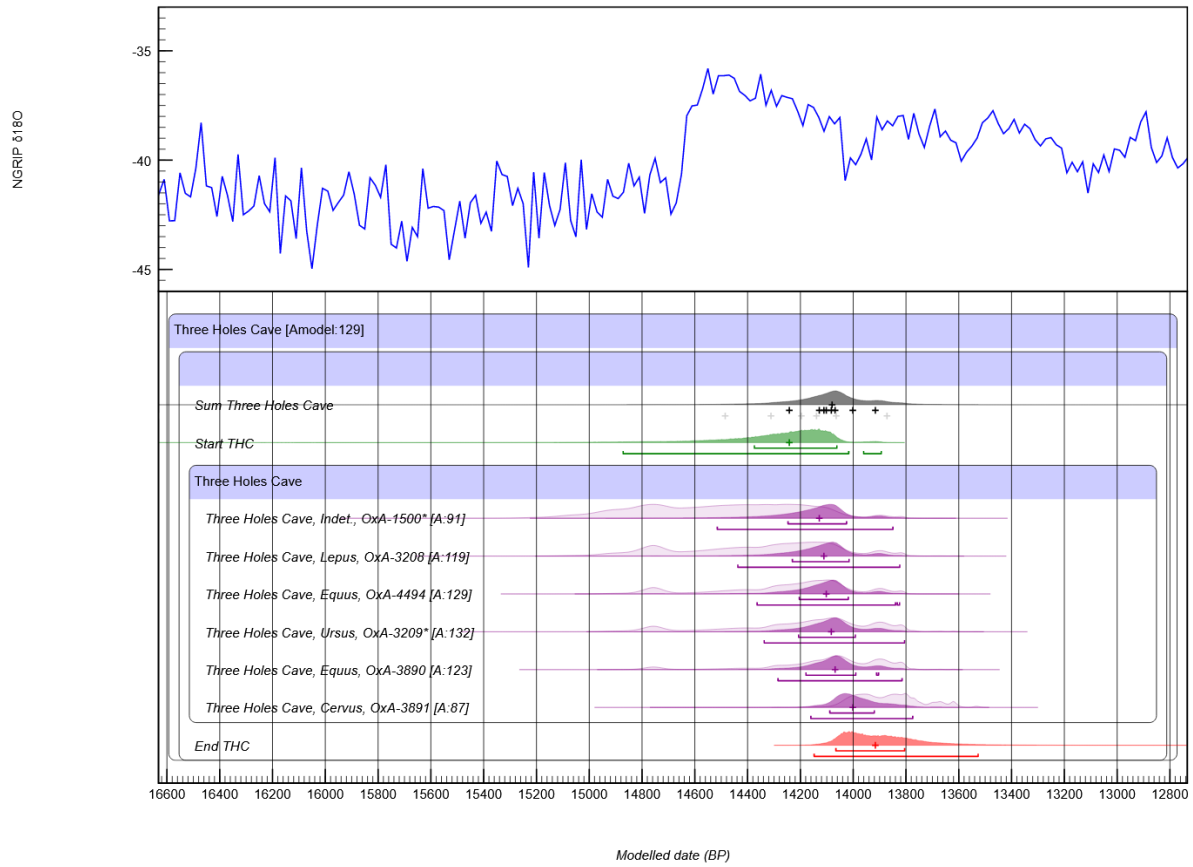


Figure A.154 Three Holes Cave (THC). Dates from Jacobi and Higham 2011. Single uniform phase. The Bayesian modelling constrains the dates, with a grouping towards the end of GI-1e. With recent excavations at GNC, this is the only Creswellian assemblage recovered from stratigraphic context with modern methods. All of the dates are from the archaeological assemblage associated to the Creswellian scatter (Barton and Roberts 1996). The dating is consistent, although relatively old AMS dates. THC is also the latest clearly dated Creswellian assemblage.

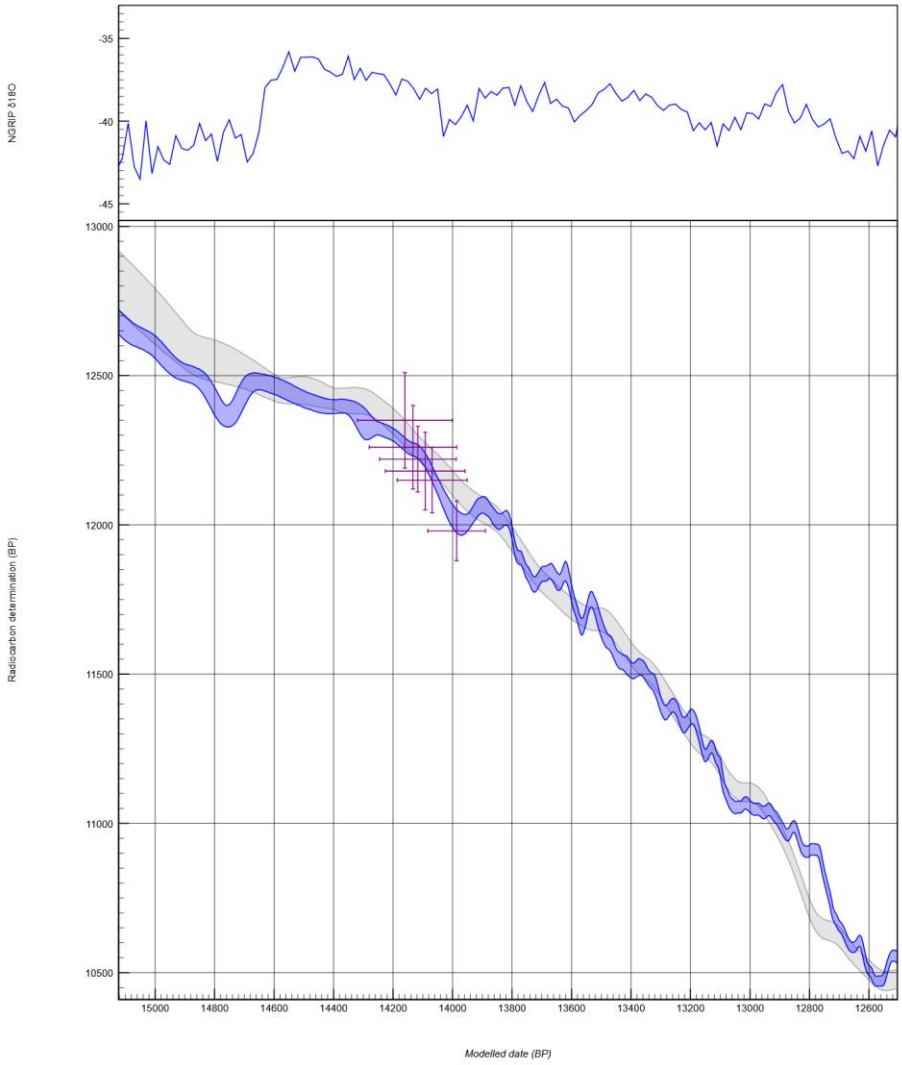


Figure A.155 Three Holes Cave (THC). Dates from Jacobi and Higham 2011. Single uniform phase. The Bayesian modelling constrains the dates, with a grouping towards the end of GI-1e. With the modelling the dates form a cluster on the regular segment of curve on the transition from GI-1e to GI-1d.

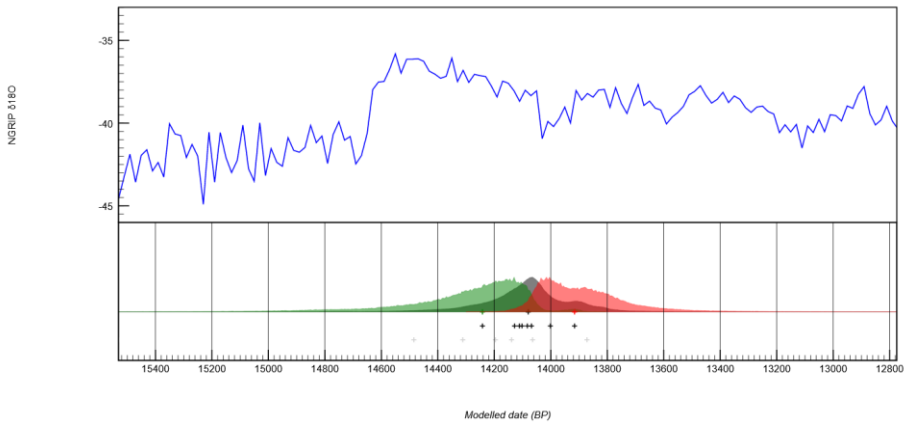


Figure A.156 Three Holes Cave (THC). Dates from Jacobi and Higham 2011. Single uniform phase.

Kendrick's Cave (KDC) Bølling

Simple Plot

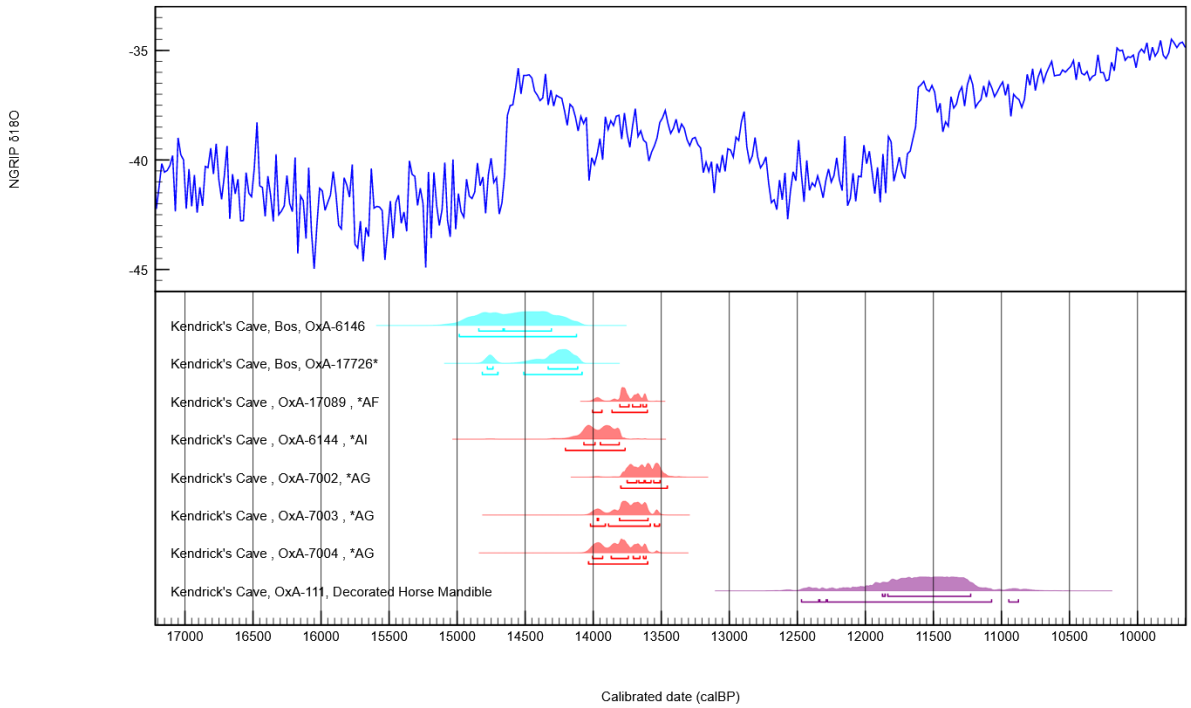


Figure A.157 Kendrick's Cave (KDC), human material is in red and dates to the Allerød. Dates from Jacobi and Higham 2011. Simple Plot. Three distinct groups of dates, transitional GS-2a to GI-1e (bos), GI-1c (human remains), and GS-1 (decorated horse mandible). Upper Kendrick's Cave has been associated to the Creswellian (presence of en-en-éperon preparation on the proximal of a blade), whereas the human bone material is Allerød (Rees and Nash 2017). The decorated horse mandible from Kendrick's Upper Cave (Sieveking 1971) was dated to the Younger Dryas (OxA-111: 10000 +- 200 BP, Gillespie et al. 1985) and associated to the burials (although not directly or conclusively, David 1991, Davies 1979, Dawkins 1880, 154-6). The material appears to have been mixed with neolithic finds, and from a sediment of a thickness of over 1m (Sieveking 1971). Multiple periods are therefore probable. The Bos dates would corroborate well with a Creswellian occupation, as demonstrated by the en-en-éperon blade preparation (Jacobi and Higham 2011). Questions remain as to potential contamination of some artefacts by organic preservatives as they are old finds. The older radiocarbon counts, and more recent counts overlap well.

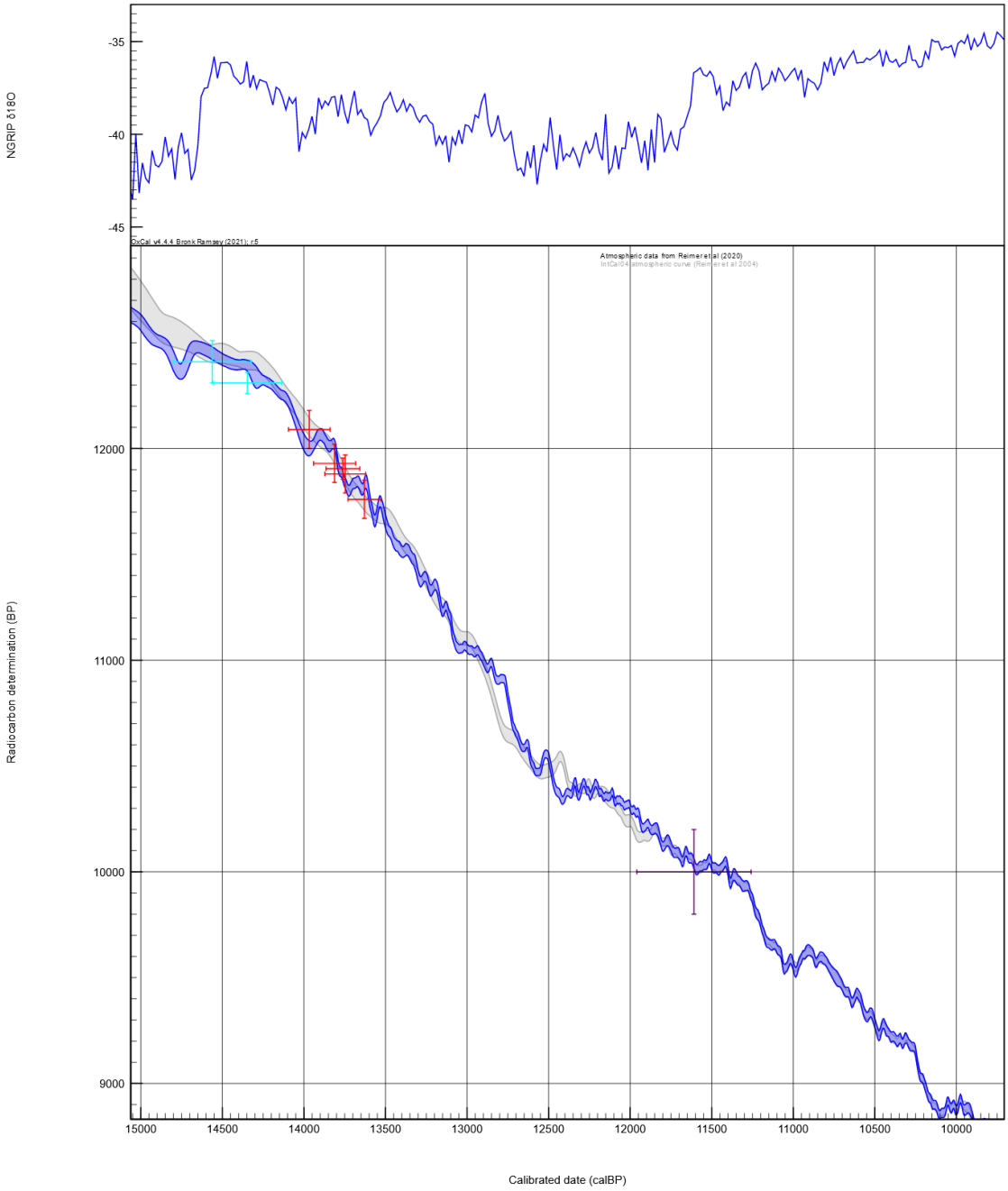


Figure A.158 Kendrick's Cave (KDC). Dates from Jacobi and Higham 2011. Simple Plot. IntCal04 (grey) (Reimer et al. 2004) is in the background for reference.

Single Uniform Phase

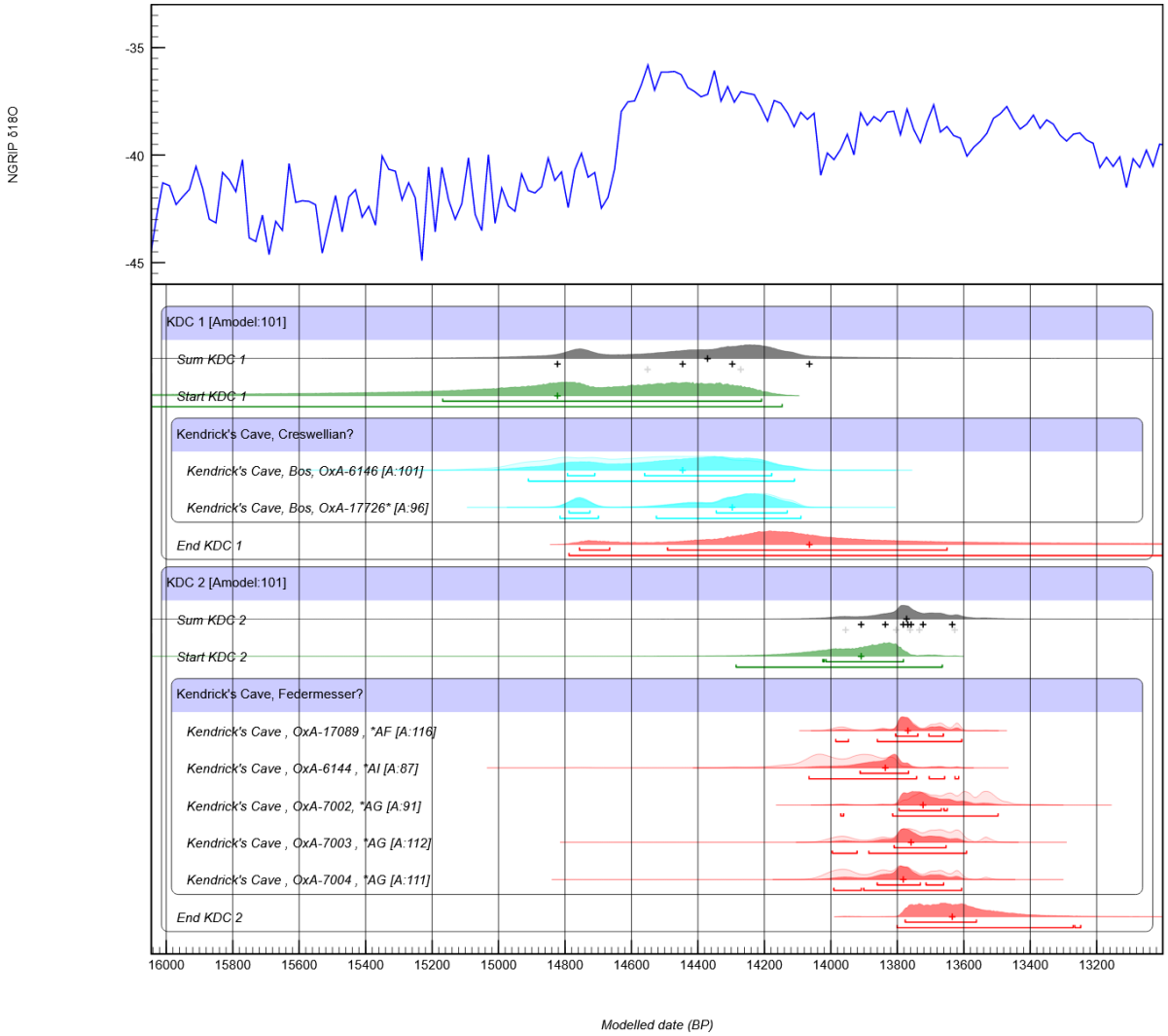


Figure A.159 Kendrick's Cave (KDC). Dates from Jacobi and Higham 2011. Single uniform phase. Kendrick's Cave, bos (blue) and human remains (red). The model has a good agreement (>60), A: 101. There are two distinct occupations with a significant hiatus. Whereas the bos dates fall within GS-1e, the human remains are fall within GI-1c. Upper Kendrick's Cave has been associated to the Creswellian (presence of en-en-éperon preparation on the proximal of a blade), whereas the human bone material is Allerød and considered as most likely Federmesser.

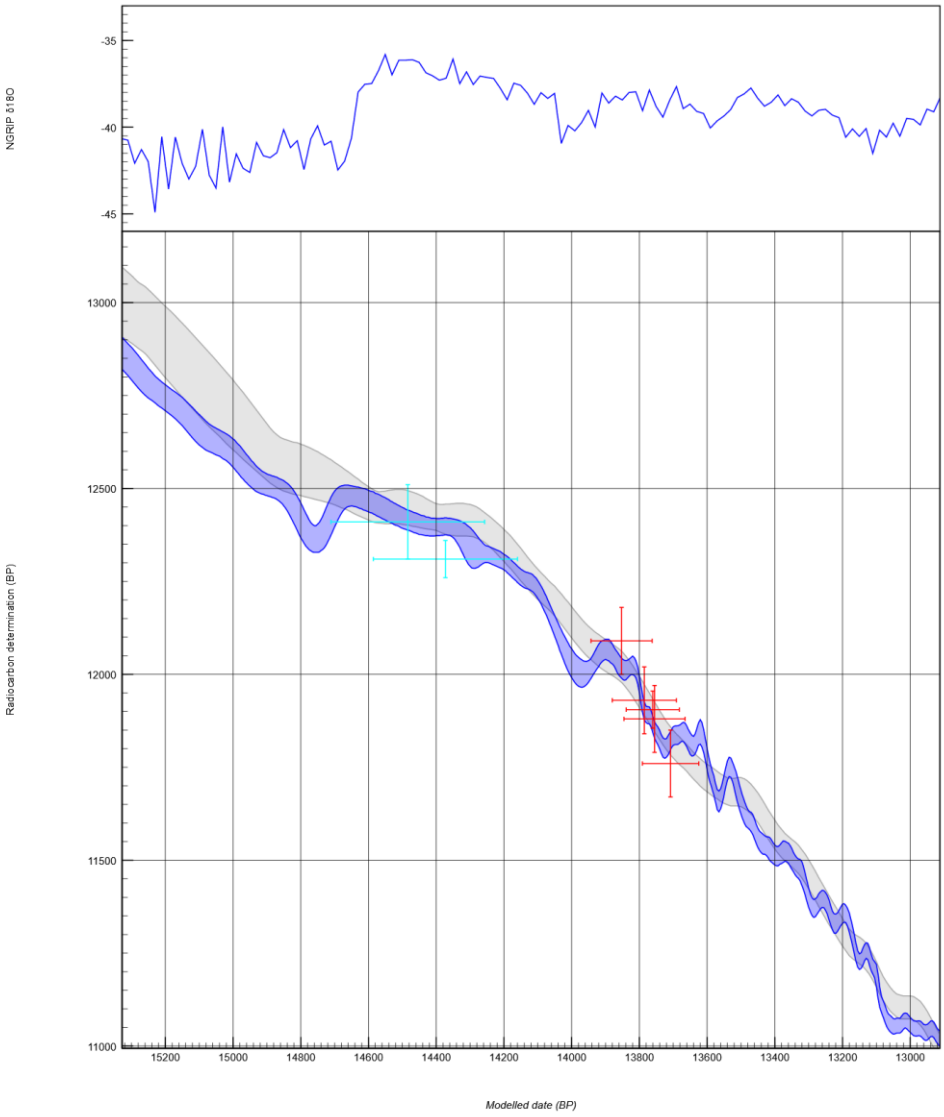


Figure A.160 Kendrick's Cave (KDC). Dates from Jacobi and Higham 2011. Single uniform phase.

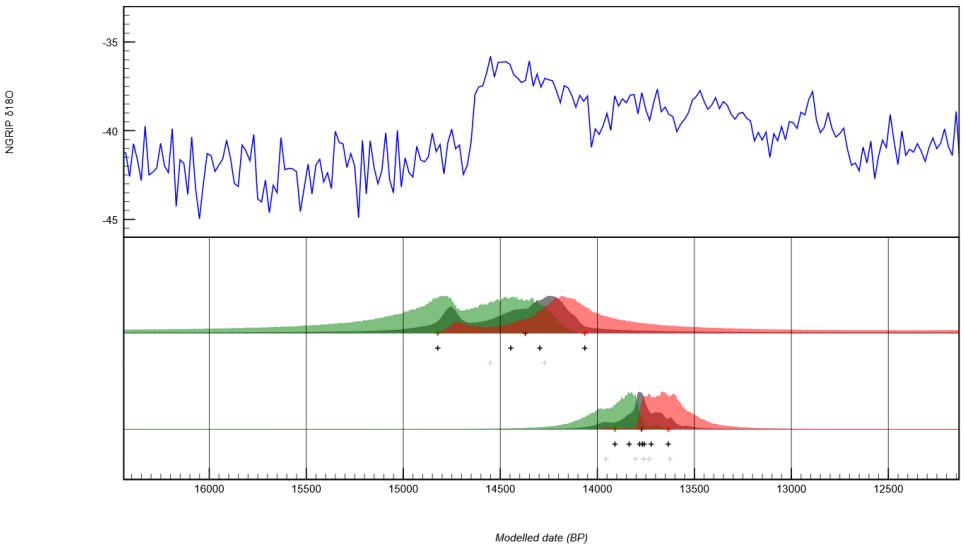


Figure A.161 Kendrick's Cave (KDC). Dates from Jacobi and Higham 2011. Single uniform phase.

Condover (CON) mammoths compared to other Northern European LG mammoths (Lister 2009)

Single Uniform Phase

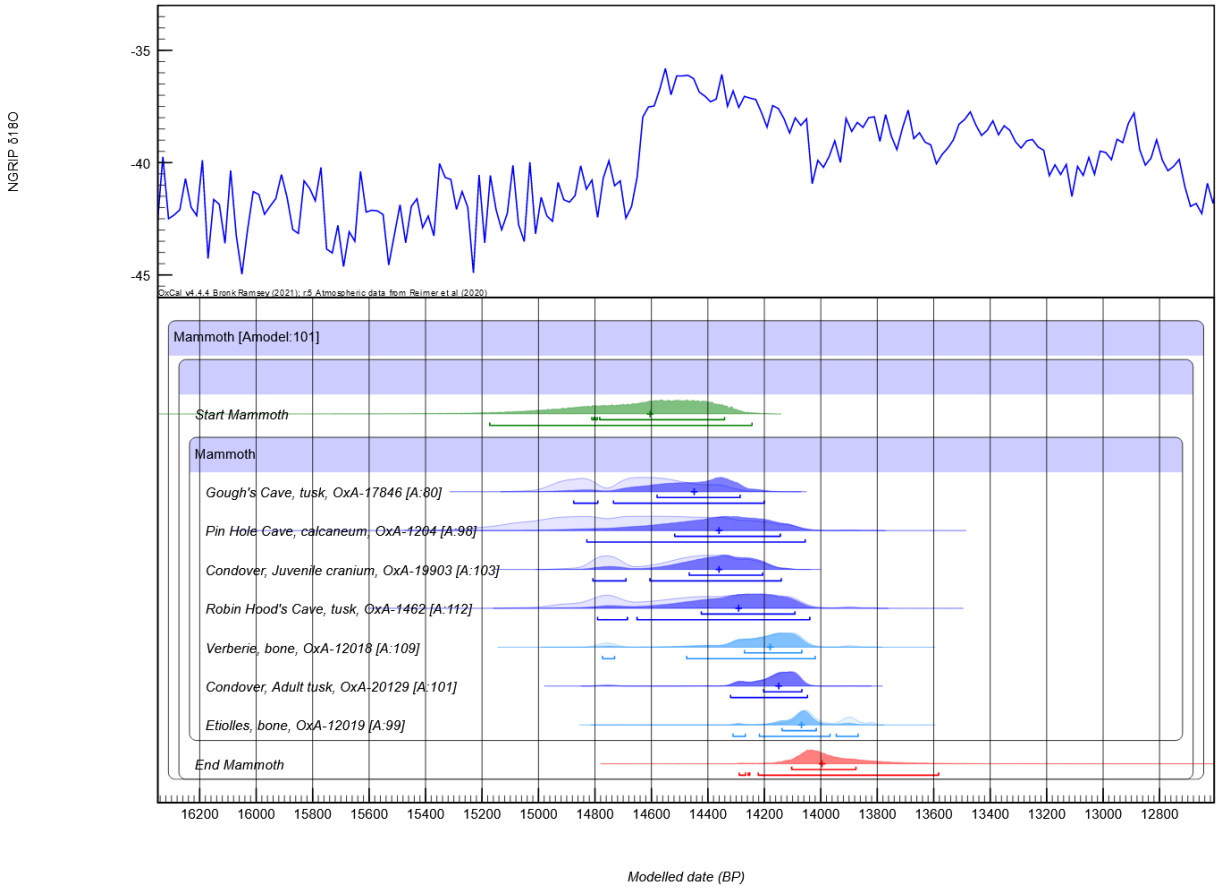


Figure A.162 Condover (CON) mammoths. Dates from Lister 2009. Single uniform phase. The Bayesian model confirms the spread of mammoth across the second half of GI-1e (Lister 2009).

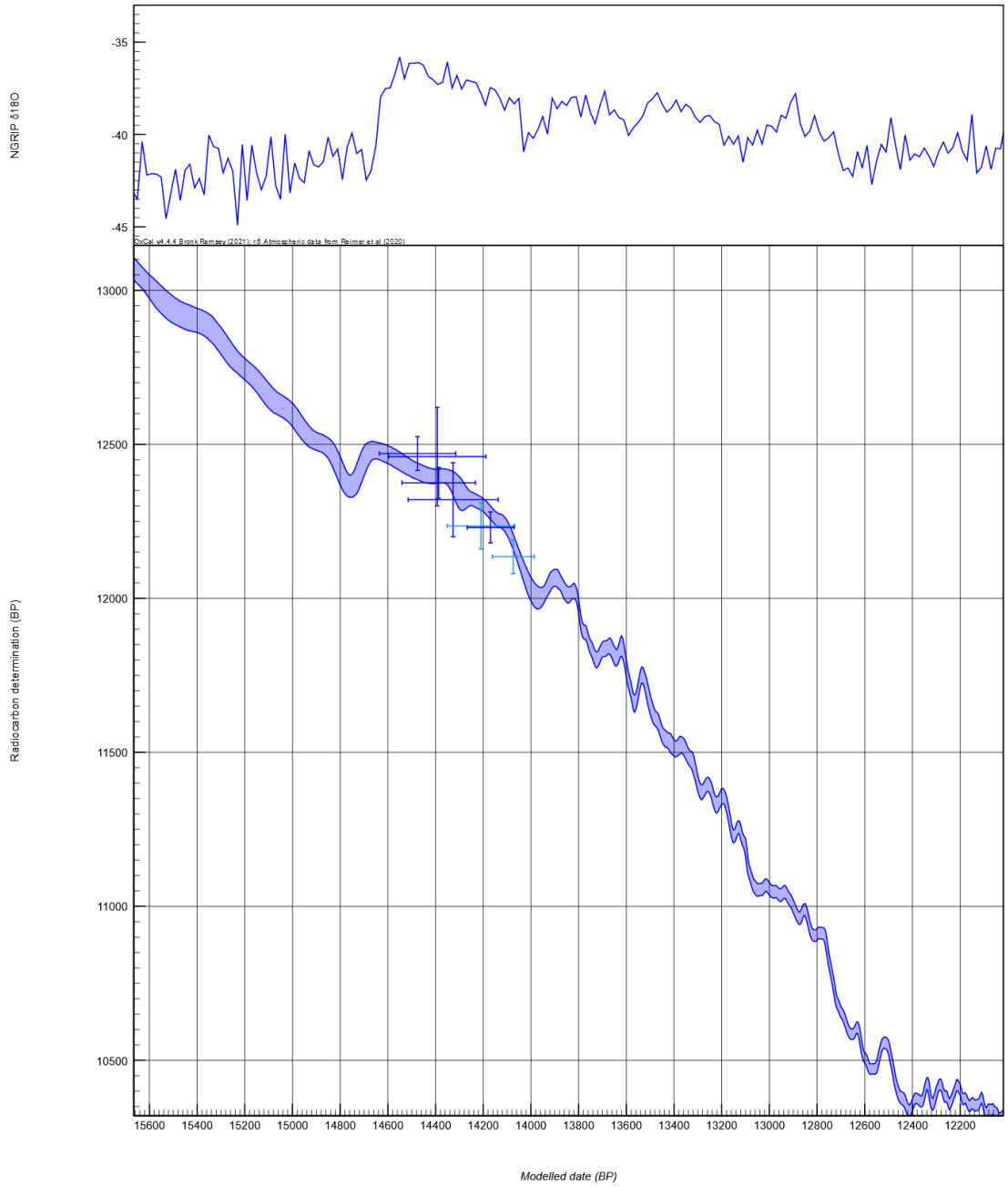


Figure A.163 Condover (CON) mammoths. Dates from Lister 2009. Single uniform phase. The earliest Condover dates fall within the GI-1e plateau, whereas the Condover adult and the two dates from the Paris Basin fall on a regular section of the curve.

KDE Model

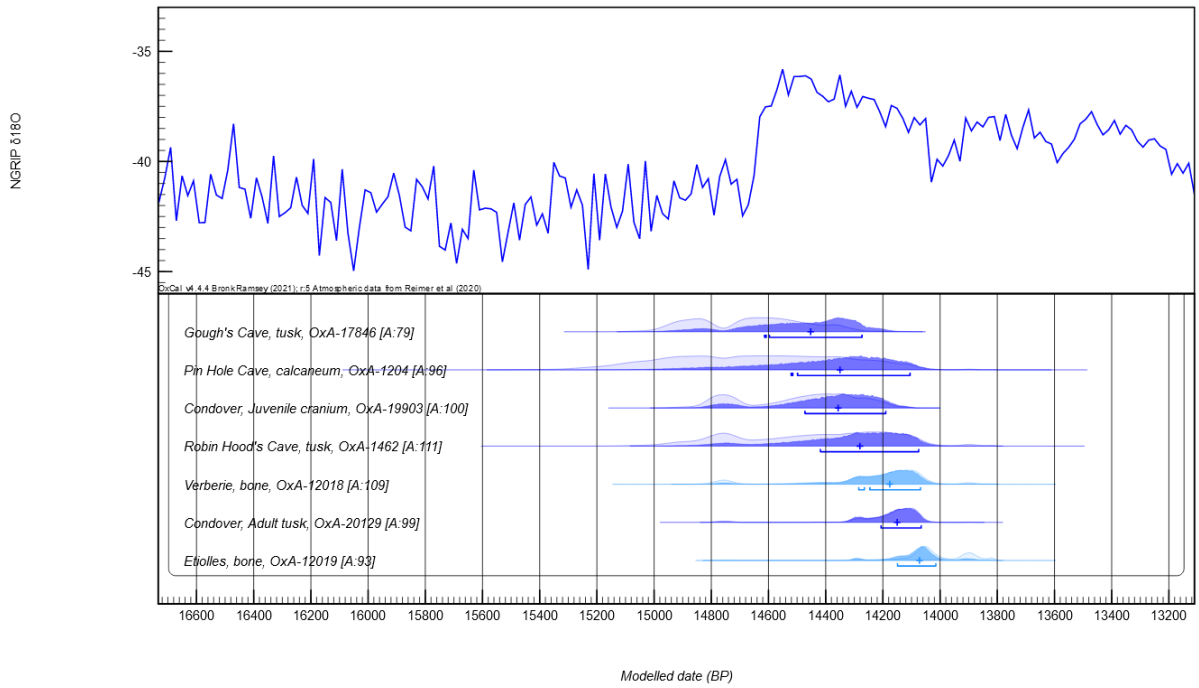


Figure A.164 Condover (CON) mammoths. Dates from Lister 2009. KDE model. The KDE model confirms the spread of mammoth across the second half of GI-1e.

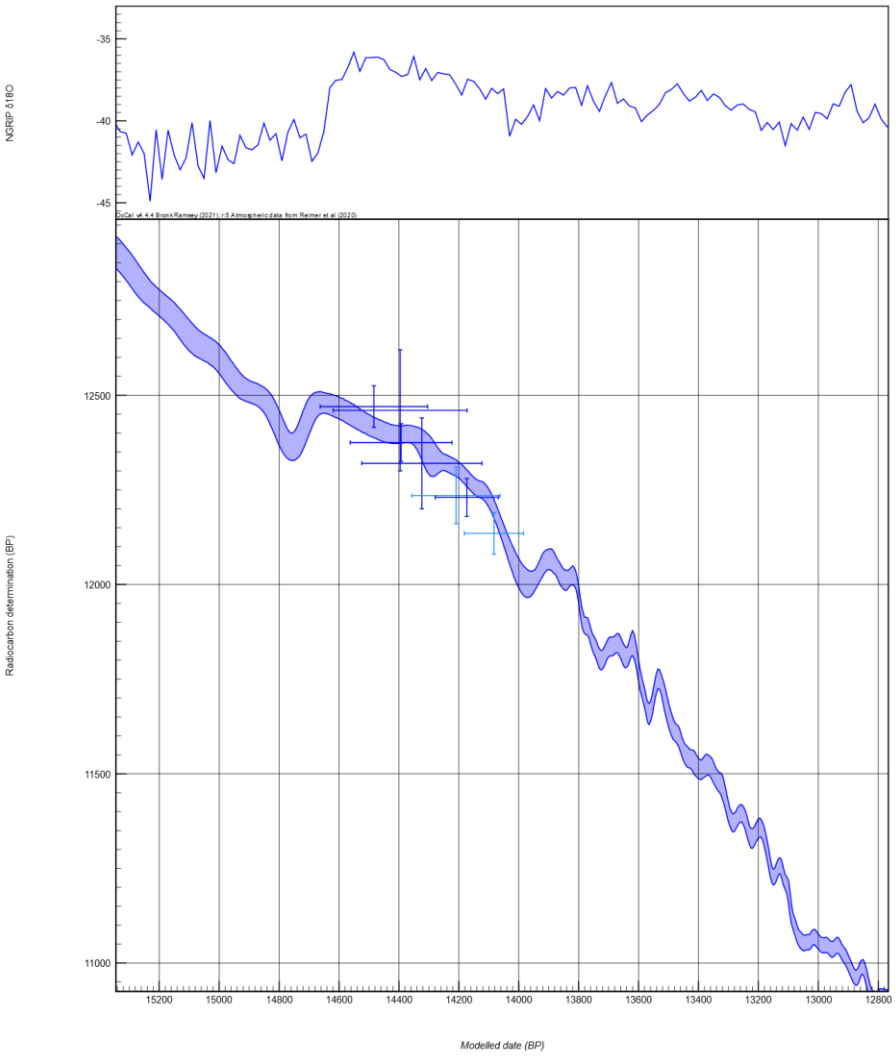


Figure A.165 Condover (CON) mammoths. Dates from Lister 2009. KDE model.

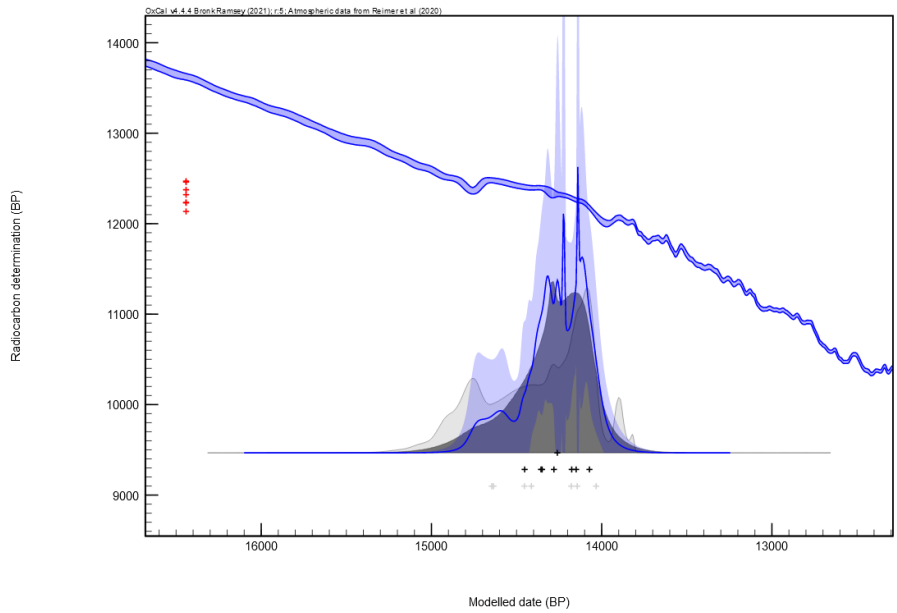


Figure A.166 Condover (CON) mammoths. Dates from Lister 2009. KDE model.

Domestic Dogs (GNC, KC)

Curve Comparison

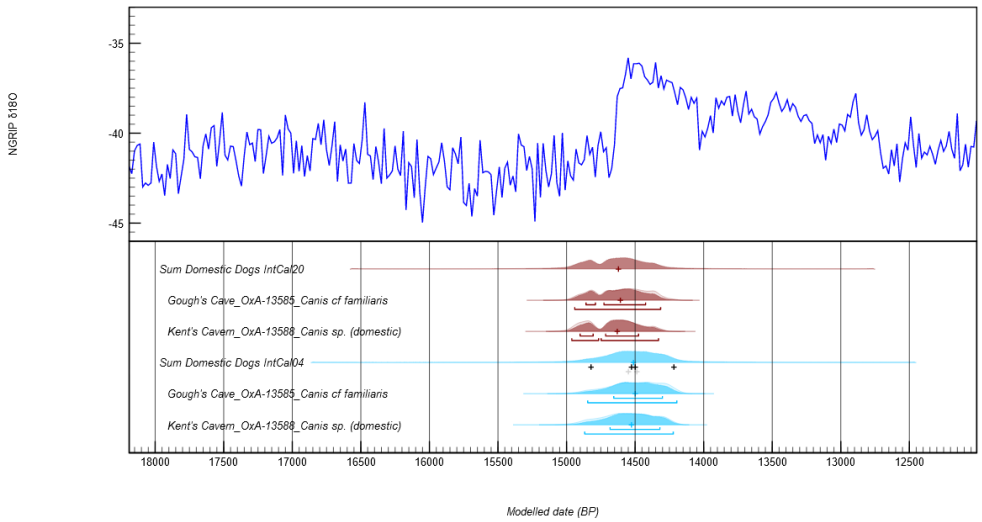


Figure A.167 Single uniform phase. Comparison of IntCal04 (blue) and IntCal20 dates (red) results. There is a shift towards earlier dates of approximately 200 years. The two occurrences appear to date to the same period.

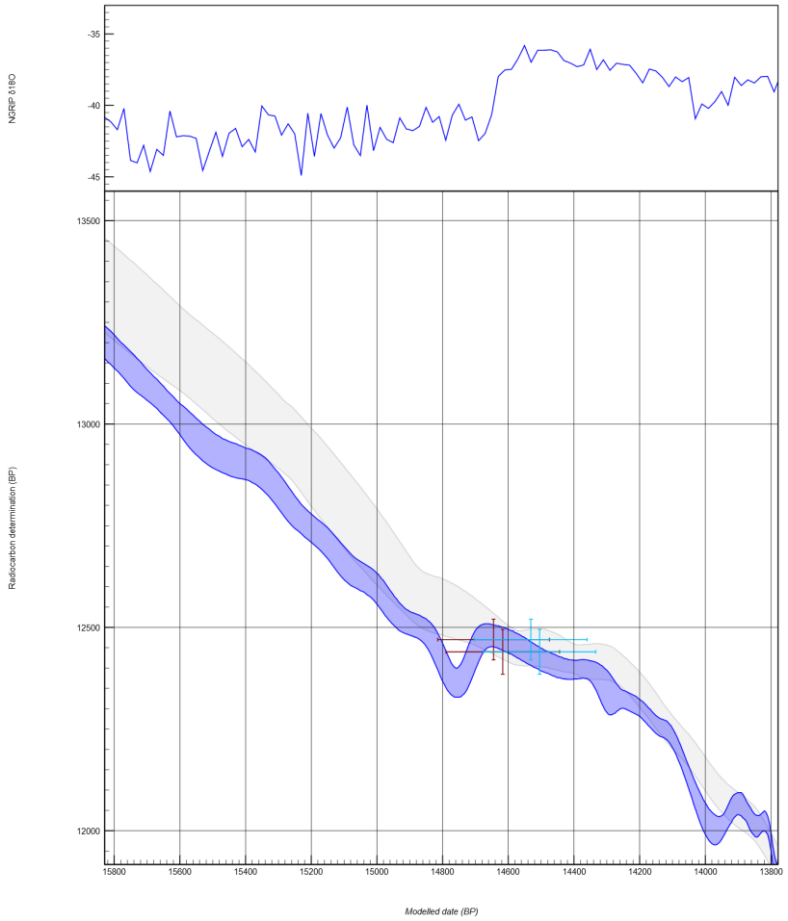


Figure A.168 Single uniform phase. Comparison of IntCal04 (blue) and IntCal20 dates (red) results. There is a shift towards earlier dates of approximately 200 years. The two occurrences appear to date to the same period.

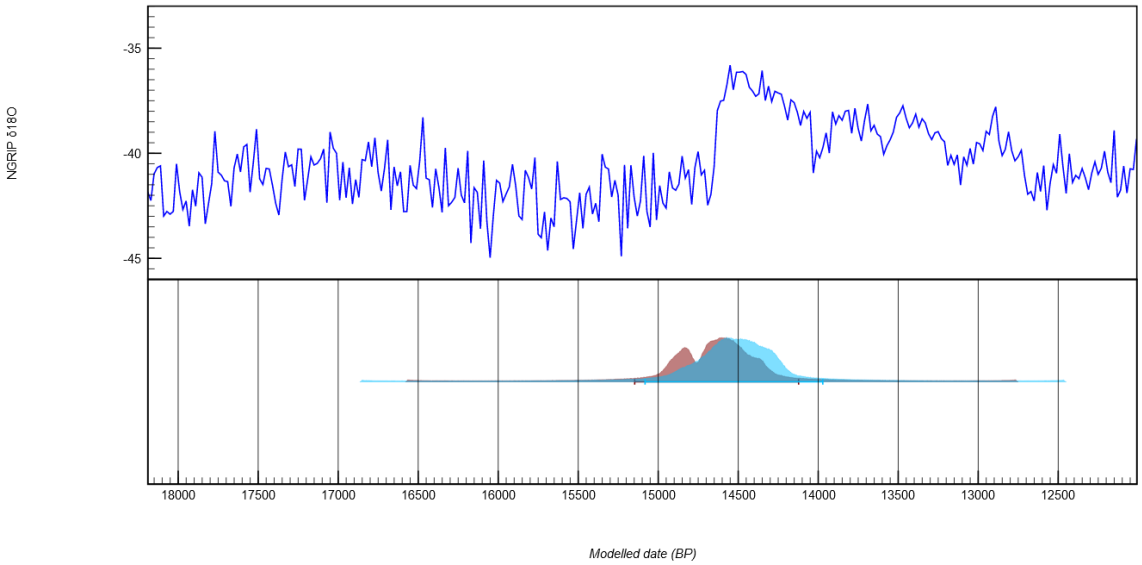


Figure A.169 Single uniform phase. Comparison of IntCal04 (blue) and IntCal20 dates (red) results. There is a slight shift towards earlier dates. The two occurrences appear to date to the same period.

Federmesser

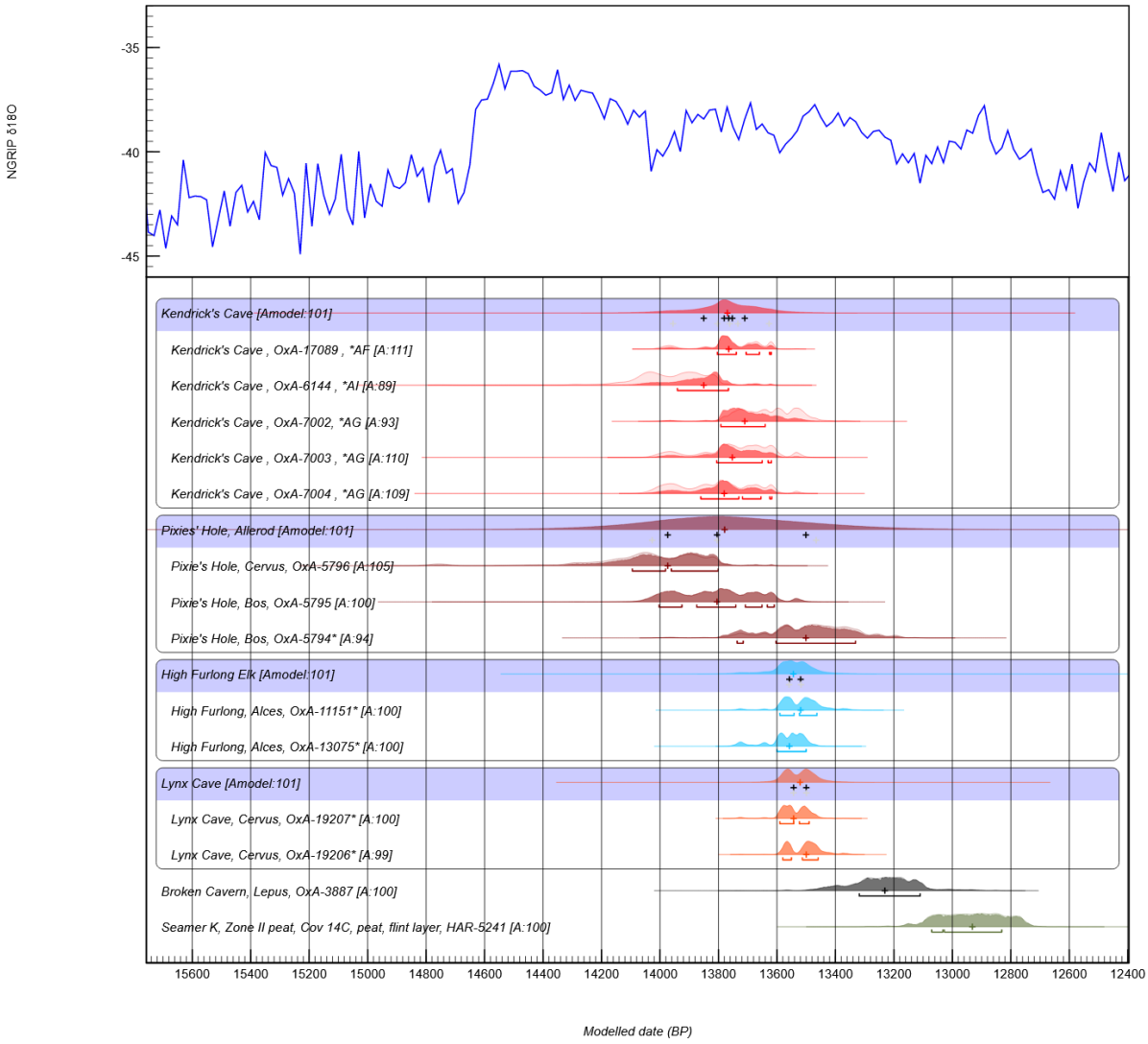


Figure A.170 Single phase KDE Model of GI-1c to 1a dates. There are less dates available when comparing the assemblages of GI-1c-a (Allerød) when compared to the rich cave assemblages of GI-1e. Often the dates associated to these Federmesser assemblages (Barton and Roberts 1996, Barton 2009) are few in number per site when compared to the Creswellian. This is mostly due to taphonomic biases, as many sites are open-air, and in the few cases that there are cave assemblages, very few have significant amounts of Allerød faunal material with anthropic modification that can be associated to this technocomplex. There are also more dates available for the first half of the Allerød (GI-1c to 1b) than the second half with only two dates.

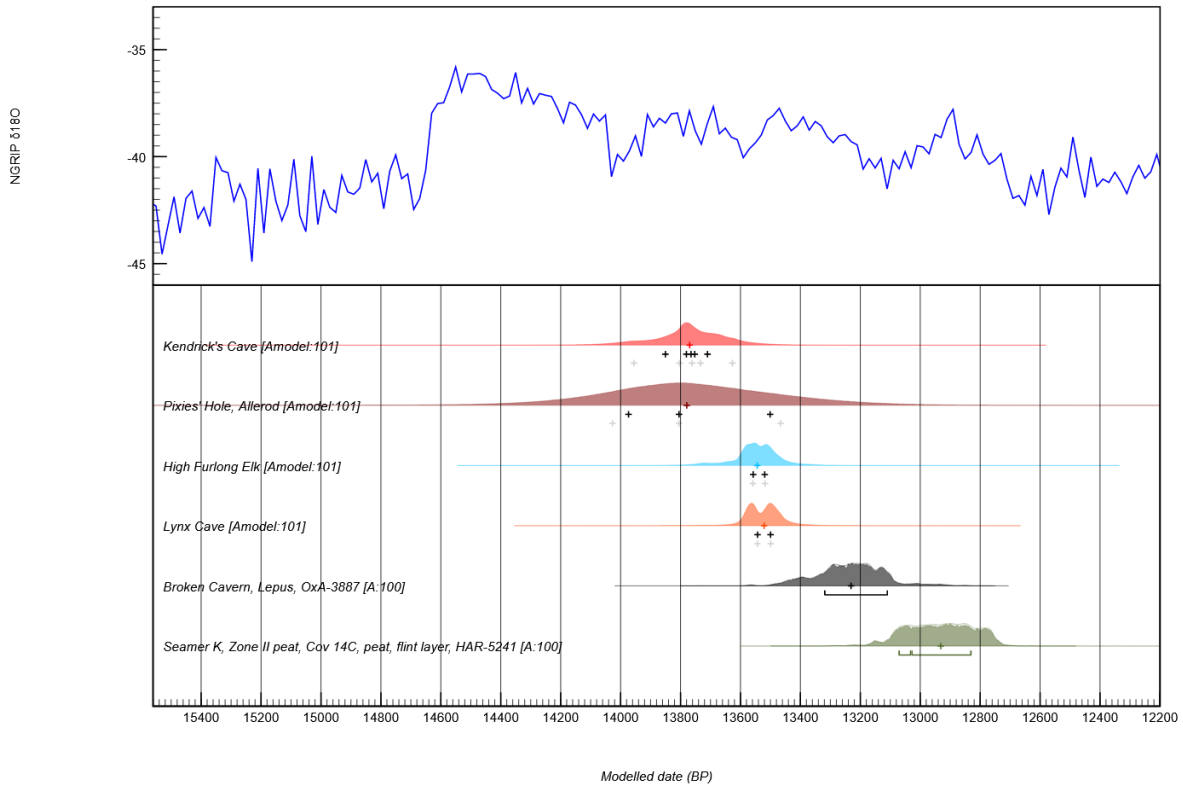


Figure A.171 Selected dated sites associated to Federmesser activity. KDE Model.

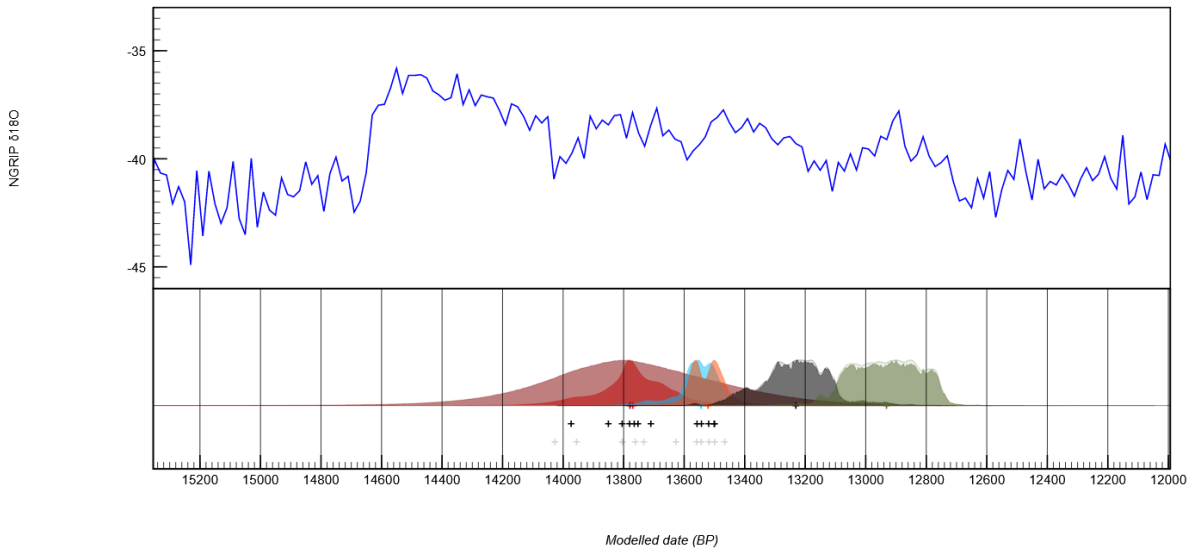


Figure A.172 Selected dated sites associated to Federmesser activity. KDE Model, stacked.

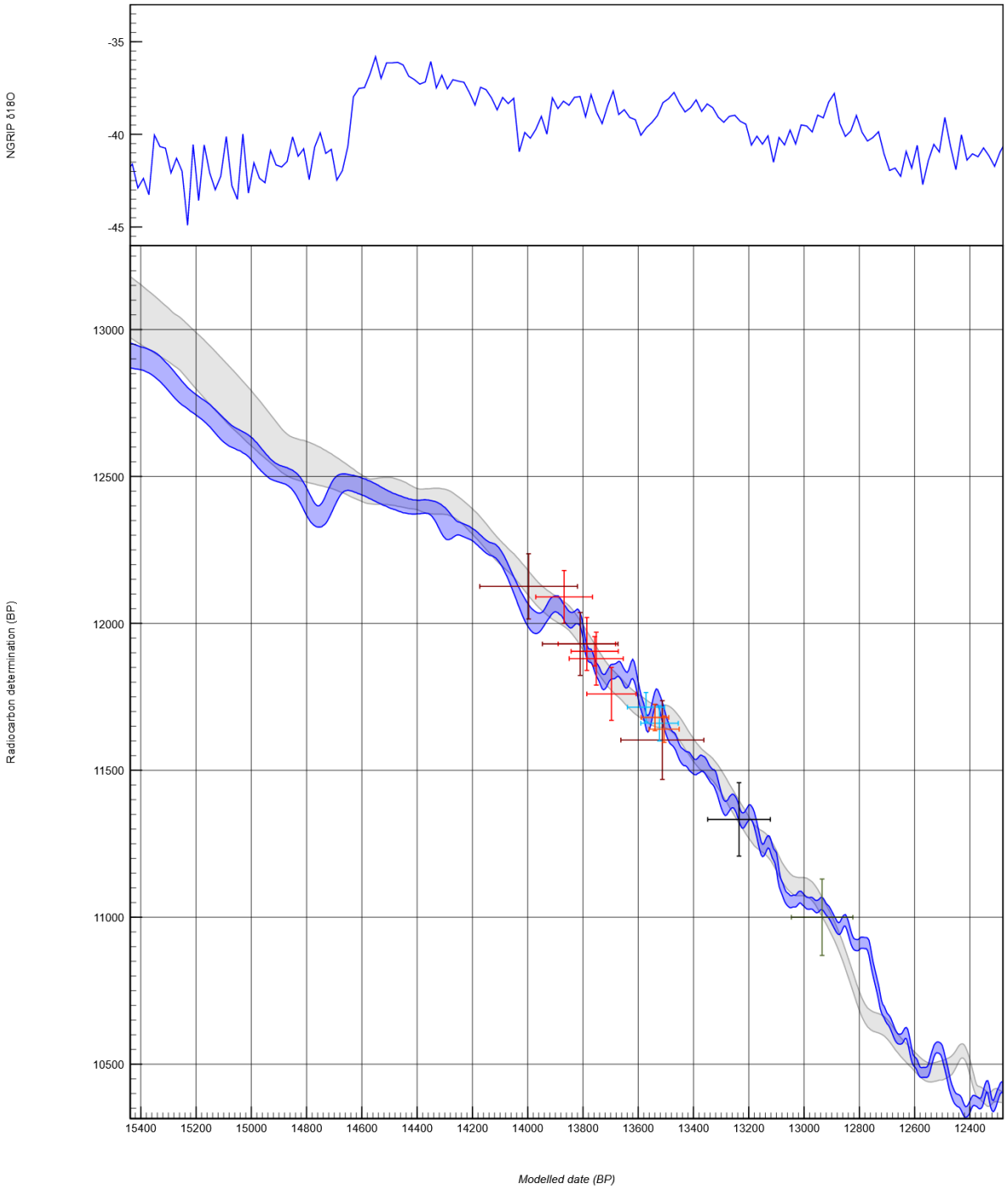


Figure A.173 Selected dated sites associated to Federmesser activity. KDE Model.

King Arthur's Cave (KAC)

Overlapping Uniform Phases

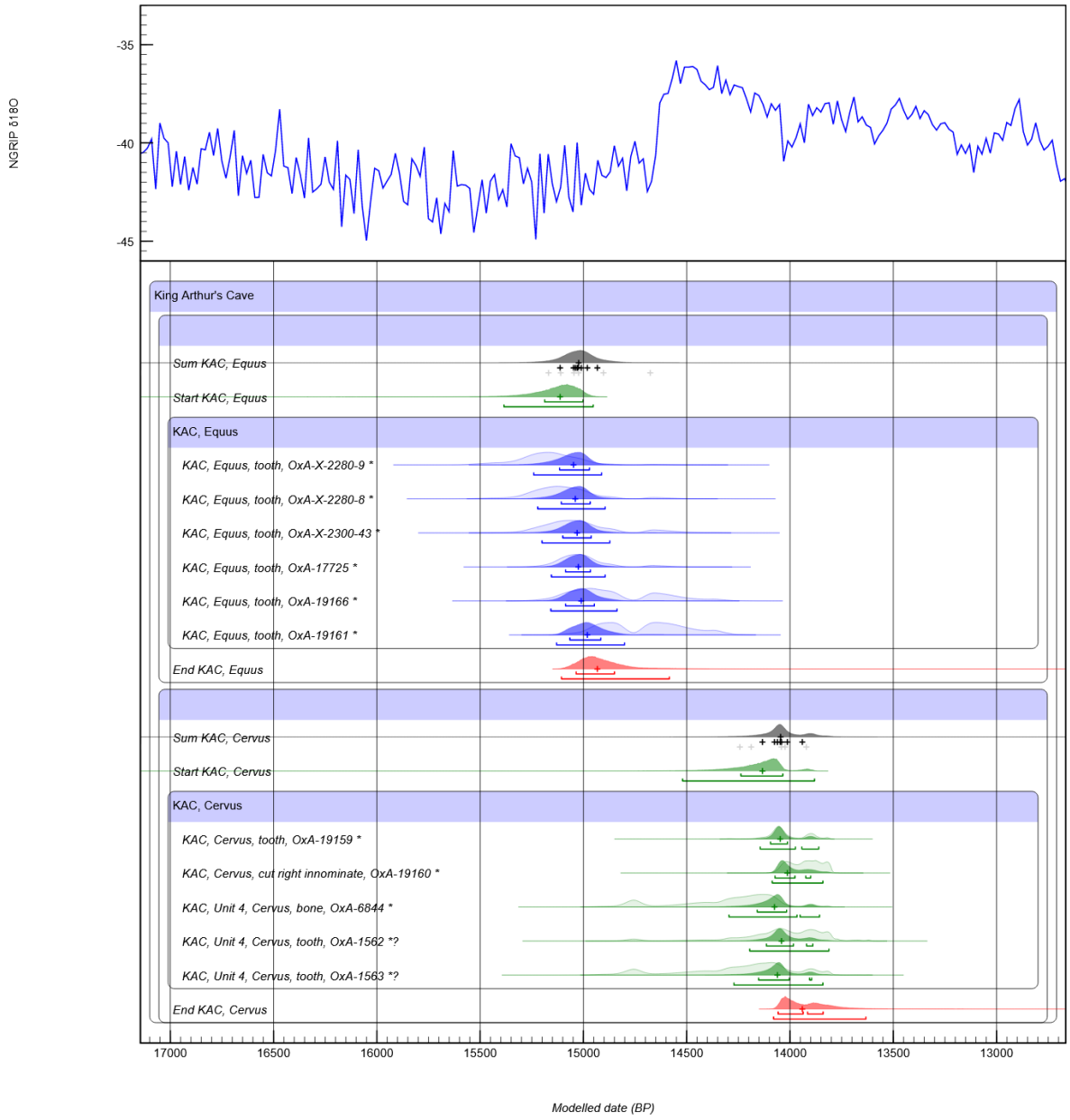


Figure A.174 King Arthur's Cave (KAC). Dates from Jacobi and Higham 2011, Hedges et al. 1987 and Bronk Ramsey et al. 2002. Simple Plot. The earliest dates are on horse (see Jacobi and Higham 2011) whereas the later dates are on Red Deer (Cervus elaphus). Overlapping uniform plot. All material is either cut marked or intentionally fractured. Although the Equus material has been modified, no lithics have been found directly in relation to this horizon, however the dates would place it within the Creswellian. The Cervus material was found in relation to the second hearth (OxA-1562 and -1563 Hedges et al. 1987) and a well stratified horizon with a lithic scatter (OxA-6844 Barton 1996, Bronk Ramsey et al. 2002), the dates corroborate a Federmesser interpretation of the lithics techno-typology (Barton 1996, Barton and Roberts 1996), and dates to before the GI-1d. This could be the earliest directly dated British Federmesser assemblage, however it remains to be fully published, and the associations remain unclear.

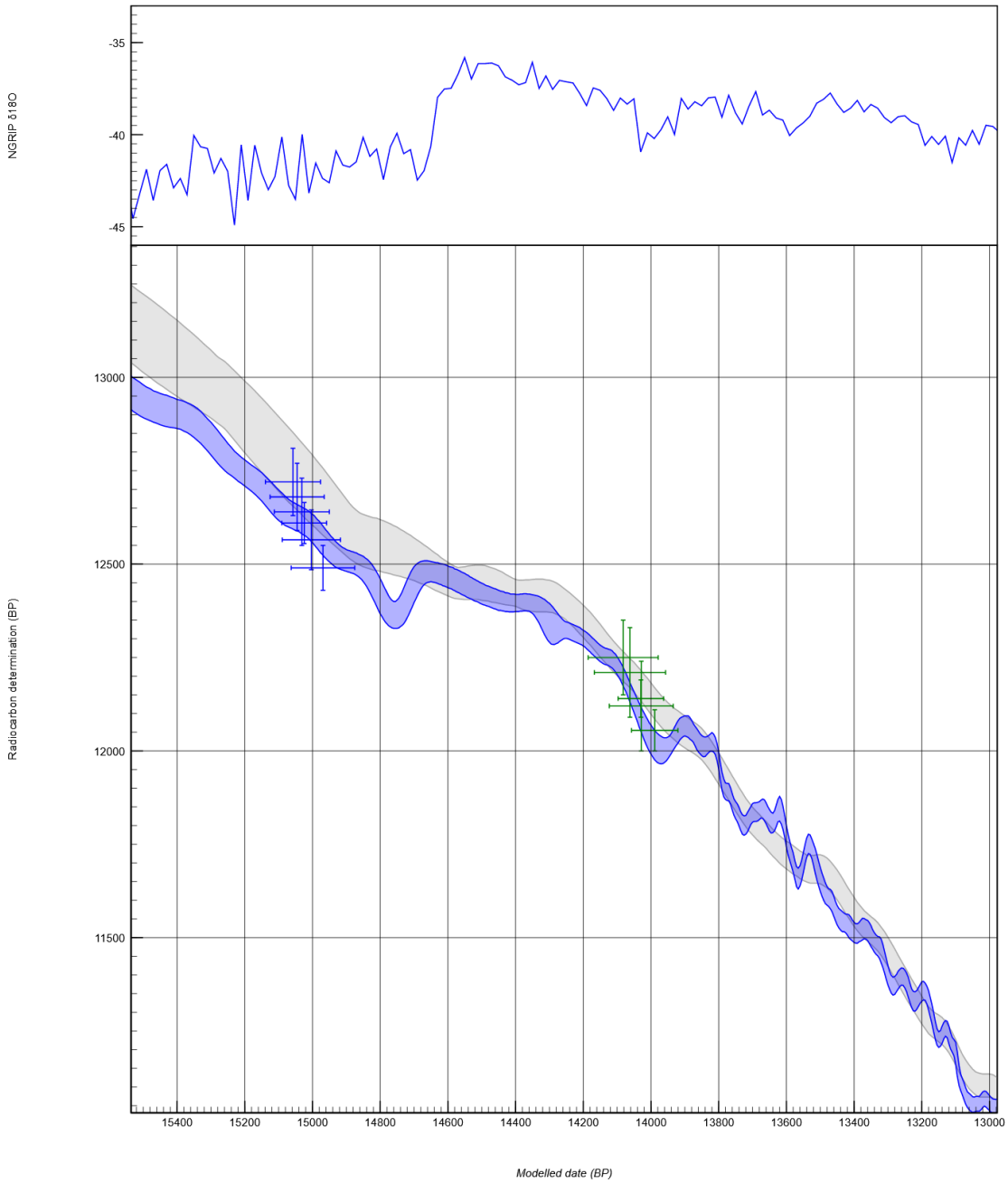


Figure A.175 King Arthur's Cave (KAC). Dates from Jacobi and Higham 2011. Overlapping uniform phases. Both series are on regular parts of the calibration curve. Both have very tight groupings.

Kendrick's Cave (KDC) Allerød

Single Uniform Phase

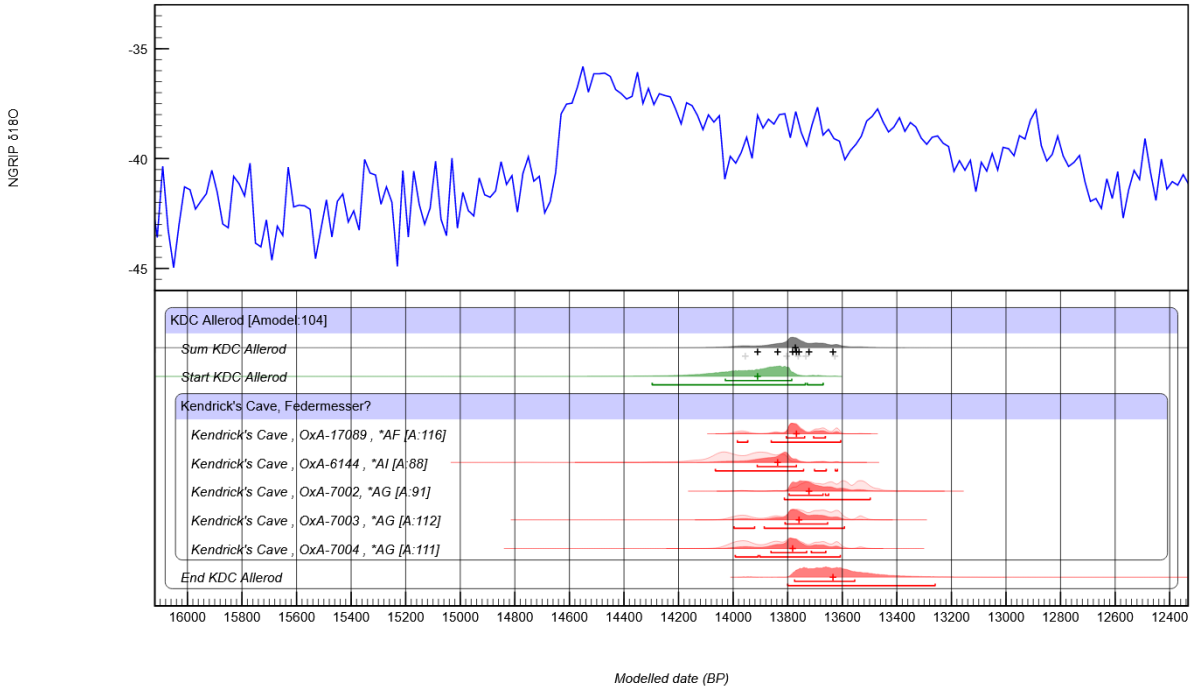


Figure A.176 Kendrick's Cave (KDC), human remains, and possible burial. Dates from Jacobi and Higham 2011. Single uniform phase. Group of human remains considered as a burial, clustering around GI-1c. Upper Kendrick's Cave has been associated to the Creswellian (presence of en-en-éperon preparation on the proximal of a blade), whereas the human bone material is Allerød (Rees and Nash 2017). The decorated horse mandible from Kendrick's Upper Cave (Sieveking 1971) was dated to the Younger Dryas (OxA-111: 10000 +- 200 BP, Gillespie et al. 1985) and associated to the burials (although not directly or conclusively, David 1991, Davies 1979, Dawkins 1880, 154-6). The material appears to have been mixed with neolithic finds, and from a sediment of a thickness of over 1m (Sieveking 1971). Multiple periods are therefore probable. The dates on human remains are consistent and overlap. Questions remain as to potential contamination of some artefacts by organic preservatives as they are old finds. The older radiocarbon counts, and more recent counts overlap well.

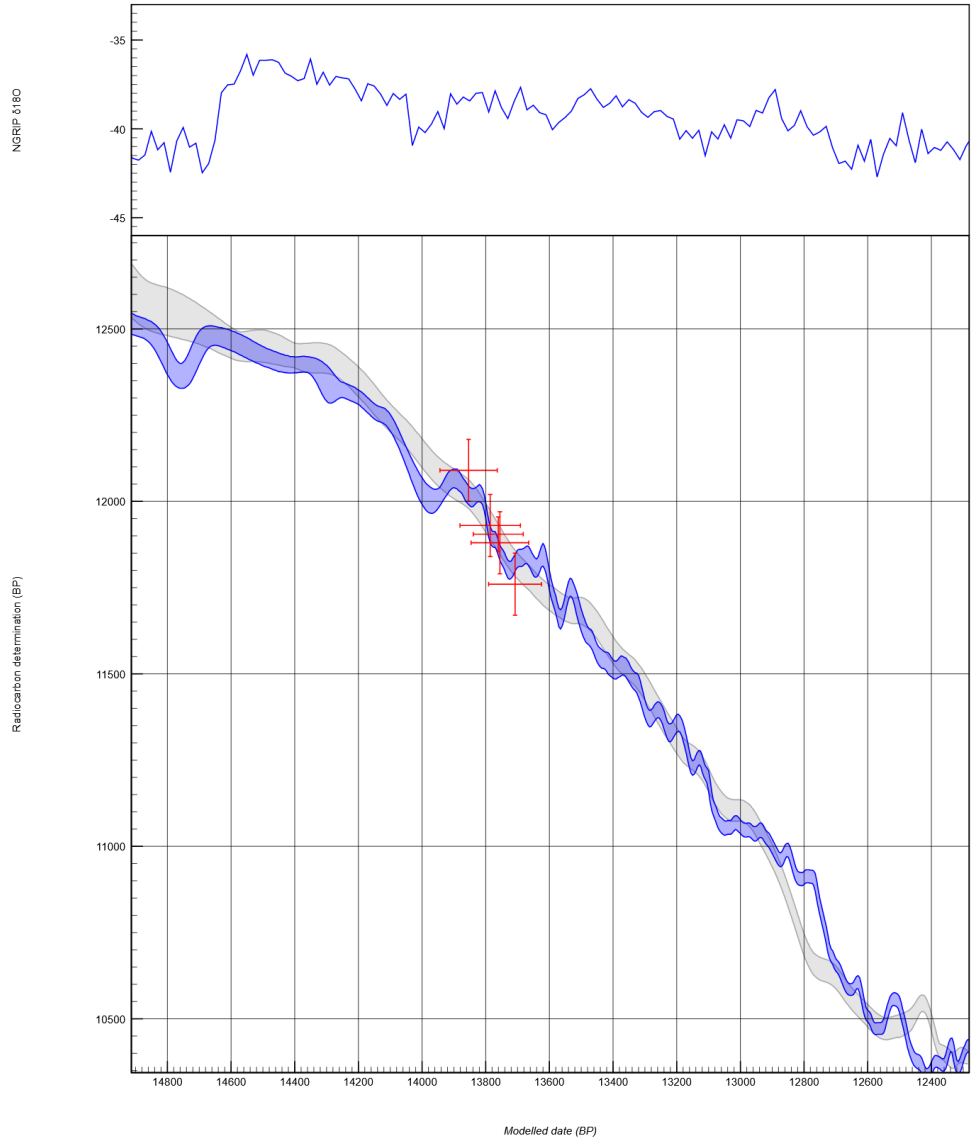


Figure A.177 Kendrick's Cave (KDC), human remains, and possible burial. Dates from Jacobi and Higham 2011. Single uniform phase.

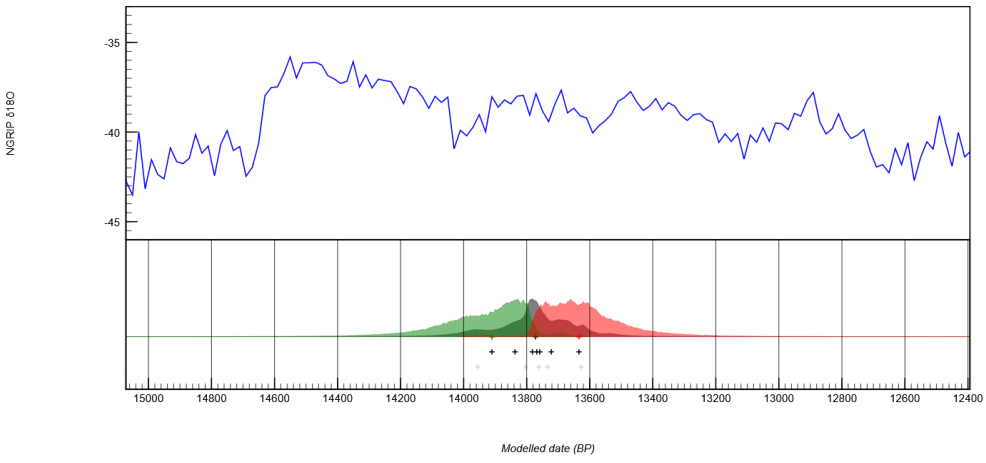


Figure A.178 Kendrick's Cave (KDC), human remains, and possible burial. Dates from Jacobi and Higham 2011. Single uniform phase.

Pixie's Hole (PH)

Single Uniform Phase

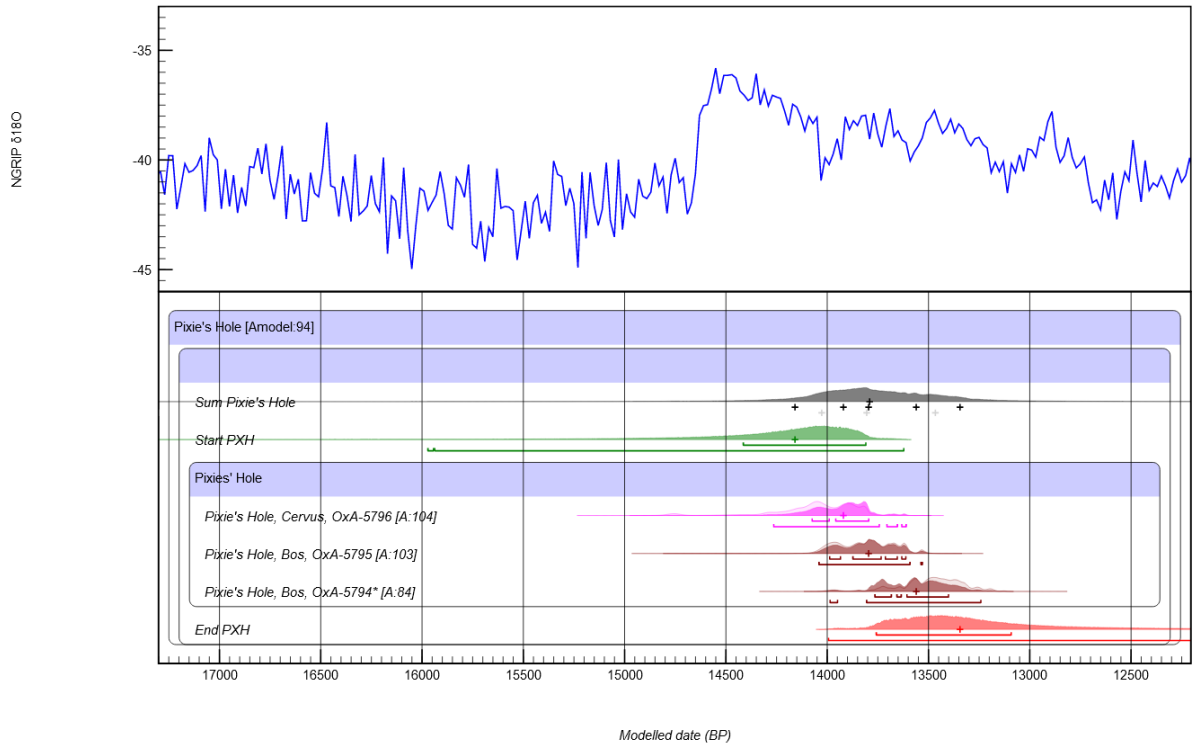


Figure A.179 Pixie's Hole (PXH), single uniform phase. Dates Barton and Roberts 1996. The bos dates group around GI-1c and are considered to relate to the Federmesser lithic assemblage (Barton and Roberts 1996). One has cut marks. No bones were directly associated to the scatter with cut marks, although a bos bone without cut marks was directly north of the hearth (Collcutt 1986). Dates from Dates from Barton and Roberts 1996. Single uniform phase.

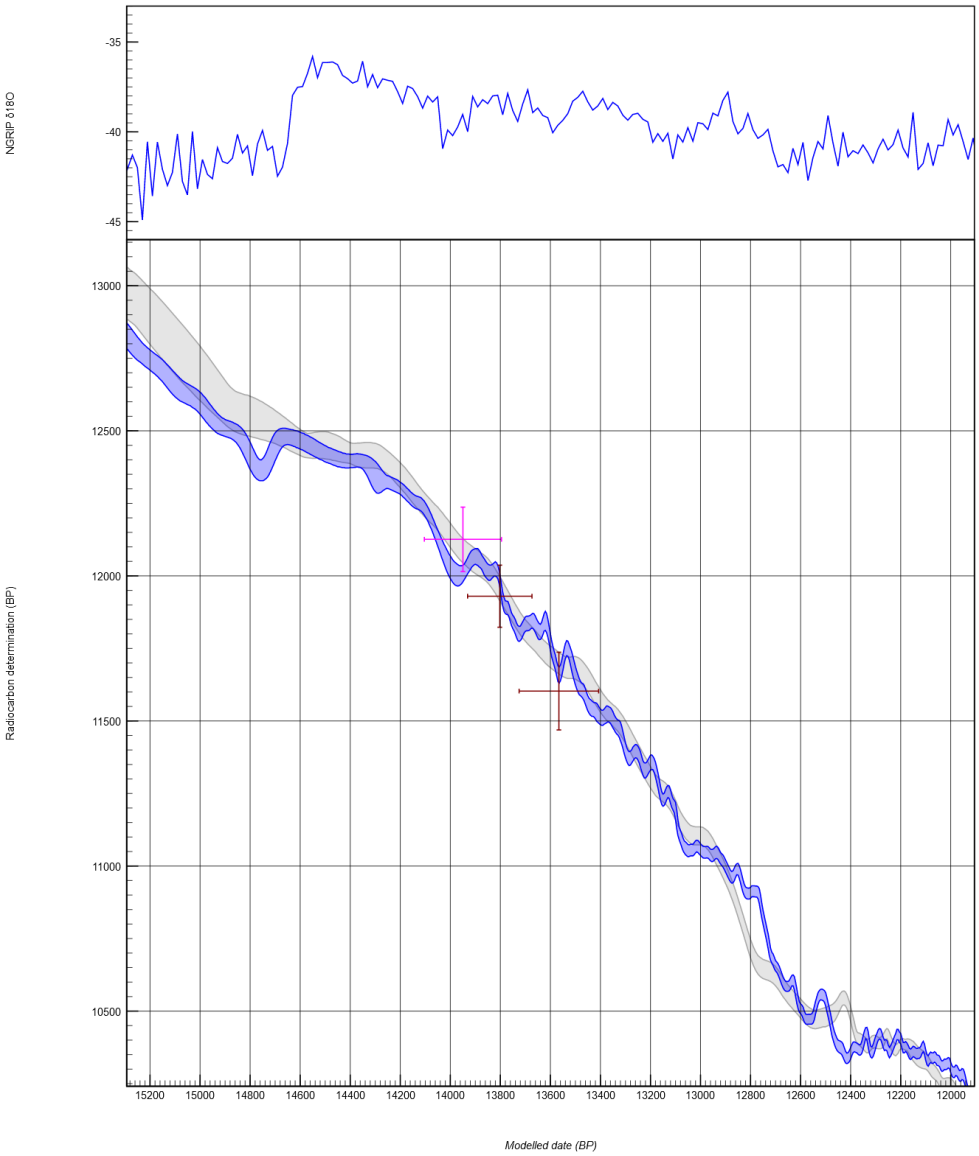


Figure A.180 Pixie's Hole (PXH), single uniform phase. Dates Barton and Roberts 1996.

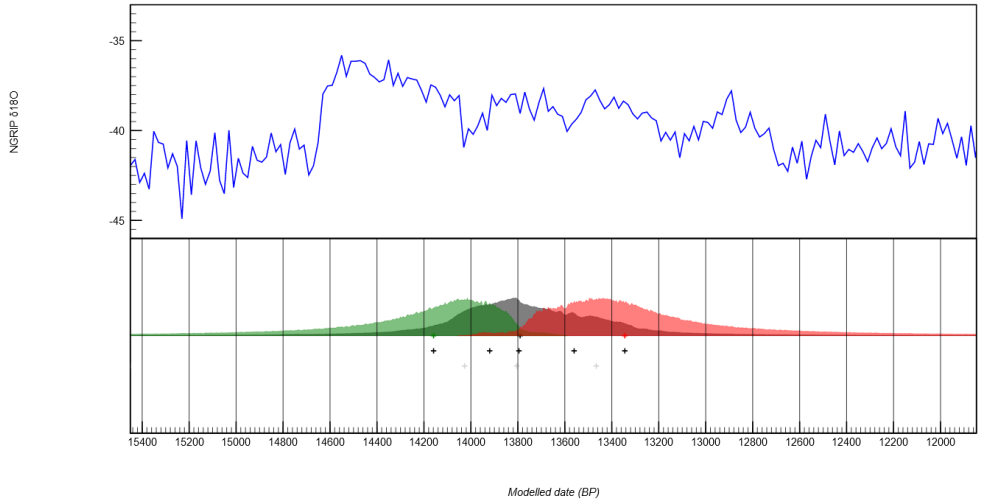


Figure A.181 Pixie's Hole (PXH), single uniform phase. Dates Barton and Roberts 1996.

High Furlong (HF), Poulton le Fylde

Single Uniform Phase

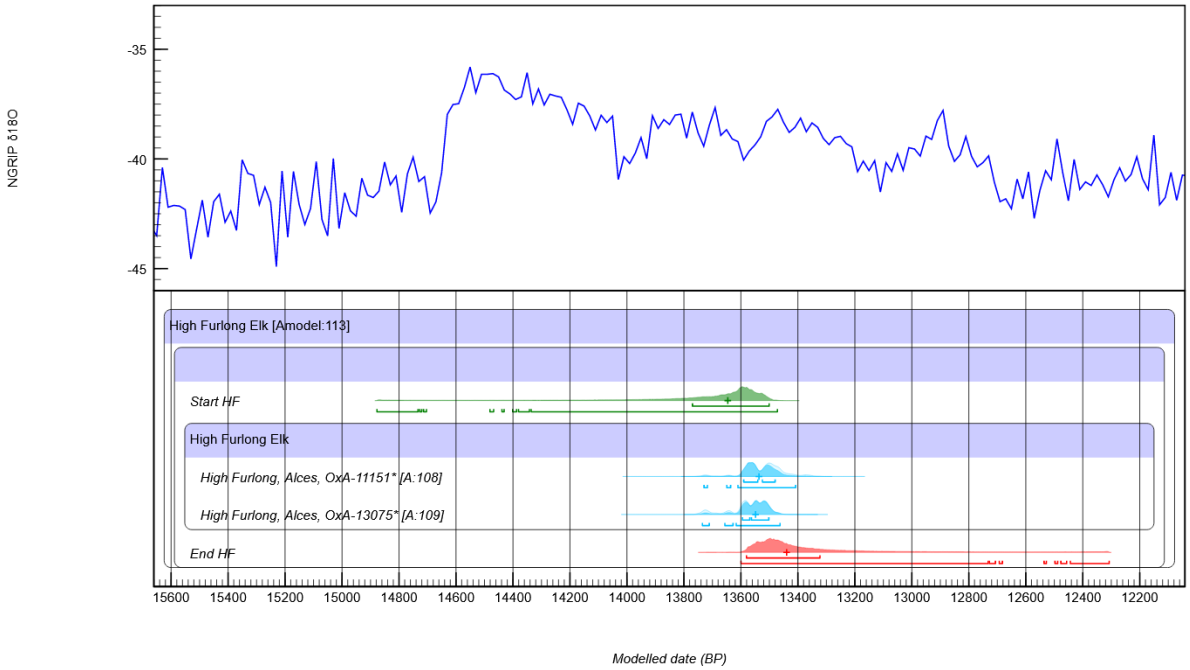


Figure A.182 High Furlong, Poulton le Fylde, elk. Dates from Jacobi and Higham 2011. Single uniform phase.

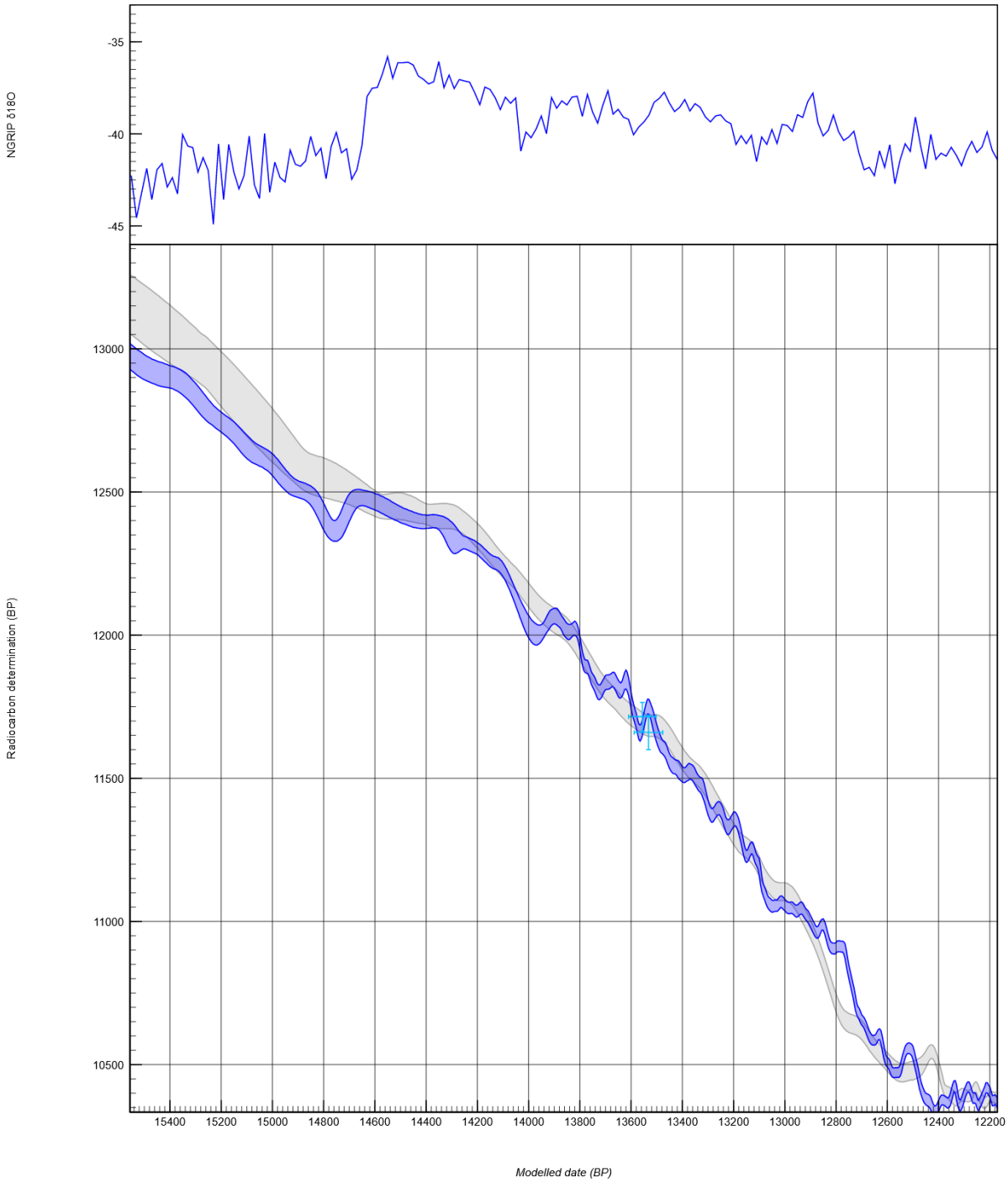


Figure A.183 High Furlong, Poulton le Fylde, elk. Dates from Jacobi and Higham 2011. Single uniform phase.

Lynx Cave (LC)

Single Uniform Phase

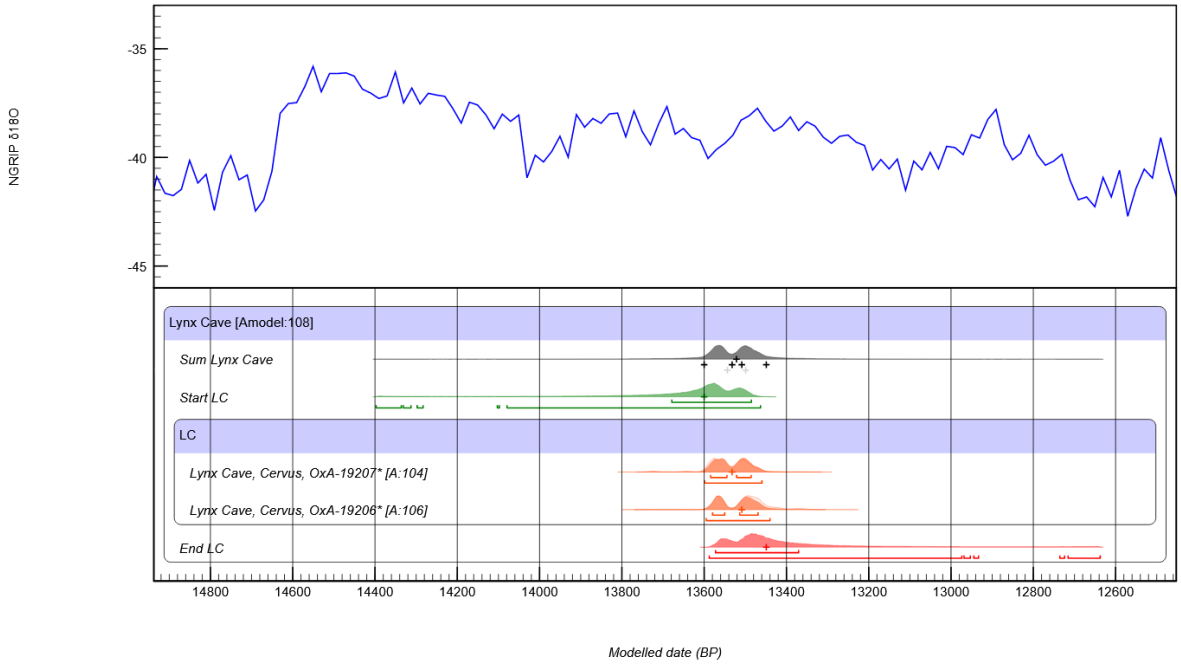


Figure A.184 Lynx Cave (LC), cut marked red deer. The cut marked bone is not in direct association with the lithic horizon at the same site. Dates from Jacobi and Higham 2011 and Bore 2012. Single uniform phase.

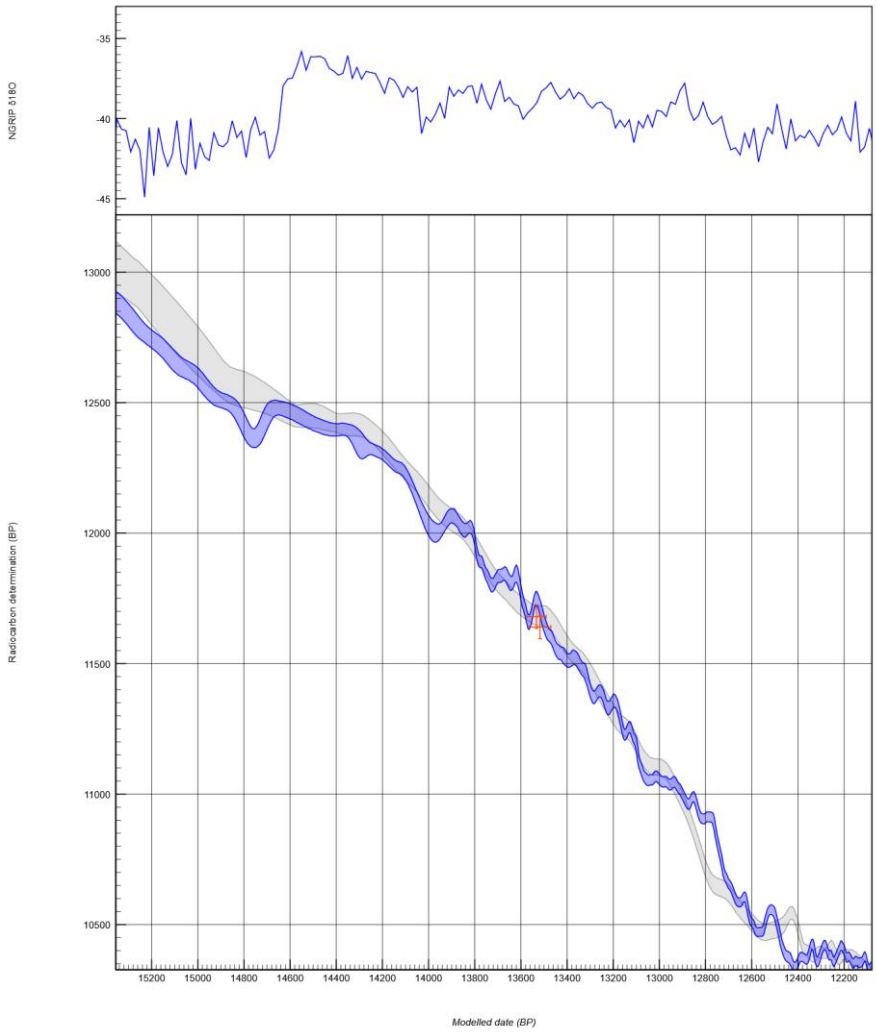


Figure A.185 Lynx Cave (LC), cut marked red deer. Dates from Jacobi and Higham 2011 and Bore 2012. Single uniform phase.

Broken Cavern (BC)

Simple Plot

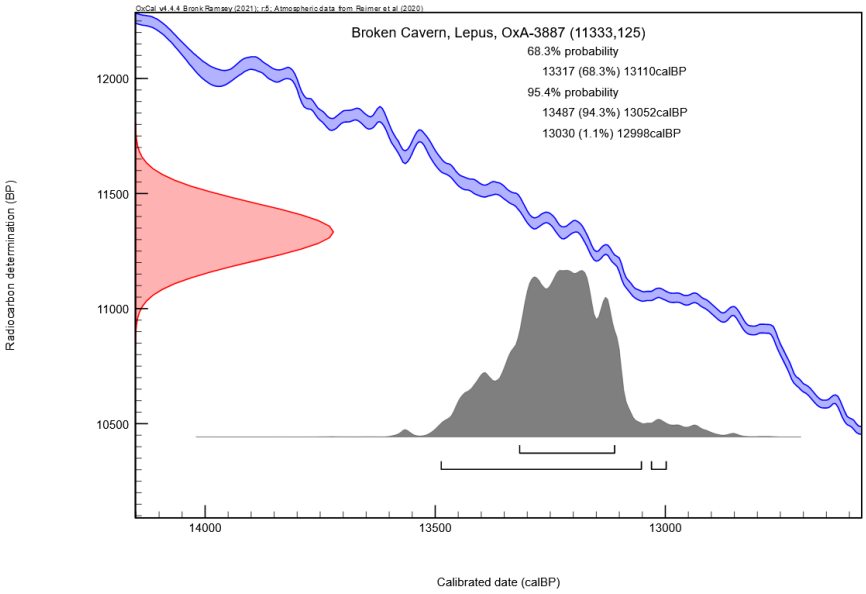


Figure A.186 Broken Cavern (BC). Date Barton and Roberts 1996. Simple Plot. Broken Cavern. The small assemblage had similar thick backed blades to Three Holes Cave's Federmesser horizon (Barton and Roberts 1996).

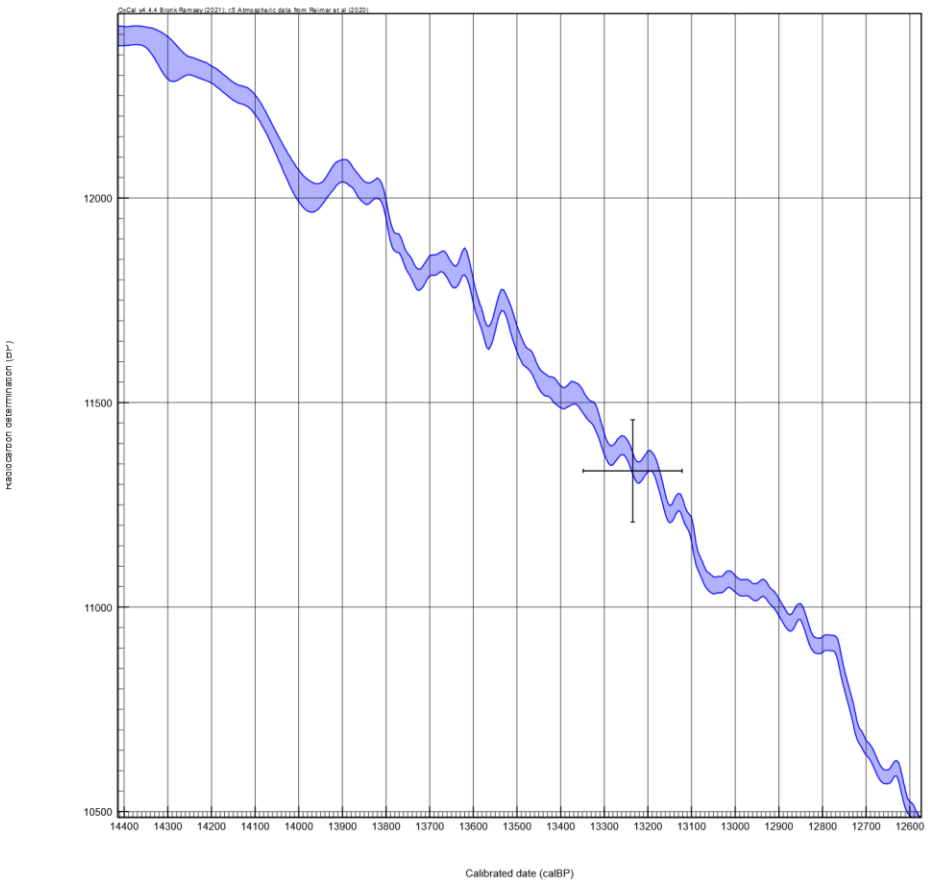


Figure A.187 Broken Cavern (BC). Dates from Barton and Roberts 1996. Simple Plot. IntCal04 (grey) (Reimer et al. 2004) is in the background for reference.

Seamer K (SK)

Simple Plot

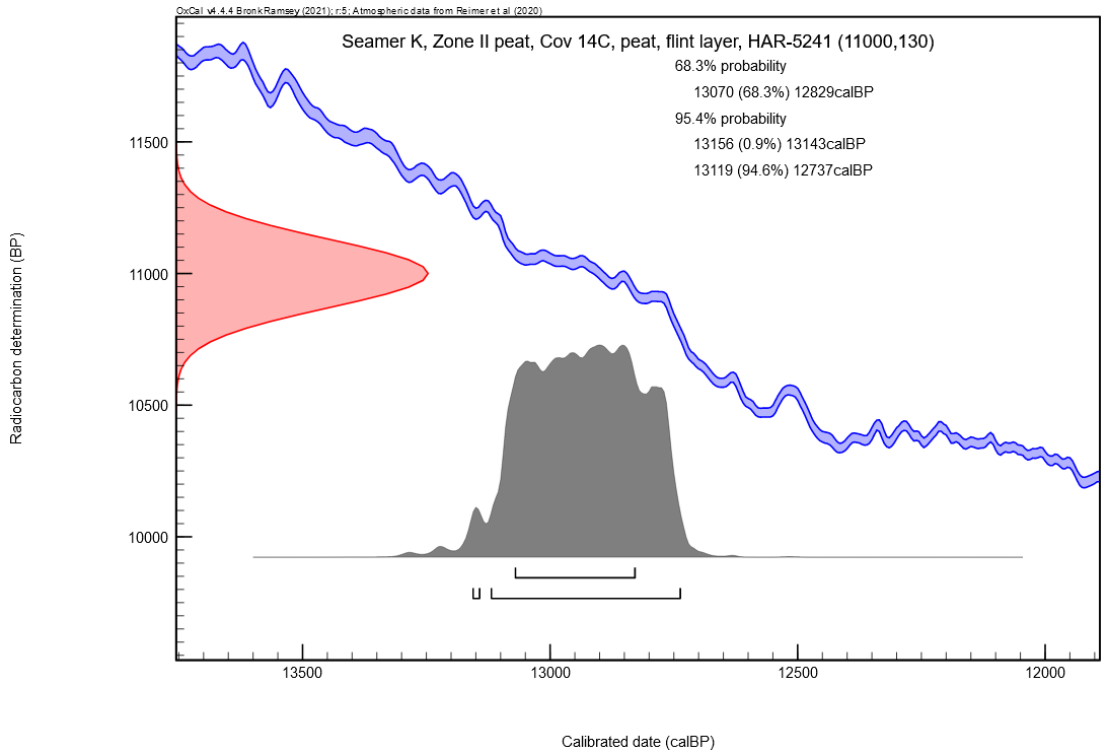


Figure A.188 Seamer Carr, dated peat associated to lithics scatter. Dates from Conneller 2007. Simple Plot.

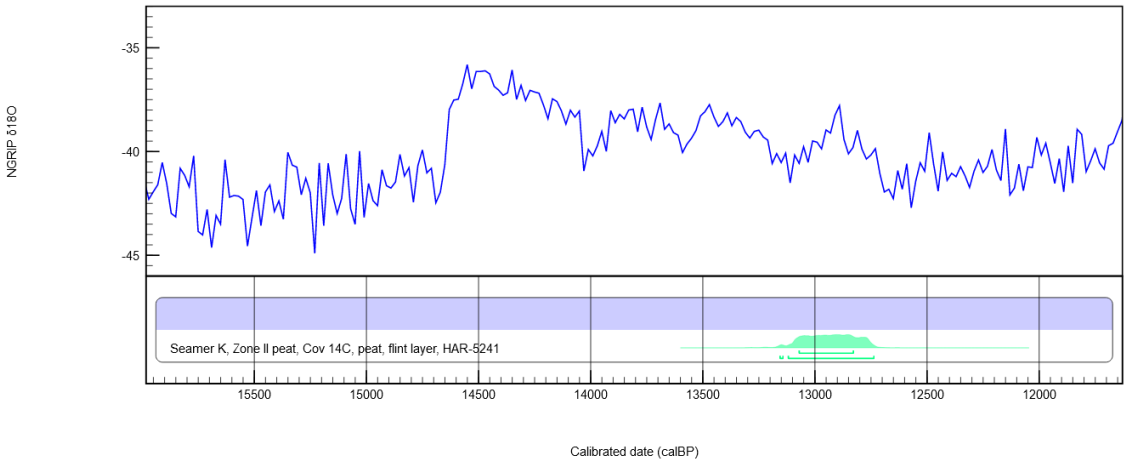


Figure A.189 Seamer Carr, dated peat associated to lithics scatter. Dates from Conneller 2007. Simple Plot.

Single Uniform Phase

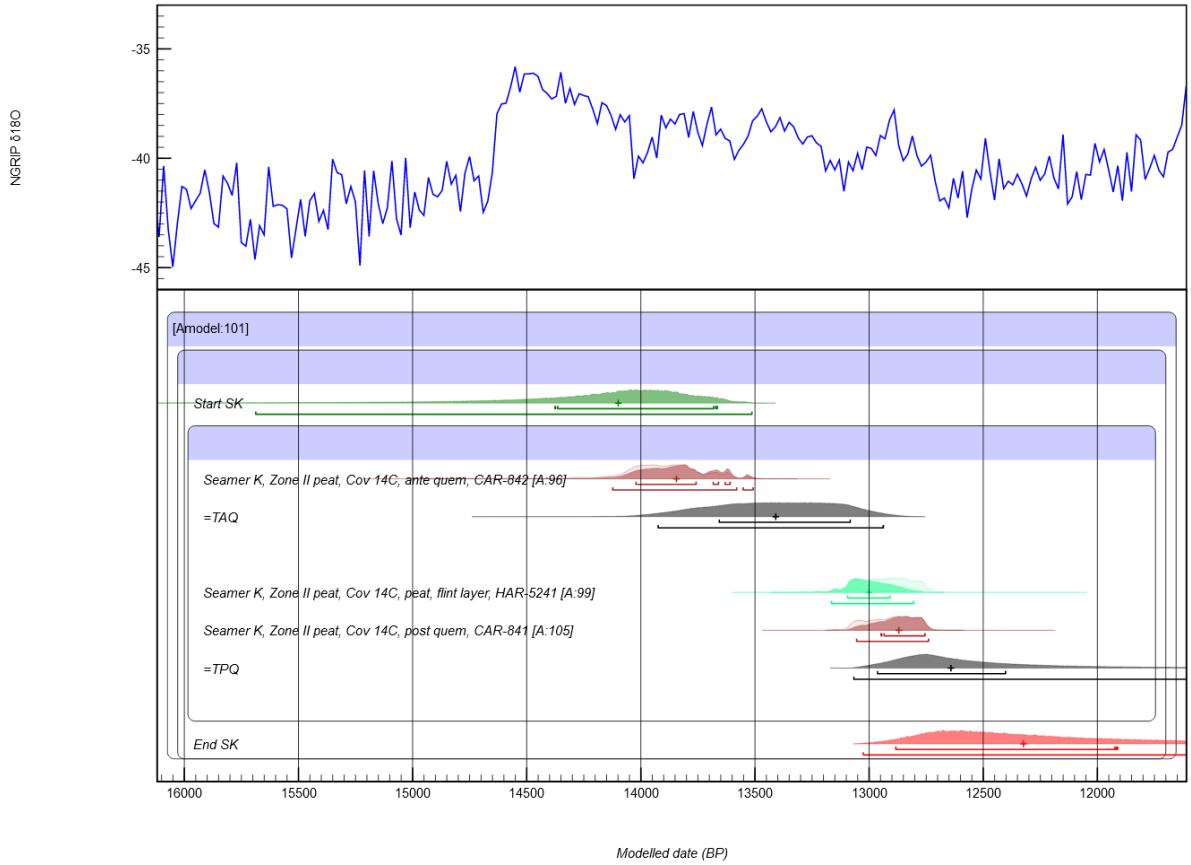


Figure A.190 Seamer Carr, dated peat associated to lithics scatter (light green) and bracketing terminal post quem (TPQ) and terminal ante quem (TAQ) in brown. Dates from Conneller 2007. Single uniform phase.

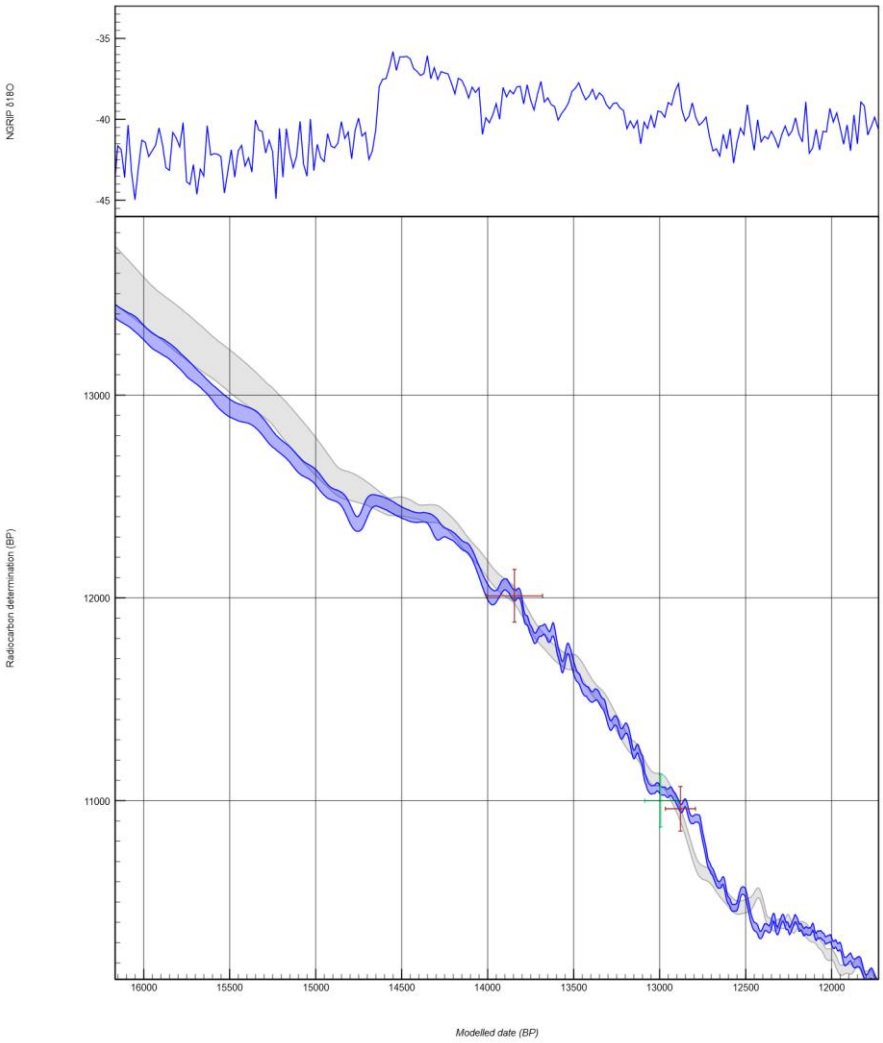


Figure A.191 Seamer Carr, dated peat associated to lithics scatter (light green) and bracketing terminal post quem (TPQ) and terminal ante quem (TAQ) in brown. Dates from Conneller 2007. Single uniform phase.

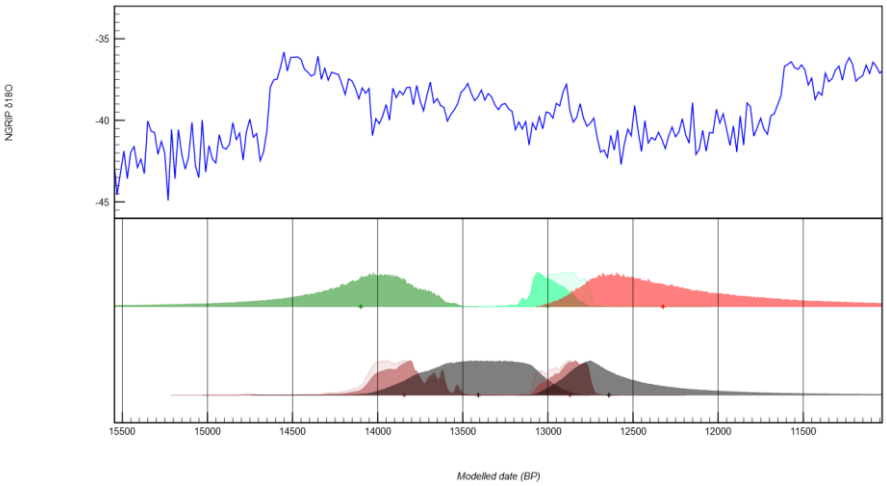


Figure A.192 Seamer Carr, dated peat (top) associated to lithics scatter (light green) with start and end boundaries, and bracketing terminal post quem (TPQ) and terminal ante quem (TAQ) in brown (bottom). Dates from Conneller 2007. Single uniform phase.

Updated Jacobi and Higham 2011 models

Jacobi and Higham 2011, Figure 12.7. SH, GNC and KC.

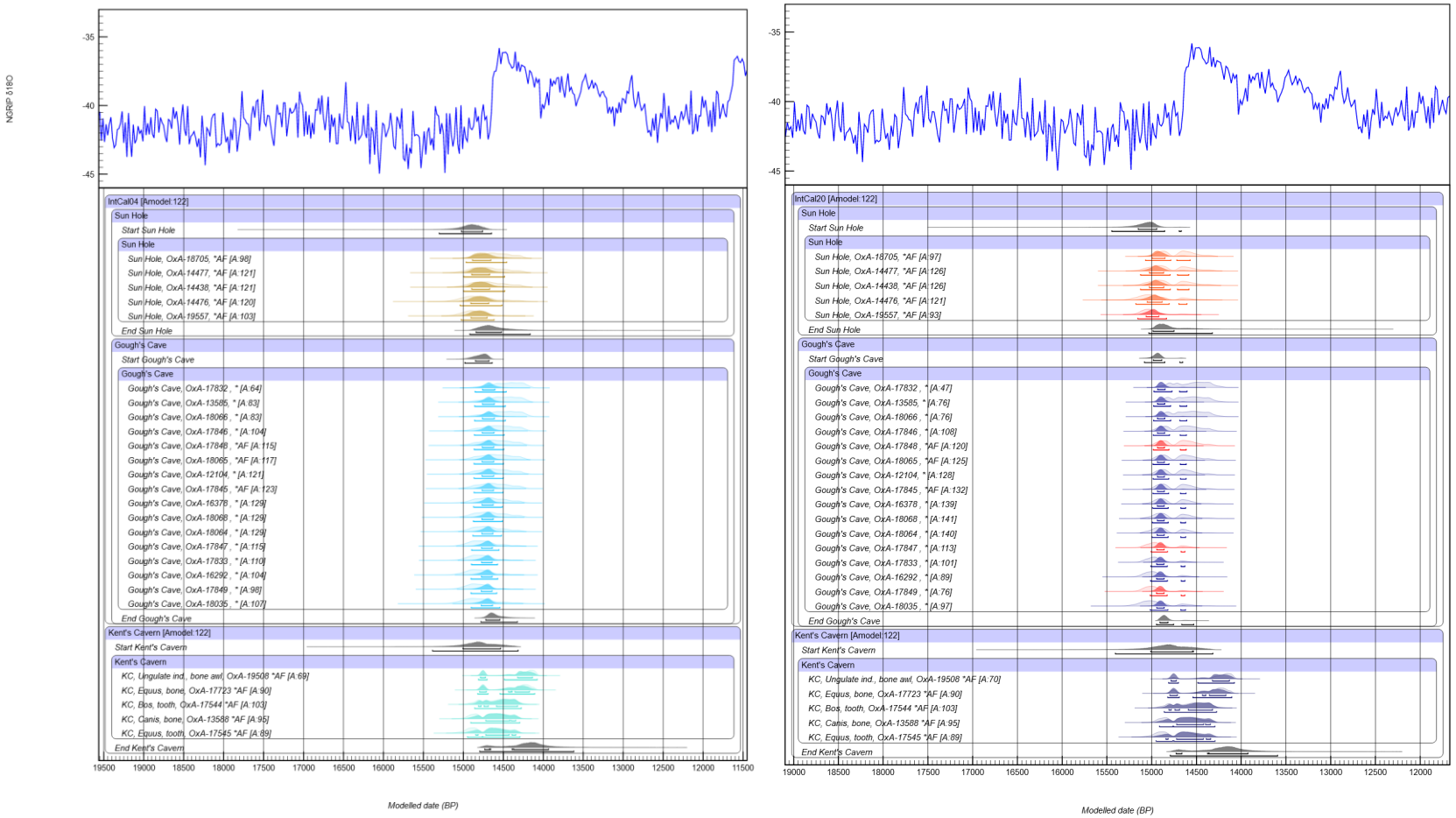


Figure A.193 Reproduction of figure 12.7, Jacobi and Higham 2011. The dates from Sun Hole, Gough's New Cave and Kent's Cavern are compared with IntCal04 (left) and IntCal20 (right). The red dates highlighted in the IntCal20 distribution are human remains. There is an overall shift an earlier date with IntCal20, as well as tightening the gap between Sun Hole and Gough's New Cave around 15,000 cal BP.

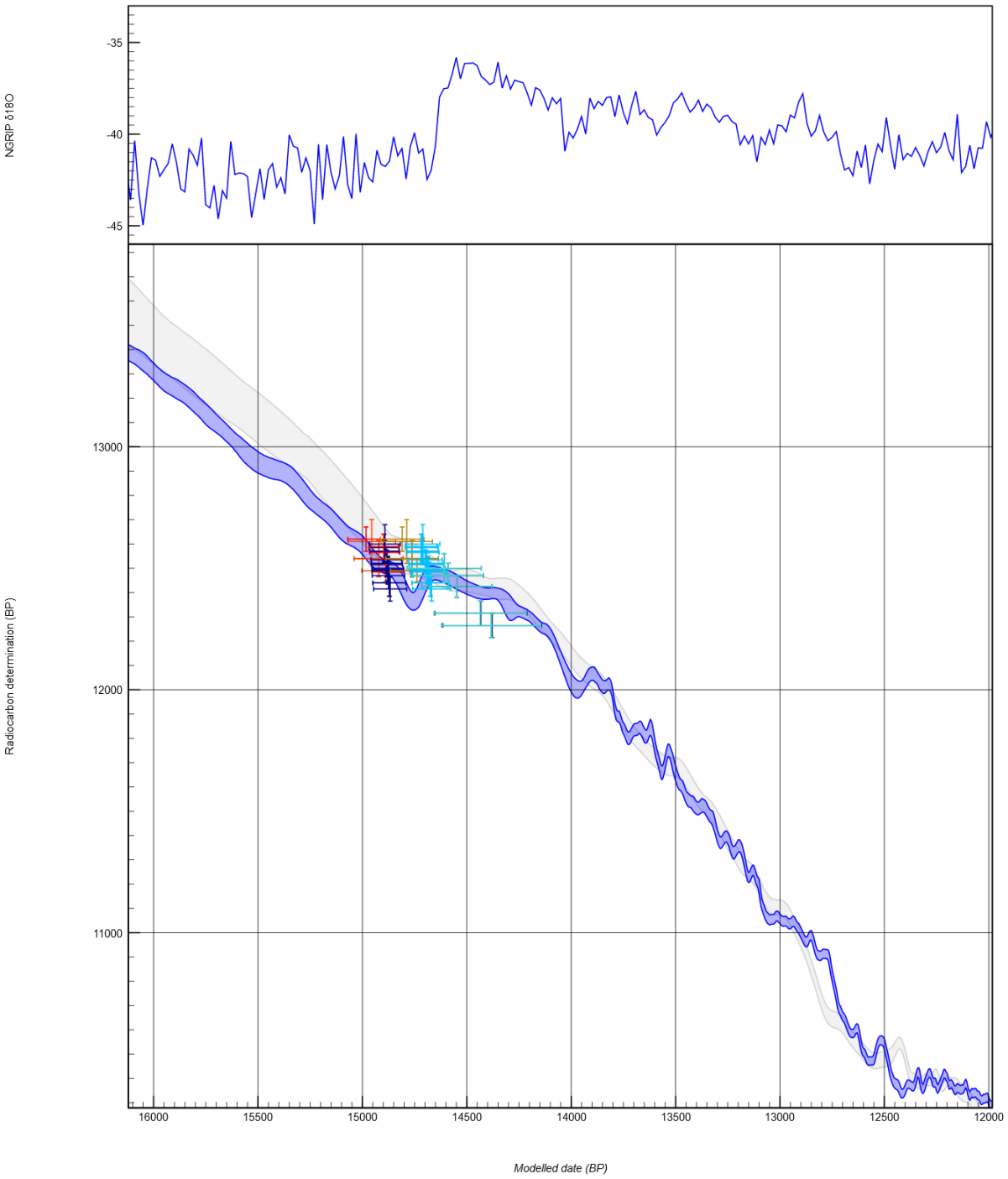


Figure A.194 Reproduction of figure 12.7, Jacobi and Higham 2011. The dates from Sun Hole, Gough's New Cave and Kent's Cavern are compared with IntCal04 (light blue, teal and yellow) and IntCal20 (dark blue, red and orange). There is an overall shift an earlier date with IntCal20, as well as tightening the gap between Sun Hole and Gough's New Cave around 15,000 cal BP.

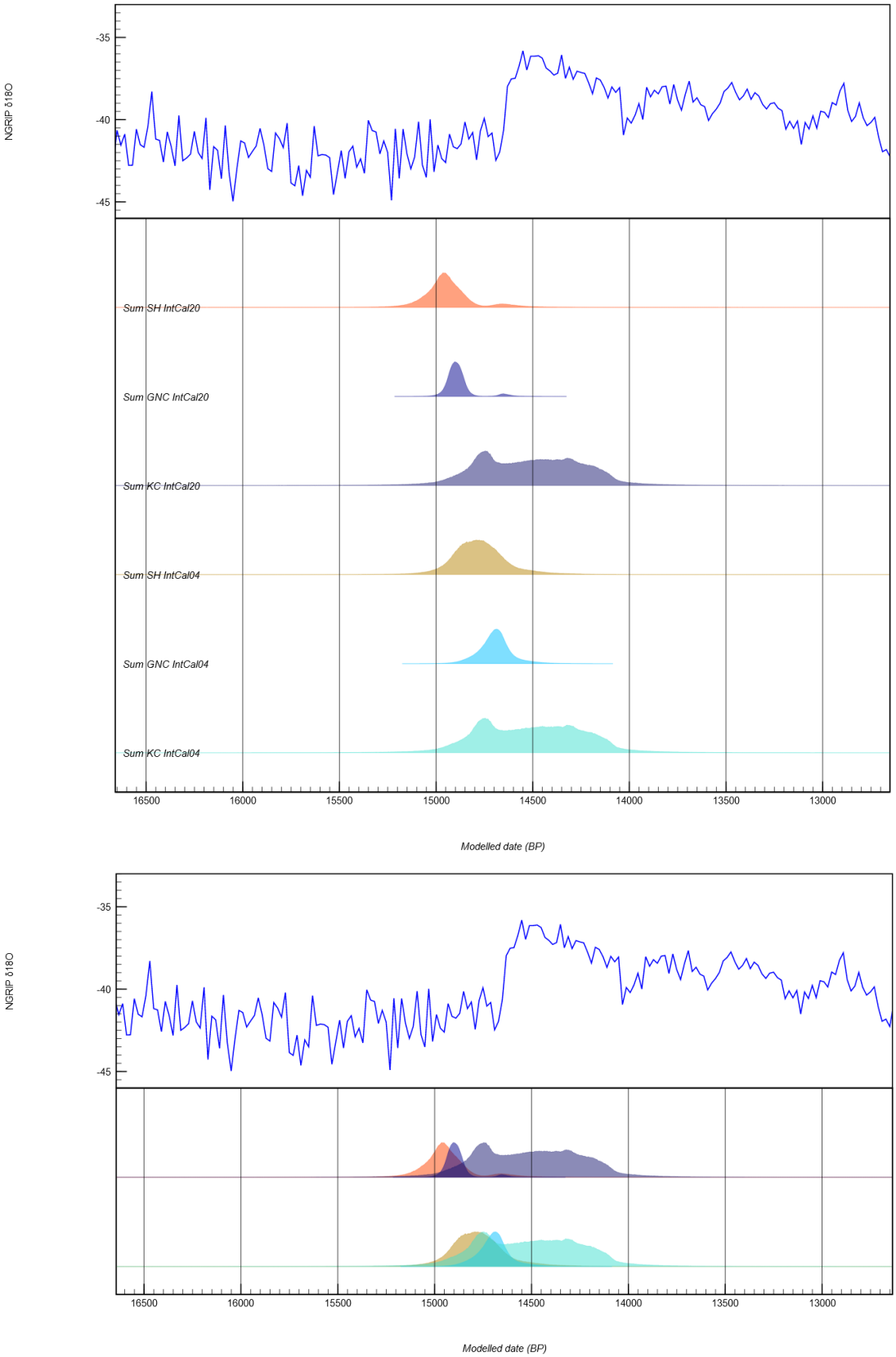


Figure A.195 Stacked sums Sun Hole, Gough's New Cave and Kent's Cavern (after Jacobi and Higham 2022: figure 12.7, p. 232). Reproducing the original dates with IntCal04 for comparison with IntCal20 results. The IntCal20 dates are notably earlier in IntCal20, and the distinction between Sun Hole and Gough's New Cave with Kent's Cavern is accentuated.

Jacobi and Higham 2011, Figure 12.9, KAC

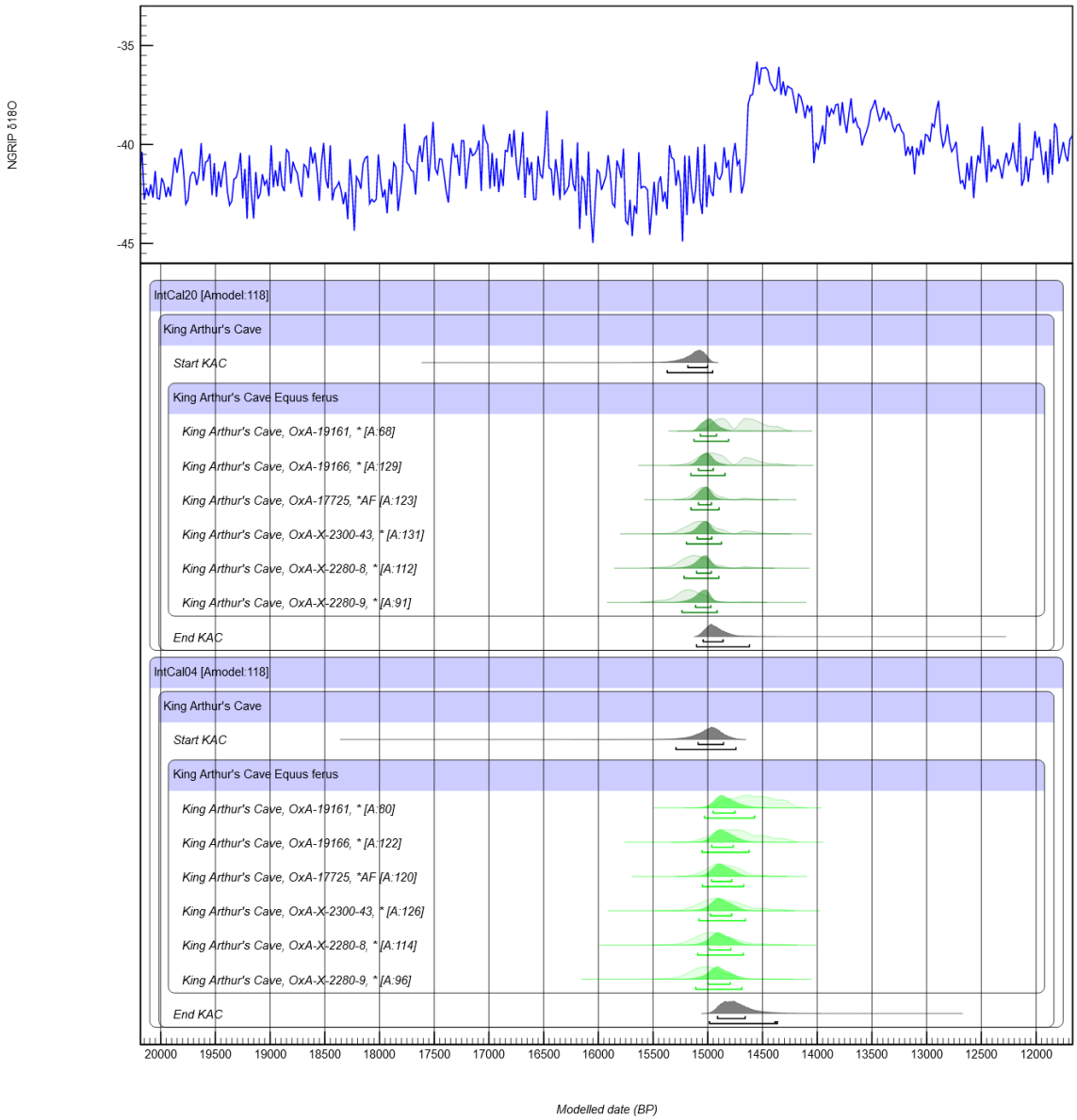


Figure A.196 Reproduction of figure 12.9, Jacobi and Higham 2011. The dates from King Arthur's Cave are compared with IntCal04 (light green) and IntCal20 (dark green). There is an overall shift to earlier dates with IntCal20, as well as tightening the precision around 15,000 cal BP.

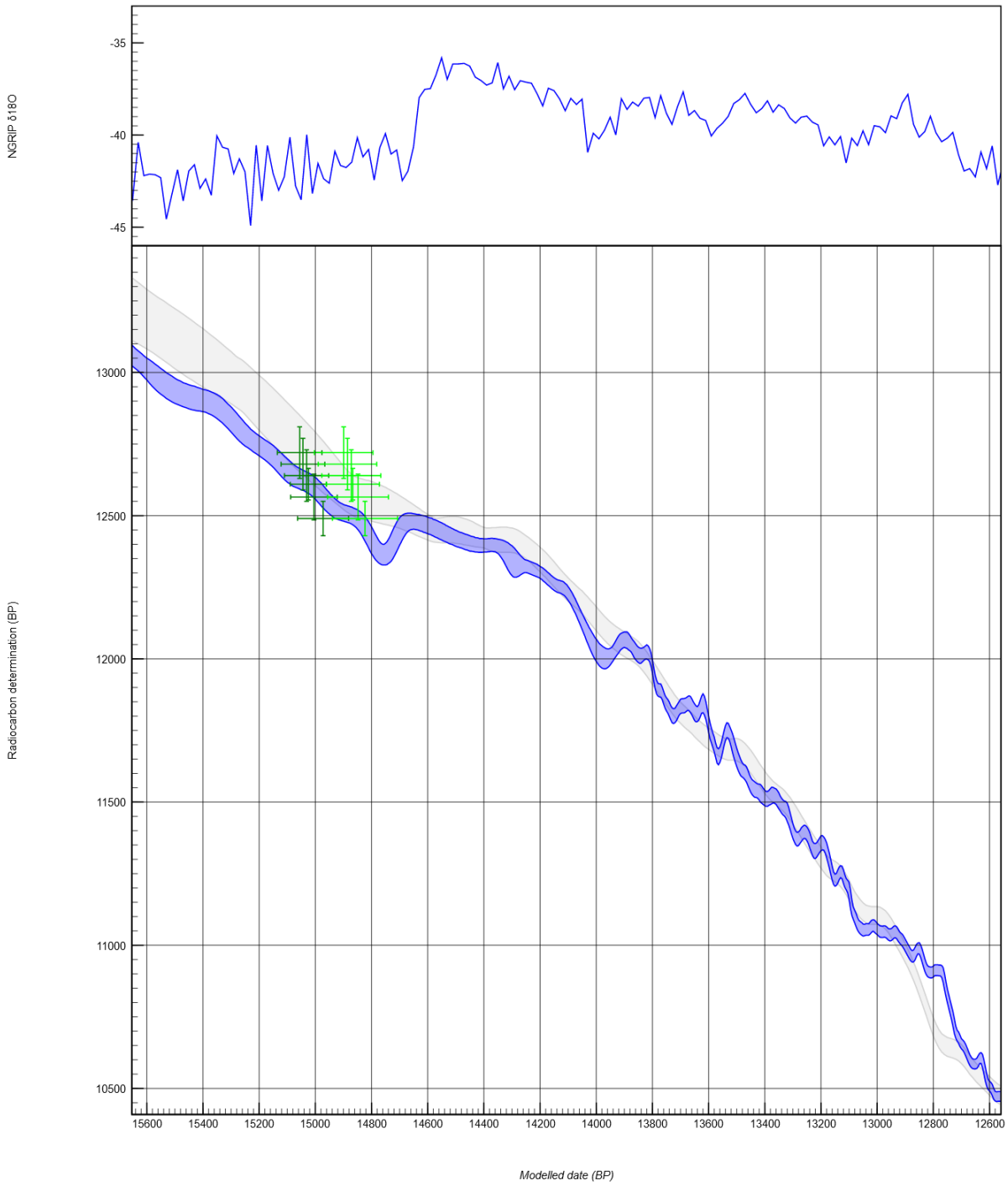


Figure A.197 Reproduction of figure 12.9, Jacobi and Higham 2011. The dates from King Arthur's Cave are compared with IntCal04 (light green) and IntCal20 (dark green). There is an overall shift to earlier dates with IntCal20, as well as tightening the precision around 15,000 cal BP.

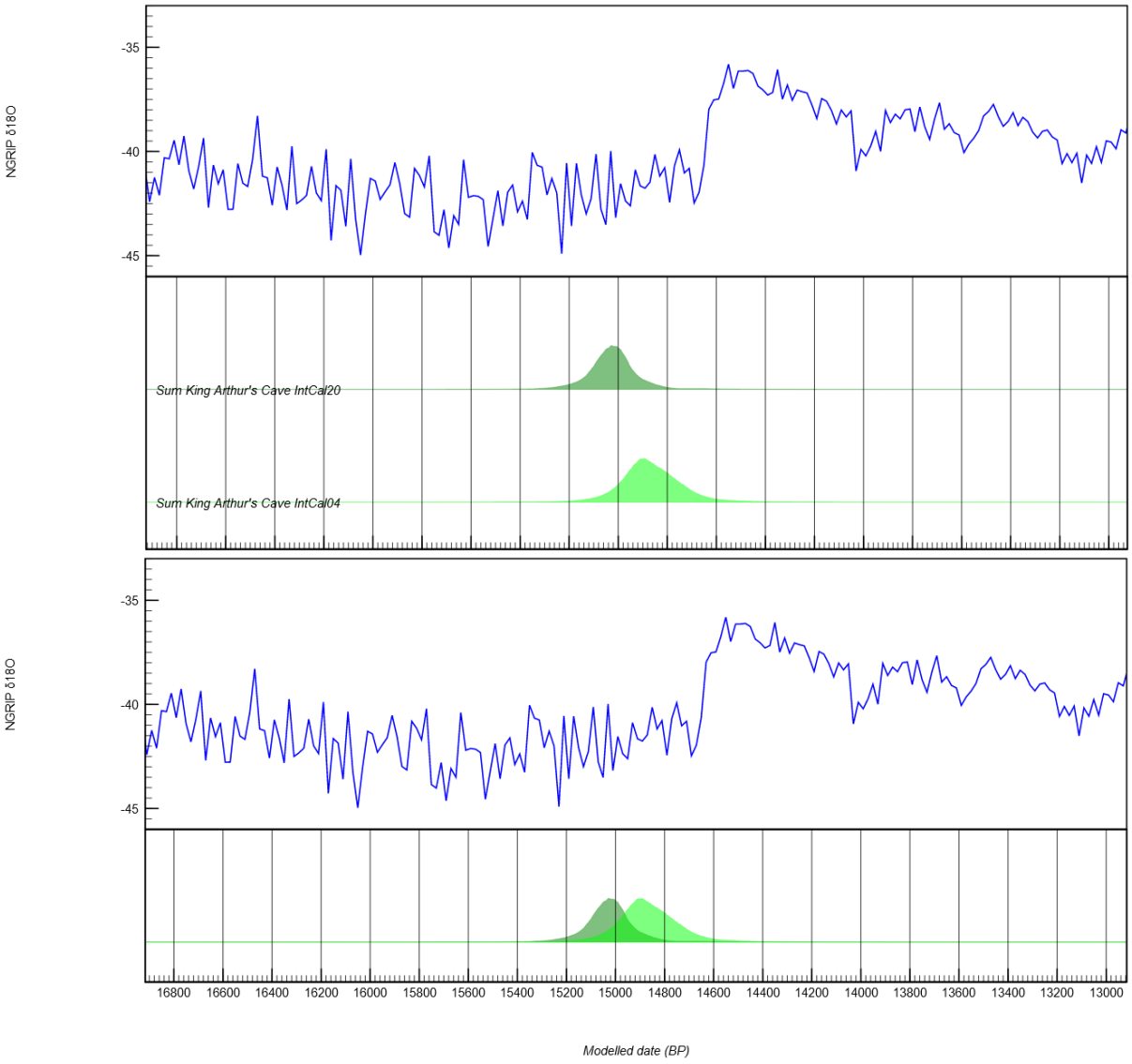


Figure A.198 Reproduction of figure 12.9, Jacobi and Higham 2011. The dates from King Arthur's Cave are compared with IntCal04 (light green) and IntCal20 (dark green). There is an overall shift to earlier dates with IntCal20, as well as tightening the precision to before 15000 cal BP. KAC remains the earliest Creswellian assemblage in Britain.

Jacobi and Higham 2011, Figure 12.13. PH, CH, RHC and MGP

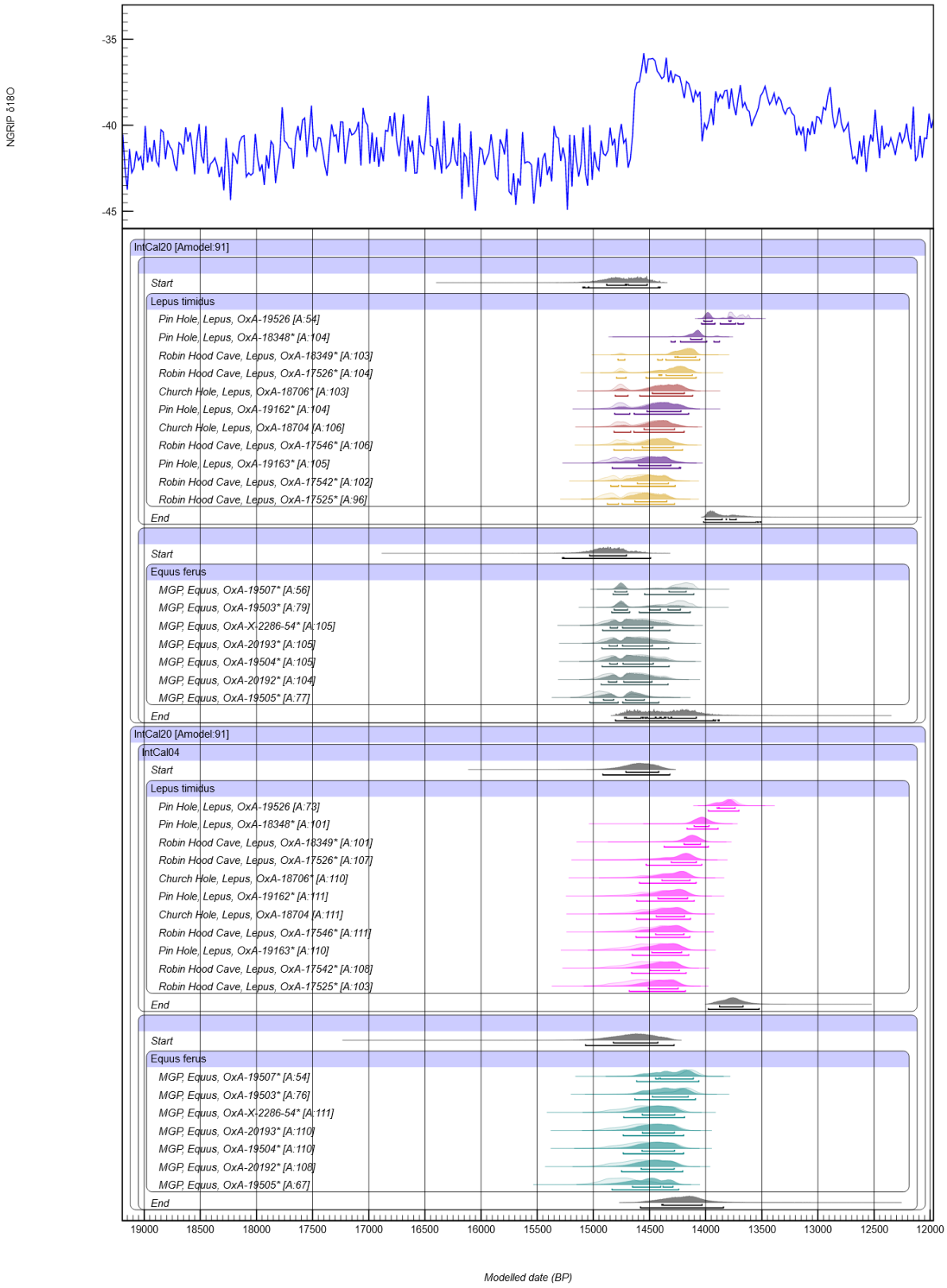


Figure A.199 Reproduction of figure 12.13, Jacobi and Higham 2011. There is an overall similar pattern with a tightening (higher precision) of the IntCal20 dates. There is a significant shift of the Equus ferus dates at Mother Grundy's Parlour to before 14500 cal BP.

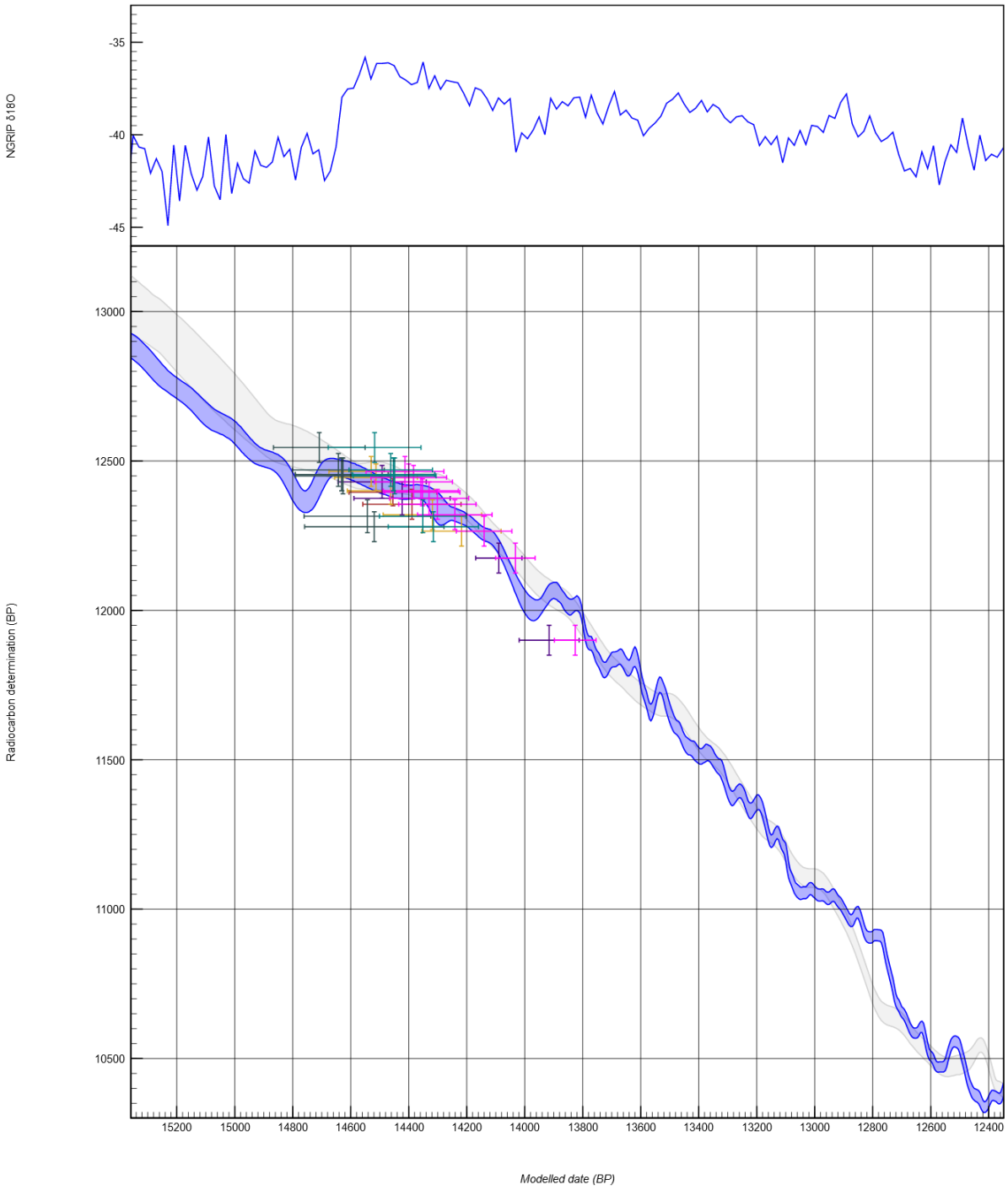


Figure A.200 Reproduction of figure 12.13, Jacobi and Higham 2011. There is an overall similar pattern with a tightening (higher precision) of the IntCal20 dates. There is an overall shift to earlier dates with IntCal20.

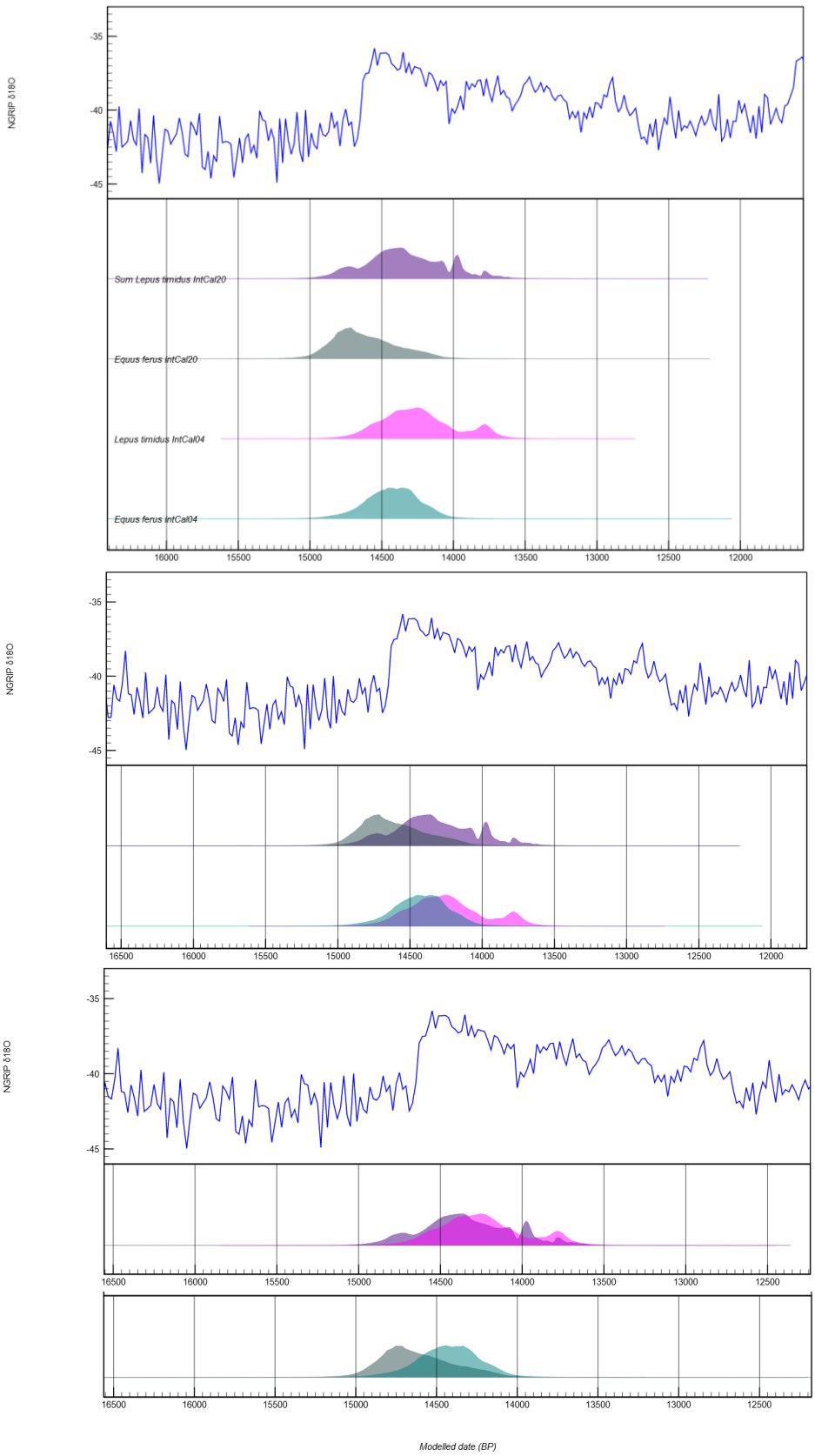


Figure A.201 Stacked sums of Equus ferus and Lepus timidus dates from Creswell Crags (after Jacobi and Higham 2022: figure 12.13, p. 240). Reproducing the original dates with IntCal04 for comparison with IntCal20 results. The IntCal20 dates are notably earlier in IntCal20, and the distinction between the two faunal groups is accentuated with Equus ferus indicating a potential earlier phase.

Table II British dates used in the thesis, KDE Model, OxCal 4.4 (Bronk Ramsey 2021) using IntCal20 (Reimer et al. 2020)

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Early Creswellian																		
KAC, Equus, tooth, OxA-X-2280-9 *	15291	15030	68.3	15517	14898	95.4	153	15169	15129	14970	68.3	15268	14907	95.4	90	15055	93.1	99.9
KAC, Equus, tooth, OxA-X-2280-8 *	15250	14984	68.3	15433	14591	95.4	172	15110	15119	14965	68.3	15243	14886	95.4	88	15044	111.8	100
KAC, Equus, tooth, OxA-X-2300-43 *	15226	14921	68.3	15335	14509	95.4	199	15046	15108	14959	68.3	15220	14860	95.4	90	15033	128.3	99.9
KAC, Equus, tooth, OxA-17725 *	15130	14941	68.3	15220	14610	95.4	130	15024	15090	14965	68.3	15165	14884	95.4	72	15026	119.5	100
KAC, Equus, tooth, OxA-19166 *	15111	14598	68.3	15200	14356	95.4	218	14903	15092	14941	68.3	15182	14816	95.4	99	15009	126.3	100
KAC, Equus, tooth, OxA-19161 *	14965	14504	68.3	15028	14315	95.4	196	14677	15068	14902	68.3	15138	14630	95.4	113	14973	72.8	99.9
SH, Homo, OxA-19557, AF *	15126	14965	68.3	15234	14833	95.4	106	15040	15085	14931	68.3	15183	14831	95.4	94	15002	96.9	99.9
SH, Equus, OxA-14438, AF *	15046	14605	68.3	15136	14471	95.4	183	14890	15030	14855	68.3	15118	14561	95.4	132	14936	118	99.9
SH, Equus, OxA-18705, AF *	14950	14535	68.3	15006	14342	95.4	177	14681	15005	14814	68.3	15061	14495	95.4	148	14891	99.9	100
adjacent horse teeth	15092	14853	68.3	15154	14531	95.4	166	14951	15045	14880	68.3	15132	14594	95.4	119	14959		100
SH, Equus, OxA-14477, AF *	15064	14560	68.3	15145	14338	95.4	215	14850	15045	14880	68.3	15132	14594	95.4	119	14959	123.4	100
SH, Equus, OxA-14476, AF *	15197	14843	68.3	15300	14440	95.4	218	14992	15045	14880	68.3	15132	14594	95.4	119	14959	120	100
Aveline's Hole, OxA-17722, *AF	15087	14848	68.3	15143	14540	95.4	162	14944	15087	14848	68.3	15143	14540	95.4	162	14944	100	99.9
Pixies' Hole, Equus, OxA-14068*	15116	14871	68.3	15193	14537	95.4	168	14975	15117	14871	68.3	15193	14536	95.4	168	14975	100	100

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
GNC, Area III, NHM 1990, Indet., OxA-18035 *	15166	14846	68.3	15269	14477	95.4	203	14983	14944	14650	68.3	14981	14602	95.4	110	14890	88.9	39.2
GNC, Area I, NHM 1987-1989, Homo, OxA-17849 *	15110	14915	68.3	15175	14584	95.4	137	14994	14945	14650	68.3	14985	14604	95.4	111	14892	62.7	39.1
GNC, Area I, NHM 1987-1989, Homo, OxA-17848 *	14949	14515	68.3	15004	14325	95.4	184	14671	14940	14853	68.3	14965	14603	95.4	108	14886	124.6	39.8
GNC, Area I, NHM 1987-1989, Mammuthus, OxA-17846 *	14935	14473	68.3	14984	14314	95.4	189	14646	14940	14653	68.3	14965	14602	95.4	108	14886	112.5	39.8
GNC, Area I, NHM 1987-1989, Rangifer, OxA-18064 *	15020	14585	68.3	15126	14444	95.4	186	14866	14942	14654	68.3	14972	14604	95.4	109	14889	136.3	39.8
GNC, Area I, NHM 1987-1989, Equus, OxA-18068 *	14996	14562	68.3	15100	14360	95.4	189	14825	14942	14854	68.3	14970	14603	95.4	108	14888	139.6	39.8
GNC, Area I, NHM 1987-1989, Equus, OxA-16292 *	15111	14887	68.3	15178	14556	95.4	156	14981	14944	14650	68.3	14981	14605	95.4	110	14891	77.4	39
GNC, Layer 8, Parry 1927-31, Equus, OxA-18065 *	14960	14514	68.3	15020	14321	95.4	190	14678	14941	14853	68.3	14966	14604	95.4	108	14887	129	39.7
GNC, Layer 11 , Parry 1927-31, Cervus, OxA-17845 *	14967	14542	68.3	15035	14341	95.4	183	14701	14941	14854	68.3	14965	14605	95.4	108	14887	134	39.8
GNC, Layer 13, Parry 1927-31, Cervus, OxA-16378 *	14985	14565	68.3	15089	14360	95.4	182	14817	14941	14854	68.3	14969	14604	95.4	108	14888	138.5	39.9

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
GNC, Layer 14, Parry 1927-31, Canis, OxA-13585	14845	14355	68.3	14951	14285	95.4	188	14592	14940	14650	68.3	14963	14603	95.4	107	14884	79.7	39.4
GNC, Layer 14, Parry 1927-31, Equus, OxA-17833 *	15081	14872	68.3	15141	14567	95.4	146	14960	14945	14650	68.3	14980	14605	95.4	110	14891	88	39.4
GNC, Layer 18, Parry 1927-31, Equus, OxA-17832 *	14827	14324	68.3	14907	14246	95.4	185	14537	14939	14650	68.3	14961	14602	95.4	107	14882	47.8	38.9
GNC, Layer 24, Parry 1927-31, Equus, OxA-12104 *	14960	14535	68.3	15021	14335	95.4	183	14689	14941	14854	68.3	14965	14605	95.4	108	14887	131.4	39.9
GNC, 'Cheddar Man fissure', 1959, Homo, OxA-17847 *	15087	14848	68.3	15143	14540	95.4	162	14944	14944	14650	68.3	14977	14605	95.4	110	14890	102.3	39.6
GNC, 'Cheddar Man fissure', 1986, Lynx, OxA-18066 *	14845	14355	68.3	14951	14285	95.4	188	14592	14940	14650	68.3	14963	14603	95.4	107	14884	79.7	39.3
GNC, 'Cheddar Man fissure', 1986, Cervus, OxA-18067 *	14237	14069	68.3	14802	14033	95.4	165	14168	14238	14069	68.3	14802	14032	95.4	165	14168		99.8
Late Creswellian																		
KC, Equus, tooth, OxA-17545 *AF	14976	14522	68.3	15056	14323	95.4	196	14695	14900	14368	68.3	14969	14298	95.4	183	14627	92.2	99.9
KC, Canis, bone, OxA-13588 *AF	14931	14482	68.3	14981	14317	95.4	183	14646	14858	14354	68.3	14930	14304	95.4	174	14609	97	99.8
KC, Bos, tooth, OxA-17544 *AF	14832	14334	68.3	14910	14279	95.4	178	14555	14821	14330	68.3	14877	14273	95.4	174	14553	100.7	99.9
KC, Equus, bone, OxA-17723 *AF	14785	14117	68.3	14816	14085	95.4	212	14283	14802	14156	68.3	14823	14100	95.4	229	14372	90.1	99.8

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
KC, Ungulate ind., bone awl, OxA-19508 *AF	14265	14086	68.3	14804	14051	95.4	175	14191	14784	14125	68.3	14813	14071	95.4	242	14285	71	99.9
Robin Hood Cave, Lepus, OxA-17525*	14922	14471	68.3	14973	14316	95.4	183	14638	14690	14330	68.3	14900	14284	95.4	174	14550	92.5	99.9
Robin Hood Cave, Lepus, OxA-17542*	14858	14360	68.3	14938	14309	95.4	178	14599	14722	14319	68.3	14873	14279	95.4	170	14529	98.2	99.9
Robin Hood Cave, Lepus, OxA-17546*	14816	14316	68.3	14859	14222	95.4	183	14501	14797	14303	68.3	14837	14231	95.4	176	14470	103.9	99.9
Robin Hood Cave, Lepus, OxA-17526*	14790	14122	68.3	14818	14089	95.4	214	14297	14790	14177	68.3	14818	14107	95.4	212	14355	93.5	99.9
Robin Hood Cave, Lepus, OxA-18349*	14265	14086	68.3	14804	14051	95.4	175	14191	14779	14124	68.3	14807	14075	95.4	222	14282	71.5	99.9
MGP, Equus, OxA-19505*	15039	14615	68.3	15125	14500	95.4	174	14896	14930	14557	68.3	15041	14471	95.4	158	14676	86.4	99.9
MGP, Equus, OxA-20192*	14935	14473	68.3	14984	14314	95.4	189	14646	14901	14524	68.3	14968	14397	95.4	152	14651	112.1	99.9
MGP, Equus, OxA-20193*	14905	14431	68.3	14966	14303	95.4	188	14620	14896	14514	68.3	14957	14389	95.4	153	14647	109.5	99.9
MGP, Equus, OxA-19504*	14905	14431	68.3	14966	14303	95.4	188	14620	14896	14513	68.3	14957	14389	95.4	153	14647	109.5	99.9
MGP, Equus, OxA-X-2286-54*	14878	14358	68.3	14971	14285	95.4	194	14612	14895	14508	68.3	14955	14380	95.4	155	14647	108.6	99.9
Pin Hole, Lepus, OxA-19163*	14838	14337	68.3	14943	14268	95.4	189	14572	14937	14335	68.3	15006	14269	95.4	210	14591	94.3	1.5
Pin Hole, Lepus, OxA-19162*	14807	14238	68.3	14847	14165	95.4	202	14459	14806	14200	68.3	14845	14097	95.4	213	14442	95	3.6
Church Hole, Lepus, OxA-18704	14815	14310	68.3	14850	14216	95.4	185	14491	14815	14310	68.3	14851	14216	95.4	185	14491	100	99.9
Church Hole, Lepus, OxA-18706*	14795	14198	68.3	14837	14124	95.4	207	14409	14795	14199	68.3	14837	14125	95.4	207	14409	99.9	99.9
Kendrick's Cave, Bos, OxA-6146	14841	14307	68.3	14984	14123	95.4	239	14552	14827	14250	68.3	14980	14128	95.4	239	14546	99.8	1.9
Kendrick's Cave, Bos, OxA-17726*	14778	14114	68.3	14815	14082	95.4	211	14271	14775	14115	68.3	14813	14082	95.4	204	14262	102.4	6.9

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Three Holes Cave, Indet., OxA-1500*	14830	14105	68.3	15100	13881	95.4	304	14485	14265	14021	68.3	14557	13816	95.4	177	14133	91	99.9
Three Holes Cave, Lepus, OxA-3208	14806	14037	68.3	14919	13810	95.4	294	14312	14242	14015	68.3	14471	13810	95.4	160	14114	117.9	99.9
Three Holes Cave, Equus, OxA-4494	14788	13880	68.3	14830	13804	95.4	260	14197	14216	14017	68.3	14377	13813	95.4	139	14104	127.3	99.9
Three Holes Cave, Ursus, OxA-3209*	14314	13809	68.3	14837	13786	95.4	278	14139	14210	13900	68.3	14358	13800	95.4	143	14085	130.4	99.9
Three Holes Cave, Equus, OxA-3890	14187	13809	68.3	14805	13783	95.4	227	14065	14181	13896	68.3	14292	13809	95.4	126	14070	121.5	99.9
Three Holes Cave, Cervus, OxA-3891	14021	13781	68.3	14065	13606	95.4	126	13872	14092	13908	68.3	14176	13757	95.4	106	13998	86.7	99.9
GNC, 'Cheddar Man fissure', 1986, Cervus, OxA-18067 *	14237	14069	68.3	14802	14033	95.4	165	14168	14237	14070	68.3	14801	14033	95.4	165	14168	100	99.4
Federmesser																		
Kendrick's Cave , OxA-17089 , *AF	13804	13609	68.3	14005	13602	95.4	104	13762	13801	13609	68.3	13995	13599	95.4	95	13743	100.2	98.3
Kendrick's Cave , OxA-6144 , *AI	14068	13809	68.3	14204	13766	95.4	128	13956	14017	13793	68.3	14105	13612	95.4	98	13886	101	97.2
Kendrick's Cave , OxA-7002, *AG	13750	13508	68.3	13797	13455	95.4	101	13627	13741	13505	68.3	13790	13470	95.4	93	13612	102.4	98
Kendrick's Cave , OxA-7003 , *AG	13971	13598	68.3	14020	13513	95.4	125	13734	13795	13600	68.3	14000	13507	95.4	113	13700	103.3	96.9
Kendrick's Cave , OxA-7004 , *AG	14005	13612	68.3	14034	13600	95.4	129	13804	13861	13603	68.3	14013	13526	95.4	122	13766	99.1	97.7
Pixie's Hole, Cervus, OxA-5796	14129	13807	68.3	14799	13760	95.4	209	14027	14053	13792	68.3	14151	13608	95.4	116	13888	104.6	97
Pixie's Hole, Bos, OxA-5795	14007	13611	68.3	14050	13524	95.4	139	13805	13860	13600	68.3	14018	13515	95.4	129	13758	99.3	96.6
Pixie's Hole, Bos, OxA-5794*	13593	13321	68.3	13760	13187	95.4	139	13466	13642	13377	68.3	13784	13296	95.4	122	13515	101.9	97.8
High Furlong, Alces, OxA-11151*	13590	13462	68.3	13734	13354	95.4	68	13518	13591	13471	68.3	13737	13403	95.4	63	13532	104.3	98.5

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
High Furlong, Alces, OxA-13075*	13601	13501	68.3	13746	13464	95.4	67	13559	13600	13503	68.3	13744	13468	95.4	65	13558	101.6	98.2
Lynx Cave, Cervus, OxA-19207*	13590	13490	68.3	13731	13448	95.4	50	13544	13591	13492	68.3	13731	13451	95.4	48	13547	101.5	98.4
Lynx Cave, Cervus, OxA-19206*	13580	13458	68.3	13598	13372	95.4	54	13499	13581	13465	68.3	13598	13424	95.4	51	13508	102.6	98.8
Broken Cavern, Lepus, OxA-3887	13317	13110	68.3	13487	12998	95.4	113	13231	13457	13116	68.3	13584	13073	95.4	134	13294	81.6	96.4
Seamer K, Zone II peat, Cov 14C, peat, flint layer, HAR-5241	13070	12829	68.3	13156	12737	95.4	111	12932	13302	12980	68.3	13455	12849	95.4	142	13104	55.9	96.5

Mainland European Dates calibrated with OxCal 4.4 and IntCal20

Table III Mainland European dates used in the thesis, KDE Model, OxCal 4.4 (Bronk Ramsey 2021) using IntCal20 (Reimer et al. 2020)

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Monruz, Lower layer, Hearth V57, ETH-6413 #	16200	15865	68.3	16350	15707	95.4	165	16034	15910	15649	68.3	16090	15495	95.4	141	15781	55.8	99.9
Monruz, Lower layer, Hearth V57, ETH-6412 #	15668	15335	68.3	15838	15196	95.4	163	15515	15631	15318	68.3	15771	15201	95.4	150	15480	102.5	99.9
Monruz, Lower layer, Hearth V57, ETH-6414 #	15531	15175	68.3	15695	14999	95.4	180	15347	15509	15187	68.3	15667	15058	95.4	156	15347	105.7	99.8
Monruz, Lower layer, Hearth C13, secteur 2 , ETH-6421 #	15957	15598	68.3	16130	15368	95.4	184	15766	15821	15512	68.3	15934	15310	95.4	157	15654	95.4	99.9
Monruz, Lower layer, Hearth S48, ETH-6420 #	15933	15569	68.3	16089	15335	95.4	185	15736	15804	15484	68.3	15918	15297	95.4	158	15636	97.5	99.9
Monruz, Lower layer, Hearth R57, ETH-6418 #	15920	15551	68.3	16070	15325	95.4	185	15721	15795	15468	68.3	15910	15291	95.4	158	15627	98.5	99.9
Monruz, Lower layer, Hearth S50, ETH-6416 #	15865	15457	68.3	16042	15269	95.4	198	15662	15742	15388	68.3	15880	15244	95.4	166	15578	102.1	99.9
Monruz, Lower layer, Hearth S50, ETH-6417 #	15778	15403	68.3	15964	15254	95.4	182	15603	15700	15365	68.3	15836	15232	95.4	159	15543	103.1	99.9
Monruz, Lower layer, Hearth S50, ETH-6415 #	15602	15256	68.3	15775	15091	95.4	173	15427	15570	15248	68.3	15720	15120	95.4	155	15406	104.1	99.9

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Monruz, Lower layer, Bone, Equus, OxA-20699	15751	15557	68.3	15842	15401	95.4	104	15646	15735	15531	68.3	15803	15367	95.4	107	15623	97.2	99.9
Monruz, Lower layer, Hearth R54, ETH-6419 #	15581	15231	68.3	15751	15066	95.4	175	15401	15551	15229	68.3	15705	15100	95.4	155	15386	104.5	99.9
Monruz, Lower layer, Hearth P49, niveau infÃ©rieur, ETH-20727 #	15415	15139	68.3	15572	15040	95.4	136	15283	15412	15153	68.3	15572	15075	95.4	127	15292	103.2	99.9
Champreveyres, Hearth A12, UZ-2283 #	15707	15269	68.3	15963	15068	95.4	225	15493	15635	15258	68.3	15804	15106	95.4	181	15444	107.9	99.9
Champreveyres, Hearth X10, UZ-2286 #	15586	15198	68.3	15774	14998	95.4	200	15389	15546	15202	68.3	15720	15069	95.4	167	15376	106.7	99.9
Champreveyres, Hearth D11, UZ-2282 #	15571	15111	68.3	15820	14630	95.4	254	15322	15526	15155	68.3	15706	15002	95.4	180	15339	111.8	99.8
Champreveyres, Bone, Equus, OxA-20700	15410	15175	68.3	15549	15110	95.4	114	15301	15411	15183	68.3	15547	15121	95.4	110	15303	101.8	99.9
Champreveyres, Bone, Equus, OxA-20701	15406	15151	68.3	15561	15076	95.4	124	15288	15402	15164	68.3	15557	15095	95.4	118	15294	102.5	99.9
Champreveyres, Hearth M17, UZ-2171 #	15413	14965	68.3	15636	14517	95.4	257	15174	15408	15071	68.3	15604	14944	95.4	168	15246	111.7	99.9
Champreveyres, Hearth L13, UZ-2175 #	15266	14601	68.3	15421	14314	95.4	285	14991	15301	15000	68.3	15520	14845	95.4	166	15159	107.6	99.9
Champreveyres, Hearth G19, UZ-2172 #	15265	14555	68.3	15463	14280	95.4	309	14957	15315	14990	68.3	15551	14833	95.4	178	15166	105	99.8

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Champreveyres, Hearth I16, UZ-2177 #	15236	14527	68.3	15396	14225	95.4	308	14912	15306	14981	68.3	15544	14819	95.4	179	15152	100.6	99.8
Champreveyres, Hearth E21, UZ-2173 #	15125	14438	68.3	15268	14187	95.4	295	14774	15268	14950	68.3	15515	14766	95.4	176	15106	84.4	99.8
Champreveyres, Hearth K12, UZ-2174 #	15047	14358	68.3	15200	14179	95.4	279	14701	15236	14932	68.3	15425	14684	95.4	170	15078	75.6	99.8
Champreveyres, Hearth O39 , secteur 2, UZ-2287 #	15027	14341	68.3	15217	14140	95.4	294	14686	15255	14933	68.3	15474	14684	95.4	179	15089	72.7	99.9
Gonnersdorf, I, Bone, Equus, OxA-V-2223-39	16030	15835	68.3	16140	15750	95.4	97	15940	15880	15722	68.3	15983	15662	95.4	80	15808	65.5	99.9
Gonnersdorf, I, Bone, Rangifer, OxA-V-2223-42	15662	15445	68.3	15730	15325	95.4	105	15549	15686	15526	68.3	15757	15405	95.4	86	15600	105.6	100
Gonnersdorf, I, Bone, Equus, OxA-5729	15625	15254	68.3	15815	15075	95.4	187	15440	15726	15485	68.3	15816	15246	95.4	138	15590	93.5	99.9
Gonnersdorf, I, Bone, Equus, OxA-5730	15474	15100	68.3	15664	14924	95.4	195	15272	15690	15380	68.3	15742	15122	95.4	165	15511	72	99.8
Gonnersdorf, I, Bone, Equus, OxA-5728	15391	14970	68.3	15623	14539	95.4	246	15176	15670	15199	68.3	15733	15081	95.4	178	15487	66.5	99.8
Gonnersdorf, II, Bone, Equus, OxA-V-2223-40	15887	15698	68.3	15986	15625	95.4	93	15796	15807	15664	68.3	15905	15601	95.4	74	15740	100.3	99.9
Gonnersdorf, II, Bone, Bos, OxA-V-2223-41	15786	15614	68.3	15899	15511	95.4	92	15699	15755	15618	68.3	15835	15541	95.4	72	15686	110.8	99.9

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Gonnersdorf, II, Bone, Rangifer, OxA-V-2222-31	15693	15484	68.3	15760	15345	95.4	105	15582	15700	15546	68.3	15771	15435	95.4	82	15618	109.9	99.9
Gonnersdorf, III, Bone, Rangifer, OxA-V-2223-43	15765	15590	68.3	15868	15468	95.4	94	15673	15742	15604	68.3	15819	15522	95.4	73	15671	111.6	99.9
Gonnersdorf, III, Bone, Rangifer, OxA-15295	15755	15565	68.3	15850	15410	95.4	104	15653	15735	15589	68.3	15815	15495	95.4	77	15659	113.5	99.9
Andernach-Martinsberg, 1883, Bone, Equus, OxA-10651	16218	15698	68.3	16501	15409	95.4	266	15955	15823	15605	68.3	15971	15475	95.4	118	15713	91.2	99.9
Andernach-Martinsberg, 1883, Bone, Equus, OxA-10493 *	15954	15706	68.3	16080	15586	95.4	124	15828	15817	15650	68.3	15928	15573	95.4	87	15737	97.5	99.9
Andernach-Martinsberg, 1883, Bone, Equus, OxA-18409 *	15706	15522	68.3	15775	15377	95.4	97	15606	15705	15563	68.3	15775	15465	95.4	75	15630	110.8	99.9
Andernach-Martinsberg, 1, Bone, Indet. , GrA-16986 *	15931	15709	68.3	16042	15608	95.4	110	15819	15816	15656	68.3	15922	15586	95.4	82	15741	97.4	99.9
Andernach-Martinsberg, 1, Bone, Equus, OxA-V-2216-43	15839	15657	68.3	15955	15582	95.4	92	15754	15786	15646	68.3	15870	15575	95.4	72	15716	106.8	99.9
Andernach-Martinsberg, 1, Bone , Indet. , GrA-16985	15842	15599	68.3	15990	15460	95.4	128	15721	15774	15610	68.3	15877	15516	95.4	87	15691	115.8	99.9

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Andernach-Martinsberg, 1, Bone, Equus, OxA-V-2218-38	15695	15502	68.3	15760	15362	95.4	99	15591	15698	15554	68.3	15769	15449	95.4	78	15621	110.1	100
Andernach-Martinsberg, 1, Bone (sample 8), Equus, OxA-1125	15722	15210	68.3	16030	14950	95.4	273	15467	15759	15505	68.3	15872	15243	95.4	148	15619	109.4	99.8
Andernach-Martinsberg, 1, Bone (sample 9), Equus, OxA-1126	15616	15217	68.3	15813	15008	95.4	205	15415	15728	15476	68.3	15816	15219	95.4	145	15587	91.8	99.9
Andernach-Martinsberg, 2, Bone (sample 11) , Equus, OxA-1128	16054	15643	68.3	16280	15426	95.4	209	15854	15813	15608	68.3	15950	15490	95.4	110	15710	104.5	99.9
Andernach-Martinsberg, 2, Bone, Equus, OxA-V-2218-40	15799	15635	68.3	15905	15550	95.4	86	15719	15765	15630	68.3	15841	15561	95.4	69	15698	108.4	99.9
Andernach-Martinsberg, 2, Bone (sample 12), Equus, OxA-1129	15907	15502	68.3	16072	15286	95.4	199	15692	15779	15572	68.3	15905	15425	95.4	113	15672	124.7	99.9
Andernach-Martinsberg, 3, Bone (sample 13), Equus, OxA-1130	15684	15285	68.3	15909	15105	95.4	202	15492	15741	15508	68.3	15846	15289	95.4	133	15614	104.4	99.9
Andernach-Martinsberg, 3, Bone , Equus, OxA-V-2223-37	15194	15020	68.3	15280	14950	95.4	90	15111	15551	15133	68.3	15583	15066	95.4	154	15297	41.6	99.9

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Goyet Third Cave, Horizon 1, Bone, Equus, GrA - 3237 *	15370	15090	68.3	15548	14985	95.4	145	15240	15218	15104	68.3	15324	15032	95.4	68	15162	118.6	99.5
Goyet Third Cave, Horizon 1, Bone, Equus, OxA-V-2223-48	15316	15143	68.3	15474	15065	95.4	96	15237	15220	15114	68.3	15310	15075	95.4	59	15170	100.6	99.4
Goyet Third Cave, Horizon 1, Bone, Equus, Utc-8957	15083	14656	68.3	15139	14530	95.4	166	14932	15181	15051	68.3	15218	14935	95.4	73	15111	55.5	98.8
Goyet Third Cave, Horizon 1, Bone, Ovibos, GrA 3238 *	15202	14866	68.3	15311	14467	95.4	212	15011	15201	15082	68.3	15260	14968	95.4	70	15137	113.7	99.5
Goyet Third Cave, Horizon 1, Bone, Ovibos, OxA -12121	15309	15149	68.3	15455	15074	95.4	89	15236	15221	15115	68.3	15307	15079	95.4	58	15172	97.4	99.2
Trou de Chaleux, Bone, Equus, OxA-3632 *	15430	15115	68.3	15590	14988	95.4	158	15271	15220	15104	68.3	15335	15030	95.4	71	15163	111.4	99.4
Trou de Chaleux, Bone, Equus, OxA-3633 *	15555	15255	68.3	15694	15114	95.4	148	15401	15236	15107	68.3	15376	15061	95.4	78	15175	56.6	99.2
Trou de Chaleux, Bone, Equus, OxA-V-2216-45 *	15141	14969	68.3	15259	14837	95.4	111	15052	15190	15079	68.3	15232	14981	95.4	62	15130	92	99.4
Trou de Chaleux, Bone, Ovibos, OxA-4192 *	15581	15177	68.3	15785	14971	95.4	211	15375	15227	15101	68.3	15359	15024	95.4	78	15165	86.6	99.4
Bois Laiterie, U6, YSS layer base, Bone, GX-20434	15254	14953	68.3	15425	14531	95.4	198	15083	15206	15091	68.3	15278	14986	95.4	68	15144	130.9	99.6

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Bois Laiterie, U6, YSS layer top, , Bone, GX-20433 *	15248	14622	68.3	15364	14323	95.4	264	14993	15207	15086	68.3	15280	14965	95.4	73	15142	127.4	99.5
Bois Laiterie, V-10, YSS layer, Antler, OxA-4198	15318	14620	68.3	15532	14331	95.4	296	15042	15212	15090	68.3	15301	14973	95.4	75	15147	144.3	99.5
Ã‰tiolles, 1, S 25 (niv. U5-P15), Bone, Bos, Lyon-9040 (SacA28250)	15886	15685	68.3	15993	15607	95.4	98	15790	15817	15624	68.3	15941	15502	95.4	105	15717	87.3	99.9
Ã‰tiolles, 1, cheval, Bone, OxA-5995	14792	14039	68.3	14844	13863	95.4	249	14243	14804	14074	68.3	14851	14029	95.4	251	14328	92.2	99.8
Ã‰tiolles, 1, Q31, Bone, Mammuthus, OxA-12019	14789	14110	68.3	14821	14081	95.4	215	14293	14801	14147	68.3	14828	14091	95.4	225	14341	94.8	99.9
Ã‰tiolles, 2 nord, niv. 7 ou 8, Bone, Rangifer, GifA17233-ECHo1959	15538	15304	68.3	15646	15208	95.4	113	15423	15513	15272	68.3	15630	15175	95.4	117	15393	97.3	99.9
Ã‰tiolles, 2 nord, F61 ou niv. 7, Bone, Rangifer, Lyon-12375 (SacA 43203)	15159	14973	68.3	15279	14839	95.4	117	15063	15160	14966	68.3	15271	14638	95.4	127	15056	97.9	99.9
Ã‰tiolles, 2 nord, F61 ou niv. 7, Bone, Rangifer, Lyon-	15411	15190	68.3	15543	15124	95.4	108	15307	15385	15165	68.3	15535	15105	95.4	109	15288	99.6	99.9

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
12376 (SacA 43204)																		
Ã‰tiolles, 2 nord, F61 ou niv. 7, Bone, Rangifer, Lyon-11624 (GrA)	15180	14995	68.3	15290	14902	95.4	104	15090	15175	14990	68.3	15289	14872	95.4	112	15082	98.6	99.9
Ã‰tiolles, 2 nord, niv. sup, Bone, Rangifer, GifA18182-18183	14840	14307	68.3	14980	14136	95.4	234	14550	14840	14318	68.3	14982	14163	95.4	227	14570	101.3	99.8
Ã‰tiolles, 2 sud, D71-2, Bone, OxA-8757 (Ly-924)	14791	14104	68.3	14839	14065	95.4	228	14335	14803	14156	68.3	14843	14081	95.4	230	14398	96.1	99.8
Pincevent, La Grande-Paroisse, IV30, ETH 37120#	15001	14600	68.3	15101	14488	95.4	171	14868	14999	14589	68.3	15099	14475	95.4	174	14858	98.2	99.8
Pincevent, La Grande-Paroisse, Habitation nÂ°1, Gif 358#X	15020	13806	68.3	15703	13457	95.4	590	14500	15013	14170	68.3	15460	13875	95.4	409	14636	111.6	99.5
Pincevent, La Grande-Paroisse, Habitation nÂ°1, Erl 6786	14792	14063	68.3	14848	14025	95.4	245	14288	14802	14101	68.3	14847	14052	95.4	244	14372	94	99.8
Pincevent, IV21.3/ 25 k 81, Rangifer, OxA 149	14916	14177	68.3	15255	13865	95.4	349	14566	14930	14259	68.3	15191	14057	95.4	308	14608	105.1	99.7
Pincevent, IV21.3/ 25 m 80, Rangifer, OxA 177	14843	14048	68.3	15170	13785	95.4	376	14434	14852	14182	68.3	15178	13985	95.4	318	14543	104.8	99.6

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Pincevent, La Grande-Paroisse, IV20, ETH 37119#	14876	14430	68.3	14944	14314	95.4	178	14610	14877	14431	68.3	14945	14315	95.4	178	14613	99.9	99.9
Pincevent, La Grande-Paroisse, IV20, OxA 148	15274	14370	68.3	15546	14137	95.4	376	14884	15188	14360	68.3	15433	14154	95.4	339	14823	104.1	99.6
Pincevent, La Grande-Paroisse, IV20, OxA 467#	14814	13893	68.3	14937	13802	95.4	317	14311	14825	14090	68.3	15008	13906	95.4	284	14442	99.4	99.7
Marsangy, Le Pré des Forges, Unit D14, OxA 740	14791	13756	68.3	14900	13530	95.4	356	14098	14329	13791	68.3	14831	13607	95.4	306	14105	107	99.8
Marsangy, Le Pré des Forges, Unit N19, OxA 8453	14137	13861	68.3	14295	13799	95.4	137	14036	14153	13870	68.3	14299	13802	95.4	137	14049	99.3	99.9
Etigny, Le Brassot, locus 12, OxA 10096	14813	14173	68.3	14900	14091	95.4	234	14458	14762	14097	68.3	14851	14068	95.4	229	14367	100.3	99.9
Stellmoor, D (classic), Rangifer, KN-2223 bone	15149	14640	68.3	15257	14452	95.4	208	14962	14885	14293	68.3	15034	14278	95.4	211	14672	50.5	94.8
Stellmoor, D (classic), Rangifer, KN-2224 bone/antler	15108	14358	68.3	15290	14125	95.4	316	14739	14825	14277	68.3	14979	14154	95.4	226	14603	97.8	95.3
Stellmoor, D (classic), Rangifer, W-261 antler	14985	14240	68.3	15321	13890	95.4	352	14631	14825	14245	68.3	14938	14091	95.4	238	14560	111.9	95.3
Stellmoor, D (classic),	14770	13812	68.3	14834	13791	95.4	274	14154	14806	14078	68.3	14841	13994	95.4	270	14350	84.1	95.7

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Rangifer, K-4261 antler																		
Stellmoor, D (classic), Rangifer, K-4328 bone	14314	13809	68.3	14837	13786	95.4	278	14139	14805	14075	68.3	14840	13984	95.4	272	14350	81.9	95.7
Poggenwisch, D (classic), Rangifer, K-4332 bone	15150	14533	68.3	15267	14298	95.4	267	14872	14839	14286	68.3	15017	14231	95.4	216	14641	75.2	95.1
Poggenwisch, D (classic), Rangifer, KN-2754 bone	14949	14358	68.3	15076	14212	95.4	235	14643	14821	14285	68.3	14933	14210	95.4	206	14599	97.2	95.5
Poggenwisch, D (classic), GrN-11254 #	14920	14440	68.3	14981	14296	95.4	194	14629	14821	14293	68.3	14905	14269	95.4	188	14605	91.7	95.7
Poggenwisch, D (classic), Rangifer, K-4331 bone	14908	14325	68.3	15068	14134	95.4	255	14601	14824	14271	68.3	14919	14162	95.4	217	14572	104.5	95.3
Poggenwisch, D (classic), Rangifer, K-4577 *	14908	14325	68.3	15068	14134	95.4	255	14601	14823	14270	68.3	14919	14163	95.4	217	14572	104.5	95.7
Poggenwisch, D (classic), Rangifer, KIA-32926 antler	14803	14207	68.3	14847	14137	95.4	210	14442	14809	14245	68.3	14839	14155	95.4	213	14482	106.1	96.6
Poggenwisch, D (classic), Rangifer, KIA-32927 antler	14791	14153	68.3	14828	14090	95.4	216	14338	14805	14180	68.3	14825	14105	95.4	230	14416	100.5	96.5
Poggenwisch, D (classic), KIA-32925 *	14275	14084	68.3	14803	14050	95.4	185	14198	14791	14124	68.3	14813	14065	95.4	257	14297	74.5	96.3

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Meiendorf, D (classic), Rangifer, KN-2220 bone	15073	14204	68.3	15520	13816	95.4	417	14668	14825	14238	68.3	14959	14072	95.4	246	14558	114.9	95.2
Meiendorf, D (classic), Rangifer, K-4329 antler	14820	14160	68.3	14947	14076	95.4	252	14474	14816	14223	68.3	14854	14108	95.4	227	14507	108.7	95.7
AhrenshÃ¶ft LA 73, lower layer, North, hearth A, D (classic), KIA-3833 #	14099	13867	68.3	14152	13806	95.4	102	14023	14790	14021	68.3	14808	13878	95.4	299	14163	52.9	96.3
Slotseng, DK (Havelte / Federmesser Gruppen?), AAR-906 *	15110	14329	68.3	15364	14068	95.4	350	14723	14184	14067	68.3	14346	14025	95.4	84	14126	49.9	99.5
Slotseng, DK (Havelte / Federmesser Gruppen?), Rangifer, AAR-8159 antler	14832	14313	68.3	14937	14190	95.4	208	14540	14209	14081	68.3	14358	14066	95.4	85	14153	33	99.4
Slotseng, DK (Havelte / Federmesser Gruppen?), AAR-8157 *	14310	14115	68.3	14805	14082	95.4	195	14237	14179	14083	68.3	14277	14070	95.4	58	14139	95.2	99.6
Slotseng, DK (Havelte / Federmesser Gruppen?), Rangifer, AAR-8165 bone	14787	14079	68.3	14830	14049	95.4	225	14276	14169	14073	68.3	14284	14049	95.4	65	14126	120.1	99.6

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Slotseng, DK (Havelte / Federmesser Gruppen?), AAR-8160 *	14215	14068	68.3	14781	14041	95.4	146	14156	14150	14074	68.3	14239	14048	95.4	49	14116	124.5	99.8
Slotseng, DK (Havelte / Federmesser Gruppen?), Rangifer, AAR-8162 antler	14779	13894	68.3	14821	13808	95.4	244	14184	14156	14060	68.3	14279	14013	95.4	64	14109	152.7	99.7
Slotseng, DK (Havelte / Federmesser Gruppen?), Rangifer, AAR-8163 bone	14210	14037	68.3	14794	13862	95.4	157	14126	14145	14063	68.3	14232	14025	95.4	51	14105	135.1	99.8
Slotseng, DK (Havelte / Federmesser Gruppen?), Rangifer, AAR-8164 bone	14152	14044	68.3	14310	13880	95.4	101	14096	14130	14060	68.3	14195	14026	95.4	43	14098	120.3	99.8
Slotseng, DK (Havelte / Federmesser Gruppen?), AAR-8158 *	14151	14019	68.3	14304	13812	95.4	106	14069	14123	14049	68.3	14189	14010	95.4	46	14089	119.4	99.6
Slotseng, DK (Havelte / Federmesser Gruppen?), AAR-8161 *	14045	13809	68.3	14112	13780	95.4	98	13931	14116	14017	68.3	14172	13909	95.4	61	14065	64.4	99.3
AhrenshÃ¶ft LA 73, upper layer, South, D	14185	14040	68.3	14776	13870	95.4	138	14115	14142	14062	68.3	14222	14025	95.4	49	14103	130.8	99.8

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
(Havelte), KIA-3605 #																		
AhrenshÃ¶ft LA 58 D, hearth, D (Havelte), AAR-2784 #	14015	13805	68.3	14049	13793	95.4	77	13916	14101	14005	68.3	14152	13911	95.4	58	14045	51.5	99
Stellmoor, D (classic), Rangifer, KN-2223 bone	15149	14640	68.3	15257	14452	95.4	208	14962	14890	14297	68.3	15030	14280	95.4	204	14687	50.1	86.7
Stellmoor, D (classic), Rangifer, KN-2224 bone/antler	15108	14358	68.3	15290	14125	95.4	316	14739	14830	14279	68.3	14976	14156	95.4	224	14633	98	89.6
Stellmoor, D (classic), Rangifer, W-261 antler	14985	14240	68.3	15321	13890	95.4	352	14631	14830	14254	68.3	14933	14092	95.4	237	14597	112.1	90.4
Stellmoor, D (classic), Rangifer, K-4261 antler	14770	13812	68.3	14834	13791	95.4	274	14154	14807	14080	68.3	14841	13995	95.4	275	14388	82.7	91.2
Stellmoor, D (classic), Rangifer, K-4328 bone	14314	13809	68.3	14837	13786	95.4	278	14139	14808	14077	68.3	14841	13989	95.4	277	14387	80.7	91
Poggenwisch, D (classic), Rangifer, K-4332 bone	15150	14533	68.3	15267	14298	95.4	267	14872	14844	14292	68.3	15016	14236	95.4	211	14662	75.1	88.5
Poggenwisch, D (classic), Rangifer, KN-2754 bone	14949	14358	68.3	15076	14212	95.4	235	14643	14828	14288	68.3	14934	14215	95.4	203	14629	97.4	89.4

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Poggenwisch, D (classic), GrN-11254 #	14920	14440	68.3	14981	14296	95.4	194	14629	14830	14298	68.3	14906	14272	95.4	185	14630	91.7	89.2
Poggenwisch, D (classic), Rangifer, K-4331 bone	14908	14325	68.3	15068	14134	95.4	255	14601	14825	14274	68.3	14917	14165	95.4	215	14606	104.8	90.1
Poggenwisch, D (classic), Rangifer, K-4577 *	14908	14325	68.3	15068	14134	95.4	255	14601	14826	14274	68.3	14916	14165	95.4	215	14607	104.8	90.1
Poggenwisch, D (classic), Rangifer, KIA-32926 antler	14803	14207	68.3	14847	14137	95.4	210	14442	14811	14246	68.3	14840	14158	95.4	214	14513	106.4	92.2
Poggenwisch, D (classic), Rangifer, KIA-32927 antler	14791	14153	68.3	14828	14090	95.4	216	14338	14806	14184	68.3	14827	14107	95.4	233	14445	100	92.4
Poggenwisch, D (classic), KIA-32925 *	14275	14084	68.3	14803	14050	95.4	185	14198	14793	14128	68.3	14814	14066	95.4	263	14305	72.4	91.5
Meiendorf, D (classic), Rangifer, KN-2220 bone	15073	14204	68.3	15520	13816	95.4	417	14668	14830	14244	68.3	14951	14076	95.4	244	14596	115.2	90
Meiendorf, D (classic), Rangifer, K-4329 antler	14820	14160	68.3	14947	14076	95.4	252	14474	14819	14225	68.3	14855	14111	95.4	228	14544	108.8	91.1
AhrenshÃ¶ft LA 73, lower layer, North, hearth A, D (classic), KIA-3833 #	14099	13867	68.3	14152	13806	95.4	102	14023	14792	14022	68.3	14809	13881	95.4	310	14179	50.9	89.6

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Slotseng, DK (Havelte / Federmesser Gruppen?), AAR-906 *	15110	14329	68.3	15364	14068	95.4	350	14723	14182	14067	68.3	14348	14026	95.4	83	14125	49.7	98
Slotseng, DK (Havelte / Federmesser Gruppen?), Rangifer, AAR-8159 antler	14832	14313	68.3	14937	14190	95.4	208	14540	14208	14080	68.3	14357	14066	95.4	84	14152	32.7	96.8
Slotseng, DK (Havelte / Federmesser Gruppen?), AAR-8157 *	14310	14115	68.3	14805	14082	95.4	195	14237	14179	14083	68.3	14276	14070	95.4	58	14138	94.7	97.7
Slotseng, DK (Havelte / Federmesser Gruppen?), Rangifer, AAR-8165 bone	14787	14079	68.3	14830	14049	95.4	225	14276	14168	14073	68.3	14284	14049	95.4	64	14125	119.9	98.4
Slotseng, DK (Havelte / Federmesser Gruppen?), AAR-8160 *	14215	14068	68.3	14781	14041	95.4	146	14156	14150	14074	68.3	14237	14049	95.4	48	14116	124.7	99
Slotseng, DK (Havelte / Federmesser Gruppen?), Rangifer, AAR-8162 antler	14779	13894	68.3	14821	13808	95.4	244	14184	14156	14060	68.3	14277	14013	95.4	64	14109	152.9	98.7
Slotseng, DK (Havelte / Federmesser	14210	14037	68.3	14794	13862	95.4	157	14126	14144	14063	68.3	14231	14025	95.4	51	14105	135.4	99

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Gruppen?), Rangifer, AAR-8163 bone																		
Slotseng, DK (Havelte / Federmesser Gruppen?), Rangifer, AAR-8164 bone	14152	14044	68.3	14310	13880	95.4	101	14096	14130	14060	68.3	14193	14028	95.4	43	14098	120.7	99
Slotseng, DK (Havelte / Federmesser Gruppen?), AAR-8158 *	14151	14019	68.3	14304	13812	95.4	106	14069	14124	14049	68.3	14189	14010	95.4	46	14090	119.1	98.4
Slotseng, DK (Havelte / Federmesser Gruppen?), AAR-8161 *	14045	13809	68.3	14112	13780	95.4	98	13931	14116	14017	68.3	14172	13910	95.4	61	14066	63.8	96.5
AhrenshÃ¶ft LA 73, upper layer, South, D (Havelte), KIA-3605 #	14185	14040	68.3	14776	13870	95.4	138	14115	14141	14062	68.3	14220	14025	95.4	48	14103	131.2	99
AhrenshÃ¶ft LA 58 D, hearth, D (Havelte), AAR-2784 #	14015	13805	68.3	14049	13793	95.4	77	13916	14103	14005	68.3	14153	13911	95.4	58	14046	50.7	94.9
Marsangy, Le Pré des Forges, Unit D14, OxA 740	14791	13756	68.3	14900	13530	95.4	356	14098	14768	13764	68.3	14906	13507	95.4	351	14095	100.1	14.7
Marsangy, Le Pré des Forges, Unit N19, OxA 8453	14137	13861	68.3	14295	13799	95.4	137	14036	14145	13817	68.3	14785	13798	95.4	200	14041	94.6	0.5

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Etigny, Le Brassot, locus 12, OxA 10096	14813	14173	68.3	14900	14091	95.4	234	14458										
Le Closeau, locus 33, lower horizon, GrA-18860 Equus sp.	15010	14492	68.3	15106	14312	95.4	221	14710	14692	14325	68.3	14968	14242	95.4	193	14550	88	97.5
Le Closeau, locus 33, lower horizon, GrA-18815 Bovinae	14960	14461	68.3	15033	14291	95.4	207	14660	14682	14321	68.3	14937	14249	95.4	184	14533	93.4	97.5
Le Closeau, locus 46, lower horizon, AA-41881 Sus scrofa	14837	14327	68.3	14950	14215	95.4	203	14564	14726	14268	68.3	14865	14189	95.4	182	14473	102.7	97.3
Le Closeau, locus 46, lower horizon, GrA-11665 (Ly-790) Cervidae	14801	14198	68.3	14845	14116	95.4	212	14430	14769	14186	68.3	14828	14114	95.4	191	14395	103.4	98
Le Closeau, locus 46, lower horizon, GrA-11664 (Ly-789) Equus sp.	14798	14181	68.3	14841	14102	95.4	215	14407	14762	14178	68.3	14825	14099	95.4	193	14377	102.8	97.5
Le Closeau, locus 46, lower horizon, GrA-18816 Sus scrofa	14801	14174	68.3	14846	14097	95.4	221	14418	14762	14168	68.3	14830	14096	95.4	198	14384	103.8	98
Le Closeau, locus 56, lower horizon, GrA-18819 Cervidae	14798	14160	68.3	14843	14087	95.4	223	14395	14760	14160	68.3	14823	14088	95.4	199	14367	103.4	97.8
Le Closeau, locus 46, lower horizon, AA-	14279	14068	68.3	14808	14029	95.4	193	14187	14306	14072	68.3	14803	14035	95.4	191	14210	93.4	97.9

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
41882 Panthera leo																		
Le Closeau, locus 4, lower horizon, OxA-5680* (Ly- 166) Equus sp.	14068	13809	68.3	14204	13766	95.4	128	13956	14115	13861	68.3	14320	13792	95.4	162	14030	86.9	97.7
Le Closeau, locus 4, lower horizon, OxA-6338* (Ly- 313)	14037	13805	68.3	14170	13611	95.4	127	13928	14101	13856	68.3	14760	13770	95.4	163	14009	86.6	96.7
Le Closeau, locus 51, intermediate horizon, Ly-570 (OxA)	13238	13100	68.3	13343	13009	95.4	75	13178	13229	13100	68.3	13315	13071	95.4	66	13164	106.5	98.9
Le Closeau, locus 18, intermediate horizon, Ly-562 (OxA)	13241	13096	68.3	13341	12993	95.4	82	13170	13230	13096	68.3	13318	13002	95.4	72	13159	107.3	98.6
Le Closeau, locus 34, intermediate horizon, Ly-566 (OxA)	13237	13088	68.3	13314	12929	95.4	87	13150	13230	13090	68.3	13308	12981	95.4	76	13146	108.3	98.8
Le Closeau, locus 14, intermediate horizon, Ly-358 (AA- 21677)	13234	13090	68.3	13311	12995	95.4	75	13150	13225	13091	68.3	13304	13000	95.4	66	13146	107	98.4
Le Closeau, locus 32, upper horizon, Ly-565 (OxA)	13237	13000	68.3	13308	12896	95.4	106	13118	13232	13064	68.3	13298	12909	95.4	94	13124	109.6	99

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Le Closeau, locus 25, upper horizon, Ly-564 (OxA) Pinus sylves- tris?	12891	12742	68.3	13060	12724	95.4	83	12823	12885	12734	68.3	13071	12721	95.4	89	12813	100.9	98.9
Le Closeau, locus 8, upper horizon, OxA6337* (Ly-312)	12894	12719	68.3	13073	12673	95.4	101	12806	12887	12712	68.3	13075	12680	95.4	101	12800	102.9	97.9
Le Closeau, locus 25, upper horizon, Ly-563 (OxA) Pinus sylves- tris?	12818	12630	68.3	12890	12498	95.4	77	12729	12817	12681	68.3	12892	12615	95.4	67	12736	105.7	99.2
Le Closeau, locus 3, upper horizon, Ly-7189	12745	12500	68.3	12880	12194	95.4	131	12655	12753	12631	68.3	12837	12492	95.4	80	12700	111.1	98.2
Bonn-Oberkassel, Canis, OxA-4793	14792	14057	68.3	14850	13885	95.4	249	14281	14282	14055	68.3	14521	13818	95.4	149	14171	117.2	98.1
Bonn-Oberkassel, Canis, KIA-4161	14067	13866	68.3	14080	13809	95.4	80	13953	14066	13868	68.3	14080	13810	95.4	79	13960	100.4	98.6
Bonn-Oberkassel, Homo, OxA-4792	14283	13867	68.3	14805	13797	95.4	228	14110	14208	13870	68.3	14320	13800	95.4	144	14076	112.2	98.3
Bonn-Oberkassel, Canis, KIA-4162	14197	14045	68.3	14786	13877	95.4	146	14129	14176	14047	68.3	14315	13882	95.4	88	14114	108.1	98.2
Irlich, Sandgrube, Homo, OxA-9736	14805	14082	68.3	14955	14027	95.4	267	14395	14325	14055	68.3	14582	13809	95.4	166	14197	109.4	97.8
Irlich, Sandgrube, Homo, UtC-9221	14089	13810	68.3	14297	13786	95.4	144	13987	14087	13815	68.3	14196	13790	95.4	113	13982	103.5	98.1

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Irlich, Sandgrube, Homo, OxA-9848	14009	13770	68.3	14040	13611	95.4	103	13865	14010	13783	68.3	14044	13615	95.4	98	13886	102.2	99
GÃ¶nnersdorf V, OxA-15296, Alces, bone	14817	14249	68.3	14888	14159	95.4	208	14488	14410	14165	68.3	14607	14084	95.4	139	14306	95.1	98.3
Andernach-Martinsberg, , Equus sp., OxA-V-2218-39	14271	14090	68.3	14804	14055	95.4	180	14199	14227	14087	68.3	14330	14058	95.4	88	14170	112.8	98.7
Andernach-Martinsberg, AN2-East, Young artiodactyl, OxA-985	14837	14050	68.3	15096	13798	95.4	354	14426	14337	13867	68.3	14603	13756	95.4	213	14140	102.9	97.6
Andernach-Martinsberg, AN2-East, Bos/Bison, GrA-16991	14023	13807	68.3	14068	13788	95.4	84	13920	14030	13820	68.3	14066	13792	95.4	81	13926	100.5	99
Andernach-Martinsberg, AN2-East, Cervus elaphus, OxA-984	14140	13500	68.3	14841	13317	95.4	378	13893	14101	13653	68.3	14361	13347	95.4	242	13894	115	96.1
Andernach-Martinsberg, AN2-East , Artiodactyl , GrA-16990	13759	13603	68.3	13800	13502	95.4	86	13677	13780	13626	68.3	13985	13504	95.4	90	13696	99.1	99.1
Andernach-Martinsberg, AN2-Centre, Castor fiber , GrA-16987	14031	13809	68.3	14073	13791	95.4	84	13923	14035	13815	68.3	14069	13794	95.4	81	13928	100.4	98.8

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Andernach-Martinsberg, AN2-Centre, Cervus elaphus, GrA-16989	14011	13764	68.3	14040	13609	95.4	109	13857	14013	13775	68.3	14044	13613	95.4	104	13876	102.4	98.6
Andernach-Martinsberg, AN2-Centre, Cervus elaphus, OxA-1924	13993	13598	68.3	14041	13506	95.4	147	13757	14009	13618	68.3	14053	13515	95.4	144	13794	97.7	98.4
Andernach-Martinsberg, AN2-Sondage, Cervus elaphus, OxA-997	13745	13599	68.3	13754	13531	95.4	55	13671	13748	13601	68.3	13757	13595	95.4	53	13689	100.9	99.5
Andernach-Martinsberg, AN3-North, Indet., GrA-16993	13572	13355	68.3	13600	13305	95.4	83	13448	13576	13346	68.3	13736	13247	95.4	95	13445	94.2	98.6
Andernach-Martinsberg, AN2-South, Bos/Bison, OxA-998	13407	13114	68.3	13585	12927	95.4	148	13264	13366	13097	68.3	13585	12927	95.4	146	13244	101.4	98.2
Andernach-Martinsberg, AN3-South , Indet. , GrA-16994	13164	12998	68.3	13227	12896	95.4	80	13081	13165	13002	68.3	13226	12905	95.4	76	13087	103	98.9
Andernach, upper horizon 2, OxA-998, Bos, bone	13407	13114	68.3	13585	12927	95.4	148	13264	13357	13096	68.3	13585	12931	95.4	146	13244	101.7	98.4

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Urbar, OxA-1137, Cervus, bone	13326	13117	68.3	13485	13076	95.4	107	13244	13312	13115	68.3	13475	13070	95.4	104	13230	101.9	98.6
Kettig, Hd-18123, Cervus, bone	13291	13124	68.3	13303	13115	95.4	52	13207	13285	13123	68.3	13301	13114	95.4	51	13204	100.1	99.2
Niederbieber 3, OxA-1135, Equus, bone	13161	12904	68.3	13290	12764	95.4	126	13025	13165	12930	68.3	13298	12826	95.4	118	13053	102.7	98.8
Niederbieber 2 (19), OxA-2066, Alces, bone	13116	12898	68.3	13225	12765	95.4	108	13008	13156	12926	68.3	13236	12822	95.4	103	13032	102.1	98.5
Boppard, KIA-26644, Cervus, bone	13092	12933	68.3	13110	12845	95.4	66	13010	13095	12970	68.3	13115	12848	95.4	63	13021	102.2	99
Bad Breisig, GrA-17493 #	12823	12736	68.3	12892	12720	95.4	45	12780	12833	12740	68.3	12958	12718	95.4	60	12803	85.6	99.2
Conty Le Marais Niv. inf., bone, Bos, OxA-6151/Ly-260	13981	13601	68.3	14022	13518	95.4	127	13748	13717	13511	68.3	13857	13485	95.4	99	13643	95.2	99.1
Conty Le Marais Niv. inf., bone, Bos, OxA-6148/Ly-257	13587	13360	68.3	13742	13305	95.4	97	13478	13583	13355	68.3	13735	13251	95.4	96	13468	99.3	99.1
Conty Le Marais Niv. inf., bone, Bos, OxA-6149/Ly-258	13496	13331	68.3	13597	13242	95.4	90	13421	13495	13321	68.3	13595	13187	95.4	93	13414	97.5	98.8
Conty Le Marais Niv. inf., bone, Bos, OxA-6150/Ly-259	13343	13179	68.3	13455	13125	95.4	80	13283	13339	13172	68.3	13452	13120	95.4	85	13271	97.2	99.3
Saleux, 234, GrA-15945 (Lyon-1141), Bos	13176	13074	68.3	13242	12925	95.4	72	13120	13174	13076	68.3	13240	12930	95.4	68	13120	102.4	99.4

	Unmodelled								Modelled									
	from	to	%	from	to	%	sigma	median	from	to	%	from	to	%	sigma	median	A	C
Saleux, 234, GrA-15946 (Lyon-1142), Bos	13164	12998	68.3	13227	12896	95.4	80	13081	13165	13001	68.3	13180	12904	95.4	74	13087	104.3	99.4
Saleux, Sondage Tr.A17, Beta - 170949, Cervus	13161	13084	68.3	13177	12934	95.4	51	13109	13160	13084	68.3	13178	12973	95.4	49	13109	101.3	99.5
Saleux, 114/120, OxA-4932 (Lyon-81), Bos	13059	12839	68.3	13087	12769	95.4	89	12936	13084	12911	68.3	13100	12784	95.4	85	12979	100.4	99.2
Saleux, 114, OxA-4933 (Lyon-82), Bos	12905	12625	68.3	13085	12489	95.4	147	12776	13077	12753	68.3	13104	12672	95.4	125	12899	79.7	98.3
Rekem, resin, OxA-942	13396	13101	68.3	13573	12929	95.4	139	13247	13359	13100	68.3	13571	12927	95.4	139	13248	99.8	97.9

Catalogue B

Background Historic and recovery history of British LG assemblages

Introduction

The following historic context aims to provide a background to the variability of recovery conditions for the current LG reference assemblages used in this thesis. The history of British LG excavations can be summarised into three phases:

1. Early pre-radiocarbon excavations;
2. Controlled stratigraphy and multi-disciplinary excavations 1960's to 2000;
3. Open-air contract archaeology and the end of research excavations in the new millennium.

Pre-radiocarbon dating (19th to mid-20th Century)

The earliest recorded excavated LG assemblages date to the 19th century, and a detailed description can be found in (Campbell 1977). The main collections cited in the thesis dating to this period are Kent's Cavern, Mother Grundy's Cave and Gough's Cave. The excavations were recorded in good detail for the time although not up to modern standards. The main unit was spits, and therefore there is no fine stratigraphic control. The conditions were with low light, using mostly heavy tools to remove the spits quickly and sort out the large finds form the spoil. The material was not sieved, and this has currently led to many questions concerning the presence or absence of backed bladelets amongst Creswellian assemblages linking these original assemblages to the continental Late Magdalenian. More recent projects have sieved spoil heaps identified as dating to this period, without any recovery of any backed bladelets (Barton 1995; Campbell 1977). The records from these excavations are however of good quality with three dimensional recordings at the two principle sites of Kent's Cavern and Gough's Cave that has enabled a coarse contextualisation and sequencing of the finds (Jacobi 2004; Proctor *et al.* 2017).

The publication of "The Upper Palaeolithic Age in Britain" by Dorothy Garrod (1926), formalised the LG in Britain for the first time. This work was carried out collaborating with H. Breuil, and

many cross-Channel parallels with French assemblages (e.g. Magdalenian, Azilian), and discerning the originality of Creswellian, Cheddar and Grundy (penknife) points. This is also where the term 'Creswellian' was coined (Davies & Charles 2017; Jacobi & Roberts 1993).

The first half of the 20th century the quality of excavation methods improved, but without systematic sieving and controlled stratigraphic excavation at Pin Hole, Soldier's Hole and King Arthur's Cave. During the Second World War several collections were damaged by incendiary bombs, notably at the Bristol Museum where collections from Sun Hole and Aveline's Hole were very damaged and many pieces were lost, reducing the collections significantly (Jacobi 2004). Some elements have been recovered from past publications and comparing the burnt material to earlier publications (Jacobi 2004).

This early phase of excavation focussed on cave sites, and these are amongst the largest collections of LGI lithics, and the vast majority of the faunal material available was recovered from this period. Unfortunately most of the largest caves were nearly completely emptied during this period. The resolution of excavation is relatively low, and many questions remain considering mixing or palimpsests within major collections such as Gough's Cave (Jacobi & Higham 2011a; 2009b; Jacobi 2004). The surface collection of Brockhill was collected during this period, although only recognised as Late Glacial in 1977 (Bonsall 1977).

Controlled stratigraphy and multi-disciplinary excavations 1960s to 2000

During the second half of the 20th century three major techniques helped improve the resolution of excavation and archaeological interpretation and control. Emphasis on controlled stratigraphic excavation with geoarchaeological insights, radio-carbon dating and palaeoenvironmental (initially pollen and molluscs) analyses (Campbell 1977). This is also the period of the first excavations of LG open-air sites, starting with Hengistbury Head (Mace 1959).

This was followed by a period of surveying and new excavations of cave and open air-sites with multidisciplinary teams and strict stratigraphic control. The excavations of the Torbryant caves (Barton & Roberts 1996b) led to the first chronological and techno-typological sequencing of British LG into a separate Creswellian and FUP entities at the sites of Three Holes Cave, Torbryant and Broken Cavern (*ibid.*). This was accompanied by geoarchaeological developments and better controlled cave excavations (Collcutt 1985; 1986a; 1986b; 1984). Large regions were surveyed and new cave sites and rockshelter were examined (Barton 1995; 1996; 1997), notably Symonds Yat and Pixie's Hole (Barton & Roberts 1996b; Collcutt 1986a), and numerous Welsh LG cave assemblages notably Hoyle's Mouth and Nana's Cave (David 1991; 2007).

The excavation of Hengistbury Head was the first multi-disciplinary excavation with expansive horizontal excavation, fine sieving, 3d recording of all objects and intensive post-excavation program of refitting, usewear analysis and detailed techno-typological analysis (Barton *et al.* 1992).

Certain past excavations were returned to with multi-disciplinary teams and careful stratigraphically controlled and sieving methods. The British Museum returned to Gough's Cave and recovered the only refitting sequence of Creswellian lithics, faunal, artistic and human remains from the same horizon and therefore the only homogeneous and consistent Creswellian assemblage from Gough's Cave (Currant et al. 1989; Jacobi 2004).

These later excavations produced many of the reference assemblages referred to in this thesis.

Developer led archaeology and the age of open-air sites

From the 1990s onwards research excavations dwindled and 'development' or 'contract' archaeology developed (Darvill *et al.* 2018; Lisk *et al.* 2016). Many of these excavations were run

by internal specialists or in collaboration with researchers working in the field of LG archaeology. This has produced only open-air sites, as there are no developer funded cave site excavations. The excavations are therefore under constant pressure for time, and whereas the technical aspects (stratigraphic excavation, sieving and palaeoenvironmental sampling) are systematically carried out, the time pressure and speed of excavation does cut corners and only as much as possible is recorded in 3d, and they are rarely truly excavated horizontally as living floors. Most of these excavations are also exposed to the weather whilst under excavation, and therefore there is a certain percentage of loss. Although the recovery is not optimal, there is a relatively good standard that is improving. The archaeological firms (units) have made much progress since 2000 to include refitting and post-excavation analyses into these projects. There have been no research funded LG excavations since 2000, although some of the post-excavation work (most refitting and use-wear analyses) do fall within research projects as external specialist consultants. It is more a collaboration/integration of research and developer funded archaeology. Also important has been community archaeological societies running excavations in collaboration with LG specialists (Cooper 2015; Garton & Jacobi 2009; Mills 2013). The most important reference assemblages mentioned in the thesis are the following:

- Nea Farm (Barton *et al.* 2009)
- Bradgate park (Cooper 2002)
- Rookery Farm (Conneller *et al.* 2009)
- La Sagesse convent (Conneller & Ellis 2007)
- Wey Manor Farm (Jones 2013)
- Guildford Fire Station (Attfield *et al.* 2014)
- Farndon Fields (Garton & Jacobi 2009)

During the same period new LG sites have also been recovered from Scotland, extending the landscape usage much further north, with two new reference sites: Howburn(Ballin 2017a; Ballin *et al.* 2010) and Kilmelfort Cave (Ballin 2017a).

Catalogue C LG Reference faunal assemblages

Catalogue Table A LG Reference faunal assemblages by chronozone , after Currant and Jacobi 2011

Lab no	Site	Species	Sample description	Radiocarbon age BP	±	Cal BP from	Cal BP to	2 sigma %	chronozone
OxA-18067	Gough's Cave, Somerset	*Cervus elaphus*	cut distal right tibia	12245	55	14802	14033	95.4	Bølling
OxA-17832	Gough's Cave, Somerset	*Equus ferus*	cut distal right metacarpal	12415	50	14907	14246	95.4	Bølling
OxA-13585	Gough's Cave, Somerset	*Canis sp.* (domestic)	right dentary	12440	55	14951	14285	95.4	Bølling
OxA-18066	Gough's Cave, Somerset	*Lynx lynx*	cut shaft of left femur	12440	55	14951	14285	95.4	Bølling
OxA-17846	Gough's Cave, Somerset	*Mammuthus primigenius*	ivory sagaie	12470	55	14984	14314	95.4	Bølling
OxA-17848	Gough's Cave, Somerset	*Human*	adult frontal	12485	50	15004	14325	95.4	Bølling
OxA-18065	Gough's Cave, Somerset	*Equus ferus*	cut left 1st phalange	12490	55	15020	14321	95.4	Bølling
OxA-17845	Gough's Cave, Somerset	*Cervus elaphus*	cut 2nd phalange	12500	50	15035	14341	95.4	Bølling
OxA-16378	Gough's Cave, Somerset	*Cervus elaphus*	cut distal right metatarsal	12515	50	15089	14360	95.4	Bølling
OxA-18068	Gough's Cave, Somerset	*Equus ferus*	cut cervical vertebra	12520	55	15100	14360	95.4	Bølling
OxA-18064	Gough's Cave, Somerset	*Rangifer tarandus antler*	bâton percé	12535	55	15126	14444	95.4	Bølling
OxA-17847	Gough's Cave, Somerset	*Human*	cut right scapula	12565	50	15143	14540	95.4	Bølling
OxA-17833	Gough's Cave, Somerset	*Equus ferus*	cut 2nd phalange	12570	45	15141	14567	95.4	Bølling
OxA-16292	Gough's Cave, Somerset	*Equus ferus*	cut cervical vertebra	12585	55	15178	14556	95.4	Bølling
OxA-17849	Gough's Cave, Somerset	*Human*	cut adult calotte	12590	50	15175	14584	95.4	Bølling

OxA-18035	Gough's Cave, Somerset	*Gough's Cave*	Cut herbivore rib	12600	80	15269	14477	95.4	Bølling
OxA-11151	Poulton le Fylde, Lancashire	*Alces alces*	Left metacarpal	11660	60	13734	13354	95.4	Allerød
OxA-13075	Poulton le Fylde, Lancashire	*Alces alces*	Right metatarsal	11715	50	13746	13464	95.4	Allerød
OxA-11597	Ballaugh, Isle of Man	*Megaloceros giganteus*	Antler (shed)	11650	55	13604	13355	95.4	Allerød
OxA-12118	Glen Wyllin, Isle of Man	*Megaloceros giganteus*	Shaft of femur	11130	45	13157	12917	95.4	Allerød
OxA-19207	Lynx Cave, Denbighshire	*Cervus elaphus*	Left tibia (distal)	11680	45	13731	13448	95.4	Allerød
OxA-19206	Lynx Cave, Denbighshire	*Cervus elaphus*	Left astragalus	11640	45	13598	13372	95.4	Allerød
OxA-6116	Kendrick's Cave, Conwy	*Capreolus capreolus*	Scored right metacarpal (distal)	11795	65	13789	13506	95.4	Allerød
OxA-11154	Kinsey Cave, N. Yorks	*Rangifer tarandus*	Antler	11465	75	13472	13179	95.4	Allerød
OxA-12884	Lynx Cave, Denbighshire	*Bos primigenius*	Shaft of left femur	11245	65	13300	13079	95.4	Allerød
OxA-16339	Kinsey Cave, N. Yorks	*Bos primigenius*	Cervical vertebra	11555	50	13502	13315	95.4	Allerød
OxA-12143	Victoria Cave, N. Yorks	*Bos primigenius*	Calcaneum	11600	45	13580	13347	95.4	Allerød
OxA-17828	Chelm's Combe Shelter, Somerset	*Rangifer tarandus*	Right metacarpal	10655	45	12735	12507	95.4	Younger Dryas
OxA-17829	Chelm's Combe Shelter, Somerset	*Rangifer tarandus*	Left dentary	10150	40	11940	11508	95.4	Younger Dryas
OxA-17830	Chelm's Combe Shelter, Somerset	*Cervus elaphus*	Right dentary	10995	40	13073	12775	95.4	Younger Dryas
OxA-17831	Chelm's Combe Shelter, Somerset	*Rangifer tarandus*	Right dentary	10480	45	12667	12105	95.4	Younger Dryas

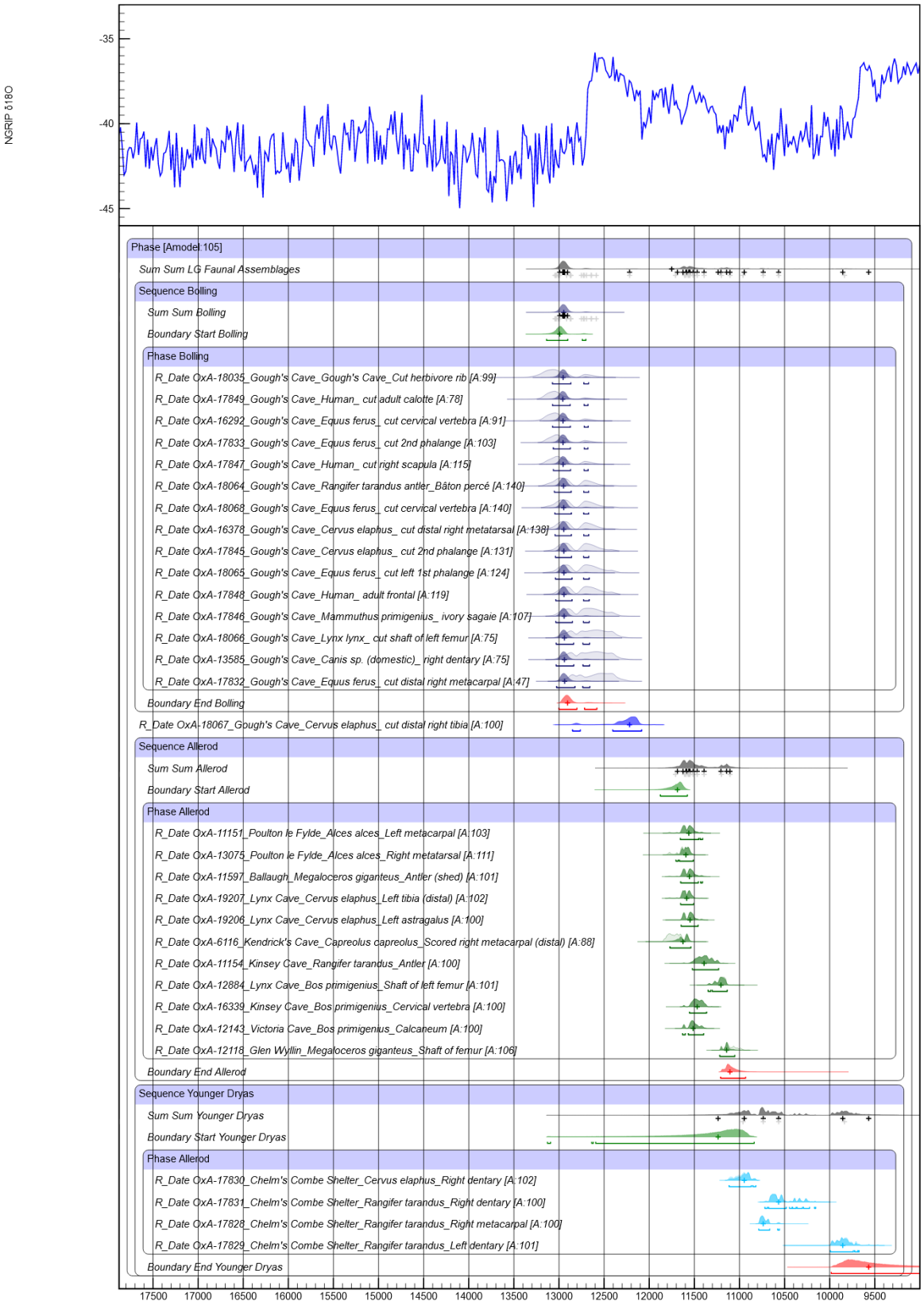


Figure C.1 LG Reference faunal assemblages by chronozone, after Currant and Jacobi 2011. The gap at Gough's Cave in GI-1e was previously noted by Jacobi and Higham(2011), and is considered as a potential later occupation. This is further reinforced by the recalibration using IntCal20.

Catalogue D European Reference sites and Locations

Catalogue of European LG Reference sites located in Figures 3.4 to 3.69.

Figure 3.4 Directly dated 'Classic' Late Magdalenian reference sites							
FID	Shape *	FID_	site name	country	coord_lat	coord_long	Label
0	Point	0	Andernach-Martinsberg	Germany	50.43337	7.4005	4
1	Point	1	Belloy-sur-Somme, Plaisance	France	49.96565	2.12106	11
2	Point	2	Bois Laiterie	Belgium	50.35	4.85	6
3	Point	3	Champréveyres	Switzerland	47.00935	6.97782	2
4	Point	4	Etiolles, Les Coudrays	France	48.63819	2.45981	14
5	Point	5	Gönnersdorf	Germany	50.44778	7.415278	3
6	Point	6	Goyet	Belgium	50.44556	5.01333	10
7	Point	7	Monruz	Switzerland	47	6.9667	1
8	Point	8	Orp west	Belgium	50.69444	4.973056	5
9	Point	9	Pincevent, La Grand-Paroisse	France	48.38723	2.90656	
10	Point	10	Trou Da Somme	Belgium	50.23333	4.883333	7
11	Point	11	Trou de Chaleux	Belgium	50.22167	4.941667	8
12	Point	12	Trou des Blaireaux	Belgium	50.12056	4.737778	9
13	Point	13	Verberie, Le Buisson Capin	France	49.30627	2.73077	13
Figure 3.13 Distribution of reference sites with Cepoy-Marsangy facies							
FID	Shape *	FID_	site name	country	coord_lat	coord_long	Label
0	Point	13	Bois Laiterie	Belgium	50.35	4.85	2
1	Point	46	Grand Canton, Marolles-sur-Seine	France	48.36667	3.051944	3
2	Point	61	Kohlerhöhle	Switzerland	47.41667	7.533333	1
3	Point	71	Marsangy, Le Pre des Forges	France	48.0999	3.2488	4
4	Point	125	Tureau des Gardes	France	48.36667	3.05194	5
Figure 3.21 Distribution of reference sites with Early 'Classic' Hamburgian facies							
FID	Shape *	ID	site name	Country	g_coord_lo	g_coord_la	
0	Point	84	Meiendorf D	Germany	10.19939	53.63747	1
1	Point	85	Mirkowice 33	Poland	17.41194	52.76877	2
2	Point	86	Poggenwisch D	Germany	10.20052	53.63829	3
3	Point	87	Stellmoor D	Germany	9.36667	53.15	4
4	Point	88	Teltwisch 1	Germany	10.20501	53.64072	5

Figure 3.34 Distribution of reference sites with Early Creswellian facies							
FID	Shape *	FID_	site name	country	y	x	Label
0	Point	0	Bois Laiterie	Belgium	50.35	4.85	1
1	Point	1	King Arthur's Cave	United Kingdom	51.83719	-2.66074	2
2	Point	2	Sun Hole	United Kingdom	51.28355	-2.76359	3
3	Point	3	Three Holes Cave	United Kingdom	50.51	-3.66	4
Figure 3.37 Distribution of reference sites with Havelte Hamburgian facies							
	Shape *	FID_	site name	country	y	x	Label
0	Point	0	Ahrenshöft LA 58	Germany	54.5667	9.0667	1
1	Point	1	Ahrenshöft LA 73	Germany	54.5667	9.0667	2
2	Point	2	Duurswoude II	Netherlands	53.05874	6.23669	3
3	Point	3	Oldeholtwolde	Netherlands	52.91508	6.00808	4
4	Point	4	Slotseng Solrod	Denmark	55.32207	9.19415	5
Figure 3.42 Distribution of reference sites with Early Federmesser/Azilian characteristics							
FID	Shape *	FID_	site name	Country	y	x	Label
0	Point	0	Alt Duvenstedt LA 120b	Germany	54.35414	9.58772	1
1	Point	1	Bonn-Oberkassel	Germany	50.71444	7.174721	2
2	Point	2	Gönnersdorf	Germany	50.44778	7.415278	3
3	Point	3	Irlich	Germany	50.43333	7.466667	4
4	Point	4	Hangest-sur-Somme (le Marais: gravières III)	France	49.9833	2.0667	5
5	Point	5	Hengistbury Head	England	50.7	-1.73333	6
6	Point	6	Nea Farm	England	50.86903	-1.81865	7
7	Point	7	Grotte du Cheval	France	49.35	1.15	8
8	Point	8	Le Closeau, Locus 46	France	48.87623	2.15952	9
9	Point	9	Pont d'Ambon	France	45.31667	0.6	10
10	Point	10	Bois Ragot	France	46.36667	0.683333	11
Figure 3.52 Distribution of reference sites with Late Creswellian facies							
FID	Shape *	FID_	site name	Country	coord_lat	coord_long	Label
0	Point	0	Aveline's Hole	England	51.324	-2.753	1
1	Point	1	Gough's Cave	England	51.2818	-2.76653	2
2	Point	2	Kent's Cavern, Black Band	England	50.47	-3.53	3
3	Point	3	Robin Hood's Cave	England	53.26064	-1.20579	4
4	Point	4	Oldeholtwolde	Netherlands	52.91508	6.00808	5
5	Point	5	Presles	Belgium	50.38306	4.583056	6
6	Point	6	Emmerhout	Netherlands	52.78859	6.937952	7

7	Point	7	Neer II	Netherlands	51.25429	5.941773	8
8	Point	8	Siegerswoude II	Netherlands	53.10237	6.232853	9
9	Point	9	Zeijen	Netherlands	53.04978	6.546478	10

Figure 3.62 Distribution of reference sites with Early Allerød Federmesser characteristics

FID	Shape *	FID_	Site name	Country	y	x	Label
0	Point	0	Andernach-Martinsberg	Germany	50.43337	7.4005	1
1	Point	1	Conty, Le Marais	France	49.74139	2.1525	2
2	Point	2	Hengistbury Head	England	50.7	-1.73333	3
3	Point	3	Kettig	Germany	50.39527	7.46805	4
4	Point	4	Niederbieber	Germany	50.47093	7.47482	5
5	Point	5	Pincevent, La Grand-Paroisse	France	48.38723	2.90656	6
6	Point	6	Urbar	Germany	50.37623	7.62151	7

Figure 3.69 Distribution of reference sites with Late Allerød Federmesser characteristics

FID	Shape *	FID_	site name	Country	coord_lat	coord_long	Label
0	Point	0	Andernach-Martinsberg	Germany	50.43337	7.4005	1
1	Point	1	Bad Breisig	Germany	50.5167	7.2667	2
2	Point	2	Hangest-sur-Somme	France	49.9833	2.0667	3
3	Point	3	Kettig	Germany	50.39527	7.46805	4
4	Point	4	Klein Nordende	Germany	53.71	9.64	5
5	Point	5	Le Closeau, Locus 46	France	48.87623	2.15952	6
6	Point	6	Milheeze	Belgium	51.51639	5.82444	7
7	Point	7	Mother Grundy's Parlour	England	53.2627	-1.1964	8
8	Point	8	Niederbieber	Germany	50.47093	7.47482	9
9	Point	9	Presles	Belgium	50.38306	4.583056	10
10	Point	10	Rekem	Belgium	50.915	5.69	11
11	Point	11	Saleux, Les Baquets	France	49.8667	2.25	12
12	Point	12	Three Holes Cave	England	50.51	-3.66	13
13	Point	13	Urbar	Germany	50.37623	7.62151	14
14	Point	14	Risby Warren	England	53.61303	-0.5547	15
15	Point	15	Rissen	Germany	53.57803	9.760243	16