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CREMATION VS. INHUMATION: MODELING CULTURAL CHANGES IN FUNERARY PRACTICES FROM THE MESOLITHIC TO THE MIDDLE AGES IN BELGIUM USING KERNEL DENSITY ANALYSIS ON ^{14}C DATA

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ABSTRACT. The adoption of a new funerary ritual with all its social and cognitive meanings is of great importance to understanding social transformations of past societies. The first known occurrence of cremation in the territory corresponding to modern Belgium dates back to the Mesolithic period. From the end of the Neolithic onward, the practice of cremation was characterized by periods in which this rite was predominant and periods of contractions, defined by a decrease in the use of this funerary ritual. This paper aims to quantify such phenomenon for the first time by modeling discontinuities in burial practices through kernel density analysis of 1428 radiocarbon (^{14}C) dates from 311 archaeological sites located in Belgium from the Mesolithic to the Middle Ages. Despite possible taphonomic and sampling biases, the results highlight the existence of periods with a large uptake of cremation rite followed by periods of contractions; such discontinuities took place in correlation with changes in the socio-economical structure of local communities, as, for example, during the later Middle Bronze Age and at the end of the Roman Period.

KEYWORDS: archaeology, Belgium, cremation, inhumation.

INTRODUCTION

In 1998, it was demonstrated that calcined bone can be radiocarbon (^{14}C) dated using the carbon present in the inorganic fraction of bone commonly called bioapatite (Lanting and Brindley 1998; Lanting et al. 2001). This discovery led to an exponential increase in the amount of ^{14}C dates associated with cremation burials. As such, a great number of cremated human remains from archaeological contexts located in Belgium were ^{14}C dated over the last two decades. Most of these data were placed in public repositories such as the Royal Institute for Cultural Heritage web-based ^{14}C databases (http://c14.kikirpa.be/ and http://radiocarbon.kikirpa.be/). This large volume of data, combined with the great number of ^{14}C dates obtained on collagen samples from inhumations since the introduction of

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^{14}C dating method in the late 1940s, constitutes a valuable dataset to explore changes in funerary practices in in Belgium from the Mesolithic to the Middle Ages.

Archaeological records highlight the existence of periods in which cremation was widely used, as is the case during the Late Bronze Age with the macro-scale diffusion of the so-called Urnfield culture (Falkenstein 2012; Capuzzo and Barceló 2015; De Mulder et al. 2016). In other periods, such as the Mesolithic and the Neolithic, inhumation seems to be the dominant funerary rite in Belgium (Toussaint 2013; Meiklejohn et al. 2014). However, ^{14}C dates are rarely used as data to describe these changes in funerary practices (Capuzzo 2014; Morell 2019; Schmid 2019). Previously published ^{14}C dates are used here to quantify such changes in the area corresponding to modern Belgium from the Mesolithic to the Middle Ages covering more than 11,000 years.

SITES, CONTEXTS, AND SAMPLING

Available information on ^{14}C-dated funerary contexts located in Belgium is spread over various databases and publications. The majority of these ^{14}C dates were processed by the Radiocarbon Dating Laboratory at the Royal Institute for Cultural Heritage (KIK-IRPA) in Brussels (Belgium) and are included in their web-based ^{14}C databases. The database at http://c14.kikirpa.be/ includes samples measured between the creation of the Laboratory in the 1960s and 2014. These samples were measured in the facilities of the KIK-IRPA using liquid scintillation counters (IRPA-series), the AMS facilities of Utrecht (UtC-series) (van der Borg et al. 1984, 1987), and Kiel (KIA-series) (Nadeau et al. 1998). Dates measured after 2014, year of the MICADAS installation at the KIK-IRPA (Boudin et al. 2015), are gathered in the database at http://radiocarbon.kikirpa.be/ (RICH-series). Additional dates on Belgian material were also obtained by the laboratories of Louvain-la-Neuve (Lv-series), Frankfurt (Fra-series), Hannover (Hv-series), Beta Analytic (Beta-series), CEDAD-Lecce (LTL-series), Gif-sur-Yvette (GifA-series), Groningen (GrA- and GrN-series), Geochron Laboratories (GX-series), Glasgow (SUERC-series), Oxford (OxA-series), and Poznan (Poz-series).

The collected dataset is composed of 592 ^{14}C dates from 176 archaeological sites associated with inhumations, 760 ^{14}C dates from 117 archaeological sites referring to cremation graves, 2 ^{14}C dates linked to both cremated and inhumed human remains, and 74 ^{14}C dates from charcoal collected from 20 barrows (Figure 1 – Supplement 1). Since ^{14}C dates on charcoals collected from barrows cannot be linked to the practice of inhumation or cremation due to the absence of human remains in these contexts (see section Biases of the Data and Adopted Solutions), these data were used only to highlight the presence of this particular type of funerary structure. Samples from inhumations were mainly obtained from human bone collagen (93%) and charcoal (7%). Cremations were dated using bone apatite from cremated human (78%) and animal (2%) bone, as well as charcoal (20%). The spatial distribution of the collected data is not homogeneous (Figure 1). A lack of ^{14}C-dated cremations is observable in the Walloon region in southern Belgium, while Flanders (north of Belgium) has a higher concentration of dated cremations which can be explained by the introduction of commercial archaeology in Flanders in 2005.

BIASES OF THE DATA AND ADOPTED SOLUTIONS

The preservation of human bone from archaeological contexts varies across different parts of Belgium. Human remains dating to the prehistoric periods (Mesolithic and Neolithic) were almost exclusively found in Wallonia thanks to excellent preservation conditions of caves

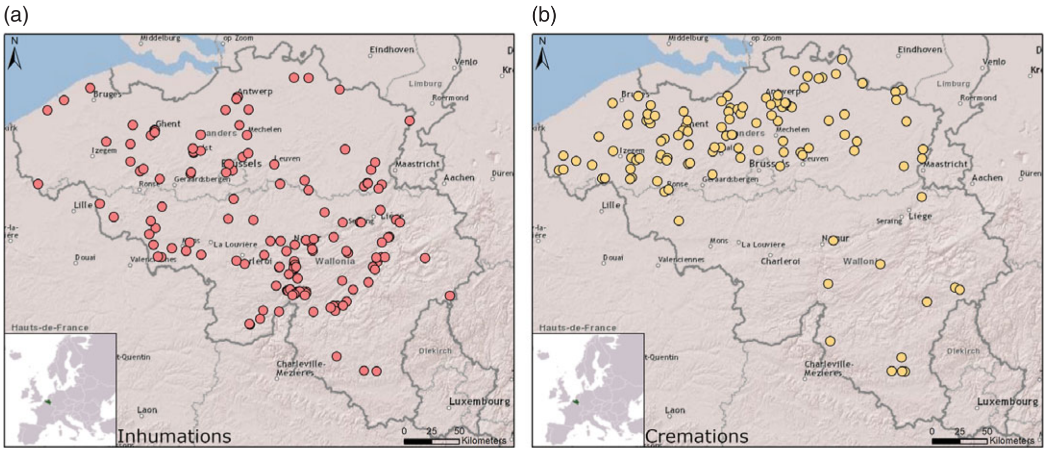

Figure 1 Spatial distribution of radiocarbon-dated funerary contexts in Belgium: (a) inhumations and (b) cremations from 10,000 BC to 1200 AD.

and rock shelters. These contexts are absent in Flanders, where open-air burial sites were more likely to be destroyed or buried under meters of sediment, as often happens in dynamic alluvial and marine systems (Verhegge et al. 2014, 2016; Verhegge 2015; Sergant et al. 2016).

Furthermore, poor preservation of unburnt bone (inhumations) is common in acidic soils such as the schist soils of the Ardennes plateau, in southern Belgium, and the sandy soils of northern Flanders (Garland and Janaway 1989; Nafte 2000; Nielsen-Marsh et al. 2007; De Reu 2012; Surabian 2012; Estévez et al. 2014; Kendall et al. 2018). In these regions unburnt bone (inhumations) is rarely recovered and, thus, unavailable for anthropological studies. This is the case of the La Tène cemetery of Neufchâteau-Le Sart "Bourzi", located in the Ardennes, where inhumation burials under tumuli were only recognised thanks to the shape of the grave, the funerary goods, and the discolouration of the soil where the skeleton used to be (Cahen-Delhaye 1997). The same is also observed in the other sites located in the same geological region, such as the La Tène cemetery of Léglise-Gohimont (Cahen-Delhaye and Hurt 2013). In both cases, charcoal samples recovered from the grave were interpreted as elements of the wooden funerary structure and were used for ^{14}C dating. In the sandy regions of northern Belgium, aerial photographic surveys identified a large number of circular soil and crop marks. These were interpreted as funerary barrows but, in most cases, human remains were not recovered (Bourgeois and Talon 2009; De Reu and Bourgeois 2013; De Reu 2014). This not only due to the soil's acidity, but also to the intense ploughing activities carried out in northern and western Flanders, that flattened the barrow mounds leaving the ditches as only visible traces in the archaeological record. Samples of charcoal were nevertheless found in some of these ditches and were used to date the structures. To this effect, De Reu (2014) proposed to use ^{14}C-dated charcoal samples collected in the bottom layer of the ditches, thereby rejecting samples derived from upper or other layers. This paper adopts the same approach; however, a specific assignment of these dates to either the inhumation or the cremation practice is not always possible due to the absence of graves and human remains. For this reason, these dates were only used to visualize the temporality of barrows and not as a proxy to understand variations in the number of individuals buried in this type of funerary structures.

The much higher crystallinity of calcined bone compared to unburnt bone (e.g. Lebon et al. 2010; Zazzo and Saliège 2011; Snoeck et al. 2014b) increases the material's resistance to taphonomic alterations. For this reason, calcined bones are often recovered even in acidic soils (e.g. Quintelier and Watzeels 2018; Annaert et al. 2020). Burned at temperatures above 650°C, calcined bone is generally white as all organic matter has been destroyed (Stiner et al. 1995; Zazzo et al. 2009) and only the inorganic fraction, called bioapatite, remains. In 1998, Lanting and Brindley showed that calcined bone provided reliable ^{14}C dates. It is important, however, to remain critical when interpreting results obtained from calcined bone, since a large part of the carbon present in calcined bone (up to 95%) originates from the fuels used during the cremation process (Olsen et al. 2008, 2012; Zazzo et al. 2009, 2012; Van Strydonck et al. 2005, 2010, 2015; Hüls et al. 2010; Snoeck et al. 2014a, 2016). A recent ^{14}C dating study of the Early Medieval cemetery of Broechem (Belgium) has shown that calcined human and pig bone from the same grave yielded differences of up to 100 years (Annaert et al. 2020). At present, it is unclear what causes this difference ("old-wood" effect, freshwater reservoir effect, etc.), but this study highlights the need for critical evaluation of ^{14}C dates that were obtained from calcined bone. Overall, research on human bones from Roman to post-Medieval Belgian sites indicated a lack of importance of fish products for the diet, thus the bias caused by the reservoir effect seems to be negligible (Ervynck et al. 2014). Still, in the frame of this work, differences of up to 100 years will only minimally affect the modeling results.

While calcined bone can suffer from an "old-wood" effect, dates obtained from charcoal samples can also be problematic. When an organic sample is ^{14}C dated, the timespan between the death of the live-being and the moment of measurement is calculated in terms of the residual ^{14}C remaining. Still, the moment in which an organism stops exchanging ^{14}C with the atmosphere does not always coincide to the particular moment that we want to date. In case of charcoal, the ^{14}C date refers to the moment in which the plant was cut down or even to a previous moment during the life of the plant recorded in its inner structure made of growth rings (Schiffer 1986; Bowman 1990; Ashmore 1999; Capuzzo 2014). Since the exact contemporaneity of the ^{14}C measurement and the calendrical date of the archaeological context cannot be reliably asserted, dates on charcoal must have a value as *terminus post quem*. In addition, charcoal can be intrusive from a younger layer by bioturbation and resulting in a too young ^{14}C date, or residual, which means that it was present before the archaeological event occurred and will lead to a too-old ^{14}C date (Crombé et al. 1999; Van Strydonck et al. 2001).

Eventually, the sampling biases need to be taken into account. These biases are particularly intense for archaeological remains dating to the Roman period. A large number of Roman inhumations and cremations lack ^{14}C dates because of the archaeological preference of typological dating of grave goods, such as pottery and metal objects.

To reduce the uncertainty of certain previously published dates, and to improve precision and accuracy of the analyses carried out, the dataset was refined as follows: (1) Priority was given to dates that were derived from human bone collagen (inhumations) and from fully calcined human bone apatite (cremations). (2) Dates from cremated animal bone and charcoal were excluded if dates based on human remains (i.e. recovered in the same grave) existed. (3) To avoid counting the same depositional event twice and to prevent the non-independence of dated events (Barceló et al. 2014), multiple ^{14}C dates from the same grave (obtained on the same material and the same individual) were combined before calibration using the `R_Combine` function of the program OxCal 4.3 (Bronk Ramsey 2009). Their pooled mean was calibrated using the IntCal13 calibration curve (Reimer et al. 2013). Examples of this are the two ^{14}C dates on the cremated remains of the Middle Bronze Age structure S107 at Zingem "Ouwegemsesteenweg", which were combined in a unique measurement, and the two dates from the Late Bronze Age cremation grave 1 at Borsbeek "Vogelenzang" (De Mulder et al. 2012). (4) ^{14}C dates with $\sigma > 100$ years were rejected for the most recent periods (from the Bronze Age onwards), this choice resides in the necessity to reduce the error within the modeled dataset while at the same time maintaining a usable sample size. (5) Samples not clearly associated with the funerary evidence and structure, like infiltrated charcoals and samples that provided aberrant dates were excluded from the analyzed dataset. This is the case of the date obtained on the calcined bone KIA-37581 from Grave 52 at Destelbergen "Eenbeekeinde" which is much older than expected, probably due to presence of secondary carbonates (De Mulder et al. 2009). The date on charcoal KIA-28310 from the site of Waardamme, Vijvers, was also excluded. It is more recent than expected and can probably be linked with the Roman occupation next to the monument rather than the use of the barrow itself (De Reu and Bourgeois 2013). (6) The ^{14}C dates from the laboratory of Louvain-la-Neuve (Lv-series) (Gilot 1997) were not corrected for the isotopic fractionation after the measurement of the $^{13}C/^{12}C$ ratio and needed to be corrected and made 80 years older, as suggested by Vrielynck (1999).

As a result of the filtering and combining process, from the original dataset of 1428 ^{14}C dates, we retained 1286 ^{14}C dates (90%) for the analysis, 667 related to cremations, 582 to inhumations, and 38 to unknown burials (barrows).

METHOD: DATES AS DATA

^{14}C dates as data are frequently used in order to track long-term processes, such as demographic variations in the past (Shennan et al. 2013; Capuzzo et al. 2018; Fyfe et al 2019) or to interpret changes in dated variables such as settlements, burials structures, metal and pottery typologies (Caracuta et al. 2012; De Reu and Bourgeois 2013; Capuzzo 2014). The most frequently used method is the Summed Calibrated Probability Distribution (SCPD), which is based on the sum of individual confidence intervals of ^{14}C dates after calibration (see Capuzzo et al. 2018 for references on the method). Peaks in the SCPD curve correspond to episodes of maximum development of the studied phenomenon, whilst troughs are interpreted as moments of crisis or contraction. This method, however, is affected by biases due to sample size and calibration process (Williams 2012; Contreras and Meadows 2014; Crema et al. 2017). The very sharp and punctual peaks, observable in most SCPDs, are in fact a direct consequence of the calibration process. They are the effects of particular sections of the IntCal13 calibration curve, called calendar-age steps, whose shape is the result of a fast decrease in ^{14}C concentrations in the atmosphere (Williams 2012). To avoid the noise artefacts characteristic of SCPDs, this study uses kernel density plots (Feeser et al. 2019; Loftus et al. 2019; McLaughlin 2019; Mazzucco et al. 2020) to describe variations in the use of funerary practices in Belgium. The OxCal 4.3 tool `KDE_Plot` that provides a kernel density distribution for the samples (Bronk Ramsey 2017), is implemented with Belgian data. The kernel plot removes the high frequency noise of the SCPDs, retaining only the lower frequency signal and thus eliminating data dispersion (Bronk Ramsey 2017). The result is a smoother curve, without sharp spikes and edges typical of the SCPDs, which are still visible in the background of the KDE plots (Figures 2–5).

The shape of the KDE plots and the corresponding scale of probability density values is directly correlated to the number of samples per timespan. The overall probability of each KDE plot is normalised to the number of included events and is based on probability per year. Considering the effects of taphonomic biases on temporal series, much more dated samples are expected for the most recent periods compared to the oldest phases. For this reason, variations in the number of dated contexts for periods characterized by few samples are barely detectable when included in the same KDE plot with periods with a high number of dated contexts. To avoid such a bias, nine KDE curves were produced. For each period, defined according to the conventional chronological framework (i.e. Mesolithic, Neolithic, Metal Ages, and Roman/Medieval), two KDE curves were made: one composed of ^{14}C dates from inhumations and another one with measurements on cremations. An additional KDE plot was obtained with dates on charcoal from barrow structures. The values of probability density obtained for each KDE plot were used to determine the intensity of the variations detected in ^{14}C data. The KDE plots were then used as a proxy to infer changes in the use of the two funerary practices. Our data were also tested using the OxCal 4.3 tool `KDE_Model` (Bronk Ramsey 2017). While for some periods (e.g. the Neolithic) the results of the modeling are the same as when using the `KDE_Plot` function, for others (e.g. the Metal Ages), the `KDE_Model` emphasizes the spurious peaks resulting from the calibration. To avoid this, the `KDE_Plot` function was chosen.

To date the abandonment of cremation in Belgium during the Middle Ages, statistical modeling in the OxCal 4.3 software was used (Bronk Ramsey 2009). Middle Ages ^{14}C dates were constrained in a single phase delimited by two simple boundaries. This allowed to calculate the time span of the boundary which describes the abandonment of cremation, obtaining a probability distribution in which the dated event is located according to the 1-σ and 2-σ probabilities.

RESULTS

The Mesolithic Period

The first known occurrence of cremation burials in Belgium dates to the Mesolithic period. The oldest dated context is the site of Abri des Autours, where cremated remains were recovered in an Early Mesolithic rock shelter (OxA-5838, 9090 ± 140 BP; Polet and Cauwe 2007). The second oldest ^{14}C-dated Mesolithic cremation burial is from the site of Leuze-en-Hainaut/Blicquy "Ville d'Anderlecht", where a pit yielded calcined bones, charcoal, and lithic tools (KIA-26463, 7695 ± 35 BP; Pleuger et al. 2005). Cremation represents an exception in the Mesolithic period, since the predominant rite appears to be inhumation as confirmed by the 28 ^{14}C dates from 12 archaeological sites with inhumations against only two dates from cremation contexts (Figure 2c–d). ^{14}C-dated Mesolithic inhumations appear exclusively in caves such as the Grotte du Bois Laiterie at Profondeville/Rivière (Otte and Straus 1997), Grotte Margaux at Dinant/Anseremme (Cauwe 1998), and rock shelters, like the Abri de Chauveau at Yvoir/Godinne (Toussaint and Becker 1993), clustered in the Sambre and Meuse basin in southern Belgium (Meiklejohn et al. 2014) (Figure 2a).

The Neolithic Period

During the Neolithic inhumation continues to be the predominant funerary practice in Belgium, whilst the use of cremation remains limited. Collective inhumation burials were often found in caves and rock shelters located in the Walloon region between the karstic

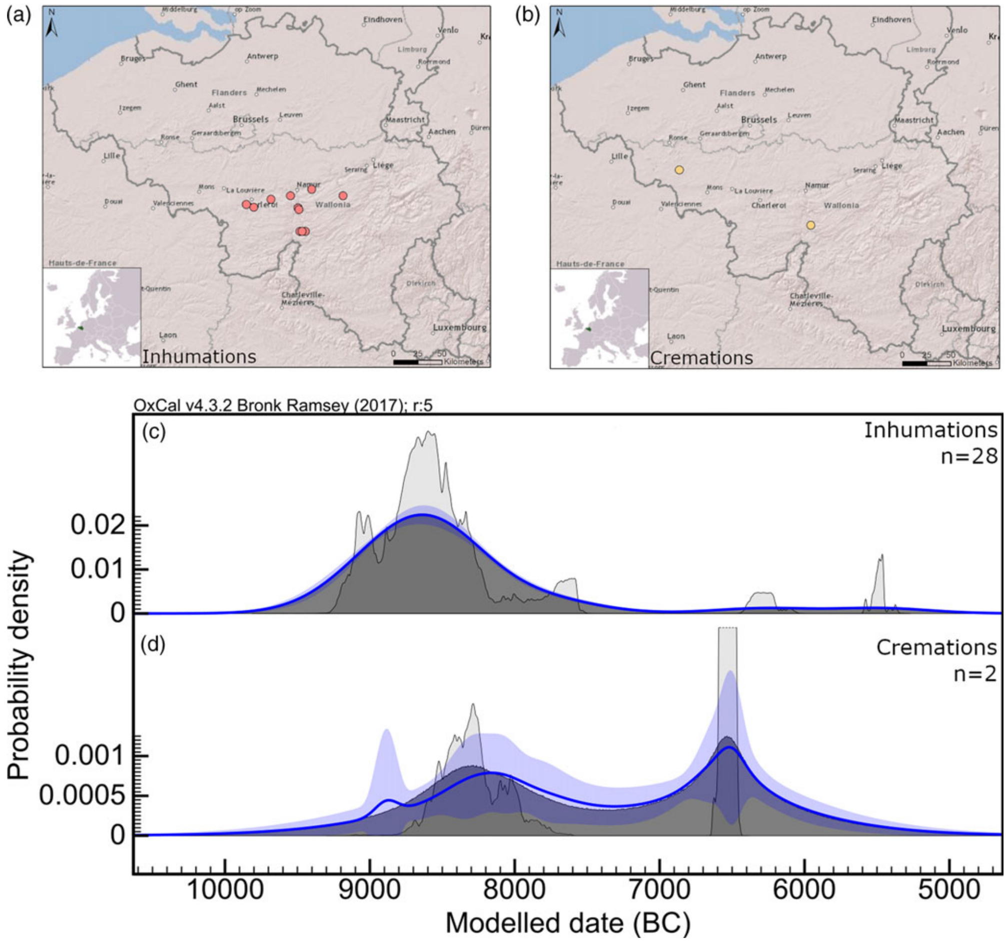

Figure 2 Maps with the spatial distribution of Mesolithic ^{14}C-dated funerary contexts and KDE plots showing the temporal distribution of the data for (a, c) inhumations and (b, d) cremations.

areas of the Belgian Meuse basin and the Ardennes (Figure 3a). In the same area, collective burials are also present in megalithic structures, such as the ^{14}C-dated sites of Lamsoul (Toussaint et al. 2005) and Wéris I (Toussaint 2003). Inhumations are also found in mine shafts such as at Spiennes (Toussaint et al. 1997; Collet et al. 2011; Lavachery et al. 2015) and Avennes-Braives (Toussaint et al. 1997).

In Flanders, Late Neolithic barrows were recognised, although no human remains were recovered in it, therefore the attribution to inhumations or cremations is not possible. An example is the site of Deinze, Aquafin "RWZI", which is considered to be one of the earliest barrows in northwestern Belgium (De Clercq and Van Strydonck 2002; De Reu and Bourgeois 2013).

Seventy-three archaeological sites with inhumed human remains provided 142 ^{14}C dates that were used for the analysis. The number of dated cremation contexts is much lower, only four ^{14}C dates from three archaeological sites (Kruishoutem "Wijkhuis", Oud-Turnhout "Hueve Akkers", Ranst "Zevenbergen") could be included in the KDE plot (Figure 3b, d).

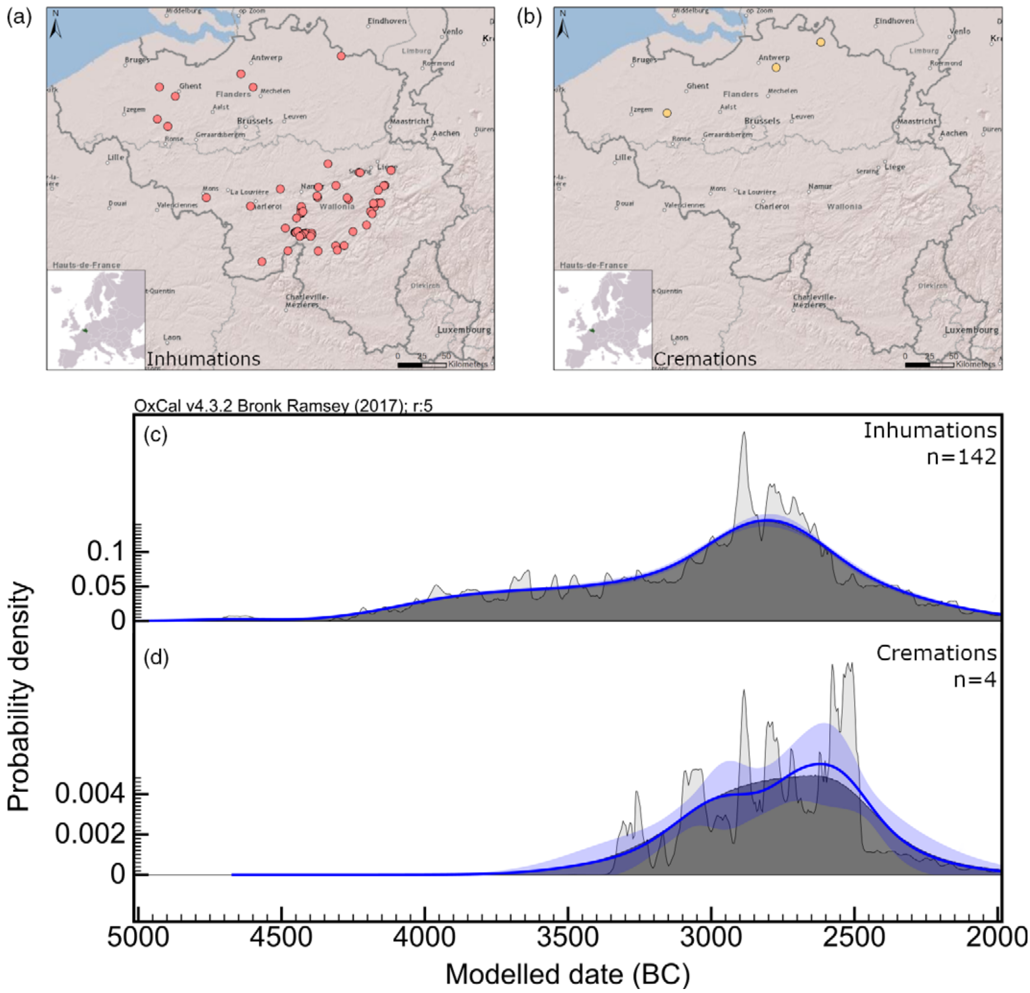

Figure 3 Maps with the spatial distribution of Neolithic ^{14}C-dated funerary contexts and KDE plots showing the temporal distribution of the data for (a, c) inhumations and (b, d) cremations.

The KDE plot shows a peak in the practice of inhumation in the Late/Final Neolithic, between ca. 3100-2600 BC (Figure 3c). The sharp peak at 2900 BC is a calibration effect caused by the presence of a calendar-age step between 2950 and 2850 BC in the IntCal13 calibration curve (Reimer et al 2013). This period is followed by the introduction of the Bell Beaker tradition on the Belgian territory as attested by the presence of Bell Beaker vessels at the ^{14}C-dated sites of Mol "Bergeijkse Heide" (Beex and Roosens 1963; Lanting and van der Waals 1976), Kruishoutem "Kapellekouter" (Braeckman 1991), Sint-Denijs-Westrem "Flanders Expo" (Hoorne et al. 2008) and Hansbeke "Voordestraat" (Hoorne et al. 2009). The only Bell Beaker archaeological context clearly related to cremation practice is the site of Kruishoutem "Wijkhuis" (De Laet and Rogge 1972) where a layer of charcoal and cremated bones were found associated with a Bell Beaker with maritime decorations and a flint arrowhead as grave goods. The site was dated using charcoal, but the large standard deviation of the date does not allow to refine its chronology (IRPA-131, 4035 ± 190 BP).

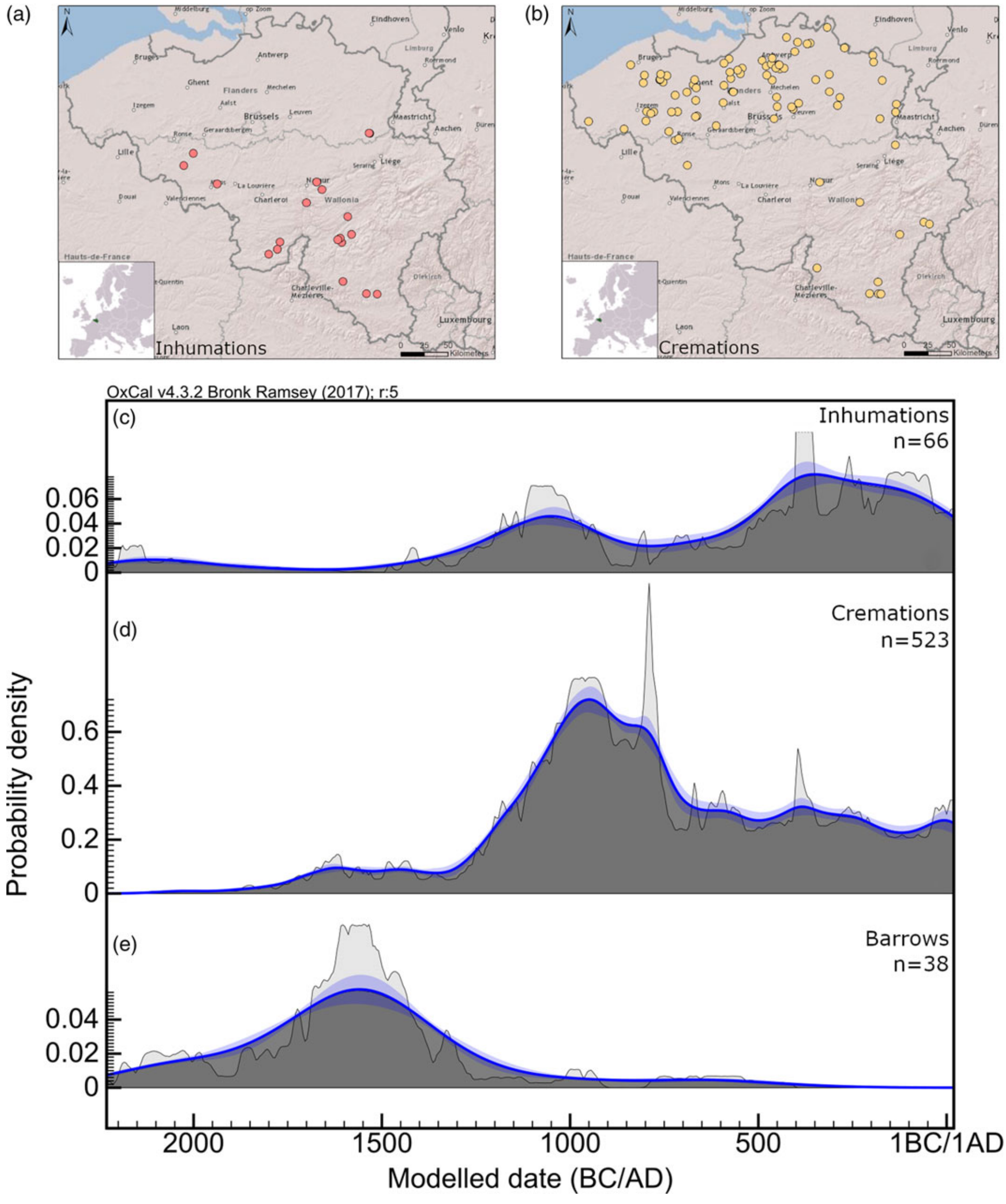

Figure 4 Maps with the spatial distribution of Metal Ages (Bronze and Iron Ages) ^{14}C-dated funerary contexts and KDE plots showing the temporal distribution of the data for (a, c) inhumations, (b, d) cremations and (e) barrows.

The Metal Ages (Bronze and Iron Ages)

The trend marked by a predominant adoption of inhumation over cremation seems to change entirely during the Metal Ages. The data retained for the KDE modeling after the filtering process include 66 ^{14}C dates from 19 archaeological sites with inhumations, 523 ^{14}C dates from 90 archaeological sites with cremated remains, and 38 ^{14}C dates from 18 barrows (Figure 4). A large variety of burial structures can be observed in the Metal Ages. During the Early and Middle Bronze Age, barrows are often present in northern Flanders such as the sites of Oedelem-Wulfsberge (Bourgeois et al. 2001; Cherretté and Bourgeois 2005), Waardamme-Vijvers (Demeyere and Bourgeois 2005), and Merelbeke-Axxes (De Clercq et al. 2004), Weelde-Groenendaalse Hoef (Beex 1959) and Weelde-Hoogeindse Bergen (Van Impe and Beex 1977). Barrows are also present in the Walloon region, but these contexts were not excavated and/or dated. In the large majority of the Flemish barrows no bone material was preserved due to the intense ploughing in the area. Cremated human remains were only recovered in few sites, such as at Ronse-De Stadstuin (Pede et al. 2015) and Weelde-Schootseweg (Annaert et al. 2012). The KDE plot obtained with ^{14}C dates from charcoal samples collected in the bottom layers of the ditches shows a peak in the use of the barrows during the Middle Bronze Age at ca. 1500 BC (Figure 4e), as already observed by De Reu and Bourgeois (2013).

The deposition of unburnt individuals in collective cave burials is still practised in Late Bronze and Iron Age Wallonia (e.g. the sites of Trou del Leuve at Sinsin (Warmenbol 2006), Trou de Han at Han-sur-Lesse (Warmenbol 1996, 2013; Jasinski and Warmenbol 2017; Gautier and Warmenbol 2019), and Grotte de On at Jemelle (Polet et al. 2017)). Less frequent are the funerary contexts located in the Walloon region that can be dated to the Early Bronze Age. An exceptional case is the site of Rebaix "Couture-Saint-Vaast". Although no bones were preserved due to soil's acidity, structure 2, interpreted as an inhumation grave, was dated using charcoal originating from the original wooden planks of the grave structure (Lv-2195, 3660 ± 80 BP; Cammaert et al. 1996).

Cremation burials seem to be concentrated in the Flemish regions, although this may be a consequence of the higher research intensity in the area. A large variation in the type of cremations exists: (1) urn cremations in many cases with remains of the pyre, (2) the so-called "bonepack grave" (*Knochenlager*) in which the bones probably were wrapped in a perishable container before being deposited in the soil, (3) the *Brandgrubengrab* with cremated remains and a large amount of charcoal from the pyre (De Mulder et al. 2009; De Mulder et al. 2013; De Mulder 2014).

The popularity of the inhumation rite appears to be very low in the Early Bronze Age and at the beginning of the Middle Bronze Age, which are characterized by the almost total absence of ^{14}C-dated inhumations. Then, from ca. 1500 BC onward, a slow increase of dated contexts is visible. In general, the magnitude of such change is very low as marked by the low values of probability density corresponding to only 19 sites included in the KDE plot; an overall stability seems to be the distinctive trait for the use of inhumation in the Metal Ages. On the contrary, cremation shows a different pattern with a slowly positive trend from the end of the Early Bronze Age to the beginning of the Middle Bronze Age, which becomes more pronounced from ca. 1300 BC. The maximum development of cremation burials occurs around 1050–800 BC, corresponding to the Late Bronze Age. This period is defined by the European-scale diffusion of cremation burials within the traditionally defined "Urnfield culture" (Capuzzo and Barceló 2015), whose introduction in the Belgian area was mediated by the *Rhin-Suisse-France orientale* group (Brun and Mordant 1988; De Mulder et al. 2008). It is interesting to observe that this pronounced increase of cremation burials matches the decrease of inhumation contexts detected for the Late Bronze Age-Iron Age transition. During the Iron Age, the number of those who were cremated does not show significant variations and stability seems to be apparent.

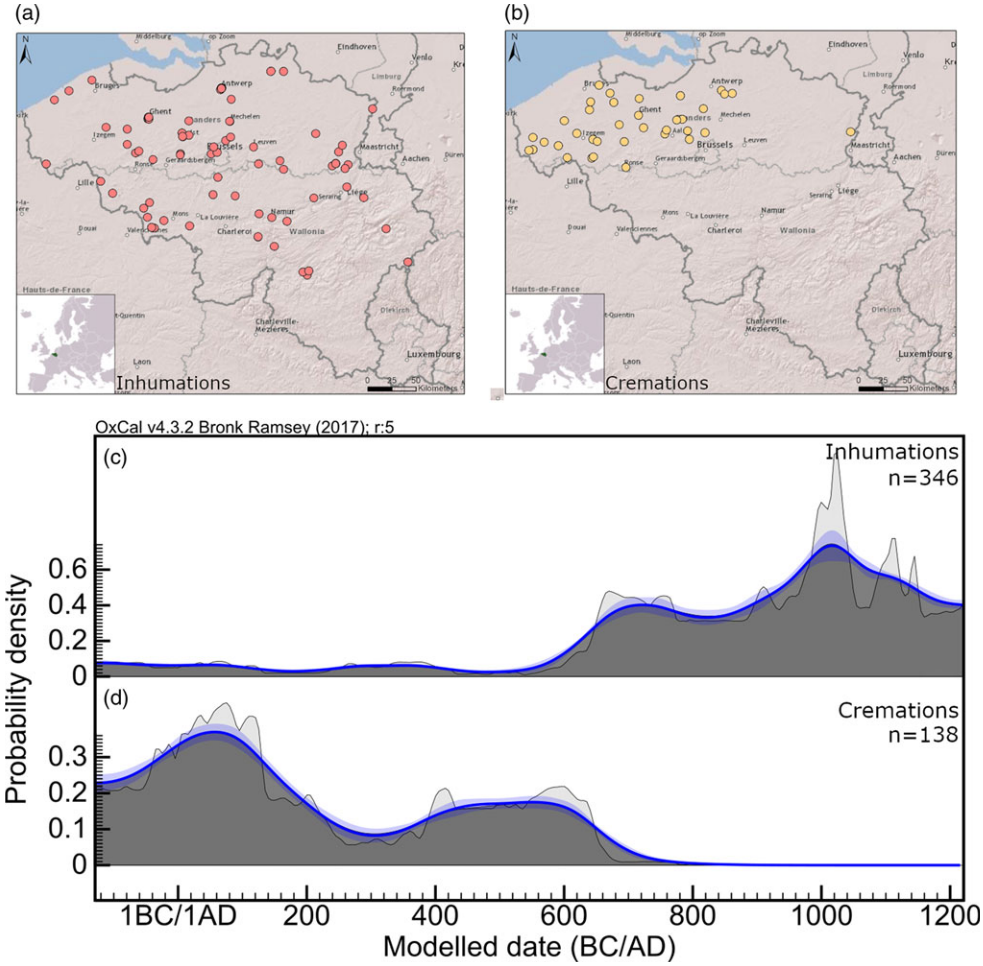

Figure 5 Maps with the spatial distribution of Roman and medieval ^{14}C-dated funerary contexts and KDE plots showing the temporal distribution of the data for (a, c) inhumations and (b, d) cremations.

The sharp peaks, visible at ca. 800 and 400 BC in the background of the KDE graphs are an effect of the calibration process on the SCPDs. These time spans correspond to two large calendar-age steps located just before and after the so-called Hallstatt Plateau (van der Plicht 2004) in the IntCal13 calibration curve (Reimer et al. 2013).

Roman Times and Early Middle Ages

The last analyzed chronological window covers the period of the Roman Empire and the Early Middle Ages. The spatial distribution of collected data is not univocal (Figure 5). ^{14}C-dated inhumations are spread all over the Belgian area with some apparent gaps in forested areas like Limburg and the Ardennes, while ^{14}C-dated cremations appear to be clustered exclusively in Flanders, and in particular in the Scheldt valley. Collected data include 346 ^{14}C dates from 86 archaeological sites with inhumation contexts and 138 ^{14}C dates from 36 archaeological sites with cremations. Roman burials were placed preferably along and in the surroundings of roads leading to main cities, such as Atuatuca Tungrorum (present

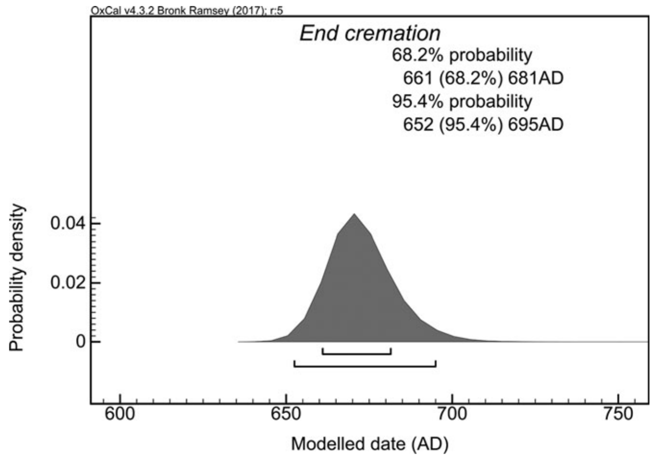

Figure 6 Boundary showing the 1-σ and 2-σ probabilities for the abandonment of the cremation practice in Belgium during the Early Middle Ages.

Tongeren), the Roman *civitas* close to the river Meuse (Brulet 2008; Veldman et al. 2012; Hanut 2017). *Brandgrubengräber*, that became increasingly popular during the Late Iron Age, remained the main cremation type used in the most Romanised part of Flanders (De Mulder et al. 2013). In the peripheral Campine region, in northeastern Flanders, a continuity in indigenous rituals prevails, as at Weelde-Schootseweg, where cremated remains were scattered on the bottom of circular or rectangular enclosures (Annaert et al. 2012).

In the Early Middle Ages, the topographical distribution of burial grounds is rather complex. In the 5th and 6th centuries, people used larger communal burial grounds, often situated near roads or waterways. A spatial reference to either Bronze Age burials or Roman burial grounds is not uncommon. From the 7th century onwards, the burial grounds tend to become smaller and more focused on families and ancestors. It is only in the 8th and 9th centuries that we see the reorganization of the funerary rites around churches (a.o. monasteries), with the arrival of the first churchyards around private churches (Theuws 2004; Loveluck 2013).

The analysis of ^{14}C-dated funerary context shows contrasted patterns for inhumations and cremations. For the Roman period cremation seems to be the predominant rite. An increase in the use of cremation is visible between the second half of the 1st century BC and the Romanization of present Belgium at the end of the first century AD, although the intensity of such a rise in the KDE plot can be emphasized by the calibration process. Then, the end of the Roman period shows a contraction in the amount of cremations. This negative trend is interrupted only at the beginning of the Middle Ages. From ca. 400 AD, a mild positive trend in the use of cremation is visible in the KDE plot. This is probably related to new influences and arrival of new settlers from the northeast of Europe, but this requires further research (Tys 2012).

After ca. 640 AD a dramatic drop in cremations is visible in the KDE plot, and cremation as funerary rite clearly goes out of use. After the early 8th century, cremation burials are absent from the record. As a result of the OxCal modeling, at the current stage we can date the abandonment of the cremation practice in the second half of the 7th century AD: between

661 and 681 AD for the 1-σ probability and between 652 and 695 AD for 2-σ probability (Figure 6).

The use of the inhumation rite follows a reverse trajectory. Until ca. 600 AD the KDE curve related to inhumation burials maintains a neutral trend, suggesting a constant and moderate popularity of this rite during the Late Roman period and the ages immediately afterwards (the so-called migration period). From 600 AD onward, the curve acquires a remarkably positive trend, which persists until the end of the analyzed time span. In other words, the beginning of the general use of inhumation as predominant burial rite starts in present-day Belgium in the course of the 7th century.

DISCUSSION

The KDE-based reconstructions show variations in funerary practices across Belgium between the Mesolithic and the Middle Ages. The comparison between KDE plots representing the use of inhumation and cremation allows to observe changes in funerary practices among local communities and to identify temporal trends in funerary dynamics over 11,000 years.

During the Mesolithic, inhumation is the dominant funerary practice while cremation was only observed in two cases. ^{14}C-dated inhumations appear clustered in the Early Mesolithic, in the time span 9300–7600 BC, with a peak at ca. 8600 BC (Figure 2c). This result confirms the decline in the number of sites from the Early to the Late Mesolithic (Meiklejohn and Babb 2009; Miller et al. 2009; Sergant et al. 2009). In northwestern Belgium, a marked dominance of contexts belonging to Early Mesolithic was observed both from the analysis of excavated archaeological sites and the distribution of ^{14}C dates from salvage excavations. The distribution of these dates also showed a strong concentration between 8700 and 7000 BC, corresponding to the Early Mesolithic and the first part of the Middle Mesolithic (Crombé et al. 2008; Sergant et al. 2009). Among the possible contributing factors causing this decrease in sites is the 8200 cal BP (6200 cal BC) climatic event causing a decrease in temperature in Europe between 8500 and 8100 cal BP (Alley et al. 1997; Von Grafenstein et al. 1998; Barber et al. 1999; Alley and Ágústsdóttir 2005; Matero et al. 2017). However, new hypotheses highlight the resilience in hunter-gatherer societies to climate and environmental change (Crombé et al. 2015; Crombé and Robinson 2017) and consider the possibility of a subsistence specialization and changes in social structure or mobility strategies (Miller et al. 2009; Griffiths and Robinson 2018). The introduction of cremation in northwestern Europe during the Mesolithic was confirmed by other archaeological contexts such as the ^{14}C-dated cremated human remains from Heffingen-"Loschbour", in Luxembourg (Beta-132067, 7960 ± 40 BP; Toussaint et al. 2009; Brou et al. 2015) and those from the Site 21 at Oirschot V in the Netherlands (GrA-13390, 8320 ± 40 BP; Arts and Hoogland 1987; Lanting et al. 2001). The low number of ^{14}C-dated cremation burials for this period, however, limits further interpretation of the results.

The Neolithic does not seem to indicate a shift in funerary practices. Inhumation is still the predominant rite, as shown by the 73 archaeological sites with inhumations compared to the three sites with cremations (Figure 3). The increase in the number of inhumations dating to the Middle Neolithic as shown in Figure 3c, can be linked to the presence of human groups whose material culture belongs to the Michelsberg culture and, in particular, to the Spiere group (Cauwe 2004; Bostyn et al. 2011; Crombé et al. 2011) in the Belgian area. The bias caused by taphonomic degradation, most likely contributed to the positive trend observed in this KDE plot. The peak in inhumation graves observed between ca. 3100–2600 BC (Figure 3c) is determined by ^{14}C dates from funerary contexts located in caves and rock shelters in the Meuse basin in Wallonia. This signals the importance of collective cave burials during the end of the Late and the beginning of the Final Neolithic (Cauwe et al. 2001; Cauwe 2004; Toussaint 2013). The analysis of ^{14}C dates from collective burial caves shows that the depositions are frequently not contemporary, proving a continuous use of these contexts for more than one generation. Therefore, the ^{14}C dates demonstrate that these burials do not correspond to a single depositional event but to a series of events with different calendar ages. This allows to reject the possibility of a bias caused by multiple dates of contemporary individuals in collective burials. The KDE plot for the Neolithic inhumations (Figure 3c), including dates from different individuals buried in different periods, reflects well this situation.

The KDE plots referring to the Metal Ages (Figure 4c–d) show a small number of ^{14}C-dated inhumations and cremations in Early Bronze Age. This can be an effect of the limited archaeological evidence for this period, as demonstrated by the still existing problems in recognising specific types in the material culture of the first phase of the Bronze Age in Belgium (Warmenbol 2004). However, it can be also a consequence of the ploughing activities, which dramatically flattened most of the barrow mounds, destroying the burials and causing a lack of available samples to date. The high diffusion of barrows in Flanders dates to the Early and Middle Bronze Age (Figure 4e), thus proving the existence of funerary structures in this period. In the few cases where some information remained, cremation seemed to be the traditional practice in barrows, and most tombs were quite poor (Bourgeois and Talon 2009: 42). This would imply that the increase of cremations documented at the end of the Middle Bronze Age (Figure 4d) should be dated to an earlier phase. However, due to the lack of reliable archaeological evidence, this hypothesis cannot be confirmed.

The end of the Middle Bronze Age and the beginning of the Late Bronze Age represent a moment of change in funerary dynamics (Figure 4c–d) with a large increase in the number of individuals using cremation. The *floruit* in the use of cremation burials in the Ha A2-B1 phases (Figure 4d) matches the arrival of the first pottery from the *Rhin-Suisse-France orientale* (RSFO) cultural group that was dated to the beginning of Ha A2 phase (ca.1100 BC) (Leclercq 2014). RSFO pottery was found associated with inhumed individuals at the sites of Trou del Leuve at Sinsin and Trou de Han at Han-sur-Lesse (Warmenbol 1988, 1996, 2006, 2013), but also, and mainly, with cremated remains from the sites of Blicquy and Velzeke-Paddestraat (De Mulder et al. 2007). The RSFO influence extended all over Belgium until the northern part of the Scheldt basin. The arrival of new people, objects, and ideas from Central European areas in Belgium, could have promoted the large adoption of (urn) cremations as observed in our results. However, cremations in urns belonging to the “urnfield” tradition were already present, although sporadic, since the Middle Bronze Age B (De Mulder 2019), as recorded at the sites of Kruishoutem “Moerasstraat” (KIA-38496, 3250 ± 40 BP; Deschieter and De Wandel 2010), Aalter “Oostergem” (KIA-40864, 3060 ± 20 BP; Vanhee and De Mulder 2013), Blicquy (KIA-23752; 3185 ± 30 BP; De Mulder et al. 2007) and Tessenderlo “Engsbergen” (KIA-33618, 3210 ± 30 BP; De Mulder 2010).

During the Iron Age the amount of people practicing cremation and inhumation seems to be constant. The Early Iron Age matches the Hallstatt plateau, a flat portion in the IntCal13 calibration curve (Reimer et al. 2013); this implies that dates between 750 and 400 BC are characterized by large timespans when calibrated. Such a bias contributed to the flat shape of the KDE plots for that period (Figure 4c–d).

In the Iron Age, cremation is predominant, with a slow transition from urn cremations towards cremations without urn (Bourgeois 1989). This could partially explain the decrease in the amount of cremations (Figure 4d), determined by the less visibility in the archaeological record of "bonepackgraves" and *Brandgrubengraben* compared to the traditional cremations in urn. This poor knowledge of Late Iron Age burial grounds in Flanders can perhaps be explained by the different burial structures. In the Campine region, for instance, from the Late Iron Age onwards, cremated remains were scattered over the bottom of the grave, e.g. Weelde-Schootseweg (Annaert et al. 2012) and Klein-Ravels (Verhaert et al. 2001/2002). These kinds of burials are not visible anymore due to intensive ploughing activities.

Important transformations in social dynamics occurred during the Bronze-Iron Age transition and along the Iron Age, referring to the cultural and social exchanges among Hallstatt C warrior elites, spreading across Western and Central Europe (Kristiansen 1998, 2009; Milcent 2004; Brun et al. 2009; Schumann and van der Vaart-Verschoof 2017). This is reflected in funerary contexts by the presence of weapons and prestige objects amongst grave goods. It is the case of grave 72 from the site of Neerharen-Rekem "Hangveld" (GrA-17787, 2690 ± 60 BP and GrA-19062, 2670 ± 45 BP), in which the cremated remains of three individuals were deposited together with three bronze swords, three bronze spearheads and two chapes (parts of a scabbard), and grave 122.05 at Hofstade "Kasteelstraat" (RICH-24353, 2784 ± 28 BP; Hiddink 2018) where the urn of a cremation grave contained broken and bent fragments from a bronze sword and a chape (De Mulder 2017; Warmenbol 2017). The centrality of the role of the warrior persists in the Late Iron Age society, as proven by the discoveries of chariot burials dating back to the Hallstatt D-La Tène period in the Ardennes region in southern Belgium, as at the site of Neufchâteau-le Sart "Bourzy" (Cahen-Delhaye 1997).

Among the Romans in Belgium, cremation seems to be the main funerary practice (Figure 5c–d). Roman inhumations and cremations were commonly not ^{14}C dated because of typological dating of grave goods, such as pottery and metal objects, partly explaining the low amount of dates recorded (Figure 5c). This sampling bias is clearly visible in the absence of dated cremations from Wallonia, suggesting limited use of cremation in this region. However, cremations are largely documented in the Walloon region, e.g. at the sites of Biesme Mettet, Bois Saint-Pierre Ellezelles, Beauflot-Pivache Fize-le-Marsal, Pommeroeul and Wanzoul (Van Doorselaer 1964; Brulet 2008; Hanut 2017), contradicting this observation. Future research aims to fill this lacuna.

The Romanization of the Belgian provinces started in the second half of the first century AD, 100 years after the victory of Julius Caesar over the "Belgian" tribes. During the Early and Middle Roman Period, Belgium and, in particular, Flanders underwent intensive socio-economic transformations as shown by the archaeological, historical and palynological data (De Clercq 2009). This period shows an increase in the number of cremation burials. In contrast, in the Late Roman Period the number of cremations decreases (Figure 5d). This is in agreement with the archaeological evidence since Late Roman graves were mostly inhumation graves (Brulet 2008). This period experienced the first contacts with tribes from the other side of the Rhine (second half of the 2nd century AD) leading to a time of socio-economic and political upheaval and decline. Such a climate of instability could have affected the number of funerary contexts recorded.

The resumption of cremations at ca. 400 AD seems to be an indication of arrival of people from northern regions where cremation remained the dominant funerary rite (De Mulder et al. 2012; Annaert et al. 2009; Annaert 2018). The dissolvement of the Roman governance, the regionalization and the arrival of new Germanic settlers give a certain context to this process. The reference to ancestors by the re-use of Bronze-Iron Age funerary structures is a remarkable feature of the burial rite in these centuries (Van Beek and De Mulder 2014). An example is at the site of Beerse "Krommenhof" where four of the Bronze Age barrows were re-used as burial context between approximately 600 and 775 AD (Annaert 2018; Delaruelle et al. 2014). At Borsbeek the re-use of a Late Bronze Age urn in the Merovingian period during the 5th-6th century AD was confirmed by two ^{14}C dates on cremated remains (KIA-37917, 1460 ± 35 BP; KIA-40552, 1465 ± 30 BP; De Mulder et al. 2012).

In the second half of the 7th century AD the cremation rite gradually lost its importance. The explanation for this process is not Christianization as such, since before that period, cremation was used in distinctive Christian burial contexts as was the case elsewhere in Western-Europe (for example the double grave in the Frankfurter dom dated ca. 700–730 AD, containing the bodies of two 4-year-old girls, one inhumed and one cremated—Wamers 2015). The shift towards exclusive inhumation is most likely the result of the stronger organization of the Christian church and the way it implemented a certain orthodoxy in liturgical matters and in afterlife rituals (Gilchrist 2012). More particularly, the rise of church burial grounds and the increasing value of bodily preservation for the *peregrinatio* to the Christian heaven appear to have been of some importance here.

CONCLUSION

Kernel density models are applied to ^{14}C-dated archaeological contexts to reconstruct variations in funerary practices, specifically inhumation and cremation, in the Belgian territory from the Mesolithic to the Middle Ages. As in every kind of research dealing with the analysis of big datasets of ^{14}C-dated archaeological contexts, it is always important to take into account the possibility of sampling and taphonomic biases that can alter the shape of the KDE plots. Comparison with local archaeological narratives provides crucial additional information for the interpretation of KDE plots.

The plots confirm that during the Mesolithic, Neolithic and the Early Bronze Age inhumation was the main funerary practice in the Belgian area. The earliest occurrence of cremation is dated to the Mesolithic period, but its practice remained sporadic until the Metal Ages. Starting from the Middle Bronze Age, cremation became the predominant rite with a high intensity during the Late Bronze Age in correspondence to the "urnfield" phenomenon. During the Iron Age and the Roman period cremation remained the most adopted funerary practice, with a slightly negative trend towards the Late Roman Period. A resumption is documented in the Early Middle Ages, due to the arrival of new people practicing cremation. Cremation was then abandoned in the second half of the 7th century AD. Inhumation, which is characterized by an overall stability until the ca. 600 AD, shows a positive trend from that date, becoming the unique rite used in the Belgian territory during the High Middle Ages.

This study shows the high potentialities of kernel density analyses applied to ^{14}C-dated archaeological contexts as a method to quantify changes in social dynamics in the past, and in particular when comparing continuities and discontinuities in two different proxies. Furthermore, the influence of the calibration bias is less important than in summed calibrated probability distributions. Finally, the obtained values of probability density play an important role in the interpretation of the KDE plots, since they provide information on the intensity and therefore the significance of the observed variations.

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SUPPLEMENTARY MATERIAL

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REFERENCES

Alley RB, Ágústsdóttir AM. 2005. The 8k event: cause and consequences of a major Holocene abrupt climate change. Quaternary Science Reviews 24(10–11):1123–1149.

Alley RB, Mayewski PA, Sowers T, Stuiver M, Taylor KC, Clark PU 1997. Holocene climatic instability—a prominent, widespread event 8200 yr ago. Geology 25(6):483–486.

Annaert R, editor. 2018. Het vroegmiddeleeuwse grafveld van Broechem. Merovingian archaeology in the Low Countries 5. Bonn: Habelt Verlag.

Annaert R, Deforce K, Vandenbruaene M. 2009. The cremation graves at the Broechem cemetery (Belgium, province of Antwerp). In: Panhuysen T, editor. Transformations in north-western Europe (AD 300–1000). Guidebook, 60th Sachsen-symposium 19–23 Sept. 2009, Maastricht. p. 1–28.

Annaert R, Cooremans B, Deforce K, Vandenbruaene M. 2012. Toch Romeinen in de Antwerpse Noorderkempen. Inheems-Romeins grafveldje op een middenbronstijdnecropool in Weelde, ontdekt tijdens de ruilverkavelings-werken Poppel (gem. Ravels, prov. Antwerpen). Relicta. Archeologie, Monumenten- en Land-schapsonderzoek in Vlaanderen 9:7–90.

Annaert R, Boudin M, Deforce K, Ervynck A, Haneca K, Lentacker A, Snoeck C. 2020. Anomalous radiocarbon dates from the Early Medieval cremation graves from Broechem (Flanders, Belgium): reservoir or old wood effects? Radiocarbon 62(2):269–288.

Arts N, Hoogland M. 1987. A Mesolithic settlement area with a human cremation grave at Oirschot V, municipality of Best, the Netherlands. Helinium 28(2):172–189.

Ashmore P. 1999. Radiocarbon dating: avoiding errors by avoiding mixed samples. Antiquity 73(279):124–130.

Barber DC, Dyke A, Hillaire-Marcel C, Jennings AE, Andrews JT, Kerwin MW, Bilodeau G, McNeely R, Southon J, Morehead MD, Gagnon J-M. 1999. Forcing of the cold event of 8,200 years ago by catastrophic drainage of Laurentide lakes. Nature 400:344–348.

Barceló JA, Capuzzo G, Bogdanović I. 2014 Modeling expansive phenomena in early complex societies: the transition from Bronze Iron Age in prehistoric Europe. Journal of Archaeological Method and Theory 21:486–510.

Beex G. 1959. Onderzoek van grafheuvels te Weelde. Archaeologia Belgica 47. Brussels.

Beex G, Roosens H. 1963. Drieperiodenheuvel met klokbekers te Mol. Archaeologia Belgica 72. Brussels.

Bostyn F, Monchablon C, Praud I, Vanmontfort B. 2011. Le Néolithique moyen II dans le sud-ouest du Bassin de l'Escaut : nouveaux éléments dans le groupe de Spiere. In: Bostyn F, Martial E, Praud I, editors. Le Néolithique du nord de la France dans son context européen. Habitat et économie aux 4e et 3e millénaires avat notre ère. Revue archéologique de Picardie. Numéro spécial 28. p. 55–76.

Boudin M, Van Strydonck M, van den Brande T, Synal H-A, Wacker L. 2015. RICH – A new AMS facility at the Royal Institute for Cultural

Heritage, Brussels, Belgium. Nuclear Instruments and Methods in Physics Research B 361:120–123.
Bourgeois J. 1989. Grafrituelen in de ijzertijd in de provincie Oost-Vlaanderen. Nieuwe gegevens uit de opgravingen van Ursel en Kemzeke. In: XLIXe congres van de Federatie van Kringen voor Oudheidkunde en Geschiedenis van België. 18–21 VIII 1988. Handelingen II. Namur. p. 79–92.
Bourgeois J, Cherretté B, Meganck, M. 2001. Kringen voor de doden. Bronstijdgrafheuvels te Oedelem-Wulfsberge (W.-Vl.). Lunula. Archaeologia protohistorica 9:23–27.
Bourgeois J, Talon M. 2009. From Picardy to Flanders: Transmanche connections in the Bronze Age. In: Clark P, editor. Bronze Age connections. Cultural contact in prehistoric Europe. Oxford: Oxbow Books. p. 38–59.
Bowman S. 1990. Radiocarbon dating. London: British Museum.
Braeckman K. 1991. Klokbekermateriaal te Kruishoutem-Kapellekouter (Oost-Vlaanderen), een voorlopig verslag. Notae Praehistoricae 10: 69–74.
Bronk Ramsey C. 2009. Bayesian analysis of radiocarbon dates. Radiocarbon 51(1):337–360.
Bronk Ramsey C. 2017. Methods for summarizing radiocarbon datasets. Radiocarbon 59(6):1 809–1833.
Brou L, Le Brun-Ricalens F, Toussaint M, Spier F. 2015. La plus ancienne « Luxembourgeoise » : la sépulture mésolithique à incineration de Heffingen-« Loschbour » (Grand-Duché de Luxembourg). Archaeologia luxemburgensis 2:14–41.
Brulet R, editor. 2008. Les Romains en Wallonie. Bruxelles: Éditions Racine.
Brun P, Chaume B, Dhennequin L, Quilliec B. 2009. Le passage de l'âge du Bronze à l'âge du Fer … au fil de l'épée. In: Rouliere-Lambert M-J, Daubigney A, Milcent P-Y, Talon M, Vital J, editors. De l'âge du Bronze à l'âge du Fer en France et en Europe occidentale (Xe – VIIe siècle av. J.-C.). La moyenne vallée du Rhône aux âges du Fer, Actes du XXXe colloque international de l'A.F.E.A.F., co-organisé avec l'A.P.R.A.B. (Saint-Romain-en-Gal, 26-28 mai 2006). Dijon. Revue Archéologique de l'Est 27. p. 477–485.
Brun P, Mordant C, editors. 1988. Le groupe Rhin-Suisse-France orientale et la notion de civilization des Champs d'Urnes, Actes du colloque international de Nemours 1986. Mémoires du Musée de Préhistoire d'Ile-de-France 1.
Cahen-Delhaye A. 1997. Nécropole de la Tène à Neufchâteau-Le-Sart. Musées Royaux d'Art et d'Histoire.
Cahen-Delhaye A, Hurt V. 2013. La nécropole de La Tène ancienne à Léglise-Gohimont en Ardenne belge, Études d'archéologie – Artefact 11, Libramont-Treignes.
Cammaert L, Clarys B, Van Assche M, Gailly O, Bloch N, Mathieu S. 1996. Un ensemble funéraire de l'Age du Bronze ancien/moyen à Rebaix « Couture-Saint-Vaast » (Ath, Ht.). Lunula. Archaeologia protohistorica IV: 12–15.
Capuzzo G. 2014. Space-temporal analysis of radiocarbon evidence and associated archaeological record: from Danube to Ebro rivers and from Bronze to Iron Ages [PhD thesis]. Universitat Autònoma de Barcelona.
Capuzzo G, Barceló JA. 2015. Cultural changes in the second millennium BC: a Bayesian examination of radiocarbon evidence from Switzerland and Catalonia. World Archaeology 47:622–641.
Capuzzo G, Zanon M, Dal Corso M, Kirleis W, Barceló JA. 2018. Highly diverse Bronze Age population dynamics in central-southern Europe and their response to regional climatic patterns. PLoS ONE 13(8):e0200709.
Caracuta V, Fiorentino G, Martinelli MC. 2012. Plant remains and AMS: dating climate change in the Aeolian Islands (northeastern Sicily) during the 2nd millennium BC. Radiocarbon 54(3–4):689–700.
Cauwe N. 1998. La Grotte Margaux à Anseremme-Dinant: étude d'une sépulture collective du Mésolithique ancien. ERAUL 59, Liège.
Cauwe N. 2004. Les sépultures collectives néolithiques en grotte du Bassin mosan. Bilan documentaire. Anthropologica et Præhistorica 115:217–224.
Cauwe N, Vander Linden M, Vanmontfort B. 2001. The Middle and Late Neolithic. Anthropologica et Præhistorica 112:77–89.
Cherretté B, Bourgeois J. 2005. Circles for the Dead. From Aerial Photography to Excavation of a Bronze Age Cemetery in Oedelem (West-Flanders, Belgium). In: Bourgeois J, Meganck M, editors. Aerial Photography and Archaeology 2003. A Century of Information. Gent: Academia Press. p. 255–265.
Collet H, Vanmontfort B, Jadin I. avec la collaboration de F. Hubert. 2011. Des pots dans les mines. La céramique Michelsberg des minières et de l'enceinte du site de Spiennes (Hainaut, Belgique). In: Bostyn F, Martial E, Praud I, editors. Le Néolithique du Nord de la France dans son contexte européen : habitat et économie aux 4e et 3e millénaires avant notre ère. Revue Archéologique de Picardie n° spécial 28. p. 167–181.
Contreras D, Meadows J. 2014. Summed radiocarbon calibrations as a population proxy: a critical evaluation using a realistic simulation approach. Journal of Archaeological Science 52:591–608.
Crema ER, Bevan A, Shennan S. 2017. Spatio-temporal approaches to archaeological radio-

carbon dates. Journal of Archaeological Science 87:1–9.
Crombé P, Groenendijk H, Van Strydonck M. 1999. Dating the Mesolithic of the Low Countries: some practical considerations. In: Evin J, Oberlin C, Daugas JP, Salles JF, editors. Actes du colloque "C14 et Archéologie", 1998. Mémoires de la Société Préhistorique Française 26 and Supplément de la revue d'Archéométrie. p. 57–63.
Crombé P, Perdaen Y, Sergant J. 2008. Le Mésolithique ancien dans l'ouest de la Belgique : Quelques réflexions concernant l'occupation du territoire. In: Ducrocq T, Fagnart J-P, Souffi B, Thévenin A, editors. Actes de la table ronde. Le Mésolithique ancien et moyen de la France septentrionale et des pays limitrophes, Amiens 9-10/10/2004. Mémoires de la Société Préhistorique Française. Paris, Société Préhistorique Française.
Crombé P, Robinson E. 2017. Human resilience to Lateglacial climate and environmental change in the Scheldt basin (NW Belgium). Quaternary International 428(B):50–63.
Crombé P, Sergant J, Lombaert L. 2011. L'occupation en région sablonneuse du nord-ouest de la Belgique au IVe et au IIIe millénaires: bilan des recherches récentes en région sablonneuse. In: Bostyn F, Martial E, Praud I, editors. Le Néolithique du Nord de la France dans son contexte européen : habitat et économie aux 4e et 3e millénaires avant notre ère. Revue Archéologique de Picardie n° spécial 28. p. 103–118.
Crombé P, Verhegge J, Deforce K, Meylemans E, Robinson E. 2015. Wetland landscape dynamics, Swifterbant land use systems, and the Mesolithic-Neolithic transition in the southern North Sea basin. Quaternary International 378: 119–133.
De Clercq W. 2009. Locale gemeenschappen in het Imperium Romanum. Transformaties in rurale bewoningsstructuur en materiële cultuur in de landschappen van het noordelijk deel van de civitas Menapiorum (provincie Gallia-Belgica, ca. 100 v. Chr.–400 na Chr.) [PhD thesis]. Ghent University.
De Clercq W, Bastiaens J, Deforce K, Desender K, Ervynck A, Gelorini V, Haneca K, Langohr R, Van Peteghem A. 2004. Waarderend en preventief archeologisch onderzoek op de Axxes-locatie te Merelbeke (prov. Oost-Vlaanderen): een grafheuvel uit de Bronstijd en een nederzetting uit de Romeinse periode. Archeologie in Vlaanderen 8/2001/2002: 123–164.
De Clercq W, Van Strydonck M. 2002. Final report from the rescue excavation at the Aquafin RWZI plant Deinze (prov. East-Flanders, Belgium): radiocarbon dates and interpretation. Lunula. Archaeologia protohistorica 10:3–6.
De Laet S, Rogge M. 1972. Une tombe à incinération de la civilisation aux gobelets campaniformes trouvée à Kruishoutem (Flandre orientale). Helinium 12:209–224.
Delaruelle S, de Smaele B, Thijs C, Verdegem S, Scheltjens S, Van Doninck J. 2014. Barrows and ancestors, Neolithic, Middle Bronze Age and Merovingian burials at Beerse "Krommenhof" (province of Antwerp, Belgium). In: Cahen-Delhaye A, De Mulder G, editors. Des espaces aux esprits. L'organisation de la mort aux âges des métaux dans le Nord-Ouest de l'Europe. Études et documents. Archéologie 32. Namur. p. 61–67.
De Mulder G. 2010. Old bones, new ideas: ^{14}C-dating of cremated bones from Late Bronze Age and Early Iron Age urnfield cemeteries in Flanders, Belgium. In: Sterry M, Tullett A, Ray N, editors. In search of the Iron Age. Proceedings of the Iron Age Research Student Seminar 2008, University of Leicester. Leicester Archaeology Monograph 18. p. 217–243.
De Mulder G. 2014. Les rites funéraires dans le nord du bassin de l'Escaut à l'âge du Bronze final et au premier âge du Fer. In: Cahen-Delhaye A, De Mulder G, editors. Des espaces aux esprits. L'organisation de la mort aux âges des métaux dans le Nord-Ouest de l'Europe. Études et documents. Archéologie 32. Namur. p. 29–52.
De Mulder G. 2017. The early Hallstatt elite burials in Belgium. An analysis of the funerary ritual. In: Schumann R, van der Vaart-Verschoof S, editors. 2017. Connecting Elites and Regions. Leiden: Sidestone Press. p. 329–347.
De Mulder G. 2019. Funeraire veranderingen tijdens de midden bronstijd. De opkomst van het vlakgraf in Vlaanderen (België). Lunula. Archaeologia protohistorica XXVII:29–34.
De Mulder G, Van Strydonck M, Boudin M, Leclercq W, Paridaens N, Warmenbol E. 2007. Re–evaluation of the Late Bronze Age and Early Iron Age chronology of the western Belgian urnfields based on ^{14}C Dating of Cremated Bones. Radiocarbon 49(2):499–514.
De Mulder G, Leclercq W, Van Strydonck M. 2008. Influence from the 'Group Rhin-Suisse-France orientale' on the pottery from the Late Bronze Age Urnfields in Western Belgium. A confrontation between pottery forming technology, ^{14}C-dates and typo-chronology. In: Berg I, editor. Breaking the Mould: Challenging the Past through Pottery. Oxford: BAR International Series 1861. p. 105–115.
De Mulder G, Van Strydonck M, Boudin M. 2009. The impact of cremated bone dating on the archaeological chronology of the Low Countries. Radiocarbon 51(2):579–600.
De Mulder G, Van Strydonck M, Annaert R, Boudin M. 2012. A Merovingian surprise: early medieval radiocarbon dates on cremated bones (Borsbeek, Belgium). Radiocarbon 55:581–588.
De Mulder G, Van Strydonck M, De Clercq W. 2013. ^{14}C dating of "Brandgrubengräber" from the

Bronze age to the Roman period in western Flanders (Belgium). Radiocarbon 55(2–3): 1233–1245.
De Mulder G, Leclercq W, Van Strydonk M, Warmenbol E. 2016. Les débuts du Bronze final en Belgique et dans le Sud des Pays-Bas : ruptures et continuités. In: Lachenal T, Mordant C, Nicolas T, Véber C, editors. Le Bronze moyen et l'origine du Bronze final en Europe occidentale, de la Méditerranée aux pays nordiques (XVIIe –XIIIe siècle av. J.-C.), Colloque APRAB "Bronze 2014", Strasbourg 17 au 20 juin 2014, Mémoires d'Archéologie du Grand-Est 1, Strasbourg. p. 236–268.
De Reu J. 2012. Land of the Dead. A comprehensive study of the Bronze Age burial landscape in north-western Belgium [PhD thesis]. Ghent University.
De Reu J. 2014. The Northwest Belgian Bronze Age barrow in context: a review of the ^{14}C chronology from the Late Neolithic to Bronze Age. Radiocarbon 56(2):479–488.
De Reu J, Bourgeois J. 2013. Bronze Age barrow research in Sandy Flanders (NW Belgium): an overview. In: Fontijn D, Louwen AJ, van der Vaart S, Wentink K, editors. 2013. Beyond Barrows. Current research on the structuration and perception of the prehistoric landscape through monuments. Leiden: Sidestone Press. p. 155–194.
Demeyere F, Bourgeois J. 2005. Noodopgraving te Waardamme (Oostkamp, West-Vlaanderen): grafheuvels uit de Bronstijd en een bewoning uit de vroege IJzertijd. Lunula. Archaeologia protohistorica 1:25–30.
Deschieter J, De Wandel T. 2010. Het archeologisch noodonderzoek in de Moerasstraat te Kruishoutem in 2007. Velzeke: Archeologisch Museum Velzeke, Provincie Oost-Vlaanderen.
Ervynck A, Boudin M, van den Brande T, Van Strydonck M. 2014. Dating human remains from the historical period in Belgium: diet changes and the impact of marine and freshwater reservoir effects. Radiocarbon 56(2): 779–788.
Estévez J, Villagran XS, Balbo AL, Hardy K. 2014. Microtaphonomy in archaeological sites: The use of soil micromorphology to better understand bone taphonomy in archaeological contexts. Quaternary International 330:3–9.
Falkenstein F. 2012. The Development of Burial Rites from the Tumulus to the Urnfield Culture in Southern Central Europe. In: Ancestral Landscape. Burial mounds in the Copper and Bronze Ages (Central and Eastern Europe – Balkans – Adriatic – Aegean, 4th–2nd millennium B.C.). Proceedings of the International Conference held in Udine, May 15th–18th 2008. Lyon : Maison de l'Orient et de la Méditerranée Jean Pouilloux. p. 329–340.
Feeser I, Dörfler W, Kneisel J, Hinz M, Dreibrodt S. 2019. Human impact and population dynamics in the Neolithic and Bronze Age: Multi-proxy evidence from north-western Central Europe. The Holocene.
Fyfe RM., Woodbridge J, Palmisano A, Bevan A, Shennan S, Burjachs F, Legarra Herrero B, García Puchol O, Carrión J-S, Revelles J, Roberts CN. 2019. Prehistoric palaeodemographics and regional land cover change in eastern Iberia. The Holocene 29(5):799–815.
Garland AN, Janaway RC. 1989. The taphonomy of inhumation burials. In: Roberts C, Lee F, Bintliff J, editors. Burial archaeology: current research, methods and developments. BAR British Series 211:15–37.
Gautier A, Warmenbol E. 2019. Nouvelles données sur la Grotte de Han (Rochefort, prov. de Namur, Belgique): ossements humains et animaux du Néolithique récent aux Temps modernes. Anthropologica et Præhistorica 127/2016:31–54.
Gilchrist R. 2012. Medieval life: archaeology and the life course. Boydell and Brewer, Woodbridge.
Gilot E. 1997. Index général des dates Lv. Laboratoire du carbone 14 de Louvain/Louvain-la-Neuve. Studia Praehistorica Belgica 7.
Griffiths S, Robinson E. 2018. The 8.2 ka BP Holocene climate change event and human population resilience in northwest Atlantic Europe. Quaternary International 465: 251–257.
Hanut F, editor. 2017. Du bûcher à la tombe. Diversité et évolution des pratiques funéraires dans les nécropoles à crémation de la période gallo-romaine en Gaule septentrionale. Études et Documents Archéologie 36. Namur.
Hiddink H. 2018. Archeologisch onderzoek aan de Kasteelstraat te Hofstade (stad Aalst, Oost-Vlaanderen). Een urnenveld uit de Late Bronstijd/Vroege IJzertijd, graven uit de Romeinse tijd en bewoningssporen uit de Midden Ijzertijd – Romeinse tijd. Zuidnederlandse Archeologische Rapporten 75. Amsterdam: VUhbs archeologie/ Vrije Universiteit.
Hoorne J, Sergant J, Bartholomieux B, Boudin M, De Mulder G, Van Strydonck M. 2008. Een klokbekergraf te Sint-Denijs-Westrem - Flanders Expo (Gent, provincie Oost- Vlaanderen). Notae Praehistoricae 28:99–108.
Hoorne J, Sergant J, Boudin M, Taelman E, Vanhee D, Van Strydonck M. 2009. Een finaalneolitische? Potbeker op het Aquafintracé te Hansbeke (gemeente Nevele, provincie Oost-Vlaanderen). Notae Praehistoricae 29:81–5.
Hüls CM, Erlenkeuser H, Nadeau M-J, Grootes PM, Andersen N. 2010. Experimental study on the origin of cremated bone apatite carbon. Radiocarbon 52(2–3):587–599.
Jasinski M, Warmenbol E. 2017. The Trou de Han in Han-sur-Lesse, Belgium. In: Campbell B, editor.

The archaeology of underwater caves. Highfield Press Southampton. p. 163–182.
Kendall C, Høier Eriksen AM, Kontopoulos I, Collins MJ, Turner-Walkere G. 2018. Diagenesis of archaeological bone and tooth. Palaeogeography, Palaeoclimatology, Palaeoecology 491:21–37.
Kristiansen K. 1998. Europe before history. Cambridge.
Kristiansen K. 2009. Premières aristocraties. Pouvoir et métal à l'âge du Bronze. In: Demoule J-P, editor. L'Europe. Un continent redécouvert par l'archéologie. Paris: Gallimard. p. 73–83.
Lanting JN, Brindley AL. 1998. Dating cremated bone: the dawn of a new era. Journal of Irish Archaeology 9:1–7.
Lanting JN, Aerts-Bijma AT, van der Plicht J. 2001. Dating of cremated bones. In: Proceedings of the 17th International ^{14}C Conference. Radiocarbon 43(2A):249–254.
Lanting JN, van der Waals JD. 1976. Beaker Culture relations in the Lower Rhine Basin. In: Lanting JN, van der Waals JD, editors. Glockenbecher Symposion. Oberried 1974. Haarlem. p. 2–80.
Lavachery P, Collet H, Toussaint M, Woodbury M. 2015. Mons/Spiennes : fouille du puits d'extraction de silex ST 6 à « Petit-Spiennes ». Chronique de l'Archéologie wallonne 23:88–90.
Lebon M, Reiche I, Bahain J-J, Chadefaux C, Moigne A-M, Fröhlich F, Sémah F, Schwarcz HP, Falguères C. 2010. New parameters for the characterization of diagenetic alterations and heat-induced changes of fossil bone mineral using Fourier transform infrared spectrometry. Journal of Archaeological Science 37(9): 2265–2276.
Leclercq W. 2014. Les nécropoles de l'âge du Bronze final entre les bassins de l'Escaut et de la Meuse moyenne : approche chronologique et culturelle de leur occupation. In: Cahen-Delhaye A, De Mulder G, editors. Des espaces aux esprits. L'organisation de la mort aux âges des métaux dans le Nord-Ouest de l'Europe. Études et documents. Archéologie 32. Namur. p. 15–27.
Loftus E, Mitchell PJ, Bronk Ramsey C. 2019. An archaeological radiocarbon database for southern Africa. Antiquity 93(370):870–885.
Loveluck C. 2013. Northwest Europe in the Early Middle Ages, c. AD 600–1150. Cambridge: Cambridge University Press.
Matero ISO, Gregoire LJ, Ivanovic RF. 2017. The 8.2 ka cooling event caused by Laurentide ice saddle collapse. Earth and Planetary Science Letters 473:205–14.
Mazzucco N, Gibaja J, Capuzzo G, Gassin B, Mineo M, Ibáñez JJ. 2020. Migration, adaptation, innovation: the spread of the Neolithic harvesting technologies in the Mediterranean. PLoS ONE 15(4):e0232455.
McLaughlin TR. 2019. On Applications of Space–Time Modelling with Open-Source ^{14}C Age Calibration. Journal of Archaeological Method and Theory 26:479–501.
Meiklejohn C, Babb J. 2009. Issues in burial chronology in the Mesolithic of northwestern Europe. In: Crombé P, Van Strydonck M, Serant J, Boudin M, Bats M, editors. Chronology and evolution within the Mesolithic of north-west Europe: proceedings of an international meeting, Brussels, May 30th–June 1st 2007. p. 217–238.
Meiklejohn C, Miller R, Toussaint M. 2014. Radiocarbon dating of human remains in Belgium and Luxembourg. Mesolithic Miscellany 22(2):10–39.
Milcent P-Y. 2004. Le premier âge du Fer en France centrale. Mémoire de la Société Préhistorique Française XXXIV. Paris.
Miller R, Stewart J, Zwyns N, Otte M. 2009. The stratified Early to Late Mesolithic sequence at Trou Al'Wesse (Modave,Belgium). In: Crombé P, Van Strydonck M, Serant J, Boudin M, Bats M, editors. Chronology and evolution within the Mesolithic of North-West Europe: Proceedings of an international meeting, Brussels, May 30th–June 1st 2007. p. 277–296.
Morell B. 2019. Chronology as a means of social interpretation: the funerary contexts of the north-east of the Iberian Peninsula in the period between the end of the 5th and the beginning of the 4th millennium cal. BC [PhD thesis]. Universitat Autònoma de Barcelona.
Nadeau M-J, Grootes PM, Schliecher M, Hasselberg P, Rieck A, Bitterling M. 1998. Sample throughput and data quality at the Leibniz-Labor AMS facility. Radiocarbon 40(1):239–245.
Nafte M. 2000. Flesh and Bone: An Introduction to Forensic Anthropology. Durham, NC: Carolina Academic Press.
Nielsen-Marsh CM, Smith CI, Jans MME, Nord A, Kars H, Collins MJ. 2007. Bone diagenesis in the European Holocene II: taphonomic and environmental considerations. Journal of Archaeological Science 34(9):1523–1531.
Olsen J, Heinemeier J, Bennike P, Krause C, Hornstrup KM, Thrane H. 2008. Characterisation and blind testing of radiocarbon dating of cremated bone. Journal of Archaeological Science 35(3): 791–800.
Olsen J, Heinemeier J, Hornstrup KM, Bennike P, Thrane H. 2012. "Old wood" effect in radiocarbon dating of prehistoric cremated bones? Journal of Archaeological Science 40(1):30–34.
Otte M, Straus LG., editors. 1997. La Grotte du Bois Laiterie. Récolonisation Magdalénienne de la Belgique. ERAUL 80, Liège.
Pede R, Clement C, De Cleer S, Guillaume V, Cherreté B. 2015. Ronse De Stadstuin. Archeologisch onderzoek. Solva archeologie rapport 20. Erpe-Mere.
Pleuger E, Paridaens N, Gillet E, Van Assche M. 2005. Une fosse Mésolithique découverte à

Leuze-en Hainaut/Blicquy « Ville d'Anderlecht » (Hainaut) lors de la campagne de fouille 2003. Amphora 83:19–24.
Polet C, Cauwe N. 2007. Étude anthropologique des sépultures préhistoriques de l'abri des Autours (Province de Namur, Belgique). Anthropologica et Præhistorica 118:87–126.
Polet C, Warmenbol E, Boudin M, Goffette Q. 2017. Étude anthropologique des restes humains (Bronze final) de la Grotte de On sous Jemelle (prov. de Namur, Belgique). Lunula. Archaeologia protohistorica XXV:73–78.
Quintelier K., Watzeels S. 2018. Analysis of the human cremated remains and interpretation of the funerary rites at the Merovingian cemetery of Broechem, Antwerp (Belgium). In: Annaert R, editor. Het vroegmiddeleeuwse grafveld van Broechem. Merovingian Archaeology in the Low Countries 5. Bonn: Habelt Verlag. p. 188–95.
Reimer PJ, Bard E, Bayliss A, Beck JW, Blackwell PG, Bronk Ramsey C, Buck CE, Cheng H, Edwards RL, Friedrich M, Grootes PM, Guilderson TP, Haflidason H, Hajdas I, Hatté C, Heaton TJ, Hoffmann DL, Hogg AG, Hughen KA, Kaiser KF, Kromer B, Manning SW, Niu M, Reimer RW, Richards DA, Scott EM, Southon JR, Staff RA, Turney CSM, van der Plicht J. 2013. IntCal13 and Marine13 radiocarbon age calibration curves, 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887.
Schiffer MB. 1986. Radiocarbon dating and the "old wood" problem: the case of the Hohokam chronology. Journal of Archaeological Science 13(1):13–30.
Schmid C. 2019. Evaluating Cultural Transmission in Bronze Age burial rites of Central, Northern and Northwestern Europe using radiocarbon data. Adaptive Behaviour.
Schumann R, van der Vaart-Verschoof S, editors. 2017. Connecting elites and regions. Leiden: Sidestone Press.
Sergant J, Crombé P, Perdaen Y. 2009. Mesolithic territories and land-use systems in north-western Belgium. In: McCartan S, Schulting R, Warren G, Woodman P, editors. An offprint from Mesolithic Horizons Papers presented at the Seventh International Conference on the Mesolithic in Europe, Belfast 2005. Oxbow Books. p. 277–281.
Sergant J, Vandendriessche H, Noens G, Cruz F, Allemeersch L, Aluwé K, Jacops J, Wuyts F, Windey S, Rozek J, Depaepe I, Herremans D, Laloo P, Crombé P. 2016. Opgraving van een mesolithische wetlandsite te Kerkhove 'Stuw' (Avelgem, West-Vlaanderen, BE). Eerste resultaten. Notae Praehistoricae 36:47–57.
Shennan S, Downey SS, Timpson A, Edinborough K, Colledge S, Kerig T, Manning K, Thomas MG. 2013. Regional population collapse followed initial agriculture booms in mid-Holocene Europe. Nature Communications 4:2486.
Snoeck C, Brock F, Schulting RJ. 2014a. Carbon exchanges between bone apatite and fuels during cremation: impact on radiocarbon dates. Radiocarbon 56(2):591–602.
Snoeck C, Lee-Thorp JA, Schulting RJ. 2014b. From bone to ash: compositional and structural studies in burned modern and archaeological bone. Palaeogeography, Palaeoclimatology, Palaeoecology 416:55–68.
Snoeck C, Schulting RJ, Lee-Thorp JA, Lebon M, Zazzo A. 2016. Impact of heating conditions on the carbon and oxygen isotope composition of calcined bone. Journal of Archaeological Science 65:32–43.
Stiner MC, Kuhn SL, Weiner S, Bar-Yosef O. 1995. Differential burning, recrystallization, and fragmentation of archaeological bone. Journal of Archeological Science 22(2):223–237.
Surabian D. 2012. Preservation of buried human remains in soil. U.S. Department of agriculture, Natural Resources Conservation Service. Connecticut.
Theuws F. 2004. Exchange, religion, identity and central places in the early Middle Ages. Archaeological Dialogues 10(2):121–138.
Toussaint M, editor. 2003. Le « champ mégalithique de Wéris ». Fouilles de 1979 à 2001. Volume 1. Contexte archéologique et géologique. Études et Documents Archéologie 9. Namur.
Toussaint M. 2013. Transitions, ruptures et continuité dans les pratiques sépulcrales préhistoriques du karst mosan belge et de ses abords. In: Jaubert J, Fourment N, Depaepe P, editors. Transitions, ruptures et continuité en Prehistoire. Actes du XXVIIe Congrès préhistorique de France, Bordeaux/Les Eyzies, 31 mai–5 juin 2010. p. 183–200.
Toussaint M, Becker A. 1993. Yvoir/Godinne: abri sous roche de "Chauveau". Chronique de l'Archéologie wallonne 1:102.
Toussaint M, Collet H, Vander Linden M. 1997. Découverte d'un squelette humain dans le puits de mine néolithique ST 11 de Petit-Spienne (Hainaut). Notae Praehistoricae 17:213–219.
Toussaint M, Pirson S, Jadin I. 2005. L'allée couverte de Lamsoul à Jemelle-Rochefort (prov. de Namur). Campagne de fouilles de 2005. Notae Praehistoricae 25:179–185.
Toussaint M, Brou L, Le Brun-Ricalens F, Spier F. 2009. The Mesolithic site of Heffingen-Loschbour (Grand Duchy of Luxembourg). A yet Undescribed Human Cremation Possibly from the Rhine-Meuse-Schelde Culture: Anthropological, Radiometric and Archaeological Implications. In: Crombé P, Van Strydonk M, Sergant J, Boudin M, Bats M, editors. Chronology and evolution within the Mesolithic of north-west Europe. Cambridge: Cambridge Scholars Publishing. p. 239–260.
Tys D. 2012. Beyond migration and ethnicity? Introduction to the theme of "The very beginning

of Europe? Cultural and Social Dimensions of Early Medieval Migration and Colonisation (5th–8th centuries)". In: Annaert R, De Groote K, Hollevoet Y, Theuws F, Tys D, Verslype L, editors. The very beginning of Europe? Cultural and Social Dimensions of Early-Medieval Migration and Colonisation (5th–8th century). Brussels. p. 21–26.

Van Beek R, De Mulder G. 2014. Circles, Cycles and Ancestral Connotations. The Long-term History and Perception of Late Prehistoric Barrows and Urnfields in Flanders (Belgium). Proceedings of the Prehistoric Society 80:299–326.

Van der Borg K, Alderliesten C, Haitjema H, Hut G, Van Zwol NA. 1984. The Utrecht accelerator facility for precision dating with radionuclides. Nuclear Instruments and Methods in Physics Research Section B: Beam. Interactions with Materials and Atoms 5(2):150–154.

Van der Borg K, Alderliesten C, Houston CM, De Jong AFM, Van Zwol NA. 1987. Accelerator mass spectrometry with ^{14}C and ^{10}Be in Utrecht. Nuclear Instruments and Methods in Physics Research Section B: Beam. Interactions with Materials and Atoms 29 (1–2):143–145.

Van der Plicht J. 2004. Radiocarbon, the calibration curve and Scythian chronology. In: Marian Scott E, Alekseev AY, Zaitseva G, editors. Impact of the environment on human migration in Eurasia. NATO Science Series IV, Earth and Environmental Sciences 42. Springer: Dordrecht. p. 45–61.

Van Doorselaer A. 1964. Repertorium van de begraafplaatsen uit de Romeinse tijd in Noord-Gallië. Répertoire des nécropoles d'époque romaine en Gaule septentrionale. Repertorium der römerzeitliche Gräber in Nord-Galliën, 1, België, Belgique, Belgien; Deutschland, France, Grand-Duché de Luxembourg, Nederland. Brussels.

Vanhee D, De Mulder G. 2013. Een eenzame kuil met aardewerk uit de late bronstijd-vroege ijzertijd te Aalter/Drogenbroodstraat (prov. Oost-Vlaanderen, België). Lunula. Archaeologia protohistorica XXI:71–76.

Van Impe L, Beex G. 1977. Grafheuvels uit de Vroege en Midden Bronstijd te Weelde. Archaeologia Belgica 193. Brussels.

Van Strydonck M, Crombé P, Maes A. 2001. The Site of Verrebroek 'Dok' and its contribution to the absolute dating of the Mesolithic in the Low Countries. Radiocarbon 43(2B):997–1005.

Van Strydonck M, Boudin M, Hoefkens M, De Mulder G. 2005. ^{14}C-dating of cremated bones, why does it work? Lunula. Archaeologia protohistorica XIII:3–10.

Van Strydonck M, Boudin M, De Mulder G. 2010. The carbon origin of structural carbonate in bone apatite of cremated bones. Radiocarbon 52(2):578–586.

Van Strydonck M, Decq L, Van den Brande T, Boudin M, Ramis D, Borms H, De Mulder G. 2015. The protohistoric 'quicklime burials' from the Balearic Islands: cremation or inhumation. International Journal of Osteoarchaeology 25(4): 392–400.

Veldman H, Geerts R, Hazen P, van der Velde H, editors. 2012. Aan de rand van de Romeinse stad: Atuatuca Tungrorum. Een archeologische opgraving aan de Beukenbergweg in Tongeren. ADC monografie 16.

Verhaert A, Annaert R, Langohr R, Cooremans B, Gelorini V, Bastiaens J, Deforce K, Ervynck A, Desender K. 2001–2002. Een inheems-Romeinse begraafplaats te Klein-Ravels (gem. Ravels, prov. Antwerpen). Archeologie in Vlaanderen 8:165–218.

Verhegge J. 2015. Spatial and chronological prehistoric landscape reconstruction using geoarchaeological methods in the lower Scheldt floodplain (NW Belgium) [PhD thesis]. Ghent University.

Verhegge J, Missiaen T, Van Strydonck M, Crombé P. 2014. Chronology of wetland hydrological dynamics and the Mesolithic-Neolithic Transition along the Lower Scheldt: a Bayesian approach. Radiocarbon 56(2):883–898.

Verhegge J, Missiaen T, Crombé P. 2016. Exploring integrated geophysics and geotechnics as a Paleolandscape reconstruction tool: archaeological prospection of (prehistoric) sites buried deeply below the Scheldt Polders (NW Belgium). Archaeological Prospection 23:125–145.

Von Grafenstein U, Erlenkeuser H, Müller J, Jouzel J, Johnsen S. 1998. The cold event 8200 years ago documented in oxygen isotope records of precipitation in Europe and Greenland. Climate Dynamics 14:73–81.

Vrielynck O. 1999. La chronologie de la préhistoire en Belgique. Inventaire des datations absolues. Mémoire 8, Société Wallonne de Palethnologie. Liège.

Wamers E. 2015. Franconofurd 2. Das bi-rituelle Kinderdoppelgrab der späten Merowingerzeit unter der Frankfurter Bartholomäuskirche («Dom»). Schriften des Archäologischen Museums Frankfurt 22/2. Frankfurt.

Warmenbol E. 1988. Le groupe Rhin-Suisse-France orientale et les grottes sépulcrales du Bronze final en Haute Belgique. In: Brun P, Mordant C, editors. Le groupe Rhin-Suisse-France oriëntale et la notion de la civilisation des Champs d'Urnes. Mémoires du Musée de Préhistorie d'Ile-de-France 1. Nemours: Editions A.P.R.A. I.F. p. 153–158.

Warmenbol E. 1996. L'or, la mort et les Hyperboréens. La bouche des Enfers ou le Trou de Han à Han-sur-Lesse. In: Archäologische Forschungen zum Kultgeschehen in der jüngeren Bronzezeit und frühen Eisenzeit Alteuropas.

Ergebnisse eines Kolloquiums in Regensburg 4–7 Oktober 1993. Bonn: Rudolf Habelt GmbH. p. 203–234.

Warmenbol E. 2004. Le début des âges des Métaux en Belgique. Anthropologica et Præhistorica 115:27–48.

Warmenbol E. 2006. Le Trou del Leuve à Sinsin. In: L'archéologie à l'Université Libre de Bruxelles (2001–2005), Matériaux pour une histoire des milieux et des pratiques humaines. CReA: Etudes d'archéologie 1. Bruxelles. p. 135–141.

Warmenbol E. 2013. Le deuxième Âge du Fer (fin Ve-début I er s. avant notre ère) dans la grotte de Han (commune de Rochefort, province de Namur, Belgique). Revue du Nord 403:91–112.

Warmenbol E. 2017. The Early Iron Age in Belgium. Earth and fire, and also water. In: Schumann R, van der Vaart-Verschoof S, editors. 2017. Connecting Elites and Regions. Leiden: Sidestone Press. p. 201–219.

Williams AN. 2012. The use of summed radiocarbon probability distributions in archaeology: a review of methods. Journal of Archaeological Science 39(3):578–589.

Zazzo A, Saliège J-F. 2011. Radiocarbon dating of biological apatites: a review. Palaeogeography, Palaeoclimatology, Palaeoecology 310(1–2):52–61.

Zazzo A, Saliège J-F, Person A, Boucher H. 2009. Radiocarbon dating of calcined bones: Where does the carbon come from? Radiocarbon 51(2): 601–611.

Zazzo A, Saliège J-F, Lebon M, Lepetz S, Moreau C. 2012. Radiocarbon dating of calcined bones: insights from combustion experiments under natural conditions. Radiocarbon 54(3–4):855–866.