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The Chalcolithic–Bronze Age transition in southern Iberia under the influence of the 4.2 ka BP event? A correlation of climatological and demographic proxies

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The end of the third millennium BCE represents (not only) on the Iberian Peninsula the time of transition to the Bronze Age. At the same time this is the time of a general climatic event, the so-called 4.2 ka BP event, which can be observed (in different manifestations) in different regions of the northern hemisphere. By synchronizing cultural and climatic developments and above all by assessing demographic developments and their spatial development, a much-discussed connection between the two phenomena can be made plausible and opens the perspective for further, more detailed research on the interdependence between cultural, demographic and climatological processes. For this purpose, the results of aoristics, ^{14}C sum calibration and the evaluation of the concentration of long-chain n-alkane homologues of terrestrial origin as precipitation predictor are combined, their correlation is presented and possible responses are interpreted from the mapping of the settlement system development. This article provides an initial overview of the current results.

Introduction

The turn to the third millennium BCE on the Iberian Peninsula is a period of a dynamic development characterized by regional differences. It is mainly represented by the Copper Age and the transition to the Bronze Age.

In the last three decades, the Iberian Copper Age or Chalcolithic (ca. 3200–2200 cal BCE) and the transition to the Bronze Age (ca. 2200–900 cal BCE) was probably the most controversial period in the discourse on Iberian prehistory (García Sanjuán/Murillo-Barosso 2013, 119). Key issues were early social stratification and state formation. The peninsula is indeed a good laboratory for the study of these phenomena (Cruz Berrocal et al. 2013, 3).

Research today is dominated above all by the narrative that economic activity and social inequality intensified during the Copper Age (Gilman 1987; Chapman 1990; Hutado 1997; Sanjuán 1999; Díaz del Río 2004), and that these tendencies would have been strongly reinforced in the course of the Early Bronze Age, especially in the southeastern area of the peninsula. In contrast, the other regions seem to show signs of disintegration and collapse at the time of transition and thereafter. This observation inevitably raises questions about demography and possible migration movements, which are currently increasingly discussed on the basis of aDNA analyses (Martiniano et al. 2017; Günther et al. 2015; Szecsenyi-Nagy et al. 2017; critical e.g. Linden 2016; Furholt 2017). From an archaeological point of

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view, this perspective has so far received relatively little critical appreciation (Rivero/Carrasco 2015; Lillios 2015; Lillios et al. 2016; contrary e.g. Chapman 2008, 205).

Following a general trend, the climatic changes on the Iberian Peninsula in connection with the 4.2 ka BP event have recently been examined in more detail, from an archaeological (Lillios 1997; Cardoso 2005; Fabián García et al. 2006; Lillios et al. 2016) and a natural science approach (Carrión et al. 2007; Magny et al. 2009; Jalut et al. 2009; Waterman et al. 2016). The former approach often cannot argue with a local climate signal, the latter often lacks a connection to cultural-historical development. In addition, these are often small-scale studies that can hardly trace an overall development.

In general, human-environment relations have an important role in the archaeological interpretation on the Iberian Peninsula, especially against the background of the in part marginal conditions with regard to agricultural potential. However, a stable climatic situation was widely assumed (Gilman and Thornes 1985), climate change and its relations to cultural changes have hardly been focused on so far, perhaps with the exception of the archaeology of the southeast of the peninsula. Climatic influences are also partly explicitly rejected there (Risch et al. 2015).

The CRC Project

The Collaborative Research Centre (CRC) 'Scales of Transformation: Human-Environmental Interaction in Prehistoric and Archaic Societies' of the German Research Foundation (DFG) investigates transformation processes in a key period of human history (15,000 to 1 BCE) in a long-term perspective.

Within the framework of the CRC, the subproject F1 'Supra-regional Crises: Abrupt Climate Change and Responses of (Multi-cultural) Ancient Societies in the Western Mediterranean Area and in Southern Central Europe around 4200 years BP' investigates the interdependence between climatic and socio-cultural changes in connection with the 4.2 ka BP event.

The project aims to unravel complex socio-ecological transformation processes from a supra-regional and supra-cultural perspective and in particular to evaluate the role of abrupt climate changes and socio-ecological crises in shaping archaeological transformations. In the first phase of this project (2016–2020), this will be done on the basis of two areas of activity in southern Portugal and south-western Spain. The temporal focus is on the time between 2700 and 1700 cal BCE (4650–3650 BP) in order to cover the 4.2 ka BP event, but at the same time also the preconditions and the consequences of the archaeologically tangible change in the material culture and social configuration of the societies under consideration.

In the quantitative framework of our approach, scenarios of both climatic and social variables are quantitatively reconstructed in relation to the 4.2 ka BP event (i.e. time slices before, during and after the event). Time series of climate and population reconstructions will be produced on the basis of refined chronologies to assess the timing and extent of ecological and social changes and to evaluate the relationships between them. The magnitude of possible social, cultural and technological/innovative responses to these external constraints will be analysed. In the course of the project, archaeological variables reflecting transformation processes (indications of changes in material culture, subsistence and settlement patterns and social organization) are identified that indicate the susceptibility or resilience to external disturbances.

In two work packages, a broad approach is taken to obtain information on the role of archaeological and environmental variables. Both research areas will compile and process existing data from literature and regional archives in order to reconstruct scenarios of climate and social variables.

In the climatological part, climate change in connection with the 4.2 ka BP event in the western Mediterranean is reconstructed from marine archives relevant for the Iberian Peninsula. New high-resolution time series are created on the basis of multiproxy reconstructions at key locations, e.g. in the Alboran Sea. In this way, the extent and speed of the hydroclimatic, temperature-related and seasonal changes in connection with the 4.2 ka BP event can be quantitatively assessed. The precipitation estimates are derived from the n-alkane concentrations of the plant waxes. Since plant waxes are mainly introduced into the marine sediments via river systems and/or wind transport, the data on the catchment area of the river systems integrate and thus reconstruct the regional rather than the local climate.

The archaeological work package will examine the patterns of archaeological changes associated with the 4.2 ka BP event in the western Mediterranean and identify its possible links with Central Europe with the aim of quantitatively evaluating the intensity and extent of the transformations from the archaeological record. Information on settlements, architecture, material culture and archaeological data on the environment and subsistence is collected and evaluated. These allow in particular quantitative proxy reconstructions for settlement patterns, continuity, population density and other derived variables such as the stability of a society, integration into exchange networks and changes in material culture at the regional level.

In the following we would like to present some first results of our work. Here we limit ourselves to the evaluation of supra-regionally available indicators. Aspects such as cultural changes based on material culture and individual site biographies also play a non-subordinate role in the project. These detailed studies will be presented elsewhere.

Presentation of the working area

In the first phase of the project underlying this contribution, on the study of human-environmental relations and the assessment of the climatic influence on socio-cultural development, the work focuses on two areas 1: southern Portugal including the Spanish borderland (catchment of River Tejo and Guardiana) and south-western Spain (catchment of River Guadalquivir). These two areas were selected because they have different trajectories from an archaeological point of view, and because they represent the catchment areas of the Guadiana and Guadalquivir river systems from a climatological perspective, for which the rainfall development is to be reconstructed with the help of plant waxes (n-alkanes).

Today, the Mediterranean coastal regions are characterised by a dry to semi-arid climate, with some regions receiving less than 200 mm of precipitation per year (Lionello et al. 2006). The border areas of the Mediterranean, including the southern Iberian Peninsula, are therefore vulnerable to desertification and drought, and the climate has a strong impact on local society and economies. This is particularly true since the environment and the way of farming depend heavily on winter precipitation (Lionello et al. 2006). In general, the climate zones of the middle and late Holocene (from the 6th century BCE) in the Mediterranean region show a tendency towards gradual warming that is more pronounced in southwestern Europe than in

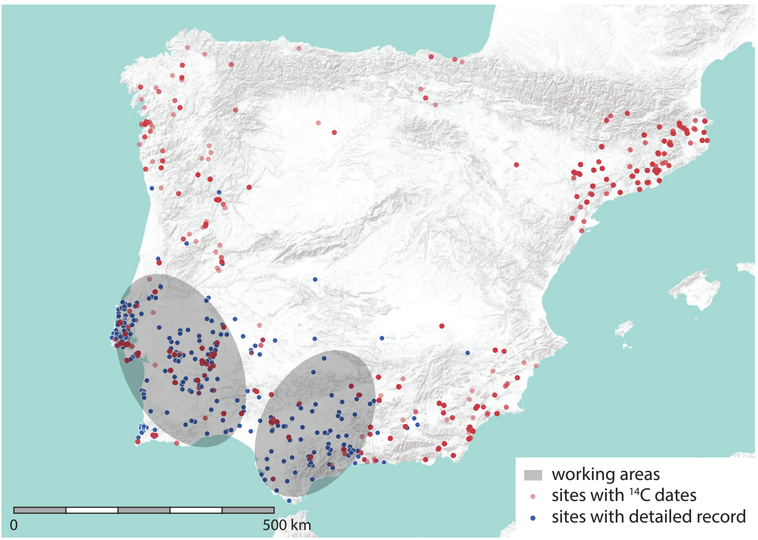


Fig. 1. Map of the working areas.

southeastern Europe (Davis et al. 2003), while the Atlantic region of medium latitude, including the Iberian margin, has an opposite trend.

Long-term Holocene tendencies were interrupted by short drought episodes (Finné et al. 2011). During the Holocene these episodes changed in frequency and character (Fletcher et al. 2007). The more serious of these episodes, including the 4.2 ka BP event, are probably related to the Bond cycles in the North Atlantic (e.g. Bond et al. 1997; Bond et al. 2001; Marino et al. 2009) and are therefore considered to be driven and/or modulated by large-scale oceanic and atmospheric circulation changes. According to the current state of climate research, however, the bond cycles themselves are probably not the actual, hitherto unknown trigger of the climatic shifts, more likely are changes in solar activity in connection with changes in atmospheric circulation and volcanic activities affecting a complex chaotic system (e.g. Ruan et al. 2016; Wanner et al. 2008).

The 4.2 ka BP event

The so-called 4.2 ka BP event represents an aridification event that probably lasted the entire 22nd century BCE (or longer) (Magny et al. 2009; Ruan et al. 2016). This climate event marks the transition from the middle to the late Holocene and in many regions of the northern hemisphere also the beginning of almost modern (pre-industrial) climate and environmental conditions (Walker et al. 2012). It is often cited as an analogue of current socio-ecological change under rapid global warming (e.g. deMenocal 2001; Booth et al. 2004; Riehl 2008), which poses a threat to social, economic and environmental stability, and as a predictor for aggravating the existing problems of poverty, conflict, health and escalating food and water shortages in crises (IPCC 2013). The 4.2 ka BP event at the transition from the middle to the late Holocene affected the climatic stability of the entire northern hemisphere.

The widespread accompaniment of major social upheavals and abrupt climate changes in geographically and culturally distant regions makes it plausible that the regional developments of the 4.2 ka BP event are linked and reinforced by complex socio-ecological processes, including large-scale climate processes, social responses to changing environmental conditions and internal social and intercultural processes. On the other hand, the emergence of early Bronze Age cultures throughout Europe can point to resistance strategies that enable transformation into new cultural phenomena and lay the foundations for later developments.

The abrupt onset of drought is considered to be one of the main causes of or at least in favour of widespread social instability in the monsoon area. The synchronicity of regionally related drought events is well limited at 4.1–4.2 ka BP. The effects affect large areas in Asia (e.g. the Indus region, Staubwasser et al. 2003) and Central China (Wenxiang/Tungsheng 2004), Mesopotamia and North Africa (e.g. deMenocal et al. 2000; Welc/Marks 2014; Ruan et al. 2016; Kaniewski et al. 2017). Recent high-resolution reconstructions using marine deuterium recordings (Tierney/deMenocal 2013) and high-resolution terrestrial reconstructions of speleothems, paleo-river valleys and sea levels have further narrowed the extent and magnitude of the dramatic monsoon failure (Dixit et al. 2014), leading to massive changes in the precipitation rate (z.B. Bar-Matthews et al. 1997; Gupta et al. 2003).

In the eastern Mediterranean and the Middle East, the 4.2 ka BP event manifests itself as an episode of barely 300 years (22nd to 19th century BCE; e.g. Weiss 2013), after a general, long-term shift from humid to drier conditions (Rohling/De Rijk 1999).

Unfortunately, the available climate data sets of the middle and late Holocene in the western Mediterranean mostly lack the multi-decadic resolution that is necessary to document a short episode of several hundred years in detail (Weinelt et al. 2015). Some speleothem data records (eg. Cruz et al. 2015) are exceptions. Accordingly, reconstructed patterns based on different proxies are still fragmentary and need to be revised to examine the potential extent of a supra-regional drought period in the western Mediterranean.

On the south-eastern Iberian peninsula and in the Mediterranean region of France, where pollen/terrestrial climate data are mainly available from the mountain ranges, an irreversible change in vegetation dates back to about 4.0–4.2 ka BP (e.g. Brisset et al. 2013; Carrión et al. 2003). On the south-eastern Iberian peninsula, from 4.2 ka BP an increase in fire events (Jalut et al. 2000; 2009; López-Sáez et al. 2014) accompanied the vegetation changes (Carrión et al. 2003). These changes were probably a consequence of the intensification of agriculture and/or the climate, whereby the climatological explanation is the more likely one (Burjachs/Expósito 2015). Dust layers of Sahara origin are described in the records of the Central Italian lakes and indicate prevailing southern wind directions at 4.2 ka BP (Magri/Parra 2002). In contrast to these indications of hotter and drier conditions, some marine records based on biomarker proxies suggest a cooling during the 4.2 ka BP event in the Alboran Sea (Cacho et al. 2001).

Climate patterns and socio-ecological implications of the 4.2 ka BP event are well researched in the eastern Mediterranean and the Middle East, especially in the area of written sources, which testify to a series of declines in early thriving and fast-growing societies that lead to 'collapses' under the influence of severe drought. By contrast, little is known about the impact and possible effects of this event on societies in the western Mediterranean and possible long-term effects on central Europe. Its role in the Late Neolithic/Chalcolithic and Early Bronze Age transformations at the transition to the Late Middle Holocene (Late Atlantic) is still to be explored.

Archaeological transformations

In the western Mediterranean and Central Europe in general, a broad transition horizon from the Neolithic/Chalcolithic to the Bronze Age can be observed, which is reflected in an overwhelming amount of literature on the strong regional cultural changes that characterize this period (e.g. the bell beaker phenomenon). This transition is most often dated around 4.2 ka BP and indicates widespread and (within the dating accuracy) synchronous upheavals, so that a common trigger and mutual influences appear likely. However, despite striking convergence and coincidences, social change in Western and Central Europe has so far hardly been viewed from the perspective of a socio-ecological crisis on a supra-regional scale.

In the Mediterranean region in France (Cauliez 2015), but also on the Greek mainland discontinuities and hiatuses are reported (Andel et al. 1990, fig. 10; Maran 1998). They give the impression that in large parts of Southern Europe with a formerly continuous development of several centuries settlements were abandoned towards the end of the 3rd millennium BCE.

On the Iberian Peninsula there is a significant transition working at different levels in temporal relation to the 4.2 ka BP event: the disappearance of the Chalcolithic and the emergence of new cultural units of the Early Bronze Age, changes in regional population, changes in settlement structures and patterns, in demography, in material culture, in subsistence and resource management, and in changes in social practices. This transition marks a period of increasing social complexity on the way to the development and hierarchisation of Bronze Age societies (Chapman 1982; Chapman 1990; Lull et al. 2014; Enrich/Mejías 2017, 1933).

Although the respective natural conditions and cultural development can be very different locally, the Copper Age Iberian Peninsula can be roughly divided into two zones. In the north the human activities resulted in a significantly lower archaeological evidence and must therefore also be considered as less well investigated (Ontañón 2013, 207). The (semi-permanent) settlements, which are scattered mainly in flat areas, reach an extent of up to 1–2 ha, an amount that will not be reached again until Roman times. These are mainly found in the form of 'pit fields' *(campos de hoyos)*, which are generally the most common form of settlement on the Iberian peninsula until the Bronze Age (Lull et al. 2013, 605). Livestock seems to dominate economically (Ontañón 2013, 212). There are some signs of supra-regional contacts, and the burial tradition suggests abandoning the existing megalithic tradition. A few small *enclosures* as ritual places complete the picture (Parcero et al. 2013, 244–255). Copper mines such as Picos de Europa (El Milagro in Asturias) are unique due to their size and complexity (Lull et al. 2013).

This picture does not change fundamentally in the transition to the Bronze Age, even if the archaeological evidence is even more scarce. Settlement evidence remains rare and can be found in zones similar to those of the Chalcolithic. Furthermore, a temporary or seasonal use of the sites by a few (dozen) persons seems to predominate. The finds indicate a broad spectrum of economic activities and a high degree of self-sufficiency. Economically, agriculture seems to gain in importance, which is also indicated by an increase in storage capacity (Lull et al. 2013, 605). On the other hand, a certain shift of the settlement areas to higher areas suggests a focus on cattle breeding, which may result in a diversified farming method (Valcarce/Priego 1994, 148; Bettencourt et al. 2007, 152–153). The burials remain in the Chalcolithic tradition and show a great variety, whereby individual burials are more prominent (Lull et al. 2013, 606–607).

The southern Iberian Peninsula, on the other hand, has been a hotspot of archaeological research for decades, due to its partly permanent character and the good preservation conditions for settlement structures and the rich funeral archaeology. In particular, the investigation of early complexity and the hypothesis of the emergence of a state based on archaeological finds in the course of the Chalcolithic and the Early Bronze Age El Argar phenomenon (Chapman 1990; 2008; Nocete et al. 2010; Lull et al. 2011; 2013) have caused a completely different kind of archaeological activity here. To what extent such an interpretation is justified, however, remains controversial (Gilman 2001; Bartelheim 2012; García Sanjuán/Murillo-Barosso 2013).

In general, a significant increase in settlement evidence in areas with good agricultural conditions can be observed in this region during the Copper Age. This applies on the one hand to the unfortified settlements, but especially to the emergence of extraordinarily large fortifications such as Zambujal, Los Millares or Valencina de la Conception, which are connected with metal objects, beakers and the depositing of the deceased in extra-mural megalithic tombs (Chapman 2008, 201–202).

Direct evidence of agricultural production shows the use of cereals, legumes and wild plants and predominantly domesticated animals (mainly cattle and sheep/goats). The knowledge of the water and nutritional needs of the exploited plant and animal species suggests that agricultural production was stable within the relatively marginal environment. A system of dry agriculture with fallow periods and stubble grazing, coupled with the cultivation of legumes along watercourses in valley bottoms, can be considered realistic (Chapman 2008, 201–202).

In the first half of the third millennium a continuous process of social expansion took place. However, around 2200 cal BCE, taking into account regional diversity, there were significant discontinuities which either intensified some of the previous trends or slowed or interrupted them. In any case, new forms of social organization emerged, which according to traditional chronology are usually attributed to the Early Bronze Age (2200–1600 cal BCE) (García Sanjuán/Murillo-Barosso 2013, 120).

With the transition to the Bronze Age, different trajectories became apparent within the southern region. In some parts elements of the bell beaker phenomenon are at least partially and temporarily continued, in others (especially in the southeast) there is a clear break with them (Lull et al. 2013). Especially in the domain of settlement structures, however, a clear change is generally perceptible, which is accompanied by the abandonment of collective burial customs and possibly associated with the emergence of a new symbolic system (Senna-Martinez 2014).

In the southwest there is a widespread abandonment of settlements and discontinuity. Where stratigraphic continuity is evident, there is a clear change in the archaeological remains within a complex (Rivero/Carrasco 2015). The settlement system is now more dispersed, concentrations are found in artificially terraced settlements in higher, more defensible locations and further away from cultivable soils (Chapman 2008, 244). The settlement tradition is also being discontinued in the south-east, but in a different way. The rapid spread of Early Bronze Age cultures on the southeastern Iberian Peninsula seems to be accompanied by a demographic growth (Lull et al. 2011; Risch et al. 2015), as predicted from regional land use reconstructions (Lullet al. 2011) and supported by estimations of grain production (Delgardo-Raack/Risch 2015). New settlements are emerging even more prominently than in the west in well-protected and inaccessible locations, either on steep slopes, or on elevated plains with steep cliffs, such as the eponymous settlement El Argar (Chapman 2008, 205; Risch et al. 2015). This is accompanied by signs of a strongly stratifying society with control over resources and food production (Chapman 2008, 210; Lull et al. 2011). The standard model here is a 'vertical' production system (Lull et al. 2011, 390–398), in which the raw materials were exclusively collected and further processed in the controlling, fortified hilltop settlements. A barley monoculture seems to have developed (Chapman 2008, 205; Delgardo-Raack/Risch 2015, 27), which is cautiously related to drought (Stika 1988; 2001; for late El Argar Lull et al. 2013). In the west as well as in the east the burial tradition is changing to individual (or double) burials, even though the choice of grave goods shows a certain continuity. In the west, extramural burials are more common (Chapman 2008, 245; Lull et al. 2013, 607), in the east, however, burials typically take place within the houses (Risch et al. 2015, 386). Also in the catchment area of the Guadalquivir there are clear indications of settlement discontinuities, where the Chalcolithic settlements at the lower reaches are abandoned and settlement activity shifts to the upper ones. Here archaeozoological findings from the long-term populated Úbeda site also point to a shift in domestic animal husbandry towards sheep/goats, indicating changes in subsistence strategies (Nocete et al. 2010). Not least, climatic influences and the resulting population shifts are also taken into account for these changes (Cardoso 2005).

Widespread settlement discontinuities are also evident in Portugal, where about 4200 years BP the ditch and wall enclosures that characterise the Late Neolithic/Chalcolithic were largely abandoned in the south and survived only sporadically in the north (Valera 2015, 417). The partly monumental and fortified Chalcolithic settlements are abandoned, leaving smaller settlements in the lowlands without any monumentality, which are preserved in the form of 'pit fields' and as 'negative structures'. Monumentality is also disappearing in relation to funeral architecture, in ceramics the proportion of closed forms is increasing, and the previously blade-based lithic industry is now becoming a flaking industry. The iconographically rich symbolic world of the Chalcolithic disappears completely, so that this change is referred to as an iconoclasm (Valera 2015, 418). These significant cultural and settlement changes were apparently accompanied by major demographic changes: a continuous population growth is assumed for the Chalcolithic, but this process abruptly breaks off with the transition to the 2nd millennium cal BCE (Valera 2015, 422).

Materials and Methods

Data acquisition and proxy development

In the following, two data sources for recording the change in settlement intensity at different scaling levels are presented: aoristics and evaluation of sum-calibrated ^{14}C data. The results of these independent data sources both complement and confirm each other, as far as their data basis overlaps spatially. For a more in-depth discussion of the methodology of sum calibration (Hinz et al. 2012; Shennan et al. 2013; critical e.g. Williams 2012; Contreras/Meadows 2014) and aoristics (Ratcliffe 2000; Mischka 2004; Crema 2012; Kolář et al. 2016; Palmisano et al. 2017) we refer to the relevant literature and two methodological contributions from the project, which are currently in progress (aoristics: Hinz and Müller-Scheeßel, n.d.; sum calibration: Hinz, n.d.).

Aoristic is a method that was originally used to investigate crimes (Ratcliffe 2000). As with these, the exact (absolute) dating is often unknown, but can be limited to a phase of a certain duration by marginal information, indicating the start and end of the period within which the event must have taken place. By means of aoristics, the probability that the event took place (100 %) is distributed over this time interval in such a way that each temporal subunit (e.g. one year) receives the total probability divided by the number of subunits.

If there are several objects belonging to such events, describing the same facts (e.g. several settlements indicate the settlement density), the respective probabilities are summed up for each temporal subunit, and in this special case an expectation value is obtained, which describes how many simultaneous settlements most likely existed. A disadvantage of this method is that no uncertainty range can be given. Derived Monte Carlo-based methods (Crema 2012; Kolář et al. 2016) make this possible in a certain sense, although they can also quantify only the internal, not the external, uncertainty. For this reason, the original procedure was used here, as it is much simpler and more comprehensible.

Summed ^{14}C data from archaeological contexts are increasingly used to reveal changes in population density and/or human activities in the broader sense. This approach has now been applied in a large number of studies on different temporal settings (e.g. Hinz et al. 2012; Shennan et al. 2013; Whitehouse et al. 2014; Weinelt et al. 2015; Lillios et al. 2016 to name just a few recent examples). Admittedly, there are a number of problems associated with this approach, such as: the ambiguity of the archaeological contexts of dated materials, the uneven distribution of sampling in space and time, possible differences between burial and settlement contexts, sensitivity to differential preservation and selective material loss and, perhaps most importantly, its dependence on regional and temporal research intensity (critical voices for example Williams 2012; Contreras/Meadows 2014, both with further literature). A desirable random distribution is per se unattainable and accordingly the underlying database is inevitably distorted.

These uncertainties require careful verification and filtering of the data sets, including merging the data per site (i.e. each site then contributes with the weight of 1 to the final sum calibration, regardless of the number of ^{14}C samples taken) and cross-checking with independent quantitative population data. The main advantage of the approach is clearly the constantly increasing availability and quality of archaeological ^{14}C data and the statistical robustness of large data sets, the resulting absolute chronologies and the continuity of the data sets, with each individual sample representing a three-dimensional variable in space and time.

Furthermore, the inherent independence of this proxy from regional archaeological circumstances (e.g. chronology systems) allows the comparison of regional patterns for different cultural units over long distances and the synchronisation of these patterns with reconstructions of environmental changes. It is therefore particularly suitable for investigating transitions in the archaeological remains and in past social-ecological developments at regional to supra-regional level.

Aoristics

The basis for the aoristic analysis consists of 4084 sites with Neolithic, Chalcolithic and/or Bronze Age date from southern Portugal (Algarve, Alentejo and Lisbon). Of these sites taken from the 'Portal do Arqueólogo' of the 'Direção Geral do Património Cultural', 1437 sites remained for evaluation after filtering, as exclusively settlement sites were chosen in order to ensure comparability.

The temporal resolution of the data, which was taken directly from the database, is relatively low: Neolithic, Chalcolithic and Bronze Age each break down into three phases, thus adding up to nine phases altogether.

Sum calibration

For the southeastern Iberian Peninsula, it is certainly true that a strong focus on the El Argar phenomenon distorts the data basis. However, given the scale of this study over several hundred years, such distortion is of secondary importance. Spatially, the scope was extended beyond the work area, since at the time of the analysis (summer 2017) the data basis for the work areas themselves was too small for statistically significant results to be achievable. Therefore, all data in the databases RADON and RADON B (Hinz et al. 2012; Kneisel et al. 2013) of relevant time settings available for the Iberian Peninsula were included. At the same time, however, the analysis was limited to sites with settlement character, again with the premise that distortions due to time-dependent deposition and detection probabilities can be largely avoided in this site category (Hinz et al. 2012, 3332). Thus, 1895 ^{14}C dates of 302 settlement sites remained to be included in the sum calibration. Each site was given a weight of 1 to compensate for different dating frequencies at individual sites.

The software package oxcAAR (Hinz et al. 2018) for the statistical environment R (R Core Team 2017) was used for the actual calibration of the sums. This enables the utilization of the calibration program OxCal (Ramsey 2009), which is widely used in archaeology as a quasi-standard, in conjunction with the automation and programming possibilities offered by R which are indispensable for checking the statistical significance of the sum-calibrated results. The software package oxcAAR is open source and can be downloaded for free.

To check the significance of the result, a Monte Carlo-based simulation approach was chosen. Unlike comparable studies, we assume an equal distribution of ^{14}C data as a null model, not an estimation of a general trend based on a generalized linear model (e.g. Shennan et al. 2013; Lillios et al. 2016). The reason is that we look for significant local variations within a given time window and not, as there, for significant over- or underruns of a population growth assumed as given. Within a time window, the same number of ^{14}C data as in the actual data set was uniformly distributed, this simulation was repeated 1000 times and the 95 % interval of random effects was extracted from this. Where the curve of the real data leaves the envelope of the simulation (in the figure these areas are highlighted in red), with 5 % error probability the observed effect (over- or undershot) is not random or induced by the calibration curve, and the interpretation as event of interest can then be regarded as robust.

Climatological examinations

Methodology

The climate reconstruction is based on the marine sediment core ODP-161–976A from the Alboran Sea (36°12.32′ N; 4°18.76′ W; 1108 m water depth). The age model of this sediment core is taken from a published source (Jiménez-Amat Patricia/Zahn Rainer 2015). The sediment core was sampled in the range of 103 cm to 145 cm depth in 0.5 cm resolution. The samples had already been freeze-dried and for the organic-geochemical analysis initially mortared to a homogeneous sediment powder. The lipids were then extracted at 100 bar pressure and 100°C using an accelerated solvent extractor (ASE-200, Dionex). A solution mixture consisting of dichloromethane (DCM) and methanol (MeOH) in a ratio of 9:1 v/v was used. After extraction, the samples were desulfurized with activated copper chips for 30 minutes. The neutral fraction (using hexane) was separated from the desulfurized samples by liquid chromatography with activated silica gel (pretreated for 4 hours at 450°C). The neutral fraction containing the n-alkanes was also passed through a liquid chromatographic column of silver nitrate treated silica gel to separate aromatics and unsaturated fatty acids to purify the n-alkane fraction. The samples were then left for homogenization at room temperature for about 24 hours.

Subsequently, the n-alkanes were measured with a gas chromatograph (GC) at the Christian-Albrechts-University in Kiel. An Agilent 6890N GC equipped with a flame ionization detector and a Restek XTI-5 capillary column (30 m × 320 µm × 0.25 µm) was used. The n-alkanes were identified and quantified using a standard mixture of n-alkanes of known chain length and concentration. The retention time was used as the basis for identification and the peak areas of the respective components were integrated for quantification.

Proxy

In the context of this publication we unfortunately cannot go into details of the climatological proxies. Details can be found elsewhere (Schirrmacher et al. 2019). In short: The concentration of long-chain n-alkane homologues of terrestrial origin is taken as a precipitation proxy. Since the concentration of these n-alkanes in marine sediments is strongly dependent on the river flow, low concentrations are interpreted as low river flow or dry phase. The data are presented here in a roughly simplified form to avoid pre-empting a separate publication. In the raw data, several phases of relatively stable conditions – delimited by rapid changes – were identified. These are roughly represented here. Small values represent a low n-alkane concentration in the raw data and are therefore indicative for dry climatic conditions.

Results

Aoristics

If we consider the result of the aoristic sum for work area (Fig. 2), it becomes clear that a relatively well represented Neolithic phase is followed by a further significant increase in settlement activity in the Chalcolithic. In the transition to the Bronze Age, an abrupt decline in settlement intensity becomes apparent. Only in the late Bronze Age a slight recovery phase can be derived.

The changes in the spatial structure become apparent when the settlements of the individual phases are mapped. In the Neolithic (Fig. 3) three intensive settlement clusters are recognizable: in the western Algarve, as well as two clusters in the Evora region, of which the western one concentrates west of today's city Evora, the eastern one in the concelho Reguengos de Monsaraz.

This concentration intensifies during the course of the Chalcolithic, where the Algarve region is clearly less represented, and an even stronger clustering in Evora becomes apparent.

With the transition to the Bronze Age, the settlement of the Evora region largely ceased, and there are hardly any Bronze Age settlement sites preserved here. Rather, the region southeast of Beja and again the Algarve are more prominent now, but above all because the northern regions are disappearing. Overall, the settlement is significantly thinner (as can already be seen from the aoristic sum) and more dispersed than in previous periods.

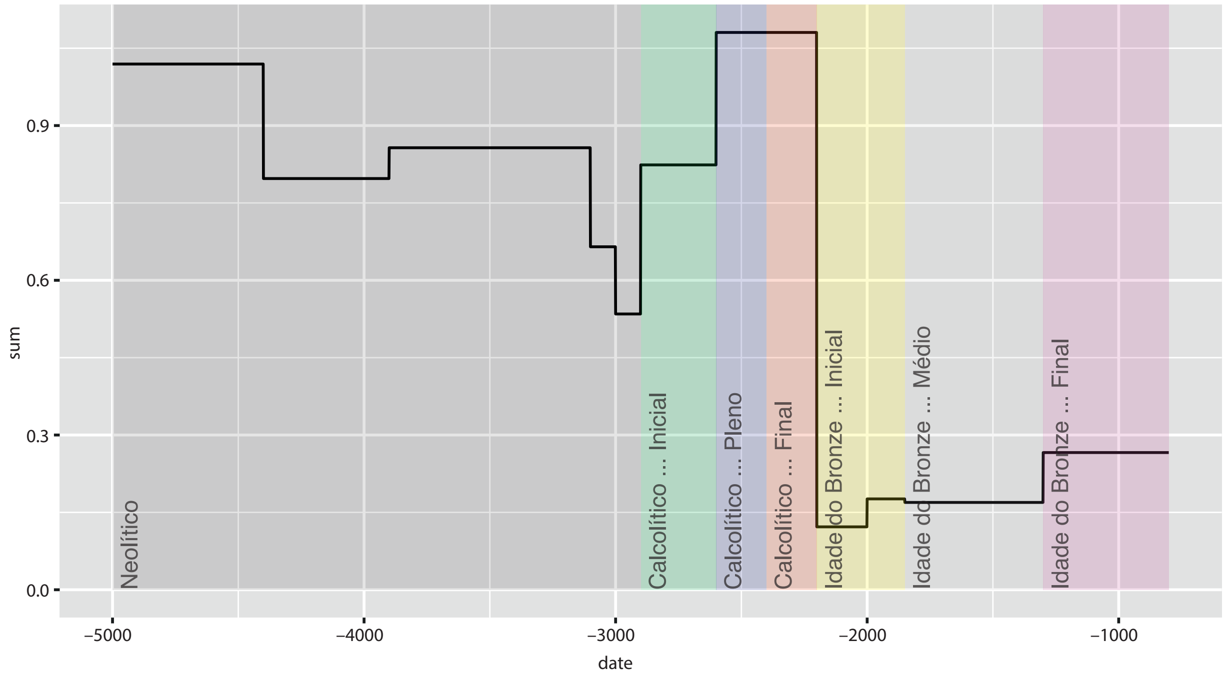


Fig. 2. The aoristic sum of the 1437 settlement sites within southern Portugal.

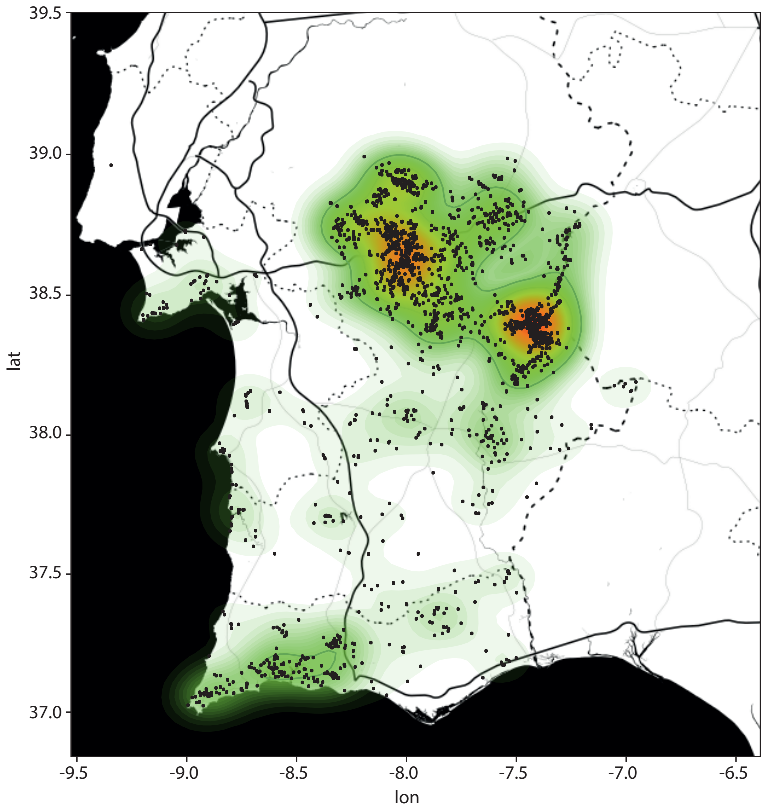


Fig. 3. Map of the aoristic evidence from the Neolithic settlement sites of southern Portugal.

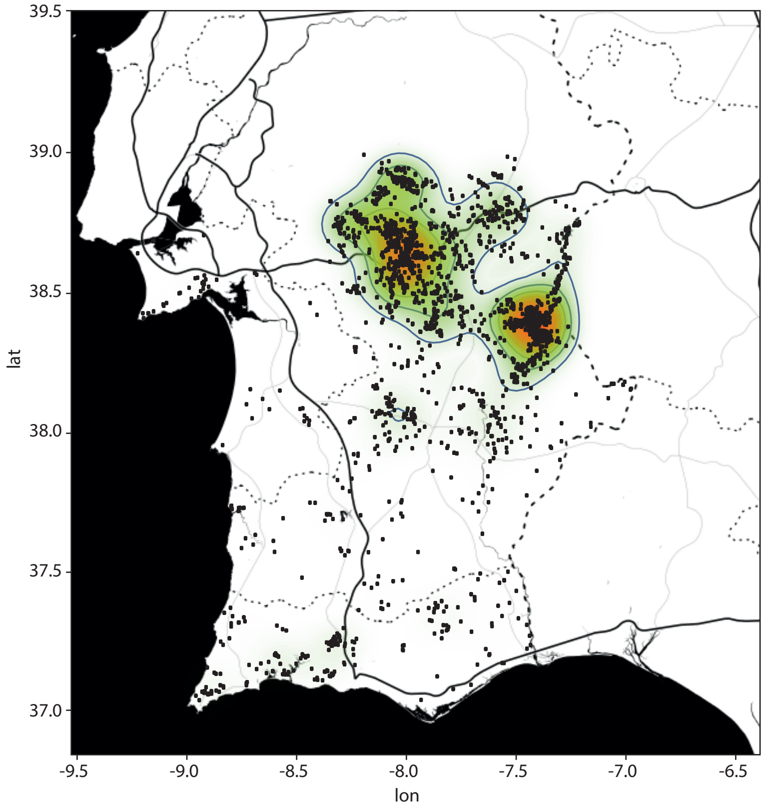


Fig. 4. Map of the aoristic evidence from the Chalcolithic settlement sites of southern Portugal.

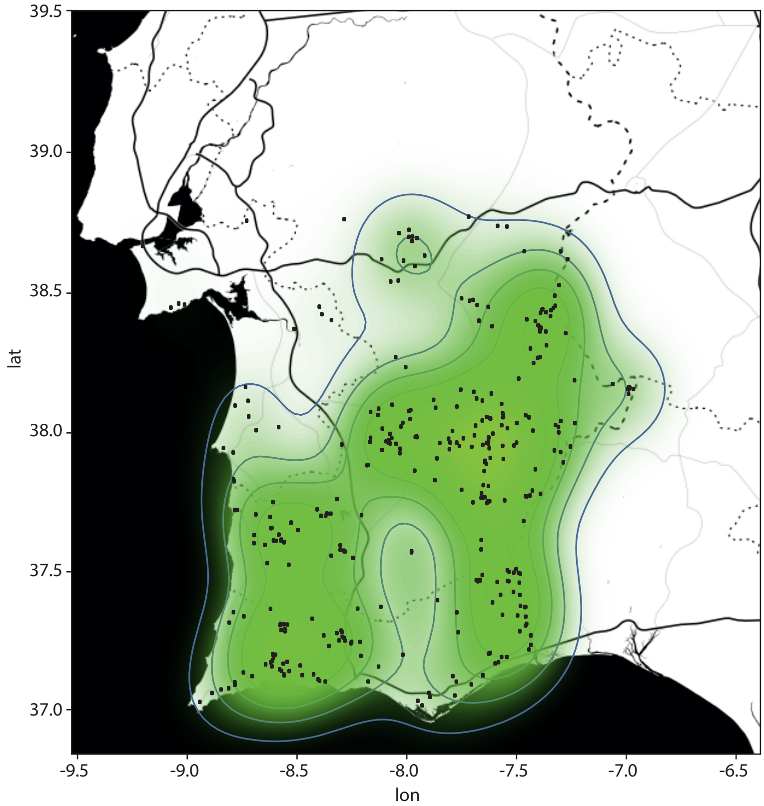


Fig. 5. Map of the aoristic evidence from the Bronze Age settlement sites of southern Portugal.

Sum calibration

Figure 6 shows the result of the sum calibration for the entire Iberian Peninsula. While the Neolithic represents a more or less constant plateau, the settlement intensity documented by the ^{14}C data increases significantly by 3000 cal BCE in the transition to the Chalcolithic. If the probability values of the sum calibration are taken

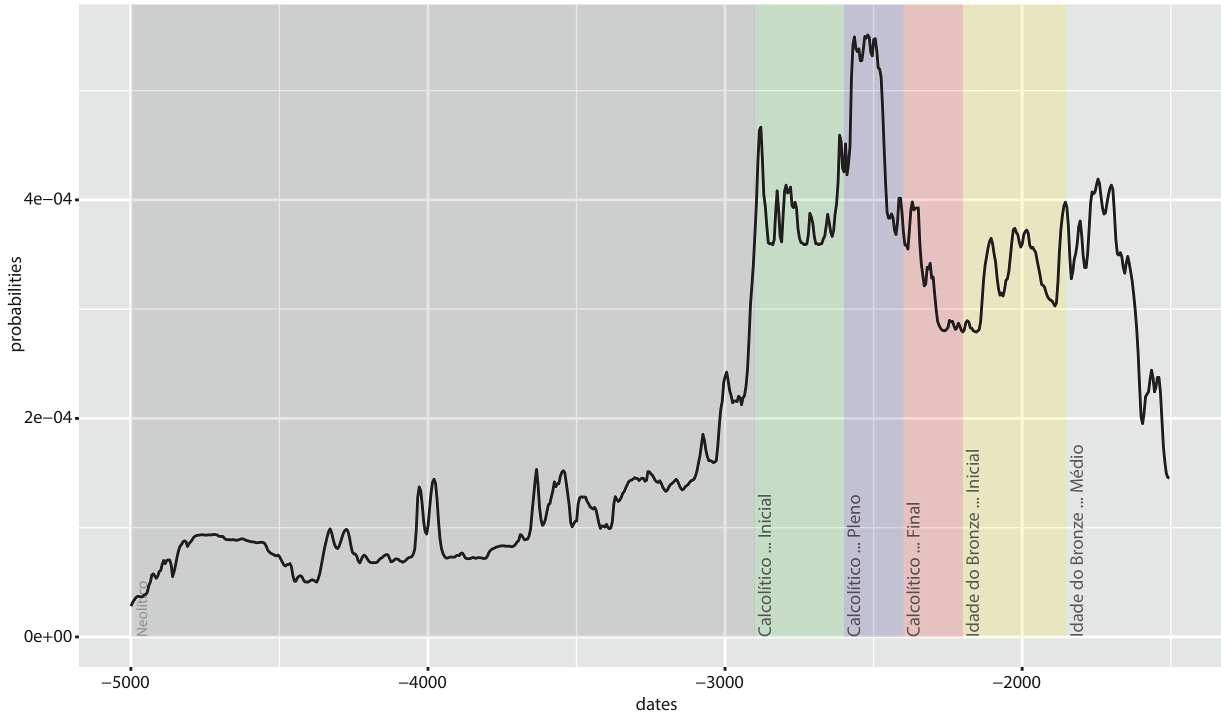


Fig. 6. Sum calibration of 1895 ^{14}C dates (from 302 settlement sites) of the whole Iberian Peninsula.

literally (which, however, is risky due to the possible distortions caused by research), the population density would have quadrupled. Shortly after 2500 cal BCE, and thus after the maximum of the curve, a decrease in intensity is again apparent, which forms a minimum between 2300–2100 cal BC. Shortly after the beginning of the Early Bronze Age, the curve rises again, in contrast to the (aoristic) observation of the southern Portuguese area. This difference is certainly due to different trajectories in the individual southern Iberian regions, as they are already apparent in Lillios et al. (2016), and as they will be described in detail in a later study (Schirrmacher et al. submitted).

The result of the significance analysis shows on the one hand (Fig. 7) that the Chalcolithic and parts of the (early) Bronze Age are significantly overrepresented within the time window between 4000 and 500 cal BCE, and that on the other hand (Fig. 8) within the plateau between 2900 and 1600 cal BCE the decrease at 2200 cal BCE represents a significant anomaly.

Overall, it can be stated here that around the canonical date of the 4.2 ka BP event (~2200 cal BCE) a minimum of settlement activity can be determined.

Climatology

For the detailed evaluation of the climatological investigations and their results, the reader must be referred to another publication (Schirrmacher et al. 2019). Very briefly summarized, the corresponding analyses result in the following picture: In general, according to the proxy used, the climate between 2800 and 1100 cal BCE is rather stable and relatively humid. The precipitation reconstruction shows two rapidly occurring, pronounced dryness phases from 2350 to 2200 cal BCE (4.3–4.15 ka BP) and from 2100 to 2000 cal BCE (4.05–3.95 ka BP), standing out from this background. These two dry phases are interrupted by a return to more humid conditions.

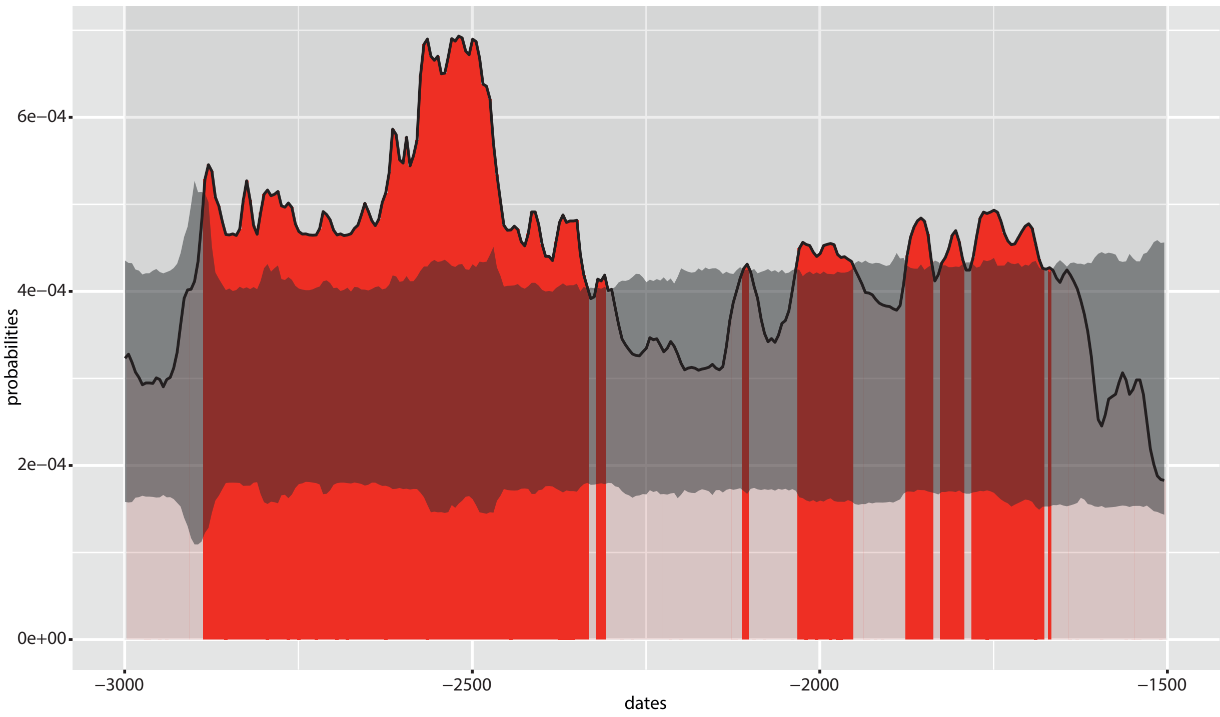


Fig. 7. Significance test for the sum calibration within the time window of 4000–500 cal BCE. Null hypothesis is a uniform distribution of site evidence within this time frame. Number of dates for this time window: 1394 dates from 254 sites.

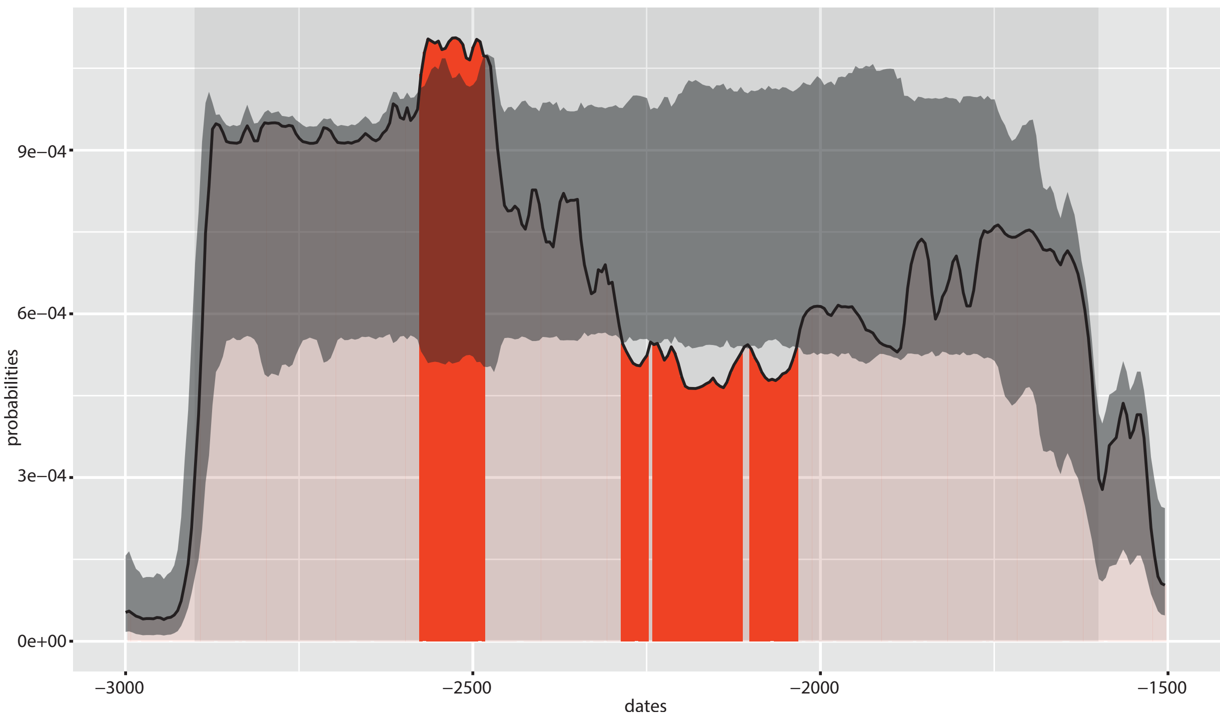


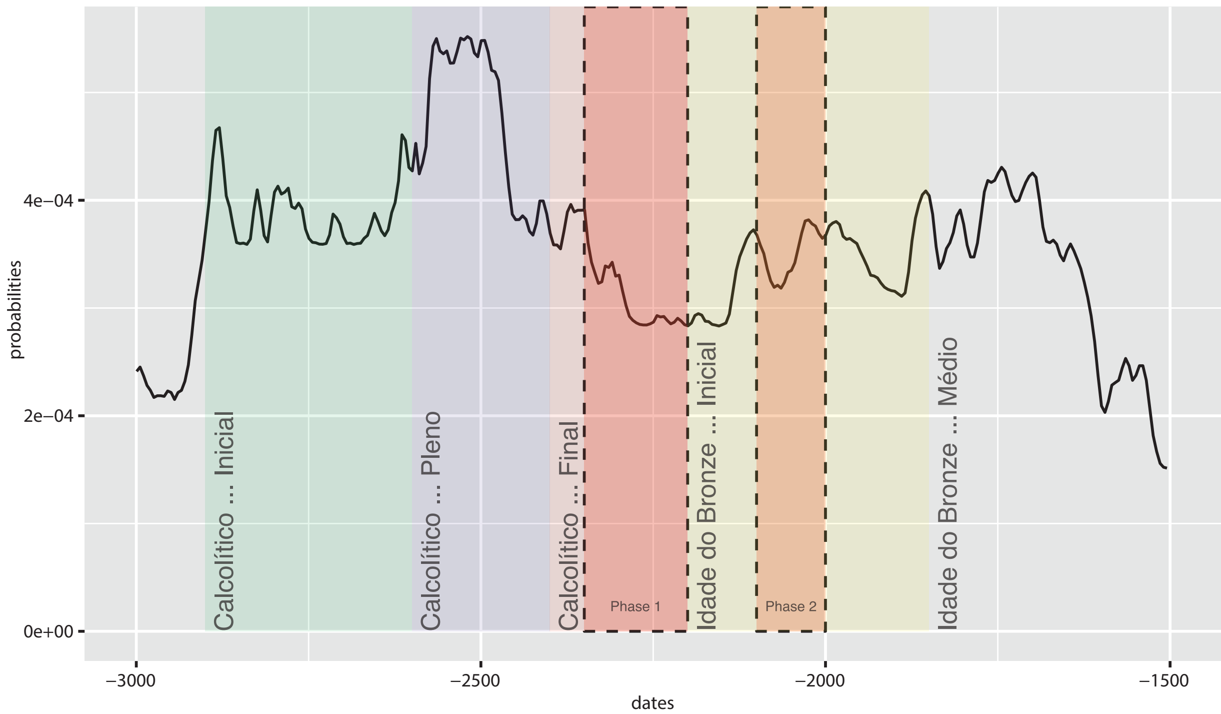
Fig. 8. Significance test for the sum calibration within the time window of 2900–1600 cal BCE. Null hypothesis is a uniform distribution of site evidence within this time frame. Number of dates for this time window: 969 dates from 176 sites.

Discussion

Climate linkage and correlation

By comparing regional and supra-regional proxies for population development with local climate change around the period of the 4.2 ka BP event, new insights and interpretations of the interrelationship of the two developments can be formulated. With regard to the overall development between 4000 and 500 cal BCE, it can be stated that the Chalcolithic period is clearly overrepresented compared to an equal distribution of settlement and thus population evidence. This also applies to some parts of the (Early) Bronze Age, which are certainly due to the expansion of the El Argar phenomenon. The Copper Age on the Iberian Peninsula certainly represents a heyday in settlement terms, even if this is not always easy to grasp in individual cases due to the specific type of occupation and the resulting preservation conditions. Only in the synopsis does this development become clear.

Fig. 9. Sum calibration of the settlement sites of the whole Iberian Peninsula, detail (see Fig. 6), with periods of drought.



Within these Chalcolithic and Early Bronze Age expansion and climax phases, the decline in the period between roughly 2500 and 2100 cal BCE represents a significant decrease, which culminates in a significantly under-represented settlement frequency between 2300 and 2100 cal BCE. From approx. 2000 cal BCE we can see a gradual recovery of settlement intensity, which, however, remains significantly below that of the Copper Age. A partial explanation may be an increased concentration of the settlement structure, since our method essentially analyses the number of settlements over time and is therefore 'blind' to differences in the size of individual settlements and their temporal dynamics. However, if we look at the results of aoristics (based on the same measure), it becomes apparent that, at least in individual regions, there are clear tendencies towards decentralisation that prevent such an explanatory approach from being generally valid.

If we parallelize the climatic and the derived demographic development (Fig. 9) and take into account the smoothing effects of the

^{14}C proxy, it becomes clear that the second decline in settlement intensity can well be associated with the first drought phase in connection with a two-part and 'prolonged' 4.2 ka BP event. In reality, a lag of forcing and effect is very likely, but due to the mentioned smoothing effect and the general temporal uncertainty, this is not apparent here. The minimum in the ^{14}C cumulative curve touches the margins of the second dryness phase, but is itself in the range of returning to more humid conditions. The described synchronism becomes even clearer if one compares the curve of the climatic signal directly with the ^{14}C sum curves and takes into account the regionally different characteristic of the dynamics. For reasons of publication policy (the climatological studies within our project take place within the framework of a natural scientific dissertation), however, reference must unfortunately be made to a later paper for such a detailed presentation. However, the figure shown here and the data presented already indicate that there are good reasons to postulate a connection between the drought events and the decrease in settlement evidence. The fact that the first decline in settlement intensity cannot be linked to a climatic signal is a reminder that socio-economic changes cannot and must not always be attributed to external factors, but may very well be the result of internal, more difficult to identify or unknown factors.

Spatial shift

As the aoristics have shown, very different trends can be seen in the different regions of the Iberian Peninsula, as they have already been shown elsewhere (Lillios et al. 2016). If we concentrate on the southern region, there is a very clear decline in the south-west in connection with the first drought phase, which is equivalent to the interruption of settlement activity, and in which the settlement indicators remain at a very low level in the Early Bronze Age. In the Andalusian region there has also been a significant decline, but there has been a strong recovery during the return to more humid conditions, which continues into the Early Bronze Age and only decreases to a level equal to that of the settlement minimum during the first drought phase with the advent of the El Argar phenomenon. The second drought phase does not appear to have a significant effect here. The south-eastern region is quite different: the first drought phase does not seem to have a significant influence here, but rather a decline in the course of the more humid intermediate phase and the second drought phase can be derived, which leads to a boom after the drier conditions have eased, which can be associated with the El-Argar expansion of the Early Bronze Age.

For the reasons mentioned, no raw data of these trends can be presented here, but from the mappings of the ^{14}C based settlement evidence the alluded shifts can be derived (Fig. 10).

Overall, a general shift in settlement activity from the Copper Age to the Early Bronze Age from the west to the east can be observed, which can be linked to climatic developments, their effects on agricultural conditions and the associated evasion and adaptation strategies via intermediate stages. At the end of the development is the El Argar phenomenon, within which people were able to create a flourishing and expanding socio-economical complex in the economically non-optimal areas of south-eastern Spain by means of adapted and (not least on drought) optimized farming methods. It is precisely these regions, namely Almeria and Murcia, which today are among the driest in Europe and one of the most mountainous on the peninsula.

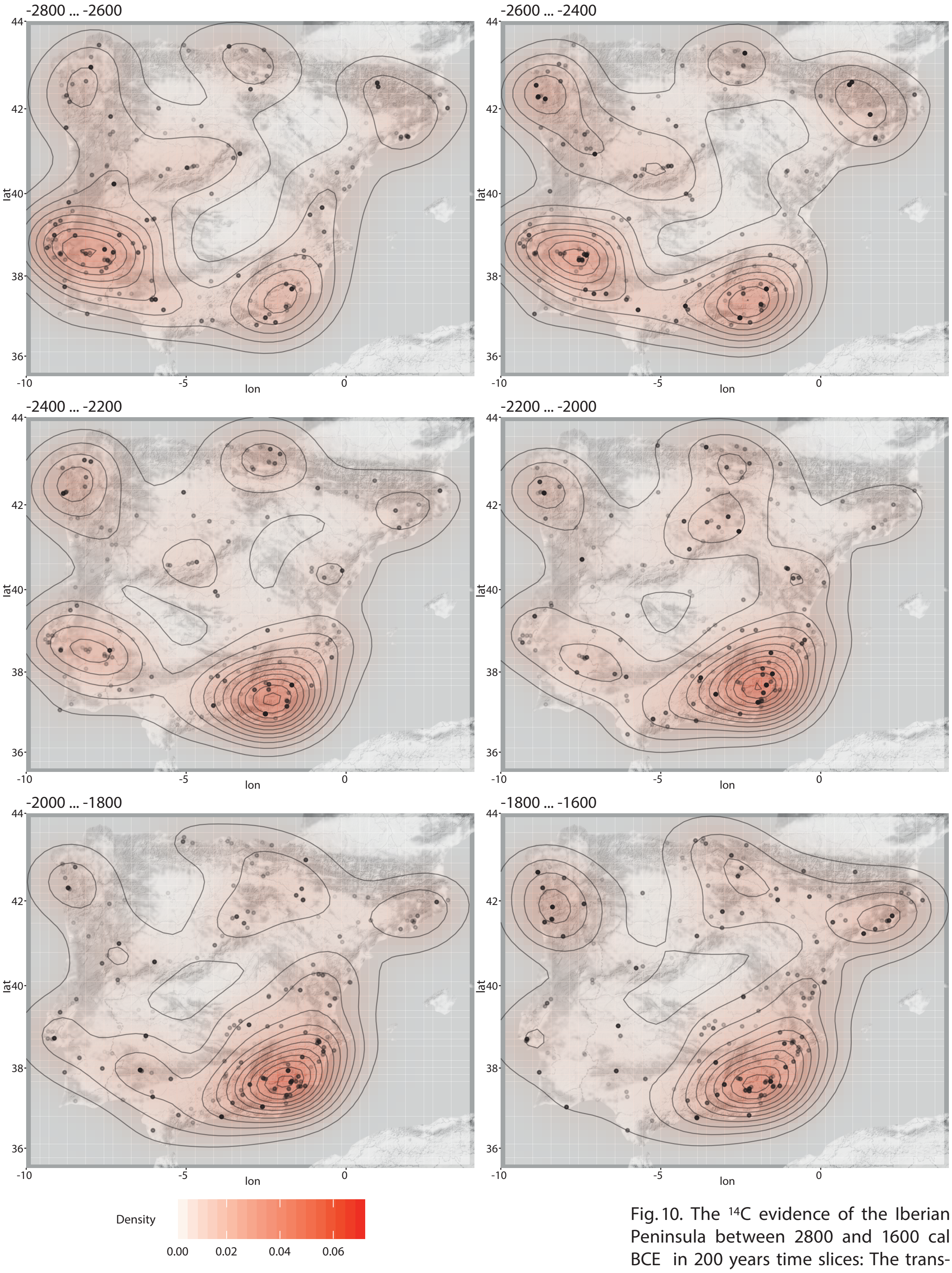


Fig. 10. The ^{14}C evidence of the Iberian Peninsula between 2800 and 1600 cal BCE in 200 years time slices: The transparency of the sites represents probability from the ^{14}C data, the shading and contour lines represent density of sites.

Conclusions and Outlook

As has been shown, the transition from the Chalcolithic to the Early Bronze Age on the southern Iberian Peninsula, which primarily represents a cultural and technical innovation, is taking place in the course of a demographic transformation and is accompanied by a climatic development in which two rapidly occurring, pronounced periods of drought are likely to have influenced the environmental conditions and thus also the economic basis of the societies in this region. The aim of the project presented here is, and will continue to be, to establish the connection between these different levels. A first step in this direction is to determine to what extent these developments can actually be parallelized. According to the available results, this seems very well possible.

The next step will be to ask whether causal relationships can also be established here, and how the mechanisms of change present themselves in detail. We were able to show that the drought phases can be linked not only in general to the overall dynamics of population development on the southern Iberian peninsula, but that spatial shifts of population centres are also connected with the drought phases. This makes a causal relationship beyond a mere correlation likely. In the first drought phase, for example, the result appears to have been the abandonment of areas that were no longer economically viable, while the second phase may have necessitated new adaptation strategies that may have been the driving force behind the further development and the emergence of the El Argar complex.

However, it must be noted that a complex social event cannot be explained by monocausal reasons and that, despite the obvious relationships, it is not our intention to formulate here a simple equation from climate to economy and demography to socio-cultural change.

Reinforcement, feedback and consequential effects are likely to have culminated in regional crises, up to a supra-regional scale. Such a supra-regional socio-ecological crisis can threaten social and environmental stability equally, and the resulting social pressures could have played an important role in the spread, acceleration and shaping of general transformations at the end of the 3rd millennium BCE in the western Mediterranean and through far-reaching effects also on the development of contemporary societies in central and northern Europe. Potential crisis drivers whose role must be assessed beyond external triggers and amplifiers such as drought or other abrupt climate deteriorations are social inequality, overexploitation and competition for resources, demographic change due to increased mobility and possibly large population shifts, and violent conflicts.

Nevertheless, all these influences on the course of human history are interrelated, which is one more reason not to lose sight of climatic development. The investigation of the situation of the southern Iberian Peninsula has shown on an overarching level that general trends converged at a certain point in time in the second half of the 3rd millennium BCE, and influenced the trajectories of further development in this area and beyond. In the further process of the investigations, smaller-scale and more detailed analyses will now have to be carried out, which will make it possible to focus more strongly on local characteristics. This will be the work of the next three years. However, it should already be noted that the close cooperation between the humanities and the natural sciences that we are striving for in our project, which goes beyond simple interdisciplinarity, opens up new perspectives and investigation possibilities with regard to human-environment relations and their historical role.

References

Andel et al. 1990: T.H. van Andel/ E. Zangger/ A. Demitrack, Land Use and Soil Erosion in Prehistoric and Historical Greece. Journal of Field Archaeology 17, 4, 1990, 379–396. doi: 10.2307/530002.

Bar-Matthews et al. 1997: M. Bar-Matthews/ A. Ayalon/ A. Kaufman, Late Quaternary Paleoclimate in the Eastern Mediterranean Region from Stable Isotope Analysis of Speleothems at Soreq Cave, Israel. Quaternary Research 47, 2, 1997, 155–168. doi: 10.1006/qres.1997.1883.

Bartelheim 2012: M. Bartelheim, Detecting social structures in the Bronze Age of southeastern Spain. In: T.L. Kienlin/ A. Zimmermann (eds.), Beyond elites : Alternatives to hierarchical systems in modelling social formations ; international conference at the Ruhr-Universität Bochum, Germany, October 22–24, 2009. Universitätsforschungen zur prähistorischen Archäologie 215 (Bonn 2012) 339–354.

Bettencourt et al. 2007: A. Bettencourt/ A. Dinis/ I. Figueiral/ A. Rodrigues/ C. Cruz/ I. Silva/ M. Azevedo/ R. Barbosa, A ocupação do território e a exploração dos recursos durante a Pré-História Recente do Noroeste de Portugal. In: S.O. Jorge/ A. Bettencourt/ I. Figueiral (eds.), A concepção das paisagens e dos espaços na arqueologia da Península Ibérica: Actas do IV Congresso de Arqueologia Peninsular (Faro, 14 a 19 Setembro de 2004) (Faro 2007) 149–164.

Bond et al. 1997: G. Bond/ W. Showers/ M. Cheseby/ R. Lotti/ P. Almasi/ P. deMenocal/ P. Priore/ H. Cullen/ I. Hajdas/ G. Bonani, A Pervasive Millennial-Scale Cycle in North Atlantic Holocene and Glacial Climates. Science 278, 5341, 1997, 1257–1266. doi: 10.1126/science.278.5341.1257.

Bond et al. 2001: G. Bond/ B. Kromer/ J. Beer/ R. Muscheler/ M.N. Evans/ W. Showers/ S. Hoffmann/ R. Lotti-Bond/ I. Hajdas/ G. Bonani, Persistent Solar Influence on North Atlantic Climate During the Holocene. Science 294, 5549, 2001, 2130–2136. doi: 10.1126/science.1065680.

Booth et al. 2005: R.K. Booth/ S.T. Jackson/ S.L. Forman/ J.E. Kutzbach/ E.A. Bettis/ J. Kreigs/ D.K. Wright, A severe centennial-scale drought in midcontinental North America 4200 years ago and apparent global linkages. The Holocene 15, 321–328. doi: 10.1191/0959683605hl825ft

Brisset et al. 2013: E. Brisset/ C. Miramont/ F. Guiter/ E.J. Anthony/ K. Tachikawa/ J. Poulenard/ F. Arnaud/ C. Delhon/ J.-D. Meunier/ E. Bard/ F. Suméra, Non-reversible geosystem destabilisation at 4200 cal. BP: Sedimentological, geochemical and botanical markers of soil erosion recorded in a Mediterranean alpine lake. The Holocene 23, 12, 2013, 1863–1874. doi: 10.1177/0959683613508158.

Burjachs et al. 2015: F. Burjachs/ I. Expósito, Charcoal and pollen analysis: Examples of Holocene fire dynamics in Mediterranean Iberian Peninsula. CATENA 135, 2015, 340–349. doi: 10.1016/j.catena.2014.10.006.

Cacho et al. 2001: I. Cacho/ J.O. Grimalt/ M. Canals/ L. Sbaffi/ N.J. Shackleton/ J. Schönfeld/R. Zahn, Variability of the western Mediterranean Sea surface temperature during the last 25,000 years and its connection with the Northern Hemisphere climatic changes. Paleoceanography 16, 1, 2001, 40–52. doi: 10.1029/2000PA000502.

Carrión et al. 2003: J.S. Carrión/ P. Sánchez-Gómez/ J.F. Mota/ R. Yll/ C. Chaín, Holocene vegetation dynamics, fire and grazing in the Sierra de Gádor, southern Spain. The Holocene 13, 6, 2003, 839–849. doi: 10.1191/0959683603hl662rp.

Carrión et al. 2007: J.S. Carrión/ N. Fuentes/ P. González-Sampériz/ L. Sánchez Quirante/ J.C. Finlayson/ S. Fernández/ A. Andrade, Holocene environmental change in a montane region of southern Europe with a long history of human settlement. Quaternary Science Reviews 26, 11, 2007, 1455–1475. doi: 10.1016/j.quascirev.2007.03.013.

Cardoso 2005: J.L. Cardoso, Visibilidade e invisibilidade do património arqueológico : O caso do Bronze Pleno da Extremadura. Discursos. Lingua, Cultura e Sociedade. Estudos do Património 6, 2005, 7–27.

Cauliez 2015: J. Cauliez, The Bell Beaker Complex: A vector of transformations? Stabilities and changes of the indigenous cultures in south-east France at the end of the Neolithic Period. In: M.P. Prieto Martinez/ L. Salanova (eds.), The bell beaker transition in Europe: Mobility and local evolution during the 3rd Millennium BC (Oxford 2015) 88–112.

Chapman 1990: R. Chapman, Emerging complexity: The later prehistory of south-east Spain, Iberia and the west Mediterranean. New studies in archaeology (Cambridge [u.a.] 1990).

Chapman 2008: R. Chapman, Producing Inequalities: Regional Sequences in Later Prehistoric Southern Spain. Journal of World Prehistory 21, 3–4, 2008, 195. doi: 10.1007/s10963-008-9014-y.

Chapman et al. 1982: R. Chapman, Autonomy, ranking and resources in Iberian prehistory: Ranking, resource and exchange – aspects of the archaeology of early European society. In: C. Renfrew/ S. Shennan (eds.), Ranking, Resource and Exchange: Aspect of the Archaeology of Early European Society (Cambridge 1982) 46–51.

Contreras/Meadows 2014: D.A. Contreras/ J. Meadows, Summed radiocarbon calibrations as a population proxy: A critical evaluation using a realistic simulation approach. Journal of Archaeological Science 52, 2014, 591–608. doi: 10.1016/j.jas.2014.05.030.

Crema 2012: E.R. Crema, Modelling Temporal Uncertainty in Archaeological Analysis. Journal of Archaeological Method and Theory 19, 3, 2012, 440–461. doi: 10.1007/s10816-011-9122-3.

Cruz et al. 2015: J.A. Cruz/ M.J. Turrero/ J.O. Cáceres/ A. Marín-Roldán/ A.I. Ortega/ A. Garralón/ L. Sánchez/ P. Gómez/ M.B. Muñoz-García/ R.L. Edwards/ J. Martín-Chivelet, Long-term hydrological changes in northern Iberia (4.9–0.9 ky BP) from speleothem Mg/Ca ratios and cave monitoring (Ojo Guareña Karst Complex, Spain). Environmental Earth Sciences 74, 12, 2015, 7741–7753. doi: 10.1007/s12665-015-4687-x.

Cruz Berrocal et al. 2013: M. Cruz Berrocal/ L.G. Sanjuán/ A. Gilman, Debating early social stratification and the state in Prehistoric Iberia: An introduction. In: M. Cruz Berrocal/ L. García Sanjuán/ A. Gilman (eds.), The Prehistory of Iberia: Debating Early Social Stratification and the State (New York, London 2013) 3–10.

Davis et al. 2003: B.A.S. Davis/ S. Brewer/ A.C. Stevenson/ J. Guiot, The temperature of Europe during the Holocene reconstructed from pollen data. Quaternary Science Reviews 22, 15, 2003, 1701–1716. doi: 10.1016/S0277-3791(03)00173-2.

Delgardo-Raack/Risch 2015: S. Delgardo-Raack/ R. Risch, Social Change and Subsistence Production on the Iberian Peninsula during the 3rd and 2nd Millennia BCE. In: J. Kneisel/ M. Dal Corso/ W. Kirleis/ H. Scholz/ N. Taylor/ V. Tiedtke (eds.), The Third Food Revolution? Setting the Bronze Age table: Common trends in economic and subsistence strategies in Bronze Age Europe: Proceedings of the International Workshop "Socio-Environmental Dynamics over the Last 12,000 Years: The Creation of Landscapes III (15th–18th April 2013)" in Kiel. Universitätsforschungen zur prähistorischen Archäologie Band 283 (Bonn 2015) 21–46.

Dixit et al. 2014: Y. Dixit/ D.A. Hodell/ R. Sinha/ C.A. Petrie, Abrupt weakening of the Indian summer monsoon at 8.2 kyr B.P. Earth and Planetary Science Letters 391, 2014, 16–23. doi: 10.1016/j.epsl.2014.01.026.

Díaz del Río 2004: P. Díaz del Río, Factionalism and collective labor in Copper Age Iberia. Trabajos de Prehistoria 61, 2, 2004, 85–98.

Enrich/M. Mejías 2017: L.B. de L. Enrich/ M. Mejías, The hydrogeological and paleoclimatic factors in the Bronze Age Motillas Culture of La Mancha (Spain): The first hydraulic culture in Europe. Hydrogeology Journal 25, 7, 2017, 1931–1950. doi: 10.1007/s10040-017-1607-z.

Fabián García et al. 2006: J.F. Fabián García/ A.B. González/ J.A.L. Sáez, La transición del Calcolítico-Bronce Antiguo desde una perspectiva arqueológica y ambiental: El Valle Amblés (ávila) como referencia. Arqueología espacial, 26, 2006, 37–56.

Finné et al. 2011: M. Finné/ K. Holmgren/ H.S. Sundqvist/ E. Weiberg/ M. Lindblom, Climate in the eastern Mediterranean, and adjacent regions, during the past 6000 years – A review. Journal of Archaeological Science 38, 12, 2011, 3153–3173. doi: 10.1016/j.jas.2011.05.007.

Fletcher et al. 2007: W.J. Fletcher/ T. Boski/ D. Moura, Palynological evidence for environmental and climatic change in the lower Guadiana valley, Portugal, during the last 13 000 years. The Holocene 17, 4, 2007, 481–494. doi: 10.1177/0959683607077027.

Furholt 2017: M. Furholt, Massive Migrations? The Impact of Recent aDNA Studies on our View of Third Millennium Europe. European Journal of Archaeology, 2017, 1–33. doi: 10.1017/eaa.2017.43.

García Sanjuán/Murillo-Barosso 2013: L. García Sanjuán/ M. Murillo-Barosso, Social complexity in Copper Age Southern Iberia (ca. 3200–2200 cal. B.C.). Reviewing the "State" Hypothesis at Valencina de la Conception (Seville, Spain). In: M. Cruz Berrocal/ A. Gilman/ L. García Sanjuán (eds.), The prehistory of Iberia: Debating early social stratification and the state. Routledge studies in archaeology 6 (New York 2013) 119–140.

Gilman 1987: A. Gilman, Unequal development in copper age Iberia. In: E. Brumfiel/ T. Earle (eds.), Specialization, Exchange, and Complex Societies (Cambridge 1987) 22–29.

Gilman 2001: A. Gilman, Assessing Political Development in Copper and Bronze Age Southeast Spain. In: J. Haas (ed.), From leaders to rulers. Fundamental issues in archaeology (New York 2001) 59–81.

Gilman/Thornes 1985: A. Gilman/ J.B. Thornes, Land-use and prehistory in South-East Spain. The London research series in geography 8 (London 1985).

Gupta et al. 2003: A.K. Gupta/ D.M. Anderson/ J.T. Overpeck, Abrupt changes in the Asian southwest monsoon during the Holocene and their links to the North Atlantic Ocean. Nature 421, 6921, 2003, 354–357.

Günther et al. 2015: T. Günther/ C. Valdiosera/ H. Malmström/ I. Ureña/ R. Rodriguez-Varela/Ó.O. Sverrisdóttir/ E.A. Daskalaki/ P. Skoglund/ T. Naidoo/ E.M. Svensson/J.M.B. de Castro/ E. Carbonell/ M. Dunn/ J. Storå/ E. Iriarte/ J.L. Arsuaga/ J.-M. Carretero/ A. Götherström/ M. Jakobsson, Ancient genomes link early farmers from Atapuerca in Spain to modern-day Basques. Proceedings of the National Academy of Sciences 112, 38, 2015, 11917–11922. doi: 10.1073/pnas.1509851112.

Hinz et al. 2012 a: M. Hinz/ I. Feeser/ K.-G. Sjögren/ J. Müller, Demography and the intensity of cultural activities: An evaluation of Funnel Beaker Societies (4200–2800 cal BC). Journal of Archaeological Science 39, 10, 2012, 3331–3340. doi: 10.1016/j.jas.2012.05.028.

Hinz et al. 2012 b: M. Hinz/ M. Furholt/ J. Müller/ C. Rinne/ D. Raetzel-Fabian/ K.-G. Sjögren/ H.-P. Wotzka, RADON - Radiocarbon dates online 2012. Central European database of ^{14}C dates for the Neolithic and the Early Bronze Age. Journal of Neolithic Archaeology, 2012.
doi: 10.12766/jna.2012.65.

Hinz et al. 2018: M. Hinz/ C. Schmid/ D. Knitter/ C. Tietze, OxcAAR: Interface to 'oxcal' radiocarbon calibration (2018).
https://cran.r-project.org/package=oxcaar

Hinz n.d.: M. Hinz, To sum it up. Methodological challenges and statistical solutions for some problems related to demographic analysis of summed ^{14}C data.

Hinz/Müller-Scheeßel in prep.: M. Hinz/ N. Müller-Scheeßel, Systematic distortions and possible corrections in the use of probabilistic temporal frequency analysis (Aoristics). In preparation.

Hutado 1997: V. Hutado, The dynamics of the occupation of the middle basin of the river Guadiana between the fourth and second millennia BC. In: M. Díaz-Andreu García/S.J. Keay (eds.), The archaeology of Iberia. The dynamics of change (London, New York 1997).

IPCC 2013: IPCC, Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge, United Kingdom; New York, NY, USA 2013). www.climatechange2013.org

Jalut et al. 2000: G. Jalut/ A. Esteban Amat/ L. Bonnet/ T. Gauquelin/ M. Fontugne, Holocene climatic changes in the Western Mediterranean, from south-east France to south-east Spain. Palaeogeography, Palaeoclimatology, Palaeoecology 160, 3, 2000, 255–290.
doi: 10.1016/S0031-0182(00)00075-4.

Jalut et al. 2009: G. Jalut/ J.J. Dedoubat/ M. Fontugne/ T. Otto, Holocene circum-Mediterranean vegetation changes: Climate forcing and human impact. Quaternary International 200, 1, 2009, 4–18.
doi: 10.1016/j.quaint.2008.03.012.

Jiménez-Amat Patricia/Zahn Rainer 2015: P. Jiménez-Amat/ R. Zahn, Offset timing of climate oscillations during the last two glacial-interglacial transitions connected with large-scale freshwater perturbation. Paleoceanography 30, 6, 2015, 768–788. doi: 10.1002/2014PA002710.

Kaniewski et al. 2017: D. Kaniewski/ N. Marriner/ D. Ilan/ C. Morhange/ Y. Thareani/ E.V. Campo, Climate change and water management in the biblical city of Dan. Science Advances 3, 11, 2017, e1700954.
doi: 10.1126/sciadv.1700954.

Kneisel et al. 2013: J. Kneisel/ M. Hinz/ C. Rinne, RADON-B – Radiocarbon-dates online. Database for European ^{14}C dates for the Bronze and Early Iron Age. http://radon-b.ufg.uni-kiel.de/

Kolář et al. 2016: J. Kolář/ M. Macek/ P. Tkáč/ P. Szabó, Spatio-Temporal Modelling As A Way to Reconstruct Patterns of Past Human Activities. Archaeometry 58, 3, 2016, 513–528. doi: 10.1111/arcm.12182.

Lillios 1997: K. T. Lillios, The Third Millennium BC in Iberia: Chronometric Evidence for Settlement Histories and Socio-cultural Change. In: Third Millennium BC Climate Change and Old World Collapse. NATO ASI Series (1997) 173–191.

Lillios 2015: K.T. Lillios, Crossing Borders: Death and Life in Second Millennium BC Southern Iberia and North Africa. In: A.B. Knapp/ P. van Dommelen (eds.), The Cambridge Prehistory of the Bronze and Iron Age Mediterranean (2015) 554–570.

Lillios et al. 2016: K.T. Lillios/ A. Blanco-González/ B.L. Drake/ J.A. López-Sáez, Mid-late Holocene climate, demography, and cultural dynamics in Iberia: A multi-proxy approach. Quaternary Science Reviews 135, 2016, 138–153. doi: 10.1016/j.quascirev.2016.01.011.

van der Linden 2016: M. van der Linden, Population history in third-millennium-BC Europe: Assessing the contribution of genetics. World Archaeology 48, 5, 2016, 714–728. doi: 10.1080/00438243.2016.1209124.

Lionello et al. 2006: P. Lionello/ P. Malanotte-Rizzoli/ R. Boscolo (eds.), Mediterranean climate variability (Amsterdam [u.a.] 2006).

López-Sáez et al. 2014: J.A. López-Sáez/ D. Abel-Schaad/ S. Pérez-Díaz/ A. Blanco-González/ F. Alba-Sánchez/ M. Dorado/ B. Ruiz-Zapata/ M.J. Gil-García/ C. Gómez-González/ F. Franco-Múgica, Vegetation history, climate and human impact in the Spanish Central System over the last 9000 years. Quaternary International 353. Environmental History of European High Mountains, 2014, 98–122. doi: 10.1016/j.quaint.2013.06.034.

Lull et al. 2011: V. Lull/ R. Micó/ C. Rihuete Herrada, El Argar and the Beginning of Class Society in the Western Mediterranean. In: S. Hansen/ J. Müller (eds.), Sozialarchäologische Perspektiven: Gesellschaftlicher Wandel 5000–1500 v. Chr. zwischen Atlantik und Kaukasus : Internationale Tagung, 15. Archäologie in Eurasien 24 (2011) 381–414.

Lull et al. 2013 a: V. Lull/ Rafael Micó/ Cristina Rihuete Herrada/ R. Risch, Bronze Age Iberia. In: H. Fokkens/ A. Harding (eds.), The Oxford handbook of the European Bronze Age (Oxford 2013) 594–616.

Lull et al. 2013 b: V. Lull/ C. Rihuete/ R. Micó/ R. Risch, Political collapse and social change at the end of El Argar. In: H. Meller/ F. Bertemes/ H.-R. Bork/ R. Risch (eds.), (2013) 283–302.

Lull et al. 2014: V. Lull/ R. Micó/ C. Rihuete-Herrada/ R. Risch, The La Bastida fortification: New light and new questions on Early Bronze Age societies in the western Mediterranean. Antiquity 88, 340, 2014, 395–410. doi: 10.1017/S0003598X00101073.

Magny et al. 2009: M. Magny/ B. Vannière/ G. Zanchetta/ E. Fouache/ G. Touchais/ L. Petrika/ C. Coussot/ A.-V. Walter-Simonnet/ F. Arnaud, Possible complexity of the climatic event around 4300–3800 cal BP in the central and western Mediterranean. The Holocene 19, 6, 2009, 823–833. doi: 10.1177/0959683609337360.

Magri/Parra 2002: D. Magri/ I. Parra, Late Quaternary western Mediterranean pollen records and African winds. Earth and Planetary Science Letters 200, 3, 2002, 401–408. doi: 10.1016/S0012–821X(02)00619–2.

Maran 1998: J. Maran, Kulturwandel auf dem griechischen Festland und den Kykladen im späten 3. Jahrtausend v. Chr.: Studien zu den kulturellen Verhältnissen in Südosteuropa und dem zentralen sowie östlichen Mittelmeerraum in der späten Kupfer- und frühen Bronzezeit. Universitätsforschungen zur prähistorischen Archäologie 53 (Bonn 1998).

Marino et al. 2009: G. Marino/ E.J. Rohling/ F. Sangiorgi/ A. Hayes/ J.L. Casford/ A.F. Lotter/ M. Kucera/ H. Brinkhuis, Early and middle Holocene in the Aegean Sea: Interplay between high and low latitude climate variability. Quaternary Science Reviews 28, 27, 2009, 3246–3262. doi: 10.1016/j.quascirev.2009.08.011.

Martiniano et al. 2017: R. Martiniano/ L.M. Cassidy/ R. Ó'Maoldúin/ R. McLaughlin/ N.M. Silva/ L. Manco/ D. Fidalgo/ T. Pereira/ M.J. Coelho/ M. Serra/ J. Burger/ R. Parreira/ E. Moran/ A.C. Valera/ E. Porfirio/ R. Boaventura/ A.M. Silva/ D.G. Bradley, The population genomics of archaeological transition in west Iberia: Investigation of ancient substructure using imputation and haplotype-based methods. PLoS Genetics 13, 7, 2017. doi: 10.1371/journal.pgen.1006852.

de Menocal et al. 2000: P.de Menocal/ J.Ortiz/ T.Guilderson/ M. Sarnthein, Coherent High- and Low-Latitude Climate Variability During the Holocene Warm Period. Science 288, 5474, 2000, 2198–2202. doi: 10.1126/science.288.5474.2198.

De Menocal 2001: P.B.deMenocal, Cultural Responses to Climate Change During the Late Holocene. Science 292, 667–673. doi: 10.1126/science.1059287

Mischka 2004: D.Mischka, Aoristische Analyse in der Archäologie. Archäologische Informationen : Mitteilungen zur Ur- und Frühgeschichte 27, 2, 2004, 233–243.

Nocete et al. 2010: F.Nocete/ R.Lizcano/ A.Peramo/ E.Gómez, Emergence, collapse and continuity of the first political system in the Guadalquivir Basin from the fourth to the second millennium BC: The long-term sequence of úbeda (Spain). Journal of Anthropological Archaeology 29, 2, 2010, 219–237. doi: 10.1016/j.jaa.2010.03.001.

Ontañón 2013: R.Ontañón, Social dynamics in the recent prehistory of Northern Iberia: Examining the margins of the Mediterranean regions. In: M.Cruz Berrocal/ A.Gilman/ L.García Sanjuán (eds.), The prehistory of Iberia: Debating early social stratification and the state. Routledge studies in archaeology 6 (New York 2013) 203–230.

Palmisano et al. 2017: A.Palmisano/ A.Bevan/ S.Shennan, Comparing archaeological proxies for long-term population patterns: An example from central Italy. Journal of Archaeological Science 87, 2017, 59–72. doi: 10.1016/j.jas.2017.10.001.

Parcero Oubiña/Criado Boado 2013: C.Parcero Oubiña/ F.Criado Boado, Social Change, Social Resistance. A Long-Term Approach to the Processes of Transformation of Social Landscapes in the Northwest Iberian Peninsula. In: M.Cruz Berrocal/ A.Gilman/ L.García Sanjuán (eds.), The prehistory of Iberia: Debating early social stratification and the state. Routledge studies in archaeology 6 (New York 2013) 249–266.

R 2017: R Core Team, R: A language and environment for statistical computing (Vienna, Austria 2017). https://www.r-project.org/

Ramsey 2009: C.B.Ramsey, Bayesian Analysis of Radiocarbon Dates. Radiocarbon 51, 1, 2009, 337–360. doi: 10.1017/S0033822200033865.

Ratcliffe 2000: J.H.Ratcliffe, Aoristic analysis: The spatial interpretation of unspecific temporal events. International Journal of Geographical Information Science 14, 7, 2000, 669–679. doi: 10.1080/136588100424963.

Rohling/De Rijk 1999: E.J.Rohling/ S.De Rijk, Holocene Climate Optimum and Last Glacial Maximum in the Mediterranean: The marine oxygen isotope record. Marine Geology 153, 1, 1999, 57–75. doi: 10.1016/S0025-3227(98)00020-6.

Riehl 2008: S.Riehl, Climate and agriculture in the ancient Near East: a synthesis of the archaeobotanical and stable carbon isotope evidence. Vegetation History and Archaeobotany 17, 43. doi: 10.1007/s00334-008-0156-8

Risch et al. 2015: R.Risch/ V.Lull/ R.Micó/ C.Rihuete, Transitions and conflict at the end of the 3rd millennium BC in south Iberia. In: H.Meller/ H.Arz/ R.Jung/ R.Risch (eds.), 2200 BC – A climatic breakdown as a cause for the collapse of the old world?, Edition: Tagungen des Landesmuseums für Vorgeschichte Halle, Publisher: Landesmuseum für Vorgeschichte Halle (2015) 365–407.

Rivero/Carrasco 2015: D.G.Rivero/J.L.E.Carrasco, Del Calcolítico al Bronce antiguo en el Guadalquivir inferior. El Cerro de San Juan (Coria del Río, Sevilla) y el “modelo de reemplazo”. Zephyrvs 76, 0, 2015, 15–38. doi: 10.14201/zephyrus2015761538.

Ruan et al. 2016: J.Ruan/ F.Kherbouche/ D.Genty/ D.Blamart/ H.Cheng/ F.Dewilde/ S.Hachi/ R.L.Edwards/ E.Régnier/ J.-L.Michelot, Evidence of a prolonged drought ca. 4200 yr BP correlated with prehistoric settlement abandonment from the Gueldaman GLD1 Cave, Northern Algeria. Clim. Past 12, 1, 2016, 1–14. doi: 10.5194/cp-12-1-2016.

Sanjuán 1999: L.G.Sanjuán, Los orígenes de la estratificación social : Patrones de desigualdad en la Edad del Bronce del suroeste de la Península Ibérica: (Sierra Morena Occidental c. 1700–1100 a.n.e./ 2100–1300 A.N.E.) (1999).

Schirrmacher et al. 2019: J. Schirrmacher/ M. Weinelt/ T. Blanz/ N. Andersen/ E. Salgueiro/ R.R. Schneider, Multi-decadal atmospheric and marine climate variability in southern Iberia during the mid- to late-Holocene. Climate of the Past 15, 617–634. doi: 10.5194/cp-15-617-2019.

Schirrmacher et al. (in review): J. Schirrmacher/ J. Kneisel/ D. Knitter/ W. Hamer/ M. Hinz/ R.R. Schneider/ M. Weinelt. Spatial patterns of temperature, precipitation, and settlement dynamics at the Iberian Peninsula during the Chalcolithic and the Bronze Age. Quat. Sci. Rev.

Senna-Martinez 2014: J.C. Senna-Martinez, Death as "life's mirror"? Funerary practices and trajectories of complexity in the prehistory of peasant societies of Iberia. In: A. Cruz/ E. Cerrillo Cuenca/ P. Bueno-Ramirez/ J.C. Caninas/ C. Batata (eds.), Rendering Death – Ideological and archaeological speeches from recent prehistory (Iberia). BAR International Series 2648 (2014) 35–44.

Shennan et al. 2013: S. Shennan/ S.S. Downey/ A. Timpson/ K. Edinborough/ S. Colledge/ T. Kerig/ K. Manning/ M.G. Thomas, Regional population collapse followed initial agriculture booms in mid-Holocene Europe. Nature Communications 4, 2013, 2486. doi: 10.1038/ncomms3486.

Staubwasser et al. 2003: M. Staubwasser/ F. Sirocko/ P.M. Grootes/ M. Segl, Climate change at the 4.2 ka BP termination of the Indus valley civilization and Holocene south Asian monsoon variability. Geophysical Research Letters 30, 8, 2003, 1425. doi: 10.1029/2002GL016822.

Stika 1988: H.P. Stika, Botanische Untersuchungen in der bronzezeitlichen Höhensiedlung Fuente álamo. Madrider Mitteilungen, 29, 1988, 21–76.

Stika 2001: H.P. Stika, Fuente álamo-Botanische Ergebnisse der Grabungskampagne 1988 in der bronzezeitlichen Höhensiedlung (Prov. Almería, Südostspanien). In: H. Schubart/ V. Pingel/ O. Arteaga (eds.), Fuente álamo, Teil 1: Die Grabungen von 1977 bis 1991 in einer bronzezeitlichen Höhensiedlung Andalusiens. Madrider Beiträge 25 (Mainz 2001) 263–336.

Szecsenyi-Nagy et al. 2017: A. Szecsenyi-Nagy/ C. Roth/ G. Brandt/ C. Rihuete-Herrada/ C. Tejedor-Rodriguez/ P. Held/ I. Garcia-Martinez-de-Lagran/ H.A. Magallon/ S. Zesch/ C. Knipper/ E. Banffy/ S. Friedrich/ H. Meller/ P. Bueno-Ramirez/ R.B. Bermejo/ R. de B. Behrmann/ A.M. Herrero-Coral/ R.F. Fernandez/ C.A. Fernandez/ J.J. Echevarria/ L. Rindlisbacher/ C. Oliart/ M.-I. Fregeiro/ I. Soriano/ O. Vincente/ R. Mico/ V. Lull/ J.S. Diaz/ J.A.L. Padilla/ C.R. de T. Munoz/M.S.H. Perez/ F.J.J. Maestre/ J.L. Maurandi/ A.A. Fernandez/ K.T. Lillios/ A.M. Silva/ M.M. Ramalho/ L.M. Oosterbeek/ C. Cunha/ A.J. Waterman/ J.R. Buxo/ A. Martinez/ J.P. Martinez/ M.H. Ortiz/ J.C. Mejias-Gracia/ J.C.P. Espin/ R.C.-A. Briones/ T. Tome/ E.C. Ballestero/ J.L. Cardoso/ A.C. Araujo/ C.L. von Lettow-Vorbeck/ C.B. Bosqued/ P.R. Mendoza/ A. Pujante/ J.I. Royo-Guillen/ M.A.E. Bevia/ V.M.D.S. Goncalves/ R. Parreira/ E.M. Hernandez/ E.M. Izquierdo/ J.V. de Miguel/ R.M. Garcia/ V.M. Calvo/ O.L. Jimenez/ J. Krause/ S.L. Pichler/ R. Garrido-Pena/ M. Kunst/ R. Risch/ M.A. Rojo-Guerra/ W. Haak/ K. W. Alt, The maternal genetic make-up of the Iberian Peninsula between the Neolithic and the Early Bronze Age. bioRxiv, 2017, 106963. doi: 10.1101/106963.

Tierney/deMenocal 2013: J.E. Tierney/ P. B. deMenocal, Abrupt Shifts in Horn of Africa Hydroclimate Since the Last Glacial Maximum. Science 342, 6160, 2013, 843–846. doi: 10.1126/science.1240411.

Valcarce/Priego 1994: R.F. Valcarce/ M.R.-G. Priego, Ámbitos funerario y doméstico en la Prehistoria de NO. de la Península Ibérica. Zephyrus: Revista de prehistoria y arqueología, 46, 1994, 143–160.

Valera 2015: A.C. Valera, Social change in the late 3rd millennium BC in Portugal: The twilight of enclosures. In: H. Meller/ H. Arz/ R. Jung/ R. Risch (eds.), 2200 BC – A climatic breakdown as a cause for the collapse of the old world?, Edition: Tagungen des Landesmuseums für Vorgeschichte Halle, Publisher: Landesmuseum für Vorgeschichte Halle (2015) 409–427.

Walker et al. 2012: M.J.C. Walker/ M. Berkelhammer/ S. Björck/ L.C. Cwynar/ D.A. Fisher/ A.J. Long/ J.J. Lowe/ R.M. Newnham/ S.O. Rasmussen/ H. Weiss, Formal subdivision of the Holocene Series/Epoch: A Discussion Paper by a Working Group of INTIMATE (Integration of ice-core, marine and terrestrial records) and the Subcommission on Quaternary Stratigraphy (International Commission on Stratigraphy). Journal of Quaternary Science 27, 7, 2012, 649–659. doi: 10.1002/jqs.2565.

Wanner et al. 2008: H. Wanner/ J. Beer/ J. Bütikofer/ T.J. Crowley/ U. Cubasch/ J. Flückiger/ H. Goosse/ M. Grosjean/ F. Joos/ J.O. Kaplan/ M. Küttel/

S.A. Müller/ I.C. Prentice/ O. Solomina/ T.F. Stocker/ P. Tarasov/ M. Wagner/ M. Widmann, Mid- to Late Holocene climate change: an overview. Quaternary Science Reviews 27, 1791–1828. doi: 10.1016/j.quascirev.2008.06.013

Waterman et al. 2016: A.J. Waterman/ K.T. Lillios/ R.H. Tykot/ M. Kunst, Environmental change and economic practices between the third and second millennia BC using isotope analyses of ovicaprid remains from the archeological site of Zambujal (Torres Vedras), Portugal. Journal of Archaeological Science: Reports 5, 2016, 181–189. doi: 10.1016/j.jasrep.2015.11.017.

Weiss 2013: H. Weiss, The Northern Levant During the Intermediate Bronze Age: Altered Trajectories. In: A.E. Killebrew/ M. Steiner (eds.), The Oxford Handbook of the Archaeology of the Levant : C. 8000–332 BCE (Oxford 2013).

Welc/Marks 2014: F. Welc/ L. Marks, Climate change at the end of the Old Kingdom in Egypt around 4200 BP: New geoarchaeological evidence. Quaternary International 324. Human dimensions of palaeoenvironmental change: Geomorphic processes and geoarchaeology, 2014, 124–133. doi: 10.1016/j.quaint.2013.07.035.

Weinelt et al. 2015: M. Weinelt/ C. Schwab/ J. Kneisel/ M. Hinz, Climate and societal change in the western Mediterranean area around 4.2 ka BP. In: H. Meller/ H.W. Arz/ R. Jung/ R. Risch (eds.), 2200 BC - Ein Klimasturz als Ursache für den Zerfall der alten Welt: 7. Mitteldeutscher Archäologentag vom 23. bis 26. Oktober 2014 in Halle (2015).

Wenxiang/Tungsheng 2004: W. Wenxiang/ L. Tungsheng, Possible role of the "Holocene Event 3" on the collapse of Neolithic Cultures around the Central Plain of China. Quaternary International 117, 1. 5th International conference on the cenozoic evolution of the Asia-Pacific environment, 2004, 153–166. doi: 10.1016/S1040-6182(03)00125-3.

Whitehouse et al. 2014: N.J. Whitehouse/ R.J. Schulting/ M. McClatchie/ P. Barratt/ T.R. McLaughlin/ A. Bogaard/ S. Colledge/ R. Marchant/ J. Gaffrey/ M.J. Bunting, Neolithic agriculture on the European western frontier: The boom and bust of early farming in Ireland. Journal of Archaeological Science 51. The world reshaped: Practices and impacts of early agrarian societies, 2014, 181–205. doi: 10.1016/j.jas.2013.08.009.

Williams 2012: A.N. Williams, The use of summed radiocarbon probability distributions in archaeology: A review of methods. Journal of Archaeological Science 39, 3, 2012, 578–589. doi: 10.1016/j.jas.2011.07.014.

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