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The radiocarbon chronology of *tholos*-type megalithic tombs in Iberia: exploring diverse social trajectories*

La cronología radiocarbónica de las sepulturas tipo tholos *en la península ibérica: explorando diversas trayectorias sociales*

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ABSTRACT

Thanks to recent radiocarbon dating developments, there is now a robust and reliable radiocarbon series for exploring one of the most characteristic kinds of megalithic monument in Iberia, the *tholos*-type tomb. The new series of 193 dates has been taken from 42 monuments spread across the south of Spain and central and southern Portugal. This chronological series has been analysed using statistical models and spatial analytical tools. The results have led us to four main conclusions: i) the *tholos*-type tombs appeared for the first time in southeastern Iberia around the 32nd century cal BC as an independent development; ii) from that region they progressively spread out to reach their maximum expansion in the 29th century cal BC; iii) *Tholoi* also differ regionally in their periods of use: long periods of mortuary activity in the southeast versus short periods in the southwest; and iv) from 2200 cal BC onwards funerary rituals were restricted to occasional reuse practices except in the southeast where two pulses of mortuary activity can be found in the 19th and 14th centuries cal BC. This regional variability indicates that there were different social trajectories in the two main focuses of *tholos*-type tombs, southeastern and southwestern Iberia.

RESUMEN

Gracias al reciente desarrollo de la cronología radiocarbónica, por primera vez existe una serie de dataciones robusta y fiable para analizar uno de los tipos de monumentos megalíticos más característicos de la península ibérica, las sepulturas tipo tholos*. Una nueva serie de 193 fechas pertenecientes a 42 sepulturas distribuidas por el sur de España y el centro y sur de Portugal ha sido analizada utilizando modelos estadísticos y herramientas de análisis espacial. Los resultados permiten establecer cuatro conclusiones principales: i) las tumbas tipo* tholos *aparecieron por primera vez en el sureste de Iberia alrededor del siglo XXXII cal BC como un desarrollo independiente; ii) a partir de esa región se fueron extendiendo progresivamente hasta alcanzar su máxima expansión en el siglo XXIX cal BC; iii) los* tholoi *también difieren regionalmente en sus períodos de uso: largos periodos de actividad mortuoria en el sureste versus cortos períodos en el suroeste; y iv) a partir del 2200 cal BC, la actividad funeraria quedó restringida a prácticas ocasionales de reutilización, excepto en el sureste donde se documentan dos periodos de intensa actividad mortuoria en los siglos XIX y XIV cal BC respectivamente. Esta variabilidad regional enfatizaría diferentes trayectorias sociales para los dos focos principales de tumbas tipo* tholos*, las regiones del sureste y suroeste de la península ibérica.*

Key words: radiocarbon chronology; Bayesian modelling; Kernel density estimation; spatial analysis; megalithic phenomenon; Iberian peninsula.

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Palabras clave: *cronología radiocarbónica; modelado bayesiano; estimación kernel de la densidad; análisis espacial; fenómeno megalítico; península ibérica*.

1. INTRODUCTION

Tholoi are one of the most distinctive types of megalithic monument in Iberia. They are tombs characterised by a false dome constructed by the superposition of successively smaller rings of stones. The roofing system, together with the use of masonry, clearly reveals a different monumental concept distinct from the massive appearance of the dolmens. These architectural features were associated with the Aegean *tholoi* that were immediately considered to be their prototypes, even adopting the name (Childe 1932; Daniel 1941; Leisner and Leisner 1943; Almagro and Arribas 1963). The colonial theory was the main explanation for *tholos* until the development of radiocarbon chronology in the 1960s, when these monuments were revealed to have earlier dates than their supposed prototypes in the eastern Mediterranean (Renfrew 1967, 1973). From the 1970s onwards, these megalithic monuments were included in new narratives based mainly on functionalist and materialist approaches that agreed on an evolutionary perspective in which social complexity emerged in Iberia as a locally-based development (Gilman 1975, 1981; Chapman 1977, 1978, 1981; Ramos Millán 1981; Mathers 1984; among others). Within this framework, *tholoi* have retained their designation in the archaeological literature, although without their previous diffusionist meanings.

In spite of its importance in the new social narratives, radiocarbon chronology has not been a major concern until very recently. This is the case, for instance, of southeastern Iberia, for which there were only 5 radiocarbon dates for *tholos*-type tombs up to 2012 (Aranda Jiménez 2013). This situation has changed dramatically in recent years. Different radiocarbon programmes have substantially improved our understanding of the chronological framework in the different Iberian regions. This is the case of the Alentejo in Portugal, where a large radiocarbon series has been obtained for Perdigões (Tombs 1, 2 and 4) (Valera *et al.* 2014; Valera 2020), Centirã 2 (Robles Henriques *et al.* 2013) and Cardim 6 (Valera *et al.* 2019). In southwestern Spain, radiocarbon dating efforts have focused on the Montelirio *tholos* (García Sanjuán *et al.* 2018), and in southeastern Iberia on the El Barranquete, Los Millares and Mojácar megalithic cemeteries (Aranda Jiménez and Lozano Medina 2014; Aranda Jiménez *et al.* 2018a, 2020a, 2021; Lozano Medina and Aranda Jiménez 2017, 2018; Molina *et al.* 2020) (Fig. 1). For the latter region, in just eight years the known radiocarbon measurements have increased from 5 in 2012 to the 108 dates currently available.

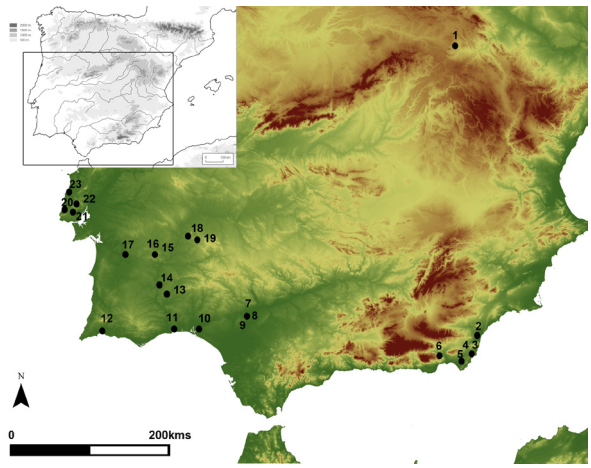

Fig. 1. Map showing the location of *tholos*-type tombs and cemeteries with radiocarbon dates in Iberia. 1 La Sima II (Miño de Medinaceli, Soria); 2 La Encantada (Cuevas de Almanzora, Almería); 3 Loma del Campo 2 (Mojácar, Almería); 4 Loma Belmonte (Mojácar, Almería); 5 Barranquete (Níjar, Almería); 6 Los Millares (Santa Fe de Mondújar, Almería); 7 Las Pastora (Valencina de la Concepción, Sevilla); 8 Estructura 1042-49 (Valencina de la Concepción, Sevilla); 9 Motenlirio (Valencina de la Concepción, Sevilla); 10 La Orden-El Seminario (Huelva, Huelva); 11 Castro Marim (Castro Marim, Faro); 12 Alcalar (Portimão, Faro); 13 Monte da Velha (Serpa, Beja); 14 Centirã 2 (Serpa, Beja); 15 Olival da Pega 2 (Reguengos de Monsaraz, Évora); 16 Perdigões (Reguengos de Monsaraz, Évora); 17 Cardim 6 (Ferreira do Alentejo, Beja); 18 La Pijotilla (Solana de los Barros, Badajoz); 19 Huerta Montero (Almendralejo, Badajoz); 20 Agualva (Sintra, Lisboa); 21 Samarra (Sintra, Lisboa); 22 Tituaria (Mafra, Lisboa); 23 Paimogo 1 (Lourinhã, Lisboa). Base map modified from CGIAR-CSI SRTM 90m 53 Digital Elevation Data (http://srtm.csi.cgiar.org/). In colour in the electronic version.

These new radiocarbon series, modelled within a Bayesian framework, have proved to be a powerful tool that has offered new insights and changed many of our current approaches to the megalithic societies (Aranda Jiménez and Lozano Medina 2014; Valera *et al.* 2014, 2019; Aranda Jiménez *et al.* 2018a, 2018b, 2020a, 2021; García Sanjuán *et al.* 2018; Valera 2020). However, all these series have been discussed in their regional contexts, but not as a whole on an Iberian scale. That is the specific goal of this paper: to discuss the social implications of the new radiocarbon chronology within a broad cultural framework. For the first time, a robust radiocarbon series has made it possible to produce refined chronologies in order to disentangle the temporality of the *tholoi*, their regional patterns, and the scale and intensity of their funerary and ritual use. Here, we begin by defining what can be considered *tholos*-type tombs, before examining the new chronological series using statistical and spatial analyses. The resulting refined chronology is then discussed with

respect to the cultural features of the different Iberian Chalcolithic societies.

2. ARCHAEOLOGICAL BACKGROUND. WHAT IS A *THOLOS*-TYPE TOMB?

Although the false dome has been considered a key feature of *tholos*-type tombs, its definition is a complex matter because in many cases no clear evidence of stone-corbelled roofing has been found. Thus, a more general and inclusive definition seems to be more appropriate. *Tholoi* are monumental constructions with a major formal variability and different degrees of complexity (Fig. 2). Nevertheless, they also share different features that categorise them as a specific kind of megalithic monument. Almost invariably they are partially dug into the bedrock. The funerary chambers are circular or oval in shape with a diameter that usually ranges between 2 and 4 m. Only in exceptional cases, such as the El Romeral *tholos*, does the diameter exceed those sizes, reaching up to 5.20 m (Gómez-Moreno 1905).

The funerary chambers follow different building systems: dry-stone masonry walls, large orthostats or, alternatively, slabs, normally slate, lining the cut in the bedrock. In well preserved cases the mortuary chambers usually present clear evidence of a false dome consisting of successively smaller rings of stones. An unusual roofing system based on vaults made with sun-dried mud has recently been suggested for the Montelirio *tholos* (García Sanjuán *et al.* 2018). This would be the only known case with a roofing structure different to the traditional stone dome. A central pillar for supporting the roof has also been found in the funerary chambers of several *tholoi*.

The mortuary chambers were entered through rectangular or trapezoidal passages that were also built of stone masonry and slabs. The length of the passages is typically around 3 m, although in exceptional cases such as La Pastora *tholos* this figure reached the 42 m in length (Tubino 1876). The passages are normally divided into equal sections by perforated slabs or other less common features such as steps or standing stones. In many cases, before entering the passages there is a trapezoidal or even a circular forecourt in which different ritual activities were developed (Leisner and Leisner 1943; Almagro and Arribas 1963). Small side-chambers in both the passages and the main chambers are another widespread feature. These detached spaces were also used for funerary purposes. Painted and engraved motifs decorate the stone slabs of different *tholoi* at Los Millares cemetery (Almagro and Arribas 1963) and in Montelirio (Bueno Ramírez *et al.* 2016). Another common feature is the mounds that cover the tombs through concentric stone walls filled with earth and small stones that give a conical appearance to the monument.

Tholoi are collective tombs in which human remains are found fragmented, commingled and piled on top each other. Occasionally, complete individuals or specific anatomical parts are found in an articulated position. The skeletal remains were placed in the funerary chambers, side-chambers and passages in one of several layers of depositions. In exceptional cases, they also appear in the mounds as funerary pits (Almagro and Arribas 1963; Almagro Gorbea 1973) and in the fore-

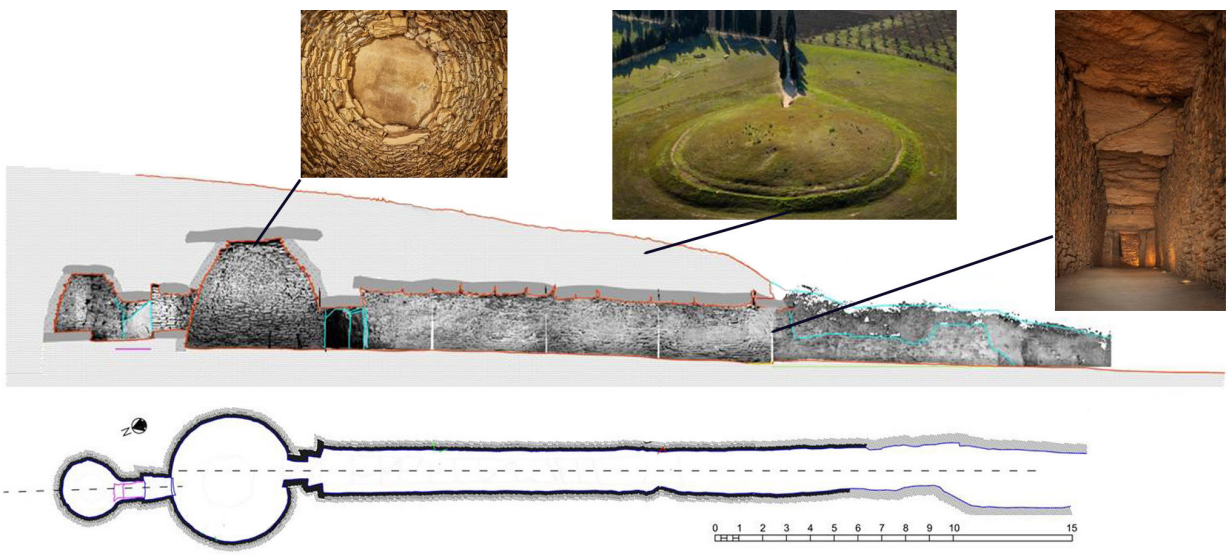

Fig. 2**.** Plan and section of El Romeral *tholos* (Dryas Arqueologia Lda., Photographs: Javier Coca). By permission of Antequera Dolmens Site. In colour in the electronic version.

courts (Valera *et al.* 2014; Silva *et al.* 2017). In those cases for which bioarchaeological studies are available, the bone remains belong to men, women and children of all ages (Díaz-Zorita Bonilla *et al.* 2016, 2017; Díaz-Zorita Bonilla 2017; Silva *et al.* 2017; Evangelista 2019; Evangelista and Godhino 2020; Valera *et al.* 2019; Aranda Jiménez *et al.* 2020a, 2021). Sex or age differences do not appear to have been determining factors in funerary practices, except for the main funerary chamber of Montelirio, in which all the sexed individuals are adult females (Pecero Espín 2016).

Tholoi are found in cemeteries such as Los Millares, El Barranquete and Alcalar or as a part of megalithic landscapes in association with other types of megalithic monument. More exceptionally, they were even physically integrated into earlier megalithic constructions. This is the case of the *tholoi* of Comenda 2, Farisoa 1 and Olival da Pega 2, all in the Reguengos de Monsaraz region (Leisner and Leisner 1951; Gonçalves 1999, 2014). Also common is the association of cemeteries or *tholos*-tombs with sites of a different character: settlements such as Los Millares, El Tarajal and Las Pilas in southeastern Iberia and ditched enclosures such as Valencina de la Concepción, La Pijotilla, Alcalar, Perdigões and Porto Torrão in the southwestern regions.

In spite of their typological variability (Leisner and Leisner 1943; Cabrero 1985; Gonçalves 1989; Sousa 2016), *tholoi* are ritual and funerary monuments that share a conceptual outline distanced from the massive construction of dolmens. We consider as *tholoi* not only the classical tombs with false dome, but also those monuments without clear evidence of vaulted roofing but with a similar architectural design and monumental character. They can be seen as a major innovation in megalithic monumental architecture, embodying a new cosmological order linked to previous traditions but also associated with growing social and political tensions.

3. MATERIALS AND METHODS

All the dates from *tholos*-type tombs in Iberia were collected, producing a radiocarbon series of 193 dates from 42 tombs (Annex SF1). This is a robust and reliable chronological series, not only for the large number of dates it contains, but also because the 80% of the whole series was produced in the last ten years. All these new measurements almost invariably present low standard deviations of ≤40 years and were obtained from properly contextualised human bone or teeth samples. In fact, if the whole series is considered, only two kinds of samples were dated, human bone/tooth (91.8%), charcoal (7.2%) and a mixture of charcoal and human bone (1%)[1]. The 193 radiocarbon measurements were calibrated using the IntCal20 atmospheric curve (Reimer *et al*. 2020), and the OxCal v4.4.2 program (Bronk Ramsey 2001, 2009, 2017). Calibrated ranges were obtained using the probability method (Stuiver and Reimer 1993) and the endpoints were rounded out by 10 years when the error was equal to or greater than 25 years and by 5 years when the error was less than 25 years (Stuiver and Polach 1977; Millard 2014).

The new chronological series was modelled in a Bayesian framework using the OxCal program v4.4.2 (Bronk Ramsey 2001, 2009). For comparative purposes, when large numbers of radiocarbon dates had to be considered, we used a statistical method based on Kernel Density Estimation (KDE) (Bronk Ramsey 2017). This method reduces the noise introduced from the calibration process and eliminates the excessive spread in data seen with unmodelled data, to produce a clearer picture of the distribution of events. It offers an advantage over the traditional summed probability distributions and is used here as an exploratory device for characterising the potential pulses of ritual activity. In addition to KDE models, the radiocarbon database was spatially analysed through the OxCal mapping functionality. This software can map calibrated radiocarbon dates producing a sequence of time slices at the chosen temporal resolution (Bronk Ramsey and Lee 2013).

When undertaking a radiocarbon dating programme based on human samples, establishing the diet of the population under study is always an important concern. If marine and freshwater resources were regularly consumed, the radiocarbon measurement will be affected by the so-called "reservoir effect", producing an earlier date than other contemporaneous terrestrial organisms (Stuiver and Braziunas 1993; Lanting and Van der Plicht 1998; Cook *et al.* 2001). Given that Iberian *tholoi* are mainly located in coastal or pre-coastal regions, we could expect a population with a diet based on marine resources. However, all the available paleodietary studies show a diet based on C_3 plants and terrestrial animals, with no evidence of any relevant intake of marine or freshwater resources. This is the case of the populations found in the *tholoi* and cemeteries of Perdigões (Valera 2020), Cardim 6 (Valera *et al.* 2019), La Pijotilla (Díaz-Zorita Bonilla 2017), Montelirio (Fontanals-Coll *et al.* 2016), Mojácar (Aranda Jiménez *et al.* 2021), El Barranquete (Díaz-Zorita Bonilla *et al.* 2019), and Los Millares (Waterman *et al.* 2017; Aranda Jiménez *et al.* 2020a). Therefore, it seems safe

[1] This 1% belongs to two radiocarbon dates from the Olival da Pega *tholos* (Soares 1999). This kind of sample would imply a mixture of different ages-at-death and they do not date any particular event or feature (Ashmore 1999).

to consider the radiocarbon dates as accurate estimates that do not require creating specific mixed-source calibration models.

4. RESULTS

As expected, the distribution of the radiocarbon dated *tholoi* affects the main regions where this kind of monumental architecture is characteristic: the south of Spain, including the Andalusia and Extremadura regions, and central and southern Portugal, comprising the Algarve, Alentejo and the Lisbon peninsula (Fig. 1). The only exception to this distribution is the *tholos* of La Sima II in the centre of Iberia, a long way from the classic *tholoi* regions (Rojo Guerra *et al.* 2005). This tomb is exceptional due to its isolated character and its radiocarbon dates that place it as the earliest *tholos* in Iberia (*ca.* 3700-3600 cal BC). Not only are the early dates surprising, but also the temporal hiatus of several centuries between the funerary use of La Sima II and the earliest mortuary depositions found in the *tholoi* of the classical regions (see below). Several reasons could explain this scenario. The radiocarbon dates could have been affected by the reservoir effect, although this seems very unlikely given the distant location of La Sima II from any significant aquatic resources. An alternative explanation is that the construction of the *tholos* could be more recent if the dated human bones belong to secondary depositions of skeletal remains brought from other places, a ritual practice suggested for other Iberian and European funerary contexts (Teather 2018; Valera 2019, 2020; Aranda Jiménez *et al.* 2020b; Booth and Brück 2020). In any case, if the radiocarbon dates are *terminus ante quem* for the construction of the tomb, La Sima II would belong to a pre-*tholos* phase with no connection to the classical development of this phenomenon. For these reasons, the radiocarbon dates of La Sima II were not included in the statistical models discussed below.

Additionally, to improve the accuracy of the statistical modelling only dates from bone/tooth samples with a standard deviation of ≥100 were considered, which mean 169 dates belonging in all cases to ritual and almost exclusively funerary activities. A first Bayesian model follows a simple bounded phase, as described in Hamilton and Kenney (2015), which assumes no stratigraphic relationship between any of the samples. This model has an overall agreement of A_{model}=54.8 that falls below the 60% considered to be the reliability threshold of the Bayesian models (Bronk Ramsey 1995). This is because the two more recent

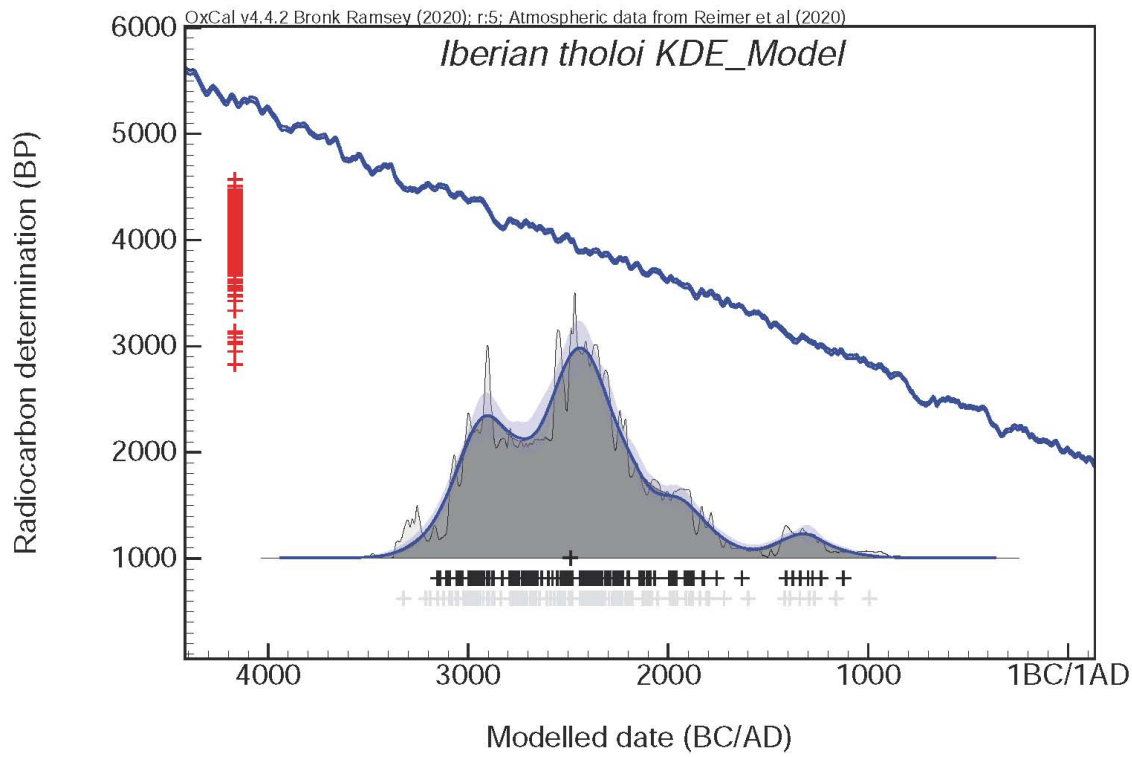

Fig. 3. Kernel Density Estimation-modelled distribution of all radiocarbon dates from *tholos*-type tombs.

radiocarbon dates –CSIC-249 (A: 0.6) and Sac-2789 (A: 49.2)– have poor individual agreement. In both cases they are anomalous young dates in relation to the other radiocarbon dates in the model. Nevertheless, they have been retained in the model as they identify well-known practices of funerary reuse and therefore it should not be considered as outliers from an archaeological point of view. Their exclusion would statistically bias the results, mainly the end period.

This model estimates that burial activity began in 3205-3105 cal BC (95% probability) and probably between 3160-3115 cal BC (68% probability). This phase of activity ended in 1375-1240 cal BC (95% probability) possibly around 1365-1320 cal BC (68% probability), which implies a very long period of use, between 1765 and 1840 calendar years (68% probability span) (Annexes SF2 and SF3). Nevertheless, if all the dates are summed in a KDE model (Fig. 3), this long period of use shows three main aspects: i) the funerary activity reached its greatest intensity in the 24th century cal BC, which agrees with the development of the Bell-Beaker phenomenon in Iberia; ii) from *ca.* 2400 to 1550 cal BC mortuary rituals progressively decreased; and iii) from *ca.* 1550 cal BC onwards the reuse of *tholoi* monuments increased again the funerary activity during the Late Bronze Age.

However, this general picture can be nuanced when the radiocarbon series is analysed from a comparative regional perspective. The radiocarbon dates have been clustered in four main regions along geographical criteria: southeastern Iberia (n=104), the lower Guadalquivir basin (n=22), the Guadiana basin (n=37)[2] and the Lisbon peninsula (n=6). Here, clear differences appear between regions in the frequency of reported radiocarbon dates. The southeast stands out with more than half of the radiocarbon dates followed by the Guadiana and Guadalquivir basins. In the last place comes the Lisbon peninsula that has not benefited from the extensive programmes of radiocarbon dating undertaken in the last decade. In addition to the Bayesian models for every region, this radiocarbon database has also been analysed through the mapping functionality of the OxCal software in order to produce a sequence of time slices.

Figure 4 shows the Bayesian model for each region in which dates are clustered as independent phases of activity (A_{model}=67.4). This model shows important differences in the regional patterns of ritual activity (Annex SF2). The first noteworthy fact is the progressive emergence of these megalithic monuments throughout the Iberian peninsula. *Tholoi* first appear in southeastern Iberia in 3330-3110 cal BC (95% probability), probably between 3230 and 3125 cal BC (68% probability). In the Guadalquivir basin funerary activity began in 3000-2795 cal BC (95% probability), probably in 2950-2885 cal BC (68% probability), which means between 200 and 340 years after the beginning

[2] Although the Alcalar and La Orden-Seminario cemeteries are not part of the Guadiana Basin, we have included them in this region because their locations in the Algarve and the Tinto and Odiel Basins respectively are in close association with the Guadiana.

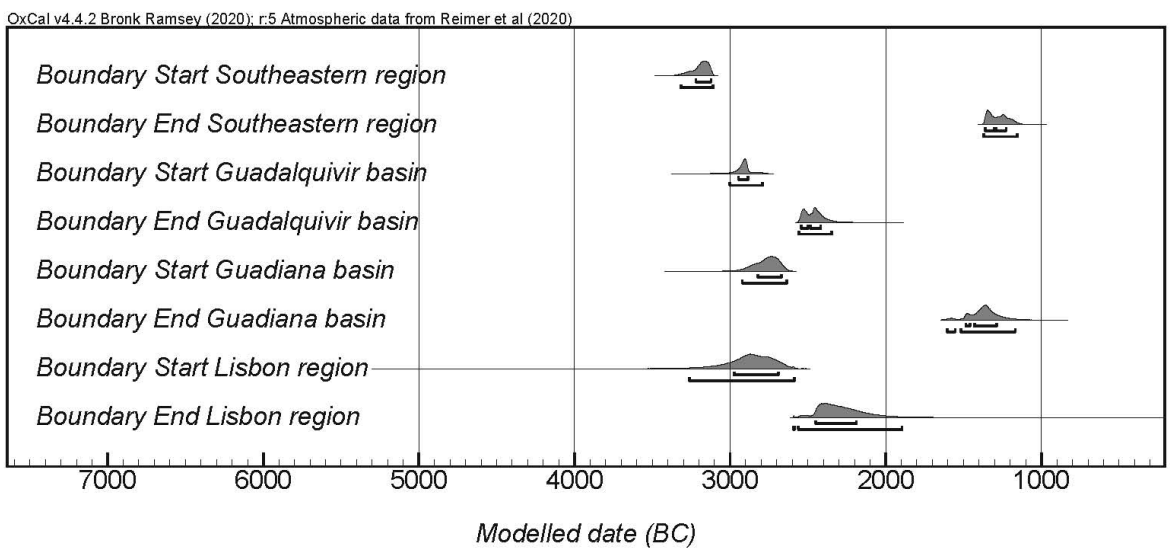

Fig. 4. Comparison between the Bayesian modelling –start and end estimations– of the four regions considered in the text: Southeast, Guadalquivir basin, Guadiana basin and Lisbon peninsula.

of southeastern *tholoi* (68% probability, difference start Southeast and start Guadalquivir). In third place, *tholoi* appear in the Guadiana basin in 2920-2635 cal BC (95% probability), probably in 2820-2670 cal BC (68% probability). In this case, the model estimates a temporal gap with the southeast of several centuries, between 340 and 525 years (68% probability, difference start Southeast and start Guadiana), and with the Guadalquivir basin between 75 and 245 years (68% probability, difference start Guadalquivir and start Guadiana). Finally, the very limited number of radiocarbon dates available for the Lisbon peninsula (n=6) prevents us from drawing any conclusion. However, the beginning of ritual activity in this region occurs between 2975 and 2690 cal BC (68% probability), in a quite similar chronological interval to that reported for the Guadiana basin. According to this gradual appearance, it seems that this megalithic phenomenon spread from the southeast to the Lisbon peninsula, from the Mediterranean coast to the Atlantic façade. Thus, *tholoi* did not arise from independent regional developments, but quite the opposite, there was a progressive expansion of these monuments from the core region in southeastern Iberia.

The previously underlined reuse events found in the different *tholoi* shape the probability intervals for the end of the megalithic activity in the different areas. In the southeastern and Guadiana regions, funerary rituals ended during the Late Bronze Age, in 1360-1225 cal BC (68% probability) and in 1485-1290 cal BC (68% probability), respectively. In the Guadalquivir basin and Lisbon peninsula there is no dated skeletal remains after the end of the Chalcolithic period. Nevertheless, this must be considered an artefact of the radiocarbon series as evidences of reuse practices during the Bronze Age are commons in these regions (García Sanjuán 2005, 2011; Costela 2018).

The difference in the periods of use between regions is another outstanding feature (Fig. 5). The southeastern KDE model shows a punctuated pattern with four pulses of ritual intensity: two stronger peaks in the 30th and 25th centuries cal BC and two milder pulses in 19th and 14th centuries cal BC respectively. The radiocarbon series from the Guadalquivir and Guadiana basins reveals a different pattern characterised by two peaks in the 28th and 25th centuries and one peak in the 24th century cal BC respectively. These differences underline the complexity of the southeastern region, in which the intensity of reuse rituals emerges as one of the main differences with the other Iberian regions.

Figure 6 shows the mapped distribution of radiocarbon dates for every tomb in time slices selected every two centuries. The size of the circle indicates the probability of the calibrated age range of a date lying within that time slice. The maps show that the first consistent

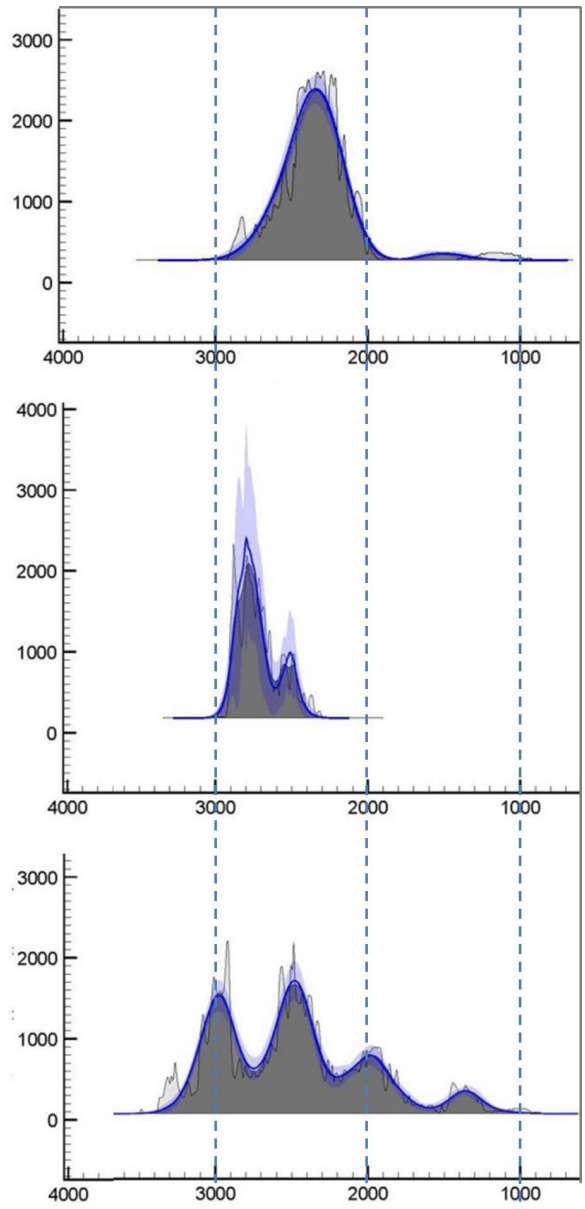

Fig. 5. Kernel Density Estimation-modelled distributions of the following regions: from bottom to top, Southeast, Guadalquivir basin and Guadiana basin. In colour in the electronic version.

appearance of funerary activity occurs in southeastern Iberia *ca.* 3200 cal BC in the three dated cemeteries –Los Millares, Barranquete and Mojácar–, with the highest intensity found at Los Millares. Two hundred years later (*ca.* 3000 cal BC) the southeast reached a peak in mortuary rituals. At that time, funerary activity began in the Guadalquivir basin. The probability that the *tholoi* also appeared in the Guadiana basin and on the Lisbon peninsula is very unlikely, as the size of the

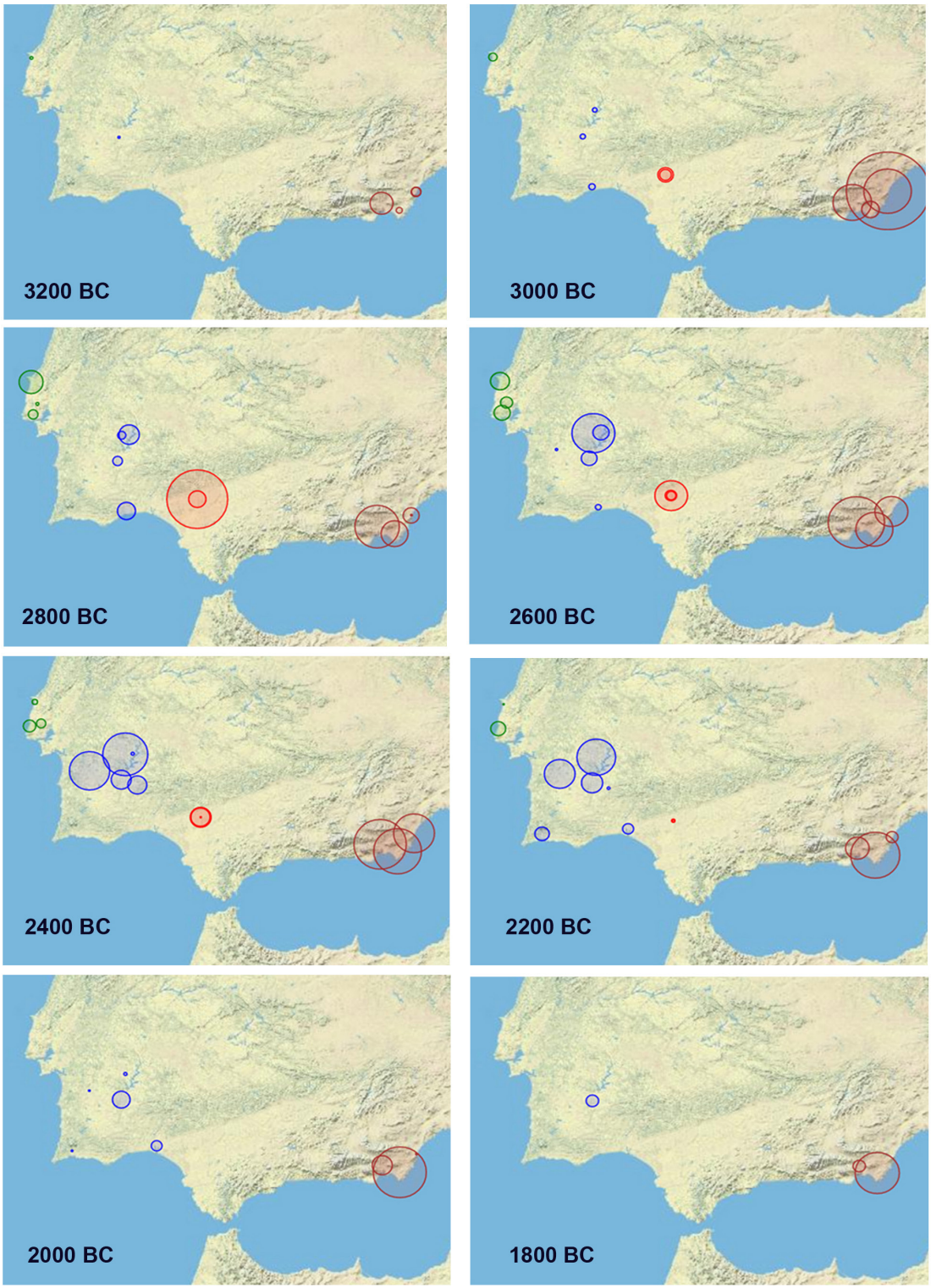

Fig. 6. Time-slice maps of radiocarbon dates of *tholos*-type tombs for southeast, Guadalquivir basin, Guadiana basin and Lisbon peninsula. Circle size shows the probability of a date occurring within that time slice. Maps were created using the OxCal mapping feature. In colour in the electronic version.

circles shows. It is in the first centuries of the 3rd millennium that the *tholoi* reached their largest geographical expansion, taking in the south of Spain and central and southern Portugal. The funerary activity shows a strong intensity in all these regions until *ca.* 2400 cal BC, when a progressive decrease began, which was especially remarkable in the Guadalquivir basin. At the time-slice of 2200 cal BC mortuary activity disappears in the Guadalquivir basin and becomes focused primarily in the Guadiana basin at sites such as Perdigões, Cardim 6 and Centirã 2 and in the southeast at Los Millares, El Barranquete and Loma de Belmonte. In the subsequent centuries, only the southeast maintained an important funerary activity at the cemeteries of Los Millares and, especially, El Barranquete.

For the first time in Iberia, it is also possible to explore the temporality of specific monuments thanks to the large radiocarbon series obtained in recent years. This is a remarkable improvement if we consider that until 2014, when the first large series from a tomb was published (Aranda Jiménez and Lozano Medina 2014), megalithic chronology in Iberia had been based on a limited number of dates per tomb, usually between one and three. Currently there are ten *tholoi* with large radiocarbon series: in the southeast El Barranquete 8 (n=12), El Barranquete 9 (n=14), El Barranquete 11 (n=13), Los Millares 74 (n=12), Loma de Belmonte (n=15) and Loma del Campo 2 (n=15); in the Guadalquivir Basin Montelirio (n=21); and in the Guadiana Basin Centirã 2 (n=8), Perdigões 4 (n=8) and Cardim 6 (n=8). Of the 193 dates available, 126 (65%) belong to these tombs. This implies a clear shift in the radiocarbon strategy that is now focusing on dating the multi-depositional funerary events that occurred in each megalithic tomb.

These tombs have been modelled according to the depositional sequence of funerary rituals discussed elsewhere in depth for every *tholos* (for further details see Aranda Jiménez and Lozano Medina 2014; Aranda Jiménez *et al.* 2018a, 2020a, 2021; García Sanjuán *et al.* 2018; Valera *et al*. 2019; Valera 2020) (Annex SF3). Comparison of the Bayesian models reveals important differences in the period of use between the southeastern and southwestern *tholoi* (Tab. 2-Annex SF2 and Fig. 7). In the southeast, funerary rituals span centuries in most cases. Periods of use of more than 500 years are common at *tholoi* such as Los Millares 74, Loma de Belmonte and El Barranquete 8, 9 and 11. This scenario contrasts sharply with the short period of funerary activity shown by the southwestern *tholoi*. Except for Centirã 2 (175-350 years, span of phase I of funerary chamber, 68% probability), no *tholos* span more than a few decades or even years. This is the case of Montelirio (1-55 years, span of main funerary chamber, 68% probability), Perdigões 4 (1-6 years and 1-9 years, span of phases I and II of the funerary chamber respectively, 68% probability), and Cardim 6 (1-14 years and 1-38 years, span of phases I and II of the funerary chamber respectively, 68% probability). Furthermore, most of these phases of mortuary activity pass the contemporaneity test. This is the case of the main funerary chamber of Montelirio (T'=9.5; T' (5%) =12.6), the phases I (T'=0.2; T' (5%)= 3.8) and II (T'=4.1; T' (5%)= 9.5) of Perdigões 4, and the phase I (T'= 1.0; T' (5%)=3.8) of Cardim 6 (Ward and Wilson 1978), which means that individuals clustered in these phases could have died at the same time and buried in a single event.

5. DISCUSSION

Tholoi were not just a major innovation in megalithic monumental architecture. Their emergence and development in different Iberian regions have been associated with important changes in the social realm. Although in many respects *tholoi* followed the previous megalithic traditions, such as the monumental conception of the funerary space or the collective ritual burial, they also entailed an evolution in the architectural features (dome vaults and masonry constructions) and in the development of a sharp contrast between grave goods. The wealthiest *tholoi* included finely crafted objects made of valuable materials such as gold, ivory, amber, green stones, rock crystal and ostrich eggs. From a general point of view, *tholoi* can be considered as the material expression of a new social order characterised by the competition and tensions between different social groups (Chapman 1981, 1990; Díaz-del-Río 2011; García Sanjuán *et al.* 2017; Aranda Jiménez *et al.* 2018a).

Nevertheless, the social role and meanings of the *tholoi* differ according to their specific cultural contexts. Clearly, different regional trajectories can be found between the two main focuses of *tholos*-type of tombs: the southeastern and the southwestern regions of Iberia. In the southeast, *tholoi* were the most recent monumental constructions that would have reinforced traditional sacred landscapes characterised by earlier megalithic monuments. Thanks to the *tholoi*, these meaningful landscapes gained in significance as gathering places and attracted different communities that settled in close association with these monumental constructions. The foundation of new and, for the first time, permanent settlements occurred precisely at those places where the early *tholoi* had already been built and were in use. This is the case of the Las Pilas, El Tarajal and Los Millares settlements (Aranda Jiménez *et al.* 2018a, 2020a, 2021; Lozano Medina and Aranda Jiménez 2018). The residential character of the new Chalcolithic sites seems well-defined and

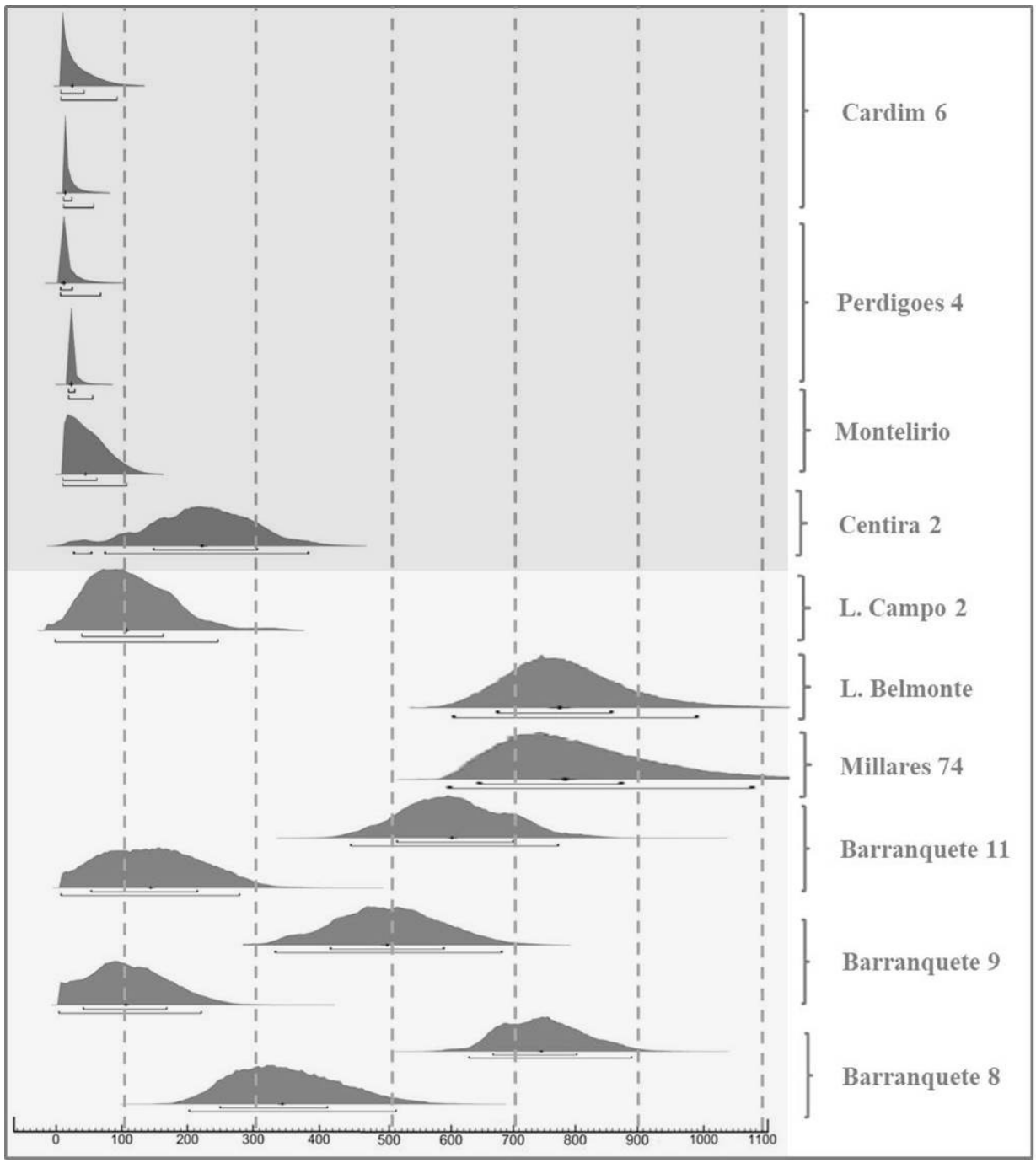

Fig. 7. Probability distributions in number of years of the *tholos*-type tombs with large radiocarbon series in Iberia. The distributions are derived from the specific model of every tomb defined in the supplementary information. Southwestern *tholoi* in dark grey. Southeastern *tholoi* in light grey.

is backed up by the archaeological features: huts with circular stone foundations associated with hearths, ovens, storage areas, pottery vessels and grinding stones found throughout the internal areas of the settlements. Funerary practices were restricted to the megalithic tombs and the deposition of human remains has not been found in any other feature of these Chalcolithic sites.

In the Iberian southwest, the main *tholoi* focuses are associated with a quite different type of site, mainly ditched enclosures characterised by underground features and the absence of stone-constructions except for the megalithic monuments. This is the case of Valencina de la Concepción, Perdigões, Porto Torrão and probably Alcalar, whose residential character is currently challenged and under discussion (Márquez Romero 2004; Márquez Romero and Jiménez Jáimez 2013; Valera *et al.* 2014; García Sanjuán *et al.* 2018; Escacena *et al.* 2018; Schumacher *et al.* 2019). At all these sites the *tholoi* appear in a context characterised by a ritual and funerary diversity unknown in the southeast. In addition to the *tholoi*, the deposition of human remains is also found in pits, hypogea and ditches, in some cases as funerary depositions in others as bones mixed with other kinds of materials in non-funerary features (Valera and Godinho 2009, 2010; García Sanjuán and Díaz-Zorita Bonilla 2013; Valera *et al.* 2014; Rodrigues 2014; Díaz-Zorita Bonilla *et al.* 2020).

The co-existence of different kinds of funerary practices and bone manipulation in ditched enclosures has been considered as evidence of complex ritual interactions that were not restricted to the time of death. It has been suggested a long and step process through which human remains were intensively manipulated and deposited in different features (Valera 2020). The ubiquity of the human remains is a key aspect that has prompted innovative explanations. In recent accounts, ditched enclosures have been explained as gathering places in which mortuary practices and the manipulation of human bodies played a major role (Valera *et al.* 2014), as assembly places that attracted people from a wide area for social gatherings and the commemoration of the dead (García Sanjuán *et al.* 2018) or specifically as large burial sites for different communities living in a wider region (Escacena *et al*. 2018).

To summarise, *tholoi* were part of very different social trajectories. In southwestern Iberian ditched enclosures such as Valencina de la Concepción and Perdigões, *tholoi* emerged as a major innovation around the 30th and 29th centuries cal BC respectively, in places with an already long tradition in funerary practices and bone manipulation. In contrast, *tholoi* were first established in the southeast around the 32nd century cal BC and preceded the foundation of new, permanent settlements that, unlike the ditched enclosures, were clearly residential. In these regional contexts, the monumental and ritual nature of the *tholoi* seems to have played different social roles.

For a better understanding of this social diversity, the current radiocarbon study also reveals a key difference between the southeastern and southwestern regions. The *tholoi* not only differ regionally in their first appearance, but also in their period of use. In southeastern Iberia, tombs with large radiocarbon series almost invariably present long periods of mortuary use, suggesting sustained ritual activity over centuries. In the southwestern regions, the trend is the opposite: tombs were used during short periods that normally spanned a very few decades or even a single funerary episode. If we assume a figure of twenty-five years per generation, not more than two generations would have been buried in tombs such as Montelirio, Perdigões 4 and Cardim 6. Thus, southwestern *tholoi* did not typically survive beyond the remembrance of their builders, in contrasts to the southeastern megalithic monuments that were used and reused for generations.

From the last centuries of the 3rd millennium onwards funerary rituals were restricted to the occasional reuse, except in the southeast, where mortuary activity reached a remarkable intensity. Once again, differences in the cultural context emerge as crucial aspects for understanding the specific social trajectories. The development of the southeastern Early Bronze Age societies (*ca*. 2200-1550 cal BC) –best known as Argaric culture– involved different cultural innovations that led to a social complexity unknown in other Iberian regions. Valley and lowland villages were abandoned and the population moved to newly-built settlements on hilltops and artificially-terraced hills. In Argaric villages, buildings were densely packed together and houses were now rectangular in shape with internal divisions, in contrast to the circular buildings that distinguished the previous Chalcolithic villages. Mortuary rituals now consisted of individual intramural inhumations, normally below house floors. These innovations were also fuelled by a process of metallurgical craft specialisation and crop farming intensification (Aranda Jiménez *et al.* 2015).

In this context, funerary activity at cemeteries such as Los Millares and El Barranquete continued with considerable intensity. Particularly remarkable is the case of El Barranquete in which half of the forty-six available dates are from the Bronze Age (Aranda Jiménez *et al*. 2018a, 2020c, 2021). Two very different mortuary and ritual practices coexisted in the southeast during the Early Bronze Age. The old tradition comprised the reuse of megalithic cemeteries, while the new mortuary programme was characterised by individual inhumations with significant differences in grave goods. The new funerary practices have been associated with the emergence of Argaric social elites and the construction of new identities based on social fragmentation and division. In contrast, individuals engaged in the communal practices would have conformed to a different social group that emphasised traditional values and would not have self-identified with Argaric innovations. These contradictory and even opposing ways of understanding social identities, one more individual

versus another more relational, can be explained in terms of sociocultural resistance. The mortuary activity in *tholos*-type tombs could be considered as part of social practices aimed at neutralising the social hierarchisation process that characterised Argaric communities (Aranda Jiménez 2013, 2015; Aranda Jiménez *et al*. 2018a, 2020c, 2021; Lozano Medina and Aranda Jiménez 2018; Milesi and Aranda Jiménez 2019).

6. CONCLUSIONS

For the first time, there is a robust radiocarbon series that has made it possible to produce refined chronologies able to disentangle the temporality of different social events traditionally linked together in narratives that emphasise long-term developments. *Tholos*-type tombs appeared for the first time in southeastern Iberia around the 32nd century cal BC. From this region, the *tholoi* progressively spread out to other regions such as the Guadalquivir basin, the Guadiana basin and the Lisbon peninsula. Several centuries after *ca.* the 29th century cal BC, *tholoi* reached their greatest expansion from the southeast to the Lisbon peninsula, from the Mediterranean coast to the Atlantic façade. *Tholoi* were an original innovation in monumental architecture that appeared in the southeast as independent development. Among the different southeastern cemeteries, Los Millares stands out as the place with the highest chronological probability for the first appearance of *tholoi* in Iberia.

In contrast with other type of contemporary burial sites, the *tholoi* stand out for the great variability in their grave goods. In some *tholoi* were deposited an unprecedented concentrations of finely crafted valuable goods made of exotic raw materials such as ivory, gold, amber, green stones, rock crystal and ostrich eggs. This is the case of several *tholoi* at Los Millares cemetery in the southeast (Leisner and Leisner 1943), Montelirio in the Guadalquivir valley (Fernández Flores *et al.* 2016) and the tomb 2 at Perdigões in the Guadiana basin (Valera *et al.* 2014). In contrast, other *tholoi* show less wealthy grave goods even the lack of any exotic materials. It is precisely based on this inter-tomb variability that an increase in social competition between kin-based groups has been widely suggested (Chapman 1981, 1990; Díaz-del-Río 2011; García Sanjuán *et al*. 2018). *Tholoi* emerged as an innovation that materialised an unstable and changing social order in which different groups would have attempted to consolidate asymmetrical social positions. But were these social tensions similar in the different Chalcolithic communities? It seems that the scale and intensity of social competition were very different in the southeastern and southwestern regions. Three main aspects support this statement. Firstly, the intensity in the funerary use of these megalithic monuments clearly separates both regions: long periods of use in the southeast *versus* short periods in the southwest. Secondly, the scale reached by the southeastern *tholoi* is another key difference. Los Millares cemetery alone has more tombs (n=80) than the whole of Portugal, where there are 61 *tholoi* (Sousa 2016), or the western Andalusia (the present-day provinces of Huelva, Sevilla, Cádiz, Córdoba and Málaga) with 33 *tholoi* (Cabrero 1985). Thirdly, in the southeast, mortuary rituals were concentrated exclusively in megalithic monuments. In contrast, southwestern *tholoi* appeared as a new kind of funerary monument in a context characterised by a wide variety of mortuary and body manipulation ritual practices. These regional differences would imply a sustained and enduring factional competition in the southeast, in contrast to the more occasional and temporally limited episodes of social tension that characterised southwestern Chalcolithic societies.

Inter-group competition shows very different degrees of intensity and a diverse ability to strengthen emerging forms of social asymmetry. Collective ties and relational identities would be strongly maintained in southwestern communities, while in the southeast the intensity of social tensions would have weakened the traditional communal bonds. Could the different degree of social competition explain the marked differences found between the Argaric Bronze Age societies and other contemporaneous Iberian communities? It seems that this could be a key aspect for understanding the appearance of ranked societies in southeastern Iberia. Social competition during the Chalcolithic period would at least have partially broken collective ties, leading to the development of social asymmetries that reached a complexity unparalleled in any other contemporary community. Nevertheless, this particular trajectory would also have triggered a process of social resistance that found the perfect setting for its material expression in the reuse of megalithic monuments. This social reaction would evidence the deep roots of the collective bonds and the instability of the new Argaric social order.

The *tholos*-type tombs were a major monumental innovation that spread from the southeast to other Iberian regions. However, the trajectories followed by these monuments were regionally and historically very variable. *Tholoi* played a very different role in social dynamics, from occasional and temporal limited events of social tensions to regular and enduring practices of inter-group competition that became in episodes of resistance to the process of social hierarchisation. Refined chronologies such as those discussed in this paper have proved the potential for a better understanding of past social trajectories and for building new social nar-

ratives. Nevertheless, it also seems clear that further developments are needed as the construction of precise chronologies for Iberian megalithic monuments is in its early stages.

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ANNEX: SUPPLEMENTARY FILES

Three annexes with supplementary materials are available in the electronic version:

Annex SF1: Radiocarbon dates from the *tholos*-type tombs in Iberian peninsula.

Annex SF2: Posterior density estimates of Bayesian and Kernel Density Estimation models discussed in the text.

Annex SF3: Bayesian Model Codes.

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