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The Chronology of Danish Dolmens. Results from ^{14}C Dates on Human Bones

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Further information can be found in the supplement available as separate download on the article webpage.
Appendix 2. Dates from Danish dolmens and earthen long barrows.

Abstract

The thousands of dolmens and long barrows spread across the Danish landscape are the earliest long-lasting expressions of architectural monumentality in Scandinavia. A series of new AMS dates on human skeletal material from several of them leads to a clarification of the generations-long debate on the relative chronology and typological evolution of this group of monuments. Earthen long barrows were raised from ca. 3700 cal BC. That is at least two centuries later than the arrival of such elements of the Neolithic world as funnel beaker pottery and domestic cattle to the region. The practice of using large stones (megaliths) for burial chambers was present by 3600 cal BC. Classical *Urdolmen* were built alongside various types of more complex dolmen chambers during the period ca. 3600–3400 cal BC, after which passage graves were erected.

Introduction

Even after more than 5 000 years, early farming societies make themselves very visible in the Danish landscape, due to the numerous monumental burial structures they erected. Approximately 2 800 of these are scheduled monuments, and thanks to generations of archaeological fieldwork there are records of a further ca. 7 300. A conservative estimate suggests that their original number exceeded 25 000 (Ebbesen 1985; Jensen 2001, 363; Hansen 2016, 10). The majority of these monuments are characterised by the architectural use of large stones (megaliths) for burial chambers and external delimitation of barrows.

Neolithic earthen long barrows, dolmens and passage graves represent the earliest lasting monumentality and architecture in Scandinavia. They are part of a spectacular building tradition that was initiated by farmer societies in Western Europe around 4500 cal BC (Schulz Paulsson 2017; 2019). Dating the introduction of their various monument types in Denmark is the topic of the present paper. It also deals with the often debated question among Scandinavian archaeologists if these monuments were constructed in the region from the onset of the Funnel Beaker Culture (FBC) and the farming way of life, or if there existed pre-monumental and pre-megalithic stages at the beginning of the Early Neolithic. The basis of this study is a series of new AMS dates measured on human teeth and bones (Fig. 1), selected for a genomic study of the European Mesolithic and Earlier Neolithic (Allentoft et al. 2022). The 21 dates obtained reveal a clear and somewhat surprising chronological pattern, to be presented below.

The interval of time dealt with is the early and middle parts of the Funnel Beaker Culture. It represents the era when farming was introduced to the

Fig. 1. Sites mentioned in the present paper (Graphics: K.-G. Sjögren).

region, and is traditionally divided into the Early Neolithic (EN) and the Middle Neolithic A (MN A). These two periods, defined on the basis of pottery typology, are often subdivided in stages I–II and I–V, respectively (e. g. Becker 1954; Nielsen 1993; Koch 1998). Based on a rather small number of radiocarbon dates of settlement assemblages etc. with pottery, the chronological range of the EN and the MN A can tentatively be stated as ca. 3900–3300 and ca. 3300–2800 cal BC, respectively (Nielsen 1993; Fischer 2002; Müller, J. et al. 2010; Nielsen/Nielsen 2020; Fischer et al. in prep. a and b).

Typology and chronology of dolmens

Ever since the pioneer work of O. Montelius (1874a; 1874b; 1905), Scandinavian megalithic tombs have been viewed as forming a typological series, starting with dolmens and continuing with passage graves and gallery graves. Subsequently, various attempts have been made to define subtypes of dolmens – with the underlying assumption that a stylistic/technological evolution of this kind of monument can be expected (e. g. Becker 1947; Aner 1963).

E. Schuldt (1972) distinguished three types: *"Urdolmen"* (Fig. 2), *"erweiterte Dolmen"* and *"Großdolmen"*. The latter, apparently an intermediate phenomenon between dolmens and passage graves, were defined as large rectangular or trapezoid chambers with a passage from the narrow end.

Fig. 2. The classical *Urdolmen* of Vig Femhøve – an example of the megalithic monuments that can now safely be referred to an early part of the Early Neolithic of Denmark, thanks to a series of recent AMS dates of human skeletal remains. From the stone chamber seen beneath the hoofs of the three goats, absolute dates of three humans of that period are now available (Photo: A. Fischer).

Additionally, a fourth type of Early Neolithic burial monument has been defined: interments beneath earthen long barrows, the architectural elements consisting of earth, smaller stones and wood only (Madsen 1979). The distinction between earthen long barrows and megalithic tombs is somewhat floating, however, since the former were often rebuilt and megalithic chambers inserted into them. The most recent contributions to the dolmen type debate by K. Ebbesen (2011) and P. Eriksen and N. H. Andersen (2014) are rather similar in describing four main variants, which briefly can be described as follows:

- Type I encompasses relatively small, closed, rectangular or slightly trapezoidal chambers, less than 3 m long, with 4–6 side stones.
- Type II is similar in shape and size to type I but has an open gable with only a low sill or entrance stone.
- Type III consists of relatively large chambers of elongated form, often oval or pear shaped, with an opening or short passage at the gable end.
- Type IV has a polygonal or rhomboid chamber of five or more stones and a short passage.

Common to all four types is that they are only covered by a single capstone. The chamber floors may be slightly sunken into the original ground surface. Types I–II correspond to *Urdolmens* while the somewhat vaguely separated types III–IV cover what Schuldt calls extended dolmens. All types can be surrounded by round or elongated barrows, and are accordingly termed Round dolmens or Long dolmens.

Regarding *Großdolmens*, Ebbesen (2007, 14–15; 2011, 45) supports the above-mentioned definition of Schuldt. Eriksen and Andersen (2014, 44; cf. Hansen 2016, 56), on the other hand, prefer to class them as passage graves on the criterion that the passages reach the mound edge.

Dolmen types I–IV have commonly been viewed as a chronological sequence (e. g. Eriksen/Andersen 2014). It has, however, also been suggested that they are contemporary regional variants (Ebbesen 2011). Most scholars have viewed dolmens as generally older than passage graves, while again some have emphasised parallel developments and regional differences (e. g. Persson/Sjögren 1996; Hansen 2016; Schulz Paulsson 2017; Blank et al. 2020).

The chronological arguments have rested on two forms of archaeological reasoning. One is based on typology: Artefacts such as pottery and flint

axes found in the chambers have been used to argue for Early Neolithic dates for these structures. Typical vessel forms found in dolmen chambers are lugged and collared flasks, commonly dated to the later EN. Such finds are rare in Danish passage graves, suggesting a time difference for at least some of these burial chambers. It should be mentioned, however, that a number of dolmens only contain MN pottery. Unless a clearing out of earlier burials from these stone chambers has taken place, they could well have been built contemporarily with the passage graves (Skaarup 1985).

Another line of argument is based on the complex building sequences starting to appear in well-investigated dolmens. At sites like Lønt in Jutland and Flintbek in Schleswig-Holstein, series of graves have been constructed to eventually form elongated monuments, allowing for relative dating of different chamber forms (Mischka 2011; 2022; Gebauer 2015). At Lønt, four chambers in round barrows have been built in a row, eventually enclosed by a long barrow (Fig. 3). The first chamber was a small type I dolmen, followed by a type III chamber and lastly by two passage graves. No ^{14}C dates are available but the pottery depositions at the different monuments suggest that the whole sequence took place in the Middle Neolithic A, from MN A I to MN A II (Jørgensen, E. 1988; Gebauer 2015; Gebauer et al. 2020).

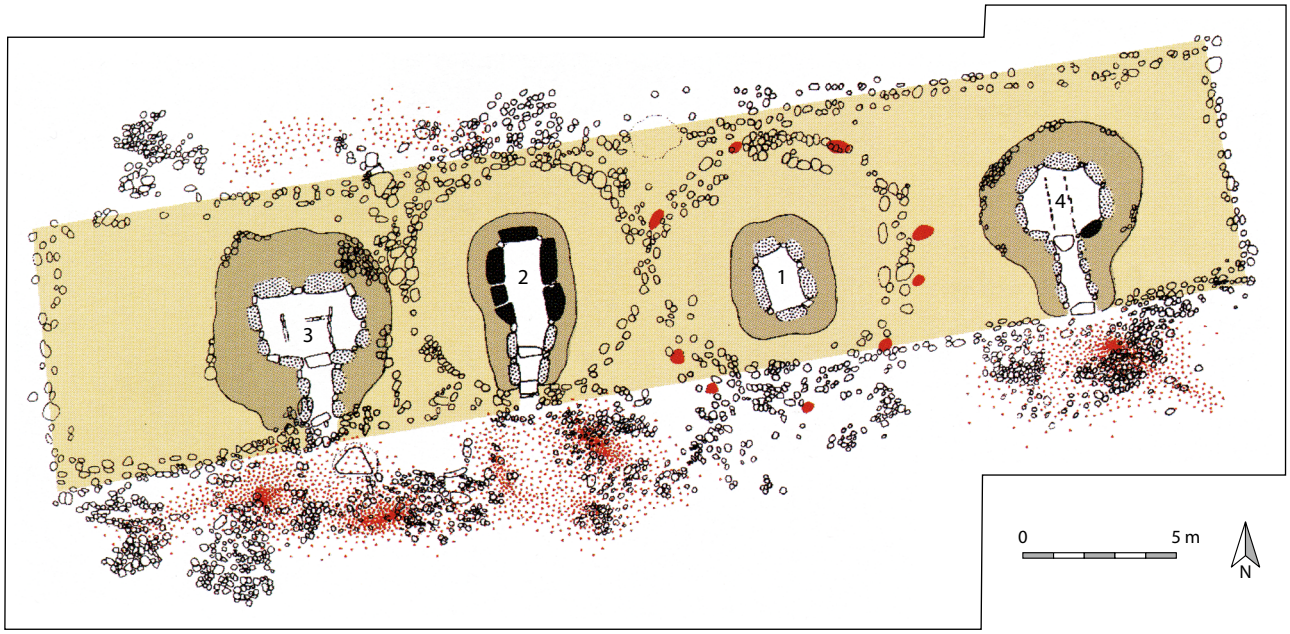

Fig. 3. Lønt, Long dolmen 13. Numbers denote the suggested order of building. Red dotting indicates pottery depositions (after Gebauer 2015, 140 fig. 13.6).

At Flintbek, a megalithic cemetery with at least 29 monuments was excavated 1976–1996. An extensive series of radiocarbon determinations has allowed detailed absolute dating of the different graves (Mischka 2011; 2022; Furholt/Mischka 2019). Of particular interest is the monument Flintbek LA 3. Here, the sequence starts with an alignment of eight non-megalithic earth graves, dated 3500–3460 cal BC (Fig. 4). Next, two small dolmen chambers (dolmens I–II) were built to the east of these, dated to 3465–3435 cal BC, and a further small dolmen to the west (dolmen III), dated to 3440–3405 cal BC. This linear arrangement was incorporated into a long mound with kerb stones. Finally, the long mound was extended to the north, and a final megalithic chamber, dolmen IV, was built in the extension at 3410–3375 cal BC. The duration of the whole sequence could be estimated to ca. 140 years, corresponding to the final Early Neolithic of Southern Scandinavia. Notable at the Flintbek site in general is also the early dating of polygonal chambers, the probably contemporary erection of different dolmen forms, and the later appearance of passage graves, after ca. 3350 cal BC.

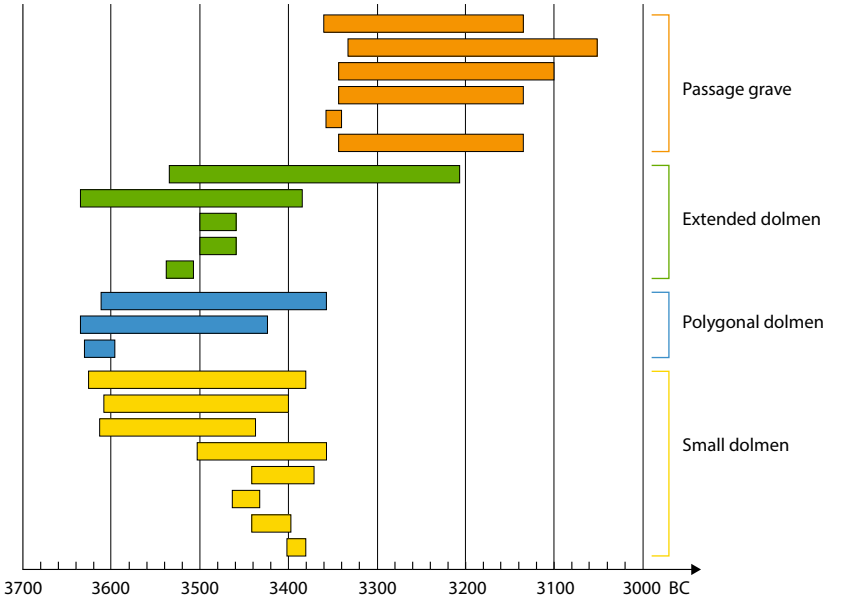

Fig. 4. Flintbek. Radiocarbon date ranges for stone chambers at the megalithic cemetery. The term "Small dolmen" refers to small rectangular chambers with four to six orthostats and some kind of opening or entrance, similar to the Danish type II dolmens (redrawn by K.-G. Sjögren after Furholt/Mischka 2019, 926 fig. 5).

Previous ^{14}C dates

The previously published radiocarbon dates of samples from Danish dolmens are listed in Table 1 and Appendix 2 (cf. Persson/Sjögren 1996; 2001; Müller, J. 1997; Sørensen 2014; Schulz Paulsson 2017; 2019).

As seen in Figure 5, most of the bone dates from dolmens are later than the expected time of construction and primary use. Eight dates fall around 2800 cal BC and thereafter, and point to use in the Middle Neolithic B (MN B, the epoch of the Single Grave Culture). Three of the dates correspond to the earlier part of the MN A, ca. 3300–3000 cal BC, and no bone dates correspond to the expected dating of early dolmens to the EN II, i. e. ca. 3500–3300 cal BC. In comparison, the dates on charcoal have an older emphasis, and four out of the five age determinations would indicate use in the late EN.

There are several problems with the previously published dates, however. Age measurements on charcoal, such as the date from Ølstykke, may contain a substantial old wood effect. The significant distance in time between the bone and charcoal dates in Figure 5 may well be explained on this basis. Unfortunately, evaluation of this proposition is difficult, since determination of tree species and estimates of old wood effect were not always done. The old bone dates from the Copenhagen laboratory, while certainly of high quality for their time, were made by conventional radiometric method and with sample preparation methods that are not up to the standards of today. For instance, extraction of secondarily introduced humus was only performed from laboratory number K-2127 onwards (Fischer 2002, 359) and ultrafiltration was not implemented. Lack of ultrafiltration also applies to the previously published dolmen dates produced at the Lund and Aarhus laboratories. Furthermore, collagen quality indicators such as the C/N ratio are not available, and standard deviations are rather high.

The reliability of the previous dates is therefore difficult to evaluate, and it can be suspected that age determinations in some cases were performed on collagen of low quality and/or that samples have not been fully cleaned from contaminants. Furthermore, some of the dated samples consist of lumped fragments, which may come from a mix of different individuals or different trees. In one case, human bones have even been lumped with animal bones of unknown species. To this, we can add the general problem of dating burial chambers that have been used and reused for long periods of time. When dating only one or a few samples per tomb, it is likely that none of the

Table 1. Previous ^{14}C dates from Danish dolmens, sorted chronologically according to the earliest bone date from each site.

Site	Type	Lab no	BP uncal	1 s	Material	Species	Element	Context
Rude	Long dolmen	K-3124	4910	90	Charcoal	nd		Facade trench
Rude	Long dolmen	K-3125	4810	70	Charcoal	nd	5 cm thick branch	Facade trench
Rude	Long dolmen	K-3123b	4260	85	Bone	Human	Vertebrae	Western chamber
Rude	Long dolmen	K-3123a	4180	85	Bone	Human	Mixed bone pieces	Western chamber
Ølstykke	Long dolmen	K-2356	4710	100	Charcoal	nd		Charcoal layer below skeleton
Tustrup	Dolmen	K-1762	4700	110	Charcoal	Oak (Quercus sp.)		Unknown
Tustrup	Dolmen	K-1763	4680	110	Charcoal	Oak (Quercus sp.)		Unknown
Vroue Hede IV	Long dolmen	K-2424	4660	100	Charcoal	nd		Below and in drystone walling
Vroue Hede I	Long dolmen	K-1566	4570	100	Charcoal	Oak (Quercus sp.)		Under pavement in chamber
Klokkehøj	Dolmen	K-2954	4550	65	Bone	Human	Rib + pelvic bones	Individual QØ, primary grave
Klokkehøj	Dolmen	K-3012	4250	90	Bone	Human	Femur	Bone pile I
Klokkehøj	Dolmen	K-3014	4200	90	Bone	Human	Femur	Bone pile III
Klokkehøj	Dolmen	K-3013	4140	90	Bone	Human	Femur	Bone pile II
Trekroner	Dolmen	Lu-1952	4500	55	Bone	Human+animal	Mixed pieces	Below secondary floor
Kellerød	Long dolmen	K-2954/ K-3515	4490	65	Bone	Human	Fragments of tibia + other long bone	Primary grave
Sarup Mølle I	Dolmen/ Passage grave	AAR-1127	4000	90	Bone	Human	6y old child, humerus	Chamber floor
Sarup Mølle I	Dolmen/ Passage grave	AAR-1128	3850	90	Bone	Human	Adult, vertebrae	Chamber floor
Sarupgård	Long dolmen	K-3491	3890	80	Bone	Human	Mixed bone pieces	Chamber F

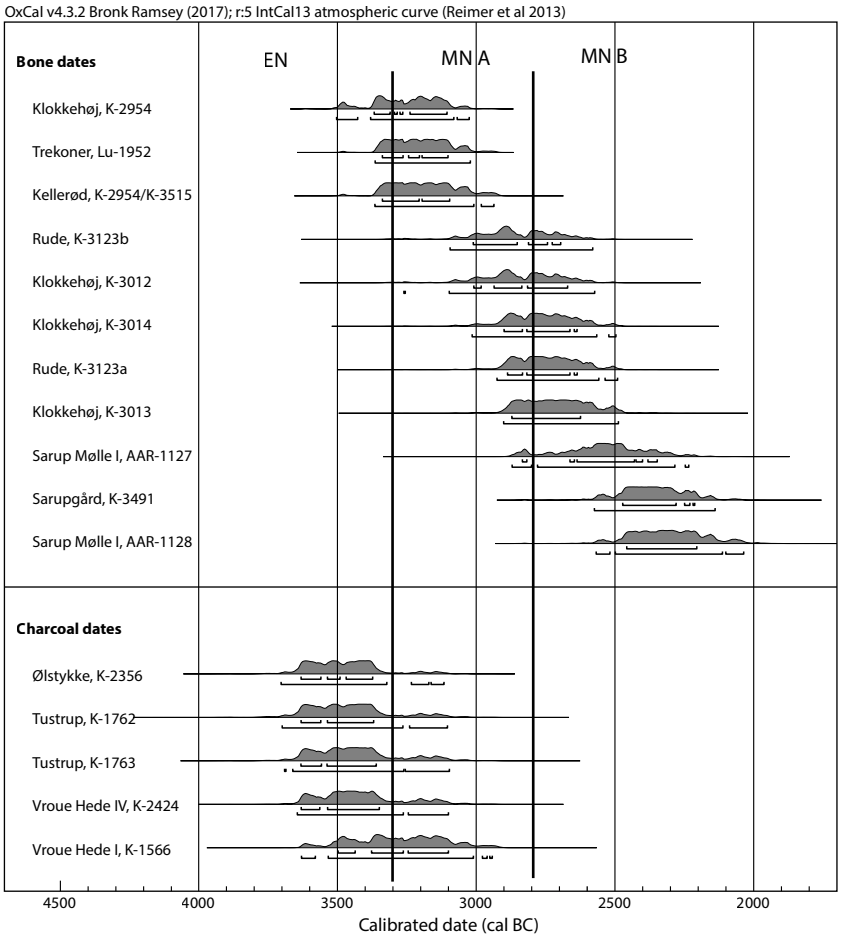

Fig. 5. Probability distributions of previously published dolmen dates from Denmark (see Table 1). Two charcoal dates from Rude were not included in the figure since they refer to the facade and not to the stone chambers. Bone dates are not reservoir corrected due to lack of isotopic data for some samples (Graphics: K.-G. Sjögren).

age determinations will represent the first interment in the chamber. This especially applies in cases when bone preservation is less than ideal, since skeletons of early interments tend to be more degraded than those of subsequent burials due to changing soil chemistry over time (successive depositions of bone will raise ph as well as phosphate levels). Finally, the classification of some of the tombs as dolmens may be questioned. Sarup Mølle I and Vroue Hede I should perhaps rather be classed as passage graves, and the context of the two dates from Tustrup is unclear.

The number of previous dates from earthen long barrows is larger, but some of the same problems apply to them. In Appendix 2, 44 dates are listed, 39 on charcoal and five on marine shells. Many of them are from the early days of radiocarbon dating. Their standard deviations are rather large, and it is often difficult to judge whether old wood effects are at hand. A special problem concerns posts in façade trenches, which are sometimes suggested to have been deliberately burned. If so, charcoal from the inner wood could well have been sampled, and as these posts are of considerable size (up to ca. 0.8 m in diameter) a sizeable old wood effect may apply to them. In other cases, however, the posts do not seem to have been burned but only scorched before being set in place, presumably to enhance durability. In such cases, the samples would represent the outer rings of the trees and not contain any larger old wood effect. The problem can to some extent be circumvented by only including the youngest dates in cases where more than one sample from the same context was dated (see Appendix 2) but it should be borne in mind that this approach is sensible to outliers.

Plotting summary graphs of these age measurements by context gives an interesting picture (Fig. 6). At around 3700 cal BC, the curves for graves and facades rise sharply. The two curves run parallel until ca. 3400 cal BC, where they both drop sharply. Dates from contexts earlier than the barrow, i. e. *terminus post quem* (tpq) dates, also end at ca 3400 cal BC but also show a shift towards earlier dates, possibly due to pre-barrow activities or in some cases old wood effect.

Three main problems with sum probability distributions (SPDs) have been pointed out: noise as a result of low numbers of samples, noise from the calibration process and spread of the dates due to measurement uncertainty (Bronk Ramsey 2017, 1811). The same issues apply to simple calibrated dates. On the other hand, SPDs take the whole probability span into consideration,

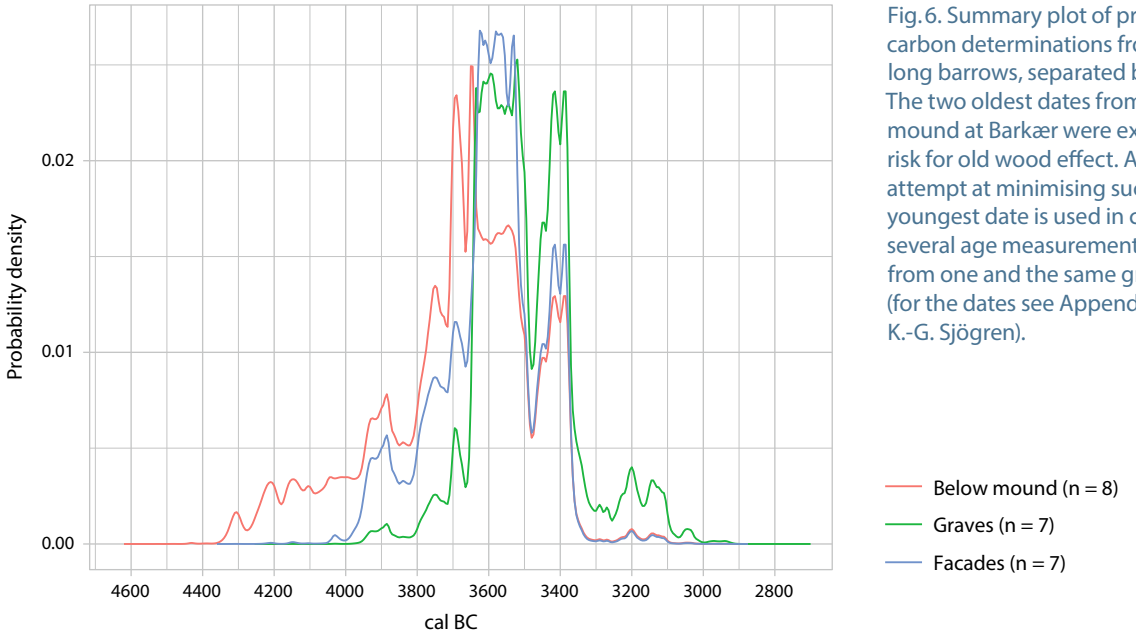

Fig. 6. Summary plot of previous radiocarbon determinations from earthen long barrows, separated by context. The two oldest dates from below the mound at Barkær were excluded due to risk for old wood effect. As an additional attempt at minimising such effects, the youngest date is used in cases where several age measurements are available from one and the same grave or façade (for the dates see Appendix 2; graphics: K.-G. Sjögren).

and unlike Bayesian phase models, they do not presuppose any particular distribution of events. For the dates discussed here, Bayesian modeling was tested for some of the sites but did not actually contribute to any different understanding of the chronologies. As stratigraphic or other sequence information is mostly lacking, we abstain from applying phase modeling as there is no information regarding which underlying distribution of events is relevant, and sufficient tools to evaluate different models against each other are lacking in Oxcal.

The datings would seem to indicate a building period for long barrows of ca. 300 years, ca. 3700–3400 cal BC. For several reasons, this should only be taken as an approximation. First, the number of dated monuments is still rather low. Second, the tpq dates and the dates from constructions do not always come from the same site. Third, the age determinations of façade timbers may not always concern the oldest part of the constructions, as facades sometimes seem to have been built in several phases (e. g. at Rude and Højensvej, see Appendix 1). Consequently, there is room for a somewhat earlier start of long barrow construction than is indicated by these dates. Still, it seems likely there was an earliest phase of the Neolithic when no long barrows or other monuments were built, perhaps covering the time ca. 3900–3800 cal BC (Fischer 2002; Fischer et al. in prep. b).

New dates and isotope results

In view of the problems discussed above, additional ^{14}C determinations produced with up-to-date methods are highly desirable. We will now report such a series, consisting of 21 radiocarbon measurements on human bone and teeth. 18 are from seven dolmens, while two derive from a long barrow (Table 2). The latter two are the first made on human skeletal material from Danish non-megalithic long barrows. All dates are based on material sampled from one individual only.

All except two of the new dates were produced at the Chrono lab in Belfast. Collagen extraction methods for this laboratory have been described by P. Reimer et al. (2016). The exceptions are the measurements for Kellerød (made in Oxford) and Esbenshøj (made in Aarhus). In all cases several physical/chemical cleaning steps, including ultra-filtering, were performed.

Additionally, δ^{13}C and δ^{15}N isotope values were measured, allowing estimates of dietary contributions from marine or freshwater sources, and detecting possible reservoir effects. Marine reservoir effects were estimated as a simple linear relation between the δ^{13}C endpoints of -21 ‰ (terrestrial) and -10 ‰ (marine). A. Fischer et al. (2007) suggested the end values -21.7 ‰ and -10.1 ‰, based on measurements on Mesolithic and Neolithic local fauna. Values from Early Neolithic domestic animals are slightly higher, however, probably due to more open environment (Gron/Rowley-Conwy 2016). We therefore use the end value -21 ‰ for terrestrial and the rounded value of -10 ‰ for fully marine protein sources. Furthermore, we have used a new marine reservoir effect value for early Neolithic Denmark, calculated to 273 ± 18years (Fischer/Olsen 2021). The results of these calculations are given in Appendix 2 and point to very limited influence of marine diet on the dates. Likewise, the generally low δ^{15}N values suggest little or no influence from freshwater protein for all individuals, with the possible exception of Vig Femhøve 3 (Table 2). C/N ratios were provided for all samples, and were found to be within the accepted range for well-preserved collagen, 2.9–3.6 (De Niro 1985; Van Klinken 1999). Calibrations were made in Oxcal 4.4 using the Intcal20 calibration curve (Reimer et al. 2020).

An overview of the chronological distribution in relation to dolmen typology is presented in Figures 7 and 8.

Table 2. New dates and isotope values on human bone and teeth from Danish dolmens and a long barrow. Full details of the samples and measurements are found in Appendix 2. PMD refers to Bröste et al. 1956.

Site	Type	Context	Individual	Lab no	BP uncal	1s	Cal BC rescorr (95.4%)	δ^{13}C (‰ VPDB)	δ^{15}N (‰ AIR)
Bygholm Nørremark	Long barrow	grave D	II	UBA-38881	4912	29	3709–3533	-19.2	9.6
Bygholm Nørremark	Long barrow	grave D	I	UBA-37227	4836	35	3645–3526	-20.0	9.6
Esbenshøj	IV			AAR-22190	4459	37	3343–2939	failed	failed
Grøfte	I	chamber A		UBA-38228	4828	35	3644–3525	-20.1	9.7
Grøfte	I	chamber B		UBA-40437	4731	32	3626–3372	-20.0	10.6
Kellerød	I		PMD 6	OxA-39594	4772	24	3631–3370	-20.3	10.2
Klokkehøj	III		RW	UBA-35706	3983	39	2574–2306	-20.0	9.9
Klokkehøj	III		GA	UBA-35707	4170	38	2883–2626	-20.7	9.6
Klokkehøj	III		QK	UBA-35708	4086	42	2851–2471	-20.0	10.6
Klokkehøj	III		MH	UBA-35709	4238	38	2906–2668	-20.1	10.3
Klokkehøj	III		QØ	UBA-37888	4847	34	3648–3528	-20.0	10.2
Klokkehøj	III		QÅ	UBA-40811	4756	37	3632–3376	-20.0	10.2
Klokkehøj	III		RL	UBA-37889	4750	58	3633–3372	-19.8	10.5
Rude	I	east chamber	H	UBA-37876	4838	29	3639–3527	-19.3	10.6
Rude	I	west chamber	I	UBA-37877	4901	37	3707–3528	-19.1	10.5
Rude	I	west chamber	I?	UBA-39551	4488	38	3331–2924	-19.0	10.6
Rude	I	west chamber	I?	UCIAMS-232708	4725	15	3517–3372	-19.1	11.1
Stasevang	II	east chamber	PMD 5	UBA-38236	4669	37	3621–3364	-20.5	9.9
Vig Femhøve	I		1	UBA-37892	4657	36	3517–3341	-19.6	10.3
Vig Femhøve	I		2	UBA-40810	4833	40	3648–3386	-19.7	10.3
Vig Femhøve	I		3	UBA-37893	4709	52	3625–3192	-18.6	12.4

Discussion

With the new series of precise and well contextualised AMS radiocarbon measurements (Figs. 7–8) a very different picture arises of the chronology of the erection of FBC funeral monuments as compared with the older one based on radiometric dates of charcoal and bone (Fig. 5). In this respect there are methodological as well as culture historical lessons to be told.

As to the methodological aspect: From at least two individuals we have duplicate measurements produced on the one hand by the radiometric method and on the other hand by the AMS method (Table 3). For these two individuals, the radiometric dates are nearly 300 ^{14}C-years younger than the AMS dates. Since the radiometric Copenhagen dates are consistently younger, we suspect that the difference is due to insufficient sample preparation, in particular the lack of ultra-filtration, potentially leaving low quality collagen and organic contaminants such as humic acids in the samples.

Another case is the large discrepancy between the dates of the tooth and the petrous bone at Rude west. Here, a more likely explanation is that different individuals have been dated.

As to the culture historical aspect: The new dates from Bygholm fit well with previously published charcoal and shell dates from long barrows, as referred above and in Appendix 1. Grave D at this site probably dates to before 3600 cal BC, but this grave was preceded by other features. Based on the

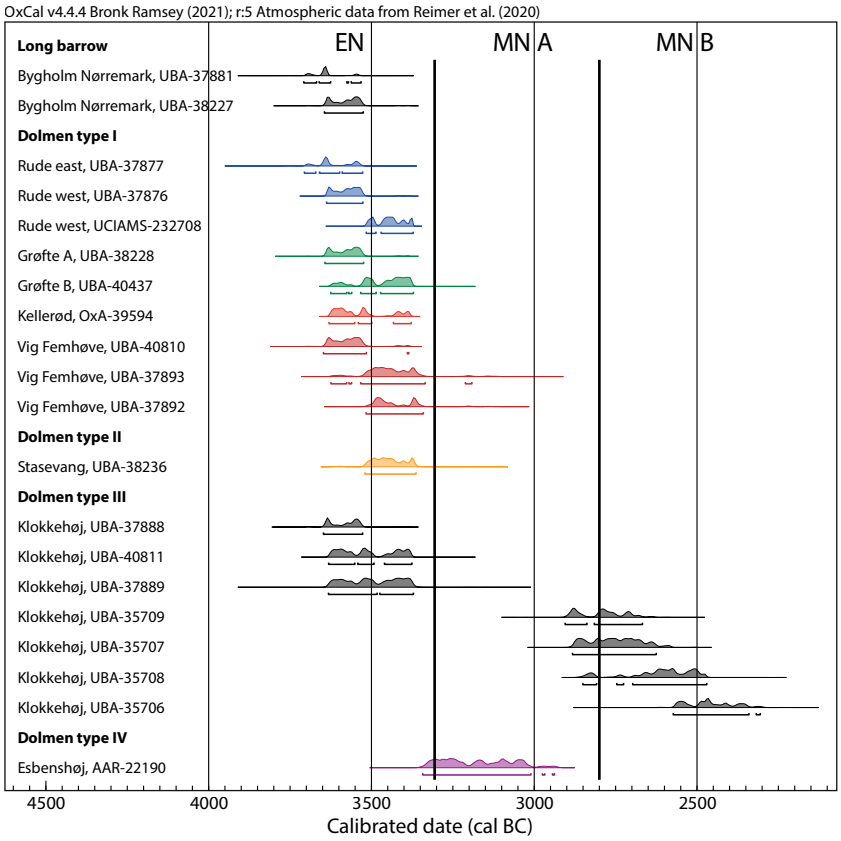

Fig. 7. Calibration of the new radiocarbon measurements on human bones and teeth from Danish long barrows and dolmens, based on reservoir corrected dates according to Appendix 2. The monuments are arranged by chamber type and by the oldest date within a site. Sites are differentiated by colour. NB: the dates represent episodes of use, which may be significantly later than the erection of the monument in question (Graphics: K.-G. Sjögren).

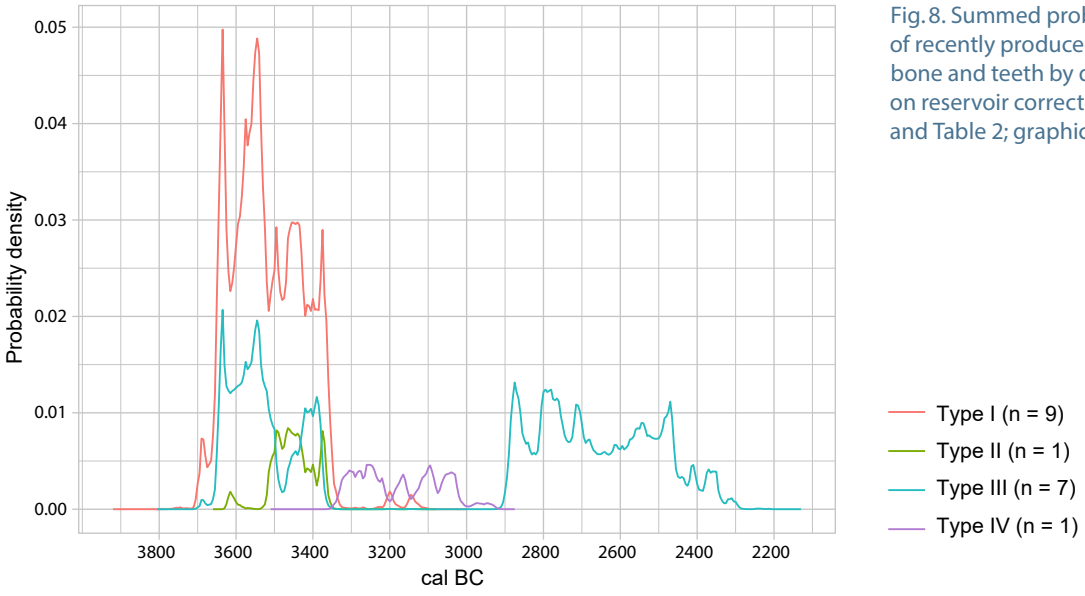

Fig. 8. Summed probability distributions of recently produced dates for human bone and teeth by dolmen type, based on reservoir corrected dates (cf. Figure 7 and Table 2; graphics: K.-G. Sjögren).

date of shells in a pit postdating house II, a start of the building sequence before ca. 3700 cal BC is probable. Similar time frames can be suggested for Højensvej and for the long barrow phase at Rude (Appendix 1).

The earliest dates from type I chambers (Rude, Grøfte, Kellerød and Vig Femhøve) are indistinguishable and fall in the range ca. 3650–3500 cal BC, with the Rude west chamber possibly being slightly older than the others, most likely around 3600 cal BC. The oldest date from the type III dolmen Klokkehøj is similar. This is broadly in line with the results from Flintbek, where only open chambers are known, and would suggest that the earliest stone chambers were constructed already in the EN I, and likely

Table 3. Duplicate measurements of skeletons based on radiometric method and AMS method. Only the results of the latter method, using up-to date collagen extraction techniques, are considered reliable.

Site	Radiometric date	AMS date	Difference in central value
Kellerød	4490 ± 65	4770 ± 24	280
Klokkehøj QØ	4550 ± 65	4847 ± 34	297

around 3600 cal BC. Taken as a whole, these new investigations strongly confirm a start of megalithic stone construction in Scandinavia around 3600 cal BC, and also the parallel construction of different dolmen types during the EN. The use of these chambers may continue into the EN II, but the human bone dates available at present do not indicate use in the later TRB phase, MNA. That such late use (and possibly construction) is still probable is indicated by pottery at sites such as Lønt (see above, for further sites see Skaarup 1985). At Klokkehøj and possibly at Rude, a second period of use in the MN B is indicated.

A chronological tendency may be seen in the orientation of dolmen chambers relative to their surrounding barrows, although data are insufficient for a clear statistical evaluation: Those six with the cist placed parallel to the longitudinal axis of the barrow are generally relatively early, while the relatively late Stasevang cist is the only one certainly oriented perpendicularly to the barrow. As to the remaining two, Klokkehøj and Esbenshøj, there is no information on the orientation of their barrows.

Judging from the low $\delta^{13}C$ and $\delta^{15}N$ values, marine and freshwater reservoir effects should be small in most of these dates (Table 2; Appendix 2). The exception is individual 3 from Vig Femhøve where a marine reservoir effect in the order of ca. 65 years can be estimated (Table 2; Appendix 1–2).

The new series of radiocarbon measurements allow for a preliminary evaluation of previous attempts at a relative chronology of the various chamber types. The probably earliest of our dates come from the two rectangular, closed cists at Rude. These can be classed as type I chambers, even if somewhat unusual in their construction (Appendix 1). In fact, Eriksen and Andersen (2014, 111) suggest the term "dolmen cists" for Rude and a few other similar graves. Here we view them as a subgroup of the type I dolmens. The early dates from Rude also lend support to their hypothesis of a local development of stone chambers from wooden cists.

The group dated to EN I contains chambers of different types: type I (Grøfte, Kellerød, Rude and Vig Femhøve) and type III (Klokkehøj). Most of these age determinations (Grøfte A, Grøfte B, Kellerød, Klokkehøj QØ, Rude east) are considered reliable expressions of the time of erection of the monuments in question, since they derive from what appear to be single primary interments – skeletons in supine position, closely associated with funeral pottery (Appendix 1). The closed type I chambers with only single or a couple of interments are unlikely to have been used on more than one occasion, even if this cannot be completely ruled out, as shown by the Rude west case. Open chambers such as Klokkehøj present more difficulties due to repeated use of the chambers, and such dates generally represent use events rather than construction. In any case, the Early Neolithic dates from Klokkehøj suggest a latest probable construction time for this chamber.

Another possibility is that of reburial of older bones from other graves, as a kind of foundation ceremony (cf. Teather 2018; Blank et al 2020). We consider this possibility less likely in the cases presented here, as many of the inhumations seem to be primary burials of complete, articulated skeletons. Importantly, this includes the articulated male skeleton in Klokkehøj, individual QØ. Reburied bones would rather be expected to be in the form of selected and disarticulated skeletal parts, perhaps primarily crania and

larger bone elements. Further investigation of this question would require new osteological examination of the bone materials with modern methods, as well as a series of dates on different bone elements. Such dating programs may well disclose interesting aspects of burial treatment, as exemplified by a recent case from Spain (Aranda Jimenez et al. 2020).

Type II and IV chambers are only represented by a single date each. The somewhat late dates of the type II (Stasevang, ca. 3500–3350 cal BC) and type IV (Esbenshøj, ca. 3300–3000 cal BC) chambers, are not necessarily representative of the earliest interments in these chambers nor of the earliest constructions of these types of cists. In fact, the dates for type IV dolmens from Flintbek are earlier and belong to the EN (Fig. 3). Dates from a type II dolmen chamber, Tiarp 26, in Sweden are similar to the one from Stasevang (Henriksson 2016; Blank et al 2020). Only further dating can clarify the chronological position of these dolmen types. No monuments of the *Großdolmen* type were dated in the present project.

In recent years, a series of dates from long barrows, dolmens and possibly free-standing facades have been forthcoming from Scania in southernmost Sweden (Larsson 2002; Rudebeck 2002; Andersson/Wallebom 2011; Andersson et al. 2016; Andersson 2017). The majority are charcoal dates from quite small fragments, but a few dates on cereals and one human bone date are also available. The dates from Scania are broadly in agreement with the new Danish data, although many of the problems raised in relation to the Danish charcoal dates also apply. One of the problems with the Scanian dates is that chamber forms are often difficult to determine due to overploughing and removal of stones. No certain chambers of types I–II were dated in Scania. In six cases, from Döserygg and Östra Odarslöv, the chambers can be classed as types III or IV (Andersson/Wallebom 2011; Andersson et al. 2016; 2022). The charcoal dates from these chambers are rather scattered and range from the Early Neolithic to the late Middle Neolithic, with a few even later dates. It would seem that problems of context apply to some of these samples. The Scanian data merit a detailed evaluation, which is beyond the scope of this paper.

It shall briefly be mentioned that eight bone samples from human skeletal material found in passage graves have been dated as part of the genomic project from which this paper is a spinoff. They span the time interval ca. 3000–1500 cal BC and may all be secondary interments. They can therefore only be taken as *terminus ante quem* (latest possible) dates for the erection of the monuments in question. Thanks to a series of ten AMS dates based on birch bark used as part of the building material it was, however, previously demonstrated that passage graves in Denmark were most likely erected in the course of a short period of perhaps only two hundred years from around 3400 cal BC (Dehn/Hansen 2006).

A further notable feature is the overlap between the oldest measurements on human bones in dolmens and those achieved from non-megalithic constructions in long barrows, as referred above. From the dates presently available it is not possible to see a general development from earthen long barrows to dolmens, even if such chronological sorting is often seen on a site level. Rather the picture is one of coexistence of burial forms. However, there may be issues around the resolution of these dates. A general typological development may still be possible if earthen long barrows were first built around 3800 cal BC and dolmens started to be built after 3700 cal BC.

A further conclusion from the overlap of monument forms may be just as significant, as the burial treatment also would be more varied than previously recognised. Earthen long mounds and type I–II dolmens usually contain only remains of 1–2 individuals, whereas the larger and more accessible chambers contain multiple interments deposited over a period of time, as in the case of Klokkehøj. Mortuary practices emphasising the importance of

small numbers of particular individuals therefore seem to coexist with practices emphasising longer term group continuity.

As data look now, long barrows seem to arrive in Denmark later than other Neolithic features such as cereals, Funnel Beaker pottery and domestic cattle. The former possibly dates back before 3900 cal BC, while cattle and TRB pottery certainly were present by that time (Fischer 2002; Fischer/Gotfredsen 2006; Price et al. 2007, 207; Sørensen 2014; Fischer et al. in prep. a). Danish burials indisputably belonging to this initial period of the Neolithic are wanting. The Dragsholm male interment is currently the most convincing example – and even in this case issues on sample contamination may be raised (Fischer et al. in prep. b). According to literature, its construction included neither monumental stones nor a barrow (Petersen 1974; Price et al. 2007; cf. Ebbesen 1994).

Conclusion

Long barrows seem to have arrived in Denmark later than other elements of the Neolithic world such as Funnel Beaker pottery, cereals and domestic cattle, which were present at least from 3900 cal BC. The erection of monumental architecture may therefore be one of the relatively late aspects of the neolithisation of Denmark.

The new radiocarbon dates have resulted in a clarification of the history of long barrow and dolmen construction in this country. Drawing also on older dates, we estimate the building period for earthen long barrows to have lasted ca. 300–400 years, ca. 3800/3700–3400 cal BC. The earliest stone chambers were constructed already in the EN I, around 3600 cal BC. The probably oldest dates come from the rectangular, closed cists at Rude, which can be classified as type I dolmens, even if somewhat unusual in their construction according to Danish standards. Comparable structures are found in present-day north and middle Germany, possibly indicating a social and genetic background in this geographical zone for the first megalithic monument-builders in Denmark. Alternatively, as suggested by Eriksen and Andersen (2014, 111), they can be seen as translations into stone of wooden plank-built cists of EN type. In this perspective, the first stone chambers may well have been developed independently in the northern TRB culture.

The construction of type I dolmens continued during the period 3650–3400 cal BC (Grøfte, Kellerød, Vig Femhøve) alongside with the building of type II (Stasevang) and type III (Klokkehøj) chambers. Cists placed parallel to the longitudinal axis of the barrow may generally be earlier than those with a transversal orientation.

Taken as a whole, our investigation demonstrates a start of building megalithic stone monuments in Scandinavia around 3600 cal BC, and also the parallel construction of different dolmen types throughout the Early Neolithic.

Acknowledgements

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Archaeologists/cultural heritage managers Torben Dehn, Klaus Ebbesen, Thomas Eriksen, Lutz Klassen, Poul Otto Nielsen and Sven Thorsen are thanked for assistance in the resolution of archaeological questions relating to specific monuments. Doris Mischka and Martin Furholt are thanked for clarifications on the Flintbek monuments. Likewise, the assistance by Kaare Lund Rasmussen and Marie Kanstrup in solving questions on laboratory pre-treatment procedures for radiocarbon samples in Copenhagen and Aarhus, respectively, is highly acknowledged.

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Appendix 1: The dated monuments

In the following, we will present the monuments that are discussed in the main text. This is done for two main reasons: 1) giving a general overview of the nature of the interesting and often spectacular monuments in question, including their architecture, burial goods and skeletal material; 2) presenting a critical scrutiny of the samples dated for the purpose of evaluating their representativity and overall credibility. Additionally, we make an effort of presenting informative illustrations not yet made use of in (readily available) literature. The sites are mentioned in chronological order as far as this can presently be determined, based on a source critical evaluation of the radiocarbon measurements available. For the geographical location of these sites we refer to Figure 1 in the main text.

Bygholm Nørremark, Jutland

This important site was excavated in 1975–1978 and published preliminarily by P. Rønne (1978; 1979). It was originally located in a hilly landscape about three quarters of a kilometre from the coast. Initially, the excavation revealed a barrow of 75 × 13 m with the remains of a destroyed megalithic chamber in its eastern part. This chamber could be classed as either a *Großdolmen* or a passage grave and dated to the Middle Neolithic (MN) according to pottery finds.

During later stages of the excavation a series of non-megalithic structures were revealed below the mound (Fig. 9). These consisted of a wooden façade in the eastern end, two or possibly three house foundations, two earth graves and a palisade trench surrounding the whole complex. The trench was trapezoidal in ground plan, ca. 60 m long and up to 13 m wide. In the eastern end, a couple of meters within the trench was a façade trench surrounded by a post setting, possibly an oval house (house II). Charcoal from the façade trench was dated to the Early Neolithic (EN).

Somewhat further west was an oval house (house I) containing a stone framed, non-megalithic grave (burial A), and in this the poorly preserved remains of a skeleton from a young person. By the waist was an amber bead and in the chest region a flint arrowhead, possibly the cause of death.

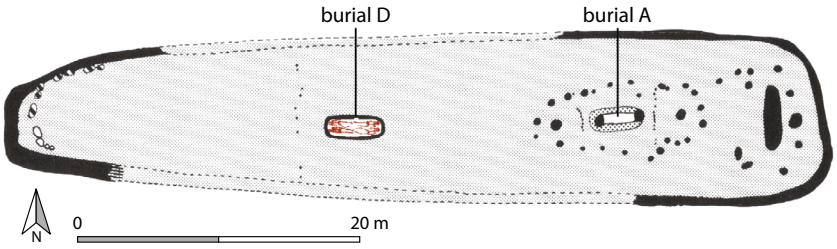


Fig. 9. Bygholm Nørremark. The major constituting elements of the long barrow in its earlier stages (redrawn by R. Potter/Gothenburg University, in cooperation with A. Fischer; after Nielsen 1981, 74).

Even further west was another earth grave, consisting of a rectangular pit with traces of a wooden cist (burial D). It contained the skeletons of four adult persons laid out on their backs in an orderly fashion, in two by two pairs opposing each other. No burial goods were encountered in this grave.

A third small house was found in the narrow end of the monument (house III).

According to Rønne's interpretation, the first phase would have been the trapezoid palisade and house I. Subsequently, when burial A was constructed, this house was torn down and instead the eastern façade and the posts surrounding it were established. Shortly after, four people were interred in burial D further west, and possibly the western house was erected. Then, an earthen mound of trapezoid shape was raised on top of the complex. Finally, a stone chamber was inserted into the mound and additional earth and stones were added to make the barrow a rectangle framed by megaliths.

In the present project radiocarbon measurements were performed on samples from two of the individuals in grave D (Table 2; Appendix 2). One of them was genetically determined as male (Allentoft et al. 2022). Together with previously published dates (Sørensen 2014), the available ^{14}C determinations come from three different contexts, i. e. charcoal from the façade, oyster shells from a pit postdating a posthole in house I, and human teeth in grave D. The stratigraphic relations between these contexts are not clear. The charcoal date was made on a sample of twigs and should not contain an old wood effect (Nielsen, P. O. pers. com. 2018). Calibrations of the new dates are shown in Figure 10 together with the two previously published age determinations. For archaeological reasons the skeletons in burial D can be considered contemporaneous, which is also confirmed by Chi2-test of the dates. The combined date of these individuals is 4841 ± 23 uncal BP (3654–3532 cal BC [95.4 %]). The most likely interval is 3654–3623 cal BC (59.5 %), however, an interval of only 31 years (Fig. 10). A smaller probability peak occurs at 3581–3532 cal BC (35.9 %).

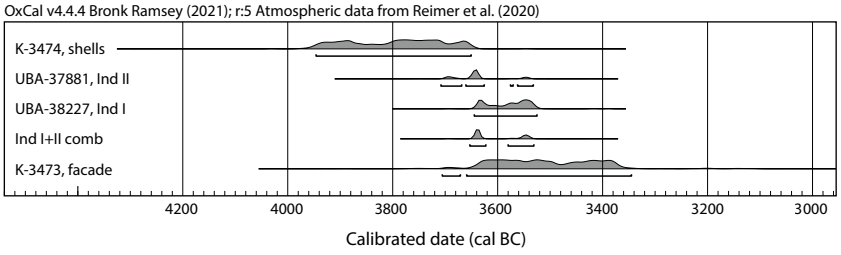


Fig. 10. Bygholm Nørremark. Calibration of dates, with bone and shell dates corrected for reservoir effect (Appendix 2). K-3473 is based on twigs from the façade, implying a negligible old wood effect (Graphics: K.-G. Sjögren).

The reservoir corrected date of the shells from a pit postdating a posthole in house I (K-3474) likely indicates an early date for this house as well as for grave A, probably before 3700 cal BC. As can be seen from Figure 10, the charcoal date from the façade is contemporaneous or slightly later than the bone dates from grave D. The latter could have been constructed 3654–3623 cal BC, or with a lower probability around 3550 cal BC. The façade may have been contemporary with grave D, or more likely slightly later (in accordance with Rønne 1979).

The radiocarbon measurements available also supply an earliest possible date for the mound and of the *Großdolmen* or small passage grave inserted into it.

Unpublished sources consulted: National site inventory (Fund & Fortidsminder) no. 17.04.03-128. Anthropological Laboratory j. no. AS 9/78+16/79.

Rude, Jutland

The partly excavated site (Madsen 1980) consists of a long barrow, at least 58 m long and 8–9 m wide (east–west), containing two small stone cists/dolmens (Fig. 11). These were of unusual type and do not quite fit the definition of Danish dolmens, the main difference being the use of thin stone slabs in place of thicker blocks. Early Neolithic parallels are to be found south of the Baltic Sea, primarily in Mecklenburg, northern Germany (ibid. 98). An interesting alternative was proposed by Eriksen and Andersen (2014, 111), who point out similarities in these "dolmen cists" with plank-built coffins from the Early Neolithic in Denmark. This would then indicate a local development of dolmen chambers from wooden to stone-built constructions.

The eastern cist measured ca. 2.4 × 0.5 m. It was constructed by eight thin side stones and a roof consisting of five slabs of split stone. In the chamber poorly preserved human skeletal remains were revealed, possibly from a single adult person. Sex could not be determined morphologically but the individual was genetically determined as a male (Allentoft et al. 2022). No artefacts of Neolithic date were found.

The dimensions of the western cist were 1.9 × 0.6 m. It was constructed from seven side stones and a roof stone, all of which were thin slabs, possibly artificially split. The chamber was previously disturbed and from this

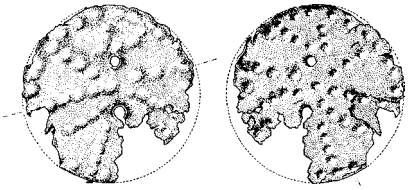
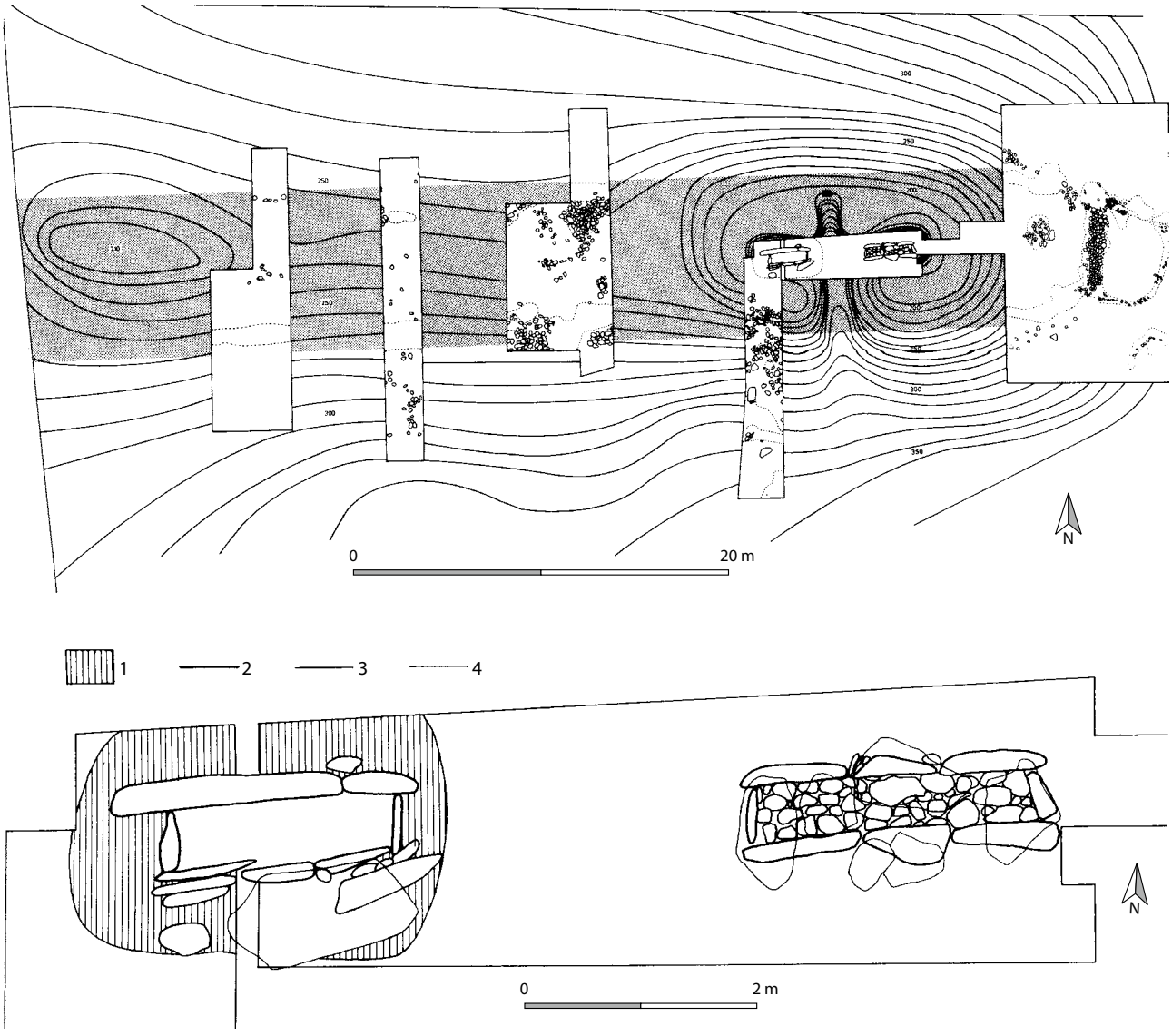


Fig. 11. Rude. Top: the copper disc from the western chamber. Bottom: overall plan of barrow; detail of the stone cists; (after Madsen 1980, figs. 2; 6).



derived the find of a copper disc of Early Neolithic type (Randsborg 1970; Madsen 1980; Klassen 2000). The excavation revealed poorly preserved and disarticulated human bones, potentially from more than one person. Sex could not be determined morphologically but a sample from the petrous bone was genetically determined as a male (Allentoft et al. 2022), and age was estimated to 20–40 years. According to two previous radiocarbon dates with the radiometric method, these individuals should be from the MN A/B transition (Table 1). These dates do not fit the expected date of the copper disc found in the chamber.

A trench at the eastern end of the barrow revealed the remains of a burnt wooden façade, with traces of seven cloven upright wooden posts ca. 0.6–0.8 m in diameter. By the façade was a deposition of three complete funnel beakers of Early Neolithic type, and parts of 4–5 other vessels. Two age determinations of charcoal from the burnt façade referred this feature to EN I (Table 1). Outside the façade were traces of a small enclosed space delimited by a wickerwork fence. According to T. Madsen (1980), these features probably belong to an early façade, which had not been burned.

The copper disc was analysed for element composition by L. Klassen (2000, 198 ff.). The metal turned out to be rich in arsenic, similar to Mondsee copper but also to south Alpine (north Italian) metal sources.

The two previous dates on human bones both placed the burial in the MN A/B transition (Table 1; Figs. 4; 12). This was problematic since it did not fit the archaeological interpretation of the monument. The four new dates from this site give a very different picture of the building sequence, and one that fits better with the original archaeological interpretation. Both chambers can now be referred to EN I, and are currently among the oldest dated dolmens in Denmark. The radiometric method determinations on charcoal from the façade fit well with these dates, especially K-3125, which was sampled from a thin branch and should not exhibit much old wood effect, if any.

One of the new dates from the western chamber was considerably later and fell in the MN period (UBA-39551; Table 2; Appendix 2). This sample, from a petrous bone, was redated (UCIAMS-232708) and the new date was Early Neolithic, a date which is accepted here. Still, the date from a tooth in the chamber is considerably earlier and combining these two dates failed the Chi2-test. In all likelihood, at least two persons have been buried in this chamber. The two previous dates from the western chamber might indicate the presence of a third person, but we believe that insufficient sample pretreatment may be a more likely explanation (cf. our comments on Kellerød and Klokkehøj). In support of this inference, it can be mentioned that one of the radiometric dates was made on a porous bone (vertebra), which will typically imply poor bone collagen preservation and a high content of humic acids. Additionally, the other radiometric date was produced on a mixture of small bone pieces.

Bayesian modelling of the dates indicate a very short construction period, most likely 3670–3650 cal BC, and not longer than 3700–3600 cal BC. In conclusion: Madsen's (1980) suggestion of a short building sequence, with the

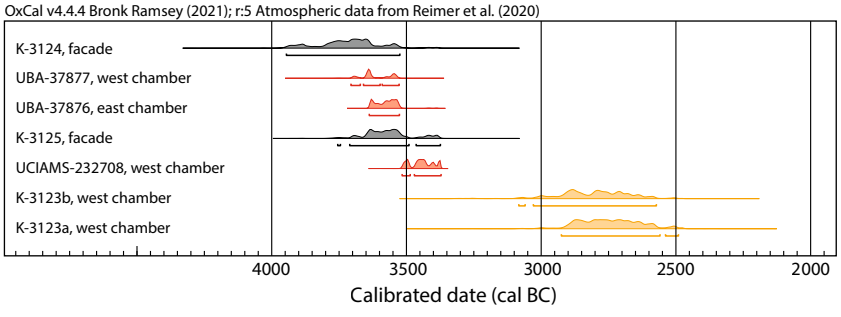


Fig. 12. Rude. Calibration based on reservoir corrected dates (Appendix 2). New bone dates in red, old bone dates in orange, charcoal dates in black (Graphics: K.-G. Sjögren).

western chamber connected to the first (unburnt) phase of the façade and the eastern chamber connected to the second façade phase fits very well with the new radiocarbon dates (Fig. 12).

Unpublished sources consulted: National site inventory (Fund & Fortidsminder) no. 15.02.12-6. Anthropological Laboratory j. no. AS 1/78.

Højensvej høj 7, Funen

With ten radiocarbon determinations, Højensvej mound 7 (Fig. 13) is until now the best dated and best published Danish long barrow (Beck 2013). One of the contexts dated is from pre-barrow activity (ard ploughing), while the others are from two graves (features K-7002 and K-7005 in the excavator's terminology) and an eastern façade (K-7001). According to the excavator, K-7005 was constructed first and covered with a stone packing, whereafter the monument was extended to the east and west. Grave K-7005 was a rectangular wooden coffin built by planks, possibly surrounded by a small building. It contained neither burial goods nor skeletal remains. The eastern grave, K-7002, was surrounded by a small rectangular building, and contained a thin-butted flint axe (type IIIa according to P.-O. Nielsen 1977), twelve transverse arrowheads and a blade knife. Typologically, the axe is dated to the EN I or the EN I/II transition. At the western end of the barrow, faint traces of a third structure were found, possibly a grave or a small building. The burials were covered by a mound, probably built in several phases, as differing fill material as well as internal divisions were observed.

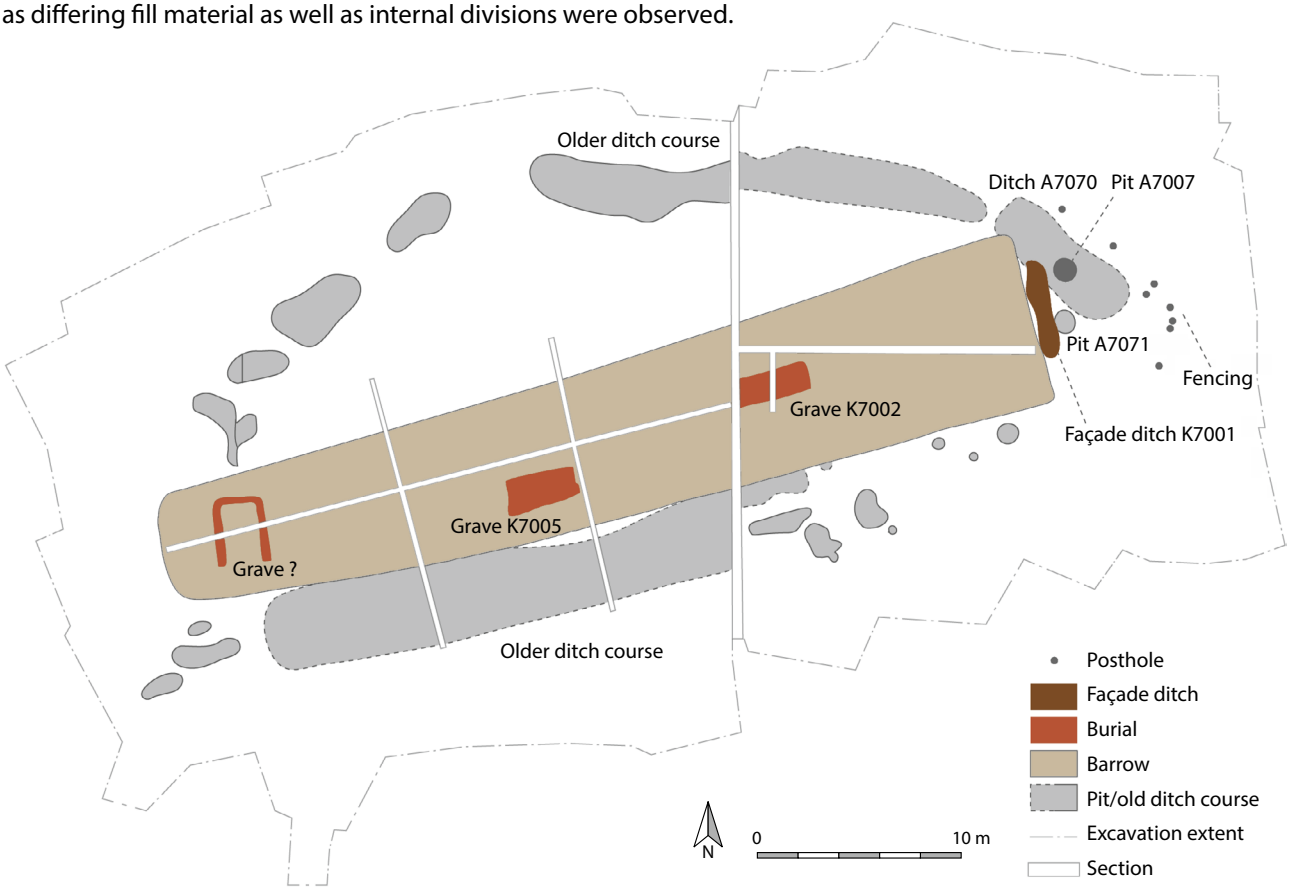


Fig. 13. Højensvej. Barrow 7 (redrawn by R. Potter/Gothenburg University, in cooperation with A. Fischer after Beck 2013, fig. 3).

In the view of the excavator, the eastern façade was built in three phases, corresponding to three phases of burial and barrow building. The first phase would have comprised nine posts, while the later included five. In contrast to some other long barrows, no traces of burning were seen. Finds

of charcoal in the trench therefore have no clear relation to the construction but may relate to earlier activities or to material introduced in connection with reconstructions. Finds of EN pottery were made in the façade trench, but cannot be dated more closely.

Five of the six radiocarbon measurements from the two graves are taken from burned wood in the constructions and are therefore directly related to the these. The wood species specified are birch *(Betula)*, oak *(Quercus)* and maple/stone fruit *(Acer/Prunus)*, the biological age of which can amount to several decades or even centuries. Therefore, an old wood effect cannot be excluded – not least since the excavator infer the samples to derive from solid poles and planks. As to the sixth date (4985 ± 35 uncal BP, from K-7005), the excavator considers admixture from previous activity at the site a possibility (Beck 2013). This date is in fact clearly older than the other two age determinations from this burial (Appendix 2). A combination of the two younger measurements from K-7005 is statistically acceptable, giving the result 4873 ± 27 uncal BP (3703–3637 cal BC [95.4 %]). If instead only the youngest date is regarded as representative, we arrive at a calibrated date of 3698–3523 cal BC, i. e. a similar start but a wider range.

The dates from K-7002 are more homogenous. Calibration shows a large degree of overlap in the range ca. 3630–3380 cal BC. Combination of all three dates from this grave is statistically acceptable and results in 4707 ± 21 uncal BP. However, due to the shape of the calibration curve this does not improve resolution, as the calibrated range is still 3628–3376 cal BC (95.4 %).

The combined dates from the different contexts are plotted in Figure 14. This gives some support to the idea that K-7005 is older than K-7002. The dating of the latter is difficult to pinpoint due to the low resolution after calibration. The dating of the façade, K-7001, is more ambiguous – but the interpretation of the excavator, of contemporaneity with the graves, is not contradicted. In all, the dated structures should all be set within a time window of ca. 3700–3500 cal BC, although the range could in reality be much narrower.

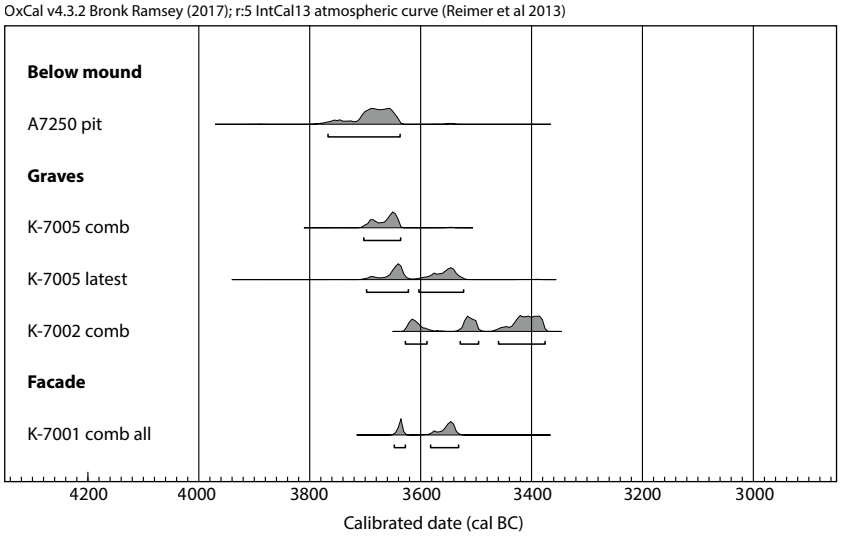


Fig. 14. Højensvej. Calibration of dates from graves and façade at mound 7 (Graphics: K.-G. Sjögren).

Finally, the date on charred hazelnut shells *(Corylus avellana)* from A7250, a pit below the mound, should be commented. This pit does not have any direct stratigraphic relation to the graves or facade structures but predates the mound and postdates the ard furrows found under the barrow. The dating of this sample, 4900 ± 40 uncal BP (3768–3638 cal BC [95.4 %]) overlaps partly with the oldest date from K-7005, and it is indeed possible that it relates to ceremonial activity connected to this grave. As it overlays plough

marks found beneath the barrow, it gives a *terminus ante quem* (latest possible) date of the use of ard ploughing at the site, at present the earliest from northern Europe (Beck 2013, 71 ff.).

Unpublished sources consulted: National site inventory (Fund & Fortidsminder) no. 09.05.04-28.

Vig Femhøve, Zealand

When a stone mason, engaged in demolishing the site, first looked into this dolmen there was a direct view to its prehistoric interments. Prior to opening the soil-free cist it had been completely covered by crushed flint, a stone packing and a topping of earth. The chamber was excavated in 1909 by Georg Sarauw (Müller, S. 1911). It was set near the centre of a mound, approximately 3.5 m high, surrounded by a megalithic frame. Due to demolition, the original shape and dimensions of the barrow cannot be determined. As it looks now the remaining kerb stones form an irregular rectangle, extending ca. 12 × 9 m in a west-south-west–east-north-east orientation (Fig. 1).

The rectangular chamber measures ca. 1.65 × 0.85 m at the bottom and slightly less at its top (Fig. 15). It is built of four equally high side stones and a roof stone. All of them are deliberately split and have a flat side turned towards the chamber. Additionally, the upper side of the roof stone also results from splitting. The cap stone appears to derive from one and the same original block as the north-western side stone.

According to the field report the floor of the dolmen consisted of a pavement of 0.2–0.4 m large moraine stones, apparently laid out on the ancient surface. The distance between this surface and the roof stone was 1.1 m. On top of the paving was a 0.2 m thick layer of gravel and crushed flint. Resting on this was a dense deposit of disarticulated human bones. A subsequent laboratory inspection of the bones reached the conclusion that remains of as much as six individuals were present: four adults, one juvenile and a child (Nielsen 1915, 276). In the same stratigraphic position as these bones two Early Neolithic ceramic vessels were found (Fig. 16). Additionally, some undecorated sherds were recovered, including two small handles, which may derive from mentioned vessels. In between the bones some stray charcoals and a shell of cockle *(Cardium edule)* were observed.

The Neolithic interments were covered by a layer of small stones on which the skeletal remains of a human individual rested. Based on the burial goods, this individual is dated to Bronze Age period III (Aner/Kersten 1976, 77).

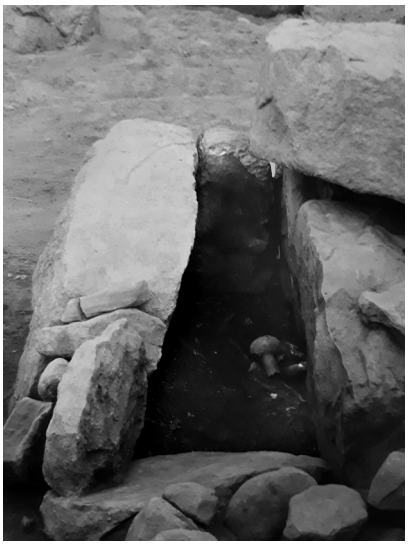


Fig. 15. Vig Femhøve. A view from west-south-west into the dolmen during the excavation of its Early Neolithic deposits in 1909. Besides human skeletal remains a tipped over ceramic vessel (lugged flask) is seen (Photo: G. Sarauw/ Danish National Museum).

Fig. 16. Vig Femhøve. A fragmented and a nearly intact lugged flask from the dolmen chamber. This characteristic, high-necked pottery type is often found in early megalithic burial chambers in Denmark. Diameter of the two vessels is 16 and 17 cm, respectively. According to the standards of this type, they originally had two or more small handles, vertically placed at their body-neck junction (Photo: J. Lee/Danish National Museum, in cooperation with A. Fischer).

As part of the present project three human mandibles (Fig. 17) were sampled for aDNA, AMS dating, and isotope studies. They represent a male who died around the age of 40 years and two further individuals aged ca. 25–30 and ca. 20–30 years at death, respectively. According to the AMS dates, they belong to the middle and late parts of the Early Neolithic (Fig. 7; Table 2; Appendix 2). Judging from the low $\delta^{13}C$ and $\delta^{15}N$ values, marine and freshwater reservoir effects should be small or negligible in two of these dates (Table 2; Appendix 2). The exception is individual 3 ($\delta^{13}C$: -18.6 ‰; $\delta^{15}N$: 12.4 ‰) where a marine contribution to protein diet in the order of 25 %, resulting in a reservoir effect of ca. 65 years, can be estimated (procedure explained in main text).

Unpublished sources consulted: Danish National Museum inventory numbers A 25358-60; excavation report 1909 by Georg F. L. Sarauw, j. no. 24/1909. National site inventory (Fund & Fortidsminder) no. 03.04.12-150. Anthropological Laboratory (no j. number).

Fig. 17. Vig Femhøve. The three AMS dated individuals, each represented by a lower jaw. From left to right: individuals 3 (male?, ca. 40 years), 2 (male?, 20–30 years) and 1 (female?, 25–30 years) (Photo: J. Lee/Danish National Museum, in cooperation with A. Fischer).

Klokkehøj, Funen

This is a relatively large oval chamber, possibly without passage. In the typology used in the present paper, it can be classed as a type III dolmen, and it is the only dolmen of this type included in the present project. Previous radiocarbon dates had suggested a primary period of use in the early Middle Neolithic, i. e. ca. 3300–3000 cal BC, followed by a hiatus and then by a period of reuse in the late MN A–early MN B. These age measurements based on the radiometric method must now be revised, particularly regarding the primary use period of the dolmen.

The megalithic chamber, excavated in 1977, is one of the very few Danish dolmens where the location of human bones has been documented in detail (Thorsen 1981). It has played a central role in the discussion since, and has often been used to argue for a change from primary burials during the Early Neolithic and earliest Middle Neolithic to a practice of secondary deposition of skeletal material later in MN A (ibid.).

The chamber measured 3.1 × 1.9 m (Fig. 18) with an original distance between floor and roof of ca. 1.75 m. It had an entrance in the narrow side to the southeast, with a 0.6 m opening between the sill and the cap stones. S. Thorsen (1981) classified it as an extended dolmen and it fits type III in the typology of Eriksen and Andersen (2014). It was constructed of granite boulders and had a floor of sandstone slabs, covered with a thin clay layer. The roof block had been removed, and the southern half of the chamber had been disturbed in recent time. The surrounding mound had been almost completely ploughed away, along with any possible traces of a passage.

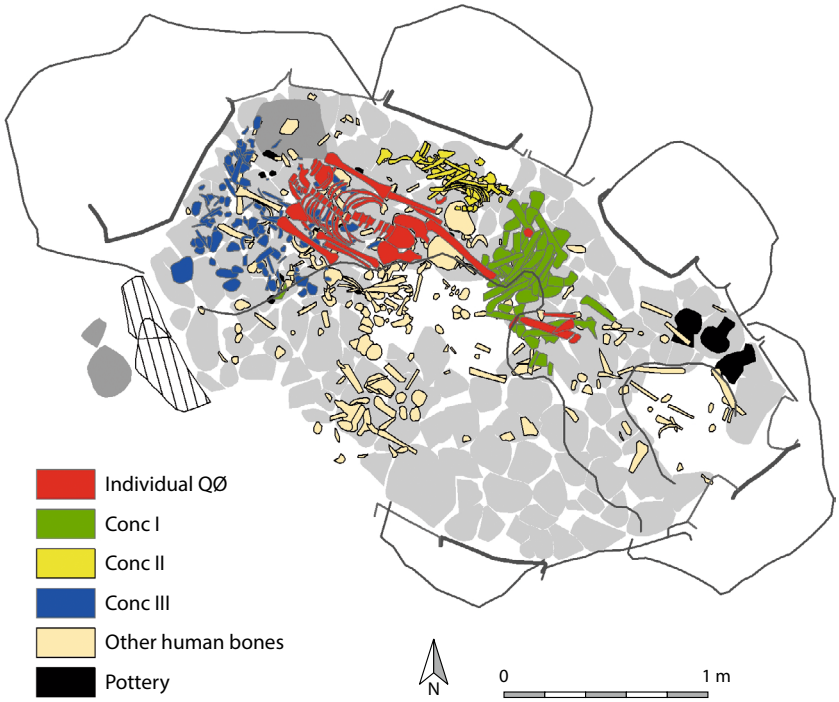


Fig. 18. Klokkehøj. Chamber with remains of primary interments and location of funeral pottery of late EN date. Light grey – stone pavement; dark grey – other stones; hatched – dry stone walling. Thin black line indicates limit of disturbance (redrawn from field documentation by K.-G. Sjögren).

On the chamber floor, >500 human bones estimated to derive from at least 22 persons were found. Among them was the articulated skeleton of an individual (QØ) aged ca. 25 years, osteologically probably a male. It was lying on its back in extended position. The right arm and the legs were partly disturbed, and of the head only the mandible was present. A cranium was found between the legs, but it is not clear whether it belongs to this person or not. This individual was interpreted as a primary burial by the excavator. The only funeral pottery found in the chamber was located near the feet of this skeleton (Fig. 18).

On the basis of the radiometric method individual QØ was dated to 4550 ± 65 uncal BP (K-2954), i. e. the early MN A (Table 1; Appendix 2). Subsequently we have arranged for an AMS date of the mandibula. Interestingly, the result was 4847 ± 34 uncal BP (UB-37888). Consequently, we are left with the suspicion that the first date is erroneous, possibly due to contamination.

In the bone layer, three concentrations of human bones were noted (I–III). One femur from each of the bone piles was selected for dating by Thorsen (1981). They all date to the MN A/MN B transition (Table 1; Appendix 2). The same uncertainty as above may apply to these measurements.

Concentration I was found in the uppermost layers in the chamber and consisted mainly of cranial fragments and long bones packed tightly together. For morphological reasons, one femur was attributed to the articulated individual, QØ. The concentration was interpreted as recent, probably consisting of bones collected during the partial destruction of the chamber. Concentration II was found along the northern wall. It contained more than 50 bone pieces, several of which were in partial articulation. For instance, four vertebrae from a child were found in anatomical position, as well as a bundle of ribs from the right side. It was suggested that this represents placing or rearrangement of bones not very long after death. Concentration III was less distinct but most of the bones were close to the north-western wall. Only in one case, a collection of ribs, some anatomical order was noted.

The osteological analysis showed that several individuals were represented in the concentrations, at least 6 in concentration II. Also, bones from one and the same person could be found in both pile II and III. For instance, parts of a cranium coming from both piles could be refitted.

The probability distributions of the new dates are shown in Figures 7 and 19 and the dates are presented in detail in Appendix 2. They form two groups, one in the Early Neolithic and one in the late Middle Neolithic. Of special interest is the dating from individual QØ, which the excavator interpreted as a primary interment, possibly the first burial in the chamber. The new date suggests burial at 3648–3528 cal BC res corr (95.4 %), corresponding to EN I. The other two early AMS measurements have wider spans, ca. 3600–3400 cal BC. Together, these dates put Klokkehøj firmly in the EN, and most likely in the EN I, around 3600 cal BC. This is an unexpectedly early date for this type of tomb, and together with the other radiocarbon measurements reported in the present paper this suggests contemporaneous construction of different chamber types during the later phases of the EN I.

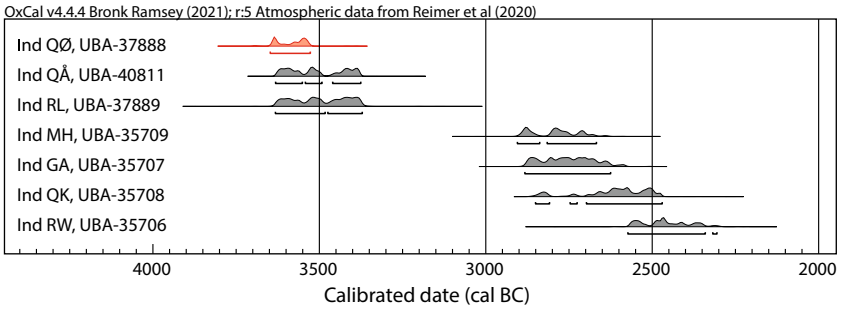


Fig. 19. Klokkehøj. Calibration of the new, reservoir corrected dates (see Appendix 2). The articulated male individual (QØ) is marked in red (Graphics: K.-G. Sjögren).

In spite of this chronological revision, a basic proposition put forward by Thorsen (1981) remains completely possible, namely a change in burial practice during the use period of the monument. In his view individual QØ represented an early phase of primary burials, with complete bodies in supine positions, while the later phase was characterised by secondary burial practices, represented in heaps of disarticulated bones.

It is also interesting that more than half of the new dates are from the MN B, i. e. the epoch of the Single Grave Culture, which is not represented by any artefacts at the site. The gap between the two phases of use corresponds to the MN A (later part of the Funnel Beaker Culture). In fact, these later age determinations cover a period otherwise very poor in human remains, corresponding to the earliest phase of the Single Grave Culture. If the interpretation of burial practices can be upheld, it is also notable that this phase is characterised by secondary burials, in stark contrast to what until now has appeared as normal practices in Single Grave Culture burials. One of these late inhumations, Ind QK, was genetically determined as a female with European Farmer ancestry, in contrast to contemporary individuals at Gjerrild in Jutland (Allentoft et al. 2022; Egfjord et al. 2021).

Unpublished sources consulted: National site inventory (Fund & Fortidsminder) no. 09.04.12-68. Anthropological Laboratory j. no. AS 14/77.

Grøfte, Zealand

At Grøfte, a long barrow containing two small closed dolmen chambers was partly excavated in 1946 (Ebbesen 1990). The earthen barrow was more than 80 m long and 9 m wide (Fig. 20). With a height of up to 1.5 m it reached well above the top of the relatively flat cap stones of the chambers. These were found ca. 5 m apart near the eastern end of the mount. Both are cists of type I, so-called *Urdolmen*. Closer to the centre of the barrow, an elongated stone setting was found. In accordance with the excavator (H. Andersen, pers. comm. 1986), K. Ebbesen interprets it as the remains of an earth grave, connected to an early stage of the long barrow.

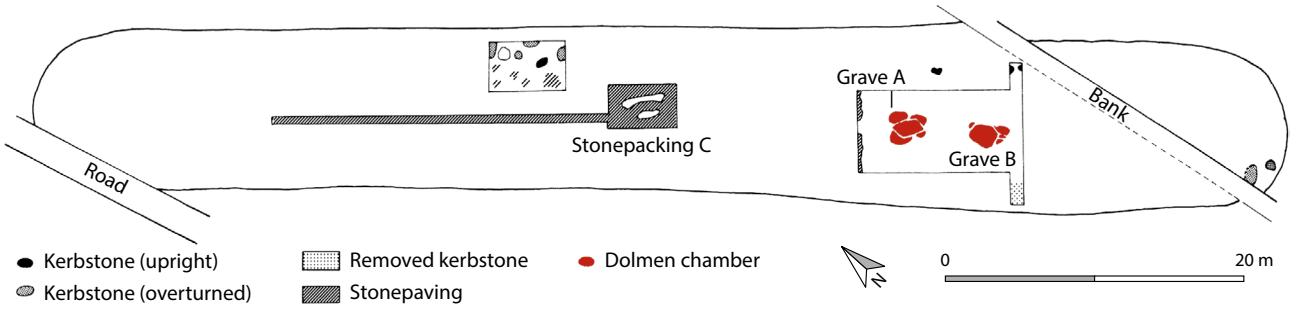


Fig. 20. Grøfte. Layout of the dolmen (redrawn by R. Potter/Gothenburg University, in cooperation with A. Fischer after Ebbesen 1990, fig. 3).

The western chamber (A) was a rectangular dolmen of type I, measuring 1.7 × 0.8 m and built of six side stones (Fig. 21). It had a single large cap stone and was roughly parallel to the west-north-west–east-south-east oriented barrow. On the floor were remains of two human skeletons. Two lugged flasks were located in the southern corner. Additionally, a fragmentary flint halberd was found within the chamber. Based on pottery typology the burial is firmly dated to the EN. The eastern chamber (B) was very similar. Here, skeletal remains of one person was found together with a lugged flask of Early Neolithic type. Like in chamber A, the vessel was located in the southern end of the cist. Skull fragments were clustering in the opposite end.

The chambers were interpreted by Ebbesen as undisturbed from later human activity. However, mice had clearly been present and caused bioturbation in chamber A and possibly also in B. The skeletal remains were analysed by P. Bennike (1990), who also re-evaluated the anthropological determinations in relation to the current project. Chamber A contained 23 identifiable bones and three teeth, belonging to an adult and a 15–25 years old person. In chamber B, 20 identifiable bone fragments were found, most likely all from one person, probably an adult female.

The bones were very fragmented and showed marks from animal gnawing – furrows from mice teeth in chamber A and circular depressions from canine or fox teeth in chamber B. Only fragments from crania and long bones were present, along with some teeth. With the possible exception of two lower arm bones, they were all disarticulated. In Bennike's view, the lack of small bones and the disarticulated position of the remaining ones can be explained by taphonomic factors, namely a combination of differential physical/chemical breakdown and animal activity in the chambers. According to Eriksen and Andersen (2014), however, large animals could not have gained access to the chambers, and they see the tooth marks of dog/fox as evidence of primary burial at another location.

No radiocarbon dates of the burials had previously been made. The two new ones derive from each of the two stone chambers. Both are clearly Early Neolithic (Fig. 22). The sample from chamber A dates to ca. 3645–3525 cal BC, well before 3500 cal BC which is often regarded as the border between EN I and EN II. The date of the person in chamber B has a much wider span due to the shape of the calibration curve. It may be as early as the one from chamber A but could also be from EN II. In any case, the date from chamber A is a clear indication of type I chambers being erected already in EN I.

Unpublished sources consulted: Danish National Museum j. no NM1 819/46; Anthropological Laboratory j. no. AS 5/47; National site inventory (Fund & Fortidsminder) no. 04.03.06-3.

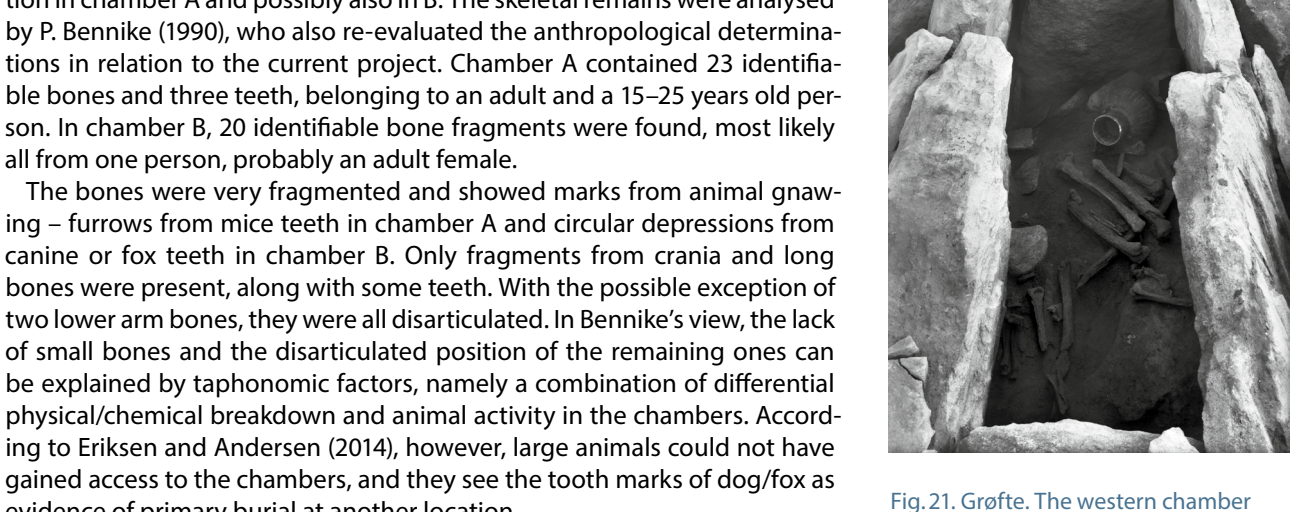


Fig. 21. Grøfte. The western chamber during excavation in 1946 seen from north-west, consisting of six side stones. The situation shown is after removal of soil and exposure of bones. Funeral pottery – an intact and a fractured lugged flask – are seen at the upper right, apparently next to the feet of the two individuals interred in the chamber (Photo: H. Andersen/Danish National Museum).

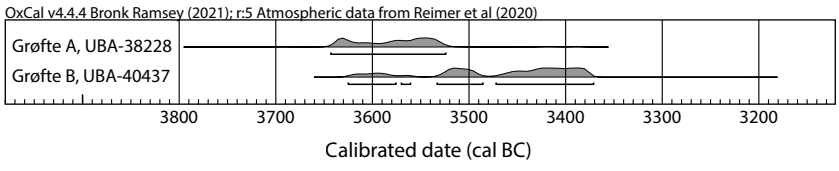


Fig. 22. Grøfte. Calibration of new, reservoir corrected dates (see Appendix 2; graphics: K.-G. Sjögren).

Fig. 23. Kellerød. The megalithic monument on a hilltop above Lake Tystrup (Photo: A. Fischer).

Kellerød, Zealand

With a length of 124 m this is the largest scheduled megalithic monument from Zealand (Kunwald 1961). Its builders have selected a location that enhances monumentality – at a hilltop above one of Zealand's largest lakes (Fig. 23). Like many other Early Neolithic barrows and settlements, it is located on easily farmed soil – in this case sand mixed with silt and a little gravel. The north-north-east–south-south-west oriented, 9 m wide and up to 1.5 m high mound is demarcated with a rectangular arrangement of more than 150 kerb stones. It was excavated in 1933–1934 (Thorvildsen 1941; Ebbesen 2009). Ca. 30 m from the northern end was a rectangular dolmen chamber of type I, ca. 2.5 × 0.8 m large and built by six side stones (Fig. 24). It was covered by a single capstone of limestone, measuring 1.6 × 0.35–0.50 m, and was oriented parallel to the barrow. The cist, including the roof stone, seems to have been hidden below the surface of the earthen mound. In the barrow an elongated setting of stones has also been excavated, possibly the remains of a non-megalithic burial construction.

On the stone paved floor of the dolmen chamber the remains of a skeleton from a heavily built mature male was found, lying extended on his back (Fig. 24). The bones appeared to be gnawed by mice. On his forehead was a depression from a healed wound (Bennike 2003; cf. Fischer-Möller 1935; Bröste et al. 1956). A lugged flask of EN type stood by his feet and in the pelvic region, next to the lower end of the right arm, a flint blade was found (Thorvildsen 1941). Bones from the skeleton were previously dated by the radiometric method to 4490 ± 65 uncal BP, i. e. the early Middle Neolithic, which does not fit the typological date of the pottery vessel (K-3515; Thorsen 1981).

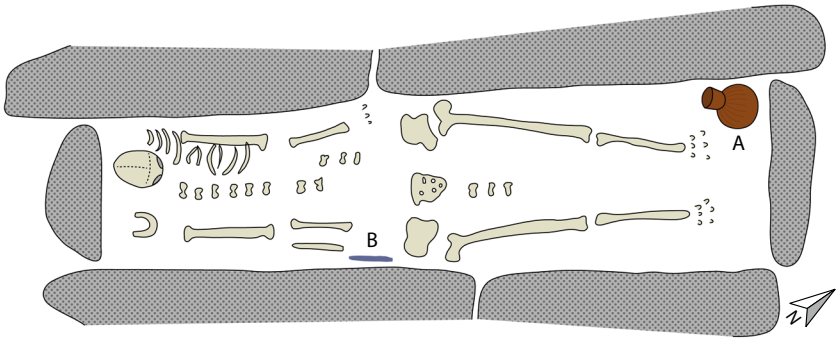


Fig. 24. Kellerød. The dolmen chamber with the approximate location of the skeleton and burial goods: A) lugged flask; B) flint blade (drawn by R. Potter/ Gothenburg University on the basis of contemporary written sources and a sketch map by the excavators H. and A. Andersen).

As part of the present project a sample from the mandible was dated. The result, 4772 ± 24 uncal BP (3631–3379 cal BC [95.4 %]), corresponds to the EN I period or the early EN II, although the highest probability lies in the EN I (3634–3500 cal BC [73.6 %]) This matches the typological date of the lugged flask. Here, like at Rude and Klokkehøj, we have an example of significant deviation between an old dating result produced via the radiometric method versus a new result based on the AMS method and the use of ultrafiltering. The former must be suspected to be erroneous due to deficient sample preparation.

Unpublished sources consulted: Danish National Museum j.no. 532/33; National site inventory (Fund & Fortidsminder) no. 04.05.13-1.

Stasevang, Zealand

Since 1937, all reasonably intact dolmens found across the Danish landscapes are to be left undisturbed, even from archaeological excavation (Nielsen 1987). Consequently, there is no information available on the specific contents and dates of the great majority of dolmen chambers in this country. A stone cist in a long dolmen by Stasevang was one of the last to be excavated: an illegal break-in generated an excavation, which from a present-day cultural heritage administrative view would probably be seen as excessive.

Fig. 25. Stasevang. The long barrow seen from east-south-east. The roof stone of the megalithic chamber dealt with in the present paper is seen in the foreground (Photo: A. Fischer).

Fig. 26. Stasevang. Traces of a modern stone mason's re-use of kerb stones at the megalithic long barrow. Marks of this type of stone splitting are frequently seen locally on building stones in modern prestigious monumental constructions (Photo: A. Fischer).

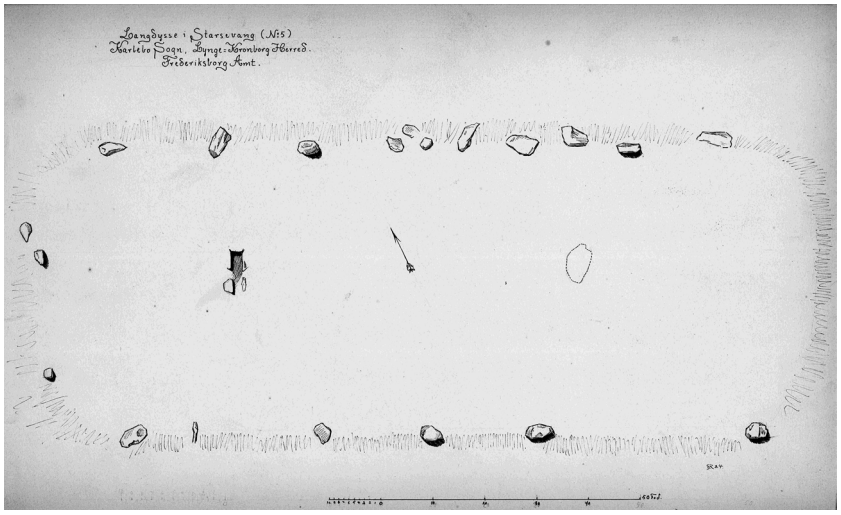


Fig. 27. Stasevang. The long dolmen as depicted by E. Rondahl 1884. Scale in Danish feet (1 fod = 31.4 cm).

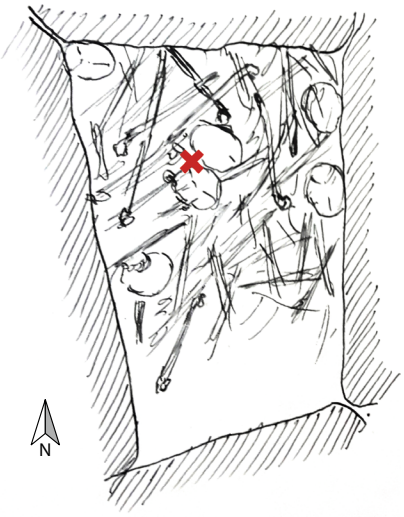


Fig. 28. Stasevang. The base of the excavated dolmen chamber with approximate location of human skeletal materials. The "×" marks the find spot of the antler arrowhead (Fig. 29) (modified drawing in the unpublished field report by C. J. Becker 1936).

The rectangular megalithic long barrow measures ca. 50 × 9 m and is oriented west-north-west–east-south-east (Fig. 25). Several of its kerb stones are missing and some of the remaining ones show marks (Fig. 26) indicating the reason and date for this misdeed: furrows from a stone splitting technique frequently applied in this part of Zealand for the purpose of producing building materials for royal palaces, etc. during the 1600–1700s AD (Kaul/Krogh 1990; Lotz 2017). Within the barrow two small dolmens, oriented transversally to the longitudinal axis of the mound, have been observed (Fig. 27). One of these, located 14 m from the eastern end of the barrow, was cursorily excavated in 1936 by the National Museum as part of a repair after a private attempt of looting. The cist was slightly trapezoidal, 1.8 m long and 0.9–1.2 m wide (Fig. 28). Below its cap stone were three side stones and a low entrance stone to the south. The distance between burial bottom and roof stone was 1.3 m. According to Ebbesen (2008, 29), the chamber is a type II dolmen.

The floor, apparently established on top of the original surface, consisted of ca. 20 cm of crushed flint. On top of this was an up to 25 cm thick deposition of disarticulated human bones (Fig. 28). Judged on the basis of cranial remains they may represent as much as 7 adults and a child. The only artefact observed was a fragmentary antler arrowhead (Fig. 29), probably from red deer (A. B. Gotfredsen, pers. comm. 2020). It is similar to the one found embedded in the skull of the Early Neolithic bog find from Porsmose (Becker 1952). A complete bone projectile point of this type was also found next to the skeleton of an Early Neolithic male individual who suffered an apparently traumatic death in a mire named Salpetermose, only 10 km from Stasevang (Jørgensen, T./Hagedorn 2015). The morphology of the serrated and somewhat sigmoid fracture of the Stasevang specimen reminds of what is seen on projectile points of flint shot into meaty carcasses (Fischer et al. 1984; cf. Nielsen 2013). The arrowhead may therefore have arrived in the coffin embedded in the body of one of the individuals deposited in the chamber.

In the present project one sample (UBA-38236) from the excavated chamber was dated. It is a third molar from the skull of an individual aged 22–35 years at death. According to physical anthropology this person was possibly male (Bröste et al. 1956, no 5). The sample was dated to 4669 ± 37 uncal BP, 4655 ± 37 uncal BP after reservoir correction. This corresponds to 3521–3364 cal BC (95.4 %), i. e. the EN II period.

Unpublished sources consulted: Danish National Museum inventory number A 36522; excavation report 1936 by C. J. Becker, j. no. 732/35. National site inventory (Fund & Fortidsminder) no. 01.04.11-15. Anthropological Laboratory j.no. AS 14/44.

Fig. 29. Stasevang. Fragmentary arrow point of antler from the eastern dolmen chamber (cf. Fig. 28) – possibly the cause of death of one of the humans deposited in the cist. Extant length 75 mm, largest diameter 9 mm (Photo: J. Lee/Danish National Museum, in cooperation with A. Fischer).

Esbenshøj, Jutland

On a hill crest overlooking the sea, the ruin of an over-ploughed megalith was subject to rescue excavation in 1973. No kerb stones were observed, but in the centre of the monument three side stones and a low sill stone were found *in situ*. Two more side stones appeared to have been removed in recent time. The excavator concluded that originally these stones had probably formed a polygonal dolmen chamber. The floor of the cist would have measured ca. 1.0 × 0.6 m, and the entrance would have been to the south-east (Fig. 30). The height of the chamber, from the floor to the top of the side stones, was estimated to 0.9–1.0 m. Ebbesen (2008, 248) classifies it as type IV dolmen. It was set in the centre of a mound that – at the time of excavation – was 16–20 m in diameter and approximately 1 m high. Earlier accounts state the barrow to have been considerably higher, and in the 1920s, when it was already being ploughed, it measured ca. 2 m.

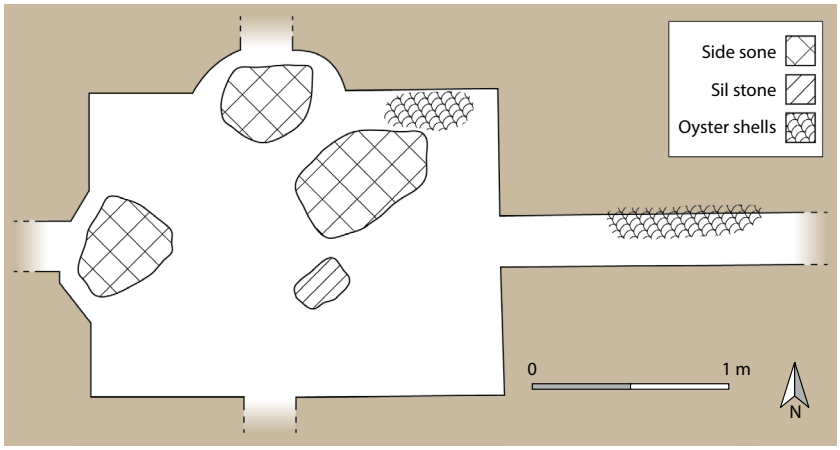


Fig. 30. Esbenshøj. Layout of the dolmen (redrawn by R. Potter/Gothenburg University, in cooperation with A. Fischer, on the basis of an unpublished field report by C. L. Vebæk 1973).

At the bottom of the mound, near the chamber, deposits of oyster shells were observed in two places (Fig. 30). No artefacts were found in these layers. The excavator considered them to be contemporaneous with the construction of the chamber, and suggested they represent either meals for those who built the megalithic grave or food sacrificed to individuals interred in the chamber. Human bones and fragments of a small amber bead or two were found next to a side stone in the chamber. A sample of a human premolar was AMS dated (Appendix 2; Klassen pers. comm. 2019). The result (AAR-22190) 4459 ± 37 uncal BP, corresponds to 3344–3012 cal BC res corr (95.4 %), i. e. the MN A period.

Unpublished sources consulted: Danish National Museum excavation report 1973 by C. L. Vebæk, j. no. 664/72 and 497/1973. National site inventory (Fund & Fortidsminder) no. 11.04.09-68. Anthropological laboratory j.no. AS 8/87.

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