RADIOCARBON DATES OF THE EARLIEST NEOLITHIC IN CENTRAL EUROPE

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ABSTRACT. I discuss here a series of radiocarbon dates from sites of the earliest phase of the Linearbandkeramik (LBK) culture. The samples were collected during excavations directed by Prof. Jens Lüning (Frankfurt am Main) between 1979 and 1987. The samples were mainly charcoal, including cereals and food remains, but bones and potsherds containing organic temper were also included in the study. Although the results on cereal, bone and food remains were consistent, almost all differed from those measured on charred wood. From a series of dates measured by accelerator mass spectrometry (AMS) on organic temper in potsherds, variable amounts of sample contamination were observed, probably deriving from the natural organic components of the clay used in the ceramic production. By critically evaluating ^{14}C dates, individual activities on the sites were dated as accurately as possible. A chronological framework could then be established for the earliest phase of the LBK culture. The dating results provided information on taphonomic processes.

INTRODUCTION

The Earliest Linearbandkeramik Culture

The early Neolithic period in Central Europe is represented by the Linearbandkeramik (LBK) culture. Traditionally, prehistoric cultures are defined typologically, mainly by pottery decoration and form, as well as by specific stone artifacts. Typical features are alignments of postholes, which mark the interred construction elements of longhouses and refuse pits where artifacts are found. The LBK culture is characterized by the domestication of plants and animals, contrasting with earlier Mesolithic hunter-and-gatherer communities.

Although many studies on the LBK culture have been made (Soudský 1962; Lüning 1982; Modderman 1988), little was known of the earliest phase defined by H. Quitta (1960). From 1979–1987, J. Lüning (Frankfurt am Main) excavated 10 sites in Germany and two in Austria to find "The Earliest Linearbandkeramik Culture in Central Europe" (Fig. 1). The fact that these sites spread over a vast geographical area made data interpretation difficult. The sites varied in size: at Schwanfeld, 7500 m^2 were excavated, whereas the other excavations range from 1000 to 3000 m^2. Many samples were ^{14}C-dated from these sites. Of the resulting 100 dates, measured between 1982 and 1992, 14 samples belonged to structures of younger periods (Stäuble 1994). As the samples were of six different materials measured in as many laboratories, the results were difficult to evaluate, but, on the other hand, offered the possibility of cross-checking the varying results.

Aims and Problems of Radiocarbon Dating Archaeological Contexts

When dating typologically defined archaeological cultures, sites or single activities, isolating representative results from ones that do not fit our expectations is always a problem. If one accepted only those dates belonging to the period already known, the ^{14}C method would hold no value. Although dates that differ substantially from expectations are also problematic, I focus here on those that deviate only slightly. However, all results must be considered, as they are sometimes the only clue to the formation of deposits.

The reasons for outlying dates should be sought in sampling strategies, chemical preparation, the measurement itself, calibration of the result, or the archaeological interpretation. Other consider-

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Proceedings of the 15th International ^{14}C Conference, edited by G. T. Cook, D. D. Harkness, B. F. Miller and E. M. Scott. RADIOCARBON, Vol. 37, No. 2, 1995, P. 227–237

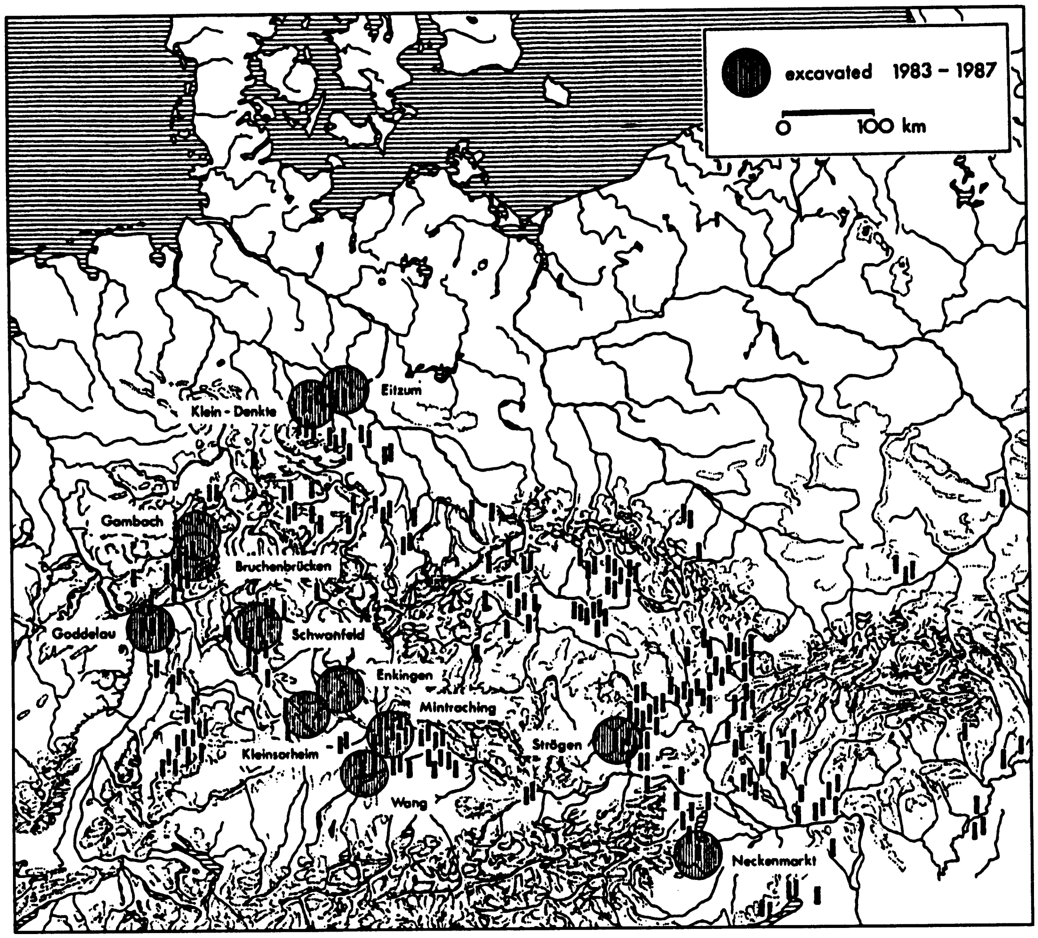


Fig. 1. Distribution of the Earliest LBK sites (▌) (updated from Quitta 1960). ◍ = sites excavated during this project.

ations in interpreting a result are fluctuations in atmospheric ^{14}C content, sample materials and sample size. The main questions facing archaeologists are the nature of the material dated and the interpretation of their context, which relates to depositional and post-depositional activities. Thus, there is a problem of reliability, because it is difficult to know if the ^{14}C-dated material indeed represents the activity of the period under study, or that of an older disturbance, or a younger intrusion. Thus, each sample must be analyzed individually (Waterbolk 1971). This was also important for the Earliest LBK culture project, as one of the aims for using ^{14}C dating was to check whether the absolute dates of typologically different sites matched their relative chronological interpretation. In this way, one can decide whether processes inferred from archaeological material are either sequential or simultaneous (Whittle 1988). ^{14}C dating can define the chronological boundaries that enable the archaeologist to trace the process of development of a culture.

Dating Different Sample Materials

As finding undisturbed prehistoric activities *in situ* is extremely rare, direct ^{14}C dating of artifacts is ideal. Dates on pottery should be considered reliable, as they usually represent the archaeological culture itself. However, other problems arise in the direct dating of pottery, to which I refer below. Reliable results may also be obtained from food or other organic remains on pottery. Bone from domesticated animals or carbonized cereals also provide a direct answer to the absolute age of the phenomenon they represent. Wood charcoal, the material most often used in ^{14}C dating, offers less reliability. For the LBK culture, one is rarely able to determine the precise activity that caused the wood charring. There is no reliable method—except the ^{14}C method itself—to determine whether the charcoal represents human activity or is the result of a natural process. For the earliest Neolithic, the reliability of dating bones and cereals is better, for they could only be younger intrusions.

The living age of the dated material (Evin 1983) should also be considered. Charcoal of wood can be older than the activity being dated by hundreds of years if it does not come from branches or twigs (*e.g.*, Waterbolk 1971; Cahen and Gilot 1983; Breunig 1987). This is particularly true for oak. Attempts to solve this problem in a general manner (Neustupný 1968) cannot succeed, as there are too many variables. Thus, each wood sample must be evaluated individually (Warner 1990).

RESULTS AND DISCUSSION

Dating Individual Sites and Activities

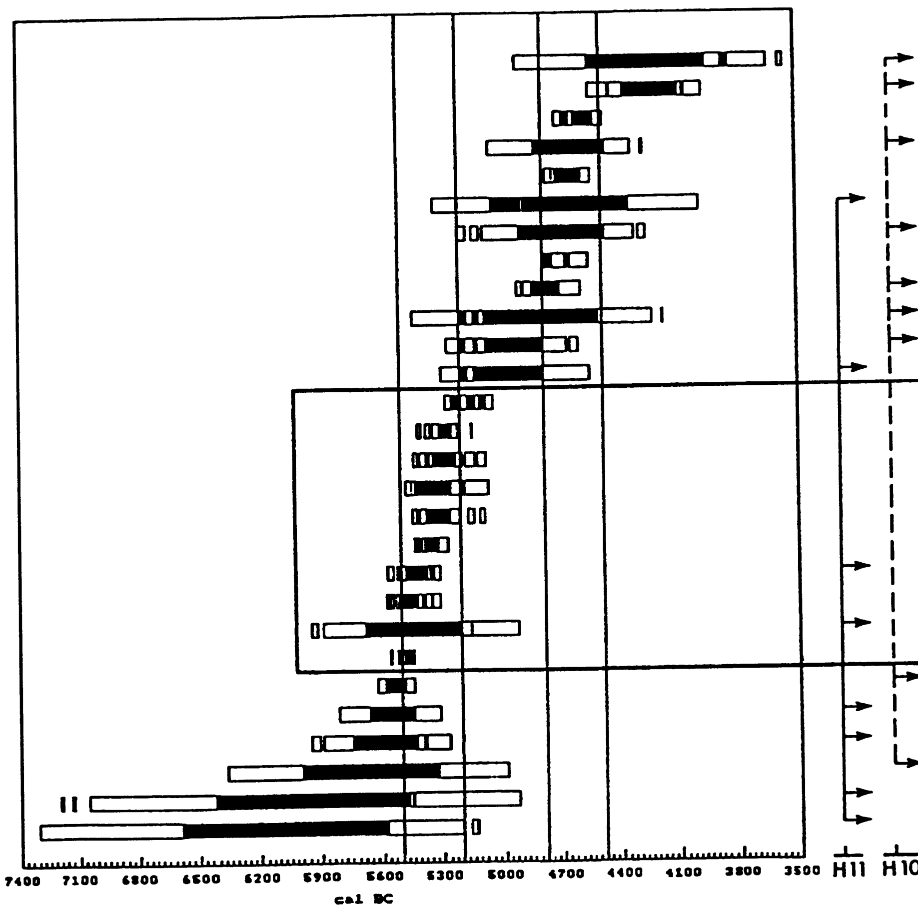
I used the CALIB 3.03 program (Stuiver and Reimer 1993) to calibrate single dates. The calibrated period is always the 68.3% range. For calibrating groups of dates, I used the program of B. Weninger (1986, version April 1993).

If we evaluate the ^{14}C dates from the 12 sites of the Earliest LBK examined in the project (Fig. 1), the sites' existence can be traced to no earlier than *ca.* 5500 cal BC. The earliest reliable Neolithic date for Central Europe is Hd-14219: 6580 ± 20 BP (5521–5444 cal BC). The sample was taken from the right femur of a man *ca.* 30 yr old, buried at the bottom of a long pit of a house from Schwanfeld (Lüning 1986). As this site was the largest and most intensively studied LBK component, undisturbed by younger phases, we also expected to have dated the longest sequence (Fig. 2). The ^{14}C-dated bones, cereals and one sample of food encrustation on a potsherd were found in structures belonging to 6 of the 11 house plans. The samples date the Earliest LBK activities at this settlement between *ca.* 5500 and 5200 cal BC (Fig. 2); one bone date (Hd-14032) could be even younger.

The relatively large number of charred wood samples from Earliest LBK pits in Schwanfeld extend beyond the period determined through short-lived material (Fig. 2, *e.g.*, H11). Samples from postholes belonging to one Middle Neolithic house also show that they date back to the LBK and earlier (Fig. 2, H10). Apart from the low carbon content (mostly <1% C), some fragments were from old wood and some were from younger intrusions. These samples hold no value without information on identification (*e.g.*, inner *vs.* outer rings of wood, branch *vs.* trunk) and sample quality.

The ^{14}C date of a horse bone (Hd-14272: 5735 ± 50 BP, 4676-4515 cal BC) from a typical Middle Neolithic pit complex confirms the archaeological date to the Grossgartach culture (Fig. 2). Two other bone fragments from cattle date to the same period (Hd-14394: 5820 ± 45 BP and Hd-14177: 5785 ± 45 BP), but were found in Earliest LBK features (long pits of Houses 8 and 16, Fig. 2). As the settlements overlap, this would not be surprising, but these features were not disturbed by Middle Neolithic artifacts (*e.g.*, ceramics), even if they are typologically distinguishable. I would interpret the two results not as erroneous measurements, but as unrecognized disturbances of the Earliest LBK structures during the Grossgartach culture.

The same type of situation occurred in Eitzum (Fig. 1). Three bone samples, 1 from a long pit of a house (Hd-14374: 5780 ± 45) and 2 from a ditch (Hd-14545: 5715 ± 40 and Hd-14373: 4560 ± 55),



Sample ID	AGE BP		mat.	feat.
KN-3037	5400	300	wood	ph H10
KN-3032	5420	140	wood	ph H10
HD-14272	5735	50	bone	GG-pit
KN-3036	5780	170	wood	ph H10
HD-14177	5785	45	bone	lp H16
KN-3217	5800	320	wood	lp H11
KN-3039	5810	200	wood	ph H10
HD-14394	5820	45	bone	lp H8
KN-2966	5890	65	wood	ph H10
KN-3038	5940	300	wood	ph H10
KN-3035	6050	140	wood	ph H10
KN-3192	6060	170	wood	lp H11
HD-14032	6240	55	bone	lp H18
HD-14111	6343	42	bone	lp H8
UtC-2340	6350	80	org.cr.	lp H18
HD-14031	6380	100	bone	lp H16
OxA-1539	6380	80	cer.	pit H6
KN-3427	6430	60	wood	lp H12
KN-3425	6520	65	wood	lp H11
KN-3436	6530	70	wood	lp H12
KN-3216	6540	260	wood	lp H11
HD-14219	6580	20	bone	lp H16
KN-3034	6660	65	wood	ph H10
KN-3046	6690	140	wood	ph H11
KN-3041+3043	6700	190	wood	ph H11
KN-3033	6800	370	wood	ph H10
KN-3040	7100	500	wood	ph H11
KN-3044+3045	7250	500	wood	ph H11

Fig. 2. Calibrated results from the Schwanfeld series. The samples derive from Earliest LBK houses (H6, 11, 12, 16 and 18), postholes of one Middle Neolithic (Grossgartach culture) house (H10) and one pit of this period (GG-pit). The materials analyzed were charred wood, bones, cereals and organic crust on pottery (see Table 1). The ^{14}C dates from structures of houses H10 and H11 have been marked, as well as the period 5500–5200 cal BC, defining the beginning and end of the Earliest LBK settlement. The reliable period of the Middle Neolithic activity best represented by three bone samples (Hd-14272, -14177, -14394) is 4800–4500 cal BC.

which should be even older (Stäuble 1990), yielded dates from 4700–4500 cal BC and 3400–3100 cal BC, respectively. No artifacts found in these features could explain the dates. However, nearby, some pits belonging to the Middle Neolithic Rössener culture were excavated in the 1950s (Niquet 1963). This fact may help explain at least the two older dates.

The duration of the Earliest LBK phase until at least 5200 cal BC in Schwanfeld is also supported by samples from Goddelau (Fig. 1). The importance of the Goddelau dates lies in the fact that only the Earliest LBK phase is represented here. The possible intrusions deriving from other, much younger prehistoric as well as historic structures were easily recognized when dated (*e.g.*, Kn-3430: 1730 ± 65 BP). Except for one bone sample from Structure 71 (Fig. 3) (Hd-14176: 6370 ± 35 BP = 5325–5267 cal BC), the site consists mostly of material from only one pit (Structure 9). Compared to other Earliest LBK structures, the pit seems to be a long pit of a house. All three samples of short-lived material (2 bone fragments of domesticated cattle, Hd-14009: 6260 ± 40 BP, Hd-14173: 6295 ± 50 BP and 1 charcoal sample of 8 fragments of cereals, OxA-1628: 6300 ± 90 BP from three

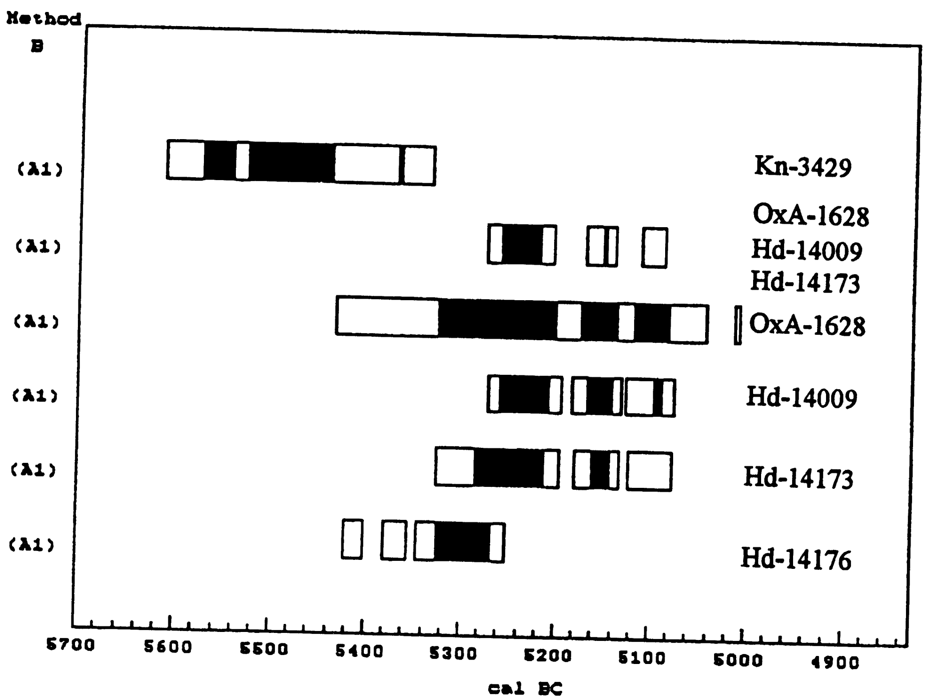


Fig. 3. ^{14}C dates of four short-lived samples from Goddelau, and one mean value (2 bone / 1 cereal) from Pit 9 compared to the result of a charred wood sample from the same feature (■ = 1 σ, □ = 2 σ).

Lab no.	Material	Feature	yr BP ± 1 σ
Kn-3429	Charcoal	9	6600 ± 85
OxA-1268 } Hd-14009 } Hd-14173 }		9	6277 ± 31
OxA-1628	Cereal	9	6300 ± 90
Hd-14009	Bone	9	6260 ± 40
Hd-14173	Bone	9	6295 ± 50
Hd-14176	Bone	71	6370 ± 35

different strata of the pit) are consistent and date the pit contents between *ca.* 5250 and 5100 cal BC (Fig. 3, mean of the three dates: 6277 ± 31 BP = 5261–5149 cal BC). Comparing these results with that of a charcoal sample from the same pit (Kn-3429: 6600 ± 85 BP = 5578–5437 cal BC), shows a significant age difference. As it is unlikely that the structure was used for such a long period, the sample probably derived from the center of an older fragment of wood. Even though, typologically, flint artifacts from the pits suggest an older age, (Gronenborn 1990), one cannot conclude that the three consistent results from short-lived materials are intrusions because of one deviant date of charred wood.

Based on 15 results dated on wood (4 samples), bone (5 samples) and charred cereals (6 samples) dated by accelerator mass spectrometry (for the 6 AMS dates, see Whittle 1990), another important settlement, Bruchenbrücken (Fig. 1) (Stäuble 1989; Lüning, ms.) is not as old as expected on archaeological grounds. However, this site cannot be used to determine the end of the Earliest LBK phase, because it was also inhabited during younger phases. As for Schwanfeld, there is always a danger of contamination in structures of long-term occupations. For example, one burial was dated to the LBK culture by artifactual association, whereas the ^{14}C date of a bone fragment indicated the end of the Neolithic (Hd-13895: 4030 ± 45 BP = 2580–2477 cal BC). As the position of the burial is typical of the Corded Ware culture (Fischer 1956), I judge the ^{14}C date more reliable than the archaeological interpretation of the pit-filling. In Bruchenbrücken (Fig. 1), younger intrusions were also observed among the artifacts, for younger LBK potsherds occurred in all Earliest LBK contexts (Lüning, Kloos and Albert 1989). Thus, the importance of the dates for this site lie in the oldest results, which date the beginning of the occupation, *ca.* 5350–5250 cal BC (68% range of a group calibration of three dates).

From these results, one can conclude that the settlement of Bruchenbrücken began earlier than that of Goddelau (Fig. 1), and both were occupied later than Schwanfeld, although all three settlements were, for some time (the 53rd century cal BC), contemporaneous. However, it should be noted that the excavations did not cover the complete settlement surface. With the exception of Enkingen (Fig. 1), all the other Earliest LBK settlements were either disturbed (*e.g.*, Wang, Neckenmarkt) (Fig. 1) or lacked datable material at all (*e.g.*, Mintraching) (Fig. 1). From other settlements (*e.g.*, Strögen) (Fig. 1), only charred wood could be dated (Stäuble 1994), and it was not possible to cross-check these results to determine whether the ^{14}C result dated the activity or old wood.

The same problems exist for *ca.* 30 partially older measurements from sites in Austria, Germany, Poland and the Czech Republic (Breunig 1987; Hedges *et al.* 1989; Kohl and Quitta 1964; Jankowska 1990; Kaufmann 1983; Neustupný 1968; Pavlů and Zápotocká 1979; Stäuble 1994). Although the ^{14}C dates generally fit into the same period determined by the results of this project (5500–5200 cal BC), the quality of the material and the archaeological context also have to be tested. The dates of the single settlements are vague, as the dating uncertainties are often > 50 or 100 yr.

One can infer from the examples given above that, not only do we need undisturbed archaeological contexts and reliable materials for dating, but we also need high-quality samples, on which the precision of the measurement depends. Current results show that dates with uncertainties > 50 yr may be used only for orientation. Only high-precision ^{14}C dates can answer more detailed questions. A critical evaluation of the available ^{14}C dates shows that we cannot determine the beginning of the Earliest LBK phase of Central Europe before 5500 cal BC. This contradicts the dating of the primary Neolithic in this region *ca.* 5800–5700 cal BC, which is dependent on measurements of wood charcoal (Lüning 1988).

The present results also confirm that some of the Earliest LBK sites (Goddelau and Schwanfeld) were inhabited until *ca.* 5200 cal BC. Despite typological differences, they were contemporary with Phase II of the LBK culture for at least 100 yr, which supposedly began *ca.* 5300 cal BC in the Rhineland (Stehli 1989) and is traditionally believed to have succeeded Phase I. The same is true for differences within the Earliest LBK. Unlike the distribution of raw flint materials, which is interpreted chronologically (Gronenborn 1992), the existing typological differences of pottery as well as of housing structures are not necessarily seen as time-dependent, but may be the result of different traditions in different geographical areas (Cladders 1995; Stäuble 1994).

Dating Organic Matter in Pottery

Because of the old-wood effect, on the one hand, and general taphonomic problems on the other, attempts have been made to determine the age of organic components of pottery. Typically, the Earliest LBK pottery is well-tempered with organic material (Quitta 1960), and was fired at moderate temperatures (Riederer 1985), which would have preserved the carbon fraction (Kohl 1961). The Berlin laboratory (Kohl and Quitta 1963) dated many LBK sherds satisfactorily in the past; two new series consisting of 12 sherd and daub fragments from 6 sites were AMS-dated by the Utrecht Laboratory in 1992 (Table 1). These results were much older than expected (Fig. 4), implying that much of the extractable carbon must have derived from organic material forming a natural component of the original clay (de Atley 1980; Gabasio, Evin and Andrieux 1986; Hedges, Tiemei and Housley 1992). As the dates of the alkaline-soluble fraction of the clay matrix from the first series of samples

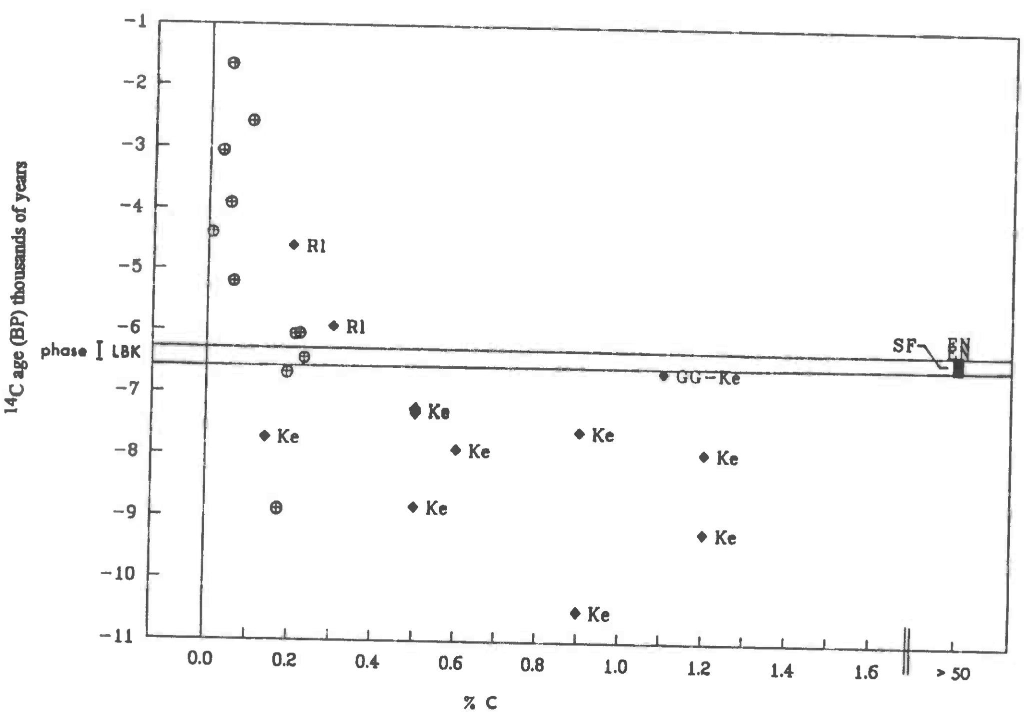


Fig. 4. Distribution of ^{14}C dates of the organic components in pottery (Ke) and daub (Rl), as well as the three results of organic crust (■) on pottery from Schwanfeld (SF) and Enkingen (EN) by their carbon content (%C). Apart from one sample (GG-Ke), which was a Middle Neolithic potsherd from Schwanfeld (see Table 1), all other sherds belong to the Earliest LBK phase (Phase I), which is marked on the y-axis. ⊕ = alkali-soluble fraction; ◆ = L-AAA residue fraction.

TABLE 1. ^{14}C Dates of Pottery of the Earliest Linearbandkeramik Culture

No.	Site	Feature	Ceramic material*	Culture	%C	Lab no.	Fraction type†	^{14}C age (yr BP)
1	Klein Denkte	71	Org. comp. in sherd	LBK phase 1	0.9	UtC-1836	Residue	14,120 ± 100
2	Klein Denkte	71	Org. comp. in sherd	LBK phase 1	0.17	UtC-1837	Alk-sol	880 ± 120
3	Klein Denkte	59	Org. comp. in sherd	LBK phase 1	1.2	UtC-1834	Residue	7930 ± 60
4	Klein Denkte	59	Org. comp. in sherd	LBK phase 1	0.21	UtC-1835	Alk-sol	6050 ± 110
5	Eitzum 2	26	Org. comp. in sherd	LBK phase 1	1.2	UtC-1830	Residue	9220 ± 80
6	Eitzum 2	26	Org. comp. in sherd	LBK phase 1	0.22	UtC-1831	Alk-sol	6030 ± 70
7	Eitzum 2	11	Org. comp. in sherd	LBK phase 1	0.5	UtC-1832	Residue	8830 ± 70
8	Eitzum 2	11	Org. comp. in sherd	LBK phase 1	0.23	UtC-1833	Alk-sol	6340 ± 70
9	Kleinsorheim	48	Org. comp. in sherd	LBK phase 1	0.14	UtC-1840	Residue	7730 ± 120
10	Kleinsorheim	48	Org. comp. in sherd	LBK phase 1	--	--	Alk-sol	--
11	Steinfurth 2	3	Org. comp. in sherd	LBK phase 1	0.5	UtC-1838	Residue	7260 ± 70
12	Steinfurth 2	3	Org. comp. in sherd	LBK phase 1	0.19	UtC-1839	Alk-sol	6770 ± 70
13	Enkingen	30	Org. crust on sherd	LBK phase 1	>50	UtC-2344	Residue	6460 ± 80
14	Enkingen	30	Org. crust on sherd	LBK phase 1	0.1	UtC-2345	Alk-sol	2580 ± 120
15	Enkingen	30	Org. crust on sherd	LBK phase 1	>50	UtC-2325	Residue	6320 ± 90
16	Enkingen	30	Org. crust on sherd	LBK phase 1	0.05	UtC-2346	Alk-sol	1650 ± 80
17	Schwanfeld	792	Org. crust on sherd	LBK phase 1	>50	UtC-2340	Residue	6350 ± 80
18	Schwanfeld	792	Org. crust on sherd	LBK phase 1	0.06	UtC-2341	Alk-sol	5190 ± 90
19	Schwanfeld	792	Org. comp. in sherd	LBK phase 1	0.6	UtC-2320	Residue	7900 ± 80
20	Schwanfeld	792	Org. comp. in sherd	LBK phase 1	0.05	UtC-2339	Alk-sol	3910 ± 80
21	Schwanfeld	360	Org. comp. in sherd	LBK phase 1	0.5	UtC-2321	Residue	7280 ± 100
22	Schwanfeld	360	Org. comp. in sherd	LBK phase 1	0.03	UtC-2342	Alk-sol	3060 ± 110
23	Schwanfeld	360	Org. comp. in sherd	LBK phase 1	0.9	UtC-2322	Residue	7600 ± 80
24	Schwanfeld	360	Org. comp. in sherd	LBK phase 1	--	--	Alk-sol	--
25	Schwanfeld	800	Org. comp. in sherd	Grossgartach	1.1	UtC-2323	Residue	6620 ± 70
26	Schwanfeld	800	Org. comp. in sherd	Grossgartach	0.01	UtC-2324	Alk-sol	4380 ± 110
27	Schwanfeld	360	Org. comp. in daub	LBK phase 1	0.2	UtC-2343	Residue	4600 ± 190
28	Schwanfeld	360	Org. comp. in daub	LBK phase 1	--	--	Alk-sol	--
29	Eitzum 2	11	Org. comp. in daub	LBK phase 1	0.3	UtC-2326	Residue	5920 ± 70
30	Eitzum 2	11	Org. comp. in daub	LBK phase 1	--	--	Alk-sol	--

*Total clay pottery or daub matrix (org. comp. in sherd or daub); organic crusts (org. crust) on pottery (shaded area)
†Alk-sol = alkaline-soluble fraction

(Table 1: 1–12) were closer to the expected dates, they could have derived from cooking fats (K. van der Borg, personal communication 1992). The same types of potsherds in the second series yielded different results (Table 1: 19–30). Figure 4 shows the low carbon content (0.03 to 1.3% C) of these samples, but no relation between the percent carbon and the dates was found.

Dating organic crusts or food remains on pottery can determine the last time that the vessel was used. In contrast to the low carbon content of the clay matrix, the residue fraction of food remains from three sherds contained > 50 % carbon (Table 1: 13–18; Fig. 4). The results from Schwanfeld (UtC-2340: 6350 ± 80 BP) and Enkingen (UtC-2325: 6320 ± 90 BP; UtC-2344: 6460 ± 80 BP) are both consistent and expected. Because samples UtC-2325 and UtC-2344 were from a long pit of the only house excavated in Enkingen (Fig. 1) and their results showed large standard deviations, we computed the mean value (6398 ± 61 BP) to 5420–5273 cal BC.

Although the Earliest LBK pottery contains much chaff temper, the results also show a high concentration of natural organic material in the clay. However, as we do not know the clay source used in manufacturing, we do not know whether the date indicates the age of the clay alone or a mixture of different organic sources.

Dating of the Earliest LBK Phase

After excluding 23 results of organic components in sherds, 14 dates from younger contexts and 3 other samples dating younger than 4000 BP from a total of 100 dates, we compared the calibrated dispersion of the remaining 60 dates from the archaeologically defined Earliest LBK features with that of 15 critically selected short-lived samples.

Following Ottaway's (1986) statistical distribution method, and cutting 25% from each side of the curve of all 60 dates, I derive a time span between 5410 and 5040 cal BC. For the 15 dated samples, I used the whole distribution (94.8%) of the calibrated dates, which shows a range of 5500 to 5060 cal BC. Both younger ends of the interval are determined by a plateau of the dendrological curve, and therefore does not necessarily represent the archaeological material. I prefer to use the second method. On the one hand, it seems unlikely that old wood is distributed evenly throughout the sites, as the structures may be disturbed by younger intrusions. On the other hand, I also wanted to date single activities and set up a chronology for different sites. Thus, all dates were analyzed and interpreted separately. The 50% middle range of the total distribution, the floruit, will give a general time range of the culture under study, but cannot be used to solve more detailed problems, as, for example, the boundaries of archaeological cultures, phases or the duration of individual houses.

Conclusion

The Earliest LBK culture in Central Europe dates between 5500 and 5200 cal BC. To eliminate all possible sources of uncertainty, I used only ^{14}C measurements of short-lived materials from samples considered more reliable archaeologically, that is, from sites that furnished evidence of a hiatus after the earliest phase of LBK settlement.

Typological differences are generally interpreted as chronological differences, yet these ^{14}C dates suggest that many of the studied settlements or parts of settlements must have been contemporary. All dates, except most of the charred wood samples, fit into the sequence determined by the results from Schwanfeld, the largest settlement analyzed in the project. Also, the typological features succeeding Phase II of the LBK culture show at least partial contemporaneity (5300–5200 cal BC) with the last century of the earliest phase.

Much research remains to be done, for both periods before and after the Earliest LBK. In addition, problematic dates will have to be studied more intensively, which will involve interpreting dated material, and well-controlled excavations. In sum, good results can be achieved for solving archaeological problems when interdisciplinary teams combine high-precision ^{14}C dates with archaeological interpretation.

Acknowledgments

I am grateful to J. Lüning for his kind permission to work on and publish the material from his project. I am also indebted to the Deutsche Forschungsgemeinschaft in Bonn, which financed the project and saw the need for the ^{14}C dates.

For the dates, comments and discussions I owe my thanks to all the laboratories involved, namely to J. Freundlich and B. Weninger (Labor für ^{14}C-Datierung des Instituts für Ur- und Frühgeschichte, Universität Köln), H. Willkomm (C14-Labor des Instituts für Reine und Angewandte Kernphysik, Universität Kiel), R. A. Housley (Radiocarbon Accelerator Unit, Research Laboratory for Archaeology and the History of Art, Oxford University), B. Kromer (Institut für Umweltphysik, Universität Heidelberg) and K. van de Borg (R. J. Van de Graaf Laboratory, Dept. of Subatomic Physics, Universiteit Utrecht). I like to thank also A. Whittle (University of Cardiff) and A. J. Kalis (Seminar für Vor- und Frühgeschichte, Universität Frankfurt) for mediating the AMS dating in Oxford and Utrecht. Many thanks go to J. Werning (Seminar für Vor- und Frühgeschichte, Universität Frankfurt), who kindly proofread the English text and to R. S. Kra (The University of Arizona) for the recommended revisions.

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