RADIOCARBON, Vol 51, Nr 2, 2009, p 657–674

RADIOCARBON DATING OF THE WESTERN EUROPEAN NEOLITHIC: COMPARISON OF THE DATES ON BONES AND DATES ON CHARCOALS

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ABSTRACT. The subject of this article is the radiocarbon dating on bones in the western European Neolithic. By gathering ^{14}C dates for 2 examples, one chosen in the middle Neolithic of the Rhine region and the other in the end of the early Neolithic in the same region and in the Paris Basin, a significant gap appears between the sum probabilities of dates on charcoals and the ones obtained with bones. A comparison between these results with the few available dendrochronological dates shows that dates on bones seem too young, while the sequence based on charcoals fits. The existence of too-young ^{14}C dates of bones is not new: this phenomenon was already indicated in previous studies. Most explanations agree that there was a source of contamination, during the sample's burial or its treatment in laboratory. These examples illustrate that consequences can be heavy on a chronology built, partly or entirely, on ^{14}C dates of bones.

INTRODUCTION

The purpose of this paper is to investigate the validity of radiocarbon dates on bones in the western European Neolithic. To treat this question, 2 examples are presented, the former chosen in the middle Neolithic of the Rhine region, the latter taken in the end of the early Neolithic in the Paris Basin and the Rhine Valley. The aim is less to discuss the dating of these contexts than to underline the existence in both examples of series of ^{14}C dates on bones that are too young when compared with the results given by the dendrochronology, whereas the dates on charcoals seem to agree.

THE MIDDLE NEOLITHIC

The starting point of this subject leans on an aspect of a thesis devoted to the archaeological cultures of the middle Neolithic in regions of the Rhine, namely the cultures of Hinkelstein, Grossgartach, and Rössen, and the group of Bischheim (Denaire 2009).

Before considering the ^{14}C dating, it would be useful to briefly discuss these cultures. Chronologically, they take place between the end of the 6th and the first half of the 5th millennium cal BC (Figure 1). During the entire last century, the chronological question was the subject of bitter debate, especially regarding the order in which these cultures succeed one another. The order that is accepted today is based on archaeological data (Meier-Arendt 1969). On this point, ^{14}C dating has played no role.

It is possible to claim that the Hinkelstein culture is largely contemporary with the end of the early Neolithic based on the pits of Forchheim in the southern of Baden region (Stöckl 1994) or the site of Köln-Lindenthal in North Rhineland-Westphalia (Buttler 1935), in which Hinkelstein potsherds were found in association with late Linearbandkeramik ones, as well as the famous grave of Vickletice in Bohemia, in which was found pottery of the Stroke-Ornamented ware culture and 2 other potteries imported from the Rhine Valley. One had typical decoration from the end of the Linearbandkeramik, the other had a decoration similar to Hinkelstein work (Zapotocka 1986). Moreover, Hinkelstein was previously considered as one of the groups at the end of Linearbandkeramik (Meier-Arendt 1975) before being recently categorized as a separate archaeological culture (Spatz 1999).

Studies of the ceramic works (Figure 2), the finery, and the funerary practices have shown that the cultures of Hinkelstein, Grossgartach, and Rössen and the group of Bischheim are genetically

Proceedings of the 5th International ^{14}C and Archaeology Symposium, edited by Irka Hajdas et al.
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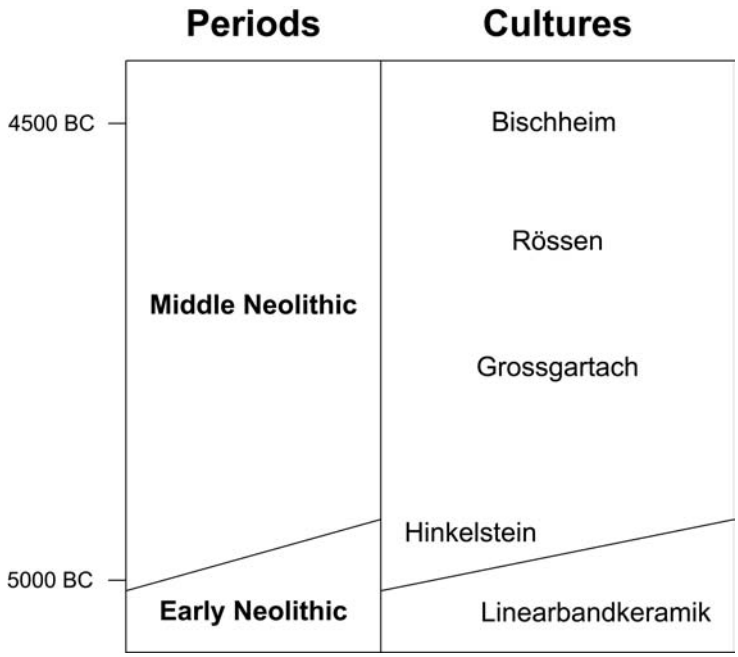

Figure 1 Simplified chronological table of the middle Neolithic for the Rhine region

linked. In addition, stratigraphies in the region of Lake Constance (Dieckmann 1987) and many recuts of pits and graves, especially in Alsace (Denaire 2009), provide proof of the succession Hinkelstein-Grossgartach-Rössen-Bischheim.

More than 170 Hinkelstein sites have been counted (Denaire 2009). Most are located in the Middle Rhine, the Palatinate, the region of the Neckar and the Wetterau, and a few in the north of Alsace, southern Baden, and the Lake Constance region (Figure 3A). This culture is especially known through its graveyards in the Palatinate, like Worms-Rheingewann and Rheindürkheim (Meier-Arendt 1975). Settlements are still unknown, with just a few domestic pits found. During the Grossgartach, the territory grew in a southern direction, to the Upper Rhine plain, the Lower Rhine, and the Moselle Valley as well as central Germany (Figure 3B). About 600 sites are indicated in this area. The quality of the documentation increases also, with large excavations on villages with buildings in the Lower Rhine and with important cemeteries, particularly in Alsace. During the Rössen period, the number of sites remains approximately the same (about 600). The area distribution evolves little, except in central Germany and the Lower Rhine where the density of sites rises (Figure 4A). If only a few funeral contexts were studied, several settlements with houses and enclosures were excavated. The Bischheim is less well known, with 120 sites. The main reason is the difficulty to find settlements of this group: houses are smaller and fewer pits have been dug. Regarding the geographical aspects, Bischheim marks a change with the colonization of the Paris Basin (Figure 4B).

After this short presentation of the archaeological context, let us consider the dating of these 4 cultures. They have together a duration of more than 500 yr. For this resolution (>100 yr), it should be possible to work with ^{14}C dates. In total, 118 ^{14}C measurements were found in the literature for Hinkelstein, Grossgartach, Rössen, and Bischheim (see Table 1, in Appendix). Of course, it is understood that these dates cannot all be usable, and it is necessary to select reliable dates. The cri-

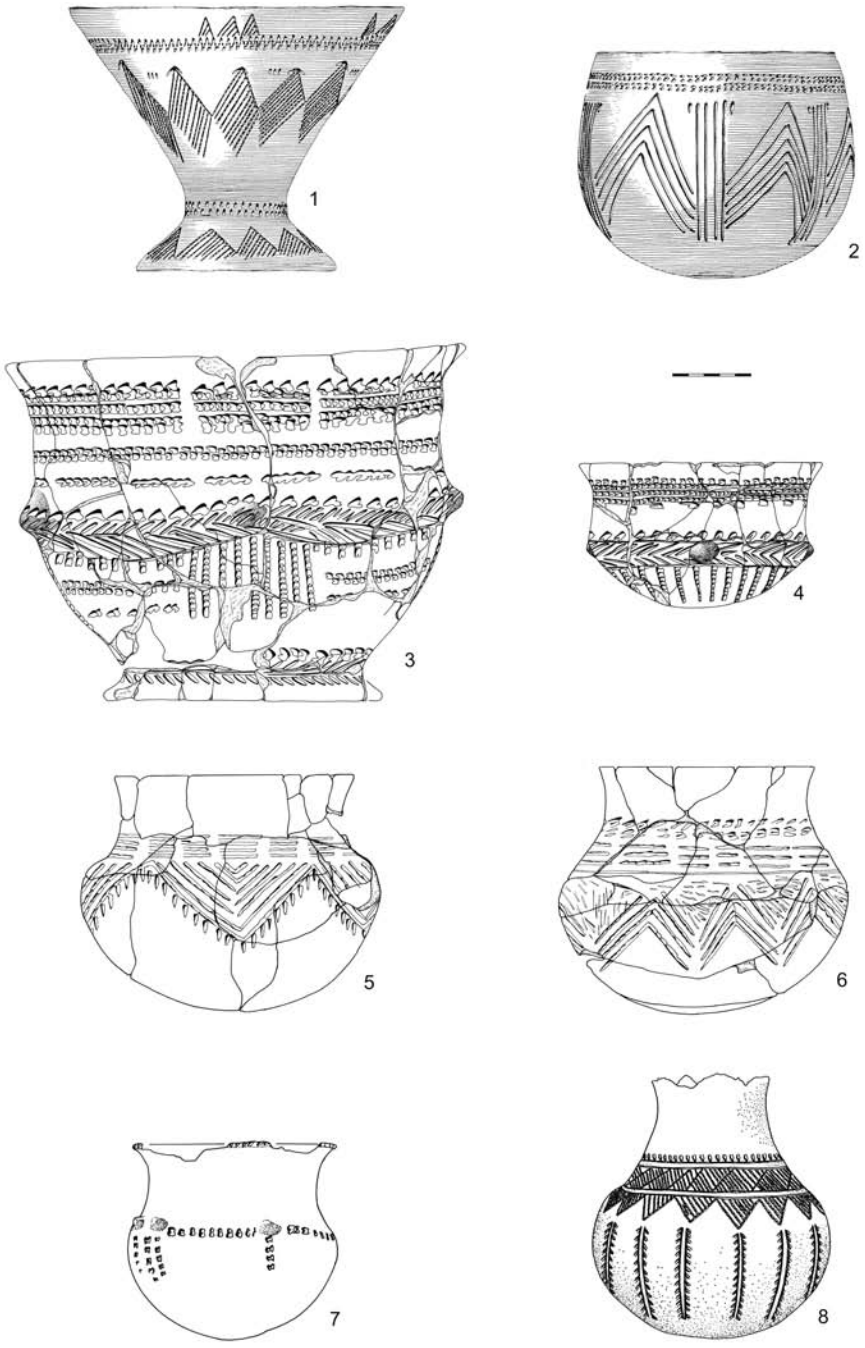

Figure 2 Selection of decorated potteries of the cultures of Hinkelstein (1–2), Grossgartach (3–4), Rössen (5–6) and Bischheim (7–8). 1–2 in Meier-Arendt 1975; 2–6 in Denaire 2009; 7–8 in Jeunesse et al. 2003.

teria are the following. The archaeological context must be certain, and the interval has to be smaller than 100 yr (<±100 yr BP). Finally, the dates affected by evidence of contamination, like the con-

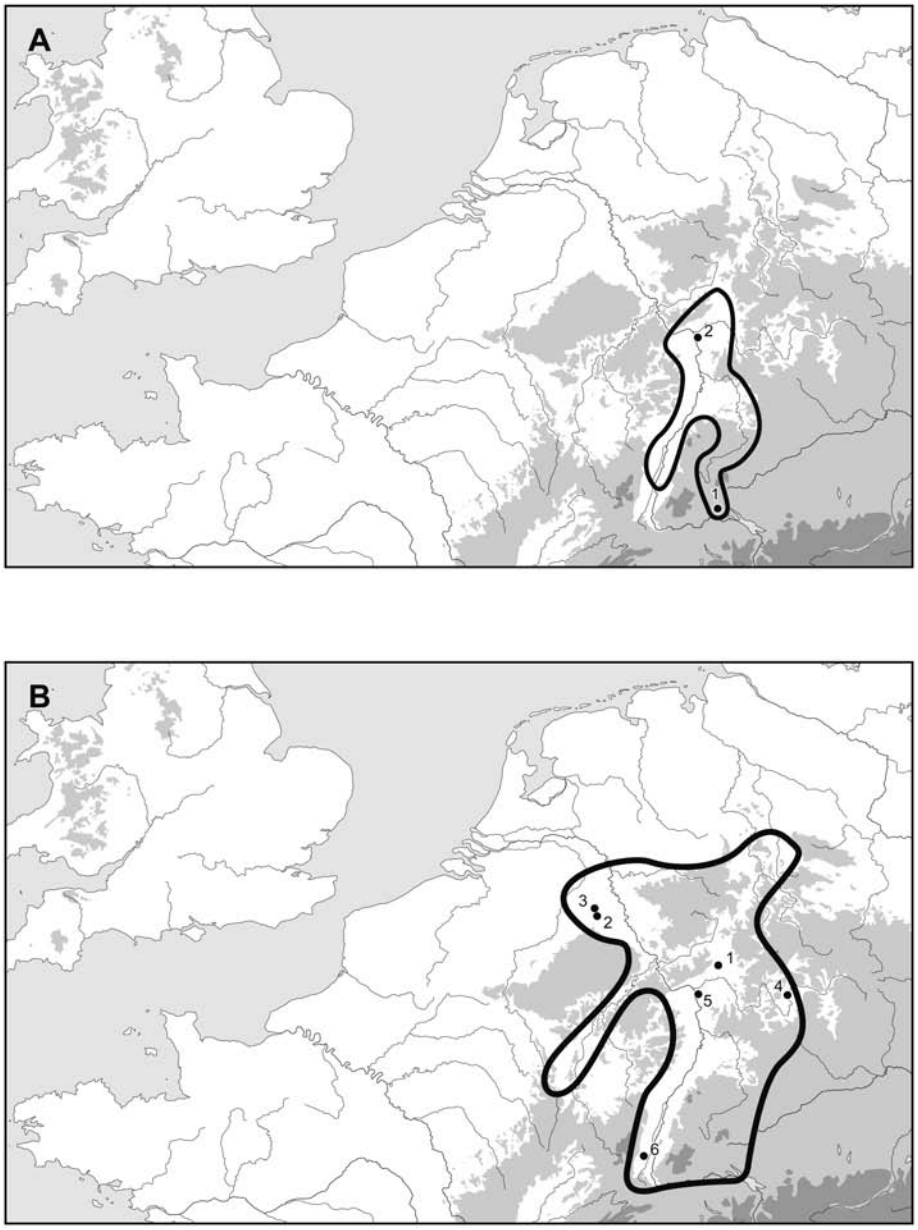

Figure 3 Distribution map of Hinkelstein (A) and Grossgartach (B). A: 1-Mülhausen, 2-Trebur; B: 1-Bad-Nauheim-Steinfurth, 2-Hambach 260, 3-Hasselweiler 2, 4-Schwanfeld, 5-Trebur, 6-Wettolsheim.

ventional measurements on human bones of Trebur, are excluded (Spatz 2001). For example, the 2 dates of Zizers, in the canton of Grisons, cannot be kept since the relation between the samples and Hinkelstein shards is not clear. Furthermore, this site is located more than 100 km from the southern limit of the distribution area for the Hinkelstein culture. It seems that we are not following the case of the Bischheim and Epirössen pottery found in Egolzwil settlements (Doppler 2007), but like the case depicted in Zurich-Mozartstrasse where Grossgartach shards were found in more recent layers than expected (Stöckli 1990). Thus, these ^{14}C samples have also been rejected.

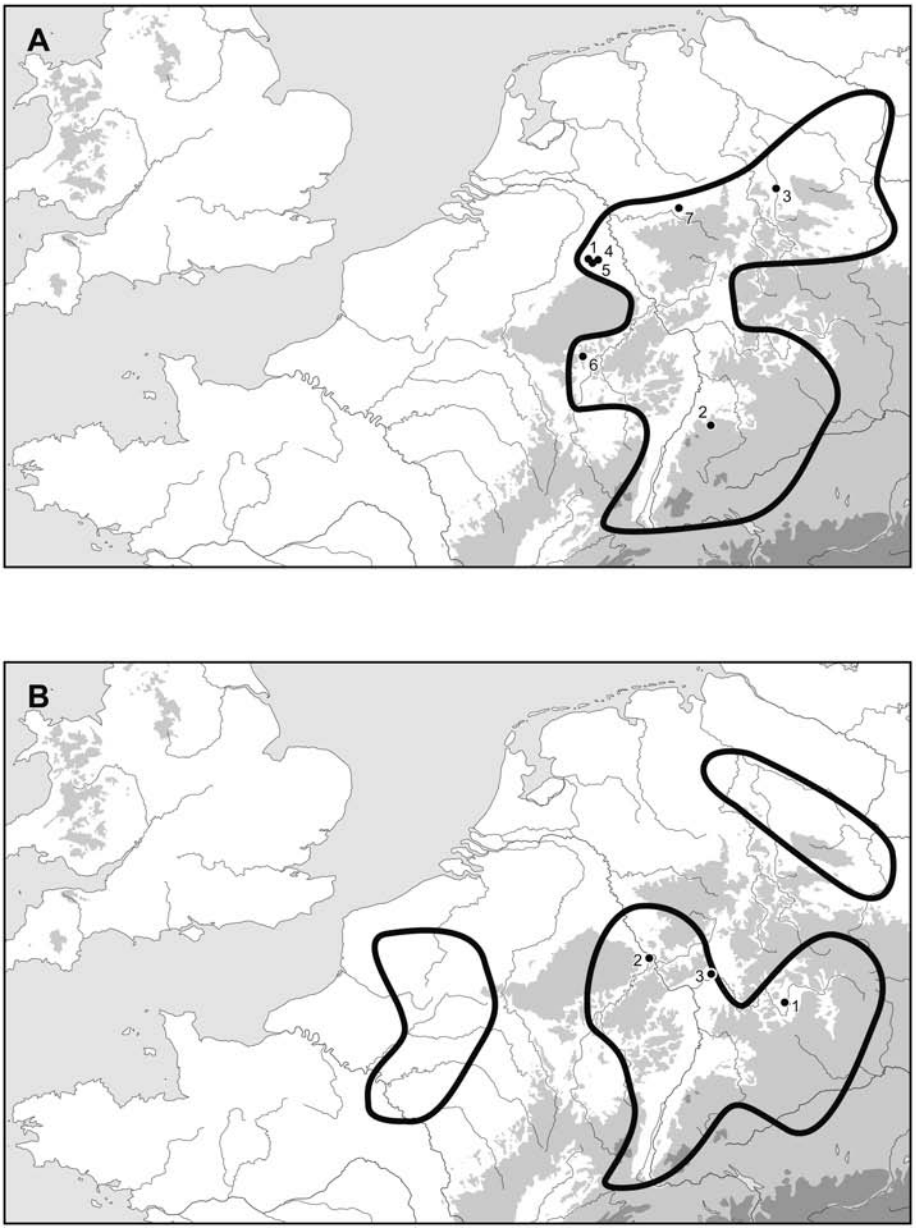

Figure 4 Distribution map of Rössen (A) and Bischheim (B). A: 1-Aldenhoen 1, 2-Deiringsen-Ruploch, 3-Einbeck-Drüber, 4-Hambach 471, 5-Inden 1 and 3, 7-Waldbillig; B: 1-Dittelbach-Schernau, 2-Kärlich, 3-Schwalheim.

From about 100 total dates, only 44 were selected: 8 for Hinkelstein, 12 for Grossgartach, 20 for Rössen, and 4 for the Bischheim. Within this selection, charcoal is the best represented material with about 70% of the samples, with most of the remaining samples from bone.

The sum of the probabilities of all the dates, on charcoals and bones, were calculated with the software OxCal 3.10 (Bronk Ramsey 1995, 2001) (Figure 5) and the IntCal04 calibration curve data

(Reimer et al. 2004). The results must be analyzed. According to observations of the stratigraphies, Hinkelstein is really the first culture and Bischheim the last, but at the expected succession between Grossgartach and Roessen, the ^{14}C sets show a strict contemporaneousness. The phase model function of OxCal software applied on the same dates is of no help. Indeed, it reduces the chronological span of Grossgartach and Roessen to a few years.

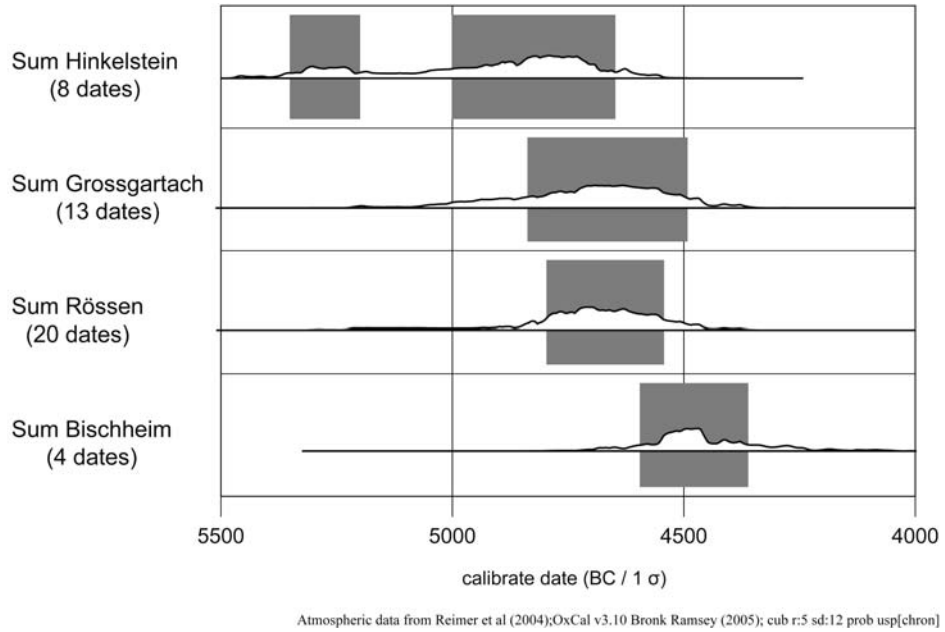

Figure 5 ^{14}C dating of Hinkelstein, Grossgartach, Rössen and Bischheim (all kind of sample). Sum of the probabilities calculated with the software OxCal 3.10.

However, if we sort the dates according to the sample material, the results are more in agreement with the stratigraphies. The sum of the probabilities for the dates on charcoals (Figure 6) shows a succession between Hinkelstein (5370–4990 cal BC, 1 σ), Grossgartach (4900–4600 cal BC), Rössen (4790–4550 cal BC), and the group of Bischheim (4590–4360 cal BC). The partial overlap between Grossgartach and Rössen could be explained by the fact that the available dates of charcoals for Grossgartach concern, according to the ceramic decorations, a young phase of this culture. This succession is confirmed by the phase model function of OxCal, which places the transitions around 4900, 4830/4790, and 4595/4510 cal BC, respectively.

As for the dates on bones, only Hinkelstein and Grossgartach contain information; no measurement on bone is currently available for the Rössen and Bischheim contexts (Figure 7). The sum of the probabilities gives for Hinkelstein and Grossgartach a younger dating than those obtained with dates on charcoals (respectively, 4950–4610 and 4770–4460 cal BC).

It now remains to determine which series is the best to use, which one links best with the end of the early Neolithic and with the period following the Bischheim (the so-called *epirössen* horizon). Luckily, these 2 events are fixed by dendrochronological and ^{14}C dating. Thus, the date of the wood-lined well of Erkelenz-Kückhoven (5057 ± 5 yr; Weiner 1998) allows to place the end of the early Neolithic at 5050–5000 cal BC. As the Hinkelstein is largely contemporary with the end of Linearbandkeramik, the sum of the probabilities should, logically, be mostly before the date supplied by

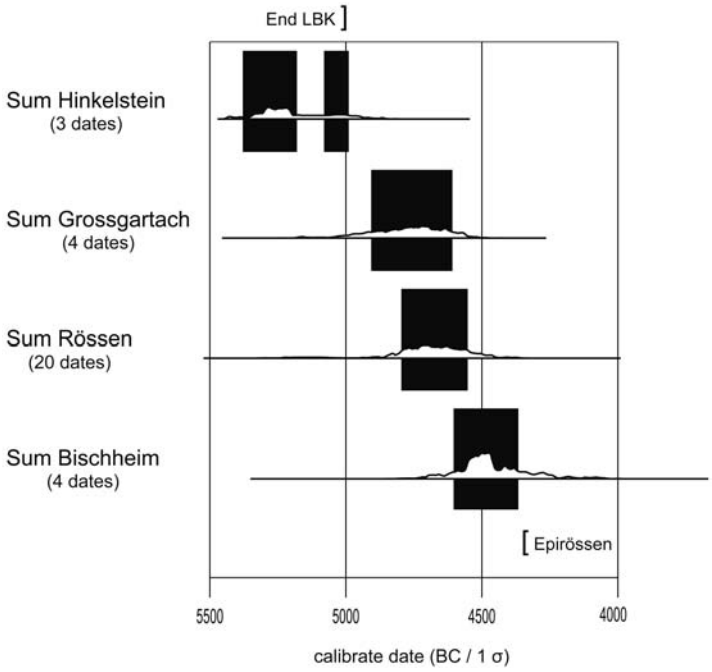

Figure 6 ^{14}C dating on charcoals of Hinkelstein, Grossgartach, Rössen, and Bischheim. Sum of the probabilities calculated with the software OxCal 3.10.

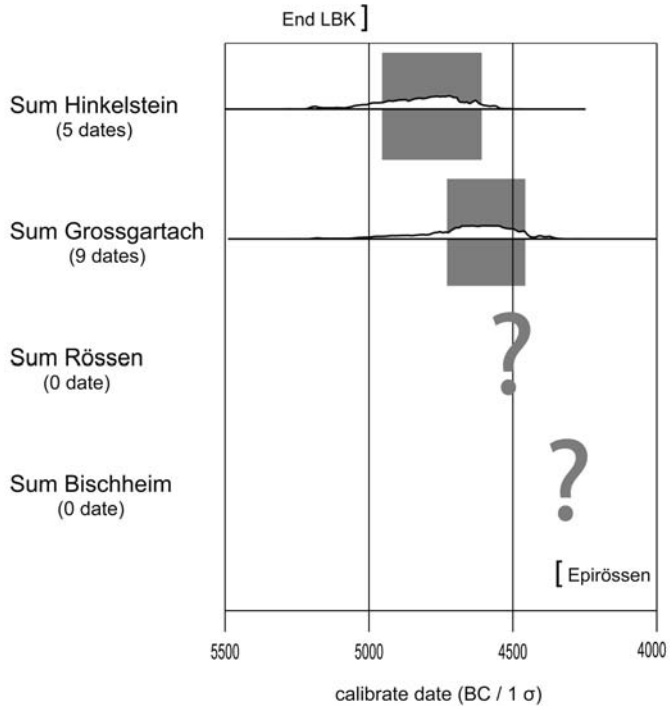

Figure 7 ^{14}C dating on bones of Hinkelstein, Grossgartach, Rössen, and Bischheim. Sum of the probabilities calculated with the software OxCal 3.10.

the well of Kückhoven. By rejecting the dating of Hinkelstein after 4950 cal BC, dates on bones do not agree with this chronological sketch, while those supplied charcoal measurements fit well (Figure 4). Available tree-ring and ^{14}C dates for the *epirössen* horizon place its beginnings towards 4350 cal BC at the latest (Jeunesse et al. 2003:146; Zeeb 1998:147–8). The dates on charcoals articulate well with this terminus (Figure 4). By rejecting dating of the Roessen and the Bischheim after 4500 cal BC, the dates on bone for Grossgartach leave too little span of time for these 2 cultures (<150 yr).

In conclusion, from this first example, it is necessary to emphasize that, contrary to what it is usually expected, the ^{14}C dates on charcoals agree well with the dendrochronology, while dates on bones seem too young.

THE END OF THE LINEARBANDKERAMIK CULTURE

The second example concerns the early Neolithic. It is not my ambition to tackle the difficult question of the ^{14}C dating of the Linearbandkeramik. I am only interested in the end of this culture, more particularly in the Paris Basin and regions of the Rhine, especially North Rhineland-Westphalia, the Middle Rhine, and the Palatinate, and the Neckar Valley (Figure 8). As recent studies support, the end of the Linearbandkeramik can be considered roughly contemporary in these regions (Lefranc 2007:227). A discussion remains concerning the very end of the Linearbandkeramik in the Paris Basin, called the RRBP *final*. Two different points of view exist. The first places the RRBP *final* before the Villeneuve-Saint-Germains (VSG) and the Augy-Sainte-Pallaye (ASP), 2 other cultures of the early Neolithic in the Paris Basin (Figure 9A; Dubouloz 2003). The second considers that the RRBP *récent*, the VSG, and the ASP are largely contemporaneous and rejects placing the RRBP *final* after them (Figure 9B; Jeunesse 1999). In this opinion, the end of the RRBP *final* could be synchronized with the beginning of the Grossgartach horizon. Considering the ^{14}C data, no difference exists between RRBP *récent* and *final* dates. As the context (*récent* or *final*) is not always indicated, both series were treated together.

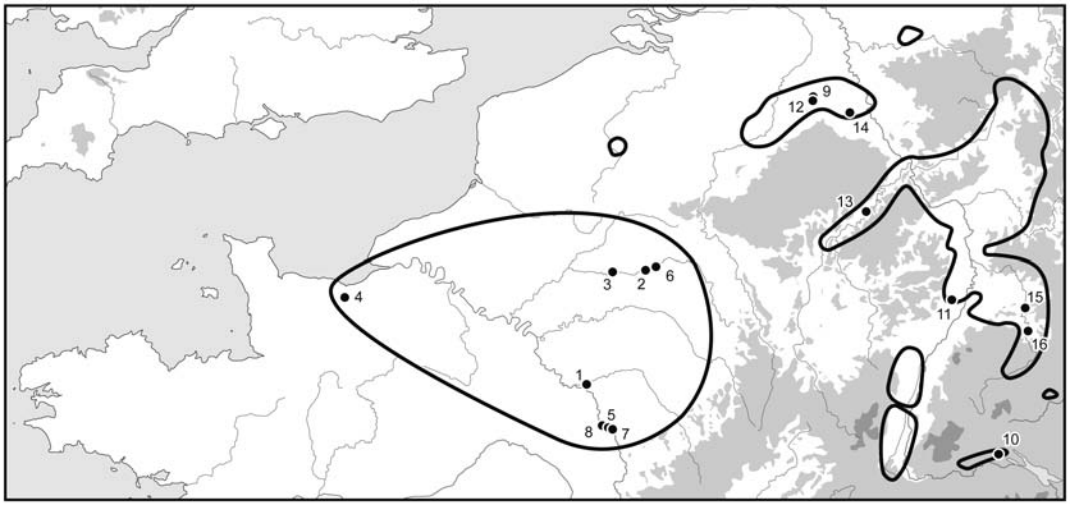

Figure 8 Distribution map of the regional groups of the Linearbandkeramik. A) Paris Basin: 1-Balloy, 2-Berry-au-Bac, 3-Bucy-le-Long, 4-Colombelles, 5-Champlay, 6-Menneville, 7-Passy-sur-Yone, 8-Saint-Julien-du-Saut; B) regions of the Rhine: 9-Aldenhoven-Niedermerz 3, 10-Hilzingen, 11-Herxheim, 12-Langweiler 2, 3, 8 and 9, 13-Mering-Noviand, 14-Müddersheim, 15-Talheim, 16-Stuttgart-Mülhausen.

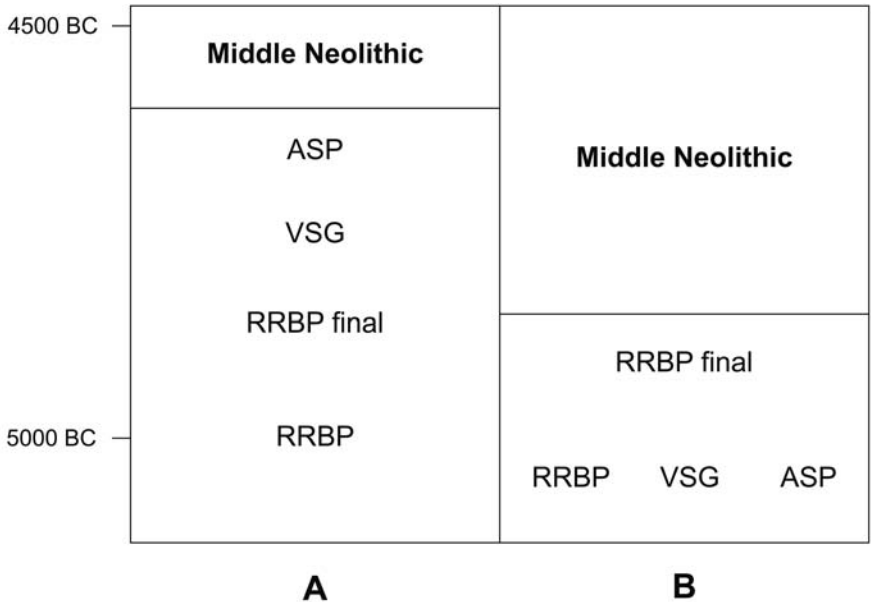

Figure 9 Simplified chronological table of the ancient Neolithic in the Paris Basin

The literature in these regions gives 119 ^{14}C dates for the end of Linearbandkeramik (Table 2, in Appendix). Of the 119, 67 were chosen as reliable, 51 for the regions of the Rhine and 16 for the Paris Basin. The used criteria of selection are the same that previously. This series of dates is dominated by measurements on bone in the Paris Basin, where only 3 dates on charcoals were able to be collected (site of Collombelles) and 3 other dates on crops and hazelnuts. In the regions of the Rhine, dates on bones are as numerous as ones on charcoal (with crops), respectively, 25 and 26 samples. The sum of the probabilities for all the dates gives about the same time span, except that the one for Paris Basin is a little wider (Figure 10).

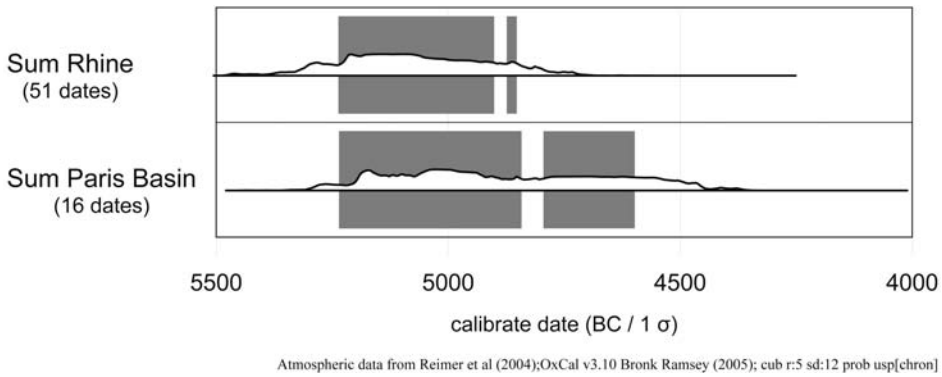

Figure 10 ^{14}C dating of the end of Linearbandkeramik in Paris Basin and the regions of the Rhine (all samples). Sum of the probabilities calculated with the software OxCal 3.10.

As in the previous example, we have separated the dates on bones from those on charcoals (Figure 11). In the Paris Basin and the Rhine region, the chronological interval is approximately the same, before 5000 cal BC. However, with only 6 dates on charcoal and crops, the series of Paris Basin can-

not be compared with the Rhine results without restrictions. New dates are needed to confirm this observation.

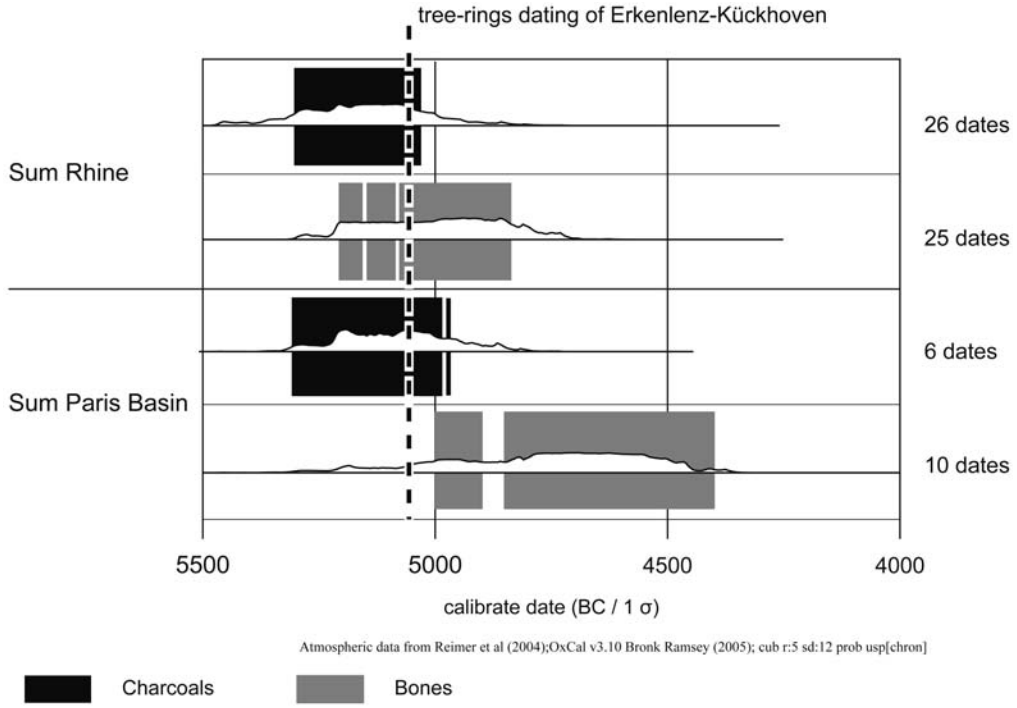

Figure 11 ^{14}C dating on charcoals and bones of the end of Linearbandkeramik in Paris Basin and the regions of the Rhine. Sum of the probabilities calculated with the software OxCal 3.10.

The dates obtained on bones are again younger: 5210–5160, 5150–5090, and 5080–4840 cal BC for regions of the Rhine; 5000–4900 and 4850–4450 cal BC for the Paris Basin. In order the best series between these 2 examples, it is possible to lean again on the dendrochronological date of Erkenlenz-Kückhoven, which allows for the Rhineland to be placed at the end of Linearbandkeramik, towards 5000 cal BC (Spatz 2001). The series that fits best into this sketch—the one which is, for the main part, previous to this tree-ring date—is the series on charcoals, whereas the dates on bones seem too young (Figure 11).

Keeping in mind the discussion above on the relative chronology of the Paris Basin, and if we consider that the date of Erkenlenz could be a reference for this region, one is able to conclude that the dates on charcoals and crops fit well (they give the same result as in the regions of the Rhine); the dating on bones is once again for a large part too young. Even if we opt for a late position of the RRBP *final* in the chronology sequence, it is impossible to support that the end of the Linearbandkeramik takes place after 4800 cal BC in the Paris Basin. The chronological span given by the bone measurements is largely younger: it is contemporaneous with the Rössen culture and a large part of the Bischheim group!

CONCLUSION

First, it is necessary to clarify the limits of the exercise in which we have engaged. Indeed, once the selection of dates is operated, each culture or phase is dated only by a few of measurements, which,

furthermore, come from different regions (Figures 3, 4, and 8). Nothing allows us to prove that the chronology in these regions is strictly the same. Furthermore, a wide part of our argument is based on the tree-ring date of the Kückhoven well. It is not impossible that new dating will bring important modifications, which has already been the case for other contexts (Conscience 2001). We can also discuss the link between the wood-lined well and the shards. Despite these reservations, we can conclude that dates on bones seem too young while those on charcoals fit better. In the example of the middle Neolithic, it is impossible to consider the Grossgartach dates on bone as good ones: they do not leave enough time for the Rössen and Bischheim before the beginning of the epirössen groups.

It is difficult to generalize these observations in other Neolithic contexts: first, only a few contexts possess ^{14}C measurements on bones and charcoals as well as tree-ring dates; second, often it is obvious that dates on charcoals are really too old, influenced by the "old wood" effect. The purpose of this paper is not to reject ^{14}C dates on bones, which are often the only available kind of sample in Neolithic sites, but to stress that this material, whose life is shorter than most of trees' species, is not exempt of problems. Consequences can be heavy on a chronology built, partly or entirely, on ^{14}C dates of bones.

The existence of too-young ^{14}C dates on bones is not new: it has been indicated in archaeological literature on the Neolithic (Spatz 2001) and ancient prehistory (Higham et al. 2006). However, it seems that for the Neolithic, this phenomenon does not concern just 1 or 2 dates, but can affect several samples, with all the consequences that it can have on the construction of a chronology built, partly or entirely, on such dates. The explanations generally advanced discuss problems of contamination during the sample's burial (Spatz 2001) or its treatment in the laboratory (Bronk Ramsey et al. 2004). Moreover, it is regrettable that for most of the dates treated in this paper, no indication specifies the quality of the sample and the procedure followed by the laboratory. Finally, this problem underlines the need for a more intense interdisciplinary cooperation between dating laboratories and archaeologists.

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APPENDIXES

Table 1 ^{14}C dates listed for Hinkelstein, Grossgartach, Rössen, and Bischheim (Jeunesse 1993; Stöckl 1994; Waton and Nilles 1998; Biermann 1997; Jeunesse and Pétrequin 1997; Eisenhauer 2002; Jadin 2003; Jeunesse et al. 2003; Lönne 2003; Stöckli 2002; Spatz 2001).

Site	Structure	Culture	Material	Lab code	Date (BP)	±	Calib. date (cal BC, 1 σ)	Prob. of context	Prob. of contamin.	>±100 yr BP
Mülhausen "Lachen"		HST	charcoal	HD-9504–9244	6505	124	5610–5550			×
Mülhausen "Lachen"		HST	charcoal	HD-9505–5245	6310	80	5470–5200			
Mülhausen "Lachen"		HST	charcoal	HD-9503–9243	6298	48	5315–5220			
Mülhausen "Lachen"		HST	charcoal	HD-9506–9245	6105	58	5210–4940			

Table 1 ^{14}C dates listed for Hinkelstein, Grossgartach, Rössen, and Bischheim (Jeunesse 1993; Stöckl 1994; Waton and Nilles 1998; Biermann 1997; Jeunesse and Pétrequin 1997; Eisenhauer 2002; Jadin 2003; Jeunesse et al. 2003; Lönne 2003; Stöckli 2002; Spatz 2001). *(Continued)*

Site	Structure	Culture	Material	Lab code	Date (BP)	±	Calib. date (cal BC, 1 σ)	Prob. of context	Prob. of contamin.	>±100 yr BP
Trebur	Grab 127	HST	bone	Oxa-5598	6065	70	5060–4840			
Bad Nauheim-Steinfurth		HST?	charcoal	HD-14135	6050	90	5200–4800	×		
Trebur	Grab 132	HST	bone	Oxa-5322	5980	90	4990–4770			
Trebur	Grab 68	HST	bone	Oxa-5321	5945	55	4900–4720			
Zizers		HST	hazelnut	ETH-26644	5935	55	4900–4720	×		
Zizers		HST	hazelnut	ETH-26643	5920	55	4850–4720	×		
Trebur	Grab 108	HST	bone	HD-15671	5893	39	4800–4715		×	
Trebur	Grab 113	HST	bone	HD-15438	5857	31	4780–4700		×	
Trebur	Grab 52	HST	bone	Oxa-5595	5840	55	4790–4610			
Trebur	Grab 107	HST	bone	Oxa-5597	5835	55	4780–4610			
Trebur	Grab 126	HST	bone	HD-14844	5773	31	4690–4585		×	
Trebur	Grab 67	HST	bone	HD-15076	5764	19	4690–4550		×	
Trebur	Grab 42	HST	bone	HD-15227	5738	25	4650–4530		×	
Trebur	Grab 53	HST	bone	HD-14818	5586	26	4455–4365		×	
Trebur	Grab 40	HST	bone	HD-15449	5534	25	4450–4340		×	
Trebur	Grab 120	HST	bone	HD-14946	5493	36	4365–4265		×	
Edingen-Neckarhausen		HST	bone	a	4918	70	3780–3640		×	
Edingen-Neckarhausen		HST	bone	b	4892	72	3770–3630		×	
Schwanfeld	Haus 10	GG	charcoal	KN-3033	6800	370	6100–5350		×	×
Schwanfeld	Haus 10	GG	charcoal	KN-3034	6660	65	5640–5530		×	
Gonvillars	couche XI	GG	charcoal	Gif-469	6250	300	5500–4800			×
Schwanfeld	Grube 800	GG	tempering material	UtC-2323	6620	70	5620–5510		×	
Schwanfeld	Haus 10	GG	charcoal	KN-3035	6050	140	5210–4790		×	×
Wettolsheim	st. 32	GG	bone	Ly-4579	6030	80	5030–4800			
Schwanfeld	Haus 10	GG	charcoal	KN-3038	5940	300	5250–4500		×	×
Hasselweiler 2	Grube 594	GG	charcoal	Kn-2992	5930	65	4900–4720			
Trebur	Grab 17	GG	bone	Oxa-5593	5910	90	4940–4680			
Hasselweiler 2	Grube 165	GG	charcoal +crops	KN-2993	5850	150	4900–4500			×
Hasselweiler 2		GG	?	KN-2994	5840	140	4900–4520			×
Trebur	Grab 58	GG	bone	Oxa-5320	5840	55	4790–4610			
Trebur	Grab 61	GG	bone	HD-15210	5834	22	4770–4620		×	
Hasselweiler 2	Grube 165	GG	charcoal	KN-2995	5830	60	4780–4610			
Schwanfeld	Haus 10	GG	charcoal	KN-3039	5810	65	4730–4550		×	
Trebur	Grab 38	GG	bone	HD-14812	5782	20	4690–4610		×	
Trebur	Grab 21	GG	bone	Oxa-5594	5770	55	4690–4550			
Trebur	Grab 130	GG	bone	Oxa-5599	5760	55	4690–4540			
Trebur	Grab 31	GG	bone	HD-15465	5698	20	4550–4495		×	
Trebur	Grab 106	GG	bone	Oxa-5596	5685	55	4590–4450			
Trebur	Grab 25	GG	bone	HD-15314	5613	24	4490–4370		×	
Trebur	Grab 16	GG	bone	HD-14947	5602	25	4460–4370		×	
Trebur	Grab 60	GG	bone	HD-15450	5520	20	4370–4335		×	
Trebur	Grab 122	GG	bone	HD-15133	5375	27	4330–4170		×	
Moringen-Großenrode	Stelle 1191	GG	charcoal	KN-4415	6600	150	5670–5370			×
Hambach 260	Grube 532	GG	charcoal	KN-2947	6530	150	5620–5360			×
Hambach 260	Grube 718	GG	charcoal	KN-2948	6030	75	5030–4800			
Hambach 260	Grube 732	GG	charcoal	KN-2949	5810	65	4730–4550			

Table 1 ^{14}C dates listed for Hinkelstein, Grossgartach, Rössen, and Bischheim (Jeunesse 1993; Stöckl 1994; Waton and Nilles 1998; Biermann 1997; Jeunesse and Pétrequin 1997; Eisenhauer 2002; Jadin 2003; Jeunesse et al. 2003; Lönne 2003; Stöckli 2002; Spatz 2001). *(Continued)*

Site	Structure	Culture	Material	Lab code	Date (BP)	±	Calib. date (cal BC, 1 σ)	Prob. of context	Prob. of contamin.	>±100 yr BP
Schwanfeld	Haus 10	GG	charcoal	KN-3036	5780	170	4840–4450		×	×
Bad Nauheim-Steinfurth		GG	bone	HV-20258	5765	80	4710–4520			
Schwanfeld		GG	bone	HD-14272	5735	50	4680–4510			
Strasbourg	st. 198	GG	bone	Arc 1470	/	/	4675–4150 (2 σ)	x		
Bad Nauheim-Steinfurth		GG	bone	HV-20256	5665	80	4600–4370			
Bad Nauheim-Steinfurth		GG	bone	HV-20257	5560	100	4520–4270			×
Schwanfeld	Haus 10	GG	charcoal	KN-3032	5420	140	4370–4050		×	×
Schwanfeld	Haus 10	GG	charcoal	KN-3037	5400	300	4550–3800		×	×
Lich-Eberstadt		GG	bone	HV-20259	4980	100	3940–3650			×
Schwanfeld	Grube 800	GG	tempering material	UtC-2324	4380	110	3330–2890		×	×
Moringen-Großenrode	Stelle 2	late GG or early RO	charcoal	HV-16889	6355	140	5490–5080	×		×
Moringen-Großenrode	Stelle 2	late GG or early RO	charcoal	KN-4420	6240	200	5500–4950	×		×
Moringen-Großenrode	Stelle 2	late GG or early RO	charcoal	HV-16633	6115	75	5210–4940	×		
Moringen-Großenrode	Stelle 2	late GG or early RO	charcoal	KN-4421	6050	56	5030–4840	×		
Moringen-Großenrode	Stelle 1143	late GG or early RO	charcoal	KN-4416	5800	48	4720–4590	×		
Moringen-Großenrode	Stelle 2	late GG or early RO	charcoal	KN-4411	5780	100	4730–4500	×		×
Moringen-Großenrode	Stelle 71	late GG or early RO	crops	HV-16632	5630	60	4530–4360	×		
Moringen-Großenrode	Stelle 71	late GG or early RO	charcoal	HV-16631	5515	180	4550–4070	×		×
Inden 1	Grube 985	RO	charcoal	KN-I.524	6180	50	5220–5050			
Waldbillig "Karelslé"		RO	?	Lv-2117	6050	70	5050–4840			
Inden 1	Haus 28	RO	charcoal	KN-I.523	6010	285	5300–4550			×
Moringen-Großenrode "Feldberg"	Stelle 1090	RO	charcoal	KN-4417	5990	180	5250–4650			×
Inden 1	Grube 710	RO	charcoal	KN-I.521	5900	40	4830–4720			
Diekirch		RO	?	Lv-2119	5890	100	4900–4610			×
Deiringsen-Ruploch		RO	charcoal	KN-I.759	5890	75	4900–4680			
Inden 1	Grube 245A	RO	charcoal	KN-I.525	5880	60	4840–4680			
Inden 3	Grube 75	RO	charcoal	KN-2651	5870	60	4830–4620			
Inden 1	Stelle 6	RO	charcoal	KN-I.190	5840	45	4790–4610			

Table 1 ^{14}C dates listed for Hinkelstein, Grossgartach, Rössen, and Bischheim (Jeunesse 1993; Stöckl 1994; Waton and Nilles 1998; Biermann 1997; Jeunesse and Pétrequin 1997; Eisenhauer 2002; Jadin 2003; Jeunesse et al. 2003; Lönne 2003; Stöckli 2002; Spatz 2001). *(Continued)*

Site	Structure	Culture	Material	Lab code	Date (BP)	±	Calib. date (cal BC, 1 σ)	Prob. of context	Prob. of contamin.	>±100 yr BP
Inden 3	Grube 2	RO	charcoal	KN-2650	5830	75	4790–4590			
Inden 3	Grube 77	RO	charcoal	KN-2653	5830	65	4780–4610			
Deiringsen-Ruploch		RO	?	KN-583	5820	120	4310–4530			×
Inden 3	Grube 5	RO	charcoal	KN-2652	5820	60	4770–4590			
Hambach 471		RO	charcoal	KN-3050	5820	60	4770–4590			
Aldenhoven 1	Grube 30	RO	charcoal	KN-I.489	5820	55	4770–4590			
Inden 1	Stelle 41	RO	charcoal	KN-I.517	5820	50	4770–4600			
Inden 1	Grube 1277	RO	charcoal	KN-I.527	5800	95	4780–4540			
Inden 1	Haus 23	RO	charcoal	KN-I.330	5790	50	4710–4580			
Forchheim "Lindenbrunnenbuck"	Fo 12B	RO	charcoal	Kl-3037	5780	120	4780–4490			×
Inden 1	Grube 493A	RO	charcoal	KN-I.520	5750	50	4690–4540			
Einbeck-Drüber "In Bereich der geplanten Straßen-trasse..."	Stelle 88	RO	charcoal	HV-18871	5740	60	4690–4520			
Inden 1	Grube1245A	RO	charcoal	KN-I.526	5720	90	4690–4460			
Inden 1	Grube 1175B	RO	charcoal	KN-I.345	5700	75	4670–4450			
Hambach 471		RO	charcoal	KN-2951	5690	60	4610–4450			
Inden 3	Grube 1	RO	charcoal	KN-2649	5640	145	4670–4340			×
Holzhausen		RO	charcoal	KN-I.379	5630	120	4600–4340			×
Holzhausen		RO	charcoal	KN-1379	5620	120	4620–4340			×
Aldenhoven 1		RO	charcoal	KN-I.346	5540	115	4520–4250			×
Moringen-Großenrode "Feldberg"	Stelle 81	RO	?	HV-16887	5500	250	4650–4000			×
Gondenans	niveau IXb	RO	charcoal	Ly-335	5490	140	4500–4050			×
Gonvillars	couche Xb	RO or BI	charcoal or crops?	Gif-468	5380	250	4500–3900	×		×
Dettelbach-Schernau	St. 36G	RO or BI	charcoal	KN-2112	5750	75	4690–4500	×		
Dettelbach-Schernau	St. 36G	RO or BI	charcoal	KN-2360	5730	130	4690–4460	×		×
Dettelbach-Schernau	St. 38.1	RO or BI	charcoal	KN-2401	5720	110	4680–4480	×		×
Wahlitz		RO or BI	crops	GrN-433	5300	200	4350–3800	×		×
Ittre	fosse 29	BI	charcoal	Lv-1575	5950	150	5050–4610			×
Kärlich		BI	charcoal	GrN-6347	5685	95	4680–4400			
Dettelbach-Schernau	St. 77.5	BI	charcoal	KN-2363	5660	50	4550–4400			
Schwalheim		BI	charcoal	KN-I.568	5660	40	4540–4455			
Ittre	fosse 37	BI	charcoal	Lv-1576	5640	120	4610–4350			×
Guntersblum		BI	?	Fra-96	5640	100	4590–4350			×
Guntersblum		BI	?	Fra-97	5630	100	4560–4350			×

Table 1 ^{14}C dates listed for Hinkelstein, Grossgartach, Rössen, and Bischheim (Jeunesse 1993; Stöckl 1994; Waton and Nilles 1998; Biermann 1997; Jeunesse and Pétrequin 1997; Eisenhauer 2002; Jadin 2003; Jeunesse et al. 2003; Lönne 2003; Stöckli 2002; Spatz 2001). *(Continued)*

Site	Structure	Culture	Material	Lab code	Date (BP)	±	Calib. date (cal BC, 1 σ)	Prob. of context	Prob. of contamin.	>±100 yr BP
Berry-au-Bac "LCM"		BI	charcoal	Ly-2326	5530	320	4500–3750			×
Dettelbach-Schernau	St. 77.4	BI	charcoal	KN-2361	5470	85	4450–4230			
Berry-au-Bac "LCM"		BI	charcoal	Ly-2371	5340	130	4330–4040			×
Ittre	fosse 39	BI	charcoal	Lv-1577	5330	200	4370–3940			×
Berry-au-Bac "LCM"		BI	charcoal	Ly-2370	5330	130	4330–4040			×
Ittre	fosse 48	BI	charcoal	Lv-1619	5180	100	4230–3800			×
Berry-au-Bac "LCM"		BI	charcoal	Ly-2329	5100	160	4050–3690			×

Table 2 ^{14}C dates listed for the end of Linearbandkeramik in the Paris Basin, North Rhineland-Westphalia, the Middle Rhine, the Palatinate, and the Neckar Valley (Stöckli 2002; Dubouloz 2003; Jadin 2003).

Site	Structure	Material	Lab code	Date (BP)	±	Date (cal BC, 1 σ)	Prob. of contamination	>±100 yr BP
Balloy	fosse 1	bone	Oxa-4078	6180	90	5290–5000		
Balloy	fosse 8	bone	Ly-5542	5680	60	4600–4450		
Balloy	fosse 13	bone	Ly-5541	5770	60	4690–4540		
Balloy	fosse 17	bone	Ly-5540	5720	85	4690–4460		
Balloy	sép. 20	bone	Ly-5883	6220	160	5360–4980		×
Barbey		bone	Ly-5880	5670	110	4660–4360		×
Berry-au-Bac "La Croix Maigret"	fosse 124	bone	Ly-62327	6030	130	5210–4770		×
Berry-au-Bac "Le Chemin de la Pêcherie"	fosse 201	hazelnut	Oxa-6686	6080	45	5190–4910		
Bucy-le-Long "La fosse-Tounise"	fosse 23	bone	GiF-A97057	5900	90	4910–4620		
Bucy-le-Long "La Fosse-Tounise"	fosse 159	bone	Ly-6478	5870	105	4880–4590		×
Bucy-le-Long "La Héronnière"	fosse 124	crops	Oxa-6642	6250	55	5310–5070		
Bucy-le-Long "La Héronnière"	fosse 124	bone	Orstom-1082	5780	70	4710–4540		
Colombelles		charcoal	Colombelles1	6150	40	5210–5040		
Colombelles		charcoal	Colombelles2	6150	40	5210–5040		
Colombelles		charcoal	Colombelles3	6140	40	5210–5000		
Cuiry-lès-Chaudardes	fosse 230	bone	Ly-1736	6450	160	5610–5220		×
Cuiry-lès-Chaudardes	fosse 246	bone	Ly-1737	6220	230	5500–4850		×
Cuiry-lès-Chaudardes	fosse 311	bone	Ly-2331	6000	120	5040–4720		×
Cuiry-lès-Chaudardes	fosse 357	bone	Ly-2333	5980	110	5000–4720		×
Cuiry-lès-Chaudardes	fosse 295	bone	Ly-2321	5960	170	5200–4600		×
Cuiry-lès-Chaudardes	fosse 375	bone	Ly-2336	5960	150	5060–4620		×
Cuiry-lès-Chaudardes	fosse 175	bone	Ly-1829	5930	190	5040–4550		×
Cuiry-lès-Chaudardes	fosse 324/325	bone	Ly-2330	5910	130	4950–4610		×
Cuiry-lès-Chaudardes	fosse 27	bone	Ly-1827	5880	300	5250–4400		×
Cuiry-lès-Chaudardes	fosse 378-1	bone	Ly-2335	5840	140	4900–4520		×
Cuiry-lès-Chaudardes	fosse 378-2	bone	Ly-2551	5870	175	4950–4520		×
Cuiry-lès-Chaudardes	fosse 321	bone	Ly-2332	5800	170	4850–4450		×
Cuiry-lès-Chaudardes	382	bone	Ly-2552	5730	170	4770–4360		×

Table 2 ^{14}C dates listed for the end of Linearbandkeramik in the Paris Basin, North Rhineland-Westphalia, the Middle Rhine, the Palatinate, and the Neckar Valley (Stöckli 2002; Dubouloz 2003; Jadin 2003). *(Continued)*

Site	Structure	Material	Lab code	Date (BP)	±	Date (cal BC, 1 σ)	Prob. of contamination	>±100 yr BP
Champlay	fosse 2	bone	Ly-9511	5920	40	4840–4720		
Champlay	fosse 4	bone	Ly-9510	5850	50	4790–4610		
Compiègne	fosse 2	bone	Ly-2716	6080	110	5210–4840		×
Compiègne	fosse 4	bone	Ly-2720	5950	120	5000–4690		×
Compiègne	fosse 3	bone	Ly-2717	5920	260	5250–4450		×
Menneville	fosse 13	bone	Ly-1735	6200	190	5370–4910		×
Menneville	fosse 1	bone	Ly-1734	6140	190	5300–4840		×
Menneville	fosse 13	bone	Ly-2324	6110	140	5220–4840		×
Menneville	fosse 40	crops + pitch	O×a-6644	6040	55	5000–4840	×	
Menneville	fosse 19	bone	Ly-2322	6030	130	5210–4770		×
Menneville	fosse 40	noisette	Oxa-6646	6025	55	4990–4840		
Menneville	fosse 39	crops + pitch	Oxa-6645	5985	55	4940–4790	×	
Menneville	fosse 39	bone	Ly-2323	5860	190	4950–4350		×
Passy-sur-Yone	fosse 6	bone	Ly-3447	6400	180	5560-5080		×
Passy-sur-Yone	fosse 6	bone	Ly-8823	6065	55	5050–4850		
Saint-Juliens-du-Saut	fosse 28	bone	537(Oxa)	6055	55	5040–4850		
Aldenhoven-Niedermerz 3	Grab 31	charcoal	KN-2125	5830	150	4850–4490		×
Aldenhoven-Niedermerz 3	Grab 26	charcoal	KN-I.531	6070	95	5210–4840		
Aldenhoven-Niedermerz 3	Grab 34	charcoal	KN-2286	6180	120	5300–4990		×
Aldenhoven-Niedermerz 3	Grab 23	charcoal	KN-I.530	6190	65	5230–5040		
Aldenhoven-Niedermerz 3	Grab 81	charcoal	KN-2284	6190	100	5300–5010		×
Aldenhoven-Niedermerz 3	Grab 57	charcoal	KN-2124	6210	60	5300–5060		
Aldenhoven-Niedermerz 3	Grab 2	charcoal	KN-2285	6280	185	5470–5040		×
Hilzingen	Grube 375	charcoal	HD-9910/9751	5800	110	4790–4530		×
Hilzingen	Grube 370	charcoal	HD-9906/9733	5990	180	5250–4650		×
Hilzingen	Grube 338	crops	HD-9913/9765	6000	50	4950–4800		
Hilzingen	Grube 3842	charcoal	HD-9907/9734	6100	95	5210–4910		
Hilzingen	Grube 395	charcoal	HD-9912/9760	6125	85	5210–4960		
Hilzingen	Grube 338	charcoal	HD-9914/9766	6130	45	5210–4990		
Hilzingen	Grube 3902	charcoal	HD-9909/9750	6130	110	5220–4930		×
Hilzingen	Grube 338	charcoal	HD-9904/9731	6160	50	5210–5050		
Hilzingen	Grube 335	charcoal	HD-9905/9732	6210	100	5300–5050		×
Hilzingen	Grube 334	charcoal	HD-9911/9752	6230	80	5310–5060		
Hilzingen	Grube 3663	charcoal	HD-9908/9748	6270	80	5330–5070		
Herxheim	Graben 281-14	bone	Vera-1826	6145	35	5210–5020		
Herxheim	Graben 281-117	bone	Vera-1827	6165	40	5210–5050		
Herxheim	Graben 282-7	bone	Vera-1828	6190	30	5220–5070		
Herxheim	Graben 282-86	bone	Vera-1829	6995	35	5980–5840	×	
Herxheim	Grube 296	bone	Vera-1830	6195	35	5220–5070		
Langweiler 2	Grube 785	charcoal	KN-2298	5990	140	5190–4700		×
Langweiler 2	Grube 989	charcoal	KN-I.910	6070	120	5210–4830		×
Langweiler 2	Grube 989	charcoal	KN-I.911	6070	120	5210–4830		×
Langweiler 2	Grube 800-3	crops	Oxa-2898	6170	60	5220–5040		
Langweiler 2	Grube 100-6	crops	Oxa-2896	6190	60	5220–5050		
Langweiler 2	Grube 160	charcoal	KN-2300	6200	90	5300–5040		
Langweiler 2	Grube 785-14	crops	Oxa-2897	6230	69	5300–5070		

Table 2 ^{14}C dates listed for the end of Linearbandkeramik in the Paris Basin, North Rhineland-Westphalia, the Middle Rhine, the Palatinate, and the Neckar Valley (Stöckli 2002; Dubouloz 2003; Jadin 2003). *(Continued)*

Site	Structure	Material	Lab code	Date (BP)	±	Date (cal BC, 1 σ)	Prob. of contamination	>±100 yr BP
Langweiler 2	Grube 284	charcoal	KN-2301	6340	70	5470–5220		
Langweiler 3	Grube 0017	charcoal	KN-I.665	6180	60	5220–5050		
Langweiler 8	Grube 3813-7	crops	Oxa-2900	6160	60	5220–5040		
Langweiler 8	Grube 2677	charcoal	KN-2988	6250	190	5470–4980		×
Langweiler 8	Grube 2799-16	crops	Oxa-2899	6290	70	5370–5200		
Langweiler 8	Grube 412	charcoal	KN-2990	6300	95	5470–5070		
Langweiler 8	Grube 3961	charcoal	KN-2985	6340	160	5480–5070		×
Langweiler 8	Grube 4521	charcoal	KN-2991	6380	160	5520–5080		×
Langweiler 8	Grube 3930	charcoal	KN-2981	6760	150	5800–5530		×
Langweiler 9	Grube 616-6	charcoal	KN-2698	5930	145	5000–4610		×
Langweiler 9	Grube 561	charcoal	KN-2691	6010	150	5210–4710		×
Langweiler 9	Grube 1061	charcoal	KN-2488	6210	65	5300–5050		
Langweiler 9	Grube 146-108	crops	Oxa-2901	6250	60	5310–5070		
Langweiler 9	Grube 1431	charcoal	KN-2697	6370	210	5530–5060		×
Langweiler 9	Grube 1062	charcoal	KN-2496	6520	155	5620–5340		×
Langweiler 9	Grube 1301	charcoal	KN-2694	6620	150	5710–5460		×
Langweiler 9	Grube 1090	charcoal	KN-2695	7090	135	6080–5800		×
Langweiler 9	Grube 561	charcoal	KN-2693	7130	155	6210–5840		×
Maring-Noviand	Oxa-6651	crops	Oxa-6651	6060	55	5050–4850		
Müddersheim		charcoal	H-924a/1393	6150	90	5220–4980		
Müddersheim		charcoal	KN-I.006	6210	50	5290–5060		
Müddersheim		charcoal	H-924b/1121	6330	80	5470–5210		
Talheim		bone	HD-8827/8606	5960	80	4950–4720		
Talheim		bone	HD-8828/8607	6045	60	5020–4840		
Stuttgart-Mühlhausen	Grab 26	bone	HD-7935/7761	5910	50	4840–4720		
Stuttgart-Mühlhausen	Grab 26	bone	HD-7974/7762	5950	60	4930–4720		
Stuttgart-Mühlhausen	Grab 21	bone	HD-8099/8006	5970	70	4950–4770		
Stuttgart-Mühlhausen	Grab 40	bone	HD-7949/7757	5990	40	4940–4800		
Stuttgart-Mühlhausen	Grab 21	bone	HD-8097/8005	5990	60	4950–4790		
Stuttgart-Mühlhausen	Grab 6	bone	HD-8096/8004	6000	55	4960–4800		
Stuttgart-Mühlhausen	Grab 40	bone	HD-7963/7759	6010	50	4980–4830		
Stuttgart-Mühlhausen	Grab 36	bone	HD-7920/7766	6040	50	5000–4840		
Stuttgart-Mühlhausen	Grab 6	bone	HD-8087/8003	6040	60	5010–4840		
Stuttgart-Mühlhausen	Grab 47	bone	HD-7994/7770	6050	60	5030–4840		
Stuttgart-Mühlhausen	Grab 21	bone	HD-8152/8007	6070	40	5050–4910		
Stuttgart-Mühlhausen	Grab 40	bone	HD-7918/7758	6090	50	5200–4930		
Stuttgart-Mühlhausen	Grab 47	bone	HD-7993/7769	6100	60	5210–4930		
Stuttgart-Mühlhausen	Grab 26	bone	HD-8031/7760	6100	70	4210–4930		
Stuttgart-Mühlhausen	Grab 79	bone	HD-7977/7763	6130	45	5210–4990		
Stuttgart-Mühlhausen	Grab 36	bone	HD-7980/7768	6135	90	5220–4960		
Stuttgart-Mühlhausen	Grab 36	bone	HD-7950/7767	6140	100	5220–4950		×
Stuttgart-Mühlhausen	Grab 47	bone	HD-7995/7771	6190	45	5220–5060		
Stuttgart-Mühlhausen	Grab 79	bone	HD-7979/7765	6210	45	5290–5060		
Stuttgart-Mühlhausen	Grab 79	bone	HD-7978/7764	6220	45	5300–5070		