Proceedings of the Prehistoric Society 90, 2024, pp. 105–125 doi:10.1017/ppr.2024.3 First published online 13 March 2024

Dynamic Funerary Monuments of North-western Europe: Chronological Modelling of a Late Neolithic–Pre-Roman Iron Age Cemetery Complex at Mang de Bargen, Northern Germany

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This study presents the first extensive radiocarbon dating programme of Bronze Age material from northern Germany, and it combines radiocarbon dates, relative typo-chronological date ranges, and stratigraphic data within a Bayesian chronological framework. We estimate the cemetery complex at Mang de Bargen (Bornhöved, distr. Segeberg, Schleswig-Holstein) to be in use for more than two millennia, which is exceptionally long in northern Germany and in a wider European context. The site provides a unique insight into the dynamic nature of burial monuments and associated burial practices, from the Late Neolithic and into the Pre-Roman Iron Age (c. 2500–50 BC). The barrow building tradition lasted around a millennium (c. 2350 – 1300 BC), with several barrows in concurrent use. The barrows were persistently re-used as burial ground, both within 'living memory' of the primary graves, but also long after. The burial intensity varied over the cemetery's use-life, with distinct peaks in the Late Neolithic, when the first barrows were erected; in the Older Bronze Age when more barrows were erected; in the Younger Bronze Age, when secondary cremation graves were added to existing barrows; and finally in the Pre-Roman Iron Age, with the addition of an urnfield. The funerary rituals vary considerably over the period: from inhumation to cremation, and from primary and secondary graves in barrows to flat graves. Cremation was introduced in the 14th century BC but inhumation and cremation were used in parallel for around a century before the former ritual was abandoned c. 1300 BC. The study provides absolute chronological distributions of the grave types present at Mang de Bargen and shows them to be comparable to other sites at a regional and over-regional scale, successfully demonstrating how new types were quickly adopted across large parts of north-western Europe.

Keywords: Neolithic, Bronze Age, Iron Age, Germany, radiocarbon dating, barrow cemetery, urnfield, inhumation, cremation, burial continuity, Bayesian chronological modelling

The Bronze Age (BA) in Europe was characterised by profound social, cultural, and structural internal changes related to varying exchange networks at local, regional, and over-regional scales, which influenced the subsequent political and cultural scenario in the area (Harding 2000). We can identify part of these changes through investigations of archaeological assemblages, defined by distinctive material culture and funerary practices that, for example, emerged within the Nordic Bronze Age Circle in Southern Scandinavia and northern Germany in this period (Vandkilde 2014). Barrows are a widespread architectural burial type in both time and space (Harding 2000) and an important part of

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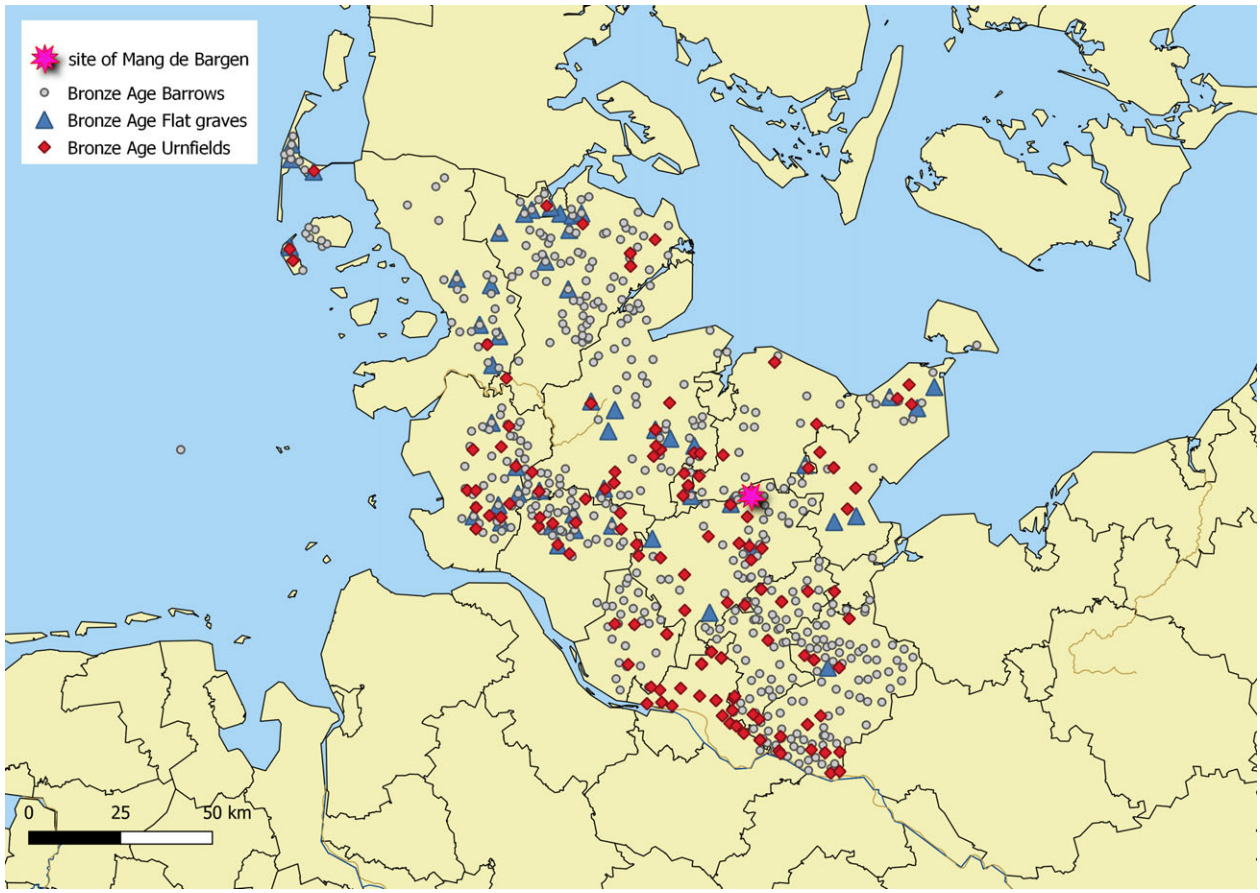

Fig. 1.
Bronze Age barrows, flat graves, and urnfields in Schleswig-Holstein, northern Germany. Mang de Bargen is marked by a purple star (Aner & Kersten 1978; 1979; 1991; 1993; Schmidt 1993, archive of the Archäologisches Landesamt Schleswig-Holstein; Aner *et al.* 2005; 2011; 2017)

Nordic Bronze Age funerary practices. Schleswig-Holstein in northern Germany is located in the southern part of the Nordic Bronze Age Circle (Kneisel *et al.* 2019, fig. 1) and, here, non-megalithic round barrow construction experienced a high intensity in the Late Neolithic (late 3rd millennium BC) and reached a peak in the Older Bronze Age (mid-2nd millennium BC; Holst 2013, 42). Construction of the vast number of barrows demanded a concerted effort, large amounts of resources, and a new complexity of co-operation, and it left a long-lasting effect on the cultural landscape that is still present today (Fig. 1). The barrows might set the stage for funerary practices, establishing and reproducing communal identity and social order (Kristiansen 2006, 175–7).

The barrows have revealed conspicuous finds, particularly from the well-preserved oak-log coffins that have produced material for typo-chronological studies (Thomsen 1836; Worsaae 1843; Montelius 1885; Müller 1891; Glob 1945). The intensification of agricultural activity from the mid-20th century onwards has been hard on the monuments and more recently excavated barrows have revealed limited new evidence on construction and burial practices (although see Freudenberg 2012; Holst *et al.* 2013b). New research has instead focused on applying new methods to material from older excavations, thereby producing new knowledge of identity and demonstrating mobility and networks across the Eurasian continent (Varberg *et al.* 2016; Reiter *et al.* 2019; Felding & Stott 2023).

There is an extensive literature on barrows from north-western Europe (Aner & Kersten 1978; 1979; 1991; 1993; Aner *et al.* 2005; 2011; 2017; Fontijn *et al.* 2013; Holst & Rasmussen 2015) but it relies largely on relatively dated typological chronologies with the addition of a minor number of oak-log coffins dated by dendrochronology (eg, Christensen 2006). Most barrows were built in several construction phases, with one or more phases of secondary burials, but there is often no discernible stratigraphic relationship between individual burials or between multiple barrows within a cemetery or funerary cluster. To understand the dynamic nature of the funerary monuments it is necessary to estimate the absolute timing of primary graves, secondary graves with additions to the barrow mound, and secondary cremation graves in and around individual barrows, but also in relation to clusters of barrows and other burial activity in their vicinity.

This study presents a chronological study of a cemetery complex at Mang de Bargen, Bornhöved (distr. Segeberg, Schleswig-Holstein, northern Germany; Fig. 2). Based on typo-chronology, the site was in use from the Late Neolithic to the Pre-Roman Iron Age, which is an exceptionally long period within northern Germany and also within a wider European context. Its prolonged longevity makes it an excellent case study for investigating the dynamic nature of funerary monuments and associated burial practices. The dataset also has the potential for evaluating the absolute chronological framework, similar to a study of Danish Bronze Age chronology (Olsen *et al.* 2011; Hornstrup *et al.* 2012), but this falls outside the scope of the present study. Readers are instead referred to Schaefer-Di Maida (2023, 136–206) for a discussion of relative and absolute dating of finds material from Mang de Bargen. This study will investigate whether burials were continuously being added over this extended period and if the number of burials increased or decreased over time. Was more than one barrow in concurrent use or were previous barrows abandoned when new ones were erected? These questions are connected to the introduction and abandonment of individual barrows and we investigate the absolute chronology of specific changes in funerary rituals and burial practices at Mang de Bargen and discuss the results in a local, regional, and over-regional context.

The chronological framework for northern Germany (Table 1) is largely comparable to other regions within the Nordic Bronze Age Circle, except for the three-part division of the Bronze Age (Mestorf 1885; Kersten 1936; Menke 1972; Struve 1979; Schmidt 1993). The absolute chronology of Bronze Age cemeteries in northern Germany has not yet been tested and this study presents the first large-scale radiocarbon dataset in support of this. The dating results have previously been presented (Schaefer-Di Maida 2018) and explored elsewhere (Kneisel *et al.* 2022, 208; Schaefer-Di Maida 2023), but this study presents the first site chronology of Mang de Bargen applying Bayesian chronological methods. It is also the first study of its kind investigating archaeological material from Schleswig-Holstein and the results are of fundamental importance for the state of research in northern Germany, and also in a wider European context.

FUNERARY RITUALS IN SCHLESWIG-HOLSTEIN FROM THE LATE NEOLITHIC TO THE PRE-ROMAN IRON AGE

Funerary rituals and grave types changed considerably in Schleswig-Holstein from the Late Neolithic to the Pre-Roman Iron Age: from primary inhumations and later additions of secondary burials in the barrows to cremations in flat graves, first in or close to existing barrows, later in separate grave fields or urn cemeteries. Such changes, in turn, might reflect political and social changes in the society (Schaefer-Di Maida 2023).

Barrow construction in northern Europe is not constricted to the Late Neolithic and Bronze Age, although the number from these periods far exceeds numbers from any other periods. The barrows in Schleswig-Holstein are located on elevated ground with a preference for young moraine ridges that help increase their visibility in the landscape. The Late Neolithic barrows show no obvious trends in spatial distribution, but by BA period I clusters emerge near Bornhöved (Mang de Bargen), and in central Schleswig-Holstein. Barrow construction reaches a maximum in BA period II in all parts of Schleswig-Holstein, before decreasing in BA period III. The Younger Bronze Age barrows are smaller than the earlier ones (although with a very few exceptions: Thrane 1984; May 2002), although their graves are conspicuously richly furnished (Schmidt 1993, 17). The smaller barrows represent a different tumulus tradition, as is also evident from the temporal and spatial gap between the BA III barrows that were constructed all over Schleswig-Holstein, and the small

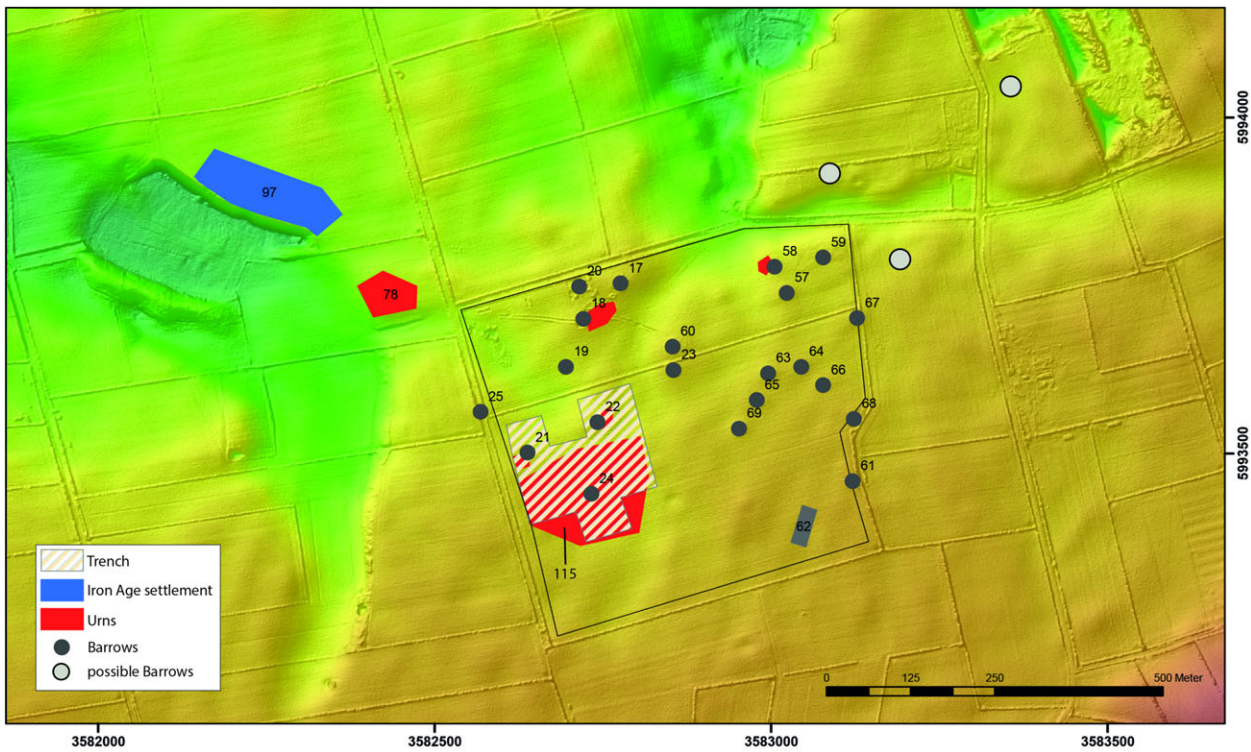

Fig. 2.
Cemetery complex at Mang de Bargen (Bornhöved, distr. Segeberg, Schleswig-Holstein, northern Germany). 2014 excavation area of the urnfield LA 115 is shaded white. LA heritage numbers are provided directly in the figure

barrows that were built from the end of period IV onwards and which are only located in the southern part of Schleswig-Holstein.

Primary graves in barrows are predominantly single burials placed in the centre of the mound in a stone cist or in an oak-log coffin, although a few barrows contain more primary burials in individual graves. The burials are primarily inhumations, although cremation burials occur in smaller numbers. Secondary graves in existing barrows, in the form of inhumations or cremations, are related to either later construction phases of the mound or to cremation burials in and close to the mound mantle. The number of secondary graves per barrow varies greatly but often exceeds the number of primary graves. Secondary burials in barrows start to occur from the Late Neolithic, increase in numbers during BA II–III, before becoming a widespread phenomenon in the Younger Bronze Age and the Pre-Roman Iron Age.

Flat graves have a low visibility and are often only found by chance, which makes it difficult to draw conclusions on their low frequency in comparison to contemporary graves in barrows. It is, however, expected that most graves were flat graves and, based on data from Jutland, Kristiansen assumes that about 10–20% of the population were buried in barrows, while the remaining 80–90% were buried in flat graves (Kristiansen 2018, 110), or not at all. It is difficult to assess the spatio-temporal distribution of flat graves in Schleswig-Holstein but the limited available data reveal a wide distribution without obvious clusters in the Older Bronze Age. Burials from the Younger Bronze Age are mostly cremation flat graves placed within grave fields or urn cemeteries, primarily in central and southern Schleswig-Holstein.

APPROACHING BURIAL TEMPORALITY WITHIN A BAYESIAN FRAMEWORK

Understanding the temporality of burial monuments is fundamental for investigating developments in funerary practices and understanding their connection with the

TABLE 1. CHRONOLOGICAL FRAMEWORK OF SCHLESWIG-HOLSTEIN, NORTHERN GERMANY

		Period/Stage	*From (BC)*	*To (BC)*
Neolithic	Late Neolithic	LN I	2200	1950
		LN II	1950	1800
Bronze Age	Early BA	Per. I	1800	1500
	Older BA	Per. II	1500	1300
		Per. III	1300	1100
	Younger BA	Per. IV	1100	920
		Per. IV/V	920	820
		Per. V	820	700
		Per. VI	700	500/530
Pre-Roman Iron Age	Early PRIA	Stage Ia	500/530	480
		Stage Ib	480	390
		Stage Ic	390	300
		Stage Id	300	250
	Late PRIA	Stage IIa	250	150
		Stage IIb	150	90
		Stage IIc	90	60

(Montelius 1885; Schwantes 1911; 1935; 1952; Hingst 1959; 1974; 1980; 1983; 1986; 1989; Vandkilde *et al.* 1996; Jensen 1997; Ethelberg *et al.* 2000; Hornstrup *et al.* 2012; Kneisel 2013; 2021)

surrounding environment and society. Relative typo-chronologies may offer date ranges for graves containing diagnostic burial goods but their usefulness is limited for artefact types with use periods spanning several chronological phases and centuries, and of no use for graves without diagnostic burial goods. Radiocarbon dating offers an alternative when suitable material is present and, by interpreting the results within a Bayesian framework (Buck *et al.* 1996), it is possible to improve the precision of individual burial monuments and cemeteries. Bayesian chronological modelling has become a standard tool in archaeology for evaluating chronometric data (most commonly radiocarbon dates) in combination with 'prior' information on archaeology (context, stratigraphy, sample character, etc), or the statistical distribution of the dated events (Bayliss 2009; Hamilton & Krus 2018). This approach also makes it possible to estimate dates of event or transitions that cannot be dated directly, such as primary graves in barrows without preserved human remains (eg, Garrow *et al.* 2014), or produce posterior estimates of relative date ranges derived from typo-chronology.

Bayesian chronological modelling is increasingly being applied to studies of prehistoric cemeteries, including non-megalithic barrow cemeteries from north-western Europe. A frequent challenge is the lack of direct stratigraphic relationships between individual monuments and applications tend to address cemeteries with informative prior information based on, for instance, artefact typology or burial sequences within single monuments (eg, Garrow *et al.* 2014; Bourgeois & Fontijn 2015; Aranda Jiménez *et al.* 2020; 2022). Robust prior information is, however, often not available, mainly due to preservation issues, and the majority of non-megalithic barrow cemeteries remain relatively dated using typo-chronology or dendrochronology (eg, Christensen 2006).

INTRODUCING THE CEMETERY COMPLEX AT MANG DE BARGEN

This study focuses on the cemetery complex at Mang de Bargen (Fig. 2). There is also documented agricultural activity at the site prior to barrow constructions (Feeser *et al.* 2023), and different forms of settlement activity and a land opening coinciding with the burial activity (Schaefer-Di Maida 2022). The barrow complex (group 'K') with 23 round barrows and one long barrow was first registered by Schwerin von Krosig (1976, 106–8), and the Schleswig-Holstein Archaeological Office carried out archaeological investigations of the site in 2004, 2005, and 2014. The last remaining mound, LA 57, was excavated by the D3 project of the Collaborative Research Centre 'Scales of Transformation: Human-environmental Interaction in Prehistoric and Archaic Societies' (CRC 1266) in 2017.

Due to heavy disturbances prior to the archaeological excavations, it is difficult to determine how many construction phases the barrows had originally, but it is likely that more of them had multiple phases containing primary and secondary burials.

Based on typo-chronology, Mang de Bargen was a centre for funeral activities from the Late Neolithic to the Pre-Roman Iron Age. The Late Neolithic barrows often contained multiple layers of stones or stone frames which could be constructed in several parallel rows, whereas the Older Bronze Age burials were limited to oak-log coffins and more simple stone settings (Fig. 3a). Burial intensity decreased noticeably around 1700/1600 BC, but it increased again around 1500 BC, coinciding with a change in burial goods. The complexity of grave constructions continued to decrease with, in particular, stone constructions becoming simpler but opposed by an increase in the number of barrows being constructed. Barrow construction demands a high investment in labour and resources, which demonstrates that the monuments were a central component of social, economic, and perhaps also political life (Holst *et al.* 2013a) and thus conditioned structuring into co-operative relationships.

The earlier barrows at Mang de Bargen were erected over centrally placed inhumations in oak-log coffins but cremation was introduced around the BA II–III transition. Cremation presents a new treatment of the dead but it was initially not accompanied by new grave constructions until around 1200 BC (Fig. 3b) (Schaefer-Di Maida 2023, 237). The earliest cremation burials in urns are relatively dated to the middle of BA II, but cremation burials in urns or within stone settings were not firmly established until the middle of BA III *(c.* 1200 BC; Fig. 3c). Cremation burials in stone settings decreased around the BA IV–V transition and, instead, urn graves became the dominant grave type. Other forms of cremation deposits, such as scattered cremated remains (*Leichenbrandschüttungsgrab*) are elsewhere interpreted as a transitional grave form (Hofmann 2008, 446–7; Schaefer-Di Maida 2018, 34–5) but at Mang de Bargen they appear to be used in parallel with urn graves.

Burial activity decreased significantly at the transition to BA VI, which is a general trend observed in Schleswig-Holstein (Schmidt 1993, 139; Schaefer-Di Maida 2023). It is debated whether BA VI in Southern Scandinavia might be viewed as a transitional phase between the Bronze and Iron Ages (Kneisel 2013; 2021; Rose & Meadows 2023), but in northern Germany it is a distinct period with the introduction of new forms of metal and pottery (Schmidt 1993, 146). The spectrum of forms changed again with the start of the Pre-Roman Iron Age when also the burial activity increased again (Schaefer-Di Maida 2023, 243–4). Burials were no longer placed in or close to the barrows but, instead, at a new urnfield that was established close to the barrows (Schaefer-Di Maida 2023, 106–10). Some of the graves have circular ditches, which is a widespread feature of the Younger Bronze Age–Pre-Roman Iron Age urnfield phenomenon in north-western Europe (Rose *et al.* 2023). The introduction of the urnfield is accompanied by changes in the cremation practice resulting in only parts of the cremated remains being buried (Schaefer-Di Maida 2023, 244).

MATERIAL AND METHODS

Sample selection

Contexts to be dated were selected by Stefanie Schaefer-Di Maida with the criterion to date as many graves as possible in order to investigate the temporal development of the cemetery complex at Mang de Bargen. The selected graves were all excavated over the last two decades where, if possible, urn graves were lifted as blocks and excavated in a controlled indoor environment. Part of the cremated human remains has been anthropologically analysed by Susanne Storch, Katharina Fuchs, and Helene Agerskov Rose. Sampling of human remains was conducted by the latter and only samples of white, cremated bone were selected, preferably from long bones. If no cremated bone was preserved, archaeobotanical remains from the burial context were sampled instead. Additional samples of charcoal and archaeobotanical remains were selected from archaeological features related to the graves. The archaeobotanical remains were analysed at the Archaeobotanical Department, Institute of Pre- and Proto-Historic Archaeology at Kiel University (Filipović 2023).

Our data set contains 114 samples from Mang de Bargen, including eight additional dates from other submitters (Supplementary Material; Appendix S2). In total, the dataset includes 79 samples of cremated bone, one of human collagen, 21 of charcoal, 12 of charred seed/grain, and one bulk sample of unidentified archaeobotanical remains. All dates are previously reported by Schaefer-Di Maida (2023).

There are no stratigraphic relationships between barrows and limited stratigraphy between burials within individual barrows at Mang de Bargen. Figure 4 depicts

Fig. 3.
Examples of grave types from Mang de Bargen: a) primary grave with a wooden coffin in a multi-layer stone construction (LA 59, feature 1); b) scattered cremated remains in a stone construction (LA 58, feature 17); c) urn grave lined with stones (LA 18, feature 88a)

the ten barrows and the urnfield (LA 115) included in this study with earlier burials (below) linked to stratigraphically later burials (above) by vertical lines.

Radiocarbon analysis

All samples were extracted and dated by accelerator mass spectrometry (AMS) at the Leibniz-Laboratory,

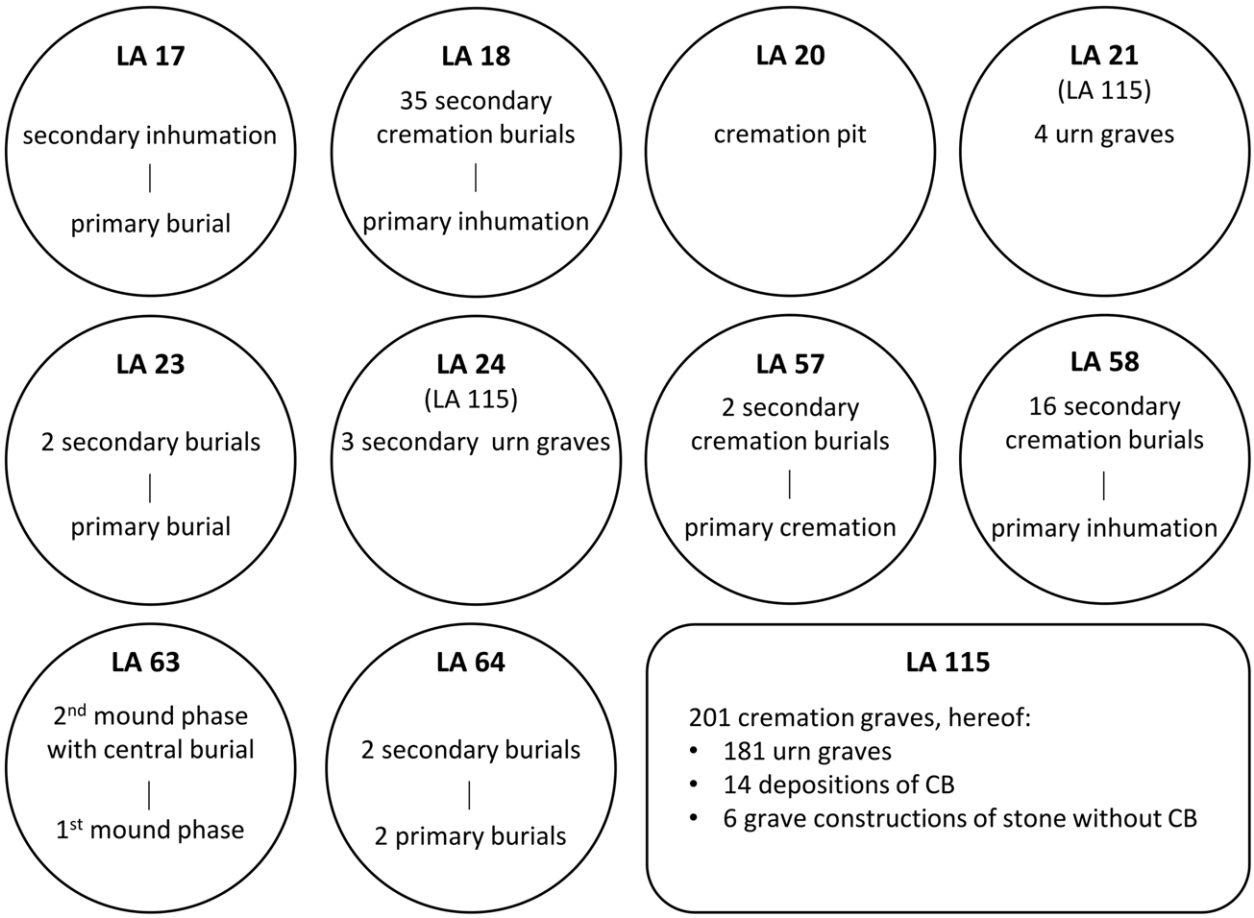

Fig. 4.
Relational matrix of the cemetery complex at Mang de Bargen, as included in this study. Earlier burials (below) are linked to stratigraphically later burials (above) by vertical lines

Kiel, Germany. To confirm that samples of cremated bone were fully calcined, aliquots of powdered, untreated material were analysed by Fourier-transform infrared spectroscopy (FTIR). The crystallinity index (CI) was estimated as the splitting factor between the two absorption bands at *c.* 603 and *c.* 565 cm–1 ($CI = (A603+A565)/A_{valley}$) (Person *et al.* 1995; Olsen *et al.* 2008).

Samples of charred organics (charcoal, seed/grains) were extracted following standard acid–alkali–acid procedures (Grootes *et al.* 2004). A single sample of human bone was crushed, treated with acetone to remove fatty contaminants, washed in distilled water, and demineralised in 1% HCI. Secondary organic compounds were dissolved with 1% NaOH, re-acidified in 1% HCI before the collagen was converted to gelatine in demineralised water, filtrated to remove insoluble particles, and freeze-dried (Grootes *et al.* 2004). Samples of cremated bone were crushed before treated with 0.6% acetic acid (5×30 min), and about 50% of the samples were leached with 1% HCI (Hüls *et al.* 2010; Rose *et al.* 2019). The extracts were reacted with phosphoric acid to produce CO_2 and combusted to remove sulphur compounds. Purified CO_2 of charred organics, collagen, and cremated bone samples was reduced to graphite for dating by AMS on a HVE 3MV Tandetron 4130 AMS system (Nadeau *et al.* 1997). All resulting ^{14}C-contents were corrected for fractionation using the simultaneously AMS measured $^{14}C/^{12}C$ and $^{13}C/^{12}C$ isotope ratios and reported results are conventional radiocarbon ages (Stuiver & Polach 1977).

RESULTS: CHRONOLOGICAL MODELLING

We report 114 AMS radiocarbon dates measured on samples related to ten barrows and one urnfield from Mang de Bargen (Appendix S2). Samples of cremated bone have acceptable CI values (>5), indicating they were fully cremated and suitable for radiocarbon dating. Samples of charred organics and cremated bone have mean values of $\delta^{13}C$ (charred organics = –24.0±2.1, cremated bone = –22.1±2.6), and %C (charred organics = 58.95±11.23, cremated bone = 0.18±0.07) within the expected ranges (Rose *et al.* 2020).

The calibrated radiocarbon ages date activity at Mang de Bargen from the Mesolithic to the early medieval period (*c.* 9500 BC–AD 1300), whereas samples related to burial activity only date *c.* 2450–100 cal BC (Bronk Ramsey 2009a; Reimer *et al.* 2020). Individual calibrations of burials from the Younger Bronze Age to the Pre-Roman Iron Age have multimodal solutions due to a major radiocarbon plateau *c.* 750–400 BC (Pearson *et al.* 1983; Stuiver & Becker 1986; Fig. S1), also known as the Hallstatt plateau (Wijma *et al.* 1996; Stäuble & Hiller 1997). Bayesian chronological models incorporating the calibrated radiocarbon ages related to burial activity and the available prior information are constructed using OxCal v4. (Bronk Ramsey 2009a). The exact code in OxCal v4's Chronological Query Language for all models is provided in Appendix S3.

In Model A we incorporate the calibrated dates and the prior information based on the burial sequence of the respective barrows and urnfield (cf Fig. 4). Barrows with minimum three dates are modelled in separate bounded phases. We know radiocarbon dates on charcoal and cremated bone are affected by wood-age offsets causing them to have potentially significant intrinsic ages (Hüls *et al.* 2010), and charcoal dates are either modelled as *terminus post quem* (TPQ) or by applying the OxCal default Charcoal Outlier_Model (OM) (Bronk Ramsey 2009b; Dee & Bronk Ramsey 2014), and a Cremation OM is applied to all dates on cremated bone (Rose *et al.* 2020). Both outlier models assume that the dated samples are older than their deposition or the cremation event and that the wood-age offsets are exponentially distributed, ie, most differences will be small but a diminishing number will be larger. Obviously intrusive samples are modelled as outliers or *termini ante quem* (TAQ). The model incorporates the relative order of burials dated by typo-chronology by cross-referencing burial dates from individual barrow models to two contiguous phases, requiring Younger Bronze Age burials to be earlier than Pre-Roman Iron Age burials. Model A has an acceptable agreement ($A_{overall}$=85.9; Figs S2 & S3) and estimates *3–378 yr* offsets in charcoal dates (95.4% probability; *3–122 yr,* 68.3%), and *7–304 yr* offsets in dates on cremated bone (95.4% probability; *12–118 yr,* 68.3%). Burial activity is estimated to start *2687–2087 cal BC* (95.4% probability), or *2432–2161 cal BC* (68.3% probability), although the burial intensity remains low until the last millennium BC. The site was used as burial ground for *1914–2770 cal BC* (95.4% probability; *2025–2400 yr,* 68.3%), until burial activities ceased *245 cal BC–cal AD 252* (95.4% probability), or *209–23 cal BC* (68.3% probability).

Almost all burials at Mang de Bargen with preserved human remains or archaeobotanical material are radiocarbon dated but this leaves undated most of the primary graves that were either destroyed prior to excavation or only partially recovered. A number of these do, however, contain diagnostic artefacts that can be relatively dated using typo-chronology. In Model B, we include the relative date ranges of four primary and four secondary graves from four barrows, plus another 31 urn graves from the urnfield LA 115 (Schaefer-Di Maida 2023, 363–492). The relative date ranges are modelled with uniform distributions, eg, distribution U(-2200, -1950) for the primary burial from LA 17 that is relatively dated to LN I. The model is otherwise structured like Model A. Model B is accepted ($A_{overall}$=79.7; Fig. 5, Figs S4 & S5) and estimates *3–835 yr* offsets in charcoal dates (95.4% probability; *3–242 yr,* 68.3%), and *1–63 yr* offsets in dates on cremated bone (95.4% probability; *5–23 yr,* 68.3%). Burial activity is estimated to start *2748–2073 cal BC* (95.4% probability), or *2436–2136 cal BC* (68.3% probability). The site was used as burial ground for *1948–2825 cal BC* (95.4% probability; *2032–2427 yr,* 68.3% probability; Fig. 6 upper), until burial activities ceased *181 cal BC–cal AD 250* (95.4% probability), or *163–15 cal BC* (68.3% probability).

The last millennium BC coincides with the Hallstatt plateau, making it necessary to test the influence of the radiocarbon calibration curve on the model outcome. We create a simulated dataset with a uniform distribution (n=150) and model these using the default KDE_Model function in OxCal (Fig. 6 lower,

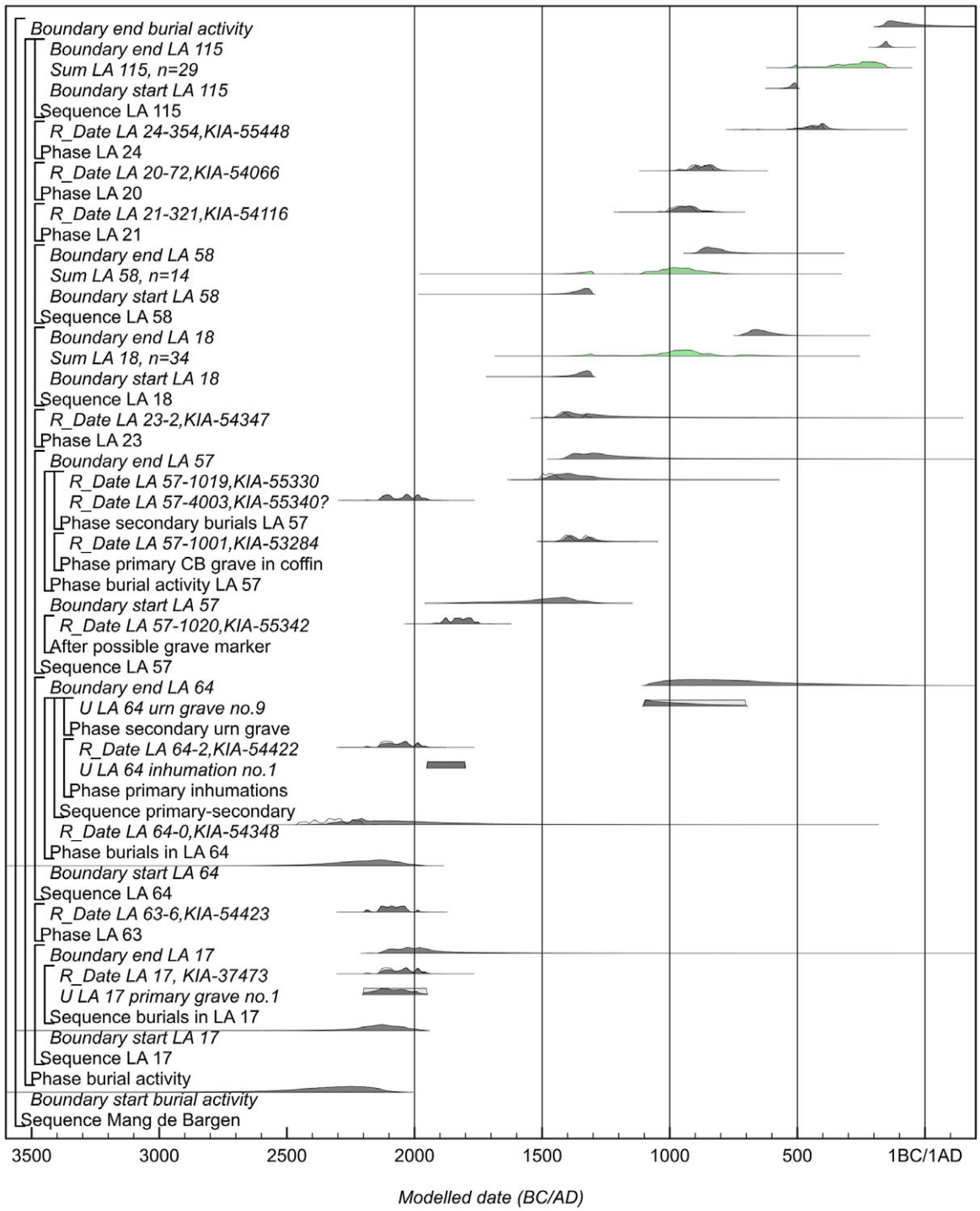

Fig. 5.
Part of chronological Model B of burial activity at Mang de Bargen. For each sample, the probability density function of the simple calibrated date is shown in outline, while the model's posterior density estimate of the sample date is shown in black. Summarised burial activity from LA 18, LA 58, and LA 115 are shown in green. Uniform distributions are employed for the typo-chronological dates of burials without absolute dates. The full model and the exact model specifications are given in Appendix S3.

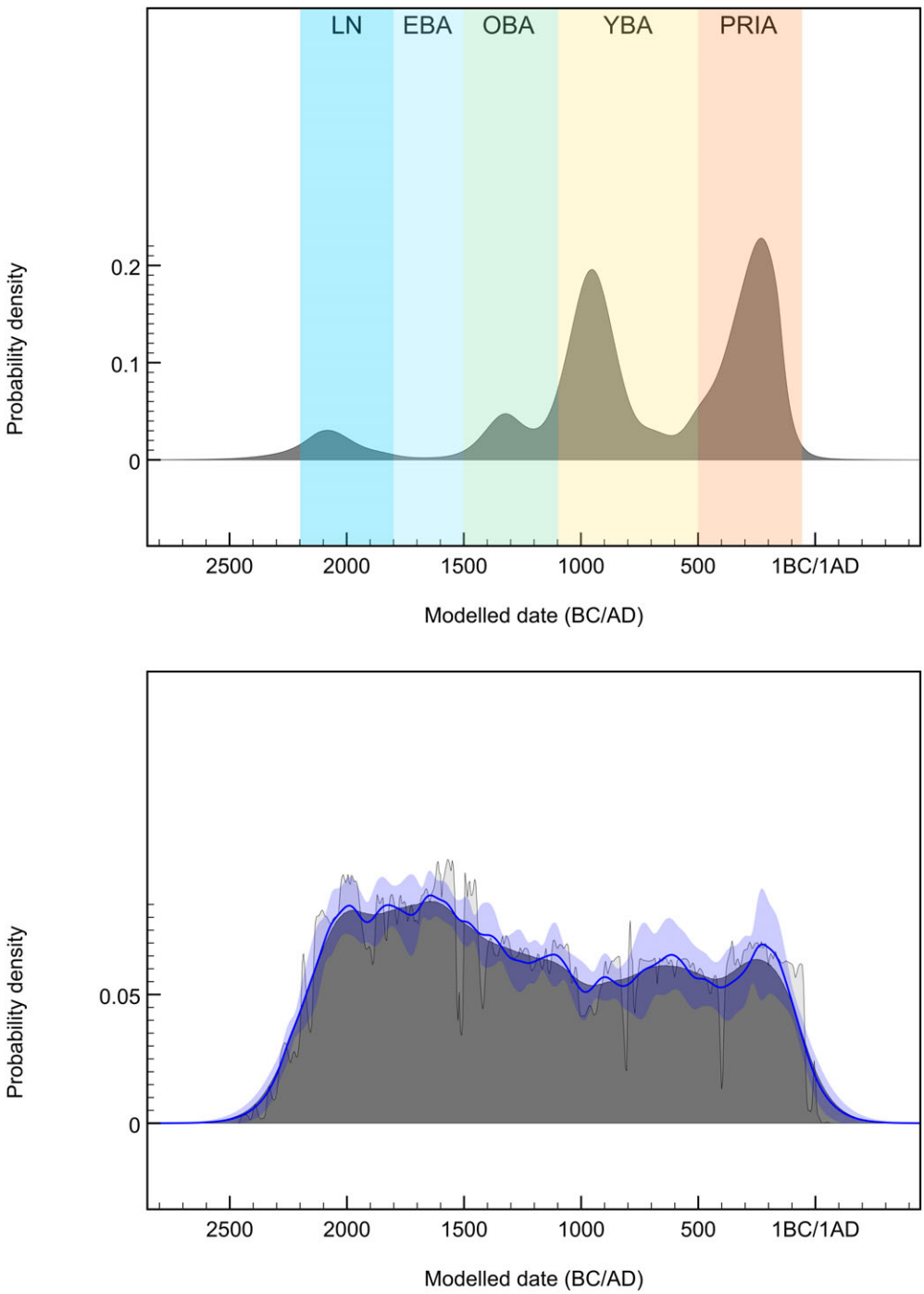

Fig. 6.
Estimated burial activity: upper) Kernel density estimate summarising burial activity at Mang de Bargen as estimated by Model B and the traditional chronological framework (LN: Late Neolithic, EBA: Early Bronze Age, OBA: Older Bronze Age, YBA: Younger Bronze Age, EIA: Pre-Roman Iron Age); lower) Kernel density estimates of simulated dataset (n = 150, uniform distribution)

Appendix S3) (Bronk Ramsey 2017). Although the resulting kernel density estimate (KDE) does have a wider uncertainty range in the last millennium BC the plot has no pronounced peaks, which successfully demonstrates that the observed peaks in burial activity at Mang are real.

As expected, Model B estimates burial activity started 50–100 yr earlier than Model A but otherwise the respective posterior density estimates are largely comparable, demonstrating model output to be reproducible and robust (Fig. 7). Model B estimates a higher burial intensity in the Late Neolithic–Older Bronze Age, in agreement with this being the main period of barrow construction and it is our preferred model because it is less biased by preservation issues. The individual barrow chronologies presented below are based on Model B. Six barrows are omitted as they are only dated by a single radiocarbon date each (LA 20, LA 21, LA 23, LA 24, LA 63).

Chronology of LA 17

LA 17 contained two burials: a primary grave with no preserved human remains, relatively dated to LN I, and a radiocarbon dated skull fragment from a later grave (Schaefer-Di Maida 2023, 364). Model B dates the primary burial to mid-22nd–mid-21st centuries BC, with a negligible gap before the later inhumation burial dating to mid-22nd–start 20th centuries. Both burials are likely interred in LN I.

Chronology of LA 18

LA 18 contained a primary inhumation interred in an oak log coffin, relatively dated to BA II. The barrow contained further 35 secondary cremation burials, whereof 34 are radiocarbon dated. Based on burial goods, most of the cremation graves date to BA IV–V, but with the youngest cremation graves dating to Pre-Roman Iron Age I (Schaefer-Di Maida 2023, 364–79). Model B dates the primary burial and construction of LA 18 to the last half of the 14th century BC and estimates that the barrow went out of use in the 7th century BC.

Chronology of LA 57

LA 57 contained a primary oak-log coffin with a cremation burial and two secondary urn graves, whereof at least one had been disturbed prior to excavation (Schaefer-Di Maida 2023, 388–415). The primary burial is directly radiocarbon dated, whereas context associated charcoal is radiocarbon dated from the other graves. Model B dates the primary cremation burial to the 14th century BC, corresponding to BA II, and the likely undisturbed urn grave to approximately the same period.

Chronology of LA 58

LA 58 contained a primary inhumation within a stone setting, relatively dated to the Early Bronze Age (I–II). The barrow contained another 15 secondary cremation graves, whereof 12 are radiocarbon dated. Based on burial goods, most of the cremation graves date to BA IV–V (Schaefer-Di Maida 2023, 416–27). Model B dates the primary grave and construction of LA 58 to the last half of the 14th century BC, corresponding to BA II, and that the barrow went out of use in the 9th century BC. The barrow did not remain in continuous use but has a considerable *c.* 200 year gap in burial activity between the primary grave and the first radiocarbon dated secondary grave.

Chronology of LA 64

LA 64 contained two centrally placed primary burials presumed to be inhumations, whereof one is relatively dated to LN II (burial no. 1), and the other is radiocarbon dated on context associated charcoal and charred grain (burial no. 2). The barrow also contained two secondary burials, whereof an urn grave is relatively dated to BA IV–V (Schaefer-Di Maida 2023, 449–51). Model B dates primary burial no. 1 to the mid-20th–start 19th centuries BC, in agreement with LN II, and primary burial no. 2 to mid-22nd–start 20th centuries, corresponding to LN I. The secondary urn grave is dated to the 11th–10th centuries BC, corresponding to BA IV.

Chronology of LA 115

The urnfield LA 115 contained 201 cremation graves, whereof 27 are dated using radiocarbon and 31 by relative typo-chronology (Schaefer-Di Maida 2023, 453–87). Model B estimates the urnfield was in use for 350–400 years, probably starting in the late 6th century BC and ending in the mid-2nd century BC. This is in agreement with the burial goods that are relatively dated from BA VI to Pre-Roman Iron Age II and corresponds well with comparative urnfields from Southern Jutland, Denmark (Rose & Meadows 2023).

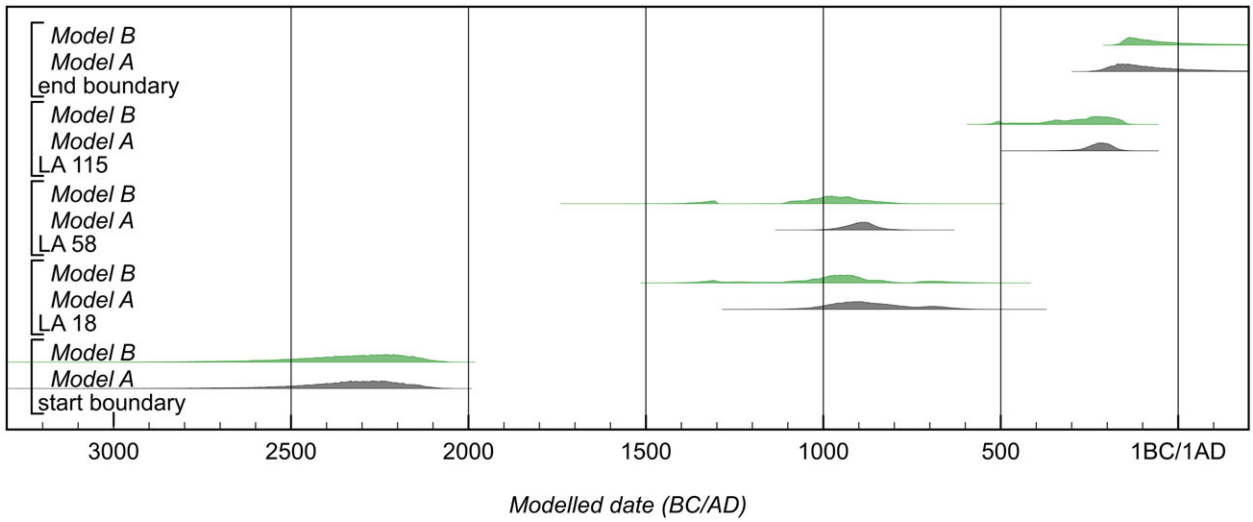

Fig. 7.
Selected model parameters from Model A (grey) and Model B (green): posterior estimated start and end boundaries of all burial activity at Mang de Bargen and summarised burial activity of individual mounds LA 18, LA 58, and LA 115.

DISCUSSION

This study presents the first extensive radiocarbon dating programme of a cemetery complex from northern Germany and it provides new insights into the dynamic nature of the burial monuments and the associated funerary rituals. Even though the radiocarbon dataset is large, it is biased towards the later part of Mang de Bargen due to preservation issues. Several of the earlier burials that date the construction of the barrows and some of the later graves from the Iron Age urnfield did not contain material datable by radiocarbon but they do contain burial goods that can be relatively dated using typo-chronology. We find that including the relative date ranges of these burials in the chronological model produces a more comprehensive picture of the burial activities at Mang de Bargen. Burials from the Older Bronze Age remain sparse, but the apparent gap is filled by LA 59, LA 60, and LA 69 that did not produce any radiocarbon dates and are thus not included in this study.

The barrow building tradition at Mang de Bargen lasted around a millennium, from the Late Neolithic to BA III, with several barrows in concurrent use. The following construction sequence relies on posterior estimations from chronological Model B, but incorporates relative dating information for LA 59, LA 60, and LA 69 (Table S1) (Schaefer-Di Maida 2023, 428–53). LA 17, LA 63, and LA 64 were built already in LN I, followed shortly by LA 59 built around the Late Neolithic–Bronze Age transition. LA 69 and LA 57 were built in BA I–II; LA 18, LA 58, LA 60 more specifically in BA II; and LA 23 in BA II–III. Urn graves from barrows LA 20, LA 21, and LA 24 only have a single radiocarbon date each, dating the first two to the Younger Bronze Age and the latter to the Pre-Roman Iron Age. LA 21 and LA 24 are situated close to LA 115 and it cannot be excluded that the urn graves belonged to LA 115 instead. The barrows continued to be used for burials long after their erection, with secondary cremation burials being added until the start of the Pre-Roman Iron Age. Aside from the possible LA 24, the last barrow actively used for secondary burials was LA 18. When this was abandoned in the 7th century BC, only the urnfield LA 115 remained in use.

Some of the secondary burials were added long after the primary burial of the barrow and it is doubtful whether the primary deceased would still have been remembered as individuals beyond 'living memory' (1–2 generations). As opposed to burials closely spaced in time where, it can be argued, they might have familial or societal ties. The persistent re-use of the older barrows as burial grounds demonstrates the great importance of creating and maintaining links between the ancestors and the living, between the past and the present (Louwen 2021, 233–8).

Mang de Bargen continued to be an important burial complex in the Bornhöved area for more than two millennia, which is exceptional in northern Germany and even within a wider European context. We do, however, expect comparable sites to exist but they remain unrecognised due to research biases. The burial intensity at Mang de Bargen varied over this long period and a cumulative plot of the burial activity has four distinct peaks: 1) in the Late Neolithic when the first barrows were erected; 2) in the Older Bronze Age when more barrows were erected; 3) in the Younger Bronze Age when secondary cremation graves were added to existing barrows; and finally 4) in the Pre-Roman Iron Age with the addition of an urnfield (Fig. 6 upper). The site was likely not abandoned in between the individual peaks; rather activity was most likely continuous, albeit with limited number of burials.

The two later peaks in the upper panel of Figure 6 are significantly more pronounced than the two earlier peaks, indicating that the burial rate was considerably higher in the last millennium BC when cremation had become the dominant burial practice. The burial rate decreased significantly in the 7th–6th centuries BC, with only a few graves dating to BA VI. With the introduction of the urnfield LA 115 the burial rate reached its maximum and adding to this are another 124 graves from LA 115 that can only be approximately dated to the Early Pre-Roman Iron Age (*c.* 500–150 BC) (Schaefer-Di Maida 2023, 199–202). Considering these, we establish that burial activity at Mang de Bargen was more intense in the Early Iron Age than any period before. Higher burial rates might relate to a growing population but it might also reflect a general change in funerary rituals, from being selective in the Late Neolithic–Older Bronze Age to more people being buried in an archeologically recognisable way in the Younger Bronze Age and later in the more spatially concentrated burial places of the Pre-Roman Iron Age.

The funerary rituals observed at Mang de Bargen vary considerably from the Late Neolithic to the Pre-Roman Iron Age, from inhumation to cremation and from primary and secondary graves in barrows to flat graves. The grave types include inhumation in a wooden coffin, cremation in a wooden coffin, urn grave, and other types of cremation deposits. The grave types have different chronological distributions and we will next compare results from Mang de Bargen (local level), from Schleswig-Holstein and Southern Jutland, Denmark (regional level), and from Belgium (over-regional level). The regional dataset is relatively dated to the Bronze Age and is comprised of 14 inhumation burials in wooden coffins dated by dendrochronology (Christensen 2006) and 20 radiocarbon dated cremation burials from six barrow sites in Schleswig-Holstein (Schaefer-Di Maida 2023). The over-regional dataset is directly based on a recent study of Late Neolithic–Early Iron Age cremation burials from Belgium (Capuzzo *et al.* 2023) which distinguishes between 'block of bones', *Brandgrubengräber* (burnt pit graves), and 'bones scattered in a pit' that, albeit carrying meaningful distinctions in terms of construction and content, have limited chronological sensitivity and the grave types have been merged into 'other cremation deposit' in this study. It was likewise decided it is chronologically irrelevant whether burials included pyre remains or not. The regional and over-regional datasets include very few absolutely dated burials before *c.* 1500 BC, largely due to preservation issues, and likewise very few burials after *c.* 800 BC due to selection biases. Grave types in the different regions are modelled using the default KDE_Model function in OxCal (Fig. 8) (Bronk Ramsey 2017).

The earliest grave type is inhumation in a wooden coffin, introduced at Mang de Bargen in the early 22nd century BC. The regional dataset includes oak coffins, all dated by dendrochronology to end 15th–end 14th centuries, corresponding with the later end of the grave type's distribution observed at Mang de Bargen. The regional dataset does not, however, include burials from the Late Neolithic or the Early Bronze Age and the observed difference between the local and regional distributions is therefore due to a sampling bias. The burial practice of cremating human remains was introduced at Mang de Bargen in the 14th century, as evidenced by a single cremation burial in a wooden coffin (KIA-53284). Evidently inhumation and cremation were used concurrently for approximately a century before the former ritual was abandoned *c.* 1300 BC. At the regional level, cremation burial in a wooden coffin had the highest frequency in the mid-15th–start 11th centuries, corresponding well with Mang de Bargen.

Flat graves in the form of different types of cremation deposits were introduced in Belgium in the early 17th century BC, and a century later in Schleswig-Holstein and Southern Jutland. They did not appear at Mang de Bargen before the start of the 13th century but we note that both the local and

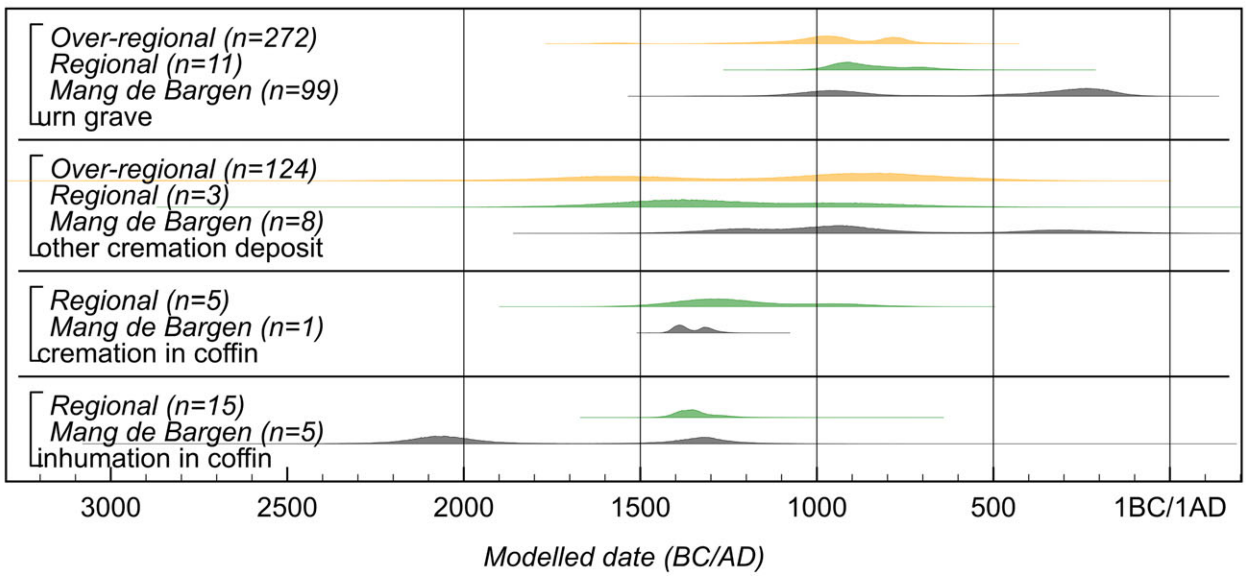

Fig. 8.
Kernel density estimates of spatio-temporal distributions of grave types at local level (Mang de Bargen, grey), regional level (Schleswig-Holstein and Southern Jutland, green), and over-regional level (Belgium, orange).

regional datasets are very small and the apparent delay might simply reflect a sampling bias. The urn grave was introduced contemporaneously in Belgium and at Mang de Bargen in the 11th century. It appears to be slightly later in Schleswig-Holstein and Southern Jutland but this is likely due to the small dataset here. Urn graves and other types of cremation deposits were used in parrallel in all regions and continued to be so at Mang de Bargen until the site was finally abandoned in the Pre-Roman Iron Age. The regional and over-regional datasets contain very few dates after *c.* 800 BC and any comparison of the distributions after this point is futile.

Comparing to Mecklenburg–Western Pomerania, it is noticeable that burial mound constructions there initially increased around 1300 BC, which can be attributed to the formation of the Mecklenburg Group and a resulting delay in the change of burial rites. Even though the first cremations also start to appear here around 1300 BC, it is not until 1100 that the erection of burial mounds ceased in Mecklenburg–Western Pomeraina and, instead, cremation burials in urn graves became the common burial form.

The spatio-temporal analysis shows the grave types have comparable chronological distributions across the investigated regions (except for Mecklenburg–Western Pomerania), demonstrating how new types quickly spread and were adopted across large parts of north-western Europe. The only noticeable difference is the later adoption of other types of cremation deposits at Mang de Bargen but this observation relies on a small dataset and might be explained by under-representation. The new absolute results are supported by other changes associated with the transformation processes, for instance, in house construction, deposition behaviour, range of crops (eg, introduction of millet) and land use processes.

CONCLUSION

This study presents the first extensive radiocarbon dating programme of Bronze Age material from northern Germany. Preservation issues, particularly pertaining to the earliest burials at the Mang de Bargen burial complex, led us to adopt an innovative research approach combining radiocarbon dates and relative date ranges derived from typo-chronology within a Bayesian chronological framework. We found that this sophisticated statistical approach generated a more comprehensive picture of the dynamic funerary rituals in north-western Europe,

as opposed to the more standard approach relying only on radiocarbon dates.

Our model estimates that burial activity took place at Mang de Bargen for more than two millennia, from the Late Neolithic and into the Pre-Roman Iron Age (*c.* 2500–50 BC). Barrows were built within the first millennium of this and several of these were in use at the same time, first for primary burials in wooden coffins, later for secondary burials in wooden coffins or flat graves. The persistent re-use of the barrows as burial ground within 'living memory' of the primary graves, but also long after demonstrates the great importance of creating and maintaining links between the ancestors and the living, between the past and the present. Burial intensity varied over the cemetery's use-life, with distinct peaks in the Late Neolithic when the first barrows were erected, in the Older Bronze Age when more barrows were erected, in the Younger Bronze Age when secondary cremation graves were added to existing barrows, and finally in the Pre-Roman Iron Age with the addition of an urnfield.

The longevity of Mang de Bargen provides a unique insight into the changing funerary rituals in northern Germany from the Late Neolithic to the Pre-Roman Iron Age. Cremation was introduced in the 14th century BC, first in wooden coffins and later in flat graves. Inhumation continued to be used for about a century alongside cremation, before it was abandoned *c.* 1300 BC, around the time when flat graves were introduced. The different grave types present at Mang de Bargen have chronological distributions largely comparable to other sites at a regional and over-regional scale, successfully demonstrating how new types and rituals were quickly adopted across large parts of north-western Europe, which is further supported by investigations of human-environmental interactions in this region (Schaefer-Di Maida 2023).

Acknowledgements The authors would like to thank the Museum für Archäologie Schloss Gottorf, Landesmuseen Schleswig-Holstein for access to the material, and the Leibniz-Laboratory at Kiel University for providing ongoing assistance with the radiocarbon results. A special thank you to the Archäologisches Landesamt Schleswig-Holstein, Almut Alsleben and Giacomo Capuzzo for making unpublished results available to us. Research was carried out at the Collaborative Research Centre 'Scales of Transformation: Human-environmental Interaction in Prehistoric and Archaic Societies' within subproject D3: 'The Bronze Age in North Central Europe: Scales of transformation' (PI Jutta Kneisel), and subproject G1: 'Timescales of Change – Chronology of cultural and environmental transformations' (PI John Meadows). Financial support by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation – Project number 290391021-SFB 1266) is thankfully acknowledged.

SUPPLEMENTARY MATERIAL

To view supplementary material for this article, please visit https://doi.org/10.1017/ppr.2024.3

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RÉSUMÉ

Monuments Funéraires Dynamiques du Nord-Ouest de l'Europe : Modélisation Chronologique d'un Complexe Funéraire Néolithique Final-Age du Fer Romain à Mang de Bargen, Nord de l'Allemagne, par Helene Agerskov Rose, Stefanie Schaefer-Di Maida, et Jutta Kneisel.

Cette étude présente le premier programme exhaustif de datation radiocarbone de matériels de l'âge du Bronze du nord de l'Allemagne. Elle associe dates radiocarbones, attributions typo-chronologiques relatives, et données stratigraphiques avec un cadre chronologique Bayésian. La durée d'utilisation du complexe funéraire de Mang de Bargen (Bornhöved, arrondissement de Segeberg, Schleswig-Holstein) est estimée à plus de deux millénaires, ce qui est exceptionnellement long pour l'Allemagne du Nord et l'Europe plus largement. Le site nous donne un aperçu unique de la nature dynamique des monuments funéraires et des pratiques rituelles associées entre le Néolithique final et l'âge du Fer préromain (*c.* 2500–50 BC). La construction de tumulus dura environ un millénaire (*c.* 2350–1300 BC), avec plusieurs tumulus utilisés de façon concomitante. Les tumulus ont été réutilisés comme lieux d'inhumation de manière persistante, lorsque les premières sépultures faisaient encore

partie de la «mémoire vivante», mais aussi longtemps après. L'intensité des dépôts funéraires a varié au cours de l'utilisation de la nécropole, avec des piques distincts durant le Néolithique final, lorsque les premiers tumulus furent construits; lors du tout premier âge du Bronze, lorsque de nouveaux tumulus furent construits; durant l'âge du Bronze récent, lorsque des sépultures secondaires en crémation furent ajoutés aux tumulus précédents; et, enfin, lors de l'âge du Fer préromain, avec l'ajout d'un champs d'urnes. Les rites funéraires varient considérablement au cours de cette période: de l'inhumation à la crémation, et de la sépulture primaire à la sépulture secondaire sous tumulus ou en pleine terre. La crémation fut introduite au 14^{e} siècle avant notre ère, toutefois, inhumations et crémations furent utilisées en parallèle pendant environ une centaine d'année avant que les premières ne soient abandonnées autour de 1300 BC environ. L'étude donne la distribution chronologique absolue des types de sépultures présents à Mang de Bargen, et montre en quoi ils peuvent être comparés à d'autres sites à l'échelle régionale et suprarégionale, démontrant ainsi comment de nouveaux types de sépultures étaient rapidement adoptés sur de larges pans de l'Europe du nord-ouest.

ZUSAMMENFASSUNG

Dynamische Grabdenkmäler Nordwesteuropas: Chronologische Modellierung eines spätneolithisch-vorrömischen eisenzeitlichen Friedhofskomplexes in Mang de Bargen, Norddeutschland, von Helene Agerskov Rose, Stefanie Schaefer-Di Maida, und Jutta Kneisel.

Die vorliegende Studie stellt das erste umfassende Radiokohlenstoff (^{14}C)-Datierungsprogramm bronzezeitlichen Materials aus Norddeutschland dar und kombiniert ^{14}C-Daten, relative Typo-chronologie und stratigraphische Informationen zur Konstruktion von Bayes'schen chronologischen Modellen. Wir schätzen, dass der Gräberkomplex von Mang de Bargen (Bornhöved, Kreis Segeberg, Schleswig-Holstein) mehr als zwei Jahrtausende lang genutzt wurde, welches in Norddeutschland und im weiteren europäischen Kontext einen außergewöhnlich langen Zeitraum darstellt. Die Fundstelle bietet einen einzigartigen Einblick in die Dynamik des Grabbaus und der damit verbundenen Bestattungspraktiken vom Spätneolithikum bis in die vorrömische Eisenzeit (*c.* 2500–50 v. Chr.). Die Tradition des Grabhügelbaus erstreckt sich etwa über ein Jahrtausend (*c.* 2350–1300 v. Chr.), bei gleichzeitiger Anlage mehrerer Grabhügel. Die Grabhügel wurden immer wieder als Begräbnisstätte aufgesucht, sowohl innerhalb des 'lebenden Gedächtnisses' der Primärgräber als auch noch lange danach. Die Bestattungsintensität variierte im Laufe der Nutzungsdauer des Friedhofs, mit deutlichen Spitzen im Spätneolithikum, als die ersten Grabhügel errichtet wurden; in der älteren Bronzezeit, mit der Errichtung weiterer Grabhügel; in der jüngeren Bronzezeit, als an den vorhandenen Grabhügeln die Bestattung sekundärer Brandgräber erfolgte; und schließlich in der vorrömischen Eisenzeit mit der Etablierung eines Urnengräberfeldes. Die Bestattungsrituale variieren vom Spätneolithikum bis zur vorrömischen Eisenzeit beträchtlich, von der Körperbestattung bis zur Brandbestattung und von Primär- und Sekundärgräbern in Grabhügeln bis hin zu Flachgräbern. Die Brandbestattung wurde im 14. Jh. v. Chr. eingeführt und Körper- und Brandbestattung fanden etwa ein Jahrhundert lang parallel statt, bevor erstere um 1300 v. Chr. aufgegeben wurde. Die Studie weist die absoluten chronologischen Verteilungen der in Mang de Bargen vorkommenden Grabtypen auf und belegt, dass die Nutzungsdauer mit anderen Fundorten auf regionaler und überregionaler Ebene vergleichbar sind und wie schnell die neuen Bestattungsformen in weiten Teilen Nordwesteuropas übernommen wurden.

RESUMEN

Dinámicas funerarias en los monumentos del noroeste de Europa: modelización cronológica del cementerio de Mang de Bargen, norte de Alemania, entre el Neolítico final y la Edad de Hierro prerromana, por Helene Agerskov Rose, Stefanie Schaefer-Di Maida, y Jutta Kneisel.

Este estudio presenta el primer programa extensivo de dataciones radiocarbónicas de materiales de la Edad del Bronce del norte de Alemania, y combina dataciones radiocarbónicas, rangos de fechas tipo-cronológicas, y datos estratigráficos en un marco cronológico bayesiano. Estimamos que el complejo cementerio de Mang de

Bargen (Bornhöved, distr. Segeberg, Schleswig-Holstein) estuvo en uso durante más de dos milenios, lo cual es excepcionalmente largo en el norte de Alemania y en su contexto europeo. El sitio aporta una visión única sobre la naturaleza dinámica de los monumentos y prácticas funerarias asociadas desde el Neolítico final hasta momentos prerromanos durante la Edad del Hierro (*c.* 2500–50 BC). La tradición de construir los túmulos se expande durante casi un milenio (*c.* 2350–1300 BC) con varios túmulos en uso simultáneamente. Los túmulos fueron persistentemente reutilizados como zona de enterramiento, tanto dentro de la 'memoria viva' de las tumbas primarias como en los momentos posteriores. La intensidad de enterramientos varía a lo largo de la vida de uso del cementerio, con distintos momentos álgidos en el Neolítico final cuando se erigen la mayor parte de los túmulos; en los inicios de la Edad del Bronce cuando las tumbas de cremación se añaden a los túmulos existentes y finalmente en época prerromana durante la Edad del Hierro con la adición de un campo de urnas. Los rituales funerarios varían considerablemente a lo largo del período: desde la inhumación a la cremación, y desde tumbas primarias y secundarias en túmulos a enterramientos planos. La cremación fue introducida en el siglo XIV BC pero la inhumación y la cremación se utilizaron en paralelo durante al menos una centuria antes de que fuese abandonada en torno al *c.* 1300 BC. Este estudio aporta las distribuciones cronológicas absolutas de los tipos de tumbas presentes en Mang de Bargen y muestra su comparación con otros sitios a una escala regional y supra regional, demostrando con éxito como los nuevos tipos fueron rápidamente adoptados en amplias zonas del noroeste de Europa.