



# Mapping the expansion of the Northwest Magdalenian

Rebecca Miller

Université de Liège, Service de Préhistoire 7, place du XX août, bât. A1, B-4000 Liège, Belgium

## ARTICLE INFO

### Article history:

Available online 30 May 2012

## ABSTRACT

New paleoclimatic data for the Lateglacial clarify climatic phases during the Lateglacial. Cold climate played a key role in limiting Magdalenian expansion from southwest and central Europe. This paper presents chronological and geographic data for the different climatic phases to map the expansion of the Magdalenian into northwest Europe. Specifically, it can be seen that initial expansion follows a southwest-northeast trajectory into southern Germany, followed by northern expansion into Belgium, central Germany and the Paris Basin at the end of the Oldest Dryas. During the Bølling and Allerød phases, human occupation intensified in the Paris Basin and contacts and/or territorial exploitation between both the Paris Basin and the Rhineland region with Belgian territory is demonstrated.

© 2012 Elsevier Ltd and INQUA. All rights reserved.

## 1. Introduction

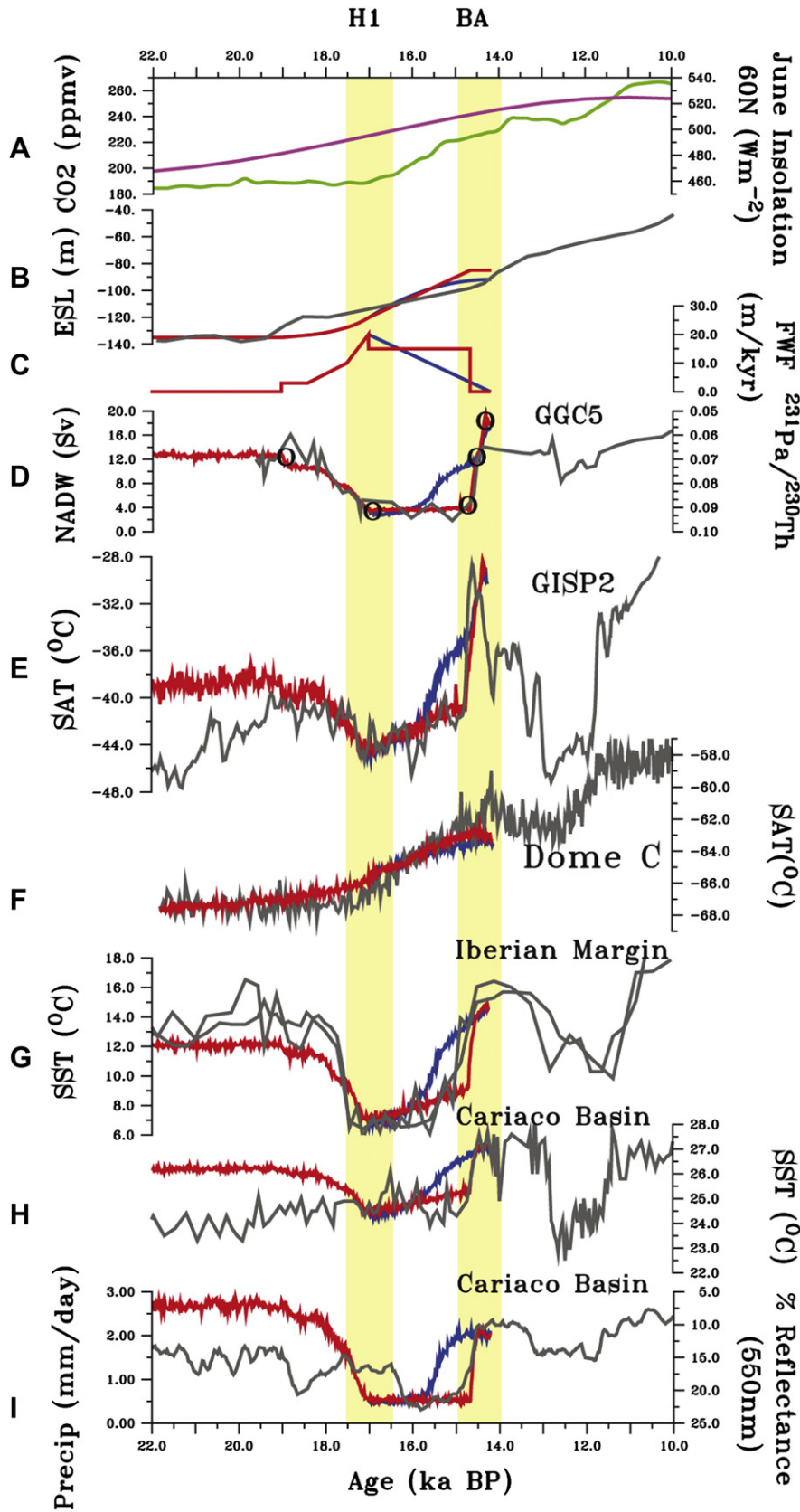
Significant research, both in the field and the laboratory, has been carried out in Northwest Europe over the last two decades to address the arrival and establishment of the Magdalenian technocomplex in this region, focusing on different issues relating to its chronology, expansion, cultural components, settlement patterns and subsistence strategies (see e.g., Rozoy, 1988; Vermeersch and Symens, 1988; Rensink, 1993; Otte and Straus, 1997; Kozłowski, 2001; Cattelain, 2005; Street et al., 2009). More specifically, the chronology of Magdalenian expansion has been the subject of critical research on the viability of the radiocarbon and AMS dates obtained for Magdalenian sites, their context and interpretation with respect to the expansion of the Magdalenian from southern Europe. For example, Charles (1994, 1996, 1998) undertook a critical review of available and new AMS dates for sites in the Belgian Ardennes, rejecting certain early dates and arguing for Magdalenian occupation “at the interface between Dryas I and the Bølling Interstadial phase” (Charles, 1998, p. 212) during the Bølling. The discussion between Housley et al. (1997, 2000) and Blockley et al. (2000) raises the issue of the validity of calibrating radiocarbon dates and their interpretation, giving rise to two competing hypotheses for the recolonization of Northern Europe, one of which argues for a two-stage process (Housley et al., 1997, 2000), and the other for a reduced population but not complete abandonment (Blockley et al., 2000). The present paper exploits the geographic and chronological data available in the Radiocarbon Palaeolithic Database version 12 to map the dated Magdalenian sites from the

onset of deglaciation after the Last Glacial Maximum to the end of the Magdalenian and the appearance of new technocomplexes prior to the Pleistocene–Holocene transition. The objective is to identify the broad trends of population movement during the Lateglacial using such data. It will be argued that the initial phase of expansion involved movement from the southwest to northeast, from Southwest and Central France to Southern Germany, followed by subsequent expansion northward to the Paris Basin.

## 2. Lateglacial climate

Recent paleoclimatic research using different proxies has significantly clarified the chronology and mechanisms for Lateglacial climate change (see e.g., Alley and Clark, 1999; Severinghaus and Brook, 1999; Alley et al., 2003; Clark et al., 2009; Liu et al., 2009; Shakun and Carlson, 2010; Williams et al., 2010). Based on Litt et al. (2001, Table 3, p. 1247), the onset of post-Last Glacial Maximum deglaciation occurs at 20–19 ka cal BP (Clark et al., 2009, Fig. 3, p. 711), with a phase of gradual warming from 19 to 17.5 ka cal BP. Heinrich event 1 occurs from 17.5 to 16.5 ka cal BP, a cold phase, followed by pre-BA (Bølling–Allerød), a warming phase, stabilizing at 14.67 ka cal BP, the threshold between stadial and interstadial climate phases. The Bølling–Allerød Interstadial (14.67–12.9 ka cal BP) includes GRIP (INTIMATE) phases GI-1e (Meindorf), GI-1d (Oldest Dryas), I-1c to 1a (Allerød). This is followed by GS-1 (Younger Dryas). Liu et al. (2009) present a synchronously coupled atmosphere–ocean general circulation model that simulates “abrupt BA warming as a transient response of the Atlantic meridional overturning circulation (AMOC) to a sudden termination of freshwater discharge to the North Atlantic before the BA” (Liu et al., 2009, p. 310) (Fig. 1). The Intra-Allerød

E-mail address: [rmiller@ulg.ac.be](mailto:rmiller@ulg.ac.be).



**Fig. 1.** Data-model comparison for several benchmark time series (from Liu et al., 2009:311, Fig. 1). Of note is the rapid temperature increase in GS-2, leading to the stable warm Bølling phase (GI-1e).

Cold Period (IACP) lasting around 150 years, was likely caused by pulses of glacial meltwater to the North Atlantic (Donnelly et al., 2005, p. 89). The Allerød is followed abruptly by the Younger Dryas (12.6–11.5 ka cal BP), considered to be a Heinrich event (Severinghaus et al., 1998; Sima et al., 2004; Brauer et al., 2008), also ending suddenly with the Preboreal phase of the Holocene (11.5–10 ka cal BP) (e.g., Björck et al., 1997).

Some differences exist between this climatic schema and the “traditional” definitions, which place the Bølling in G1-1e and the Allerød in G-1c to G-1b. Climate changes occurring during the Lateglacial played a key role in limiting or permitting the expansion of Magdalenian populations, as will be seen below. The phases used here are shown in Table 1 (based on Litt et al., 2001, Table 3, p. 1247).

### 3. Material and methods

Using the dates and coordinates available in the Radiocarbon Palaeolithic Database version 12 (Vermeersch, 2011), the expansion of the Magdalenian from southwest France to northwest Europe is mapped here in relation to the climatic oscillations of the Lateglacial (Fig. 2a–h, Tables 2–9). Sites in Northwest Europe (France, Belgium, Netherlands, Germany, Switzerland, Great Britain) have been included in the analysis; sites further north or east have not. A limit at 47° N latitude is clearly a threshold separating the relatively dense concentration of early Lateglacial sites south of this limit from the first sites reflecting Magdalenian expansion north of this latitude. The validity of dates for sites north of 47° N has been evaluated for this paper. Dates for sites south of this boundary, in southwest and central France, have not been evaluated; some of these dates, most conventional, may therefore be erroneous. Given the relatively dense concentration of sites present in these regions, the elimination of a few dates would likely not change the overall pattern, but would be important rather for the distinction between contemporaneous technocomplexes or cultures such as the Magdalenian, Badegoulian and Solutrean. Such distinctions are not addressed in this paper, which focuses on sites expanding north of 47° N. <sup>14</sup>C dates have been calibrated with OxCal v.4 to produce ages in ka cal BP to correspond to the dated climatic phases; the original uncalibrated dates are available in the Radiocarbon Palaeolithic Database version 12 as well as in the tables found in the Supplementary data. However, given advances and disadvantages in calibrating radiocarbon dates (see Street et al., 1994), the calibrated dates presented here should not be considered definitive. Time ranges reflect the main climatic phases after the LGM (Table 1). Sites with calibrated dates falling within each date range have been plotted using Google Earth (KML files for the data are available). A short discussion is presented below for each date range.

**Table 1**

Date ranges for paleoclimatic phases used in the text (based on Table 3; Liu et al., 2009; Litt et al., 2001; Table 3; Björck et al., 1998).

Phase (ka cal BP)	GRIP (INTIMATE)	Biozones, NW Germany	Traditional phases
12.9–11.5	G1-1a GS-1	Final Allerød Younger Dryas	Younger Dryas
13.9–12.9	G-1c to G-1b	Bølling to mid-Allerød	Allerød
14.1–13.9	G1-1d	Oldest Dryas	Older Dryas
14.67–14.1	G1-1e	Meindorf	Bølling
16.5–14.67	GS-2		Oldest Dryas
17.5–16.5			
19–17.5			
20–19			

### 4. Results: geographic and chronological site distribution

#### 4.1. 20–19 ka cal BP – onset of deglaciation (31 dates, 20 sites)

The earliest dates, at the onset of deglaciation between 20 and 19 ka cal BP, are Protomagdalenian and Badegoulian sites concentrated in southwest and central France, none further than 47° N (Fig. 2a). However, three AMS dates on reindeer bones, two with cut marks, ca. 23000 cal BP at Kastelhöhle Nord (Switzerland) and one date on a reindeer bone with cut marks from Y-Höhle cave indicate human settlement prior to the Magdalenian, attributed to the Badegoulian (see Leesch et al., 2012; Sedlmeier, 2010). The only dates at sites further north have been excluded: Hohle Fels (too old for the dated context, Street and Terberger, 1999) and Poggenwisch D (Hamburgian, improperly treated sediment samples, Weber and Grimm, 2009) in Germany.

#### 4.2. 19–17.5 ka cal BP – cool, gradual warming phase (64 dates, 49 sites)

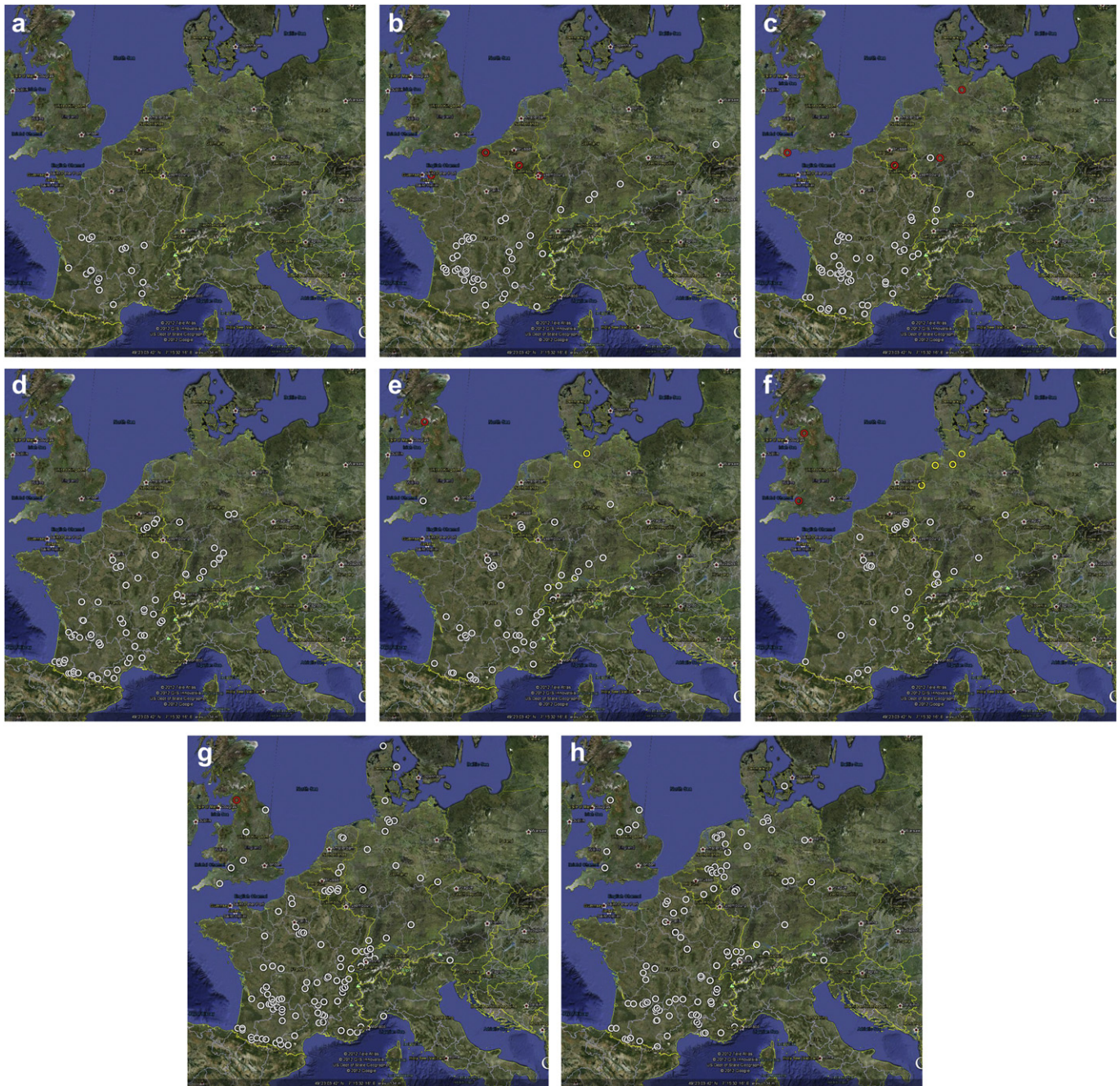
During this gradual warming phase, the concentration of Lateglacial sites in southwest and central France persists. Initial expansion located above 47° N following a southwest-northeast axis is evidenced by the sites of Munzingen, Hohle Fels Schelklingen, Spitzbubenhöhle and Regensburg in southern Germany and as far east as Maszycka Cave in southern Poland (see Terberger et al., 2009 for discussion; see also Street et al., 2012; Kozłowski et al., 2012) (Fig. 2b).

The pattern during this phase shows an increase in population density in southwest and central France with some expansion northward. The northernmost sites in France are Oisy and Grotte du Renne à Arcy-sur-Cure, in proximity at 47.5° N. Together, these southern German sites (Terberger et al., 2009; Jochim et al., 1999) and more northern French sites indicate early and probably non-intensive expansion northeast from southwest France.

Excluded dates for sites above 47° N include Rozel, Normandy (17,000 ± 700 BP, Gif-1604; conventional date from 1970 (Delibrias et al., 1982), Hallines, Pas-de-Calais, (16,000 ± 300 BP, Gif-1712, conventional date obtained in 1988 (Fagnard, 1988)). The early dates from Trou des Blaireaux in Belgium have been rejected by Charles (1996, 1998) given lack of association with archaeological material or evidence of human modification. Finally, Kakert in Luxembourg yielded two dates (16,070 ± 450 BP, Lv-466; 16,770 ± 390, Lv-467) which may be rejected given lack of association of the fauna with Magdalenian artifacts (Ziesaire, 1994). Two excluded sites not shown have been excluded given incompatibility between the dates and the archaeological context: Breitenbach B (18,100 ± 200 BP, KN-3332, too young for the Aurignacian context, see Terberger and Street, 2003), and Poggenwisch D in northern Germany (Weber and Grimm, 2009).

#### 4.3. 17.5–16.5 ka cal BP – Heinrich 1 event (or Oldest Dryas) (68 dates, 55 sites)

This cold phase corresponds to the Heinrich 1 event, centered on 17 ka cal BP (Fig. 1). Three dates were obtained at the site of Gönnersdorf during this phase (13,810 ± 90 BP, OxA-10200; 14,380 ± 100 BP, OxA-10239, 14570 ± 90 BP, OxA-10199). However, corresponding to a rhinoceros bone, a mammoth femur and mammoth ivory, all unworked, these dates do not appear to be associated with the Magdalenian occupation, but rather have been interpreted as sub-fossil material collected from the landscape and therefore much older than the Magdalenian occupation (Street and Terberger, 2004; Stevens et al., 2009: 133). In southern Germany, dates from Munzingen (14,270 ± 120 BP, OxA-4788;



**Fig. 2.** a–h. Maps showing the geographic distribution of radiocarbon dated Magdalenian sites during each of the climatic phases of the Lateglacial. a) 20–19 ka cal BP, Pleniglacial, b) 19–17.5 ka cal BP, Pleniglacial, c) 17.5–16.5 ka cal BP, Heinrich 1 event, d) 16.5–14.67 ka cal BP, GS-2, e) 14.67–14.1 ka cal BP, GI-1e, f) 14.1–13.9 ka cal BP, GI-1d, g) 13.9–12.9 ka cal BP, GI-1c and 1b, h) 12.9–11.5 ka cal BP, GI-1a, GS-1. (Maps: Google Earth; site coordinates from the Radiocarbon Palaeolithic Database, version 12).

14,510 ± 110 BP, OxA-4784) and Spitzbubenhöhle (13,840 ± 120 BP, H-4314-3715) may show persistence of human occupation during H1. However, the date for Spitzbubenhöhle is an old conventional radiocarbon date and could be excluded. Two sites are now found in Switzerland (Kesslerloch, 14,150 ± 100 BP, OxA-5749; Kastelhöhle, 13,435 ± 50 BP, see; Leesch et al., 2012), following the same general southwest-northeast trajectory. The dates for Munzingen range from 12 to 16 ka (see Housley et al., 1997 for discussion) and may be too broad, although comparisons have been made with Maszycka Cave in Poland (Kozłowski et al., 2012). Of these sites then, only dates from Kesslerloch, on worked reindeer antler, and Kastelhöhle on *Bos/Bison*, may be considered reliable. Northern France appears

to have been as yet unoccupied while central and southwest France continue to show the same pattern as in the preceding phases. In brief, this phase is comparable to the preceding one, showing initial expansion from southwest to northeast via southern Germany and Switzerland (Fig. 2c).

Excluded dates for sites above 47° N include Kent's Cavern in England (14,275 ± 120 BP, GrN-6203, questionable association with a Creswellian assemblage), Meindorf D in Germany (15,750 ± 800 BP, W-172, contaminated sediment sample, see Weber and Grimm, 2009), Trou des Blaireaux in Belgium (13,790 ± 150 BP, Lv-1314, 13,930 ± 120 BP, Lv-1433, lack of association with artifacts or evidence of human modification, Charles,

**Table 2**

Dates for 20–19 ka cal BP. (Note: All dates are conventional except for those indicated as AMS.)

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Abri Fritsch	FR	Ly-1121	17,130	550	22,020	19,385	
Abri Fritsch	FR	Ly-1123	17,280	350	21,466	19,594	
Abri Pataud	FR	Grn-2064	17,605	420	22,170	20,012	
Abri Pataud	FR	GrN-5455	17,605	420	22,170	20,012	
Bouzil	FR	Ly-5113	18,715	1480	27,486	19,402	
Abri Casserole	FR		16,960	60	20,365	19,880	
Abri Casserole	FR		17,120	60	20,891	20,088	
Champréveyres	CH	UCLA-2760	17,695	210	21,551	20,403	AMS
Gandil	FR	Ly-2485 (Poz)	16,507	144	20,096	19,410	
La Contrée Viallet	FR	ARC-94	16,553	198	20,238	19,403	
Lascaux	FR	GrN-1632	17,190	140	21,132	20,061	
Lassac	FR	Gif-2981	16,750	250	20,459	19,419	
Laugerie-Haute Est	FR	Ly-973	17,040	440	21,426	19,425	
Le Cuzoul	FR	Gif-6312	16,800	170	20,347	19,543	
Le Cuzoul	FR	Gif-6371	16,800	170	20,347	19,543	
Le Cuzoul	FR	Gif-6797	17,050	170	20,990	19,590	
Le Roc de Marcamps	FR	Ly-2292	17,410	310	21,510	19,962	
Le Taillis-du-Coteau	FR	Ly-2264	16,920	170	20,467	19,565	
Les Guinards	FR	Ly-2737	17,420	330	21,549	19,885	
Les Jambalans	FR	Gif-8668	16,490	130	20,050	19,411	
Monthaud	FR	Ly-2759	16,970	300	21,082	19,470	
Pégourie	FR	Ly-5257	16,890	300	21,019	19,436	
Pégourie	FR	Ly-1834	17,400	460	21,963	19,579	
Pégourie	FR	Ly-1836	17,420	390	21,776	19,596	
Pégourie	FR	Ly-1394	17,490	520	22,188	19,581	
Rond du Barry	FR	Gif-3038	17,100	450	21,480	19,431	
Salpêtrière	FR	Ly-940	17,900	690	23,273	19,611	
Salpêtrière	FR	Ly-941	17,900	690	23,273	19,611	
Salpêtrière	FR	Mc-2169	17,960	600	23,243	20,046	
Solutré, I-11	FR	Ly-1534	17,310	470	21,805	19,474	
Solutré, L-13	FR	Ly-316	17,350	300	21,455	19,926	

1996, 1998) and Wildscheuer (13,980 ± 120 BP, KN-3637, too young for Aurignacian context).

#### 4.4. 16.5–14.67 ka cal BP – GS-2 (156 dates, 84 sites)

This phase includes a fairly rapid increase in temperature from 16.5 to 14.67 ka cal BP (although not observed in Switzerland, see Leesch et al., 2012), with an abrupt increase at 14.67 ka cal BP, marking the pre-Bølling-Allerød (BA) to BA boundary (Liu et al., 2009, Fig. 1) between Greenland Stadial GS-2 and GI-1e (Litt et al. 2001, Table 3, p. 1247). Increasing climatic amelioration may have been a factor permitting expansion and/or seasonal occupation in more northern latitudes on a small scale compared with the denser settlement pattern subsequently observed during the Bølling (Fig. 2d). Champréveyres and Monruz in Switzerland have yielded a series of AMS dates that situate their occupations during this phase over into the next phase (see Leesch et al., 2012). Three dates have been excluded, Stafford in England (old conventional date), one date from Gönnersdorf (12,910 ± 105 BP, KN-1980 on mollusk shell) and one from Andernach (13,500 ± 90 BP, OxA-13500, experimental sample; see Stevens et al., 2009).

Three key changes occur during this phase. First, the region of initial expansion into southern Germany is now more densely occupied by a series of sites (persistence at Munzingen and Spitzbubenhöhle, as well as new occupations at Petersfels, Hohle Fels, Bockstein-Törle, Hohlenstein-Kleine Scheuer, Hohlensteinstadel and Ofnet). Kesslerloch in northern Switzerland also falls within this region. Second, initial occupations of key sites in the Paris Basin occur during this phase (Etiolles, 13,625 ± 105 BP, LYON-1894; Verberie, 12,950 ± 130 BP, GifA-95454; and Grand Canton, 12,880 ± 115 BP, Gif-9608). Third, two site clusters are now present in Belgium, one in the upper Meuse basin near Dinant (Chaleux,

12,990 ± 140 BP, Lv-1569; 13,000 ± 200 BP, LC-919; Trou Da Somme, 12,815 ± 75 BP, OxA-8308; Trou des Blaireaux, 13,730 ± 400 BP, Lv-1434D; 13,850 ± 335 BP, Lv-1309D) and the other in eastern Belgium (Sy Verlaine, 13,780 ± 220 BP, Lv-690; Grotte Walou, 13,030 ± 140 BP, Lv-1582; 13,120 ± 190 BP, Lv-1593). These Belgian sites are at roughly the same latitude as Gönnersdorf, as are Kniegrotte (13,585 ± 165, Bln-1564) and Baerenkeller (13,700 ± 380 BP, Bln-220) further east. The general pattern appears to be one of more intensive expansion, further north, with more substantial sites in the Paris Basin and the northern Rhineland.

#### 4.5. 14.67–14.1 ka cal BP – GI-1e (Meindorf [Litt et al., 2001] or traditional Bølling) (87 dates, 50 sites)

This phase, corresponding to the stabilization of a warm phase, comprises relatively fewer radiocarbon dates for sites, but these show the same pattern as during the previous phase: a south-central France concentration with a path of expansion into southern Germany and a few sites north of 50°N, but no longer with Magdalenian occupation in Switzerland (Leesch et al., 2012) (Fig. 2e). The range for the earliest date at Pincevent, one of the key Magdalenian sites in this region, corresponds to the end of the preceding phase/start of this phase (12,545 ± 120 BP, GrN-5760, Taborin, 1994). Orp, in Belgium, has been dated by TL to this phase (Vermeersch and Maes, 1996). The appearance of the Hamburgian is represented by two sites in northern Germany, Poggenwisch D and Stellmoor D. The site of Roberthill in Scotland, dated in the early 1960s, has been excluded (Godwin, 1960; Moar, 1964). Sun Hole is the earliest dated Magdalenian site in Great Britain, based on recently obtained AMS dates on wild horse and a human ulna (Jacobi and Higham, 2011).

**Table 3**  
Dates for 19–17.5 ka cal BP.

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Abri de Gandil	FR	Gif-9175	15,550	140	19,241	18,520	
Abri Fritsch	FR	Ly-1122	16,530	550	21,195	18,714	
Abri Pataud	FR	GrN-2054	15,080	100	18,588	18,011	
Abri Pataud	FR	GrN-2254	15,215	250	18,898	17,858	
Auzary-Thones	FR		15,100	70	18,590	18,025	
Baume d'Oullins (a.k.a. d'Oulen")	FR	Gif-6017	16,500	350	20,434	18,872	
Baume du Lion	FR	MC-1209	16,200	400	20,252	18,657	
Baume du Lion	FR	MC-1210	16,200	400	20,252	18,657	
Bergerie	FR	Ly-8692	15,320	110	18,825	18,083	
Bergerie	FR	Ly-1830	15,830	400	19,926	18,075	
Bois des Brousses	FR	Mc-2247	15,800	300	19,562	18,524	
Bois-des-Brousses	FR	MC-2247	15,800	300	19,562	18,524	
Chabasse	FR	Ly-1293	15,630	120	19,265	18,574	
Château	FR	Ly-10797	15,350	80	18,829	18,216	
Château	FR	Ly-10796	15,580	100	18,937	18,575	
Ferrassie	FR	Gif-2428	15,180	130	18,671	18,022	
Flageolet II	FR	Ly-918	15,250	320	19,263	17,714	
Gandil	FR	Ly-2483 (Poz)	15,033	120	18,590	17,961	
Gandil	FR	Gif-9176	15,380	140	18,889	18,100	
Gazel	FR	Gif-2655	15,070	270	18,807	17,671	
Grappin	FR	Ly-457	15,320	370	19,394	17,787	
Grappin	FR	Ly-497	15,320	370	19,394	17,787	
Grappin	FR	Ly-559	15,770	390	19,862	18,050	
Grotte de la Bergerie	FR	Ly-8692	15,320	110	18,825	18,083	
Grotte du Renne, Arcy-sur-Cure	FR	L-340D	15,350	400	19,416	17,737	
Hallines, Levert	FR	Gif-1712	16,000	300	19,846	18,619	
Hohle Fels, Hohler Fels	DE	H-5313-4898	15,760	140	19,358	18,664	
Kakert	LU	Lv-467	16,770	390	21,193	18,995	
La Chaire à Calvin	FR	Ly-1998	15,440	440	19,537	17,680	
La Garenne Grand Abri	FR	Ly-1126	15,560	580	20,146	17,571	
Lascaux	FR	SA-102	16,100	500	20,472	18,130	
Le Callan	FR	Gif-9663	15,020	70	18,550	18,005	
Le Chaffaud	FR	Gif-	15,160	150	18,681	17,995	
Le Cuzoul	FR	Gif-6638	15,980	150	19,429	18,840	
Le Placard	FR	Gif-8803	16,300	190	19,930	18,897	
Le Roc de Marcamps	FR	Ly-2681	15,700	450	19,894	17,966	
Les Fadets	FR		15,300	150	18,841	18,038	
Les Jamblands	FR	Gif-8667	14,850	130	18,529	17,712	
Les Terriers	FR		15,650	150	19,284	18,585	
Lespaux	FR	Ly-3307	17,450	780	22,977	18,991	
Maszycka	PL	Ly-2454	15,490	310	19,398	18,033	
Monthaud	FR	Ly-2758	15,450	290	19,334	18,025	
Munzingen	DE	OxA-4783	15,400	130	18,896	18,160	AMS
Munzingen	DE	OxA-4786	15,670	140	19,286	18,601	AMS
Munzingen	DE	ETH-7499	15,700	135	19,304	18,620	AMS
Munzingen	DE	H-4156-3373	15,870	135	19,406	18,779	
Munzingen	DE	OxA-4785	16,060	140	19,445	18,873	AMS
Oetrange, Plateau Haed	LU	Lv-466	16,070	450	20,315	18,526	
Oisy	FR	Beta-160915	16,020	150	19,438	18,854	
Pégourie	FR	Ly-5258	16,090	320	19,990	18,651	
Pille-Bourse, Saint-Germain-la-Rivière	FR	Gif-5479	16,200	200	19,856	18,855	
Pille-Bourse, Saint-Germain-la-Rivière	FR	Gif-5478	15,300	410	19,407	17,667	
Regensburg, Florian-Seidl-Strasse	DE	KN-4264	15,000	0	18,529	18,015	
Regensburg, Florian-Seidl-Strasse	DE	KN-4265	15,000	0	18,529	18,015	
Roc de Marcamps	FR	Ly-2291	14,910	240	18,648	17,570	
Roc de Marcamps	FR	Ly-4222	15,070	270	18,807	17,671	
Roc De Marcamps	FR	Ly-4219	16,840	520	21,385	18,950	
Rond du Barry	FR	Gif-2672	15,400	400	19,433	17,777	
Rozel	FR	Gif-1604	17,000	700	22,102	18,878	
Sainte Eulalie	FR	Gif-1745	15,100	270	18,830	17,698	
Sainte Eulalie	FR	Gif-2194	15,200	300	19,195	17,652	
Schussenquelle	DE	H-860-970	15,900	360	19,926	18,510	
Solutré, i-11	FR	Ly-9000	15,780	90	19,320	18,696	
Solutré, L-13	FR	Ly-314	16,440	300	20,270	18,921	
Spitzbubenhöhle	DE	H-4149-3348	15,230	100	18,699	18,036	
Trou des Blaireaux	BE	Lv-1558	16,130	250	19,876	18,759	
Trou des Blaireaux	BE	Lv-1385	16,270	230	20,002	18,872	
Vieux Mounoi	FR	Ly-5598	18,410	1680	27,635	18,806	
Vigne Brun	FR	Ly-2152	16,180	250	19,920	18,797	

**Table 4**

Dates for 17.5–16.5 ka cal BP.

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Abri Fritsch	FR	Ly-1001	14,960	380	18,874	17,206	
Auransan inf	FR	Ly-1107	13,910	230	17,655	16,567	
Auzary-Thones	FR		13,950	70	17,379	16,782	
Baume Noire, abri sud	FR	Ly-4716	13,950	135	17,455	16,775	
Baume Noire, abri sud	FR	Ly-4715	14,100	180	17,669	16,811	
Canecaude II	FR	Gif-2708	14,230	160	17,800	16,915	
Colombier	FR	Ly-5292	14,480	360	18,516	16,931	
Colombier	FR	Ly-5291	14,660	660	19,424	16,536	
Combe Cullier	FR	Ly-978	15,030	330	18,895	17,452	
Combe Saunière	FR	Ly-3328	13,910	230	17,655	16,567	
Conques	FR	Ly-8779	14,320	90	17,807	17,058	
Coufin	FR	Ly-2929	14,210	240	17,900	16,842	
Croze-sur-Suran, Grotte du Bare	FR	Ly-357	14,330	260	18,398	16,848	
Croze-sur-Suran, Grotte du Bare	FR	Ly-434	14,850	350	18,725	17,180	
Dufaure	FR	Ly-3582	14,570	390	18,577	16,943	
Duruthy	FR	Ly-860	13,840	210	17,554	16,505	
Duruthy	FR	Ly-861	14,180	200	17,808	16,855	
Enlène	FR	Gif-6030	13,900	120	17,409	16,742	
Enlène	FR	Gif-4124	13,940	250	17,756	16,566	
Esclauzure	FR	Ly-361	14,540	300	18,505	17,035	
Flageolet II	FR	Ly-1182	14,250	400	18,508	16,711	
Gönnersdorf	DE	OxA-10200	13,810	90	17,144	16,720	AMS
Gönnersdorf	DE	OxA-10239	14,380	100	17,875	17,128	AMS
Gönnersdorf	DE	OxA-10199	14,570	90	17,979	17,075	AMS
Grappin	FR	Ly-1535	14,530	290	18,504	17,019	
Grappin	FR	Ly-1510	14,820	370	18,740	17,132	
Grappin	FR	Ly-1536	14,840	360	18,738	17,162	
Grotte d'Aurensan, Diogène	FR	Ly-1055	14,280	300	18,435	16,803	
Igüe du Gral	FR	Ly-11518	13,682	74	17,019	16,618	
Igüe du Gral	FR	Ly-12418	13,970	90	17,417	16,795	
Jaurias	FR	Gd-2697	14,660	200	18,506	17,230	
Kastelhöhle	CH	B-4636	13,900	150	17,448	16,730	
Kent's Cavern	UK	GrN-6203	14,275	120	17,787	16,980	
La Colombière	FR	Ly-?1	14,700	300	18,575	17,165	
La Colombière	FR	Ly-?2	15,500	700	20,302	17,171	
La Garenne Grand Abri	FR	Ly-3000	14,270	270	18,015	16,825	
La Garenne Grand abri	FR	Ly-1125	15,330	950	21,199	16,739	
La Garenne-Blanchard	FR	C-578	15,847	1220	22,660	16,716	
La Marche	FR	Ly-2100	14,280	160	17,850	16,960	
La Marche, Réseau Guy Martin	FR	Orsay-3780	14,240	85	17,663	16,971	
Labastide, La Grande Grotte	FR	Gif-6611	13,700	120	17,105	16,531	
Labastide, La Grande Grotte	FR	Ly-1405	14,260	440	18,568	16,589	
Lascaux	FR	C-406	15,516	900	21,080	16,921	
Laugerie-Basse	FR	Gif-5387	13,850	160	17,435	16,663	
Le Bay	FR		13,950	50	17,221	16,790	
Le Cuzoul	FR	Gif-6372	14,560	130	18,380	17,185	
Le Martinet	FR	Ly-5069	14,098	239	17,822	16,785	
Le Taillis-du-Coteau	FR	Ly-3876	14,630	75	18,382	17,445	
Les Cottés [St. Pierre de Maille]	FR	GrN-4457	14,360	150	17,903	17,033	
Les Jamblancs	FR	Gif-8666	13,790	120	17,184	16,654	
Les Jamblancs	FR	Gif-8669	13,900	110	17,395	16,744	
Meiendorf D	DE	W-172	15,750	800	21,063	17,246	
Monruz	CH	ETH-6413	13,330	110	16,829	15,570	AMS
Monruz	CH	ETH-6421	13,140	120	16,591	15,211	AMS
Monruz	CH	ETH-6420	13,120	120	16,564	15,195	AMS
Monruz	CH	ETH-6418	13,110	120	16,550	15,188	AMS
Monruz	CH	ETH-6416	13,070	130	16,519	15,152	AMS
Montgaudier Abri Gaudry	FR	BM-2309	14,770	270	18,582	17,248	
Moulin-Neuf	FR	Ly-2275	14,280	440	18,570	16,626	
Munzingen	DE	OxA-4788	14,270	120	17,780	16,975	AMS
Munzingen	DE	OxA-4784	14,510	110	17,974	17,210	AMS
Rigney	FR	Ly-1191	14,950	500	19,263	17,029	
Roc de Marcamps	FR	Ly-2290	14,200	190	17,812	16,874	
Roc-aux-Sorciers, Abri Bourdois	FR	GrN-1903	13,920	80	17,237	16,761	
Roc-aux-Sorciers, Abri Bourdois	FR	GrN-1913	14,160	80	17,571	16,923	
Romains	FR	Ly-16	14,380	380	18,503	16,841	
Saint-Germain-la-Rivière	FR	Gif-6037	14,100	160	17,627	16,829	
Salpêtrière	FR	MC-1368	14,200	300	18,038	16,749	
Schussenquelle	DE	GRO-468	14,470	385	18,530	16,896	
Solutré, I-11	FR	Ly-1532	14,360	280	18,450	16,860	
Spitzbubenhöhle	DE	H-4314-3715	13,840	120	17,233	16,677	
Tournal (or Grande Grotte de Bize)	FR	Ly-1232	14,530	510	18,803	16,754	
Trou des Blaireaux	BE	Lv-1314	13,790	150	17,381	16,560	
Trou des Blaireaux	BE	Lv-1433	13,930	120	17,420	16,767	

(continued on next page)

**Table 4** (continued)

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Tuc d'Audoubert	FR	Gif-5867	14,350	160	17,905	17,011	
Tuc d'Audoubert, Cheval Rouge	FR	Gif-5857	14,350	160	17,905	17,011	
Wildscheuer	DE	KN-3637	13,980	120	17,452	16,799	

**Table 5**

Dates for 16.5–14.67 ka cal BP.

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Abri Ragot, Bois Ragot	FR	GrN-4677	12,890	140	16,401	14,926	
Andernach Martinsberg 1	DE	OxA-18409	13,025	50	16,343	15,163	AMS
Andernach Martinsberg 1	DE	OxA-10493	13,185	80	16,623	15,290	AMS
Andernach Martinsberg 1	DE	OxA-10651	13,270	180	16,790	15,270	AMS
Andernach Martinsberg 1	DE	OxA-10492	13,500	90	16,928	16,220	AMS
Andernach-Martinsberg	DE	OxA-1126	12,890	140	16,401	14,926	AMS
Andernach-Martinsberg	DE	OxA-1125	12,930	180	16,559	14,894	AMS
Andernach-Martinsberg	DE	OxA-V-2218-38	13,015	50	16,327	15,152	AMS
Andernach-Martinsberg	DE	OxA-1129	13,090	130	16,543	15,166	AMS
Andernach-Martinsberg	DE	OxA-V-2218-40	13,110	50	16,458	15,240	AMS
Andernach-Martinsberg	DE	GrA-16985	13,110	80	16,490	15,217	AMS
Andernach-Martinsberg	DE	OxA-V-2216-43	13,135	55	16,502	15,262	AMS
Andernach-Martinsberg	DE	GrA-16986	13,180	70	16,608	15,297	AMS
Andernach-Martinsberg	DE	OxA-1128	13,200	140	16,687	15,242	AMS
Baerenkeller	DE	BlN-220	13,700	380	17,668	15,251	
Baume de Gigny	FR	Ly-1702	13,620	480	17,896	15,060	
Baume du Lion	FR	MC-2448	13,100	300	16,868	14,811	
Belvis	FR	SacA-6973	13,080	50	16,417	15,214	
Blanzat	FR		12,870	70	16,055	14,967	
Blot	FR	Ly-563	14,030	500	18,519	15,630	
Bockstein-Torle	DE	H-4057-3354	12,980	103	16,374	15,102	
Bois du Cantet	FR	Ly-1403	13,370	270	16,926	15,202	
Bois-des-Brousses	FR	Gif-6013	13,500	230	17,073	15,300	
Bourrouilla	FR	Gif-10255	12,780	40	15,591	14,910	
Bourrouilla	FR	Gif-10254	13,220	80	16,692	15,389	
Calvaire	FR	Ly-432	13,450	300	17,073	15,190	
Campalou	FR	Ly-1958	13,400	350	17,170	15,080	
Champréveyres	CH	UZ-2285	13,050	155	16,550	15,116	AMS
Champréveyres	CH	UZ-2283	12,950	155	16,474	15,004	AMS
Champréveyres	CH	UZ-2286	12,870	135	16,386	14,900	AMS
Champréveyres	CH	UZ-2282	12,825	155	16,359	14,605	AMS
Champréveyres	CH	OxA-20700	12,815	65	15,862	14,912	AMS
Champréveyres	CH	OxA-20701	12,805	75	15,884	14,889	AMS
Champréveyres	CH	UZ-2171	12,730	135	15,892	14,238	AMS
Champréveyres	CH	UZ-2175	12,630	130	15,493	14,166	AMS
Champréveyres	CH	UZ-2172	12,620	145	15,505	14,142	AMS
Champréveyres	CH	UZ-2177	12,600	145	15,479	14,122	AMS
Champréveyres	CH	UZ-2173	12,540	140	15,194	14,106	AMS
Champréveyres	CH	UZ-2174	12,510	130	15,147	14,121	AMS
Champréveyres	CH	UZ-2287	12,500	145	15,156	14,079	AMS
Comarque	FR	Ly-2154	13,370	340	17,104	15,083	
Combarelles	FR	Ly-3202	13,680	210	17,415	15,929	
Conques	FR	Ly-8778	13,330	140	16,850	15,476	
Dufaure	FR	Ly-3583	14,020	340	18,410	16,330	
Durif	FR	Ly-2046	13,090	270	16,819	14,951	
Durif	FR	Ly-3675	13,510	230	17,093	15,435	
Durif à Enval	FR	Ly-727	13,700	380	17,668	15,251	
Duruthy	FR	Ly-859	13,510	220	17,077	15,477	
Ebbou, Ebbe, Chateau d'Ebbou	FR	Ly-800	12,980	220	16,701	14,876	
Enlène	FR	Gif-5321	12,990	140	16,461	15,079	
Enlène	FR	Gif-5770	13,400	120	16,879	15,620	
Espalungue	FR	Ly-3481	12,970	160	16,499	15,021	
Espelugue	FR	Ly-1406	13,170	260	16,812	15,102	
Etiolles, Les Coudrays	FR	LYON-1894	13,625	105	17,010	16,456	AMS
Flageolet II	FR	Ly-917	14,110	690	18,788	15,166	
Fongaban	FR	Ly-977	14,300	680	18,932	15,274	
Gnirshöhle 1	DE	H-6273-5833	12,830	100	16,137	14,875	
Gönnersdorf	DE	KN-1980	12,910	105	16,290	15,009	AMS
Gönnersdorf	DE	OxA-5729	12,910	130	16,380	14,987	AMS
Gönnersdorf	DE	OxA-V-2223-42	12,990	55	16,282	15,120	AMS
Gönnersdorf	DE	OxA-V-2222-31	13,010	55	16,327	15,146	AMS
Gönnersdorf	DE	OxA-15295	13,060	60	16,402	15,192	AMS
Gönnersdorf	DE	OxA-V-2223-43	13,075	55	16,416	15,206	AMS
Gönnersdorf	DE	OxA-V-2223-41	13,095	55	16,441	15,223	AMS
Gönnersdorf	DE	OxA-V-2223-40	13,165	55	16,565	15,298	AMS



Table 5 (continued)

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Gönnersdorf	DE	OxA-V-2223-39	13,270	55	16,734	15,567	AMS
Gönnersdorf	DE	OxA-10201	13,610	80	16,973	16,499	AMS
Goutte Roffat	FR	Ly-3092	13,350	260	16,897	15,210	
Grand Canton	FR	Gif-9608	12,880	115	16,289	14,942	
Grande Galerie 2	FR		13,900	600	18,513	15,176	
Grappin	FR	Ly-1509	14,220	560	18,704	15,656	
Grotte de Laroque II, Roque	FR		13,100	300	16,868	14,811	
Hohle Fels, Hohler Fels	DE	H-5119-4601	13,085	95	16,477	15,189	
Hohlenstein, Kleine Scheuer	DE	H-4183-3416	13,252	98	16,765	15,430	
Hohlenstein-Stadel	DE	H-3799-3045	13,110	160	16,617	15,161	
Hohlenstein-Stadel	DE	H-3779-3044	13,550	130	17,007	16,092	
Igue du Gral	FR	Ly-12419	13,360	70	16,850	15,675	
Jaurias	FR	Gd-2698	13,500	200	17,028	15,539	
Jaurias	FR	Ly-3730	13,580	140	17,050	16,119	
Jean Pierre II	FR	Ly-830	13,070	210	16,685	15,074	
Jean Pierre II	FR	Ly-926	13,280	290	16,897	15,127	
Jean Pierre II	FR	Ly-390	13,300	280	16,891	15,156	
Kesslerloch	CH	OxA-5748	12,770	90	15,855	14,652	AMS
Kesslerloch	CH	Hv-10652	12,890	90	16,166	14,976	
Kesslerloch	CH	B-3329	12,970	180	16,561	14,979	
Kesslerloch	CH	OxA-5746	13,120	90	16,518	15,217	AMS
Kesslerloch	CH	OxA-5747	13,430	100	16,890	15,909	AMS
Kesslerloch	CH	OxA-5750	13,670	100	17,044	16,541	AMS
Kesslerloch	CH	OxA-5749	14,150	100	17,585	16,900	AMS
Kniegrotte	DE	BlN-1564	13,585	165	17,082	15,938	
La Colombière	FR	Ly-177	14,150	450	18,565	16,224	
La Colombière	FR	Ly-9713	14,390	700	19,267	15,600	
La Colombière	FR	Ly-433	13,390	300	17,000	15,164	
La Garenne Grand Abri	FR	Ly-1127	14,080	350	18,448	16,453	
La Madeleine	FR	Ly-921	13,070	190	16,641	15,100	
La Madeleine	FR	Ly-922	13,440	300	17,060	15,185	
Labastide, La Grande Grotte	FR	Gif-6612	13,500	120	16,941	15,976	
Lascaux	FR	GIN-4677	12,890	140	16,401	14,926	
Laugerie-Haute Est	FR	Ly-974	13,970	480	18,498	15,528	
Malarode	FR	Ly-3484	13,620	320	17,480	15,275	
Mas-d'Azil	FR	Gif-5680	13,200	100	16,660	15,283	
Mas-d'Azil	FR	Gif-5522	13,640	110	17,030	16,464	
Monruz	CH	OxA-20699	13,055	60	16,395	15,188	AMS
Monruz	CH	ETH-6417	13,030	120	16,456	15,131	AMS
Monruz	CH	ETH-6412	12,970	110	16,378	15,089	AMS
Monruz	CH	ETH-6415	12,900	120	16,338	14,982	AMS
Monruz	CH	ETH-6419	12,880	120	16,314	14,940	AMS
Monruz	CH	ETH-6414	12,840	120	16,301	14,801	AMS
Monruz	CH	ETH-20727	12,800	85	15,905	14,759	AMS
Montgaudier Abri Paignon	FR	BM-1916	13,320	360	17,137	14,969	
Monthaud	FR	Ly-2757	13,420	200	16,942	15,300	
Moulin-du-Roc	FR	Ly-5445	15,600	1200	22,446	16,429	
Moulin-Neuf	FR	Ly-2699	13,380	250	16,911	15,238	
Moulin-Neuf	FR	Ly-2352	13,570	260	17,207	15,288	
Munzingen	DE	OxA-4820	13,230	110	16,720	15,291	AMS
Munzingen	DE	ETH-7500	13,560	120	17,007	16,219	AMS
Ofnet	DE	UCLA-1783	13,100	100	16,505	15,195	
Oisy	FR	Beta-160914	13,260	80	16,757	15,501	
Pégourie	FR	Ly-1598	13,980	510	18,509	15,521	
Petersfels	DE	H-6656-6793	12,900	90	16,192	14,993	
Petersfels	DE	H-5211-4891	12,940	125	16,388	15,040	
Petersfels	DE	H-7142-7348	12,980	90	16,347	15,108	
Petersfels	DE	H-7143-7301	13,030	100	16,422	15,146	
Petersfels	DE	H-7216-7363	13,110	90	16,504	15,210	
Peyrugues	FR	Gif-7592	13,020	140	16,486	15,105	
Roc de Marcamps	FR	Ly-2680	13,570	420	17,631	15,111	
Romains	FR	Ly-356	12,980	240	16,718	14,693	
Romains	FR	GrA9710 (Lyon-643)	13,380	60	16,843	15,943	AMS
Saint-Mihiel	FR	Lv-2096	13,160	110	16,605	15,235	
Salpêtrière	FR	MC-920	13,100	200	16,680	15,116	
Schnurenloch	CH	B-157	14,000	600	18,546	15,258	
Schussenquelle	DE	KN-4250	12,800	120	16,308	14,904	
Schussenquelle	DE	KN-4251	13,050	120	16,477	15,146	
Schussenquelle	DE	GrN-2090	13,090	110	16,508	15,181	
Solutré, I-11	FR	Ly-1530	13,680	240	17,482	15,655	
Solutré, I-11	FR	Ly-1531	13,710	230	17,493	15,931	
Solutré, P16	FR	Ly-	13,350	350	17,125	15,040	
Spitzbubenhöhle	DE	H-4052-3212	12,747	10	15,538	14,896	
Stafford	UK	BIRM-150	13,490	375	17,415	15,122	
Sy-Verlaine	BE	Lv-690	13,780	220	17,567	16,301	

(continued on next page)

Table 5 (continued)

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Teufelsbrücke	DE	BlN-1573	13,025	85	16,392	15,151	
Tournal (or Grande Grotte de Bize)	FR	Ly-1897	13,790	420	17,909	15,271	
Tournal (or Grande Grotte de Bize)	FR	Ly-1675	14,770	970	20,308	15,260	
Trou Da Somme	BE	OxA-8308	12,815	75	15,893	14,901	AMS
Trou de Chaleux	BE	Lv-1569	12,990	140	16,461	15,079	
Trou de Chaleux	BE	MC-919	13,000	200	16,636	14,987	
Trou des Blaireaux	BE	Lv-1434D	13,730	400	17,769	15,260	
Trou des Blaireaux	BE	Lv-1309D	13,850	335	17,903	15,666	
Trou du Frontal	BE	Lv-1749	12,950	170	16,519	14,964	
Trou du Frontal	BE	Lv-1750	13,130	170	16,651	15,168	
Trou Walou	BE	Lv-1582	13,030	140	16,496	15,113	
Trou Walou	BE	Lv-1593	13,120	190	16,674	15,144	
Tuc d'Audoubert, Cheval Rouge	FR	KN-5091	13,340	120	16,840	15,560	
Tuc d'Audoubert, Cheval Rouge	FR	KN-5090	13,480	80	16,910	16,212	
Vache	FR	GrN-2026	12,850	60	15,889	14,964	
Verberie, Le Buisson Campin	FR	GifA-95454	12,950	130	16,409	15,046	AMS
Vidon	FR	Ly-2701	14,000	350	18,410	16,161	

Table 6

Dates for 14.67–14.1 ka cal BP.

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Abri Taillefer	FR	Ly-637	12,590	60	15,190	14,245	
Adaouste	FR	Ly-540	12,760	250	16,411	14,157	
Adaouste	FR	LGQ-127	12,981	266	16,740	14,626	
Andernach-Martinsberg	DE	OxA-V-2223.37	12,675	55	15,460	14,596	AMS
Andernach-Martinsberg	DE	OxA-1127	12,820	130	16,209	14,637	AMS
Baume d'Oullins	FR	Gif-6016	12,800	180	16,395	14,253	
Bois du Cantet	FR	Ly-1404	13,060	430	16,910	14,189	
Bois Laiterie	BE	GX-20433	12,625	117	15,453	14,174	
Bois Laiterie	BE	GX-20434	12,665	96	15,520	14,244	
Bourrouilla	FR	Gif-10234	12,710	90	15,604	14,553	
Bourrouilla	FR	Gif-10235	12,710	90	15,604	14,553	
Bourrouilla, Grotte d'Arancou	FR	Gif-9986	12,395	35	14,921	14,113	
Calvaire	FR	Ly-431	12,970	300	16,781	14,270	
Campalou	FR	Ly-436	12,800	300	16,555	14,141	
Comarque	FR	Ly-2355	12,710	200	16,150	14,135	
Crest	FR	Ly-894	12,850	240	16,539	14,241	
Douattes	FR	Ly-647	12,680	60	15,480	14,595	AMS
Durif à Enval	FR	Ly-425	13,000	300	16,804	14,556	
Eglises	FR	Gif-3923	12,900	220	16,600	14,577	
Etiolles, Les Coudrays	FR	OxA-173	12,800	220	16,400	14,238	AMS
Etiolles, Les Coudrays	FR	OxA-175	12,900	220	16,600	14,577	AMS
Etiolles, Les Coudrays	FR	OxA-138	12,990	300	16,802	14,536	AMS
Etiolles, Les Coudrays	FR	OxA-139	13,000	300	16,804	14,556	AMS
Felsstalle	DE	H-7393-7428	12,680	120	15,565	14,230	
Flageolet	FR	Ly-916	12,870	390	16,750	14,113	
Fontanet	FR	Ly-846	13,810	740	18,665	14,541	
Gare de Couze	FR	BM-1616	12,540	75	15,119	14,219	
Gnrshohle 2	DE	H-6272-5831	13,050	300	16,823	14,667	
Gönnersdorf	DE	OxA-5728	12,730	130	15,892	14,240	AMS
Gönnersdorf	DE	OxA-5730	12,790	120	16,082	14,602	AMS
Goutte Roffat	FR	Ly-3093	12,720	180	16,089	14,165	
Hohle Fels, Hohler Fels	DE	H-5312-4907	12,770	110	15,930	14,580	
Jean-Pierre II	FR	Ly-829	12,720	230	16,305	14,131	
Kesslerloch	CH	KIA-33350	12,225	45	14,504	13,875	AMS
Kohlerhöhle	CH	B-4969	12,820	160	16,379	14,581	
La Madeleine	FR	Ly-920	12,750	240	16,376	14,158	
Labastide, La Grande Grotte	FR	Gif-6367	12,700	110	15,615	14,240	
Moulin de Laguenay, Poissière	FR	Ly-3650	13,330	480	17,521	14,267	
Oisy	FR	Beta-160913	12,500	120	15,125	14,131	
Pellebit	FR	Ly-7003	12,610	60	15,210	14,256	
Petersfels	DE	H-7137-7067	12,470	100	15,077	14,132	
Petersfels	DE	H-7134-6876	12,500	120	15,125	14,131	
Petersfels	DE	H-7140-7058	12,530	90	15,119	14,191	
Petersfels	DE	H-7133-6877	12,580	130	15,232	14,126	
Petersfels	DE	H-6653-6786	12,600	100	15,205	14,206	
Petersfels	DE	H-7144-7302	12,630	95	15,415	14,206	
Petersfels	DE	H-4277-3531	12,650	100	15,470	14,230	
Petersfels	DE	H-7214-7350	12,660	100	15,503	14,238	
Petersfels	DE	H-7217-7364	12,670	90	15,526	14,258	
Petersfels	DE	H-7135-6879	12,670	100	15,533	14,244	
Petersfels	DE	H-7141-6985	12,680	110	15,561	14,240	

Table 6 (continued)

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Petersfels	DE	H-7138-7057	12,685	75	15,524	14,573	
Petersfels	DE	H-7145-7303	12,700	100	15,605	14,258	
Pincevent, La Grande-Paroisse	FR	GrN-5760	12,545	120	15,165	14,155	
Poggenwisch D	DE	GrN-11254	12,460	60	15,020	14,160	
Poggenwisch D	DE	KN-2754	12,470	95	15,070	14,138	
Poggenwisch D	DE	K-4332	12,570	115	15,185	14,171	
Poggenwisch D	DE	H-136/116	12,980	370	16,800	14,241	
Pont d'Ambon	FR	Gif-3369	12,840	220	16,508	14,245	
Portel	FR	Gif-2943	12,760	170	16,163	14,224	
Quéroy	FR	Gif-5325	12,590	140	15,446	14,116	
Quéroy	FR	Gif-5324	12,800	140	16,254	14,573	
Roberthill	UK	Q-643	12,940	250	16,690	14,577	
Rochedane	FR	Ly-709	12,420	75	15,002	14,108	
Rond du Barry	FR	Gif-3492	12,800	170	16,386	14,266	
Saaleck	DE	KN-2562	13,200	400	17,082	14,522	
Stellmoor D	DE	KN-2223	12,590	80	15,180	14,238	
Sun Hole	UK	OxA-18705	12,490	45	15,048	14,200	AMS
Sun Hole	UK	OxA-14477	12,540	75	15,119	14,219	AMS
Sun Hole	UK	OxA-14438	12,545	55	15,125	14,237	AMS
Sun Hole	UK	OxA-14476	12,610	90	15,206	14,231	AMS
Sun Hole	UK	OxA-19557	12,620	50	15,219	14,524	AMS
Teufelsbrücke	DE	Bln-1727	12,480	90	15,074	14,151	
Tournal (or Grande Grotte de Bize)	FR	Ly-1894	12,860	320	16,642	14,186	
Trou Da Somme	BE	OxA-4199	12,240	130	14,898	13,814	AMS
Trou de Chaleux	BE	Lv-1136	12,710	150	15,882	14,197	
Vache	FR	GrN-2025	12,540	105	15,140	14,179	
Vache, Salle Monique	FR	Gif-7603	12,800	140	16,254	14,573	
Verberie, Le Buisson Campin	FR	GifA-99106	12,520	120	15,140	14,145	AMS

The lack of dramatic increase in number of dated sites during this phase suggests that northeast and northern expansion began during the warming trend prior to GRIP GI-1e rather than at and after the temperature peak at 14.67 ka cal BP.

#### 4.6. 14.1–13.9 ka cal BP – GI-1d (Oldest Dryas [Litt et al., 2001] or traditional Older Dryas (Fig. 2f)) (41 dates, 35 sites)

The Hamburgian is well-represented in northern (Poggenwisch B, Stellmoor D and Querenstede) (Weber and Grimm, 2009) while the Federmesser group is represented by Andernach in the Rhineland and Usselo in the Netherlands. Swiss sites during this phase are attributed to the Azilian. The early Azilian site Le Closeau in the Paris Basin has also produced dates around 14,200–14,800 cal BP (Bodu and Mevel, 2008). Persistence of the Magdalenian in the Paris Basin, the Meuse Basin in Belgium and the northern Rhineland shows some contemporaneity with such new, more northern, groups. In Belgium, occupations at Trou des Blaireaux and Trou Jadot were attributed to the Creswellian, but the existence of this technocomplex in Belgium has been questioned by Charles (Charles, 1996) and more recently has been considered rather a variant of the Final Magdalenian. In central and southwest France, the number of dated sites decreases significantly, but this may not necessarily reflect population decline, which is unlikely given the warmer climate south of 47° N than in northwest Europe, where populations survive during this phase. However, the number of dated sites becomes much denser in the next phase (see below). Excluded dates include St. Bees in England (non-archaeological plant material dated in the 1970s, Coope and Joachim, 1980.) and Sun Hole (date obtained in the 1970s).

#### 4.7. 13.9–12.9 ka cal BP – GI-1c to GI-1b (Bølling-Allerød [Litt et al., 2001] or traditional Allerød) (250 dates, 130 sites)

All of the regions previously discussed are now thoroughly occupied: central and southwest France, the Paris Basin, the

Meuse Basin in Belgium, the northern Rhineland and southern Germany (Fig. 2g). In addition, sites are now found in Great Britain (the northernmost being Seamer Carr, Conneller, 2007) and northern Denmark (Norre Lyngby). Pincevent persists through this period and is an example of a well-established seasonally occupied camp. Magdalenian base camps in the Paris Basin and the northern Rhineland thus appear to have been established during the warming trend prior to 14.67 ka cal BP, but do not all persist through GI-1c. Three dates for Gönnersdorf falling within this phase (11,830 ± 110 BP, OxA-2069; 12,380 ± 230 BP, Ly-768; 12,660 ± 370 BP, Ly-1172) have been rejected (see Stevens et al., 2009, Table 1, p. 134). The Hamburgian also appeared during GI-1e in northern Germany, coexisting with the Northwest Magdalenian.

#### 4.8. 12.9–11.5 ka cal BP – GI-1a and GS-1 (final Allerød and Younger Dryas [Litt et al., 2001]) (202 dates, 118 sites)

Site density (Fig. 2h) increases in northern Europe, including Great Britain, but these are no longer Magdalenian, although the Trou du Frontal in Belgium has been attributed to the Magdalenian despite its late date. Discussion of these Final Paleolithic cultures is beyond the scope of this paper.

### 5. The Northwest Magdalenian

The origins of the Northwest Magdalenian can be clearly traced back to southwest and central France, regions with continuity in human occupation through the LGM. These populations may have been demographically increased due to southern migration of northern Gravettian populations at the onset of the LGM. Conversely, the northern populations may have simply decreased in number and become locally extinct. If so, groups repopulating northwest Europe after the LGM would have had genetic continuity with modern populations in the southern latitudes, but none with the northern Early Upper Paleolithic populations.

**Table 7**  
Dates for 14.1–13.9 ka cal BP.

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Andernach-Martinsberg 2	DE	OxA-V-2218-39	12,270	50	14,832	13,928	AMS
Belvis	FR	SacA-6971	12,330	50	14,891	14,019	
Buttenloch	CH	B-4185	12,330	60	14,890	14,015	
Cabones	FR	Ly-2296	12,620	250	16,136	13,970	
Champréveyres	CH	UZ-2287	12,500	150	15,163	14,064	AMS
Chenelaz	FR	Ly-4790	12,610	200	15,860	14,024	
Coléoptère	BE	Lv-717	12,400	110	15,024	14,039	
Conty	FR	Ly-6998	12,370	70	14,937	14,048	
Dufaure	FR	Ly-3591	12,690	230	16,225	14,075	
Etiolles, Les Coudrays	FR	OxA-12019	12,315	55	14,889	13,994	AMS
Etiolles, Les Coudrays	FR	OxA-8757	12,315	75	14,896	13,979	AMS
Felsstalle	DE	H-7382-7419	12,320	70	14,894	13,993	
Felsstalle	DE	H-7392-7428	12,400	145	15,082	13,997	
Fontanet	FR	Ly-2184	12,770	420	16,715	13,960	
Gönnersdorf	DE	OxA-15296	12,385	65	14,949	14,071	AMS
Hohlenstein-Stadel	DE	ETH-2878	12,400	180	15,129	13,926	AMS
La Fru	FR	Ly-2911	12,690	380	16,580	13,914	
La Madeleine	FR	Ly-919	12,640	260	16,236	13,991	
Laugerie-Basse (Les Marseilles)	FR	Gif-5386	12,590	250	16,060	13,927	
Meiendorf D	DE	K-4329	12,360	110	15,001	13,999	
Munzingen	DE	OxA-4787	12,370	100	14,991	14,021	AMS
Petersfels	DE	H-7136-6890	12,320	90	14,930	13,965	
Petersfels	DE	KN-2884	12,400	95	15,005	14,055	
Petersfels	DE	H-6651-6780	12,400	100	15,010	14,050	
Petersfels	DE	KN-2883	12,400	100	15,010	14,050	
Pincevent, La Grande-Paroisse	FR	OxA-148	12,600	200	15,850	14,013	AMS
Pont de Longues	FR	Beta-124232	12,290	60	14,875	13,943	
Querenstede	DE	KN-2707	12,650	320	16,421	13,943	
Rheinfelden Eremitage	CH	B-4262	12,520	170	15,246	13,994	
Solutré, P16	FR	Ly-393	12,580	250	16,052	13,907	
St. Bees	UK	BIRM-378	12,560	170	15,475	14,038	
Stellmoor D	DE	KN-2224	12,530	160	15,225	14,033	
Sun Hole	UK	BM-524	12,378	150	15,071	13,962	
Teufelsbrücke	DE	Bln-1821	12,300	85	14,898	13,941	
Teufelsbrücke	DE	Bln-1924	12,315	100	14,940	13,945	
Tournal (or Grande Grotte de Bize)	FR	Ly-1231	12,550	210	15,615	13,937	
Trou de Chaleux	BE	Lv-1568	12,370	170	15,090	13,917	
Trou des Blaireaux	BE	Lv-1386	12,440	180	15,165	13,955	
Trou Jadot	BE	Lv-1412D	12,610	260	16,153	13,942	
Tureau des Gardes	FR	Ly-6988	12,290	90	14,893	13,920	
Usselo	NE	Y-139-1	12,500	180	15,242	13,953	
Verberie, Le Buisson Campin	FR	GifA-95453	12,430	120	15,062	14,058	AMS
Zigeunerfels	DE	KN-3472	12,690	280	16,381	14,039	

While the radiocarbon data provide only a partial picture of Magdalenian expansion, considering the abundance of undated sites that are technologically and typologically Magdalenian as well as sites dated by other means (e.g., TL), mapping the radiocarbon dated sites demonstrates the effects of climatic constraints on northern expansion. Sites are only found south of 47° N latitude until the gradual warming trend at the end of the GS-2 (Fig. 3). Then, expansion from southwest to northeast leads to the colonization principally of southern Germany to Poland, with rarer sites in Belgium (Grotte Walou, Sy Verlaine, Chaleux, Trou Da Somme, Frontal) and central Germany (Kniegrotte). Both the Paris Basin and the northern Rhineland show evidence of settlement sites (Etiolles, Verberie, Gönnersdorf, Andernach). Evidence (discussed below) suggests contacts or seasonal movements between both the Paris Basin and the northern Rhineland with the Belgian territory. The Northwest Magdalenian is well-established by the GI-1e, with the additional appearance of the Hamburgian in northern Germany. Population expansion continues northward during GI-1c and 1b, reaching Great Britain and Denmark, the range of technocomplexes broadening. By the final phase of the Lateglacial, GI-1a and GS-1, northwest Europe is entirely occupied by this range of cultures.

Of interest in Belgium is the absence of Magdalenian sites in the section of the Meuse between Namur and Liège, apart from Goyet on the Samson River, a tributary of the Meuse near Namur. Belgian

territory may have been exploited by two different Magdalenian groups, one based in the Paris Basin and the other in the Rhineland. According to this hypothesis, the western Belgian cluster would ultimately be associated with the Paris Basin group, and the eastern sites purely with the northern Rhineland group. The lack of sites between the two, in a cave-rich area long exploited during the Middle and Early Upper Paleolithic, suggests that the territories exploited during the Magdalenian did not overlap (Fig. 4). Alternatively, the density of Magdalenian sites in Belgian territory may indicate an intermediate territory having contacts with both the Paris basin and the northern Rhineland.

Several lines of evidence point to connections between the Paris Basin and Belgian sites along the Meuse and on the Hesbaye Plateau. De Bie and Caspar (1994, p. 145), discussing burin technology in the context of the Federmesser site of Rekem, point out a significant correlation between burin facet width and burin type at Orp (Vermeersch et al., 1987: 40) and Le Grand Canton (Valentin, 1995: 231). Wenzel (2005, p. 25) points out contemporaneity and similarity in lithic assemblage structure between Orp, Unit U5, and the site of Etiolles. Fossil marine shells from the Paris Basin are found at Belgian sites (Chaleux, Trou Da Somme, Bois Laiterie, Sy Verlaine) (Dewez, 1987; Taborin, 1993; Lozouet and Gautier, 1997) (Fig. 5). Silicified limestone, from a primary source near Charleville-Maizière, was transported downstream along the Meuse to the

**Table 8**

Dates for 13.9–12.9 ka cal BP.

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Abri du Mannlefelsen,	FR	Lv-1144	11,760	120	13,854	13,352	
Abri Gay	FR	LYON-640	12,160	60	14,190	13,819	AMS
Abri Martin	FR	MC-2348	12,000	250	14,889	13,358	
Abri nord de Bavans	FR	Gif-6061	12,220	170	14,969	13,761	
Abri Pataud	FR	Grn-2079	11,320	110	13,413	12,932	
Adaouste	FR	LGQ-126	12,054	375	15,435	13,141	
Adaouste	FR	Ly-541	12,280	190	15,046	13,797	
Adaouste	FR	LGQ-125	12,497	374	16,393	13,722	
Adaouste	FR	LGQ-374	12,497	374	16,393	13,722	
Andernach-Martinsberg	DE	OxA-999	12,500	500	16,603	13,500	AMS
Andernach-Martinsberg 2	DE	OxA-997	11,800	160	13,980	13,325	AMS
Andernach-Martinsberg 2	DE	GrA-16990	11,820	70	13,830	13,451	AMS
Andernach-Martinsberg 2	DE	OxA-1924	11,890	120	13,997	13,441	AMS
Andernach-Martinsberg 2	DE	OxA-984	11,950	250	14,857	13,296	AMS
Andernach-Martinsberg 2	DE	GrA-16989	11,960	70	14,006	13,634	AMS
Andernach-Martinsberg 2	DE	GrA-16991	12,040	70	14,073	13,733	AMS
Andernach-Martinsberg 2	DE	GrA-16987	12,050	70	14,086	13,742	AMS
Andernach-Martinsberg 2	DE	OxA-985	12,300	200	15,078	13,802	AMS
Bange	FR	Ly-3640	11,680	190	13,925	13,181	
Baume de Gigny	FR	Ly-1798	12,370	460	16,401	13,416	
Baume de Vallorgues	FR	KN-1068	11,620	110	13,740	13,272	
Baume de Vallorgues	FR	Hv-1346	12,060	250	14,953	13,413	
Baume de Vallorgues	FR	Kn-67	12,060	250	14,953	13,413	
Baume Goulon	FR		11,865	70	13,878	13,471	
Bettenroder Berg IX	DE	Hv-17371	11,770	350	14,903	12,949	
Birseck-Ermitage	CH	B-4260	11,860	100	13,926	13,442	
Birseck-Ermitage	CH	B-4261	12,040	80	14,108	13,725	
Bourrouilla, Grotte d'Arancou	FR	Gif-10002	12,260	120	14,905	13,842	
Breitenbach B	DE	KN-3620	12,320	200	15,090	13,819	
Brohltal	DE	Hd-17100	11,206	20	13,244	12,930	
Brohltal	DE	Hd-17145	11,223	22	13,275	12,956	
Brohltal	DE	Hd-17900	11,277	26	13,278	13,101	
Brohltal	DE	KN-3802	11,280	100	13,367	12,907	
Brohltal	DE	KN-3803	11,510	90	13,598	13,178	
Bruniquel, Bruniquet	FR	BM-304	12,070	180	14,846	13,461	
Budel II-2	NE	GrN-1675	11,440	120	13,591	13,098	
Buttenloch	CH	B-4187	12,090	70	14,129	13,774	
Buttenloch	CH	B-4186	12,170	50	14,185	13,843	
Cabones	FR	Ly-3079	11,520	190	13,815	12,980	
Cabones	FR	Gif-8396	12,150	80	14,465	13,766	
Canecaude	FR	Gif-3448	12,300	600	16,655	13,205	
Chabot	FR	Ly-697	12,000	410	15,517	13,085	
Chauveau	BE	Lv-1961	12,000	130	14,165	13,484	
Chez Jugie	FR	Ly-1802	13,000	1000	18,495	13,263	
Chinchon I	FR	Ly-597	12,000	420	15,570	12,985	
Coléoptère	BE	Lv-686	12,150	150	14,876	13,704	
Colle Rousse	FR	Gif-8657	12,330	150	15,028	13,898	
Colombier	FR	Ly-4811	12,150	240	15,029	13,499	
Conduché	FR	Ly-2693	12,040	160	14,542	13,454	
Conty	FR	Ly-285	11,420	65	13,420	13,142	
Conty	FR	LYON-1353	11,885	75	13,914	13,480	
Coufin	FR	Ly-2930	11,590	190	13,836	13,113	
Courbet	FR	BM-302	11,750	300	14,607	12,951	
Deux-Avens	FR	Ly-321	12,320	600	16,675	13,235	
Deux-Avens	FR	Ly-322	12,350	200	15,114	13,841	
Douattes	FR	Ly-435	12,480	260	15,846	13,789	
Doue	FR	Ly-2822	11,520	170	13,767	13,098	
Dufaure	FR	Ly-3181	11,750	300	14,607	12,951	
Dufaure	FR	Ly-3245	12,030	280	14,990	13,355	
Dufaure	FR	Ly-3182	12,260	400	16,046	13,320	
Dufaure	FR	Ly-2923	12,290	270	15,235	13,504	
Dumas (Saut du Loup)	FR	Ly-318	11,750	300	14,607	12,951	
Dumas (Saut du Loup)	FR	Ly-319	12,080	310	15,104	13,349	
Duruthy	FR	BOR7	14,500	1450	21,727	13,797	
Espelugues, Le Calvaire CPE Gauche	FR	Ly-1906	12,450	330	16,139	13,689	
Etiolles, Les Coudrays	FR	OxA-174	11,900	250	14,823	13,250	AMS
Etiolles, Les Coudrays	FR	Ly-1351	12,000	220	14,850	13,375	
Etiolles, Les Coudrays	FR	OxA-5995/LYON-202	12,250	100	14,878	13,841	AMS
Etrembieres	FR	B-3787	12,310	140	14,995	13,885	
Fanciulli, Grotte des Enfants, Baousse Rousse	FR	MC-499	12,200	400	15,883	13,279	
Fantas	FR	Ny-128	12,490	270	15,869	13,795	
Faurelie	FR	Gif-3649	11,780	180	14,006	13,286	
Faustin	FR	Ly-2700	12,370	220	15,172	13,806	
Felsstalle	DE	H-7394-7429	11,800	200	14,099	13,264	

(continued on next page)

Table 8 (continued)

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Felsstalle	DE	H-7391-7426	12,050	115	14,220	13,599	
Felsstalle	DE	H-7383-7419	12,100	60	14,124	13,790	
Gare de Conduche	FR	Ly-3693	12,040	160	14,542	13,454	
Gare de Couze	FR	Ly-976	11,750	310	14,807	12,946	
Gare de Couze	FR	Ly-975	12,430	320	16,056	13,662	
Gay	FR	Ly-725	11,660	240	14,072	13,083	
Gnirshohle 2	DE	H-6270-5832	12,360	200	15,121	13,849	
Gnirshohle 2	DE	H-6271-5830	12,600	320	16,349	13,878	
Gönnersdorf	DE	OxA-2069	11,830	110	13,910	13,415	AMS
Gönnersdorf	DE	Ly-768	12,380	230	15,218	13,772	
Gönnersdorf	DE	Ly-1172	12,660	370	16,525	13,885	
Gough's New Cave	UK	BM-2187	12,070	170	14,831	13,465	
Gough's New Cave	UK	BM-2183	12,120	120	14,558	13,689	
Gough's New Cave	UK	BM-2185R	12,200	250	15,117	13,582	
Gough's New Cave	UK	BM-2184R	12,250	160	14,967	13,798	
Gough's New Cave	UK	BM-2186R	12,470	240	15,553	13,820	
Goutte Roffat	FR	Ly-3096	11,940	280	14,898	13,275	
Goutte Roffat	FR	Ly-3095	12,090	170	14,849	13,492	
Goutte Roffat	FR	Ly-3098	12,330	300	15,561	13,500	
Goutte Roffat	FR	Ly-3094	12,420	320	16,049	13,637	
Goyet	BE	Lv-2135	11,630	150	13,805	13,220	
Grand Canton	FR	Gif-9609	11,420	100	13,473	13,103	
Grand Canton	FR	Gif-9607	12,080	115	14,483	13,633	
Grand Canton	FR	Gif-9606	12,195	130	14,874	13,766	
Graves	FR	Gif-7340	11,360	120	13,463	12,945	
Grotte du Cheval	FR	Gif-92346	12,050	130	14,480	13,489	
High Furlong	UK	St-3836	11,665	140	13,811	13,267	
High Furlong	UK	St-3832	12,200	160	14,932	13,751	
Jean Pierre II	FR	Ly-925	12,400	240	15,447	13,764	
Jean Pierre II	FR	Ly-828	12,470	200	15,413	13,873	
Jean-Pierre I	FR	Ly-627	11,700	220	14,019	13,140	
Jean-Pierre I	FR	Ly-429	11,900	360	15,071	13,114	
Jean-Pierre II	FR	Ly-693	11,630	240	14,036	12,981	
Kastelhöhle	CH	B-4637	11,380	80	13,403	13,110	
Kastelhöhle	CH	B-4253	11,389	150	13,605	12,918	
Kastelhöhle	CH	B-4255	11,680	50	13,708	13,379	
Kastelhöhle	CH	B-4256	12,110	60	14,136	13,796	
Kent's Cavern, Black Band	UK	GrN-6204	12,180	100	14,798	13,769	
Klappholz LA 63	DE	AAR-2785	11,560	110	13,698	13,206	
Klein-Nordende CR	DE	KI-2152	11,990	100	14,110	13,600	
Klein-Nordende CR	DE	KI-2124	12,035	110	14,176	13,625	
Kohlerhöhle	CH	B-4971	11,640	150	13,814	13,229	
La Caune	FR	Gif-2950	12,270	280	15,226	13,477	
La Fru	FR	Ly-2409	11,680	150	13,840	13,262	
La Fru	FR	Ly-4325	11,740	110	13,821	13,357	
La Fru	FR	Ly-2250	11,810	160	13,991	13,334	
La Fru	FR	Ly-2408	11,820	230	14,465	13,160	
La Fru	FR	Ly-2751	12,470	400	16,418	13,636	
La Fru	FR	Ly-2915	12,680	560	16,850	13,629	
La Garenne Grand Abri	FR	C-579	12,986	560	17,104	13,855	
La Goutte Roffat	FR	Ly-3097	12,150	200	14,986	13,612	
La Quina	FR	GrN-4450	11,690	70	13,742	13,370	
Le Chaumois Boivin	FR	Ly-440	12,040	270	14,981	13,377	
Le Marais Gravière III	FR	Ly-22	11,660	110	13,761	13,298	
Le Martinet	FR	Ly-1605	13,600	1100	19,276	13,622	
L'Eléphant	FR	Gif-8227	12,020	100	14,137	13,645	
L'Eléphant	FR	Gif-8228	12,290	110	14,927	13,894	
Limeuil-Village	FR	Gif-8040	11,720	110	13,805	13,340	
Longetraye	FR	Ly-512	12,720	750	17,393	13,291	
Lortet	FR	Ly-3437	12,300	200	15,078	13,802	
Malarode	FR	Ly-3706	12,420	280	15,841	13,715	
Mas-d'Azil	FR	Gif-5679	13,400	1000	18,700	13,577	
Meiendorf D	DE	W-264	11,790	200	14,086	13,256	
Meiendorf D	DE	W-281	11,870	200	14,223	13,271	
Meiendorf D	DE	H-38/121B	12,300	200	15,078	13,802	
Meiendorf D	DE	H-38/121A	12,300	300	15,492	13,478	
Meiendorf D	DE	KN-2220	12,470	250	15,617	13,791	
Miesenheim 2	DE	KN-3578	11,290	80	13,349	12,957	
Miesenheim 2	DE	KN-3517	11,290	95	13,366	12,929	
Miesenheim 2	DE	KN-3577	11,310	95	13,386	12,957	
Miesenheim 2	DE	KN-3535	11,330	100	13,415	12,960	
Miesenheim 2	DE	KN-3534	11,360	110	13,455	12,965	
Miesenheim 2	DE	KN-3529	11,370	85	13,409	13,100	
Miesenheim 2	DE	KN-3580	11,370	100	13,456	13,076	
Miesenheim 2	DE	KN-3532	11,390	90	13,429	13,105	
Miesenheim 2	DE	KN-3581	11,440	100	13,498	13,107	

Table 8 (continued)

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Miesenheim 2	DE	KN-3533	11,460	90	13,496	13,125	
Miesenheim 2	DE	KN-3531	11,460	100	13,564	13,117	
Miesenheim 2	DE	KN-3575	11,460	100	13,564	13,117	
Miesenheim 2	DE	KN-3530	11,470	100	13,567	13,127	
Milheeze-Hogeloop	NE	GrN-16509	11,445	35	13,419	13,199	
Mollendruz-Abri Freymond	CH	ETH-5600	11,760	145	13,900	13,315	AMS
Mollendruz-Abri Freymond	CH	ETH-5601	12,020	120	14,185	13,503	AMS
Mollendruz-Abri Freymond	CH	OxA-9640	12,780	80	15,846	14,715	AMS
Montgaudier	FR	BM-1912	12,180	130	14,865	13,751	
Montgaudier Abri Gaudry	FR	BM-1911	11,450	70	13,450	13,155	
Montgaudier Abri Gaudry	FR	BM-2308	11,930	190	14,479	13,323	
Moosbuhl	CH	B-2310	11,900	130	14,025	13,434	
Moosbuhl	CH	B-2316	12,060	150	14,544	13,481	
Munzingen	DE	H-4738-4660	12,130	95	14,486	13,741	
Norre Lyngby	DK	AAR-1511	11,570	110	13,711	13,224	
Oldeholtwolde	NE	GrN-11264	11,340	100	13,428	12,966	
Oldeholtwolde	NE	GrN-13083	11,600	250	14,009	12,947	
Ossom's Cave	UK	BM-2127R	12,220	320	15,461	13,389	
Oudehaske	NE	GrN-18784	11,390	65	13,393	13,125	
Pégourié	FR	Ly-1833	11,850	280	14,830	13,143	
Pégourié	FR	Ly-1832	11,870	290	14,861	13,169	
Pégourié	FR	Ly-3851	12,160	200	14,994	13,629	
Pégourié	FR	Ly-3852	12,160	200	14,994	13,629	
Pégourié	FR	Gif-2822	12,250	350	15,822	13,356	
Pégourié	FR	Ly-1392	12,690	530	16,825	13,715	
Petersfels	DE	H-4741-4145	11,300	85	13,368	12,959	
Petersfels	DE	H-4276-3535	11,700	90	13,770	13,351	
Petersfels	DE	H-6650-6779	11,700	100	13,779	13,338	
Petersfels	DE	H-4343-4137	11,890	130	14,015	13,430	
Petersfels	DE	H-5209-4865	11,975	100	14,080	13,505	
Petersfels	DE	H-6654-6787	12,100	280	15,055	13,415	
Petersfels	DE	H-7132-6984	12,120	100	14,489	13,729	
Petersfels	DE	H-5210-4866	12,160	95	14,521	13,767	
Petersfels	DE	H-7139-7300	12,180	100	14,798	13,769	
Petersfels	DE	H-6652-6783	12,230	240	15,120	13,645	
Petersfels	DE	H-7215-7349	12,270	95	14,884	13,881	
Petersfels	DE	H-6655-6788	12,500	220	15,526	13,889	
Pincevent, La Grande-Paroisse	FR	Gif-6284	11,800	130	13,922	13,371	
Pincevent, La Grande-Paroisse	FR	OxA-391	11,870	130	13,995	13,419	AMS
Pincevent, La Grande-Paroisse	FR	OxA-176	12,000	220	14,850	13,375	AMS
Pincevent, La Grande-Paroisse	FR	Gif-5971	12,100	120	14,522	13,668	
Pincevent, La Grande-Paroisse	FR	Gif-6310	12,100	130	14,565	13,624	
Pincevent, La Grande-Paroisse	FR	Gif-6283	12,120	130	14,813	13,662	
Pincevent, La Grande-Paroisse	FR	OxA-467	12,250	160	14,967	13,798	AMS
Pincevent, La Grande-Paroisse	FR	Erl-6786	12,277	96	14,887	13,893	
Pincevent, La Grande-Paroisse	FR	Erl-6786	12,277	96	14,887	13,893	
Pincevent, La Grande-Paroisse	FR	OxA-177	12,300	220	15,119	13,770	AMS
Pincevent, La Grande-Paroisse	FR	Gif-358	12,300	400	16,094	13,379	
Pincevent, La Grande-Paroisse	FR	OxA-149	12,400	200	15,159	13,872	AMS
Poggenwisch	DE	GrN-11262	11,250	50	13,298	12,961	
Poggenwisch D	DE	W-271	11,750	200	14,033	13,230	
Pont d'Ambon	FR	Gif-7223	11,600	120	13,747	13,244	
Pont d'Ambon	FR	Gif-3739	12,130	160	14,876	13,645	
Pont de Longues	FR	Beta-108629	11,720	50	13,737	13,412	
Pont de Longues	FR	Beta-110898	11,920	50	13,935	13,614	
Poyemau or Poeymaü	FR	Ly-1385	11,540	220	13,863	12,950	
Poyemau or Poeymaü	FR	Ly-1384	12,000	250	14,889	13,358	
Pré de la Chapelle	FR	ETH-15766	11,480	190	13,768	12,959	AMS
Pré de la Chapelle	FR	Ly-849	11,860	190	14,148	13,303	
Preletang	FR	Ly-93	11,730	260	14,470	13,074	
Presles	BE	Lv-1472	12,140	160	14,880	13,670	
Quinçay [Grande Roche de la Plematrie]	FR	Ly-790	11,910	200	14,481	13,297	
Rheinfelden Eremitage	CH	B-4183	11,600	120	13,747	13,244	
Rheinfelden Eremitage	CH	B-4184	11,950	50	13,964	13,662	
Rhodes II	FR	MC-997	12,100	150	14,846	13,595	
Rhodes II	FR	Gif-2258	12,160	160	14,906	13,706	
Rhodes II	FR	MC-1366	12,250	200	15,050	13,759	
Rhodes II	FR	MC-996	12,300	150	14,996	13,860	
Risliberghöhle	CH	Ly-1099	11,860	230	14,515	13,236	
Rissen 14a	NE	H-75/78	11,450	180	13,731	12,945	
Roc de Marcamp	FR	Ly-3148	11,910	230	14,596	13,267	
Roc-aux-Sorciers, Abri Bourdois	FR		12,210	80	14,790	13,809	
Rocher de la Caille (Saut-du-Perron)	FR	Ly-5645	12,214	476	16,285	13,249	
Romains	FR	MC-1276	12,540	230	15,841	13,885	
Romains	FR	MC-1215	12,540	400	16,490	13,735	

(continued on next page)

Table 8 (continued)

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Romains	FR	MC-1275	12,540	400	16,490	13,735	
Rond du Barry	FR	Gif-2671	12,380	280	15,596	13,661	
Roquemissou Abri n°2 des Usclades	FR	Gif-10313	11,400	85	13,425	13,114	
Roquemissou Abri n°2 des Usclades	FR	Gif-10312	11,590	105	13,716	13,254	
Rosenhof	DE	KN-3196	11,900	100	13,973	13,466	
Rosmos	DK	K-3697	13,240	760	17,986	13,791	
Seamer K	UK	CAR-842	12,010	130	14,181	13,484	
Soppensee	CH	ETH-1615	13,370	900	18,526	13,784	AMS
St. Bees	UK	BIRM-647	11,500	120	13,641	13,130	
Stellmoor D	DE	K-4328	12,180	130	14,865	13,751	
Stellmoor D	DE	K-4261	12,190	125	14,863	13,764	
Stellmoor D	DE	W-261	12,450	200	15,219	13,876	
Tai	FR	Ly-4217	11,580	180	13,808	13,121	
Tai	FR	Ly-4218	11,980	160	14,468	13,403	
Tai	FR	Ly-3442	12,290	220	15,114	13,763	
Trou Jadot	BE	Lv-1411	11,850	160	14,037	13,359	
Tureau des Gardes	FR	Ly-6989	11,560	100	13,681	13,224	
Vache	FR	Col-336c	11,650	200	13,912	13,137	
Verberie, Le Buisson Campin	FR	GifA-99421	12,300	120	14,956	13,896	AMS
Weissensee	DE	KN-3623	11,600	230	13,982	12,980	
Westerkappeln, Fundstelle C	DE	KI-271	11,800	200	14,099	13,264	
Zigeunerfels	DE	KN-3478	11,290	90	13,359	12,938	
Zigeunerfels	DE	KN-3474	11,300	100	13,383	12,931	
Zigeunerfels	DE	KN-3471	11,480	100	13,576	13,137	
Zigeunerfels	DE	KN-3482	11,830	100	13,887	13,425	
Zigeunerfels	DE	KN-3486	11,910	100	13,984	13,473	
Zigeunerfels	DE	KN-3473	12,100	100	14,460	13,702	
Zigeunerfels	DE	KN-3481	12,200	600	16,597	13,104	

Table 9

Dates for 12.9–11.5 ka cal BP.

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Aardhorst	NE	GrN-4180	11,140	70	13,210	12,766	
Abeurador	FR	Gif-6746	10,480	100	12,605	12,075	
Abri du Mannlefelsen,	FR	Lv-1036	10,560	200	12,897	11,770	
Abri du Mannlefelsen,	FR	Lv-1090	11,080	100	13,175	12,688	
Abri Martin	FR	MC-2345	10,200	0	12,020	11,823	
Abri Martin	FR	MC-23464	10,820	200	13,175	12,163	
Abri Pataud	FR	GrN-3644	10,450	120	12,619	11,978	
Altwasser Höhle 1	CH	ETH-9641	10,240	85	12,389	11,621	AMS
Andernach-Martinsberg	DE	GrA-16521	10,970	60	13,070	12,665	AMS
Andernach-Martinsberg	DE	H-85/91	11,300	220	13,617	12,692	
Andernach-Martinsberg 3	DE	GrA-16994	11,160	70	13,245	12,800	AMS
Andernach-Martinsberg 3	DE	OxA-998	11,370	160	13,615	12,879	AMS
Baerenkeller	DE	B-980	11,190	180	13,382	12,679	
Baraquettes	FR	Beta-122220	10,170	60	12,084	11,502	
Baume de Vallorgues	FR	Kn-61	10,910	85	13,065	12,609	
Baume de Vallorgues	FR	Hv-1344	10,910	225	13,302	12,390	
Baume de Vallorgues	FR	KN-1061	11,030	85	13,111	12,685	
Baume de Vallorgues	FR	Kn-68	11,200	115	13,310	12,765	
Baume de Vallorgues	FR	Hv-1345	11,270	230	13,601	12,667	
Bedburg-Königshoven	DE	KN-4137	10,290	100	12,523	11,648	
Bedburg-Königshoven	DE	KN-4138	10,670	100	12,839	12,230	
Bedburg-Königshoven	DE	KN-4136	10,920	100	13,072	12,620	
Blot	FR	Ly-502	11,250	500	14,807	11,830	
Bois Ragot	FR	Gif-3580	10,990	160	13,189	12,599	
Bois-du-Cantet	FR	Ly-2614	10,920	140	13,106	12,590	
Brimfield	UK	BIRM-404	10,625	282	13,142	11,508	
Brohltal	DE	?	11,025	90	13,112	12,677	
Brohltal	DE	Hv-11774	11,075	185	13,293	12,626	
Brohltal	DE	?	11,085	90	13,166	12,701	
Brohltal	DE	Hd-17101	11,121	28	13,139	12,831	
Brohltal	DE	KN-3800	11,240	100	13,341	12,857	
Brohltal	DE	KN-3801	11,260	95	13,342	12,894	
Budel IV	NE	GrN-1687	11,070	90	13,147	12,692	
Butzsee	DE	OxA-8743	10,185	65	12,121	11,502	AMS
Capeau (Lavalduc)	FR	HV-2126	11,700	450	15,061	12,680	
Champréveyres	CH	B-4530	11,120	110	13,243	12,714	
Chez Jugie	FR	Ly-1601	11,730	530	15,594	12,572	
Chez Jugie	FR	Ly-1572	11,840	580	16,068	12,617	
Closeau	FR	Ly-7190	10,465	110	12,614	12,034	



Table 9 (continued)

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Closeau	FR	Ly-7190	10,470	110	12,615	12,039	
Closeau	FR	Ly-7189	10,670	110	12,875	12,221	
Closeau	FR	Ly-7189	10,670	110	12,875	12,221	
Colombier	FR	Ly-4809	11,080	250	13,451	12,551	
Colombier	FR	Ly-4810	11,230	420	14,091	12,104	
Colombier	FR	Gif-8717	11,460	310	13,965	12,680	
Combarelles	FR	Ly-3201	11,380	210	13,707	12,782	
Conty	FR	Ly-6999	11,080	60	13,125	12,738	
Conty	FR	Ly-7407	11,130	80	13,212	12,747	
Cornille	FR	Ly-427	10,870	320	13,440	11,833	
Cornille	FR	Ly-449	10,920	210	13,275	12,425	
Coufin	FR	Ly-2931	11,020	150	13,201	12,622	
Courbet	FR	BM-303	11,110	160	13,285	12,665	
Cuze de Neussargues	FR	Ly-3261	11,580	300	14,127	12,757	
Dinslaken	DE		10,750	105	12,913	12,431	
Dinslaken	NE	Hv-1414	10,790	105	12,942	12,543	
Dufaure	FR	Ly-2666	10,910	220	13,288	12,404	
Dumas (Saut du Loup)	FR	Ly-320	11,500	380	14,500	12,597	
Duruthy	FR	Ly-858	11,150	220	13,416	12,621	
Duurswoude II	NE	GrN-1565	11,090	90	13,171	12,705	
Duurswoude Oud Leger	NE	GrN-607	10,800	250	13,245	12,072	
Duurswoude Oud Leger	NE	GrN-4871	11,150	190	13,362	12,653	
Een-Schipsloot pit I	NE	GrN-6341	10,495	60	12,595	12,143	
Een-Schipsloot pit I	NE	Y-139-2	10,880	160	13,134	12,544	
Eglises	FR	Gif-1434	11,800	500	15,507	12,645	
Espelugues, Le Calvaire CPE Gauche	FR	Ly-1905	11,750	430	15,068	12,750	
Felsstalle	DE	H-7442-7491	11,285	246	13,650	12,664	
Ferrassie	FR	Gif-4263	11,150	120	13,278	12,727	
Fontbregoua	FR	Gif-2994	11,200	150	13,351	12,716	
Gare de Couze	FR	BM-1615	11,230	180	13,422	12,695	
Gazel	FR	Gif-2654	10,760	190	13,104	12,145	
Geldrop I	NE	GrN-1059	10,960	85	13,081	12,653	
Geldrop I	NE	GrN-603	11,020	230	13,367	12,549	
Gerbaix "dessus"	FR	Ly-1952	10,670	170	12,949	12,069	
Gigot	FR	Lv-1111	10,980	80	13,086	12,666	
Gigot	FR	Lv-1112	10,980	80	13,086	12,666	
Gigot	FR	Lv-1110	11,110	95	13,206	12,714	
Gönnersdorf	DE	KN-1979	10,540	210	12,905	11,711	
Goutte Roffat	FR	Ly-2150	10,860	210	13,260	12,223	
Gramsbergen II	NE	GrN-8074	11,130	60	13,177	12,773	
Grotte du Renne, Arcy-sur-Cure	FR	BM-1818	10,500	190	12,775	11,708	
Grotte du Renne, Arcy-sur-Cure	FR	L-340B	10,900	250	13,316	12,155	
Grotte du Renne, Arcy-sur-Cure	FR	L-340A	11,400	250	13,775	12,738	
Horn-Haelen	NE	GrN-498	10,950	300	13,436	12,110	
Horn-Haelen	NE	GrN-497	11,000	320	13,575	12,123	
Horn-Haelen	NE	GrN-7297	11,200	100	13,299	12,793	
Jean-Pierre I	FR	Ly-1190	10,620	210	13,068	11,827	
Jean-Pierre I	FR	Ly-596	10,750	300	13,289	11,769	
Jean-Pierre I	FR	Ly-626	11,340	260	13,732	12,688	
Jean-Pierre I	FR	Ly-625	10,470	200	12,758	11,508	
Jean-Pierre II	FR	Ly-692	11,590	330	14,465	12,679	
Kastelhöhle	CH	B-4254	11,320	130	13,450	12,884	
Kesslerloch	CH	B3327	11,220	120	13,333	12,773	
Kniegrotte	DE	GrN-6649	10,230	90	12,393	11,502	
La Colombière	FR	W-150	11,750	600	16,125	12,551	
La Fru	FR	Ly-4326	10,360	150	12,603	11,625	
La Fru	FR	Ly-2916	10,750	190	13,097	12,143	
La Fru	FR	Ly-3596	10,800	230	13,189	12,105	
La Fru	FR	Ly-3594	10,990	190	13,252	12,583	
La Fru	FR	Ly-2912	11,030	250	13,423	12,433	
La Fru	FR	Ly-2917	11,030	250	13,423	12,433	
La Fru	FR	Ly-2499	11,190	210	13,436	12,646	
La Fru	FR	Ly-3595	11,240	160	13,405	12,731	
La Garenne Grand abri	FR	Gif-34	11,230	500	14,606	11,815	
La Garenne-Blanchard	FR	C-577	11,109	480	14,159	11,624	
La Garenne-Blanchard	FR	Lv-383	11,280	220	13,592	12,681	
Lavalduc, Valduc	FR	Hv-?	11,690	450	15,050	12,675	
Le Brassot	FR	Ly-9015	11,090	95	13,179	12,698	
Le Morin	FR	Gif-2105	10,480	200	12,770	11,615	
Lemforde	DE	Hv-14972	10,955	315	13,480	12,065	
Les Freydières	FR	Ly-451	11,380	180	13,675	12,851	
Lespoux	FR	Ly-3308	10,580	210	12,936	11,765	
Magdeleine	FR	Y-1109	11,180	300	13,708	12,563	
Margot	FR	Lv-1242	11,110	120	13,244	12,698	
Mehlbeck, Friedhof	DE	Hv-17306	10,515	95	12,620	12,110	

(continued on next page)

Table 9 (continued)

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Meiendorf	DE	Y-158	10,760	250	13,214	11,998	
Meiendorf D	DE	Y-158-2	10,760	250	13,214	11,998	
Messingham	UK	Birm-349	10,280	120	12,540	11,502	
Michelberg	DE	Bonn-763	10,800	100	12,926	12,554	
Miesenheim 2	DE	Zürich	10,840	195	13,208	12,224	
Miesenheim 2	DE	KN-3519	11,040	220	13,337	12,572	
Miesenheim 2	DE	KN-3520	11,070	100	13,163	12,683	
Miesenheim 2	DE	KN-3518	11,080	220	13,361	12,591	
Miesenheim 2	DE	KN-3576	11,160	95	13,266	12,766	
Miesenheim 2	DE	KN-3516	11,230	95	13,326	12,856	
Miesenheim 2	DE	KN-3579	11,240	95	13,332	12,871	
Milheeze Hutseberg, Milheeze la	NE	GrN-2314	10,880	125	13,076	12,586	
Milheeze-Hogeloop	NE	GrN-16508	10,810	60	12,870	12,581	
Moosbuhl	CH	B-2313	11,180	120	13,299	12,745	
Mother Grundy's Parlour	UK	Q-1459	11,160	170	13,337	12,673	
Mother Grundy's Parlour	UK	Q-1483	11,285	180	13,485	12,710	
Mother Grundy's Parlour	UK	Q-1484	11,320	230	13,660	12,699	
Moulin a Troubat	FR	Ly-5275	10,765	96	12,904	12,545	
Moulin a Troubat	FR		11,320	410	14,223	12,218	
Moulin-du-Roc	FR	Ly-5444	11,340	170	13,585	12,797	
Nahe LA 11	DE		10,172	45	12,046	11,643	
Nahe LA 11	DE		10,544	49	12,620	12,393	
Nahe LA 11	DE		10,610	80	12,713	12,225	
Nettetal	DE	W-525	10,800	300	13,336	11,826	
Nettetal	DE	?	10,880	95	13,061	12,587	
Nettetal	DE	?	10,950	190	13,241	12,560	
Oldeholtwolde	NE	GrN-12280	11,080	280	13,581	12,427	
Oldeholtwolde	NE	GrN-10274	11,540	270	13,995	12,831	
Ossom's Cave	UK	GrN-7400	10,590	70	12,681	12,230	
Oudehaske	NE	GrN-18783	11,120	70	13,180	12,750	
Pech-Merle	FR	Ly-1200	11,460	390	14,500	12,570	
Pégourié	FR	Ly-3933	10,700	290	13,252	11,720	
Pégourié	FR	Ly-1390	11,290	320	13,812	12,593	
Pégourié	FR	Ly-1391	11,680	330	14,582	12,781	
Pincevent, La Grande-Paroisse	FR	GrN-4383	10,760	60	12,806	12,557	
Pincevent, La Grande-Paroisse	FR	GrN-4383	10,760	60	12,806	12,557	
Pincevent, La Grande-Paroisse	FR	Lv-293	11,310	330	13,860	12,587	
Pincevent, La Grande-Paroisse	FR	Lv-292	11,610	400	14,840	12,660	
Poeymau	FR	Ly-1789	10,700	290	13,252	11,720	
Pré de la Chapelle	FR	ETH-15760	11,230	90	13,318	12,870	AMS
Querenstede	DE	KN-1053	11,140	240	13,454	12,590	
Remouchamps	BE	Lv-535	10,380	170	12,636	11,506	
Rissen 14a	NE	Y-157-A	10,560	200	12,897	11,770	
Robin Hood's Cave	UK	BM-0603	10,390	90	12,560	11,984	
Robin Hood's Cave	UK	BM-603	10,390	90	12,560	11,984	
Robin Hood's Cave	UK	BM-0604	10,590	90	12,692	12,151	
Roc-aux-Sorciers, Abri Bourdois	FR	GrN-2912	10,800	120	13,065	12,534	
Roc-aux-Sorciers, Abri Bourdois	FR	GrN-2913	11,265	130	13,398	12,808	
Roc-aux-Sorciers, Abri Bourdois	FR	GrN-2916	11,265	130	13,398	12,808	
Rochedane	FR	Ly-1194	10,730	190	13,086	12,131	
Rochedane	FR	Ly-1193	11,060	470	14,039	11,620	
Rochedane	FR	Ly-1192	11,090	200	13,325	12,615	
Roquemissou Abri n° 1 des Usclades	FR	Gif-8438	10,250	80	12,388	11,648	
Sainte Eulalie	FR	Gif-1697	10,830	200	13,196	12,219	
Saleux 114	FR	Gif-8706	10,640	90	12,757	12,225	
Salpêtrière	FR	Ly-937/ Ly-21678	10,680	300	13,245	11,627	
Salpêtrière	FR	Ly-938	11,080	250	13,451	12,551	
Sanglier	FR	Ly-6161	11,102	102	13,207	12,701	
Sanglier	FR	Ly-7286	11,180	80	13,276	12,810	
Seamer K	UK	CAR-841	10,960	110	13,100	12,634	
Solutré, L-13	FR	Ly-315	10,900	400	13,696	11,649	
Soppensee	CH	ETH-5290	10,760	105	12,921	12,436	AMS
Soppensee	CH	ETH-1610	11,180	100	13,284	12,775	AMS
St. Bees	UK	BIRM-1144	10,430	165	12,660	11,715	
St. Bees	UK	BIRM-649	11,180	120	13,299	12,745	
St. Bees	UK	BIRM-648	11,300	220	13,617	12,692	
Sun Hole	UK	Birm-820	10,280	120	12,540	11,502	
Sun Hole	UK	Birm-821	10,470	190	12,734	11,626	
Tai	FR	Ly-4216	11,270	190	13,486	12,688	
Thur	DE	KN-2868	11,050	120	13,176	12,658	
Thur	DE	KN-2869	11,110	90	13,199	12,718	
Thur	DE	KN-2870	11,250	95	13,336	12,884	
Tilloy, Moque Panier	FR	Gif-5838	10,400	180	12,661	11,502	
Trollesgave	DK	K-2641	11,070	120	13,198	12,669	
Trollesgave	DK	K-2509	11,100	160	13,280	12,660	
Trou du Frontal	BE	Lv-1135	10,720	120	12,929	12,390	

Table 9 (continued)

Site name	Country	Lab ID	Date	Uncertainty	From cal BP	To cal BP	Type
Usselo	NE	Y-139-2	10,880	160	13,134	12,544	
Usselo	NE	Y-139-3	11,350	150	13,571	12,872	
Vailly-sur-Aisne	FR	SA-53	11,550	450	14,912	12,595	
Venerolles (la Sabliere)	FR	Gif-8101	10,510	110	12,634	12,076	
Verberie, Le Buisson Campin	FR	Ly-3404	10,640	180	12,940	12,003	
Weissensee	DE	KN-3624	11,400	230	13,751	12,771	
Wustermark 22	DE	?	10,370	75	12,529	11,982	
Zigeunerfels	DE	KN-3485	10,340	90	12,529	11,824	
Zigeunerfels	DE	KN-3488	10,400	90	12,561	11,997	
Zigeunerfels	DE	KN-3784	10,500	110	12,628	12,068	
Zigeunerfels	DE	KN-3483	10,650	110	12,799	12,151	
Zigeunerfels	DE	KN-3477	10,880	120	13,070	12,588	
Zigeunerfels	DE	KN-3476	11,070	95	13,155	12,688	
Zigeunerfels	DE	KN-3475	11,180	100	13,284	12,775	
Zigeunerfels	DE	KN-3487	11,220	120	13,333	12,773	
Zigeunerfels	DE	KN-3480	11,250	100	13,348	12,872	

same western Belgian sites (Trou Da Somme, Chaleux, Bois Laiterie) (Miller and Noiret, 2009) (Fig. 6). In contrast, local flint sources in the Paris Basin were amply sufficient to provision these sites, and flint from Belgian sources is rare (Mauger, 1994; Féblot-Augustins, 1997; Djindjian, 2005). These data support the hypothesis of seasonal migration between the Paris Basin and at least western Belgium, indicating movement from southwest to northeast. Such movement may reflect following reindeer along their own

migration route, the Paris Basin in fall-winter and Belgian territory during summer (see Rensink, 1993, among others). Flint from the Hesbaya Plateau in Belgium is the main lithic raw material in all Belgian Magdalenian sites, additionally supplying Rhineland sites.

Overall, the Magdalenian sites in northwest Europe vary in function and include large, multi-activity base camps, flint procurement sites, short-term hunting camps and extended stay seasonal occupations. Large, complex sites interpreted as base

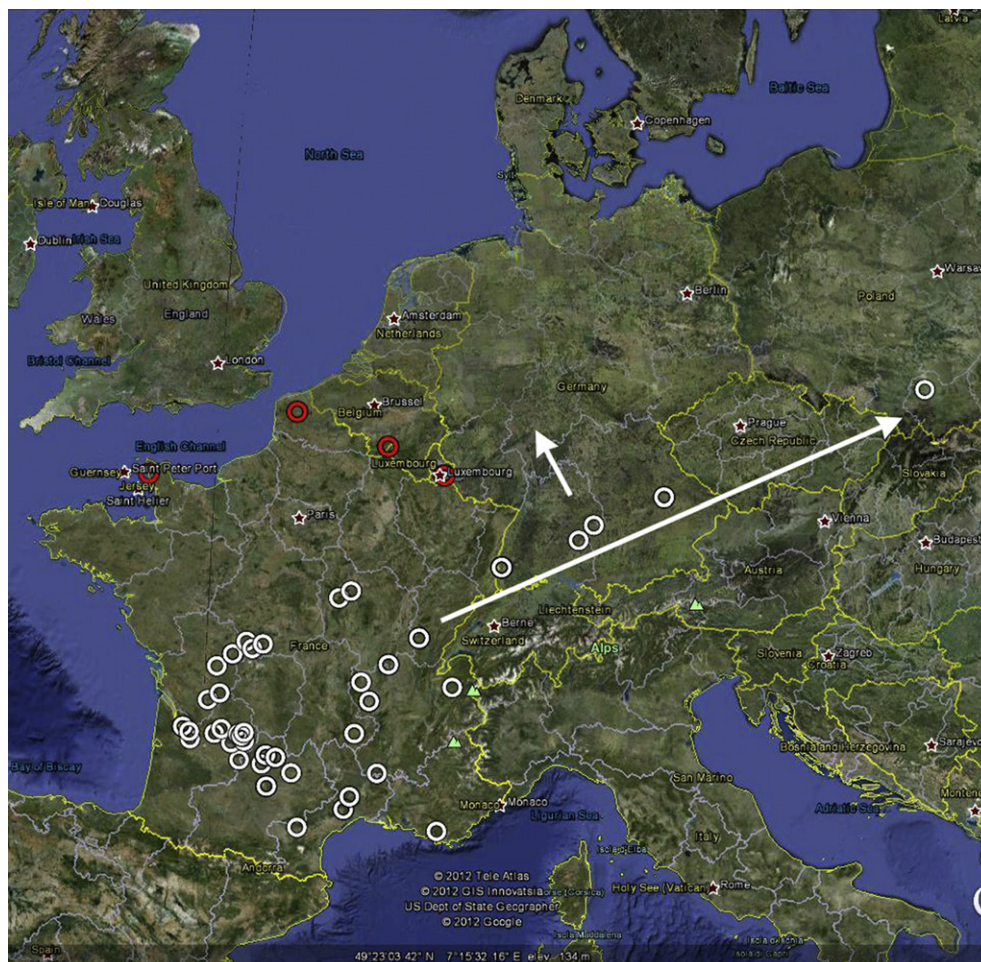
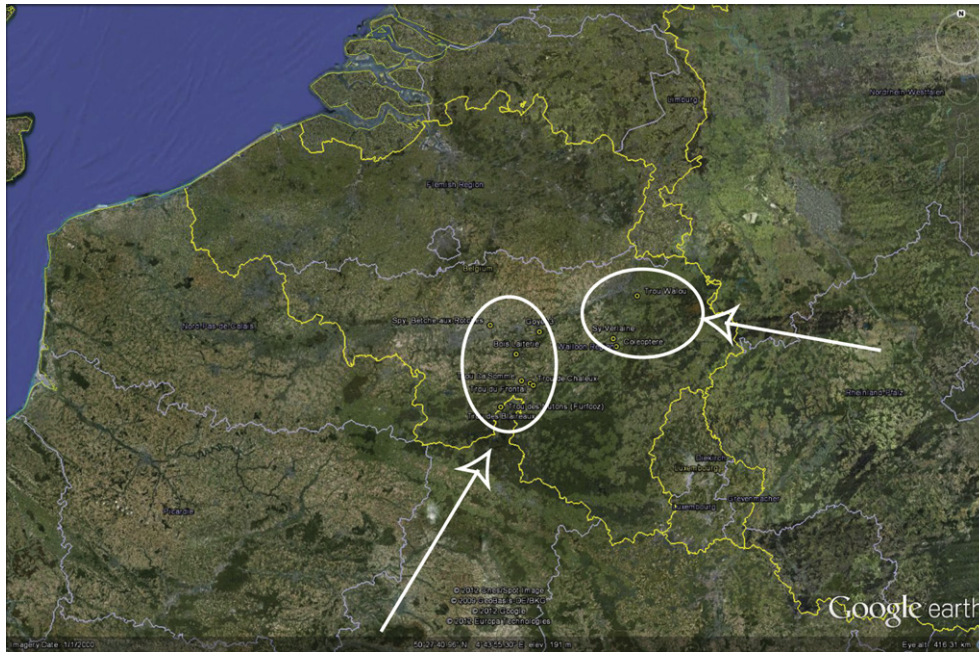


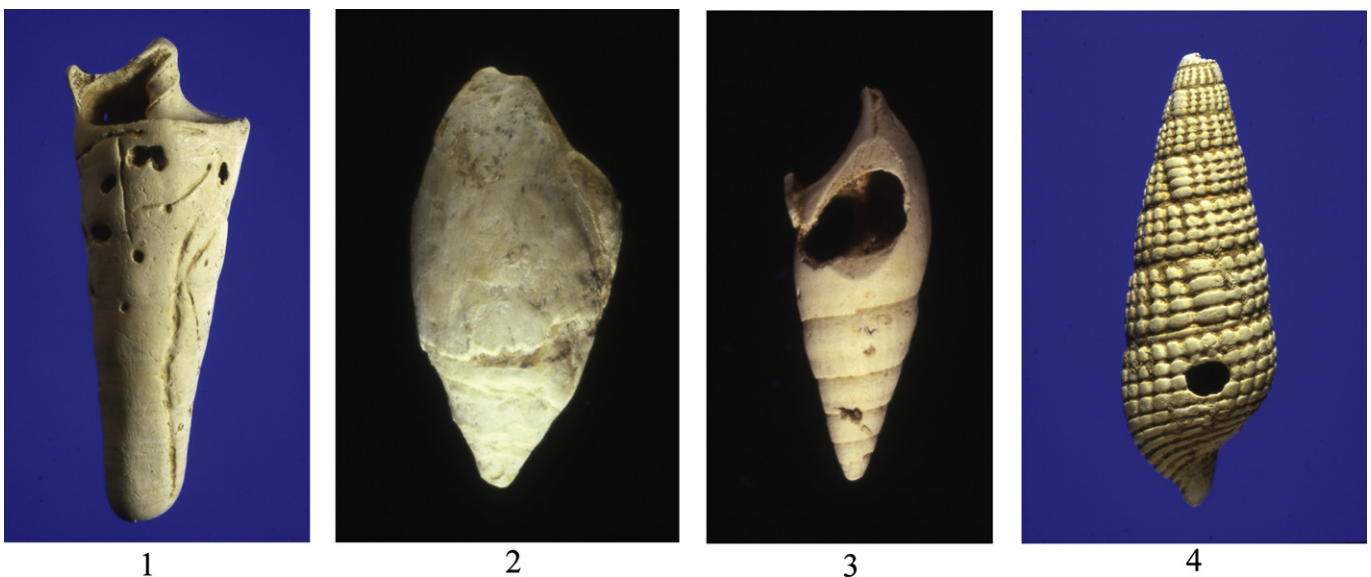
Fig. 3. Map showing the initial expansion trajectory of the Magdalenian during the 19–17.5 ka BP phase.



**Fig. 4.** Map of Belgian sites showing the western and eastern clusters. Arrows indicate possible contacts and/or migration routes from the Paris Basin and the northern Rhineland, making Belgian territory part of the territories of each.

camp are present in the Paris Basin (Etiolles, Marsangy, Pincevent, Verberie, among others) and the Rhineland (Gönnersdorf), containing evidence for multiple activities (flintknapping, hide-working, stone processing, butchery, cooking) and features including hearths, dwelling structures, stone plaquette paving, mobile art (e.g., engraved plaquettes). In Belgium, the only comparable site is Chaleux, a cave site rather than open-air, but less elaborate than those in France and Germany. It is more likely an extended stay site, for the seasonal exploitation of the resources in the Belgian territory (flint on the Hesbaye Plateau, subsistence) and linked with the larger base camps in the Paris Basin. Several small sites around Chaleux (Trou Da Somme, Frontal, Nutons) can be interpreted as short-term hunting sites, as

well as Bois Laiterie, several km downstream along the Meuse and en route toward the Hesbaye Plateau. The open-air sites of Orp (Vermeersch and Vynkier, 1980; Vermeersch et al., 1987) and Kanne (Vermeersch et al., 1985), both located at sources of Cretaceous flint, are interpreted as flint procurement workshops, possibly embedded in subsistence activities, or vice versa. The flint from Orp (or other potential comparable sites on the Hesbaye Plateau) was used at Belgian sites, and apparently not transported to the Paris Basin. In contrast, flint from the Meuse terraces and/or sites such as Kanne, near Maastricht, was transported to northern Rhineland sites. The eastern Belgian sites (Walou, Sy Verlaine) may have been part of the greater Rhineland territory, possibly hunting sites.



**Fig. 5.** Fossil marine shells present at Belgian sites. 1–3: Bois Laiterie, 4: Chaleux.

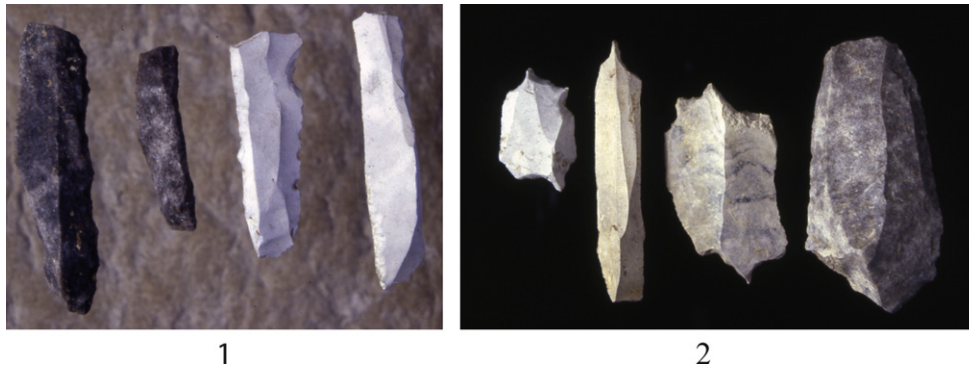


Fig. 6. Examples of silicified limestone and flint from Trou Da Somme. 1: blades, 2: percipients and an endscraper.

Interestingly, even small sites interpreted as short-term hunting stations have yielded mobile art and fossil marine shells: an engraved plaquette at Trou Da Somme, several shells at Bois Laiterie, one from Trou Da Somme and shells at Sy Verlaine. Chaleux, a larger site, contains several engraved plaquettes and shells.

## 6. Conclusions

Both demographic and climatic factors played significant roles in the expansion of the Magdalenian to Northwest Europe. Indeed, climate played a limiting role in the occupation of northern Europe throughout the Paleolithic: Neandertals are present during warm phases (Seclin, Scladina, Rocourt, Wallertheim; Spy at 36,000 BP) (see e.g., Finlayson and Carrión, 2007), while modern humans become locally extinct or abandon the northern latitudes at the onset of the LGM. Even during the Early Upper Paleolithic, the Aurignacian appears to be correlated with warm oscillations in the north. The Magdalenian does not appear in northwest Europe until the warming trend prior to 14.67 ka cal BP. Dated sites are present as far north as Wales and Scotland and northern Germany during the Meiendorf and Bølling, becoming more widespread in England and present in northern Denmark during the Allerød. New technocomplexes appear during GI-1e (Hamburgian), followed later by the Creswellian, Federmesser, Ahrensburgian and Brommean in the more northern regions (Great Britain, northern Germany, Denmark). The cold event of the Younger Dryas (GS-1), nearly 1000 years, appears to have been a factor in the southward movement of these technocomplexes, which remained, however, in northwest Europe, replacing the Magdalenien.

Finally, this study has shown that critical evaluation of radiocarbon dates, particularly conventional dates, is necessary when examining the chronological and geographic distribution of Lateglacial sites. For this paper, dates for all sites above 47° N latitude were evaluated; southern French sites were beyond the scope of this paper, their overall distribution generally reflecting Lateglacial occupation prior to expansion. However, researchers in this region for this period clearly take the validity of radiocarbon dates into consideration. Dates were excluded on the basis of large error ranges, lack of association with artifacts, dating done in the 1960s and 1970s, or evidence of contamination. The Radiocarbon Palaeolithic Database is a key tool, but the data within it needs to be evaluated, with dates to be rejected clearly identified and reason for exclusion indicated. Finally, a significant number of dates obtained in the last decade are lacking from the database; it is hoped that researchers will send their results to the database project so that it reflects the latest advances in Palaeolithic chronological research.

## Acknowledgments

I would like to thank Lawrence Straus, Thomas Terberger and Denise Leesch for their detailed comments on this paper. Any errors that remain are, however, mine.

## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.quaint.2012.05.034.

## References

- Alley, R.B., Marotzke, J., Nordhaus, W.D., Overpeck, J.T., Peteet, D.M., Pielke, R.A., Pierrehumbert, R.T., Rhines, P.B., Stocker, T.F., Talley, L.D., Wallace, J.M., 2003. Abrupt climate change. *Science* 299, 2005–2010.
- Alley, R.B., Clark, P.U., 1999. The deglaciation of the northern hemisphere: a global perspective. *Annual Reviews of Earth and Planetary Sciences* 27, 149–182.
- Björck, S., Rundgren, M., Ingolfsson, O., Funder, S., 1997. The Preboreal oscillation around the Nordic Seas: terrestrial and lacustrine responses. *Journal of Quaternary Science* 12 (6), 455–465.
- Björck, S., Walker, M., Cwynar, L., Johnsen, S., Knudsen, K.-L., Lowe, J.-J., Wohlfarth, B., INTIMATE members, 1998. An event stratigraphy for the Last Termination in the North Atlantic region based on the Greenland ice-core record: a proposal by the INTIMATE group. *Journal of Quaternary Science* 13, 283–292.
- Blockley, S.P.E., Donahue, R.E., Pollard, A.M., 2000. Radiocarbon calibration and Late Glacial occupation in Northwest Europe. *Antiquity* 74, 112–119.
- Bodu, P., Mevel, L., 2008. Enquête autour des lames tranchantes de l'Azilien ancien. Le cas du niveau inférieur du Closeau (Rueil-Malmaison, Hauts-de-Seine, France). *L'Anthropologie* 112, 509–543.
- Brauer, A., Haug, G., Dulski, P., Sigman, D., Negendank, J., 2008. An abrupt wind shift in western Europe at the onset of the Younger Dryas cold period. *Nature Geoscience* 1, 520–523.
- Cattelain, P., 2005. Propulseurs magdaléniens: marqueurs culturels régionaux? In: Dujardin, V. (Ed.), *Industries osseuses et parures du Solutrén au Magdalénien en Europe* Société préhistoriques française, Mémoires 34, pp. 301–317.
- Charles, R., 1994. Food for Thought: Late Magdalenian chronology and faunal exploitation in the north-western Ardennes. Oxford University, doctoral thesis.
- Charles, R., 1996. Back into the North: the radiocarbon evidence for the human recolonisation of the North Western Ardennes after the Last Glacial Maximum. *Proceedings of the Prehistoric Society* 62, 1–17.
- Charles, R., 1998. Late Magdalenian Chronology and Faunal Exploitation in the North-Western Ardennes. In: Oxford, BAR International Series 737.
- Conneller, C., 2007. Inhabiting new landscapes: settlement and mobility in Britain after the Last Glacial Maximum. *Oxford Journal of Archaeology* 26, 215–237.
- Clark, P., Dyke, A., Shakun, J., Carlson, A., Clark, J., Wohlfarth, B., Mitrovica, J., Hostetler, S., McCabe, M., 2009. The Last Glacial Maximum. *Science* 325, 710–714.
- Coope, G.R., Joachim, M.J., 1980. Lateglacial environmental changes interpreted from fossil coleopteran from St Bees, Cumbria, NW England. In: Lowe, J.J., Gray, J.M., Robinson, J.E. (Eds.), *Studies in the Lateglacial of North-West Europe*. Pergamon Press, Oxford, pp. 55–68.
- De Bie, M., Caspar, J.-P., 1994. Rekem, a Federmesser Camp on the Meuse River Bank. In: *Instituut voor het Archaeologisch Patrimonium*, vol. 1. Leuven University Press, Leuven.
- Delibrias, G., Guillier, M.-Th., Labeyrie, J., 1982. GIF natural radiocarbon measurements ix. *Radiocarbon* 24 (3), 291–343.

- Dewez, M., 1987. Le Paléolithique supérieur récent dans les Grottes de Belgique. In: Publications d'Histoire de l'Art et d'Archéologie de l'Université Catholique de Louvain, LVII. Louvain-la-Neuve.
- Djindjian, F., 2005. Approvisionnement en matières premières dans le Paléolithique supérieur de l'Europe occidentale: Méthodes et résultats. *Archeometriai Műhely* 4, 1–16.
- Donnelly, J., Driscoll, N., Uchupi, E., Keigwan, L., Schwab, W., Thieler, R., Swift, S., 2005. Catastrophic meltwater discharge down the Hudson Valley: a potential trigger for the Intra-Allerød cold period. *Geology* 33, 89–92.
- Fagnard, J.-P., 1988. Le gisement Levert à Hallines (Pas-de-Calais). *Révue archéologique de Picardie*, numéro spécial 7, pp. 34–45.
- Féblot-Augustins, J., 1997. La circulation des matières premières au Paléolithique. ERAUL 75. Liège.
- Finlayson, C., Carrión, J., 2007. Rapid ecological turnover and its impact on Neanderthal and other human populations. *Trends in Ecology and Evolution* 22 (4), 213–222.
- Housley, R.A., Gamble, C.S., Street, M., Pettitt, P., 1997. Radiocarbon evidence for the Lateglacial human recolonisation of Northern Europe. *Proceedings of the Prehistoric Society* 63, 25–54.
- Housley, R.A., Gamble, C.S., Pettitt, P., 2000. Reply to Blockley, Donahue and Pollard. *Antiquity* 74, 119–121.
- Jacobi, R., Higham, T., 2011. The Later Upper Palaeolithic recolonisation of Britain: new results from AMS radiocarbon dating. In: Ashton, N., Lewis, S.G., Stringer, C. (Eds.), *The Ancient Human Occupation of Britain*. *Developments in Quaternary Science* 14. Elsevier, London, pp. 223–247.
- Jochim, M., Herhain, C., Starr, H., 1999. The Magdalenian colonization of Southern Germany. *American Anthropologist* 101, 129–142.
- Kozłowski, J.K., 2001. La recolonisation Tardiglaciaire et les changements culturels à la limite Pléistocène-Holocène sur la Grande Plaine. In: Otte, M. (Ed.), *Pré-histoire de la Grande Plaine du Nord de l'Europe*. Actes du Colloque Chaire Franqui interuniversitaire au titre étranger. ERAUL 99. Université de Liège, Liège, pp. 115–127.
- Kozłowski, S.K., Połtowicz-Bobak, M., Bobak, D., Terberger, T., 2012. New information from Maszycka Cave and the Late Glacial recolonisation of Central Europe. *Quaternary International* 272–273, 288–296.
- Leesch, D., Müller, W., Nielsen, E., Bullinger, J., 2012. The Magdalenian in Switzerland: re-colonization of a newly accessible landscape. *Quaternary International* 272–273, 191–208.
- Litt, T., Brauer, A., Goslar, T., Merkt, J., Balaga, K., Müller, H., Ralska-Jasiewiczowa, M., Stebich, M., Negendank, J.F.W., 2001. Correlation and synchronisation of Lateglacial continental sequences in northern central Europe based on annually-laminated lacustrine sediments. *Quaternary Science Reviews* 20, 1233–1249.
- Liu, Z., Otto-Bliessner, B., He, F., Brady, E., Tomas, R., Clark, P., Carlson, A., Lynch-Stieglitz, J., Curry, W., Brook, E., Erickson, D., Jacob, R., Kutzbach, J., Cheng, J., 2009. Transient Simulation of last deglaciation with a new mechanism for Bølling-Allerød warming. *Science* 325, 310–314.
- Lozouet, P., Gautier, A., 1997. Coquillages fossiles et restes de "briquet" dans la Grotte du Bois Laiterie. In: Otte, M., Straus, L.G. (Eds.), *La grotte du Bois Laiterie. Recolonisation magdalénienne de la Belgique*, Liège: ERAUL 80 pp. 319–323.
- Mauger, M., 1994. L'approvisionnement en matériaux siliceux au Paléolithique supérieur. In: Taborin, Y. (Ed.), *Environnements et habitats magdaléniens dans le centre du Bassin Parisien*. Paris, Maison des Sciences de l'Homme, Document d'Archéologie Française 43: 78–93. L'abri de La Fru (Savoie).
- Miller, R., Noiret, P., 2009. Recent results for the Belgian Magdalenian. In: Street, M., Barton, N., Terberger, T. (Eds.), *Humans, Environment and Chronology of the Late Glacial of the North European Plain*, 15th Congress for the International Union of Pre- and Protohistoric Sciences (UISPP), 2–8 September 2006, Lisbon. Verlag des Römisch-germanischen Zentralmuseums Mainz, pp. 39–44.
- Otte, M., Straus, L.G. (Eds.), 1997. *La grotte du Bois Laiterie. Recolonisation magdalénienne de la Belgique*, vol. 80. ERAUL, Liège.
- Rensink, E., 1993. Moving into the North. Universiteit Leiden, doctoral thesis.
- Rozoy, J., 1988. Le Magdalénien en Europe: démographie, groupes régionaux. *Bulletin de la Société préhistorique luxembourgeoise* 10, 139–158.
- Sedlmeier, J., 2010. Die junepaläolithischen Funde aus der mittleren Fundschicht der kastelhöhle in nordwestschweizerischen Kaltbrunnental (Gemeinde Himmelried SO). Ein nachweis für die Begehung der Schweiz durch Mensch und Tier kurz nach dem Kältemaximum der letzten Eiszeit. *Jarbuch der Archäologie Schweiz* 93, 7–34.
- Severinghaus, J.P., Brook, E.J., 1999. Abrupt climate change at the end of the Last Glacial period inferred from trapped air in polar ice. *Science* 286, 930–934.
- Severinghaus, J., Sowers, T., Brook, E., Alley, R., Bender, M., 1998. Timing of abrupt climate change at the end of the Younger Dryas interval from thermally fractionated gases in polar ice. *Nature* 391, 141–146.
- Sima, A., Paul, A., Schulz, M., 2004. The Younger Dryas – an intrinsic feature of late Pleistocene climate change at millennial timescales. *Earth and Planetary Science Letters* 222, 741–750.
- Shakun, J., Carlson, A., 2010. A global perspective on Last Glacial Maximum to Holocene climate change. *Quaternary Science Reviews* 29, 1801–1816.
- Stevens, R., O'Connell, T., Hedges, R.E.M., Street, M., 2009. Radiocarbon and stable isotope investigations at the Central Rhineland sites of Gönnersdorf and Andernach-Martinsberg, Germany. *Journal of Human Evolution* 57 (2), 131–148.
- Street, M., Terberger, T., 1999. The last Pleniglacial and the human settlement of Central Europe: new information from the Rhineland site of Wiesbaden-Igstadt. *Antiquity* 73, 259–272.
- Street, M., Terberger, T., 2004. The radiocarbon chronology of the German Upper Palaeolithic: fifteen years of cooperation with ORAU. In: Higham, T.F.G., Bronk-Ramsey, C., Owen, D.C. (Eds.), *Conference Proceedings, Radiocarbon and Archaeology*, Fourth International Symposium, St. Catherine's College, Oxford, 9–14 April 2002. Oxford University School of Archaeology Monograph 62, pp. 281–302.
- Street, M., Baales, M., Weninger, B., 1994. Absolute Chronologie des späten Paläolithikums und Frühmesolithikums im nördlich Rheinland. *Archäologisches Korrespondenzblatt* 24, 1–28.
- Street, M., Barton, N., Terberger, T. (Eds.), 2009. *Humans, Environment and Chronology of the Late Glacial of the North European Plain*. 15th Congress for the International Union of Pre- and Protohistoric Sciences (UISPP), 2–8 September 2006, Lisbon. Verlag des Römisch-germanischen Zentralmuseums Mainz.
- Street, M., Jöris, O., Turner, E., 2012. Magdalenian settlement in the German Rhineland – an update. *Quaternary International* 272–273, 231–250.
- Taborin, Y., 1993. La parure en coquillage au Paléolithique. CNRS XXXIX, supplement to Gallia-Préhistoire, Paris.
- Taborin, Y., 1994. Environnements et habitats magdaléniens dans le centre du Bassin parisien. *Maison des Sciences de l'Homme*, Paris.
- Terberger, T., Street, M., 2003. New evidence for the chronology of the Aurignacian and the question of pleniglacial settlement in western Central Europe. In: D'Errico, F., Zilhao, J. (Eds.), *The Chronology of the Aurignacian and of the Transitional Technocomplexes, Dating, Stratigraphies, Cultural Implications*. Proceedings of Symposium 6.1 of the XIVth Congress of the U.I.S.P.P. Liège, Belgium September 2001. Lisboa: *Trabalhos de Arqueologia* 33, pp. 213–221.
- Terberger, T., Barton, N., Street, M., 2009. The Late Glacial reconsidered – recent progress and interpretations. In: Street, M., Barton, N., Terberger, T. (Eds.), *Humans, Environment and Chronology of the Late Glacial of the North European Plain*, Tagungsbänder des Römisch-germanischen Zentralmuseums Mainz 6, 189–207. Mainz and Bonn. (Workshop 14 for Commission XXXII, 15th U.I.S.P.P. Congress, Lisbon, September 2006), pp. 189–207.
- Valentin, B., 1995. Les groupes humains et leurs traditions au Tardiglaciaire dans le Bassin Parisien. Apports de la technologie lithique comparée. Université. Paris 1, doctoral thesis.
- Vermeersch, P., 2011. Radiocarbon Palaeolithic Database, Version 12. Available at: <http://ees.kuleuven.be/geography/projects/14c-palaeolithic/index.html>.
- Vermeersch, P., Leuwers, R., Van Peer, P., 1985. Un site magdalénien à Kanne. *Archaeologica Belgica*. NS 1, 17–54.
- Vermeersch, P., Maes, M., 1996. Chronostratigraphy of the Magdalenian at Orp. *Notae Praehistoricae* 16, 87–90.
- Vermeersch, P., Symens, N., 1988. Le Magdalénien de plein-air en Belgique. In: Otte, M. (Ed.), *De la Loire à l'Oder*. BAR S-444, Oxford, pp. 243–258.
- Vermeersch, P., Symens, N., Vyncker, P., Gijelings, G., Lauwers, R., 1987. Orp, site Magdalénien de plein air (comm. de Orp-Jauche). *Archaeologica Belgica* 3, 7–56.
- Vermeersch, P., Vynckier, P., 1980. Un site magdalénien à Orp. *Archaeologica Belgica* 223, 10–14.
- Weber, M.-J., Grimm, S., 2009. Dating the Hamburgian in the context of Lateglacial chronology. In: Crombé, Philippe, Van Strydonck, Mark, Sergant, Joris, Boudin, Mathieu, Bats, Machteld (Eds.), *Chronology and Evolution Within the Mesolithic of North-West Europe: Proceedings of an International Meeting*, Brussels, May 30th–June 1st 2007, Newcastle Upon Tyne: Cambridge Scholars Publishing, pp. 3–21.
- Wenzel, S., 2005. Orp-East: indications for a dwelling. *Notae Praehistoricae* 25, 83–90.
- Williams, C., Flower, B., Hastings, D., Guilderson, T., Quinn, K., Goddard, E., 2010. Deglacial abrupt climate change in the Atlantic warm pool: a gulf of Mexico perspective. *Paleoceanography* 25 (PA4221), 1–12.
- Ziesaire, P., 1994. Le Paléolithique supérieur du Grand-Duché de Luxembourg. Essai de synthèse. *Bulletin de la Société Préhistorique Luxembourgeoise* 16, 97–107.