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A Vinča potscape: formal chronological models for the use and development of Vinča ceramics in south-east Europe

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ABSTRACT – *Recent work at Vinča-Belo Brdo has combined a total of more than 200 radiocarbon dates with an array of other information to construct much more precise narratives for the structural history of the site and the cultural materials recovered from it. In this paper, we present the results of a recent attempt to construct formal models for the chronology of the wider Vinča potscape, so that we can place our now detailed understanding of changes at Belo Brdo within their contemporary contexts. We present our methodology for assessing the potential of the existing corpus of more than 600 radiocarbon dates for refining the chronology of the five phases of Vinča ceramics proposed by Milojčić across their spatial ranges, including a total of 490 of them in a series of Bayesian chronological models. Then we outline our main results for the development of Vinča pottery. Finally, we discuss some of the major implications for our understanding of the source, character and tempo of material change.*

IZVLEČEK – *Nedavne raziskave najdišča Vinča-Belo Brdo združujejo več kot 200 radiokarbonskih datumov z zbirko drugih podatkov z namenom ustvariti bolj natančne zgodbe o strukturni zgodovini najdišča in o izkopanem kulturnem materialu. V tem članku predstavljamo rezultate nedavnih poskusov oblikovanja formalnih modelov za kronologijo na širšem območju kulture Vinča, da lahko umestimo zdaj že podrobno razumevanje sprememb na Belem Brdu v njihove sočasne kontekste. Predstavljamo tudi našo metodologijo za ocenjevanje potenciala obstoječega korpusa več kot 600 radiokarbonskih datumov za bolj natančno kronologijo vseh petih faz vinčanske keramike, kot jih je postavil Milojčić, v njihovih prostorskih omejitvah, vključujoč še skupaj 490 datumov v seriji Bayesovega kronološkega modeliranja. Nato orišemo glavne rezultate razvoja vinčanske lončenine. Na koncu razpravljamo še o nekaterih glavnih posledicah našega razumevanja vira, značilnosti in hitrosti sprememb v materialni kulturi.*

KEY WORDS – *Neolithic; Vinča ceramics; Bayesian chronological modelling; radiocarbon dating; network*

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The significance of the Vinča culture for the development of the Neolithic in SE Europe

The Vinča culture belongs to the latter part of the sixth millennium cal BC and the first half of the fifth millennium cal BC (*Chapman 1981; Markotić 1984; Borić 2009; Porčić 2011; Orton 2012*). Its broad distribution extends through the river valleys – the Danube, its tributaries and their catchments – of the northern and central Balkans, from southernmost Hungary and easternmost Croatia through Serbia down to Kosovo and parts of Macedonia, and from Croatia and Bosnia and Herzegovina eastwards as far as parts of Transylvania in Romania and western Bulgaria (Fig. 1). The phenomenon presents a series of significant changes in the character of Neolithic settlement and social relations (*Garašanin 1979; Chapman 1981; Kaiser, Voytek 1983; Tringham, Krstić 1990a*), following the initial establishment of Neolithic existence in the area of its distribution from the late seventh and early sixth millennium cal BC onwards (*Whittle* et al. *2002*). These include changing materiality; the expansion of material networks; the spread, consolidation and diversification of settlement, involving increased sedentism in the form of large settlements and tells; the intensification of subsistence; the introduction of copper metallurgy; and the emergence of both larger communities and distinctive households within them (*Chapman 1981; 2000; Kaiser, Voytek 1983; Tringham, Krstić 1990a; Tripković, Milić 2009; Orton 2010; Orton* et al. *2016*). Important issues of settlement expansion, population increase, changes in production, a greater variety of sites including tells themselves, more permanence of occupation, the role of households and the nature of community have all been much discussed (see also *Borić 2009; 2015; Borojević 2006; Chapman 1990; Crnobrnja* et al. *2009; Lazarovici 1979; Link 2006.93–6; Orton 2010; 2012; Porčić 2012; Schier 1995; Tasić 2011; Tringham* et al. *1992; Tripković 2011; Whittle 1996.105*).

It has been clear since the first radiocarbon dates (see *Chapman 1981*) that these features developed over a timescale of several centuries. Explanations of the radical transformations which both the emergence and the demise of the Vinča culture brought have varied considerably, from migrations within the culture history framework (*e.g., N. Tasić* et al. *1990.32–33; cf. Hervella* et al. *2015*), to the increasing importance as time went on of individual households and competitive social relations (*Tringham, Krstić 1990a; Chapman 2000*). One widely shared view, within a culture-historical framework, has been of southern origins for both initiation of the Vinča culture and subsequent changes during its development (such as the claimed 'shock of Vinča C' (*e.g., Garašanin 1951; 1979; G. Lazarovici 2000; Suciu 2009*)). So the Vinča phenomenon is central to our understanding of social and cultural change in Neolithic southeast Europe, and also in surrounding areas. Despite the host of interpretations and chronological schemes produced, however, it remains the case that the calendar dating of Vinča culture changes – which principally boil down to changes in pottery – has not so far been rigorously or widely established, though important earlier efforts in that direction should be noted (*Borić 2009; 2015; Orton 2012; Schier 1995; 1996; 2000; 2014*).

Periodisation schemes for Vinča ceramics: a brief historiography

Distinctive material culture, including modelled face-like lids, figurines and copper artefacts but predomi-

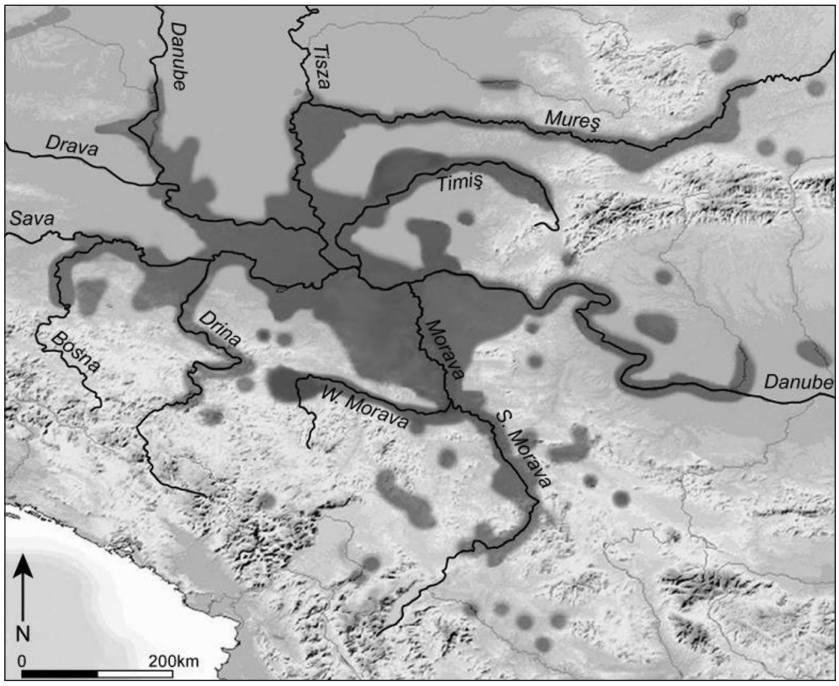


Fig. 1. Map of the maximum extent of the occurrence of Vinča ceramics across south-east Europe.

nantly the ubiquitous, abundant and high-quality, dark-burnished pottery, has been the basis for classic periodisations of Vinča material (see *Tasić* et al. *2016a;* Fig. 2). That these in turn have been the spur for prolonged debate about the nature and source of origins and subsequent changes underlines their continuing importance. The practice of researchers has been to infer chronology from changing typological phases of ceramics, sometimes placing this on an absolute scale by reference to the available radiocarbon dates or by analogy with dated schemes from neighbouring areas. This approach assumes that two typologically identical assemblages are synchronous, no matter their geographical location. Variation through time and variation through space are thus conflated by this approach, which has been the source of much confusion, controversy and debate.

Gordon Childe (*1929.27–32; cf. Menghin 1931*) had enough data to distinguish only two phases (Vinča I and II). This was based mainly on Vinča-Belo Brdo, since this provided the most abundant material. The next, more developed periodisation of Vinča-Belo Brdo was by Friedrich Holste (*1939*) based on the typology of pottery excavated and published by Miloje Vasić, and dividing the material into five phases labelled A–E, with phases A–D covering the Neolithic development of the site. Although redefined and remodelled by later authors, this basic structure continues to underpin most periodisations of Vinča material as a whole.

In 1943 and 1949 Vladimir Milojčić proposed a further refinement, using exclusively the published material from Vasić's *Preistoriska Vinča*[1]. He basically reproduced Holste's scheme but added subphases B1 and B2. His phase B1 denotes a time when meanders still appear as a decorative motif and his phase B2 is the time of appearance of curvilinear motifs which were more visible in the following Vinča C phase. Milojčić also identified a transitional C–D phase between 4.5–4 m, marking the transition to the last Neolithic phase at Belo Brdo (*Milojčić 1949a.266–267*; see also a useful English summary in *Milojčić 1949b*). He was also the first fully to incorporate other Late Neolithic sites from the central Balkans into his chronological system.

Milutin Garašanin (*1951*) was the first to make an inventory of the entire pottery collection from Vasić's excavations at Belo Brdo. He systematised the ceramic material and divided it into two major phases, Vinča-Tordoš and Vinča-Pločnik, also drawing

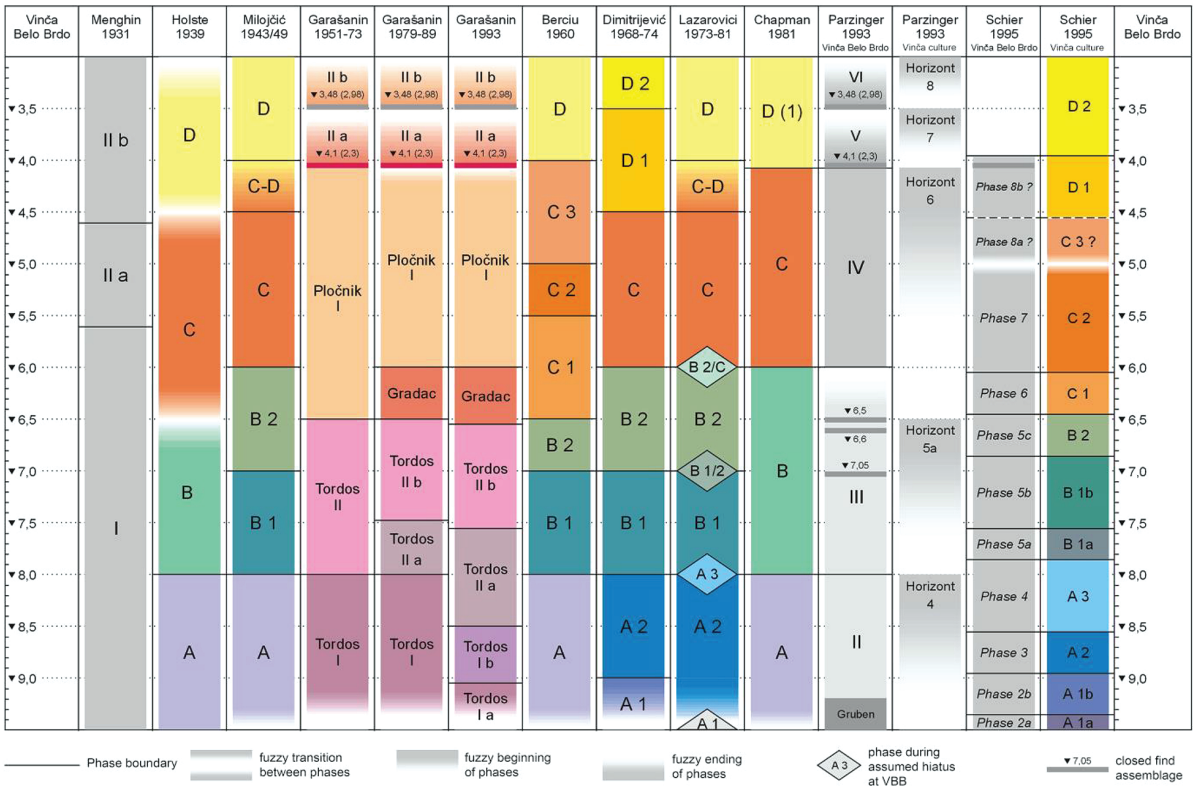


Fig. 2. Overview of alternative typological schemes for Vinča ceramics (after* Schier 1996*).

1 Some of his descriptions reveal that he had in-depth first-hand knowledge of the finds.

on material from other sites in the wider Vinča distribution. He used the labels Tordoš and Pločnik to link his early and late phases of the Vinča sequence with the northernmost and southernmost sites known at the time. At first he sub-divided both his Vinča-Tordoš and Vinča-Pločnik phases, and later elaborated this division even further (*Garašanin 1979; 1993*). He also incorporated the views of Borislav Jovanović (*1994*) on the Gradac phase, which stands for a sudden and significant change in the pottery forms first attested at the south Serbian site of Gradac[2].

Overlapping with and following the work of Garašanin, other periodisations essentially also based on the typology of pottery, such as those by Dumitru Berciu (*1961*), Stojan Dimitrijević (*1968; 1974*) and Gheorghe Lazarovici (*1979; 1981*), considered various areas of the Vinča distribution. In his quite brief treatment, Berciu essentially followed the structure already established by Milojčić, using the A–D terminology and still therefore with ultimate reliance on Vinča-Belo Brdo; his subdivision of Vinča B differs slightly from that of Milojčić and he proposed a tripartite division of C. Vinča is correlated with other cultures of south-east Europe. His scheme principally covers Banat, Oltenia, Muntenia and Transylvania. He made some reference to available uncalibrated radiocarbon dates and suggested a relatively low absolute chronology (*Berciu 1961.Fig. 1, Pl. I*).

In turn, Dimitrijević concentrated on northern Serbia, Romanian Banat and Croatian Slavonia, primarily focusing on what was then called the Sopot-Lengyel culture, and using key sites like Bapska and Vinkovci, but with consideration of relationships and correlations with its neighbours. In this, reference was still made to Vinča-Belo Brdo by depth, with variation in subdivisions of B, C and D; for the first time, Vinča D is subdivided into D1 and D2, beginning at a depth of 4.5m at Belo Brdo (*Dimitrijević 1968.89, kronološka tabela*). Subdivision of A followed in a later article (*Dimitrijević 1974*). No reference was made to radiocarbon dates, in a work completed in 1964 and a very low absolute chronology was proposed, underpinned by supposed Vinča links to Northern Greece (*Dimitrijević 1968.121–122*).

There followed further periodisation of the Neolithic ceramic sequence in the Banat of north-west Romania by Lazarovici (*1979*), using the stratigraphy of key sites such as Gornea and Parţa, but yet again with reference to Vinča-Belo Brdo. The basic structure for the Vinča sequence remains familiar in outline, but A is now subdivided differently, C is simplified, a C–D phase is reinstated, and D is proposed as a single unit; transitions were also added, as A3 between A2 and B1, and B1/B2 and B2/C, equivalent to what were seen as hiatuses in the Belo Brdo sequence (*G. Lazarovici 1979. Tab. 7, 76*). While a range of other material is considered, it is the forms and decoration of the pottery which are described in most detail, phase by phase (*G. Lazarovici 1979.105–139*). Potential imports, from surrounding groups such as the Alföld Linearbandkeramik, Szatmár, Bükk and Petreşti, are also noted (*G. Lazarovici 1979.163–168*). Detailed attention was given to small-scale geographical variation within the Banat, explicit distinction was made between relative and absolute chronology, and comparisons were made with much further afield, as far as Anatolia and Mesopotamia (*G. Lazarovici 1979.Tabs. 17–18, 178–179*). A late absolute chronology is proposed, with the Vinča sequence placed between the late fifth and later third millennia (*G. Lazarovici 1979.Tabs. 17–18, 178–179*). The origins of the Vinča culture, with differences to the preceding Starčevo-Criş complex, were seen as lying in a complex set of cultural and ethnic changes and fusions, affecting the Balkans as a whole (*G. Lazarovici 1979.221*). Subsequently, a review of the Vinča culture across Romania, summarising chronological trends in Oltenia and Transylvania/Siebenbürgen as well as Banat, reinforced this scheme; the C–D phase was omitted on this occasion (*G. Lazarovici 1981.Beilage 1*). There is still no reference to radiocarbon dating, and the chronological table lacks any absolute timescale. Famously, Vinča C was later characterised as a 'shock', involving migration from areas to the south (*G. Lazarovici 1987*). Further detail and refinement for Vinča C in the Banat were provided by Florin Draşovean (*1994; 1996; Draşovean* et al. *1996*).

Other reviews of the Romanian Neolithic have been published subsequently (*e.g., Mantu 2000; C.-M. Lazarovici 2006; Suciu 2011*). By the time of these papers, calibrated radiocarbon dates, even if rela-

2 Unfortunately, Garašanin (*1979.152*) misunderstood Milojčić's subdivision, maintaining that, according to the latter, the transition between Vinča B2 and C would occur around a depth of 5m at Belo Brdo, instead of at 6m as Milojčić had clearly stated. This led to several decades of mismatch between the two typological systems, since researchers more familiar with the Garašanin scheme consistently 'translated' the phase Vinča-Pločnik I back into the Milojčić scheme as 'Vinča B2–C' instead of correctly 'Vinča C'. We have been aware of this issue when interpreting the published ceramic phasing of dated sites in the analyses below.

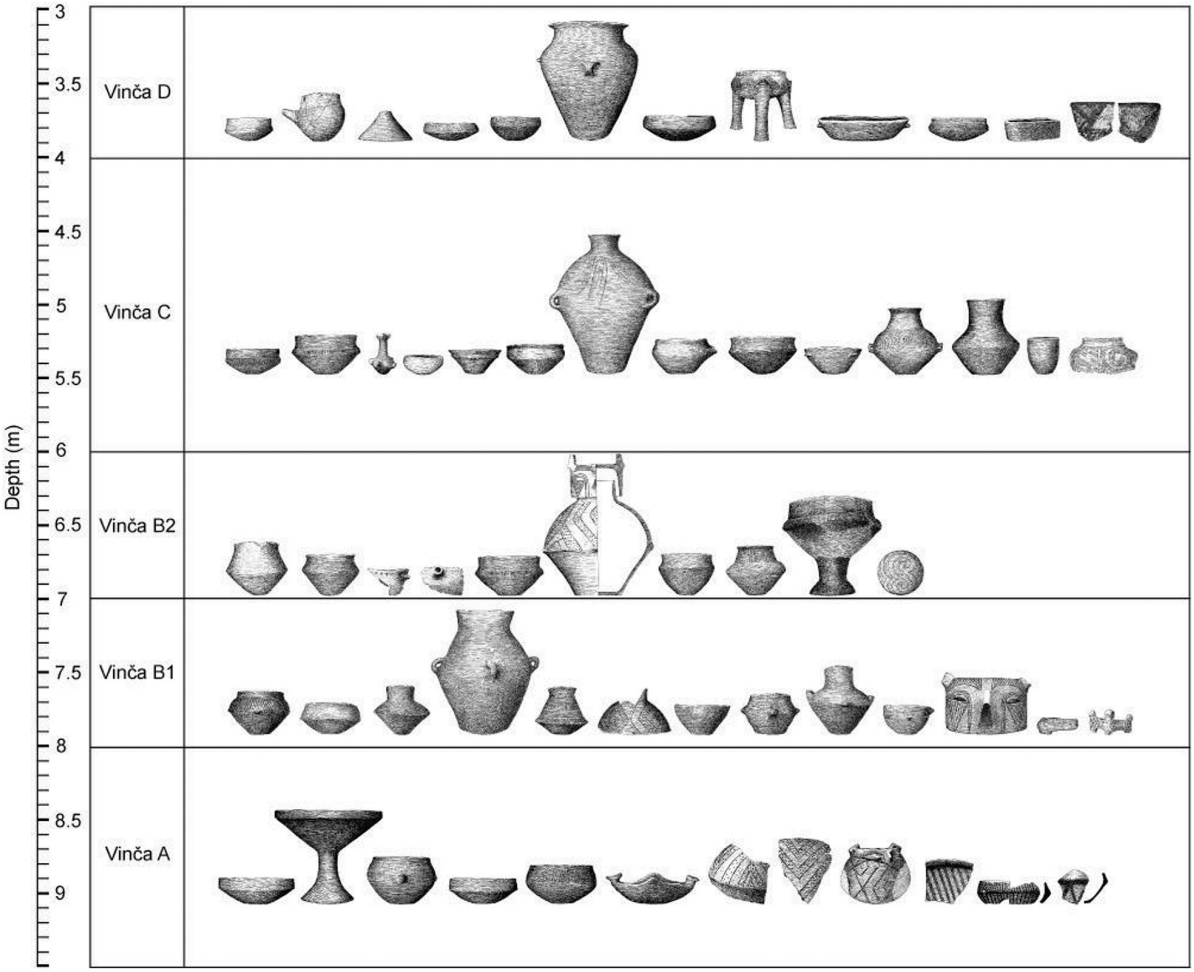


Fig. 3. Selected pot forms by depth at Vinča-Belo Brdo (after* Milojčić 1943*).

tively few in number, were incorporated into chronological periodisations. It is worth noting that terms such as 'wave', 'colonisation' and 'penetration' are frequently used with reference to the Vinča culture; for example, "*Vinča culture is part of the second great wave of southern origin*" (*Suciu 2011.75*). On the basis of available radiocarbon dates, geographical variation in the effect of 'Vinča C type communities' is seen, with contrasts between Transylvania on the one hand and Banat and Oltenia on the other; in Transylvania, these are seen as determining the appearance of the Copper Age, whereas in Banat and Oltenia, the beginning of the Copper Age is related to new migrations due to the Tiszapolgár and Sălcuţa cultures (*C.-M. Lazarovici 2006. 277*). Recently, Draşovean (*2014*) has argued that the beginning of the Copper Age in Banat and Transylvania is tied to the emergence of Foeni-Petreşti communities.

Hermann Parzinger (*1993*) quantified the varying occurrence of selective decorative motifs and forms by depth through the Belo Brdo tell. Following the common perception at that time, he did not assign chronological significance to the sequence of material from the relative depths in the tell, but instead gave more weight to what he considered closed assemblages, like the few house inventories recognised by Vasić (*Parzinger 1993.60–63*). However, this resulted in a rather small number of, arguably, unrepresentative assemblages being used in his analysis. Parzinger incorporated this in a comparative, typologically based scheme (deliberately without reference to radiocarbon dates: *Parzinger 1993. 273*) of successive cultural horizons, which covers the wider west Balkan region, and far beyond. At Belo Brdo itself he identified a series of Phases (I–VI), and over much wider areas a succession of horizons (4, 5a and 6–8 running parallel to the Belo Brdo sequence; Fig. 2).

The A–D division was endorsed by John Chapman (*1981*) for pragmatic reasons, to enable comparison within the wider Vinča culture. In his work, phases A–C denoted early Vinča and phase D late Vinča. Going beyond Vinča-Belo Brdo, and drawing on

the then available radiocarbon dates (*Chapman 1981.Fig. 14*), he sketched sequences for five regions: Serbia and Macedonia, the Vojvodina, north Bosnia, Oltenia and Transylvania (*Chapman 1981.22–31*). Taking just the example of decorative motifs on 'early Vinča' pottery, he was able to show significant regional variation (*Chapman 1981.Fig. 11*).



Fig. 4. Szederkény-Kukorica-dűlő, Grave 2484 accompanied by a Vinča A1 (*Schier 1995*) bowl (after* Jakucs *et al.* 2016*).

The scheme developed by Wolfram Schier consists of eight main phases and several subphases, and covers the sequence from the beginning of the Vinča occupation on the Belo Brdo tell to 4m from its top (*Schier 1995; 1996; 2000*). This was based on detailed analyses of changes in the form and decoration in a sample of about 2500 mostly unpublished vessel fragments (mainly bowls) recorded by relative depth, and its chronological credibility was tested by correspondence analysis. Schier also compared the newly defined phases with data from several other sites and concluded that the proposed division is valid at least for the 'core' area of the Vinča distribution, within a radius of some 100km of Vinča-Belo Brdo itself, in the middle Morava, Šumadija and the Banat (*Schier 1995.251–293; 1996.147*).

Finally, since the appearance of Schier's chronology, Garašanin (*2000*) has refined his chronological system even further, consistent with Schier's results. Additional subdivisions have been added, including Vinča-Tordoš IIb 1–3.

Regional differences, imports, imitation and influence: issues of variability

The brief review above documents how the culture concept has persisted, perhaps largely for reasons of convenience. But it is also perfectly clear that many specialists have sought both intra- and inter-regional variation within the Vinča 'culture' (*e.g., Garašanin 1979; G. Lazarovici 1979; Chapman 1981*). The notion of a Vinča core radiating around Vinča-Belo Brdo has been proposed (*Schier 1995*), though this may not necessarily be accepted from the perspective of other areas (*Leković 1990; Makkay 1990; Jovanović 1994*). There is clear recognition, even within the culture-historical framework, that the affiliation or allegiance of particular regions may shift through time; cultural boundaries were not immutable or permanently fixed. Actual imports from neighbouring or surrounding regions have also been claimed, as noted above (*G. Lazarovici 1979*), and other potential examples were given by Cornelia-Magda Mantu (*2000.80*) and Florin Drașovean (*1994; 1996*), among others. Complex, wide-ranging interactions and fusions have been envisaged. So, at various levels, many scholars have in practice broken down a monolithic Vinča culture into a more varied and nuanced network. Yet in many accounts there is also a reversion to single explanations, especially when it comes to moments of key transition, in terms of emergence, possible rupture and endings, and the dominant threads linking these are the claimed importance of areas to the south, in the southern Balkans, northern Greece and beyond, and inferred migrations.

Given developments in aDNA studies (*e.g., Brandt* et al. *2013; Szécsényi-Nagy* et al. *2015; cf. D. Hofmann 2015*), we have to deal with population changes and infiltrations (and see again *Hervella* et al. *2015*; and further discussion below). But what is missing from the wider field of Vinča culture studies is a more reflective sense of possible diversity and variability. The task then becomes to attempt to unpick the complex cultural history of interaction, innovation, imitation, influence, copying and import-

ing, not excluding the possibility of population movement and replacement but equally not assuming *a priori* that those should be the default explanations for change and variation. This paper proceeds on this basis, using pottery as its principal evidence. Ultimately, the whole range of Vinča material and practices should be the goal.

Pottery as proxy dating: absolute chronology and typochronology

Finally, by way of introduction, it is important to underline the difference between relative chronology, or sequence provided by a combination of typology (and on occasion seriation based on correspondence analysis: *Schier 1995; 2000*) and site stratigraphy, and absolute dating, based on formal modelling of calibrated radiocarbon dates on short-lived samples of known taphonomy, that are robustly associated with the archaeological contexts or diagnostic assemblages which they are used to date. Past generations of researchers, in the absence of large assemblages of high-quality radiocarbon dates and adequate statistical methodologies for their rigorous interpretation, have perforce attempted the synchronisation of relative sequences of pottery types based on typological considerations (perhaps with reference to the limited numbers of low-quality radiocarbon dates available to them). This form of 'pseudo' absolute chronology must be distinguished from what we propose here, which is the synchronisation of such sequences on the basis of robust statistical models of large numbers of radiocarbon dates that are directly associated with pottery which can be fitted within a common typological sequence. This approach builds upon the careful typological schemes of past research[3], but in proper combination with scientific dating, adds absolute timescales to these sequences. Such timings, as we describe below, allow us to disentangle spatial from chronological variation in the use of these well established types.

Aims of this paper: dating a potscape

As we have seen, the Vinča culture has long been a familiar part of the culture-historical vocabulary used to frame, order, and interpret the Neolithic of south-east Europe. Many past notions derived from the use of the culture concept, however, including those of origins, identity and change, appear to have been based, in the end, largely or principally on the character and distributions of pottery styles, and the case of the Vinča complex is no exception. We are going to use the wealth of knowledge about Vinča pottery which has been built up over now a century and more of research as a key component in constructing a formally modelled chronology for the development of Vinča pottery across its wide distribution. If the landscape is what can be seen, and a taskscape what can be heard (*Ingold 1993.162*), a Vinča potscape could be defined as what could be held in the hands of the makers and users of the many ceramic assemblages across that distribution: borrowing Ingold on the taskscape (*1993.158*), "*the entire ensemble ... in their mutual interlocking ... an array*" of related forms. Harnessing, rather than casting aside, many of the strengths of past research on the Vinča phenomenon, we seek to discuss the many implications of our model for questions of the character and tempo of material change, and the nature of cultural variability. While we do not avoid the term, 'the Vinča culture', alternative terminology could help to recast many traditional debates (*Porčić 2012.171; Borić 2015.189–195*), and from here on we use other terms such as network to characterise the potscape under discussion.

In a major project, *The Times of Their Lives* (see Acknowledgements), we have obtained substantial numbers of new radiocarbon dates and formally modelled the results in a Bayesian statistical framework for four sites with Vinča pottery: the tell of Vinča-Belo Brdo, in northern Serbia (*Tasić* et al. *2015; 2016a; 2016b*), the tell of Uivar in western Romania (*Drașovean* et al. *submitted; Schier* et al. *in preparation*), and the flat settlements at Szederkény and Versend, in south-west Hungary (*Jakucs* et al. *2016; submitted*). Encouraged by the coherent results from these sites, we were then interested to see if we could put these into the broader framework of the development of the Vinča network concentrating on the potscape of ceramic change. For this we have collected the published and other radiocarbon dates available to us in 2015. For our investigations at Vinča-Belo Brdo, we provided formal estimates for several of the available ceramic schemes (*Tasić* et al. *2016a.Figs. 22– 24, Tabs. 8–9*; and see

3 But we note the lack of rigorous, quantitative typo-chronological studies on statistically viable samples of Vinča ceramics, and the lack of representative analysis and full publication of excavated assemblages. These deficiencies in the analyses and publication of Vinča assemblages have been the major obstacle in the construction of the chronological models presented below rather than any lack of good-quality radiocarbon dates.

Fig. 2), but for this paper we have used, for the sake of simplicity and wide applicability, the A–D scheme of Milojčić (*1943; 1949a*). Specifically, we aimed to:

- relate our models for Vinča-Belo Brdo, Uivar, Szederkény and Versend to the wider pattern of ceramic change, formally modelled within the A–D scheme for the Vinča culture;
- examine critically the temporal and geographical coherence of the A–D scheme;
- identify temporal and geographical variation in the adoption, maintenance and abandonment of ceramic styles within the A–D scheme;
- and by these means investigate the character and tempo of cultural change.

Scientific dating and Bayesian chronological modelling for Vinča ceramics

The first radiocarbon dates for Vinča ceramics were very much in the tradition of their time – one or two samples of charred material from a given site. Only a handful of sites had three to six dates. Vinča-Belo Brdo itself was fortunate to obtain two measurements on charred grain samples (GrN-1537 and GrN-1546; *Vogel, Waterbolk 1963.183–184*), and one measurement on a sample of unidentified charcoal (GrN-1535; *Todorović, Cermanović 1961.71*).

At the beginning of the 1980s, Chapman (*1981.17–31*) was able to gather details of 36 radiocarbon dates from 16 sites from which Vinča pottery had been recovered, and used these uncalibrated radiocarbon dates in comparison with local stratigraphic sequences. He reached three major conclusions: that the duration of phases A–C was comparable to the duration of the entire D phase; that the final centuries of the Vinča culture were not represented at the type-site; and that the different rates of development in the various regions prevent Vinča Belo-Brdo from being used as a 'type-site' for the development of the Vinča culture as a whole.

In the 1990s, Schier (*1996.Tab. 1*) obtained a series of 14 conventional radiocarbon dates on worked antlers and large animal bones that had been recovered by Vasić at Belo Brdo and recorded by depth. These derive from the lower and middle part of the tell (4.1–9.3m) covered by his seriation of a sample of the surviving pottery assemblage. Using these results and the first series of dates produced in Groningen, Schier (*1996.Figs. 11–12*) produced the first Bayesian chronological model for Vinča-Belo Brdo, combining the radiocarbon dates with the depths through the tell recorded on the samples.

At the same time Roland Gläser (*1996*) presented a review of 76 radiocarbon dates from 14 sites containing Vinča ceramics. He provided a Bayesian chronological model combining the site stratigraphy with the corpus of radiocarbon dates for Selevac (*Gläser 1996.Fig. 5*), but otherwise his analysis is based on simple calibrated radiocarbon dates and summed probability distributions of calibrated dates for selected sites, and site and ceramic phases. He suggested that the Vinča culture spanned the period from *c*. 5200 cal BC to *c*. 4500 cal BC.

Dušan Borić (*2009*) mustered a total of 155 radiocarbon dates from 27 sites associated with Vinča pottery, including 40 new AMS measurements on short-life, single-entity samples from seven sites. Bayesian models were presented for six sites: Belo Brdo, Rudna Glava, Belovode, Pločnik, Gomolava and Divostin II. This analysis suggested that the culture dated from 5400–5300 cal BC to 4650–4600 cal BC. Contrary to Chapman, Borić argued (*2009.234*) for an approximately similar duration of each phase (A to D) of 200±50 years. More recently, a set of 26 new AMS dates on animal bone from Gomolava, Opovo and Petnica have been published and Bayesian models constructed (*Orton 2012*). These new dates generally fit the chronological framework suggested by Borić.

The chronological framework and approach

It is now time not only to compare these new site chronologies with each other, but also to set them within the wider framework of other dated sites that formed part of the Vinča network. We consider a corpus of 564 radiocarbon dates that have been published as relating to Vinča pottery (Tab. 1)[4]. Full details of these measurements are provided in Table 2 where we have gathered information from diverse sources or when measurements are published for the first time. Where full details of measurements have already been published (*e.g., Borić 2009*) references to sources used for each site are provided in Table 1.

Chronological modelling has been undertaken using the program OxCal v4.2 (*Bronk Ramsey 2009; Bronk*

4 Additionally, there are 34 radiocarbon dates from the latest levels of Vinča-Belo Brdo in Sector II (*Tasić* et al. *2015*), 101 from the recently excavated deep sounding (*Tasić* et al. *2016b*), and two from the 2011 profile that are not considered here.

Ramsey, Lee 2013) and the calibration dataset of Reimer *et alii* (*2013*). The algorithms used in the models are defined exactly either by the brackets and OxCal keywords on the left-hand side of the figures or by the CQ2 code provided as supplementary information (http://c14.arch.ox.ac. uk/). In the figures, the outputs from the models, the posterior density estimates, are shown in black, and the unconstrained calibrated radiocarbon dates are shown in outline; dates on samples of charred plant remains that may have an old-wood offset are shown in grey; the parameter names of distributions that have been excluded from the modelling are followed by '?'. Some distributions do not relate to single radiocarbon dates. These other distributions correspond to aspects of the model. For example, the distribution '*start Szederkény*' (Fig. 5) is the posterior density estimate for the time when the settlement at Szederkény was established. In the text and tables, the Highest Posterior Density intervals of the posterior density estimates are given *in italics*. Calibrated date ranges given in normal type have been calculated using IntCal13 and the probability method (*Stuiver, Reimer 1993*), and do not derive from the chronological models described. All ranges have been rounded outwards to five years.

For each measurement, we examine the character of the dated material and its association with Vinča ceramics. Given the absence of an agreed typological scheme across the region, assemblages have been allocated to Milojčić's (*1943; 1949a*) scheme: A, B1, B2 (incorporating what was later called the Gradac phase), C (incorporating *Milojčić's (1949a; 1949b*) phase C–D), and D (incorporating all proposed subdivisions) (Fig. 3). Where site stratigraphy is available, this is used in a Bayesian model to constrain the calibration of the radiocarbon dates. In some cases the available published information is not sufficient to demonstrate a robust association between the dated samples and a ceramic phase(s) (these results are reported in footnotes).

Ideally, we wish to include in our models only radiocarbon dates on short-life samples that are directly associated with typologically diagnostic assemblages of the relevant pottery. Dates on articulated animal bones from closed ceramic assemblages in pits, for example, are ideal (for a demonstration of the potential of this approach see *Denaire* et al. *in press*). Unfortunately, the samples submitted for dating by past researchers, the published typological and stratigraphic information, and the reporting of the radiocarbon measurements and their associated details (*Bayliss 2015*) are frequently less than ideal. In these circumstances, we have been forced to make pragmatic judgements about the information available to us.

We have only included radiocarbon dates in our study that are published as having a clear association with Vinča ceramics that have been assigned to various typological schemes (*cf.* Fig. 2), which we have converted to the Milojčić (*1943*) scheme. This means that sites often have more radiocarbon dates than have been used in the modelling, but these are either associated with activity of other periods or do not have explicit associations with diagnostic Vinča material. In many cases it has been impossible for us to judge the validity of the published ceramic association, as sites are not yet published in detail. Sometimes associations cannot be made at the feature or structure level, but rather an entire site is categorised as only containing material of a certain phase. It should be noted that the association between cultural material and the radiocarbon sam-

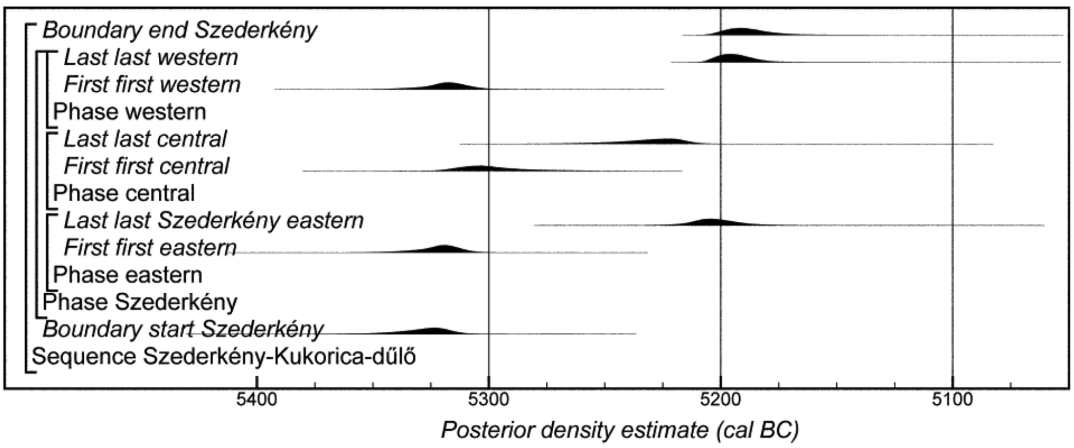


Fig. 5. Probability distributions of key parameters from Szederkény-Kukurica-dűlő, derived from the model defined by Jakucs* et al. *(*2016.Fig. 10*).

ple is critical to avoid circular arguments (by which a site is assigned to particular ceramic phase on the basis of the calibrated radiocarbon dates rather than the typological characteristics of the pottery present).

This legacy dataset is inevitably of variable quality. Although over 70% of measurements have been made by AMS, short-life, single-entity samples that can be confidently associated with the use of the feature from which the sample derived constitute less than a quarter of dates (and 80% of those derive from just two sites, Szederkény and Versend). Over 20% of samples were of unidentified charcoal (or of charcoal from long-lived species such as oak and elm) and so may incorporate an old-wood offset. Other samples consist of disarticulated animal bones or single carbonised cereal grains, where it is not known whether the dated material derived from particular concentrations. Such materials might well be residual (older than their contexts) or intrusive (younger than their contexts).

We have attempted to distil reliable chronology from this body of data, by incorporating each result into the model in a way that is appropriate for the dated material.

- Samples of human bone from graves, articulated animal bone groups, and short-lived charred plant remains (including short-life charcoal) from fired features such as hearths or large concentrations, such as coherent dumps in pits, have been incorporated into the models as short-life material likely to be contemporary with the archaeological activity of interest (n = 134).

- Disarticulated animal bones and short-lived charred plant material from houses or pits have also been included fully in the models, although we consider the archaeological association in this case to be less reliable (n = 244); in a number of cases the dates on these samples are clearly much earlier than related dates (usually having a poor individual index of agreement in the model) and so they have been modelled as residual *termini post quos* (n = 43), and in a few cases they are clearly intrusive (n = 8).

- Samples of unidentified charcoal (or charcoal from long-lived species) have been incorporated into the models as *termini post quos* (n = 115), except for a few which are statistically consistent with results on short-life materials from the same context (n = 5).

- Five results from Uivar have been excluded from the model for that site for technical reasons (*Schier* et al. *forthcoming*).

In total, therefore, our models include 490 radiocarbon measurements (with a further 66 not included in the analysis either because there is a significant possibility that the measurements are inaccurate, or because we think the dated material was intrusive, or because the association with the Vinča ceramics is unclear). A total of 134 measurements on short-lived samples firmly associated with the dated context are included fully in the models (27%); a further 193 measurements on short-life material that can be associated with the dated context less reliably have also been included fully in the modelling (40%), with another 43 such samples modelled as *termini post quos* as the dated material was probably residual (9%); and 120 measurements on charcoal samples of uncertain maturity are included in the models as *termini post quos* (24%). Our analysis suggests that overall there is approximately a 25% chance that a disarticulated animal bone, or a short-life charred plant from a deposit with which it is not functionally related, is residual or intrusive. This demonstrates the need to date articulating bone groups or single fragments of short-lived charred plant material from primary deposits (*Bayliss* et al. *2016*).

This analysis provides quantitative date estimates for Milojčić's (*1943*) ceramic phase boundaries at different sites that are independent of any synchronisation between alternative typological schemes. In some cases the character of the dated material means that samples can only provide *termini post quos* for particular ceramic phases, or can only be allocated to a range of ceramic phases. We start by considering the chronologies and ceramic associations of particular sites, and construct chronological models for sites which have more than three radiocarbon dates on short-lived material with robust ceramic associations. We then construct a series of models for the chronology of each of Milojčić's ceramic phases, utilising posterior distributions from the site-based models as inputs for these models where appropriate and calibrated radiocarbon dates where not. This ensures that sites which have many radiocarbon dates (*e.g.*, Uivar or Belo Brdo which between them have almost half of the radiocarbon measurements considered in this review) do not disproportionately affect the analysis.

The Vinča potscape

We discuss the dated sites from west to east, following the Danube downstream and examining sites in the catchments of its tributaries as these join the river (Fig. 1).

The Danube upstream of the Tisza

A linear strip 1.7km long, comprising 12.5ha, was investigated at Szederkény-Kukorica-dűlő between 2005 and 2008. The site lies approx. 20km west of the current course of the Danube in south-eastern Transdanubia, Hungary. A total of 66 longhouses, orientated NE–SW and broadly conforming to the longhouse architecture which is generally perceived as a hallmark of the central European Linearbandkeramik (LBK), and 50 crouched inhumations were recovered. Most of the graves are unfurnished, although some were accompanied by Vinča ceramics (Fig. 4). Vinča pottery, from Schier's (*1996*) A1–A3 phases, was recovered from settlement features (*Jakucs, Voicsek 2015*). This material can be related to Milojčić phase A used in this study.

Forty-one radiocarbon measurements are available from this site (*Jakucs* et al. *2016.Tab. 1*), of which 19 are from features containing diagnostic Vinča A ceramics. These dominated the assemblages from the eastern and central areas of the site (the western part contained mainly Ražište-type pottery). János Jakucs *et alii* (*2016.Fig. 11*) present a model for the chronology of Szederkény, which is summarised in Figure 5. This estimates that Vinča A ceramics appeared here in *5360–5305 cal BC* (*95% probability; start Szederkény*; Fig. 5), probably in *5340–5315 cal BC* (*68% probability*), and ceased to be used in *5230–5175 cal BC* (*95% probability; last Szederkény eastern*; Fig. 5), probably in *5215–5190 cal BC* (*68% probability*).

The site of Versend-Gilencsa lies in southern Hungary, approx. 2km east of Szederkény-Kukorica-dűlő (*Jakucs* et al. *submitted*). A linear strip totalling 2.24ha was excavated along the planned line of the motorway, divided by the course of the Versend stream. Features of the Neolithic settlement could be detected on the floodplains of the eastern and western side of the watercourse.

On the eastern side, unambiguous traces of 21 longhouses orientated NE–SW could be identified. These were arranged in rows, and each was flanked by longitudinal pits containing mixed assemblages of early LBK and Vinča A ceramics. The density of archaeological features was higher on the western side, where the extensive traces of the Neolithic settlement were heavily destroyed by later activity. The houses were consequently much less identifiable.

Sixty-eight radiocarbon measurements are available from this site (*Jakucs* et al. *submitted.Tab. 1*). Jakucs *et alii* (*submitted.Figs. 5–6*) present a model for the chronology of Versend, which is summarised in Figure 6. This estimates that the settlement began in *5305–5280 cal BC* (*2% probability; start Versend settlement*; Fig. 6) or *5255–5210 cal BC* (*93% probability*), probably in *5235–5215 cal BC* (*68% probability*), and ceased to be used in *5220–5180 cal BC* (*93% probability; end Versend settlement*; Fig. 6) or *5150–5115 cal BC* (*2% probability*), probably in *5210–5195 cal BC* (*68% probability*).

Several occupation horizons that include assemblages of Vinča pottery have been recovered from the tell settlement at Bapska, eastern Croatia, in 13 campaigns of excavation between 1911 and the present (*Burić, Težak-Gregl 2009; Burić 2011*). Two radiocarbon measurements are available from the 1964 trench; one from the foundation of House 2-A is associated with an assemblage described by Dimitrijević (*1968.92*) as Vinča D1 and equated by him with Milojčić's phase C–D. This dating, being on charcoal from a potentially long-lived species, thus provides a *terminus post quem* of 4850–4485 cal BC (Bln-348; 95% probability) or 4780–4580 cal BC (68% probability) for the end of Milojčić phase C at Bapska[5]. A further series of radiocarbon measurements have recently been obtained on short-lived material associated with Houses 1 and 2 from renewed excavations (*Burić, Težak-Gregl 2009; Burić 2015*). These appear to be associated with Vinča C or Vinča D ceramics, and can be modelled as spanning *4645–4495 cal BC* (*95% probability; start Bapska C/D*; Fig. 7), probably *4580–4515 cal BC* (*68% probability*), and *4550–4420 cal BC* (*95% probability; end Bapska C/D*; Fig. 7), probably *4535–4475 cal BC* (*68% probability*).

Tisza and Mureş valleys

The site of Maroslele-Pana is located in south-eastern Hungary, on the right (northern) bank of the Maros (Mureş) river, northwest of the village of Maroslele,

5 A second sample from the 1964 excavations (Bln-346, 5955±80 BP, 5055–4665 cal BC (94% probability) or 4640–4615 cal BC (1% probability)) is associated with Sopot II pottery and is thus not included in this study.

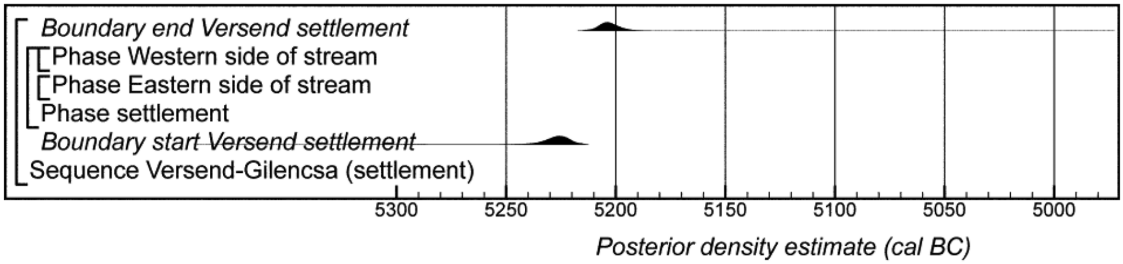


Fig. 6. Probability distributions of key parameters from the settlement at Versend-Gilencsa, derived from the model defined by Jakucs* et alii *(*submitted.Figs. 5–6*).

close to the confluence of the Tisza and Maros rivers. The site was first excavated in 1963; four Neolithic features (pits 1–4) and five crouched burials were documented (*Trogmayer 1964*). The pottery from this early campaign represented the late phases of the early Neolithic Körös culture. In 2008 there were further excavations in advance of road construction. The excavation took place on a low ridge and covered 2.7ha. A total of 71 of the 231 excavated features can be dated to the Neolithic period (*Paluch 2011*). Five radiocarbon measurements were obtained on animal bone from separate pits (Tab. 2). The dated pits contained diagnostic early Vinča A1–A2 (*Schier 1996*) and early Alföld LBK style pottery, but also some fragments and altar pieces which showed clear resemblances to the pottery style of the late Körös culture. The Vinča A1–A2 elements are most frequent in pit 85, while the other dated pits contain more equal proportions of early Vinča and Alföld LBK style material. The mixed (Vinča and Alföld LBK with early Neolithic traits) assemblage of Maroslele-Pana in the Tisza-Maros confluence area (*Paluch 2011*) can be seen as a similar phenomenon to that observed at Versend-Gilencsa in southern Transdanubia and at Satchinez in northern Banat. The model for the dated activity from Maroslele-Pana has good overall agreement (Amodel: 106; Fig. 8) and suggests that the site was occupied between *5380–5220 cal BC* (*95% probability; Start Maroslele-Pana A*; Fig. 8), probably in *5325–5250 cal BC* (*68% probability*), and *5300–5095 cal BC* (*95% probability; End Maroslele-Pana A*; Fig. 8), *probably 5275–5195 cal BC* (*68% probability*).

At Ószentiván (site 8) four measurements were taken on bulk charcoal from a pit containing Vinča A pottery that was investigated during rescue excavations in 1960 (*Kohl, Quitta 1970*). This material was identified as oak and elm charcoal, both species that can live to several hundred years, and so the combined result provides a *terminus post quem* for the pottery of 5305–5050 cal BC (95% probability; Ószentiván 8)

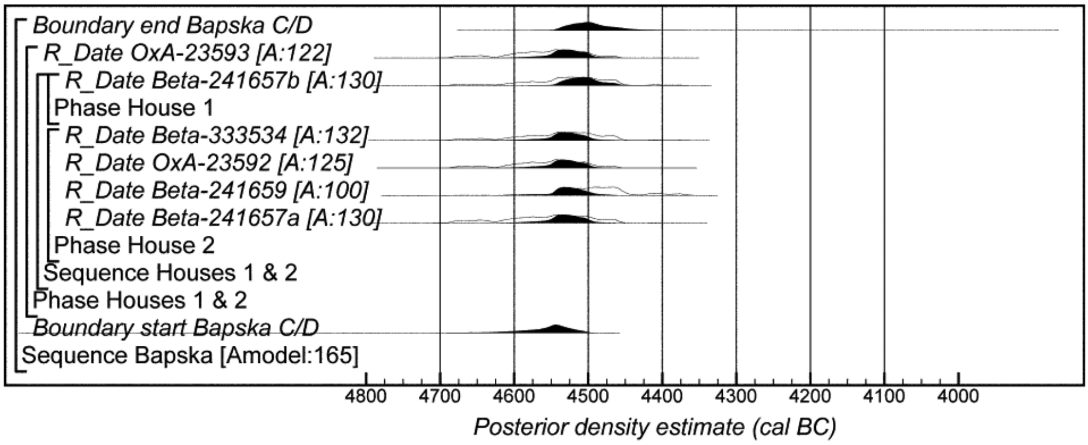


Fig. 7. Probability distributions of radiocarbon dates from Bapska. Each distribution represents the relative probability that an event occurs at a particular time. For each of the dates two distributions have been plotted: one in outline, which is the result of simple radiocarbon calibration, and a solid one, based on the chronological model used. Distributions other than those relating to particular samples correspond to aspects of the model. For example, the distribution 'start Bapska D' is the estimated date when Vinča D ceramics first appeared on the site. Measurements followed by a question mark and shown in outline have been excluded from the model for reasons explained in the text, and are simple calibrated dates (*Stuiver, Reimer 1993*). The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

or 5295–5245 cal BC (19% probability) or 5235–5200 cal BC (13% probability) or 5170–5075 cal BC (36% probability). A single sample of unidentified charcoal was dated from pit 1, recovered in later excavations at the same site (published as Tiszasiget), which was also associated with Vinča A ceramics (*Trogmayer 1980.298*). This provides a *terminus post quem* for the assemblage of 5465–5445 cal BC (1% probability; Bln-1631) or 5380–5190 cal BC (78% probability) or 5185–5055 cal BC (16% probability), probably 5340–5205 cal BC (68% probability).

The site of At is located to the north-west of Vršac in south-eastern Banat, Serbia. The settlement was located on a sloping terrace on the north-west edge of Veliki rit, a marshy area drained in the mid-nineteenth century. Several seasons of rescue excavations revealed the existence of a multi-period prehistoric site, ranging from the Lower Palaeolithic to the Late Neolithic (*Joanovič, Prikić 1978*). Renewed excavations in 2014–2015 revealed a structure of the Starčevo period, and cut features associated with Vinča C and Vinča D ceramics (*Chu* et al. *2016*). Four radiocarbon dates are available from the Vinča layers, two from pit 1 and two from the infilling of the Starčevo structure. These place this activity between *6040–5960 cal BC* (*1% probability; Start At C/D*; Fig. 9), or *5700–4660 cal BC* (*94% probability*), probably in *5050–4720 cal BC* (*68% probability*), and *4595–3510 cal BC* (*94% probability; End At C/D*; Fig. 9), or *3180–3090 cal BC* (*1% probability*), probably in *4535–4190 cal BC* (*68% probability*). These estimates are extremely imprecise, with very long tails to the distributions, because there are currently few dates from this site.

Also in the vicinity of Vršac is the 100ha flat settlement of Potporanj, which has produced early Vinča pottery and the largest quantity of obsidian found within the Vinča network. Provenance studies of this material show that it came from the Hungarian and Slovakian Carpathian Mountains (*Tripković, Milić 2009*). Three radiocarbon dates are available from recent excavations of the site by Vršac Museum. MAMS-22667, a sample of unidentified charcoal that may have an old-wood offset, provides a *terminus post quem* of 5210–5000 cal BC (95% probability) or 5210–5160 cal BC (25% probability) or 5120–5105 cal BC (4% probability) or 5080–5005 cal BC (39% probability) for an assemblage of Vinča A ceramics in the earliest occupation level. MAMS-22666, also a sample of unidentified charcoal, provides a *terminus post quem* of 5215–5015 cal BC (95% probability) or 5210–5090 cal BC (51% probability) or 5085–5050 cal BC (17% probability) for the use of Vinča B2/C ceramics in the latest habition level of the site. The third date, MAMS-22668, is on animal bone from a level associated with Vinča B2 pottery and dates this deposit to 5295–5240 cal BC (9% probability) or 5235–5190 cal BC (19% probability) or 5180–5060 cal BC (67% probability), probably 5220–5200 cal BC (13% probability) or 5170–5075 cal BC (55% probability).

A sample of antler was dated from pit 4 at the Neolithic settlement of Satchinez, north-eastern Banat, Romania, which contained sherds of Vinča A2 pottery along with LBK sherds (*Draşovean 1993; Horváth, Draşovean 2010.15*). This provides a date of 5325–5200 cal BC (Deb-2579; 87% probability) or 5165–5115 cal BC (5% probability) or 5110–5075 cal BC (3% probability), probably 5300–5220 cal BC (68% probability) for this assemblage. Also in north-eastern Banat, Romania, two samples of antler have been dated from pit 4 at Hodoni, a multi-period site which has produced 20 pits containing Vinča C pottery (*Draşovean 1994; 1996*). These dates place this assemblage at *4845–4650 cal BC* (*93% probability; Hodoni: pit 4*; Fig. 32) or *4640–4615 cal BC* (*2%*

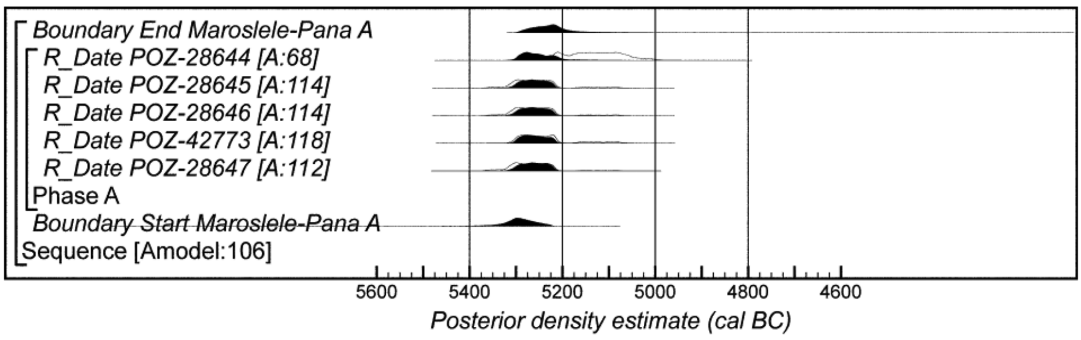


Fig. 8. Probability distributions of radiocarbon dates from Maroslele-Pana. The format is identical to that of Figure 7. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

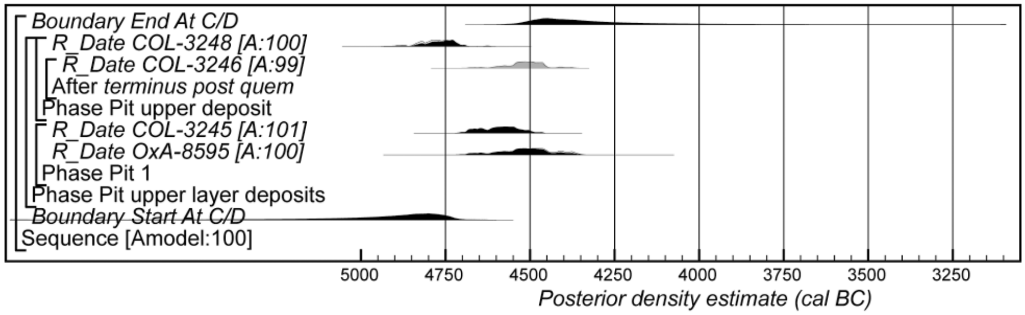


Fig. 9. Probability distributions of radiocarbon dates from At. The format is identical to that of Figure 7 (grey tone indicates the sample has a possible old-wood offset). The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

probability), probably at *4795–4705 cal BC* (*68% probability*).

The tell site of Uivar in the Romanian Banat was excavated between 1999 and 2009 by a Romanian-German team (*Schier, Draşovean 2004; Schier 2008; Draşovean, Schier 2009; Schier 2016*). It consists of a central tell settlement 4m high and covering some 3ha, which was surrounded by a series of substantial ditches, some accompanied by palisades. These enclose an area of some 12ha. A flat settlement occupied at least some of this, and may have succeeded occupation on the tell itself. A complete sequence through the tell was excavated in Trench 1. A recent programme of chronological modelling utilising a total of 182 radiocarbon measurements from the site formally estimates the chronology of this complex (*Schier* et al. *forthcoming; Draşovean* et al. *submitted*).

Only preliminary analyses of the pottery assemblages from the site have been undertaken so far. The lowest deposits in Trench 1 contained pottery predominantly in the Szakálhát tradition. The first Vinča-type sherds appear to be local imitations of Milojčić B1 (*Schier 1995.phase B*). They occur from the construction horizon of H3d in *5045–4990 cal BC* (*95% probability; build H3d+c*; Fig. 10), probably in *5035–5000 cal BC* (*68% probability*). The first sherds of Schier (*1995*) phase C1 (equivalent to late Milojčić B2, see Fig. 2) pottery appear in the construction horizon of H3c, which unfortunately could not be dated directly since the structure did not provide suitable samples. The date of its appearance can be estimated, however, since this must be between the construction of buildings H3d and H3b. This model is shown in Figure 10 and suggests that late Milojčić B2 (*Schier 1995.phase C1*) pottery first appeared in *5030–4930 cal BC* (*95% probability; start Milojčić B2 at Uivar*), probably in *5010–4950 cal BC* (*68% probability*). It becomes predominant on the site from the construction horizon H3b in *4985–4910 cal BC* (*95% probability; build H3b*; Fig. 10), probably in *4960–4925 cal BC* (*68% probability*). Milojčić C (*Schier 1995.phase C2*) pottery appears from the construction of the H3a horizon in *4920–4850 cal BC* (*95% probability; build H3a*; Fig. 10), probably in *4905–4895 cal BC* (*8% probability*) or *4890–4855 cal BC* (*60% probability*). No sherds of Milojčić C–D (*Schier 1995.phase D1*) pottery have been recovered from Uivar, and so Milojčić C ceramics appear to have been current until the end of the Neolithic occupation of the tell in *4740–4600 cal BC* (*95% probability; end Uivar tell*; Fig. 10), probably in *4725–4645 cal BC* (*68% probability*).

Three samples of bone have been dated from the site at Tărtăria, Transylvania, Romania (*Merlini 2011. 224; Merlini, Lazarovici 2008.156*). One is from a partial female skeleton found disarticulated and mixed with animal bone in the pit which is thought to have contained the Tărtăria tablets, one from cleaning of the 1942–1943 section, and one from the base of pit B2. Merlini places the pottery from the pit containing the skeleton in the Vinča phase A2 or A3, although Lazarovici (*2010.Fig 8*) places the same assemblage in Vinča A3/B1; he also places the assemblage from pit B2 in this phase. We have interpreted these classifications to refer to an assemblage of Vinča B1 pottery, which contained surviving elements of Vinča A3.

The taphonomy of the dated material and its association with the recovered ceramics are problematic. The animal bone from the base of pit B2 probably provides a date for the associated Vinča B1 pottery (although, of course, it is always possible that a disarticulated bone is residual). This result calibrates to 5315–5000 cal BC (R-1655; 95% probability), probably to 5295–5250 cal BC (13% probability) or 5230–5195 cal BC (12% probability) or 5180–5065 cal BC (43% probability). The dated animal

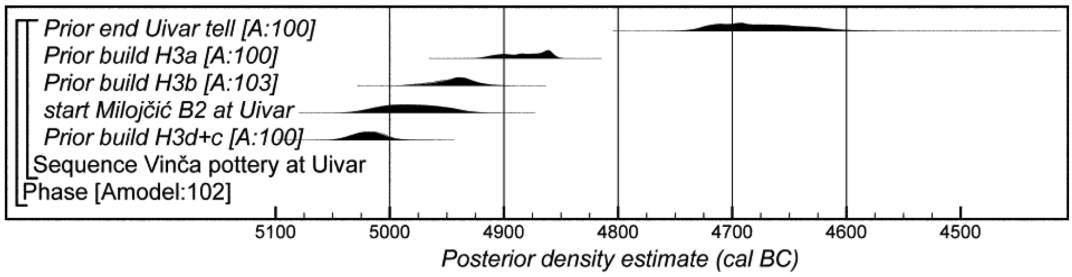


Fig. 10. Probability distributions of key parameters relating to the use of Vinča ceramics at Uivar. The format is identical to that of Figure 7. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly (key parameters have been imported from the model defined by Schier* et alii *(*forthcoming.Figs. 6.9, 6.12–6.22*).

bone from the section is effectively unstratified and cannot be securely associated with the pottery[6]. Interpretation of the date on the female partial skeleton is more complicated, since there appears to be evidence that the body was exposed for a period of time before burial in the pit associated with the tablets. For this reason, in this study we have included this date as a *terminus post quem* for the use of the Vinča B1 ceramics from the pit. This is 5470–5200 cal BC (88% probability; R-1631) or 5165–5115 cal BC (4% probability) or 5110–5075 cal BC (3% probability), probably 5360–5215 cal BC (68% probability)[7].

The settlement at Miercurea Sibiului-Petriş, in the catchment of the upper Mureş valley, consisted of surface houses and pits (*Luca* et al. *2006*). These appear to be associated with Vinča B ceramics. Four radiocarbon dates are available on short-lived materials from two pits and a house (Tab. 2)[8]. Pit 18 is stratigraphically earlier than pit 3 and house 11, although GrA-33127 from pit 18 appears to be on a residual cereal grain and so is incorporated in the model as a *terminus post quem*. This model has good overall agreement (Amodel: 79; Fig. 11), and suggests that Vinča B occupation here occurred between *5650–5025 cal BC* (*95% probability; Start Miercurea Sibiului-Petriş B*), probably *5290–5095 cal BC* (*68% probability*), and *5280–4590 cal BC* (*95% probability; End Miercurea Sibiului-Petriş B*), probably *5170–4970 cal BC* (*68% probability*)[9].

6 This sample was an unidentified animal bone recovered from the cleaning of the section of the 1942/3 excavation and produced a date of 5310–4995 cal BC (95% probability; R-1630, 6200±65 BP), probably 5285–5270 cal BC (2% probability) or 5225–5050 cal BC (66% probability).

7 The radiocarbon dates raise the possibility that Milady of Tărtăria was curated for some time before her bones were buried in this pit. It is 83% probable that R-1631 is earlier than R-1655, probably by -115–375 years (95% probability; distribution not shown), probably -10–240 years (68% probability). The negative parts of these ranges reflect the possibility that her bones were freshly deposited.

8 A further radiocarbon date from Miercurea Sibiului-Petriş (GrA-26606, 6180±40 BP, 5285–5270 cal BC (1% probability) or 5230–5000 cal BC (94% probability)) appears to be on an animal bone that was intrusive in Starčevo pit 9 (*Luca* et al. *2006*).

9 A cattle rib that was dated from L3 house, square 6–8 (110–130cm), at Limba (GrN-28112, 6290±50 BP, 5375–5200 cal BC (88% probability) or 5170–5075 cal BC (7% probability), is from a house that was expected to be contemporary with the Criş IV ceramics within it (*Biagi* et al. *2005.49*). The painted vessel has been attributed to Vinča A2 (*Lazarovici 2009.184–185; 2010. 115–116; 2014.16–18, Figs. 3, 5c*), Vinča A2–A3 (*Mazâre 2005.258, 288*), or Starčevo-Criş IV (*Drașovean 2014.footnote 10*). It appears to be a Lumea Noua import. The result is later than expected and has been reassigned to Vinča A3, although the publication does not provide evidence of an association with Vinča A3 ceramics. This result is therefore not included in the modelling presented here (*Suciu 2009.37*). Similarly, the association between the cattle tibia dated by GrN-28994 (5760±40 BP, 4710–4515 cal BC (95% probability) and the, probably earlier Vinča ceramics, recovered from Cauce Cave is unclear and this result is also not included in this analysis (*Suciu 2009.67–9, Fig. 82, Annex 1*). Three radiocarbon dates from Orăştie–Dealul Permilor (Deb-5762, 5825±60 BP, 4830–4535 cal BC (95% probability); Deb-5765, 6070±70 BP, 5210–4825 cal BC (94% probability) or 4815–4800 cal BC (1% probability); Deb-5775, 5790±55 BP, 4780–4515 cal BC (95% probability)) are again insecurely associated with Vinča pottery and are not modelled here (*Luca 2003*). Eight radiocarbon measurements are available from Cârcea Viaduct, although these samples cannot be associated with Vinča pottery at all (contra *Mantu 2000.99; Biagi, Spataro 2005.37*; Bln-1980, 6100±60 BP, 5215–4880 cal BC (93% probability) or 4870–4845 cal BC (2% probability); Bln-2008, 6550±40 BP, 5615–5585 cal BC (7% probability) or 5570–5465 cal BC (88% probability); Bln-2287, 6300±55 BP, 5465–5440 cal BC (2% probability) or 5425–5405 cal BC (1% probability) or 5385–5200 cal BC (86% probability) or 5170–5075 cal BC (7% probability); Bln-2289, 5910±55 BP, 4945–4680 cal BC (95% probability); Bln-2291, 5990±55 BP, 5005–4725 cal BC (95% probability); Bln-2292, 6350±60 BP, 5470–5220 cal BC (95% probability); Bln-2294, 5865±95 BP, 4965–4495 cal BC (95% probability); and Bln-2354, 5860±60 BP, 4850–4545 cal BC (95% probability)).

Sava valley and tributaries

The site of Lupljanica, with Vinča pottery, is located in the valley of the Bosna River, one of the main tributaries of the Sava in central Bosnia. A single sample of unidentified charcoal was dated from the lowest level of a house structure, 1.3m below the surface (*Breunig 1987.107; Crane, Griffin 1972. 190–191*), and provides a *terminus post quem* of 4910–3985 cal BC (M-2455; 95% probability), probably 4705–4255 cal BC (68% probability) for the end of Vinča D.

The Neolithic tell at Gornja Tuzla is located on the slopes of Mt. Majevica in the upper part of the Jala river catchment. It was discovered in 1949 and is estimated to be between 12 and 15ha in size. Excavations were undertaken over four seasons between 1955 and 1958 (*Čović 1961.79–139*). Five radiocarbon measurements associated with Vinča period activity have been published, but only two have robust ceramic associations[10]. These are measurements on unidentified charcoal found in association with Vinča C pottery that provide *termini post quos* for this pottery of 4535–4330 cal BC (GrN-1974; 95% probability) or 4460–4355 cal BC (68% probability) and of 4780–4355 cal BC (Bln-349; 95% probability) or 4685–4455 cal BC (68% probability).

The multi-period tell at Gomolava is in Vojvodina, Serbia, on the east bank of the river Sava. It was first detected in 1898, and small-scale excavations were undertaken in 1904–1908. The first systematic excavations took place between 1953 and 1985, with approximately half a hectare investigated (*Girić 1988.13; Brukner 1980; 1988*). This yielded a number of prehistoric occupation horizons ranging from the late Neolithic to late Iron Age. However, the site is best known for its late Vinča necropolis (*Borić 1996; Jovanović 2015*), one of only very few discovered thus far in the Balkans.

Fifteen samples are on unidentified charcoal and may have contained material with an old-wood offset; the other 17 samples are on short-lived materials (two bulk samples of carbonised cereal grain, four human burials, and 11 animal bones; *Waterbolk 1988.Beilage 1; Orton 2012.Tab. 2; Borić 2009.Tab. 5*).

A model for the dated Vinča activity at Gomolava has good overall agreement between the radiocarbon dates and the stratigraphic information (Amodel: 80; Fig. 12), only if three dates that fall in the early Bronze Age are excluded as outliers (all considered to be intrusive from later phases of activity: GrN-7373, GrN-7375 and OxA-21132).

The model presented in Fig. 12 suggests that Vinča C started at Gomolava in *5005–4845 cal BC* (*95% probability; Start Gomolava C*; Fig. 12), probably in *4955–4875 cal BC* (*68% probability*); the boundary between phases C and D occurred in *4810–4720 cal BC* (*95% probability; Gomolava C/D*; Fig. 12), probably in *4790–4735 cal BC* (*68% probability*); and

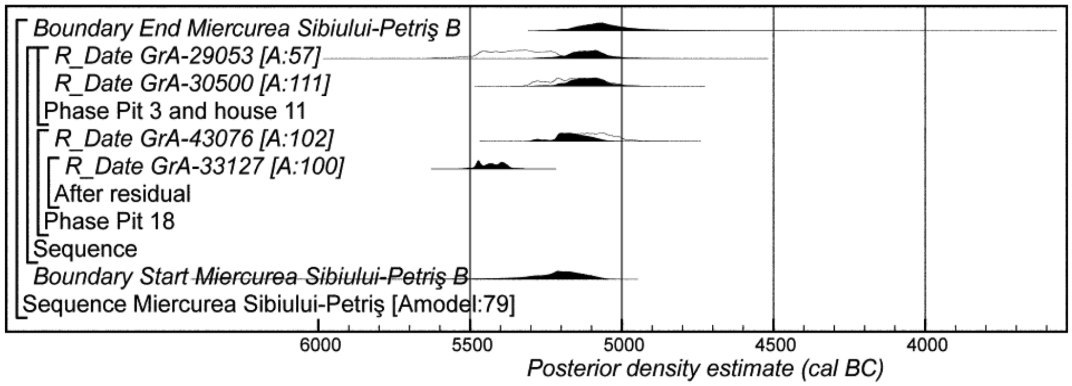


Fig. 11. Probability distributions of radiocarbon dates from Miercurea Sibiului-Petriş. The format is identical to that of Figure 7. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

10 Three further measurements have been obtained from more recent excavations at Gornja Tuzla (*Vander Linden* et al. *2014*). OxA-23297 (6165±34 BP, 5220–5015 cal BC (95% probability)) on a large mammal bone from layer 15 does not appear to be securely associated with a diagnostic ceramic assemblage. Two further statistically consistent measurements (OxA-23298, 5827±33 BP, 4785–4590 cal BC (95% probability) and OxA-23299, 5741±33 BP, 4690–4500 cal BC (95% probability): T' = 3.4; ν = 1; T'(5%) = 3.8) were obtained on different species of animal bone (*Bos taurus* and *Cervus elaphus*) from layer 8. These samples also have no known direct ceramic associations.

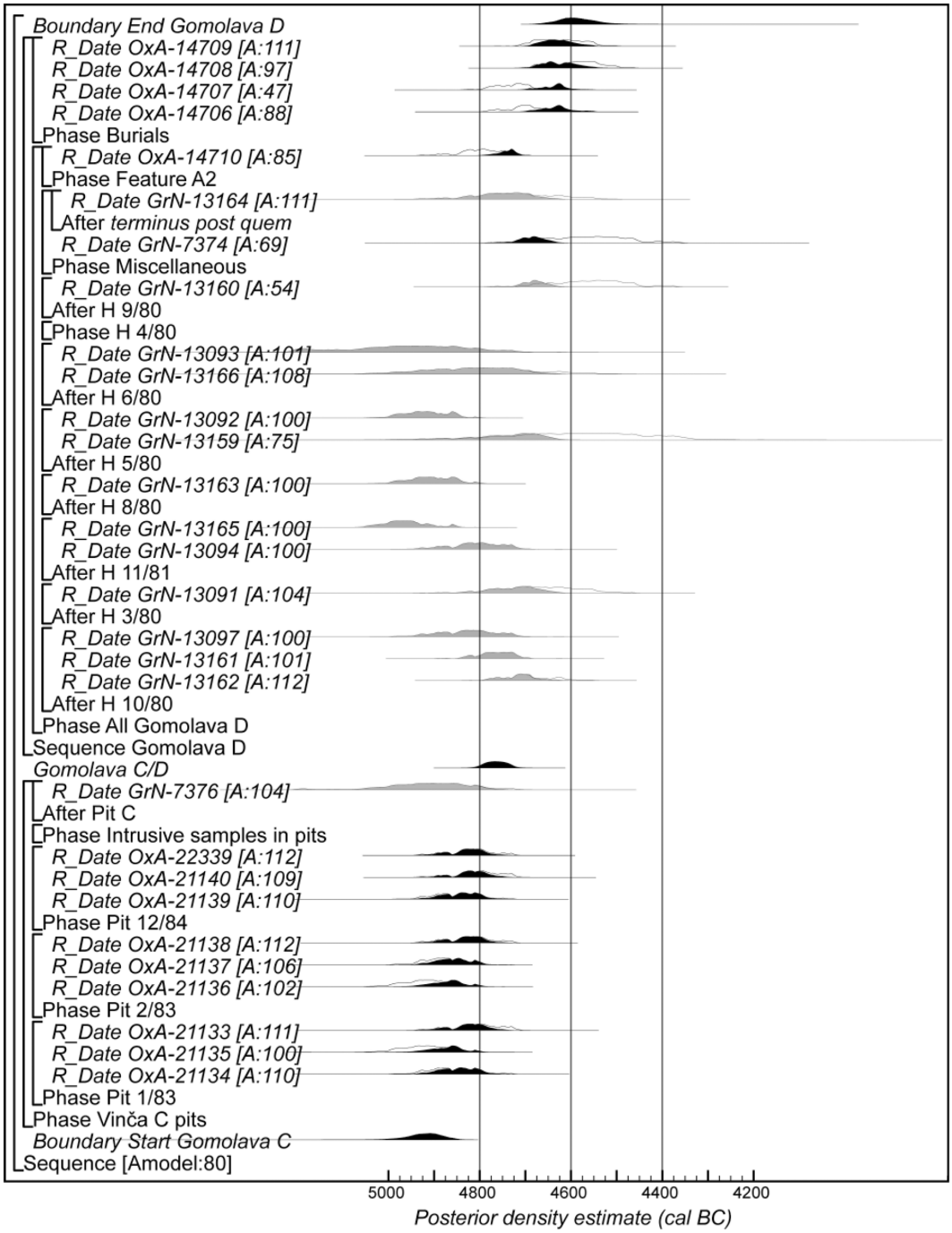


Fig. 12. Probability distributions of radiocarbon dates from Gomolava. Distributions for GrN-7373, GrN-7375, and OxA-21132, which are considered to derive from post-Neolithic activity, are not shown. Grey tone indicates that the sample has a possible old-wood offset. The format is identical to that of Figure 7. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

phase D ended here in *4670–4500 cal BC* (*95% probability; End Gomolava D*; Fig. 12), probably in *4635–4550 cal BC* (*68% probability*).

The Neolithic settlement at Petnica is located in the Kolubara valley area in western Serbia, on a slope running up to a north-facing cliff. A cave in this cliff was also occupied in this period. The site has been excavated on several occasions, yielding three late Neolithic occupation phases and several Vinča-period wattle and daub structures (*Starović 1993*).

Seven radiocarbon dates have been obtained on animal bone samples from occupation features at Petnica (*Borić 2009.Tab. 6; Orton 2012.Tab. 2*). The model for the dated activity at Petnica has good over-

all agreement (Amodel: 94; Fig. 13), if we interpret Pit 3 as being cut from above the level of House 3 and if we interpret the animal bone from House 2 as residual. We follow the ceramic phasing for Petnica published by David Orton (*2012*).

This model suggests that phase B2 at Petnica started in *5050–4850 cal BC* (*95% probability; Start Petnica B2*; Fig. 13), probably in *4995–4900 cal BC* (*68% probability*); the boundary between phases B2 and C occurred in *4965–4850 cal BC* (*95% probability; Petnica B2/C*; Fig. 13), probably in *4940–4880 cal BC* (*68% probability*); the boundary between phases C and D occurred in *4950–4845 cal BC* (*95% probability; Petnica C/D*; Fig. 13), probably in *4925–4860 cal BC* (*68% probability*) and the dated sequence ended in *4935–4735 cal BC* (*95% probability; End Petnica D*; Fig. 13), probably in *4900–4800 cal BC* (*68% probability*).

The site of Masinske Njive is located in western Serbia on a tributary of the Kolubara River. The site was originally recorded in the 1960s and was excavated in full between 2006 and 2009 in advance of coal mining. A single phase Vinča settlement was excavated, which produced Vinča B1/B2 ceramics (*M. Spasić, pers. comm.*).

Three radiocarbon measurements have been obtained on samples of animal bone from settlement features. A model for the dated activity at this site has good overall agreement (Amodel: 100; Fig. 14), and indicates that this activity began in *5705–5085 cal BC* (*95% probability; Start Masinske B*; Fig. 14), probably in *5355–5215 cal BC* (*68% probability*), and ended in *5300–4700 cal BC* (*95% probability; End Masinske B*; Fig. 14), probably in *5275–5070 cal BC* (*68% probability*).

Barely 500m west of Masinske Njive, on an elevated terrace above the same tributary of the Kolubara River, lay the early Vinča A site of Jaričište 1. Although the site was recorded in the 1960s, it was only excavated between 2006 and 2010 and has since been destroyed by the Kolubara coal mine (*Marić 2013*). The early Vinča settlement featured several dozen pits, some containing ovens, although no wattle and daub structures were detected.

A single flax seed was dated from pit 1.137, which contained an assemblage of Vinča A pottery, indicating that these ceramics date to 5320–5205 cal BC (88% probability; NOSAMS-78623) or 5165–5135 cal BC (3% probability) or 5130–5115 cal BC (1% probability) or 5110–5075 cal BC (3% probability), probably in 5300–5240 cal BC (53% probability) or 5235–5215 cal BC (15% probability).

The Belgrade area

The tell site of Belo Brdo at Vinča just east of Belgrade forms the type-site for the development of Vinča pottery. The 8m of Neolithic deposits have been excavated almost constantly since 1908, when Vasić began large scale excavations. The massive assemblage of pottery from these excavations has been the subject of a series of seminal typological

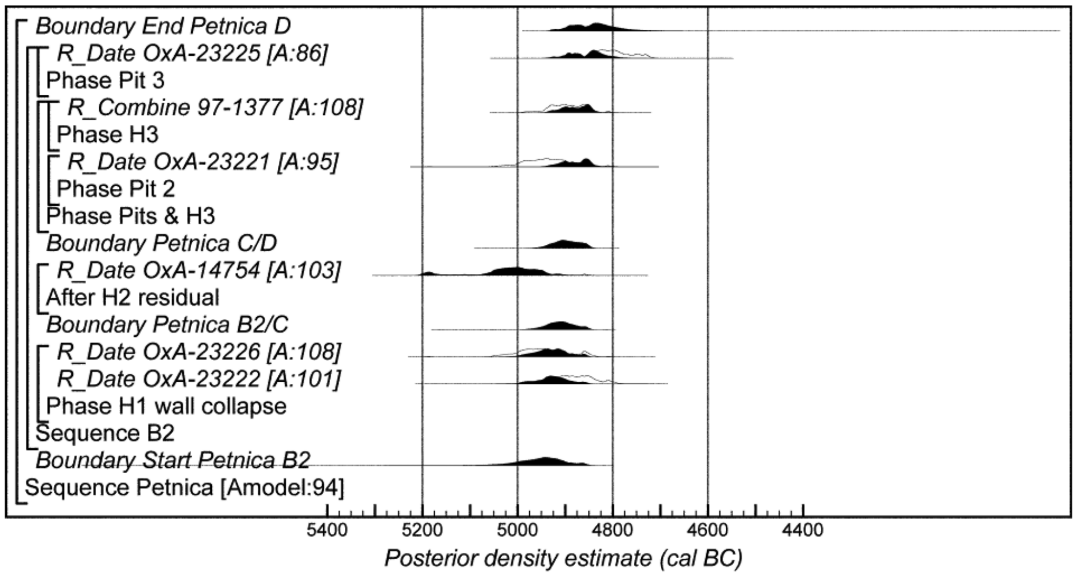


Fig. 13. Probability distributions of radiocarbon dates from Petnica. The format is identical to that of Figure 7. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

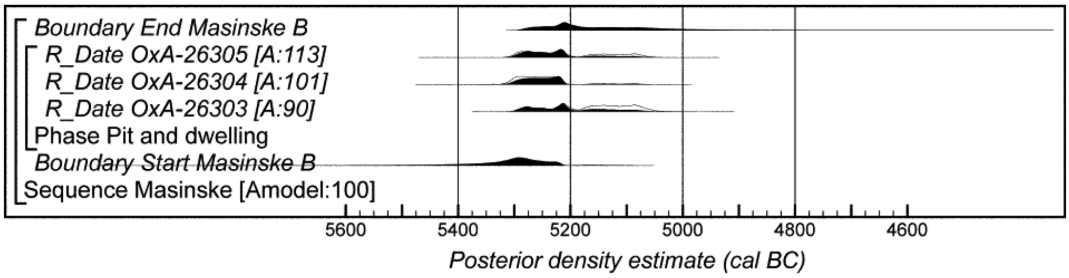


Fig. 14. Probability distributions of radiocarbon dates from Masinske Njive. The format is identical to that of Figure 7. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

studies (Fig. 2), the sequence through the tell providing relative chronology for the schemes suggested. As part of the *The Times of Their Lives* project, major new programmes of radiocarbon dating have been undertaken on the Vasić sequence (*Tasić* et al. *2016a*), the excavations of the upper levels in Sector II (*Tasić* et al. *2015*) and the sequence from a new deep sounding excavated between 2004–2014 (*Tasić* et al. *2016b*).

Most relevant to the chronology of Vinča ceramics is the model presented by Tasić *et alii* (*2016a.Fig. 17*) for the sequence of deposits excavated by Miloje Vasić, as these excavations covered a larger area than those of all subsequent excavations combined and consequently produced by far the largest assemblage of Vinča pottery. This is a Poisson process age-depth model with the rigidity of the process defined as the 10cm spits used by Vasić to excavate the tell and record the recovered finds (*Bronk Ramsey 2008; Bronk Ramsey, Lee 2013*). The typological scheme for Vinča pottery published by Milojčić (*1943*) used in this study was based on the published ceramics from this archive recorded by these spits. The age-depth model thus explicitly estimates their dates. Milojčić phase A occurs between 9.3m and 8.0m, phase B1 between 8.0m and 7.0m, phase B2 between 7.0m and 6.0m, phase C between 6.0m and 4.0m, and phase D from 4.0m to the top of Vinča cultural layers at 1.3m.

On this basis, at Belo Brdo Milojčić phase A begins in *5305–5255 cal BC* (*95% probability; Belo Brdo start A*; Fig. 15), probably in *5300–5270 cal BC* (*68% probability*). The transition between Milojčić A and B1 occurs in *5210–5135 cal BC* (*95% probability; Belo Brdo A/B1*; Fig. 15), probably in *5200–5165 cal BC* (*68% probability*). The shift between Milojčić B1 and B2 occurs in *5115–5040 cal BC* (*95% probability; Belo Brdo B1/B2*; Fig. 15), probably in *5090–5055 cal BC* (*68% probability*). The transition between Milojčić B2 and C happens in *4935–4850 cal BC* (*95% probability; Belo Brdo B2/C*; Fig. 15), probably in *4920–4875 cal BC* (*68% probability*). The transition between Milojčić phases C and D occurs in *4765–4680 cal BC* (*95% probability; Belo Brdo C/D*; Fig. 15), probably in *4760–4735 cal BC* (*12% probability*) or *4725–4690 cal BC* (*56% probability*). Milojčić (*1943*) placed the end of his phase D at 2.5m at Belo Brdo, but the accumulation of Vinča ceramics within the deposits of Belo Brdo continues up to a depth of 1.3m, until *4570–4460 cal BC* (*95% probability; Belo Brdo end D*; Fig. 15), probably in *4550–4495 cal BC* (*68% probability*).

The presence of Vinča D ceramics above relative depth of 2.5m at Belo Brdo was confirmed by excavations in Sector II undertaken between 1998 and 2009, where such ceramics occur until *4550–4485 cal BC* (*95% probability; fire 2*; *Tasić* et al. *2015. Fig. 8*), probably in *4545–4505 cal BC* (*68% probability*). This date estimate for the end of Vinča D at Belo Brdo is completely independent of that provided by the age-depth model of the Vasić sequence, but the medians of these probability distributions vary by just three years. The chronological modelling of the new sounding provides much greater detail on the structural narrative of the tell but, given the small area excavated and the small quantity of material recovered, this area does not add materially to our understanding of Vinča ceramics.

The late Neolithic flat settlement at Opovo is located on a low knoll overlooking a then active meander of the Tamiš River, about 25km north of Belgrade. During the 1980s five seasons of excavation recorded a total area of 340m^2 (*Tringham* et al. *1985; 1992*), yielding three successive building horizons associated with late Vinča C and early Vinča D ceramics.

Thirteen radiocarbon measurements are available on animal bone (*Orton 2012.Tab. 2*) and unidentified

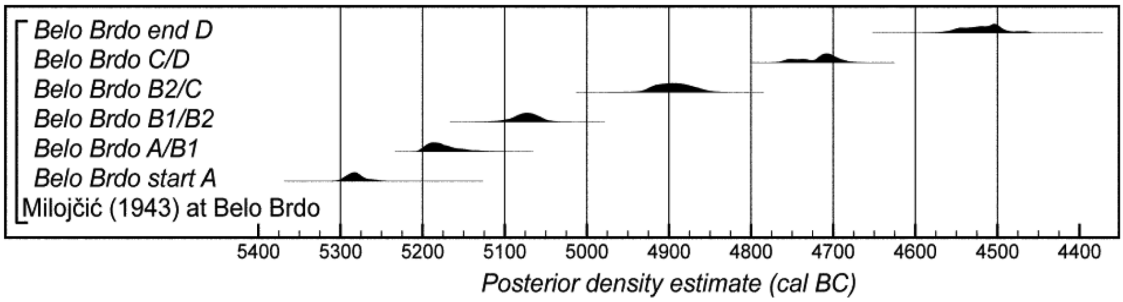


Fig. 15. Probability distributions of Milojčić (*1943*) ceramic phase boundaries at Vinča-Belo Brdo, derived from the model illustrated in Tasić* et alii *(*2016a.Fig. 17*).

charcoal (Tab. 2) from a sequence of building horizons (BH2 and 3) and associated pits. All 13 dates are in good agreement with the site stratigraphy and phasing, and the model has good overall agreement (Amodel: 115; Fig. 16).

The model indicates that activity associated with Vinča C pottery at Opovo began in *4960–4805 cal BC* (*95% probability; Start Opovo C*; Fig. 16), probably in *4915–4840 cal BC* (*68% probability*), and that the use of Vinča C pottery on the site ended in *4835–4695 cal BC* (*95% probability; End Opovo C*; Fig. 16), probably in *4820–4740 cal BC* (*68% probability*). It should be noted that there are currently no radiocarbon dates for the latest building horizon (BH 1) at Opovo and so settlement certainly continued after this time.

Located in the south-east suburb of Belgrade of the same name, the site of Banjica is a well-known late Neolithic settlement. It was situated on a plateau above the Banjica stream and was discovered during road construction in 1921 (*Todorović, Cermanović 1961*). The site has yielded five settlement horizons of wattle-and-daub structures and pits associated with Vinča D ceramics (*Tripković 2007*).

Two statistically consistent measurements (T' = 0.1; T'(5%) = 3.8; ν = 1; *Ward, Wilson 1978*) on bulk unidentified charcoal (one including charred grain) were obtained for features from Banjica associated with Vinča D pottery (Tab. 2). These provided *termini post quos* for the end of Vinča D here of 4770–4755 cal BC (1% probability) or 4730–4355 cal BC (94% probability; GrN-1542), probably 4680–4635

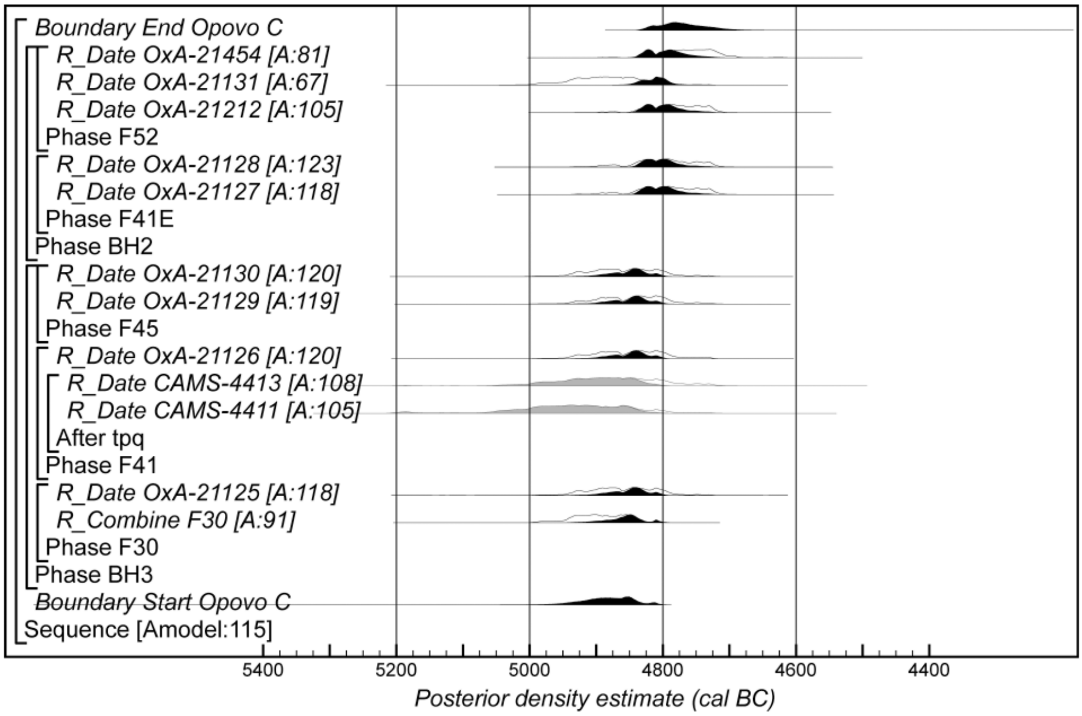


Fig. 16. Probability distributions of radiocarbon dates from Opovo. The format is identical to that of Figure 7. Grey tone indicates that the sample has a possible old-wood offset. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

cal BC (13% probability) or 4620–4455 cal BC (55% probability), and 4795–4320 cal BC (GrN-1536, 95% probability), probably 4655– 4640 cal BC (2% probability) or 4620–4365 cal BC (66% probability)[11].

Central Serbia[12]

Located in central Serbia, south-west of Kragujevac, the settlement site of Grivac lies on the east bank of the Gruža River, on a wide terrace bounded by several streams. A chance discovery in 1950, it was excavated episodically between 1952 and 1994 (*Bogdanović 2004*). The earliest phase of occupation has Starčevo pottery, and pre-dates a settlement associated with Vinča ceramics of phases A–C, which is itself sealed by an early Iron Age barrow cemetery (*Bogdanović 1977*).

Six radiocarbon dates, all on samples of unidentified bulk charcoal or 'burnt earth', can be associated with assemblages of Vinča ceramics (Tab. 2). Bln-870 provides a *terminus post quem* for the end of Vinča A of 5480–5040 cal BC (95% probability), probably of 5470–5400 cal BC (12% probability) or 5390–5205 cal BC (56% probability). The latest of the five dates associated with Vinča C ceramics[13] provides a *terminus post quem* for the end of Vinča C of *4960–4530 cal BC* (*95% probability; tpq Grivac C*; Fig. 17), probably of *4880–4680 cal BC* (*64% probability*) or *4640–4615 cal BC* (*4% probability*).

The site of Divostin (II) is situated in central Serbia, west of the town of Kragujevac, and on a slope between two streams in a landscape dominated by gentle hills. Small-scale excavations took place between 1967 and 1970 covering 1.65% of the estimated total site area of 15ha (*McPherron, Srejović 1988*). The earliest occupation on the site is associated with Starčevo pottery, but the majority of the excavated features belong to a later settlement defined by wattle and daub rectangular structures associated with late Vinča pottery.

Eleven radiocarbon dates were obtained on samples (seven unidentified bulk charcoal, one 'burnt earth' and three single animal bones) from a sequence of houses and pits associated with Vinča C and D pottery (Tab. 1). Two dates on bulk charcoal (Bln-867 and BM-574) are far too young for their stratigraphic position within the described sequence, and have been excluded from the model. These samples probably contained a component of intrusive charcoal. The remaining nine measurements include two sets of replicates (repeat measurements on the same bulk sample). Two measurements on unidentified charcoal from pit F117 are statistically consistent (Bln-865 and Bln-865a; T' = 0.2; T'(5%) = 3.8; ν = 1), as are three measurements, also on unidentified charcoal, from pit 20 (F121) (Z-336a, Z-336b and Bln-898; T' = 2.1; T'(5%) = 6.0; ν = 2).

The model which combines these radiocarbon dates with the ceramic phasing has good overall agreement (Amodel: 113; Fig. 18), although all the samples that can be associated with Vinča C ceramics are of unidentified charcoal and so only provide *termini post quos* for the end of this phase. This model suggests that the transition between Vinča C and D ceramics at Divostin occurred in *4830–4600 cal BC* (*95% probability; Divostin C/D*; Fig. 18), probably *4740–4635 cal BC* (*68% probability*) and the use of Vinča D ceramics ended in *4710–4320 cal BC* (*95% probability; End Divostin D*; Fig. 18), probably *4675–4535 cal BC* (*68% probability*).

The Morava valley and southwards

The site of Anzabegovo is located in the eastern part of FYR of Macedonia, in an area known as Ovče Pole. It was discovered by chance during the construction of a railway line in the early 1960s, with the main excavations taking place in 1969 and 1970 (*Gimbutas 1974*). The multi-period settlement was first established in the early Neolithic, with activity on site occurring into the Roman period.

Two statistically consistent measurements (LJ-2329 and LJ-2411: T' = 1.0; T'(5%) = 3.8; ν = 1) on unidentified bulk charcoal were obtained for features associated with Vinča B pottery (Tab. 2). Given the potential for the sample to have contained a component of old wood, LJ-2329 provides a *terminus post quem* for the presence of Vinča B ceramics at Anzabegovo of 5320–5025 cal BC (95% probability), probably of 5300–5205 cal BC (39% probability) or 5165–5115 cal BC (17% probability) or 5110–5075 cal BC (11% probability).

11 A third measurement is quoted by N. N. Tasić (*1988.46*) as 'GrN *** 5320±150 BP', but no further details can be traced. The Groningen laboratory has no record of this measurement, and so it was certainly produced elsewhere. It calibrates to 4455–3890 cal BC (90% probability) or 3885–3795 cal BC (5% probability).

12 Two measurements have been published by Gimbutas (*1976.Tab. IV*) as being from Medvednjak in central Serbia. Bln-480, however, is from Ószentiván, Hungary (*Kohl, Quitta 1970.411*) and LJ-2523 is from Šventoji, Lithuania (*Linick 1977.27*).

13 Z-1507 is clearly much later than the other samples from this phase and has been excluded from this analysis; it is likely that the bulk sample contained an element of intrusive later charcoal.

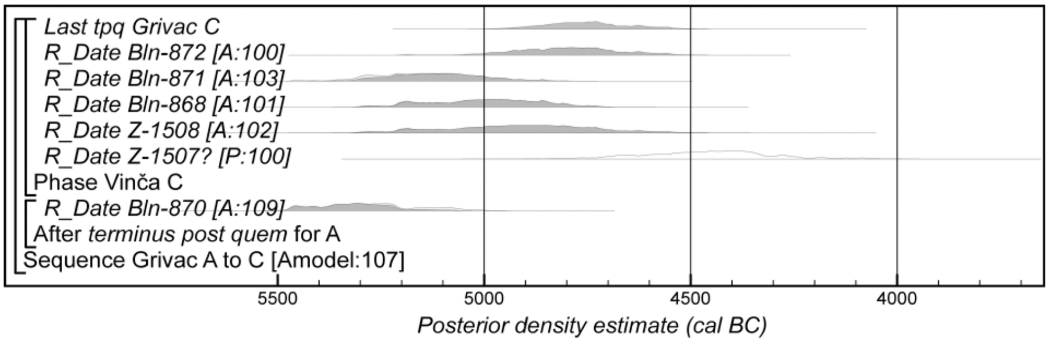


Fig. 17. Probability distributions of radiocarbon dates from Grivac. The format is identical to that of Figure 7. Grey tone indicates that the sample has a possible old-wood offset. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

The site of Belovode in Veliko Laole lies to the west of River Mlava, on one of its smaller tributaries. It was discovered by chance in the 1960s. The settlement was located on an ellipsoid plateau, barely 10km to the east of the Velika Morava River, and is cut in half by a small stream named Belovode (*Šljivar, Jacanović 1996*). The site is multi-period, with the earliest habitation occurring during the Starčevo period, followed by a longer phase of late Neolithic Vinča occupation and ending in the Late Bronze Age. The first systematic excavations took place in 1994 and continued episodically until 2015.

Nine radiocarbon dates were obtained on samples of single animal bones and antlers from a sequence of houses and associated features with Vinča A to C pottery (*Borić 2009*; Tab. 2). One date (OxA-14678) from the top of the sequence is far too late and almost certainly belongs to a later phase of activity and is excluded from the model. Three dates (OxA-14680, –14 683 and –14 700), with poor individual agreement with their relative stratigraphic positions, work well with the model presented in Figure 19 if treated as *termini post quos* (interpreted as residual animal bone within their respective contexts). If this interpretation is applied then the model, based on the stratigraphy, pottery phasing (A to C) and the radiocarbon dates, has good overall agreement (Amodel: 102; Fig. 19).

The model indicates that the activity, associated with Vinča A to C pottery, started at Belovode in *5795–5230 cal BC* (*95% probability; Start Belovode A*; Fig. 19), probably in *5515–5310 cal BC* (*68% probability*); that the transition from Vinča A to B occurred in *5365–5075 cal BC* (*95% probability; Belovode A/B*; Fig. 19), probably in *5320–5165 cal BC* (*68% probability*); that the transition from Vinča B to C occurred in *5150–4645 cal BC* (*95% probability; Belovode B/C*; Fig. 19), probably in *5050–4735 cal*

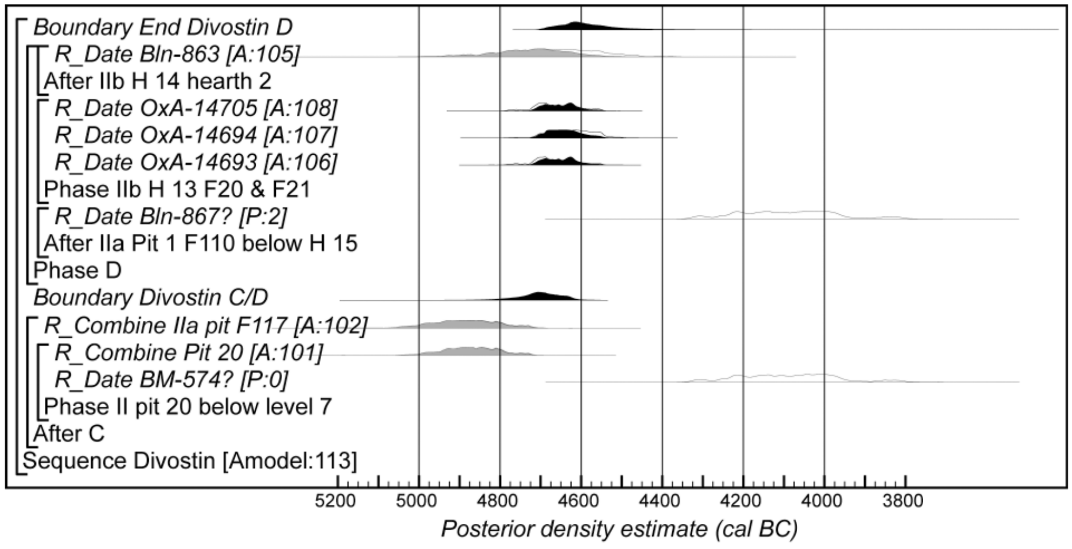


Fig. 18. Probability distributions of radiocarbon dates from Divostin. The format is identical to that of Figure 7. Grey tone indicates that the sample has a possible old-wood offset. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

BC (*68% probability*). The use of Vinča C ceramics at Belovode ended in *4775–4205 cal BC* (*95% probability; End Belovode C*; Fig. 19), probably in *4705–4495 cal BC* (*68% probability*).

Located in a village west of the town of Prokuplje, the site of Pločnik lies on an elevated terrace of the Toplica River. It was discovered in the 1920s during the construction of a railway line and was excavated episodically until 2013 (*Stalio 1964; 1973*). The site is best known for the find of approx. 17kg of copper implements excavated from buildings and hoards associated with a late phase of Vinča culture (*Šljivar* et al. *2010*).

Eight radiocarbon measurements, all on single animal bones, were obtained for features associated with houses within the settlement (Tab. 2). The dated features contained Vinča B pottery and 'Gradac' pottery. In this area the site begins with the use of Vinča B1 (D. *Šljivar, pers. comm.*), and all the dated samples are from contexts below the 'Gradac' layer except for OxA-14685 (*Borić 2009.Figs. 22–23*). Samples from sequences of deposits were dated in trenches 14 and 15, and all the radiocarbon dates are in good agreement with these stratigraphic sequences and the pottery phasing (Amodel: 102; Fig. 20).

The first use of Vinča B1 ceramics at Pločnik occurred in *5350–5060 cal BC* (*95% probability; Start Pločnik B1*; Fig. 20), probably in *5240–5110 cal BC* (*68% probability*). Vinča B ceramics ended here in *5030–4755 cal BC* (*95% probability; End Pločnik B2*; Fig. 20) probably in *4985–4860 cal BC* (*68% probability*). Trench 16 contained features associated with 'Gradac' pottery. A single radiocarbon sample associated with this ceramic phase provides a *terminus ante quem* for the start of Milojčić phase C and a *terminus post quem* for the end of Milojčić phase D at Pločnik of 4710–4530 cal BC (95% probability; OxA-14685; Tab. 2), probably of 4685–4630 cal BC (31% probability) or 4625–4555 cal BC (37% probability).

The site of Oreškovica lies on a hill dominating the surrounding territory around the village of the same name. It is approx. 6ha in size, and is surrounded by at least two enclosure ditches. It is a single-phase settlement associated with Vinča B pottery. Even though it was known by the mid-1970s it was only excavated for the first time in 2013 (*Borić* et al. *in preparation*).

Six radiocarbon dates, all on single samples of animal bone (two of them articulating) are currently available (Tab. 2). A model combining these results

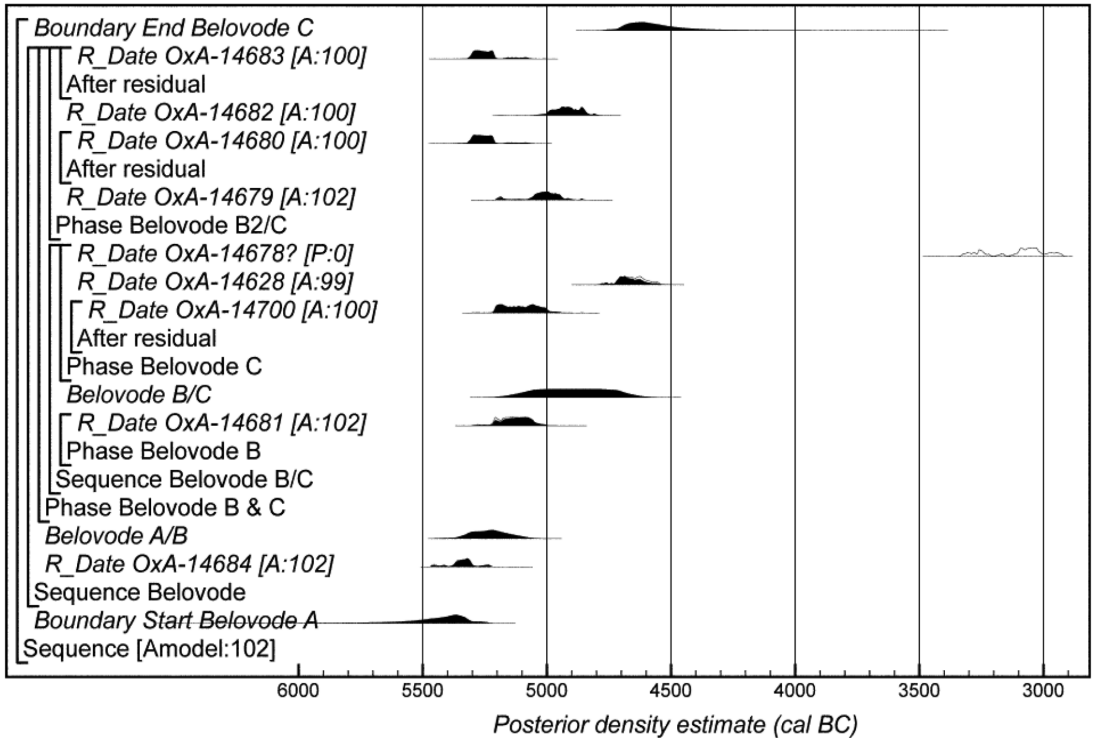


Fig. 19. Probability distributions of radiocarbon dates from Belovode. The format is identical to that of Figure 7. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

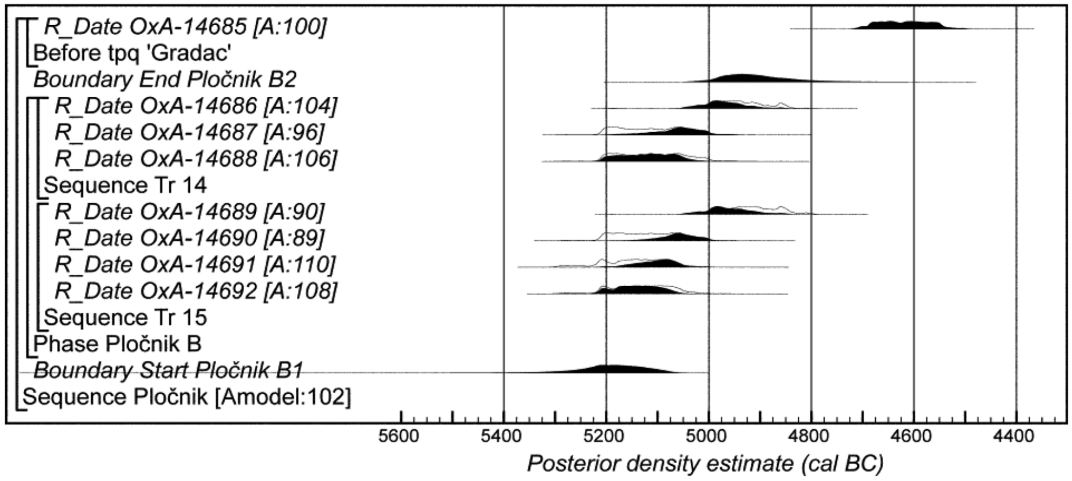


Fig. 20. Probability distributions of radiocarbon dates from Pločnik. The format is identical to that of Figure 7. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

with the stratigraphic sequence is shown in Fig. 21, and has good overall agreement (Amodel: 105; Fig. 21). This suggests that the settlement at Oreškovica (and so Vinča B ceramics) began in *5400–5080 cal BC* (*95% probability; Start Oreškovica B*; Fig. 21), probably in *5335–5210 cal BC* (*67% probability*) or *5165–5155 cal BC* (*1% probability*), and ended in *5215–4935 cal BC* (*95% probability; End Oreškovica B*; Fig. 21), probably in *5200–5180 cal BC* (*4% probability*) or *5165–5030 cal BC* (*64% probability*).

Selevac-Staro Selo site lies in the Šumadija area, to the west of the lowest part of the Velika Morava River valley, barely 22km south of its confluence with the Danube (*Tringham, Krstić 1990a*). The site is located 4.8km east of the modern village of the same name on elevated ground west of the river. The site was recognised in 1968, with small-scale excavations taking place until 1970 and again in 1973. The Selevac Archaeological Project ran from 1976 until 1981, and yielded settlement remains of the Late Neolithic Vinča period.

Twelve radiocarbon dates for Selevac were obtained on samples (bulk charcoal and bulk cereal grain) from a sequence of houses and associated features with Vinča B1 to C pottery (Tab. 2). We have used the ceramic phasing for this sequence presented by Schier (*1995.Figs. 144–5*), although unfortunately all the dates associated with Vinča B2 and C ceramics are on unidentified charcoal and so can only be included in the model as *termini post quos*. This model is shown in Fig. 22, which has good agreement (Amodel: 100). Generally, measurements from the Rudjer Bošković Institute, Zagreb, are likely to

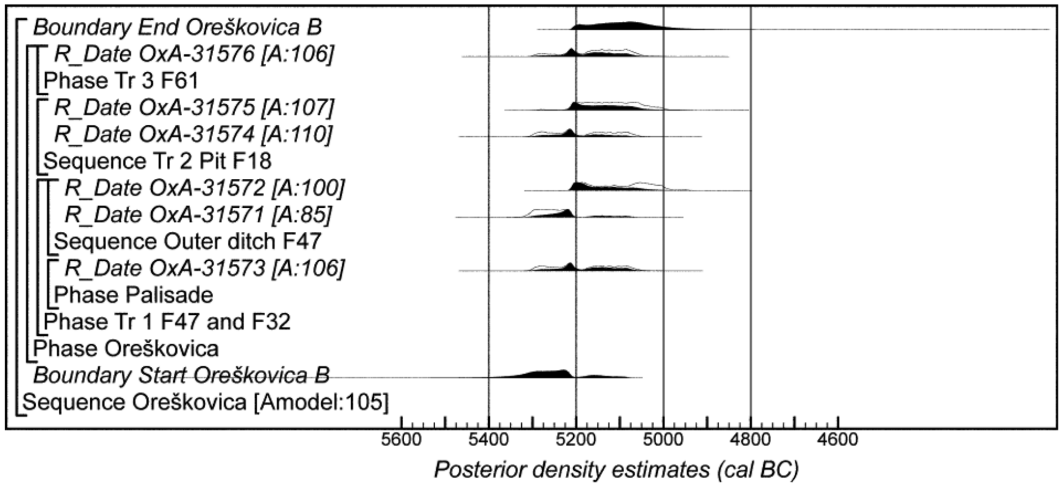


Fig. 21. Probability distributions of radiocarbon dates from Oreškovica. The format is identical to that of Figure 7. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

be on average 77 years too young (*Horvatinčić* et al. *1990.299*). In this case, however, it can be noted that the two measurements in question (Z-233a–b) are statistically consistent with a third from La Jolla (LJ-2521; T' = 0.4; T'(5%) = 6.0; ν = 2) and so they are probably accurate.

The model indicates that this activity, associated with Vinča B1 pottery, started in *6800–6685 cal BC* (*2% probability; Start Selevac B1*; Fig. 22) or *6340–4960 cal BC* (*93% probability*), probably in *5525–5010 cal BC* (*68% probability*). The transition between Vinča B1 and B2 occurred here in *5210–3585 cal BC* (*95% probability; Selevac B1/B2*; Fig. 22), probably in *5165–4655 cal BC* (*68% probability*). The dated occupation at Selevac ended in *4580–2460 cal BC* (*78% probability; End Selevac C*; Fig. 22) or *2195–1495 cal BC* (*17% probability*), probably in *4565–3190 cal BC* (*61% probability*) or *1770–1495 cal BC* (*7% probability*).

The site of Predionica is located in a suburb of Priština in Kosovo. It was excavated in 1955 and 1956 in advance of the construction of a factory building. It yielded a late Neolithic settlement with three building horizons (*Galović 1959*). A single sample of oak charcoal was dated from a fire installation associated with Vinča A ceramics, and provides a *terminus post quem* of 5470–5400 cal BC (6% probability; Bln-435) or 5390–5045 cal BC (89% probability), probably of 5360–5205 cal BC (57% probability) or 5165–5135 cal BC (5% probability) or 5130–5115 cal BC (2% probability) or 5110–5100 cal BC (1% probability) or 5095–5075 cal BC (3% probability) for the end of Vinča A at this location.

The site of Valač is located in the north-west part of Kosovo, near the town of Kosovska Mitrovica. The site is located on a terraced hill on the edge of the Ibar River valley, and it appears to have been defended by a palisade and a stone wall (*N. Tasić 1960*). It was excavated briefly in 1957. A single measurement on a bulk sample of charred acorns and peas from a pit associated with Vinča D ceramics dates this assemblage to 4960–4545 cal BC (95% probability; Bln-436), probably to 4900–4865 cal BC (7% probability) or 4855–4685 cal BC (61% probability).

Beran Krš is located on a dominant ridge on the left bank of the river Lim, approx. 3km from the town of Berane in Montenegro. Small test trenches were dug in 1961, but the main research excavations were undertaken in 1975 and 1976. The settlement consisted of several building horizons belonging to the Vinča period (*Marković 1985*).

Two measurements on unidentified bulk charcoal are available from two stratigraphically related deposits (Tab. 2). The published contextual details, how-

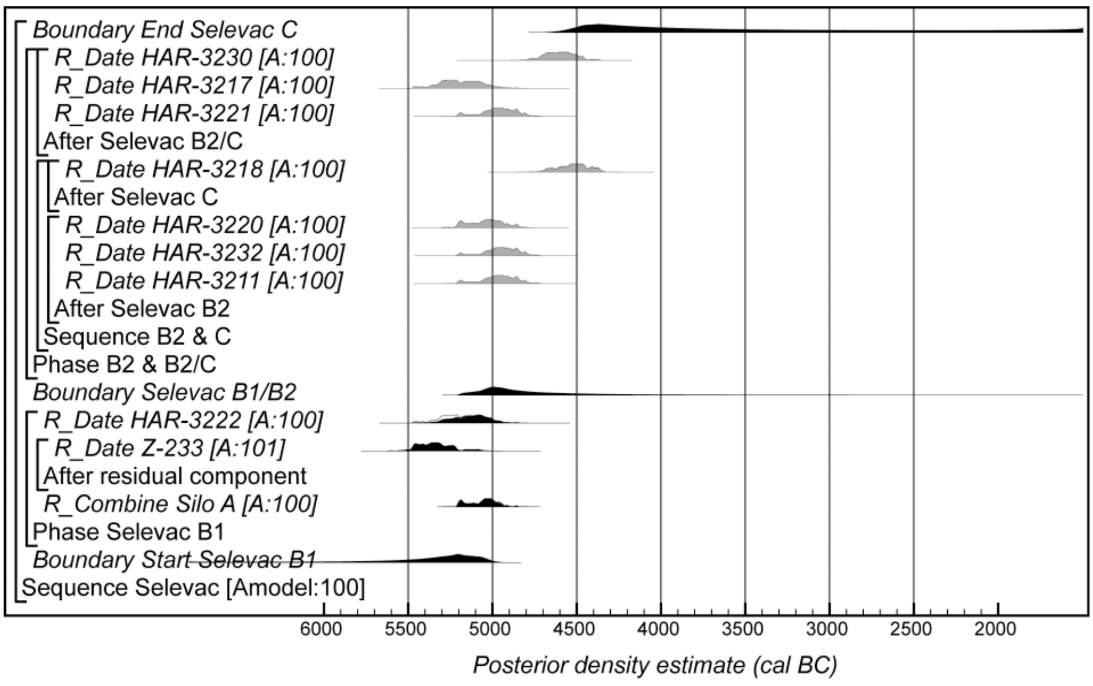


Fig. 22. Probability distributions of radiocarbon dates from Selevac. The format is identical to that of Figure 7. Grey tone indicates that the sample has a possible old-wood offset. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

ever, differ. Z-491 is attributed to Level VII and Z-492 to Level XIII (*Srdoč* et al. *1977.474*), but also to Levels III and IV/Horizon IIa (*Marković 1985.70*). Here, we follow Čedomir Marković (*1985.72*) in interpreting both dates as *termini post quos* for the end of Vinča C ceramics at this location, of 5205–5165 cal BC (2% probability; Z-491) or 5075–4765 cal BC (93% probability), probably of 5000–4840 cal BC (68% probability), and of 5210–5160 cal BC (1% probability; Z-492) or 5080–4440 cal BC (92% probability) or 4425–4370 cal BC (2% probability), probably of 4930–4920 cal BC (1% probability) or 4910–4545 cal BC (67% probability). It should be noted that both measurements are from the Rudjer Boškovi ć Institute, Zagreb, and it is likely that the measurements are on average 77 radiocarbon years too young (*Horvatinčić* et al. *1990.299*).

The site of Donje Vranje in the southern Morava valley was excavated in advance of road construction in June 2013 (*Kapuran* et al. *2016*). Several pits containing Vinča B2 ceramics were recorded. A single radiocarbon date on a disarticulated animal bone was dated from pit 1, providing a date of 5295–5240 cal BC (9% probability; SUERC-57927) or 5235–5050 cal BC (86% probability), probably of 5220–5200 cal BC (10% probability) or 5175–5070 cal BC (58% probability) for the use of Vinča B2 ceramics on the site.

The Danube downstream of Vinča-Belo Brdo

A single sample of unidentified charcoal has been dated from pit 21 at Gornea, providing a *terminus post quem* of 4895–4865 cal BC (2% probability; BM-1124) or 4850–4585 cal BC (93% probability), probably of 4825–4815 cal BC (3% probability) or 4805–4685 cal BC (65% probability) for the associated assemblage of Vinča A ceramics (*Burleigh, Hewson 1979.350*). A bulk sample of charred grain from Liubcova (*László 1997*) has been dated from a context associated with Vinča B2 pottery, dating it to 5320–4905 cal BC (95% probability; Bln-2133), probably to 5225–5000 cal BC (68% probability).

The site of Rudna Glava is located in the village of the same name on a steep slope above it. The location is about 20km south of the Danube in the area of the Iron Gorge (*Jovanović 1982*). Rudna Glava is best known for its early copper metallurgy and was the first copper ore mine to be excavated in the Balkans. Discovered in the mid-1960s, the first archaeological survey took place in 1968, followed by several seasons of excavations which uncovered multiple prehistoric shafts cut vertically into the cliff face.

Fourteen radiocarbon measurements are available on samples from Rudna Glava (*Borić 2009.Tab. 1; Burleigh* et al. *1982.255*), but only eight of these appear to be associated with Vinča ceramics[14]. These have been assigned to the Gradac phase (*Jovanović 1982; 1994*) which here we equate broadly with Milojčić phases C and D. The relationships between the dated material and the ceramics, however, are not straightforward. The deposition of hoards in which the best preserved and diagnostically most sensitive vessels were found was probably structured and possibly ritualised. This may have taken place after a long period of use of the mining shafts, and it is also possible that the hoards represent an accumulation over time rather than single events. In these circumstances, we have interpreted the start of the period when Vinča ceramics were deposited at Rudna Glava as a *terminus post quem* for the start of Milojčić phase C, and the end of the period when Vinča ceramics were deposited at Rudna Glava as a *terminus post quem* for the end of Milojčić phase D.

A model for the mining activities at Rudna Glava associated with Vinča C and D pottery is shown in Figure 23. A weighted mean has been taken on the statistically consistent measurements on antler RG8 before incorporation in the model (OxA-14624–5; T' = 0.2, T'(5%) = 3.8, ν = 1), which has good overall agreement (Amodel: 97; Fig. 23). This suggests that Vinča C ceramics appeared here after *5745–5240 cal BC* (*95% probability; tpq Rudna Glava C*; Fig. 23), probably after *5505–5325 cal BC* (*68% probability*), and suggests that Vinča D ceramics were last deposited here after *4920–4445 cal BC* (*95% probability; tpq Rudna Glava D*; Fig. 23), probably after *4870–4685 cal BC* (*68% probability*).

14 Three measurements (BM-1589, 6900±1000 BP, 8640–3780 cal BC (95% probability); OxA-14623, 7198±36 BP, 6205–6135 cal BC (8% probability) or 6115–5995 cal BC (87% probability); OxA-14627, 6665±36 BP, 5645–5520 cal BC (95% probability)) appear to indicate use of the mining complex in the earlier part of the seventh millennium cal BC. The collagen in all these samples, however, was poorly preserved and so there must be some doubt over the accuracy of these dates. One further sample appears to indicate further use of the mines in the Copper Age (OxA-14676, 4273±32 BP, 3005–2990 cal BC (1% probability) or 2930–2865 cal BC (91% probability) or 2805–2775 cal BC (3% probability)). Two of the Vinča period dates do not appear to be associated with ceramics and are not included in the model presented here (OxA-16585, 5816±35BP, 4780–4550 cal BC (95% probability); OxA-14699, 5974±39 BP, 4975–4765 cal BC (94% probability) or 4755–4740 cal BC (1% probability)).

A timescape for Vinča pottery

We begin by constructing a chronological model, in which the use of Vinča ceramics forms a continuous and relatively constant phase of activity, opening with the start of Milojčić phase A and ending with the end of Milojčić phase D (Fig. 24). The start of Milojčić phase A is constrained to be earlier than the start of Milojčić phase B1 in this model; the start of B1 is constrained to be earlier than the start of B2; the start of B2 is constrained to be earlier than the start of C; and the start of C is constrained to be earlier than the start of D. The start of phase B (sites where we are unsure whether the ceramics are phase B1 or B2) is also constrained to be later than the start of Milojčić phase A. Since we are uncertain whether the transition from one phase to the next happened at the same time everywhere, we have not constrained the end of phase A to be earlier than the start of phase B1, for example. We have however constrained the end of Milojčić phase A to be earlier than the start of Milojčić phase C and the end of Milojčić phases B1 and B2 (and the combined phase B) to be earlier than the start of Milojčić phase D. We believe these constraints to be reasonable, since there appear to be no closed assemblages containing both Vinča A and Vinča C pottery, or both Vinča B and Vinča D pottery[15].

This approach means that we can examine whether there is any overlap between the use of ceramics assigned to successive phases in the Miljočić scheme. Where there are more than three radiocarbon dates for a site, key parameters from the site-based models described above are imported as likelihoods in the synthetic models. For example, in the model component relating to the currency of Vinča A ceramics (Fig. 25), Vinča Belo Brdo is represented by two parameters – *Belo Brdo start A and Belo Brdo A/B1* – which means that the 19 radiocarbon measurements from samples recovered between the depths of 9.3m and 8.0m in the Vasić sequence are not disproportionally weighted in the model in comparison with sites with fewer dates. Where there are one or two dates on short-lived materials securely associated with a ceramic phase, these are included fully in the model (*e.g.*, *Deb-2579* from Satchinez; Fig. 25). In other cases, where there are one or two results on charred plant material that might have included a component of old wood, the dates are modelled as *termini post quos* for the end of the phase. These distributions are shown in grey (*e.g.*, *Bln-435*, a sample of oak charcoal from Predionica; Fig. 25). In a few cases, dates are clearly misfits, and have been excluded from the modelling (*e.g., BM-1124*, a sample of unidentified charcoal from Gornea) which is more than 400 years later than any other sample associated with Vinča A ceramics and must have contained component of intrusive material. These distributions are shown in red and the parameter name is followed by '?'.

The overall form of this chronological model (Model 1) is illustrated in Fig. 24 with its components illustrated in Figs. 25, 27, 29, 31–32 and 35. It is defined exactly by the CQL2 keywords and structure provided as supplementary information (Vinca_Milojcic_Model_1.oxcal).

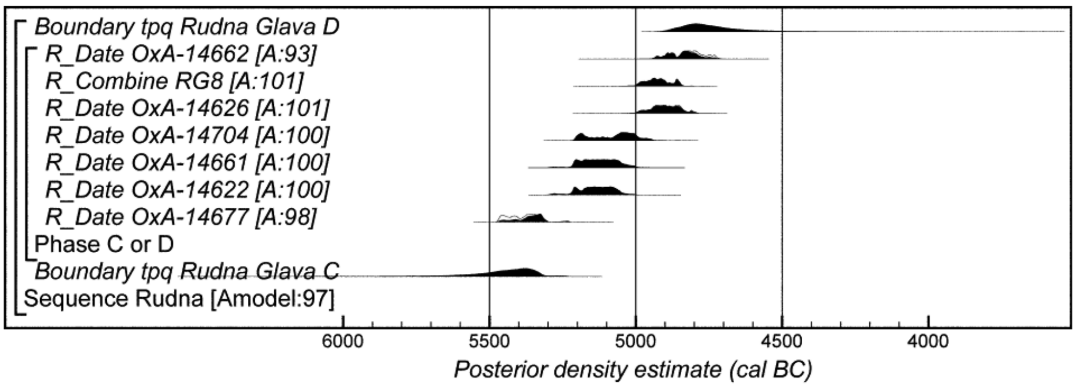


Fig. 23. Probability distributions of radiocarbon dates from Rudna Glava. The format is identical to that of Figure 7. The large square brackets down the left-hand side along with the OxCal keywords define the overall model exactly.

15 As part of the preliminary modelling undertaken for this study, we constructed a model which included no relative sequence between the phases of Vinča ceramics. This model suggests that *start A* is earlier than *start B1* (*87% probable*), that *start B1* is earlier than *start B2* (*95% probable*), that *start B2* is earlier than *start C* (*96% probable*), and that *start C* is earlier than *start D* (*88% probable*). This model also suggests that *end A* is earlier than *start C* (*96% probable*), and that *end B1* and end *B2* are earlier than *start D* (*85%* and *62% probable* respectively).

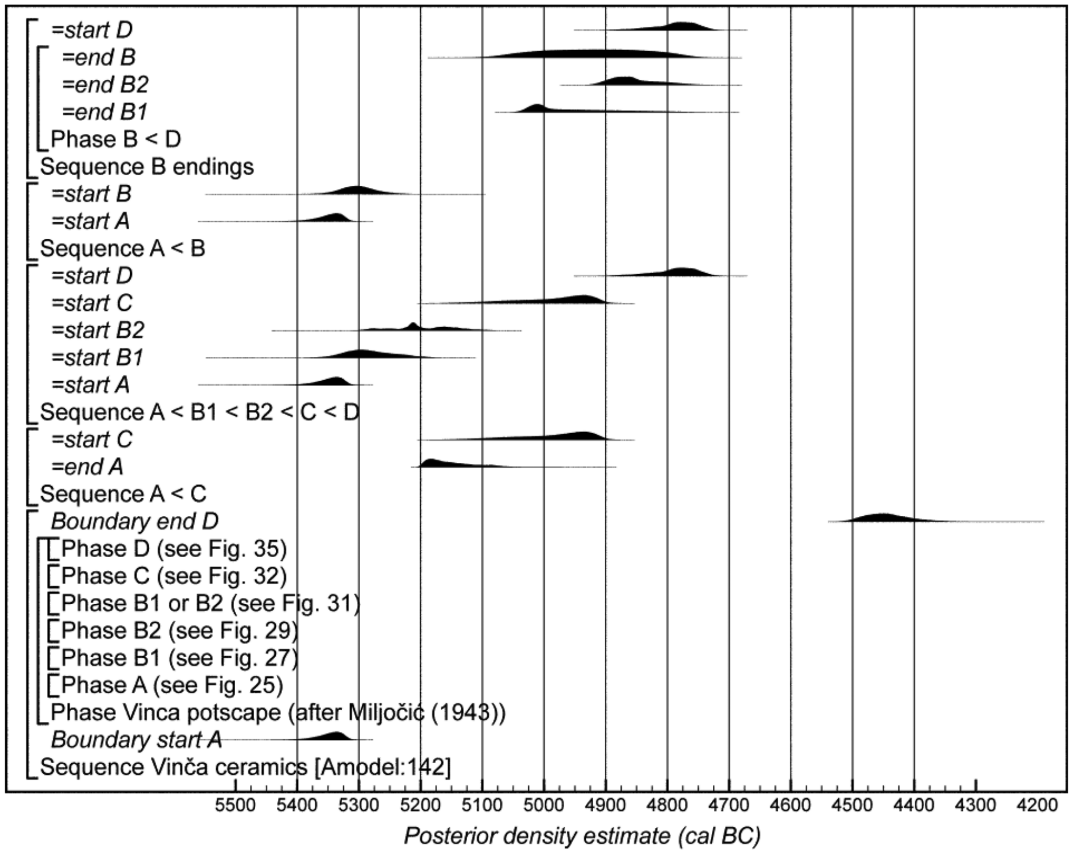


Fig. 24. Overall form of the chronological model for the phasing of Vinča pottery proposed by Milojčić (1943) (Model 1). The format is identical to that of Figure 7. Components of this model are illustrated in Figs. 25, 27, 29, 31–32 and 35. The model is defined exactly by the OxCal keywords and structure provided as supplementary information (Vinca_Milojcic_Model_1.oxcal).

The component of this model relating to the currency of Vinča A ceramics is shown in Fig. 25. It suggests that this ceramic phase begun in *5405–5310 cal BC* (*95% probability; start A*; Fig. 25), probably in *5365–5320 cal BC* (*68% probability*). The use of Vinča A ceramics ended in *5205–5070 cal BC* (*95% probability; end A*; Fig. 25), probably in *5200–5130 cal BC* (*68% probability*). Vinča A ceramics were thus in use for a period of *125–295 years* (*95% probability; duration A*; Fig. 38), probably for *140–230 years* (*68% probability*).

The Vinča network appears to have been established very quickly – within the space of one or two human generations. Sites as widely spaced as Szederkény-Kukorica-dűlő and Belovode were probably founded in the generation before 5300 cal BC (Figs. 25 and 26). Other sites came into being over the succeeding century, including the Vinča settlement at Belo Brdo itself, which as suspected by Lazarovici (*1979.105–106, Tab. 7, 122–123*) was not among the very first foundations. We have modelled radiocarbon dates from sites from the northern and the western periphery of the Vinča A network, as well as from its centre. Although there are known sites with characteristic Vinča A forms in the southern and eastern periphery of the network, either they are lacking radiocarbon dates, or the association between pottery phases and radiocarbon dates is not secure. Currently Szederkény-Kukorica-dűlő in the extreme northwest of the network is the earliest known dated site with Vinča ceramics (on present evidence it is *60% probable* that it was established before Belovode: Fig. 25). It is not possible to disentangle the direction of innovation without dating many more sites at the generational precision provided by ToTL at Szederkény-Kukorica-dűlő, Versend and Belo Brdo. The network was established so quickly that we need to trace the foundations of different sites to within a few decades across the latter part of the 54th and the earlier part of the 53rd century cal BC.

Recent formal modelling of the earliest (*älteste*) LBK, however, allows us to compare the date when the Vinča network was established with the time when LBK ceramics rapidly spread across much of north and north-west Europe. Jakucs *et alii* (*2016. Figs. 17–22*) present three alternative models for

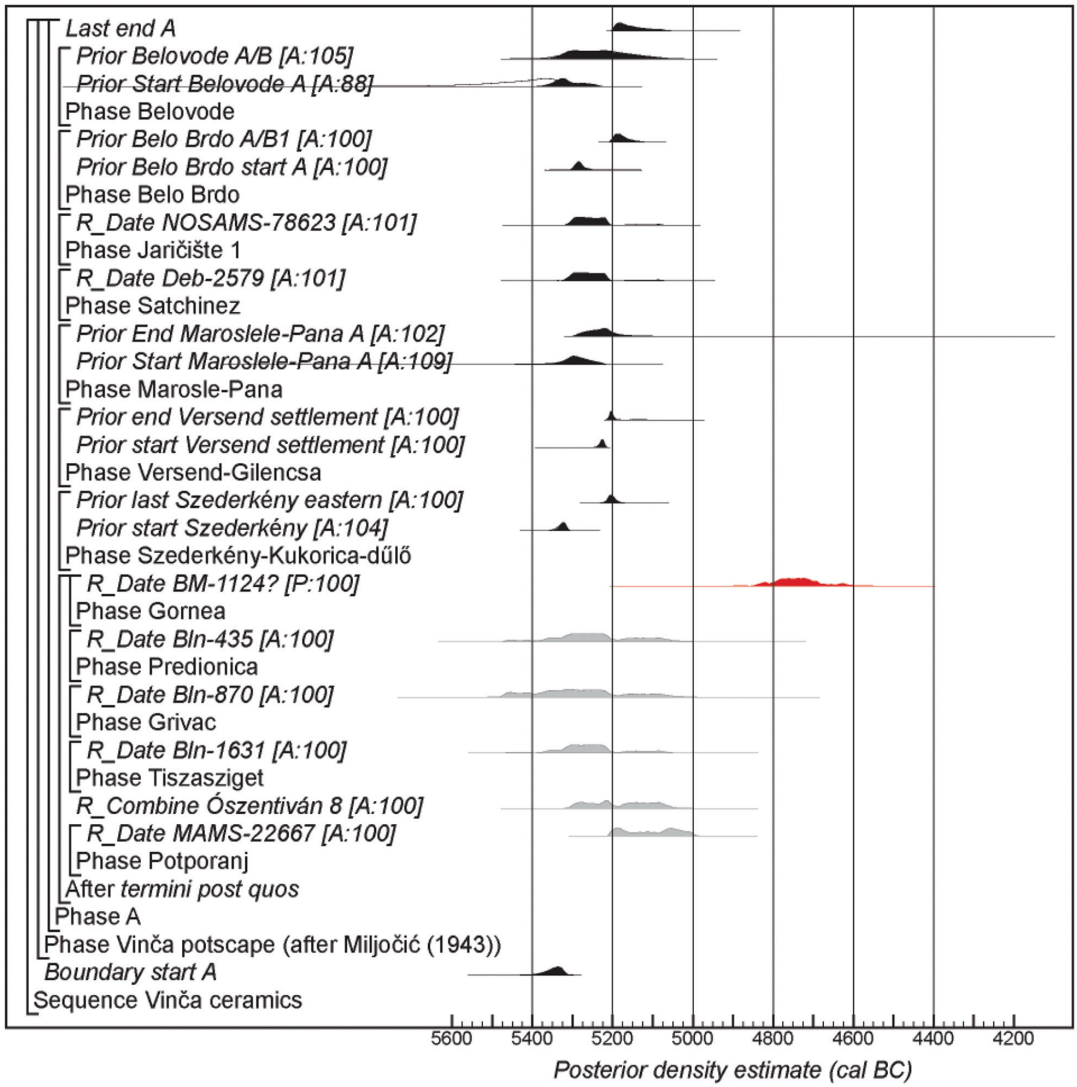


Fig. 25. Probability distributions of dates associated with Milojčić Vinča A ceramics (key parameters for individual sites have been imported from the models defined or cited in Figs. 4–23). The format is identical to that of Figure 7 (grey tone indicates the sample has a possible old-wood offset; red indicates a distribution excluded from the model). The model is defined exactly by the OxCal keywords and structure provided as supplementary information (Vinca_Milojcic_Model_1.oxcal).

the time when the LBK spread beyond the inital locus of its development in Transdanubia. Whatever the dating of its formative phase, all these models agree in placing this rapid expansion in the middle decades of the 54th century cal BC (Fig. 41). This is precisely the time when the first Vinča pottery was made. The potential implications of this are explored in the Discussion below.

The component of the model relating to the currency of Vinča B1 ceramics is shown in Fig. 27. It suggests that this ceramic phase begun in *5355–5195 cal BC* (*95% probability; start B1*; Fig. 27), probably in *5330–5245 cal BC* (*68% probability*). The use of Vinča B1 ceramics ended in *5045–4800 cal BC* (*95% probability; end B1*; Fig. 27), probably in *5040–4915 cal BC* (*68% probability*). Vinča B1 ceramics were thus in use for a period of *185–505 years* (*95% probability; duration B1*; Fig. 38), probably for *230–395 years* (*68% probability*).

There is considerable uncertainty around the dating of Vinča B1 ceramics since, with the exception of Belo Brdo itself, all the sites are poorly dated. Such data as we have, however, are consistent with a relatively swift transition from Vinča A at the beginning of the 52nd century cal BC. There was a period of overlap (*100% probable*), as is reflected in Lazarovici's (*1991.19–20, 27*) phase A3/B1. This period of overlap lasted for *25–245 years* (*95% probability; A/B1*; Fig. 39), probably for *70–185 years* (*68% probability*).

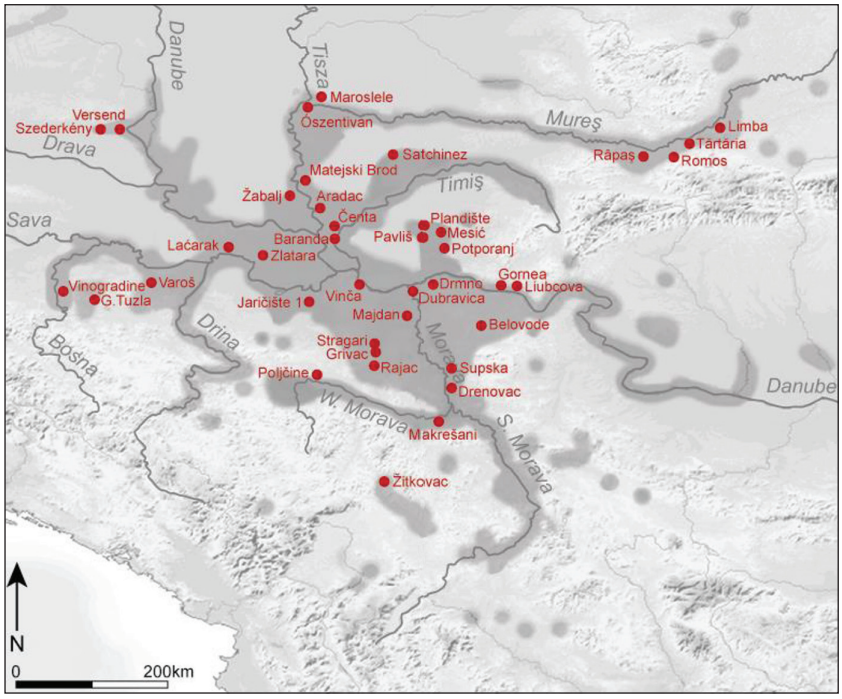


Fig. 26. Map showing distribution of sites from which Milojčić Vinča A ceramics have been recorded (grey-tone is approximately the maximum spatial extent of Vinča ceramics of all phases). For sites with radiocarbon dates see references in the text; for other sites see* Marinković 1995; 2006; Vilotijević 1965; Stalio 1970; Jovanović 1965; Tasić 1958; 1965; Benac 1988; Leković 1995; Rašajski 1962; Jacanović 1988; Suciu 2009; Joanović, Prikić 1978; Jacanović, Đorđević 1990; Katunar 1988; Perić 2006; Garašanin, Garašanin 1979; Bogdanović 1988a; Nikitović 1995; *and* Stanković 1988; 1989. *Râpaş is unpublished (A. Bărbat, pers. comm.)*.

There is a marked increase in the density of sites producing Vinča B1 ceramics (Fig. 28) in comparison to sites producing Vinča A ceramics (Fig. 26). It appears, however, that Vinča ceramics are no longer found upstream of the Danube confluence with the Tisza, although their continuing influence can be traced in the development of Sopot-type pottery. Sites with Vinča pottery are still found along the Timiş and Mureş valleys.

The component of the model relating to the currency of Vinča B2 ceramics is shown in Fig. 29. It suggests that this ceramic phase began in *5295–5105 cal BC* (*95% probability; start B2*; Fig. 29), probably in *5285–5270 cal BC* (*3% probability*), or in *5230–5130 cal BC* (*65% probability*). The use of Vinča B2 ceramics ended in *4920–4770 cal BC* (*95% probability; end B2*; Fig. 29), probably in *4905–4830 cal BC* (*68% probability*). Vinča B2 ceramics were thus in use for a period of *220–470 years* (*95% probability; duration B2*; Fig. 38), probably for *270–405 years* (*68% probability*).

Again there was clearly a period of overlap (*100% probable*) between Vinča B1 and Vinča B2 pottery. This period of overlap lasted for *90–425 years* (*95% probability; B1/B2*; Fig. 39), probably for *130–310 years* (*68% probability*).

The number of sites producing Vinča B2 pottery is greater than those producing Vinča B1 pottery, and its distribution extends further to the west and south-east. Sites in the lower Tisza valley, however, appear no longer to have access to Vinča pottery (Fig. 30), perhaps because the Szahálhát network was expanding from the north at this time[16]. The spatial distribution of the network appears to have reached its greatest extent in this phase (possibly in the later part of it, equivalent to Schier (*1995*) phase C1), spreading from Kalošević in the far west as far as Anzabegovo to the south-east and Ocna Sibilui to the north-east.

The component of the model relating to the currency of Vinča pottery which can only be assigned to Milojčić phases B1 or B2 is shown in Figure 31. It suggests that this combined phase began in *5360–5235 cal BC* (*95% probability; start B*; Fig. 31), probably in *5335–5275 cal BC* (*68% probability*). This is entirely compatible with the estimated date for the

* We are aware of a number of sites in Bulgaria (*e.g.*, Bulgarchevo) containing ceramic types which form part of the Vinča repertoire. They also occur, however, more widely in the area to the east of the Vinča network and so cannot be considered to be exclusively diagnostic Vinča forms. This contrasts with sites (*e.g.*, Satchinez) which contain diagnostic Vinča pottery in contexts mixed with other clearly non-Vinča forms.

16 The Szakálhát culture evolves during Vinča B1 along the middle Tisza area. At the time of Vinča B2 Szakálhát and the closely related Bucovăţ group dominate south-east Hungary and the western part of the Romanian Banat, extending well into the Serbian Vojvodina (*Goldman 1985.64–66; Horváth 1983.90; Goldman, Goldman-Szenaszky 1991.194*).

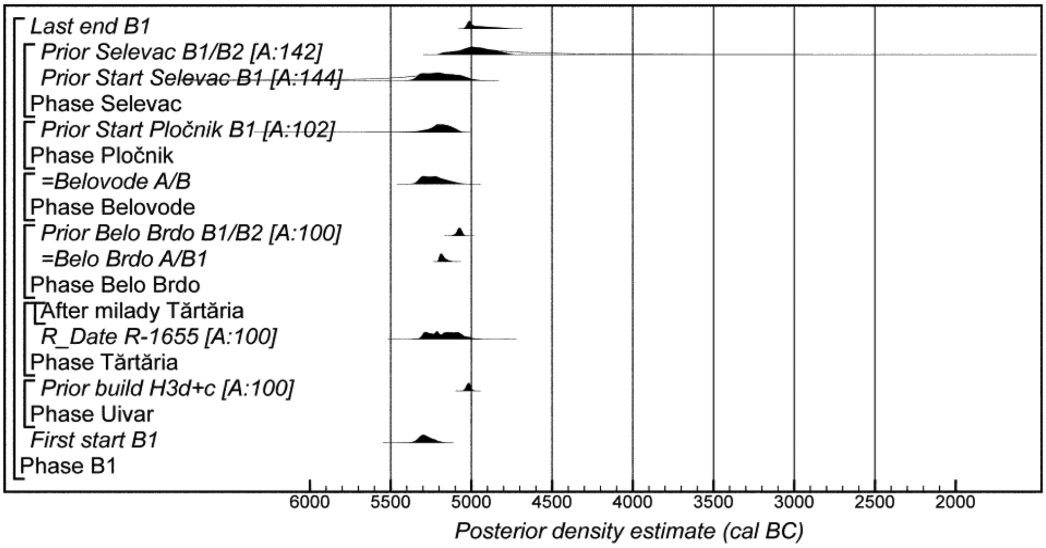


Fig. 27. Probability distributions of dates associated with Milojčić Vinča B1 ceramics (key parameters for individual sites have been imported from the models defined or cited in Figs. 4–23). The format is identical to that of Figure 7. The model is defined exactly by the OxCal keywords and structure provided as supplementary information (Vinca_Milojcic_Model_1.oxcal).

start of Milojčić phase B1 presented above (Fig. 27). This combined phase ended in *5070–4770 cal BC* (*95% probability; end B*; Fig. 31), probably in *5010–4825 cal BC* (*68% probability*). This posterior date estimate is entirely compatible with the estimated date for the end of Milojčić phase B2 presented above (Fig. 29), but is considerably less precise.

The component of the model relating to the currency of Vinča C ceramics is shown in Fig. 32. One distribution has been excluded from the model. This is the transition from Vinča C to Vinča D pottery at Petnica, which is 150 years earlier than the same transition from anywhere else. This seems implausible, since Petnica is a small occupation site which is not even on one of the major rivers that clearly provided the connectivity of the network; moreover, the stratigraphy of this site is not unproblematic (*Orton 2012.16–20*). Three distributions (shown in blue) for assemblages that can only be classified as either Vinča C or Vinča D are included as *termini ante quos* for the start of Vinča C. The model suggests that Vinča C began in *5115–4895 cal BC* (*95% probability; start C*; Fig. 32), probably in *5020–4905 cal BC* (*68% probability*). The use of Vinča C ceramics ended in *4620–4400 cal BC* (*95% probability; end C*; Fig. 32), probably in *4550–4445 cal BC* (*68% probability*). Vinča C ceramics were thus in use for a period of *325–650 years* (*95% probability; duration C*; Fig. 38), probably for *390–555 years* (*68% probability*). Only the imprecisely dated sites at Belovode, Selevac and Gornja Tuzla suggest that Vinča C ceramics may have continued in use after 4700 cal BC.

The distribution of sites producing Vinča C pottery (Fig. 33) is very similar to that of sites producing Vinča B2 pottery (Fig. 30). Vinča ceramics are still absent from sites in the lower reaches of the Tisza valley but appear to occur on more sites in the Timiş valley.

Where we have been able to date the transition from Vinča B2 to Vinča C ceramics directly, the date estimates fall in a tight group in the generations around 4900 cal BC (Fig. 34). There was clearly an overlap between these two ceramic phases (*100% probable*). This period of overlap lasted for *20–260 years* (*95% probability; B2/C*; Fig. 39), probably for *50–180 years* (*68% probability*).

The component of the model relating to the currency of Vinča D ceramics is shown in Figure 35. It suggests that this ceramic phase began in *4870–4725 cal BC* (*95% probability; start D*; Fig. 35), probably in *4810–4740 cal BC* (*68% probability*). The use of Vinča D ceramics ended in *4515–4360 cal BC* (*95% probability; end D*; Fig. 35), probably in *4490–4415 cal BC* (*68% probability*). Vinča D ceramics were thus in use for a period of *250–455 years* (*95% probability; duration D*; Fig. 38), probably for *285–390 years* (*68% probability*).

The distribution of sites with Vinča D ceramics is clearly concentrated to the south of the Danube with only a few sites in the southern Banat appearing on the north bank (Fig. 36). No pure Vinča D assemblages occur in Transylvania but it seems that the

distribution of this type of pottery reaches the Sofia basin to the east.

Vinča D ceramics began after Vinča C pottery had first appeared, and endured for longer (*100% probable*) (Fig. 37). Vinča C ceramics may have been in use for most of the currency of Vinča D types, if the late dating of Vinča C at Belovode, Selevac and Gornja Tuzla is robust (Fig. 32). The majority of dated sites came to an end in the 46th or the earlier part of the 45th century cal BC (Fig. 35).

A summary of the dating of the phases of Vinča pottery suggested by Milojčić (*1943*) is shown in Figure 37. Vinča pottery was clearly in use across a wide area from the mid-54th century cal BC to the mid-45th century cal BC.

Each of these phases endured for several centuries, Vinča A being the briefest and Vinča C being the longest (Fig. 38). Successive phases routinely overlapped by a century or two (Fig. 39), but phases C and D overlapped by around 300 years. Either the connectivity of the network was loosening in the later centuries of its existence and there was more diversity in contemporary pottery forms, or our dating of the latest sites with Vinča C ceramics (in particular Belovode, Gornja Tuzla and Selevac) is anomalous. The implications of this are discussed further below.

Sensitivity analyses

We further explore the robustness of the results from Model 1 by constructing an alternative model which treats the five Milojčić phases as sequential and abutting (*cf.* Fig. 2). This means, for example, that there is no ending to phase A and no beginning to phase B1 but rather an abrupt transition from A to B1. The overall form of this model is illustrated in Fig. 40. The components of the model are similar to those illustrated in Figs. 25, 27, 29, 31–2 and 35 but where we have formal estimates for the dates of transitions at particular sites these have been combined in the model. The model is defined exactly by the CQL2 keywords and structure provided as supplementary information (Vinca_Milojcic_Model_2.oxcal).

We must make clear from the outset that this alternative model, Model 2, has poor overall agreement between the radiocarbon dates and the strict sequence of non-overlapping abutting phases (Amodel: 4; Fig. 40). This means that it is statistically implausible. Where the radiocarbon dates contradict the typological sequence is, however, enlightening and helps us to interpret the results of the preferred model.

All the data in Milojčić Phases A and B1 have good agreement with a strict sequence between them, and the two sites where we have been able to formally

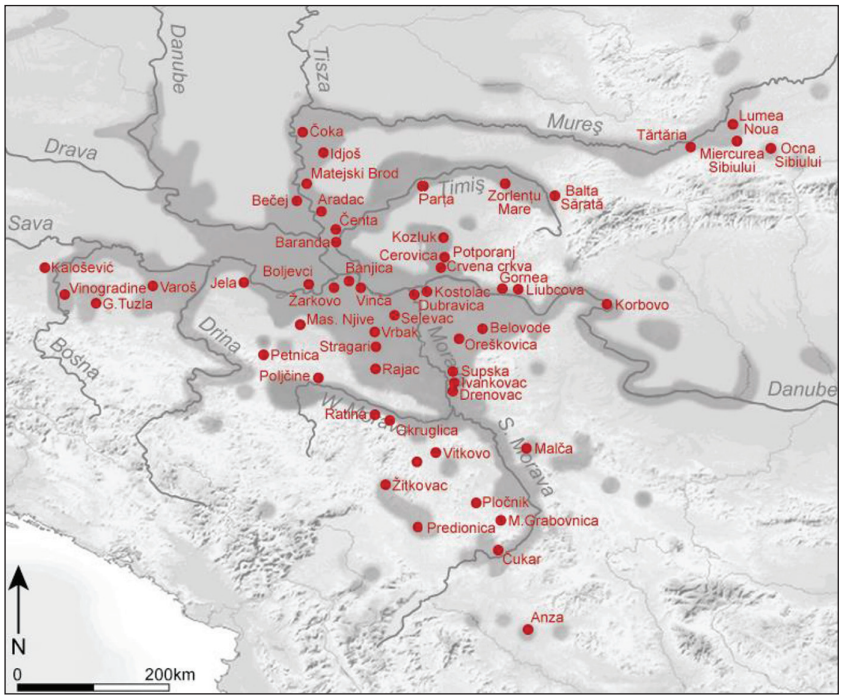


***Fig. 28. Map showing distribution of sites from which Milojčić Vinča B1 ceramics have been recorded (grey-tone is approximately the maximum spatial extent of Vinča ceramics of all phases). For sites with radiocarbon dates see references in the text; for other sites see* Banner 1960; Grbić 1950; Drașovean 1996; Suciu 2009; Gligor 2009; Lazarovici 1979; Marinković 1995; 2006; Babović 1992; Stalio 1970; Joanović, Prikić 1978; Joanovič 1992; Jovanović 1965; Benac 1988; Marijanović 1988a; Mrkobrad 1982; Babović 1986; Jacanović, Đorđević 1990; Jacanović 1988; Trbuhović, Vasiljević 1970; Garašanin, Garašanin 1955; 1958; 1979; Perić 2006; Nikitović 1995; Bogdanović 1983; 1988a; Stanković 1989; Madas 1970; Valović 1983; 1987; Tasić 1958; Krstić 1959; Tomić, Vukadin 1969; Garašanin, Ivanović 1958.**

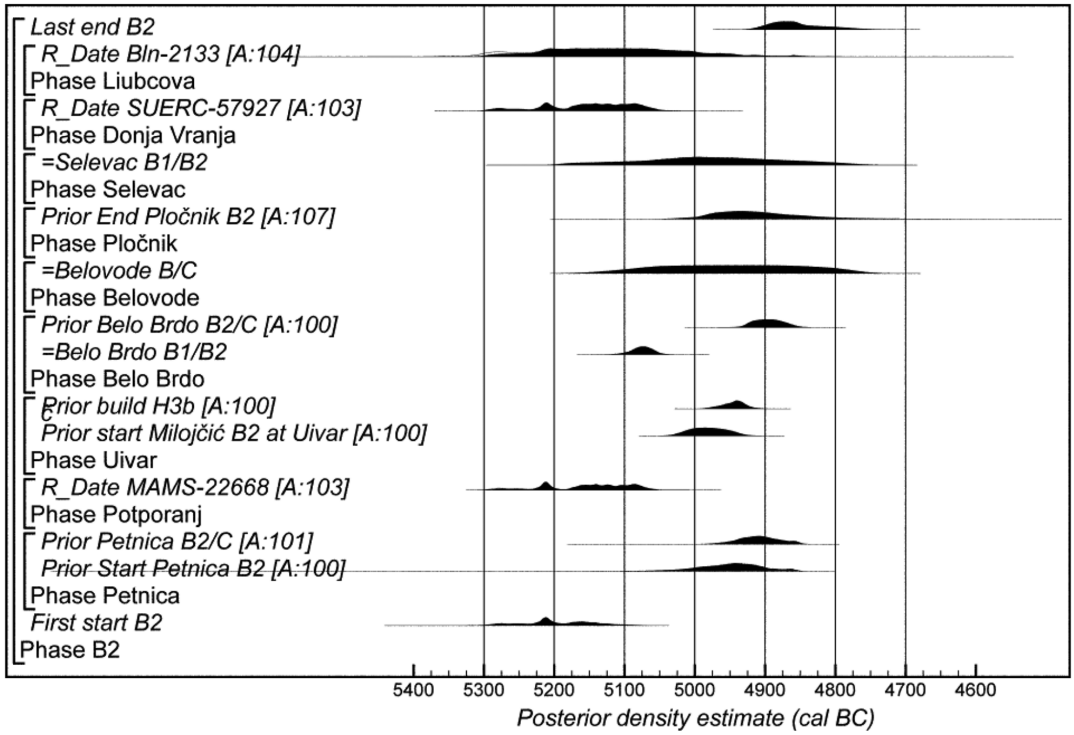


Fig. 29. Probability distributions of dates associated with Milojčić Vinča B2 ceramics (key parameters for individual sites have been imported from the models defined or cited in Figs. 4–23). The format is identical to that of Figure 7. The model is defined exactly by the OxCal keywords and structure provided as supplementary information (Vinca_Milojcic_Model_1.oxcal).

model the A/B1 boundary (at Belovode and Belo Brdo) have produced compatible date estimates for this transition (Acomb = 108, An = 50, n = 2). It seems likely therefore that the transition from Vinča A to B1 occurs relatively swiftly within the first decades of the 52nd century cal BC.

Three distributions have poor agreement with a strict sequence between Milojčić phases B1 and B2. *MAMS-22668*, an animal bone from Potporanj (A: 13), and *SUERC-57927*, an animal bone from a pit at Donje Vranje (A: 21), are both rather earlier than would be expected if the strict succession of Vinča B1 and B2 is valid everywhere. In Vinča B1, *build H3d+c* from Uivar is rather later than would be expected, on the same basis, for an assemblage of Vinča B1 ceramics. We note, however, that this Uivar assemblage is thought to be an imitation by local potters of Vinča B1 types, and so the archetype of the imitation may not have been new when copied. A variant of Model 2, which excludes *build H3d+c* from Uivar, brings the dates from Potporanj and Donje Vranje into good agreement with the sequence (A: 87 and A: 88, respectively). The two sites where we have calculated the transition from B1 to B2 directly (Belo Brdo and Selevac) have produced date estimates that are compatible (Acomb = 106, An = 50, n = 2). On this basis, it again seems likely that the transition from Vinča B1 to B2 was relatively swift, in the decades around or just after 5100 cal BC[17].

All the data from Milojčić phases B2 and C are compatible with a strict sequence between them, and the three sites where we have been able to formally model the B2/C transition (Petnica, Belo Brdo and Belovode) have produced date estimates that are also compatible (Acomb = 123, An = 41, n = 3). Model 2 therefore agrees with our inference from Model 1 (see Fig. 34) that this transition occurred swiftly in the decades around or slightly before 4900 cal BC. The data from Vinča C, however, are not compatible with a strict sequence to Vinča D. Posterior distributions for the end of Vinča C from Belovode (A: 56), Selevac (A: 2) and Gornja Tuzla (A: 0 and A: 47) are all later than would be expeted

17 Early dates from Masinske Nijve and Oreškovica may perhaps impart caution as to the speed of this transition, since the posterior density estimates for the start of both sites, currently assigned only generally to Vinča B, have poor agreement (A: 10 and A: 40, respectively) with the strict succession from Vinča A to B.

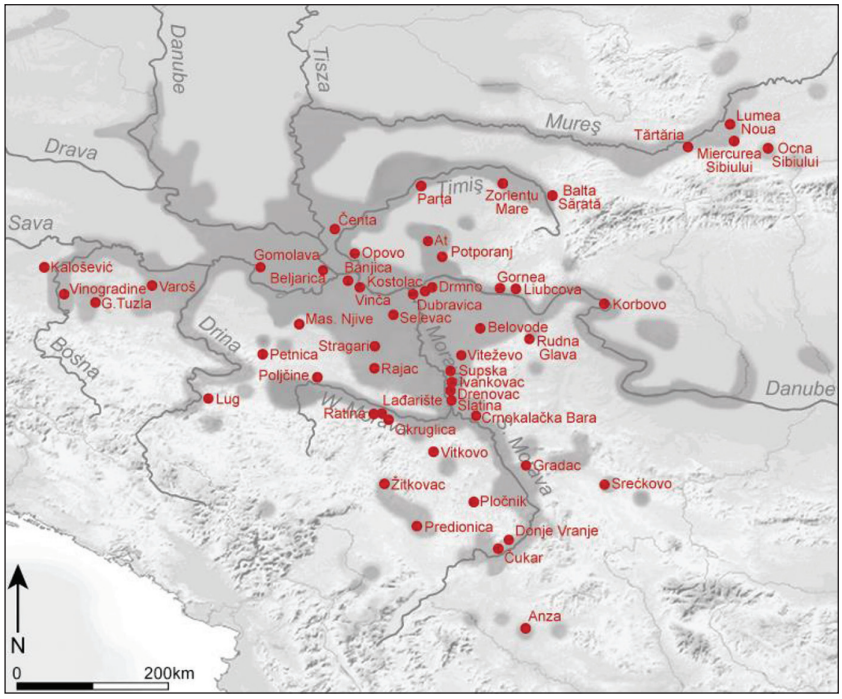


***Fig. 30. Map showing distribution of sites from which Milojčić Vinča B2 ceramics have been recorded (grey-tone is approximately the maximum spatial extent of Vinča ceramics of all phases). For sites with radiocarbon dates see references in the text; for other sites see* Gligor 2009; G. Lazarovici 1979; Tasić 1961; Marijanović 1988a; Jacanović 1988; Madas, Brmbolić 1986; Jacanović, Šljivar 1995; Benac 1988; Marinković 1995; Tasić, Tomić 1969; Babović 1986; Jacanović, Đorđević 1990; Borović-Dimić 1995; Garašanin, Garašanin 1958; 1979; Perić 2006; Nikitović 1995; Bogdanović 1988a; Stanković 1989; Madas 1970; Valović 1983; 1987; Tasić 1958; Tomić, Vukadin 1969; Marić, Marić-Mirković 2011.**

if Vinča C ceramics ceased to circulate at the time when Vinča D ceramics were first introduced. Of the three sites where we have formally modelled the C/D transition (Gomolava, Belo Brdo and Divostin[18]), the date estimate for the transition at Gomolava is substantively earlier (by almost a century; A: 2) than the other two posterior distributions (Acomb = 76, An = 41, n = 3).

It is not impossible that there was actually a swift transition from Vinča C to Vinča D in the first decades of the 47th century cal BC. The dates from Selevac and Gornja Tuzla were on conventional bulk samples of charred plant material that could have contained an element of intrusive, later material, although the date estimate from Gomolava appears to be robust, since it rests on no fewer than ten results on samples of animal bone (Fig. 12). If the earliest sample associated with Vinča D at Gomolava, *OxA-14710*, a bone tool, however, was residual, then the estimated date of the transition here would shift more in line with those from Belo Brdo and Divostin. On the whole, however, the cumulative weight of these strands of evidence may be sufficient to indicate that there was really a considerable overlap between the use of Vinča C and Vinča D ceramics. This has implications for the connectivity of the cultural network in the final centuries of its existence.

In conclusion, this sensitivity analysis suggests that, within the precision obtainable by the data that are currently available, the chest-of-drawers model of sequential ceramic phases is not importantly wrong, except perhaps in relation to the transition between Vinča C and Vinča D, where a significant period of concurrent use seems probable.

Discussion

Over 45 years later, the claim of Colin Renfrew (*1970.53*) that analysis of the development of the Vinča culture 'represents one of the most challenging tasks in European prehistory' remains valid. In our introduction, we outlined many aspects of the Vinča culture, but here we are going to concentrate, first, on beginnings or origins, and secondly, on the character of the developed stages of the phenomenon. What insights do the better timings provided by formally modelled estimates provide?

We need, first, to set out briefly the interpretive frame within which better timings can be interrogated. As one of us has recently sketched (*Borić 2015. 159–162*), three main approaches to the study of the Vinča culture can be identified in past research: culture-historical, processual and post-processual. Each of these has given rather different answers to the related questions of beginnings and the nature

18 We have already excluded the estimate for this transition at Petnica as anomalous: see above.

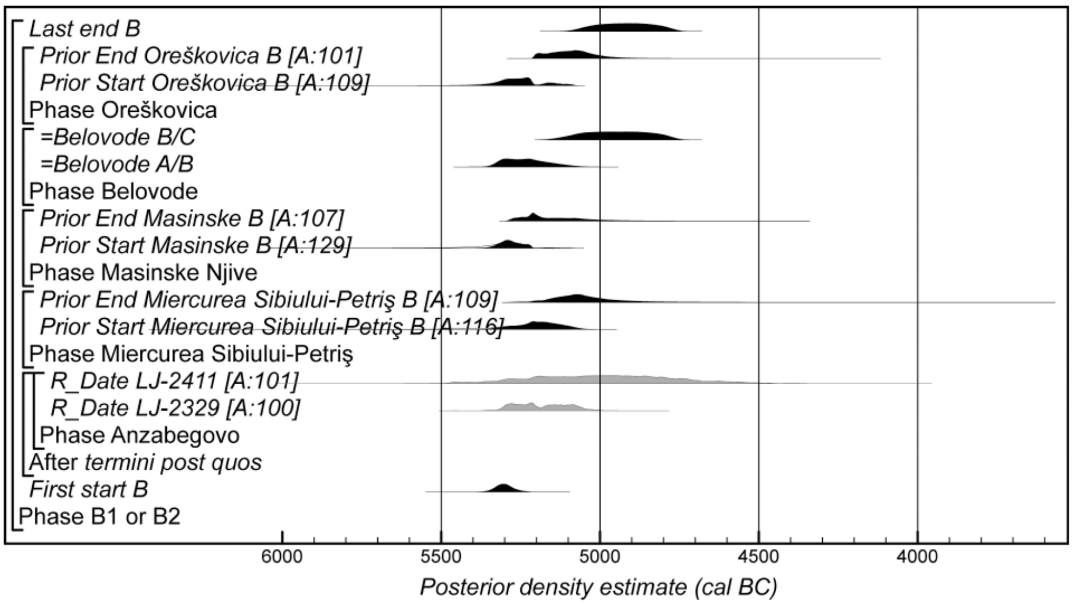


Fig. 31. Probability distributions of dates associated with Milojčić Vinča B1 or B2 ceramics (key parameters for individual sites have been imported from the models defined or cited in Figs. 4–23). The format is identical to that of Figure 7 (grey tone indicates the sample has a possible old-wood offset). The model is defined exactly by the OxCal keywords and structure provided as supplementary information (Vinca_Milojcic_Model_1.oxcal).

of subsequent development. The culture-historical approach has been dominant among researchers in the region, though not universally so (see, for example, *Korošec 1965*). Out of the total range of Vinča material culture, this approach has placed heavy reliance on pottery typology (charted by *Chapman 1981.Ch. 4*). For origins, it sees disjuncture in longer-term sequences, and derives fresh beginnings from the outside, on a large scale and potentially from long distances: in some accounts from as far afield as Anatolia (*Efe 2000; Garašanin 2000*). There was little further explicit reflection on the character and conditions of different kinds of population displacement and colonisation. Subsequent developments were largely left to take care of themselves, except in those variants which saw another wave of arrivals of southern origin: the so-called Vinča C 'shock' already noted above. The approach did, however, create coherent (though often varying) narratives about the broad history of a perceived social entity.

The processual approach to the Vinča culture was characteristically concerned with the playing out of local or regional conditions. In the quotation above, Colin Renfrew (*1970.53*) elaborated that the Vinča culture 'developed in these areas through the operation of local factors, and must be explained in terms of these factors', though he certainly took seriously the previous claims for outside involvement. In terms of origins, continuity was sought, though on then imprecisely defined timescales, especially in material sequences, including those of pottery, and in landscape use (*Chapman 1981.5, Ch. 4*). Consistent with this kind of focus, the concept of the autonomous household was proposed as a major agent of change in the processual narrative of the development and eventual break-up of the Vinča culture (*Tringham, Krstić 1990b.581*). Broad trends rather than precise chronology were the temporal currency. Post-processual approaches have focused on selected situations. An important sketch of the development of Vinča-Belo Brdo itself was offered, with careful consideration given to the character and sources of material in use at the tell; the resulting account asserting the early dominance and eventual slow decline of the site implies a wider narrative, but does not explicitly document it (*Chapman 2000.203–220*). Other themes, broadly classifiable as post-processual, have included the nature of deposition and symbolic dimensions of houses (*Borić 2008; 2015.162; Tripković 2007; 2013; Crnobrnja* et al. *2009; Spasić, Živanović 2015*). Wider narratives of beginnings and subsequent development, however, have often been laid aside in this change of focus, and for the most part, chronological precision has not been a major concern of such contextual approaches.

Other interpretive approaches might be advocated. Culture evolutionary theory (as variously set out in, for example, *Shennan 2009; Bentley* et al. *2011*) could be advocated (*Borić 2015.189–191*). The

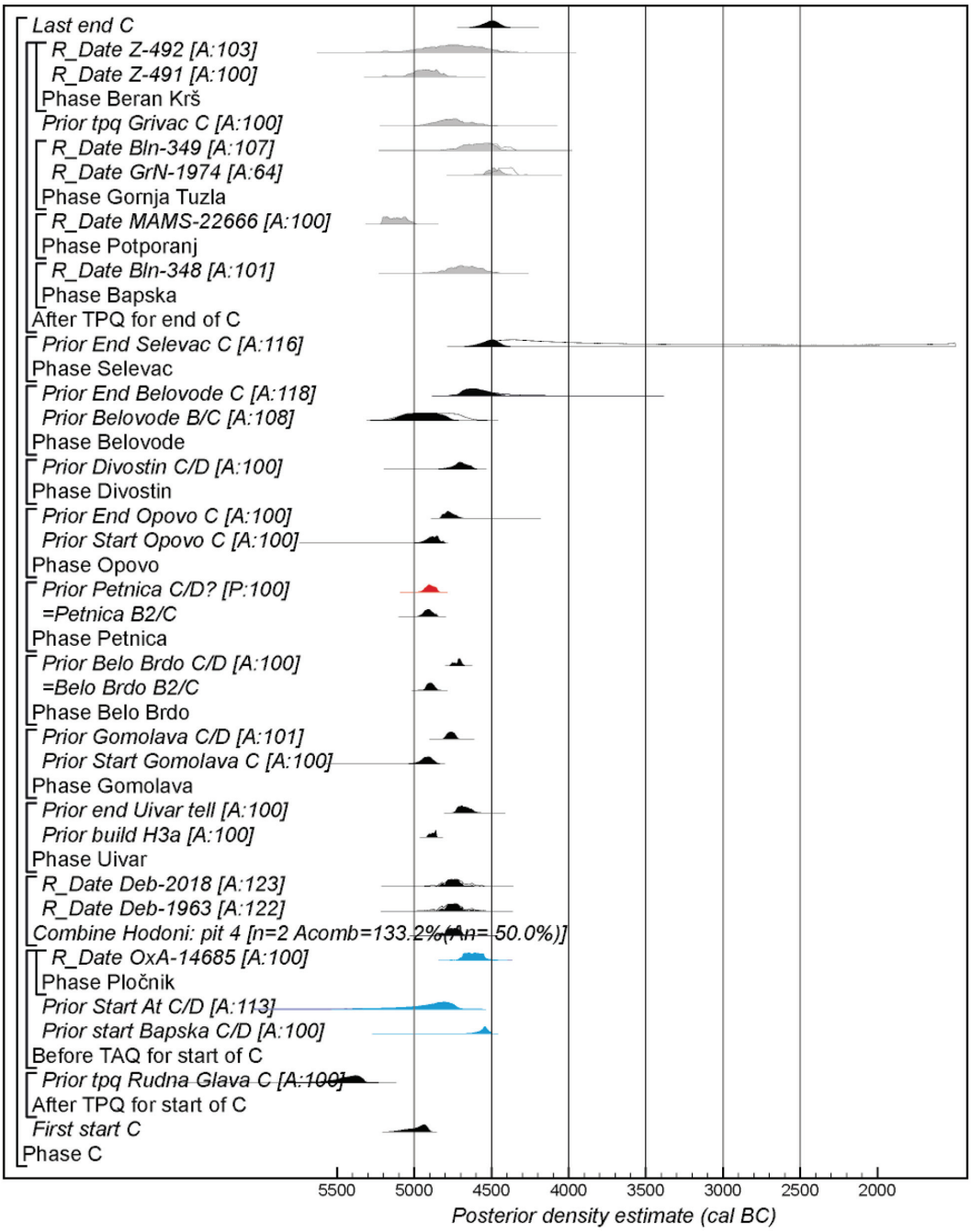


Fig. 32. Probability distributions of dates associated with Milojčić Vinča C ceramics (key parameters for individual sites have been imported from the models defined or cited in Figs. 4–23). The format is identical to that of Figure 7 (grey tone indicates that a sample has a possible old-wood offset; red indicates a distribution excluded from the model; blue indicates a distribution modelled as a* terminus ante quem*). The model is defined exactly by the OxCal keywords and structure provided as supplementary information (Vinca_Milojcic_Model_1.oxcal).

recent fashion of ascribing much greater agency to things – the ontological turn (among a host of others, see *Olsen 2010; Hodder 2012; Rivzi 2015;* see also *Borić 2015.191–193*) – could be extended to the rich material assemblages of the Vinča culture. Here, we choose not to follow either. The former tends to dehumanise complex processes of social interaction, and it is hard to escape the neo-Darwinian baggage that comes with it. The latter requires a much longer debate than we have space for here. It deliberately decentres human agency (see also *Van Dyke 2015*), much more precise narratives for which we are seeking to establish in this paper (*cf. Draşovean* et al. *submitted*). If both approaches are for further discussion elsewhere, what we have found helpful are some of the terms and concepts

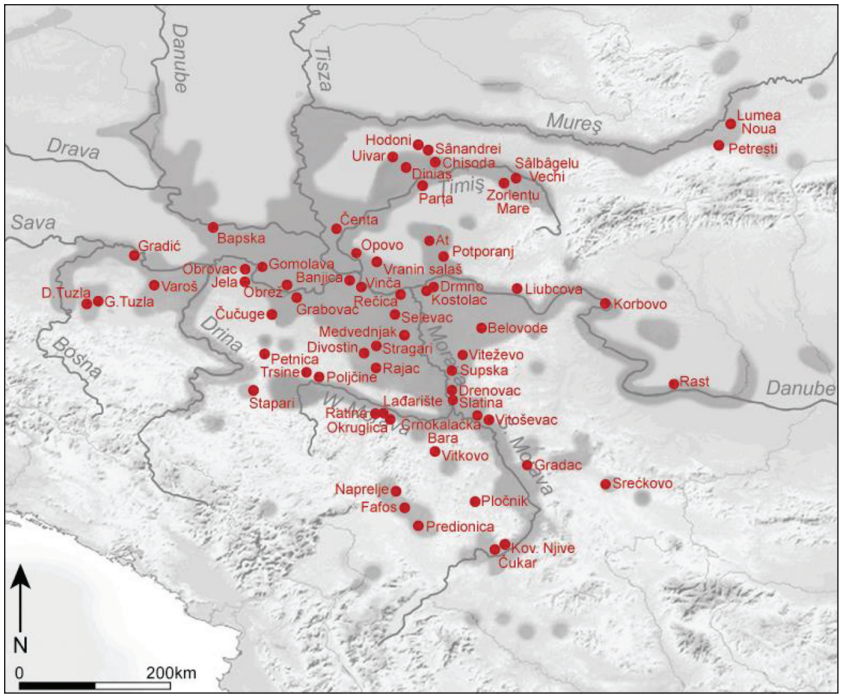


Fig. 33. Map showing distribution of sites from which Milojčić Vinča C ceramics have been recorded (grey-tone is approximately the maximum spatial extent of Vinča ceramics of all phases). For sites with radiocarbon dates see references in the text; for other sites see* Draşovean 1996; Gligor 2009; Jacanović 1988; Marijanovič 1988b; Benac 1988; Trbuhović, Vasiljević 1970; 1975; Brukner 1961; Tasić, Tomić 1969; Babović 1986; Jocić 1989; Borović-Dimić 1995; Garašanin, Garašanin 1958; 1979; Perić 2006; Nikitović 1987; 1995; Bogdanović 1988; Jurišić 1959; Krstić 1964; Anđelković-Despotović, Redžić 1991; Valović 1983; 1987; Marić, Marić-Mirković 2011; Madas, Brmbolić 1986; Lazić *et al.* 1988; Todorović 1968; Bulatović 2003; Jacanović, Šljivar 1995; Tomić, Vukadin 1969; Stalio, Galović 1956; Vuković *et al.* 2016; Dumitrescu 1980. *Petreşti is unpublished.

from ongoing debates on themes of hybridity and ethnogenesis, in the field of the archaeology of colonialism. As a proposition which is useful for us to reflect upon, Matthew Liebmann (*2013.27*) has asserted of the three primary means by which new things come into being, that invention ("*the creation of wholly original objects, styles and technologies*") is the rarest, that divergence (or evolution, by which "*changes to an existing form through time result in the eventual creation of multiple separate types through splitting and branching*") has been the focus of much archaeological attention, and that convergence, or "*creation through recombination*", is "*probably the most common*", though less studied in past research by archaeologists. In these terms, it seems clear that the culture-historical approach to the Vinča culture has favoured some version of invention for origins and kinds of divergence for subsequent development, while the processual approach has largely plumped for divergence; the possibility of convergence, in these terms, appears largely to have been neglected.

This is not the place to review in detail all the competing notions such as hybridity, acculturation, syncretism, bricolage, creolisation and *mestizaje*, or the advantages and disadvantages of their deployment (*Liebmann 2013; 2015; Silliman 2015*; and references), but it is useful to retain the sense of grounded detail which such studies offer. Matthew Liebmann (*2015.331–334*), for example, looks at the production of soup plates within the repertoire of Spanish-inspired Pueblo ceramics, over the specific timeframe of 1598–1700, noting an interplay of external and local factors in their design and decoration. Barbara Voss (*2015.665–666*) associates the wider notion of ethnogenesis with 'historical circumstances in which practices of identification are structurally transformed', often as the result of 'substantive demographic shifts – aggregation, disaggregation, displacement, and migration – combined with the emergence or imposition of new structures of power'. She stresses, however, that ethnicity has to be demonstrated rather than assumed (*Voss 2015. 658*), and questions the often lazy translation of archaeological culture into ethnic entity (*Voss 2015. 660*).

We therefore seek to interpret the timings of Vinča ceramics presented in this paper within an approach that might broadly be classified as contextual and practice-based. Our principal evidence is that of the pottery itself, and it is important to stress that the vast majority of Vinča ceramics have been found in settlement contexts, and especially in association with houses and dwelling horizons. There is a wealth of information about later Vinča houses. Well-preserved contexts such as houses at Crkvine-Stubline, part of a local network of sites of varying size, some 40km south-west of Belgrade and Vinča-Belo Brdo

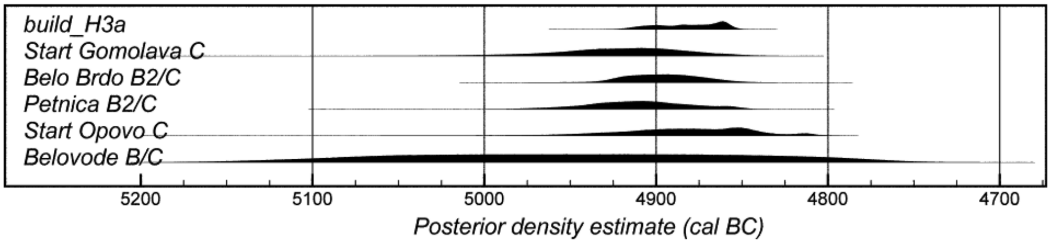


Fig. 34. Probability distributions of dates associated with the introduction of Vinča C ceramics, derived from Model 1.

(*Crnobrnja* et al. *2009; Crnobrnja 2012*), had lots of pots in them: 'dozens of ceramic vessels' and 'a large number of storage vessels' in house 1/2008 (*Spasić, Živanović 2015.220*). Some of these may have been stacked on wooden shelves (*Crnobrnja* et al. *2009.19*). There are plentiful other examples, such as at Divostin (*Tripković 2010*). Occasionally pots are found in the spaces outside, in between houses (*Nikolić, Vuković 2008*). This household setting is therefore presumably the context in which Vinča pottery was principally used, for a wide range of tasks, from food preparation (though the direct evidence for that is surprisingly sparse), storage and consumption. It may be that vessels most open to public gaze, literally passable from hand to hand, such as certain types of bowls, were the ones most likely to change the fastest through time, as evidenced in the correspondence analyses of bowls from Vinča-Belo Brdo (*Schier 1996; 2000*); these might also have been the vessels most likely to break (*David 1972*). Some forms, such as protome vessels, seem to have remained more or less unchanged through the sequence (*Spasić, Crnobrnja 2014*). And it is important to remember that pottery was only one element of the total materiality of the house, and other constituents such as tables, hearths

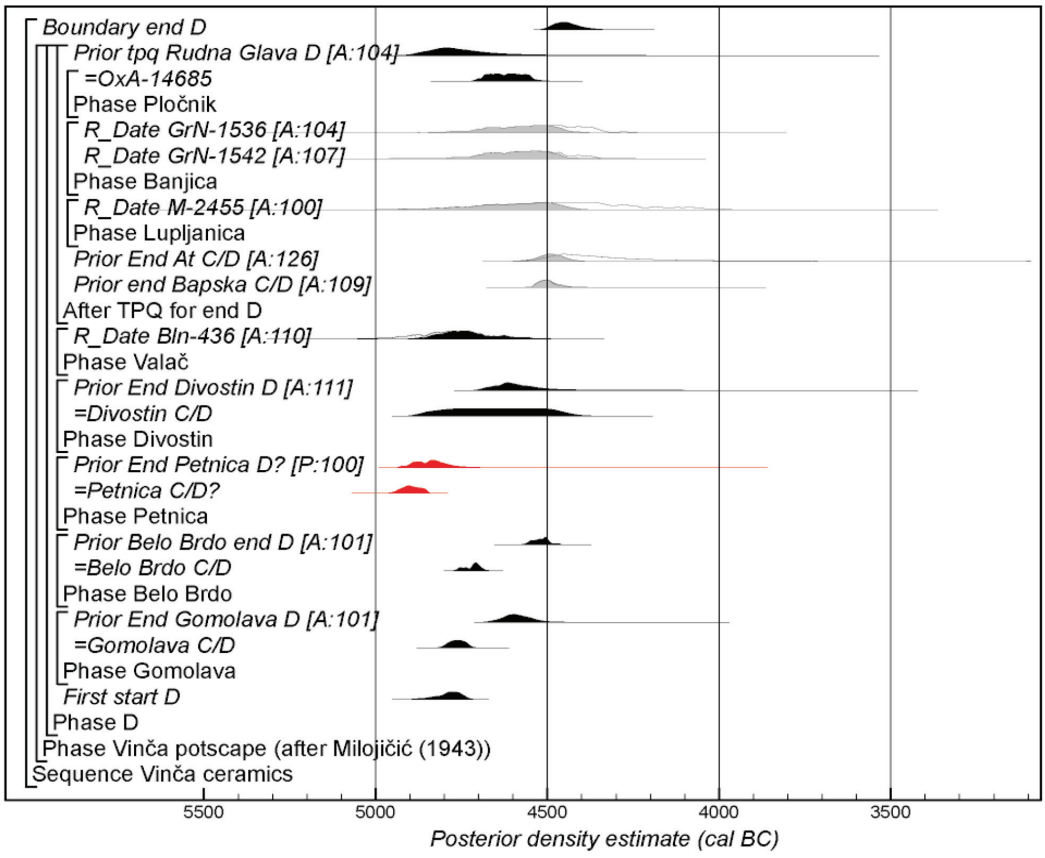


Fig. 35. Probability distributions of dates associated with Milojčić Vinča D ceramics (key parameters for individual sites have been imported from the models defined or cited in Figs. 4–23). The format is identical to that of Figure 7 (grey tone indicates that a sample has a possible old-wood offset; red indicates a distribution excluded from the model). The model is defined exactly by the OxCal keywords and structure provided as supplementary information (Vinca_Milojcic_Model_1.oxcal).

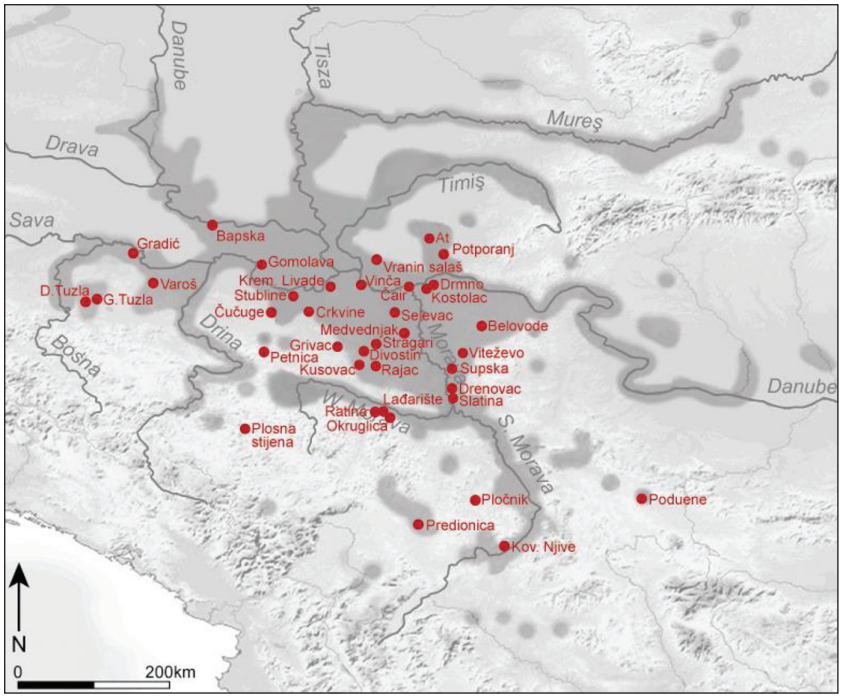


***Fig. 36. Map showing distribution of sites from which Milojčić Vinča D ceramics have been recorded (grey-tone is approximately the maximum spatial extent of Vinča ceramics of all phases). For sites with radiocarbon dates see references in the text; for other sites see* Jacanović 1988; Vuković *et al.* 2016; Marijanović 1988b; Benac 1988; Crnobrnja *et al.* 2009; Marić 2010; Todorović 1966; Bogdanović 1988a; 1988b; Jocić 1989; Borović-Dimić 1995; Garašanin, Garašanin 1979; Perić 2006; Jurišić 1960; Bogdanović 1988a; 1988b; Todorova 1990; Anđelković-Despotović, Redžić 1991; Valović 1983; 1987; Madas, Brmbolić 1986; Lazić *et al.* 1988; Jacanović, Šljivar 1995.**

and storage facilities, which help to define a suite of eating practices (*Spasić, Živanović 2015*), and the layout of house interiors themselves, could have been at least as important as pottery in the creation and projection of social identities. So the context of pottery use was probably primarily associated with houses, but given the broad sharing of style seen in the wide distributions (Figs. 26, 28, 30, 33, and 36), on this basis alone it is extremely unlikely that households were autonomous; it is far more likely that groups of houses and neighbourhoods were the nodes through which intense connections were effected. On a note of caution, we have to recognise that our knowledge so far of early Vinča domestic contexts is much worse (though that helps to define a clear goal for future research). The detailed record for Vinča A contexts in Serbia, especially, is dire. By way of brief example, Trnovača has poorly defined wattle and daub structures (*Jovanović 1965*), while Stagari is reported to have similar structures, but these are not illustrated (*Stanković 1989*). Likewise, while there is detailed information on the mix of ceramic styles associated with particular longhouses at Szederkény and Versend in south-west Hungary (*Jakucs* et al. *2016; submitted*), the material comes from flanking pits, not house floors. This lacuna hampers what we can say about the conditions of the emergence of the Vinča ceramic style.

Another gap in knowledge concerns the making of pottery. Few if any structures have been identified as being associated with pottery production; the northern part of the interior of house 8 at Banjica has been suggested as a candidate (*Tripković 2007. 74, 119*), but the evidence is ambiguous (*Todorović, Cermanović 1961*). Importantly, we do not know whether all households made pottery, or if certain potters served communities at large. Whilst more data on *chaînes opératoires* and archaeometric analyses will help us refine our understanding of pottery production as a whole, they are of limited use to identify units and scales of production. Another avenue worth exploring would be the identification of differences in standardisation, as tentatively identified by Vuković (*2011*) between the sites of Vinča-Belo Brdo and Motel Slatina, assuming that they reflect levels of craft specialisation. We further note a fragment of the perforated clay floor which separated the fire chamber from the pottery chamber in a two-chambered kiln that was recovered from a lower fill of enclosure ditch F1053 at Uivar. This find provides a *terminus ante quem* for the use of two-chambered kilns in the production of ceramics of *4855–4755 cal BC* (*95% probability; dig F1053*; *Schier* et al. *forthcoming.Fig. 6.17*), probably of *4830–4780 cal BC* (*68% probability*) – a time when Vinča B2 ceramics were current (*Schier 2005*).

In turning then to beginnings and development, it is obvious that we have gathered up a sample that represents currently available dated sites, with a range in both the quality and quantity of samples.

Without doubt, a better dataset can be created in the future. We have also raised questions about the detail of the available typological schemes. Those can also be refined in the future. But we believe that the combination of more precise estimates of timings, order and duration, the distributions and density of known sites with diagnostic pottery through successive phases, and information about context, is sufficiently powerful to enable a preliminary reconsideration of important dimensions of the Vinča culture.

Beginnings

The modelled estimates for the appearance of Vinča A pottery given above suggest a rapid introduction. The earliest sites dated so far belong in the north of the distribution. The overall density of sites is not as great as in later phases. Simply in these terms, neither the spatial pattern nor the temporal distribution match what the formerly proposed big-scale migrations might be expected to have produced. Those earlier hypotheses were never accompanied by explicit consideration of either the conditions in the homeland of colonists or of the circumstances in which newcomers operated once arrived in fresh territory. That has, however, been set out elsewhere, and on a comparative (but not necessarily universal) basis, there often seems to be a process of initial scouting, followed by movement by selective groups, rather than wholesale populations (*Anthony 1990; 1997*). To take just one specific example, Susan Alt (*2006.290, 294*) set out three criteria for detecting possible migration into the American Bottom at the onset of the Mississippian phase – regional population growth, patterns of diversity and the distribution of non-local pottery types – but she also proposed a framework in which both migration and local development could be seen as components of the same process, involving convergence and hybridity.

Now it certainly seems to be the case that ceramic traits that overlap with the Vinča repertoire are found widely in the southern Balkans and northern Greece broadly in the same horizon as the appearance of Vinča ceramics. This refers to the widely distributed dark burnished wares that are variously represented among the ceramic assemblages of Karanovo III and the Late Neolithic or Tsangli phases of Bulgaria and northern Greece (*Georgiev 1961; Lazarovici 1979.72–74; Efstratiou* et al. *1998; Kotsakis 2014*). But these dark wares are only part of much wider repertoires; there are many painted wares as well (*Kotsakis 2014.61*). To take just two examples, unusual circumstances of preservation in one context at Promachon-Topolnitsa on the Greek-Bulgarian border produced decorated bark, part of a wide range of pot forms and decorations (*Koukouli-Chryssanthaki* et al. *2007.Fig. 19*), and there were some painted vessels among the mainly dark wares in phase II at Makri in Agean Thrace, informally estimated as dating after 5500 cal BC (*Efstratiou* et al. *1998.32*). Informal estimates for the start of the northern Greek Late Neolithic are certainly compatible with the Vinča chronology set out above, but relatively few sites have so far been radiocarbon dated with rigour (see, for example, Dispilio: *Facorellis* et al. *2014*), and there has been little Bayesian modelling so far of this horizon (*Kostas Kotsakis, pers. comm.*). It does seem to be the case that in these areas this horizon sees a marked increase in the number of sites and their much wider distribution across the landscape, compared with earlier settlement (*Kotsakis 2014.60*); the lakeside site of Dispilio (*Karkanas* et al. *2011*) can usefully stand as a specific single example of this trend. So there is no need to disconnect processes in the southern Balkans and northern Greece from those operating further north, but it now appears a very clumsy explanation to derive all northern changes from the south.

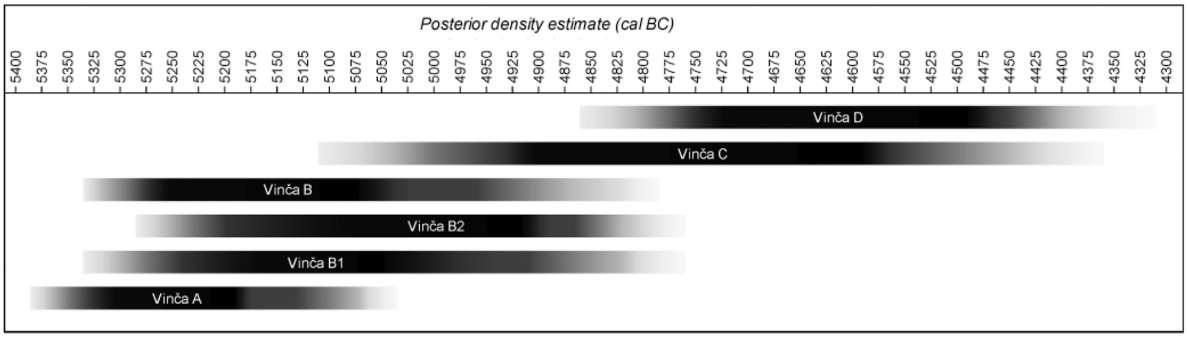


Fig. 37. Schematic diagram showing the currency of the different phases of Vinča ceramics proposed by Milojčić (1943) (the darker the shading the more probable that a ceramic phase was present in a particular 25-year period), derived from Model 1.

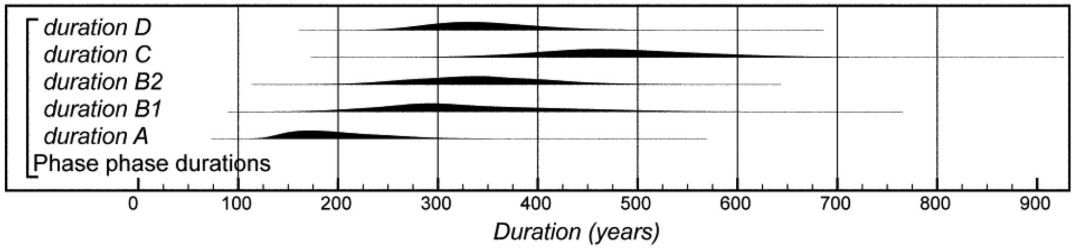


Fig. 38. Key parameters for the duration of the phases of Vinča ceramics proposed by Milojčić (1943), derived from Model 1.

The timing and distribution of Vinča A ceramics as set out above can be argued to better align with processual explanation of local or regional development. But things may not have been as simple as this, and that processual approach turns out, in our view, to have been far too myopic: too constrained within too narrow a spatial perspective. There is, first, still the question of how material culture developed from the Starčevo to the Vinča repertoire. Some elements of local continuity have already been noted (as proposed by *Chapman 1981; Leković 1990*); the Hungarian notion of 'proto-Vinča' elements (*Makkay 1990*) has long been debated. On their own, however, these seem insufficient, without a further assumption of rapid and extensive material changes. We know that there was a measurable gap in the occupation of Vinča-Belo Brdo itself between the Starčevo and Vinča phases (*Tasić* et al. *2016a; 2016b*), but there is still much work to be done – and beyond the remit of this paper – to date and model the timing and tempo of this transition (see also *Porčić* et al. *2016*). What we can stress here is the apparent synchronicity of the appearance of Vinča ceramics and the earliest LBK diaspora, as set out above. Now, entirely indigenist explanations for the appearance of the LBK (*e.g., Whittle 1996*) have not stood the test of time, and the increasing weight of aDNA evidence (now bolstered by genomic analysis) supports a substantial, perhaps major, element of new population dispersing into central and western Europe (among others, see *Brandt* et al. *2013; D. Hofmann 2015; Szécsényi-Nagy* et al. *2015; Olalde* et al. *2015; Hofmanová* et al. *2016; Lazaridis* et al. *2016*). On the evidence of Szederkény and Versend in southern Hungary (*Jakucs* et al. *2016; submitted*), the 54th and 53rd centuries cal BC were also a time of considerable cultural and material fluidity, in circumstances that also involved people on the move. So it is probably better to see the transformations which led to the emergence of Vinča material repertoires and practices in this kind of wider perspective, and a degree of convergence, as well as divergence, should certainly be kept in mind. Given the aDNA evidence both from the periphery of the Vinča world (*Hervella* et al. *2015*) and from the northern part of the Carpathian basin (*Szécsényi-Nagy* et al. *2015; Gamba* et al. *2014*) for further shifts in the patterns of haplotypes through the longer sequence from the sixth to the fifth millennia cal BC, it would be unwise to exclude entirely the possibility of some population movement from the south to the north, though that could also be derived from complex displacements and shifts within the northern part of the Carpathian basin. Further genomic analysis (*cf. Hofmanová* et al. *2016; Lazaridis* et al. *2016*) may help to clarify some of these issues in future research.

We suggest that in place of 'the old tired accounts of migration and diffusion' (*Kotsakis 2014.65*) a much more complex and challenging account needs now to be given of rapid and extensive change, that has to be seen at local, regional and inter-regional scales, which involved material transformations to suit the changing circumstances of increasing populations more widely distributed across their landscapes, and some of whom may have been caught up in processes of movement and displacement. Some strands in shifting material repertoires were very widely distributed, but those can probably best

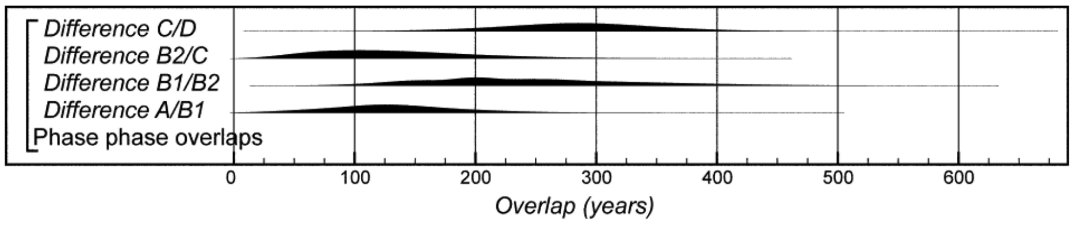


Fig. 39. Key parameters for the overlap between phases of Vinča ceramics proposed by Milojčić (1943), derived from Model 1.

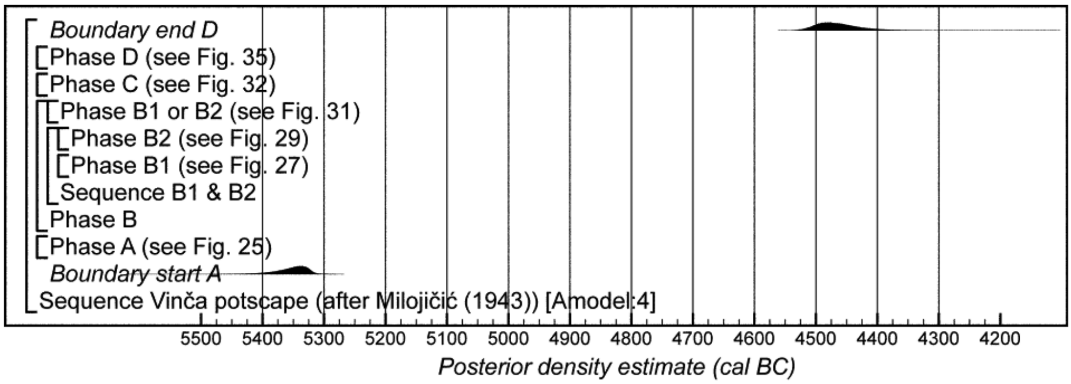


Fig. 40. Overall form of the chronological model for the phasing of Vinča pottery proposed by Milojčić (1943) (Model 2). The format is identical to that of Figure 7. Components of this model are illustrated in Figures 25, 27, 29, 31–32, and 35. The model is defined exactly by the OxCal keywords and structure provided as supplementary information (Vinca_Milojcic_Model_2.oxcal).

be further investigated as media through which social connections across this very broad, shifting world were expressed. As a discipline, we have been comfortable debating intensely the beginnings of the Neolithic, but we have been far less successful so far in thinking through subsequent transformations.

Development

Increasing connectivity seems to define the next phases of development, from Vinča B1 through Vinča D. though we have noted difficulties above in differentiating between B1 and B2 assemblages in some areas, it seems that the trend following the A phase was towards the appearance of more sites in the landscape. The greatest density is reached overall already by the Vinča B2 phase, and that is then maintained in the Vinča C phase. On the ground, this coincides, as noted also above for northern Greece and the southern Balkans, with a spread in the distributions of sites across local landscapes (*e.g., Chapman 1990*), and with the appearance of more tells and larger flat sites. At this point, we can indeed perhaps best think in terms of local and regional factors at work. This appears to have been an intensifying but at the same time stable phenomenon, the timings set out above showing long continuities at a landscape scale, and to varying degrees in particular locations. The notion of the 'shock of Vinča C' is probably now best translated into the peak connectivity of the system, and the timings suggest that that was anyway reached earlier, in Vinča B2. There appears to be no particular need to invoke further population movement at the start of the Vinča C phase, even though the models set out above suggest a probably quite rapid transition from Vinča B2 to Vinča C ceramics. But yet again, the possibility of some small-scale displacements need not entirely be excluded. It is also worth noting that the emergence of Vinča C ceramics followed the end of the LBK, and may have coincided with a hiatus between LBK and Hinkelstein in some parts of the Rhineland (*Denaire* et al. *in press*); further east, there was probably more continuity after the end of the LBK (*Link 2014*), but as with beginnings, it is useful to keep an eye on the wider situation and connections.

In our view, as already hinted at in the language used throughout this paper, it is probably best in the first place to see this developed Vinča phenomenon, from Vinča B1 right through into Vinča D, as an extended social network. The overall distribution is markedly riverine, and one of us has recently sketched the connectivity in terms of 'various influences, borrowings, emulations, exchange, trade and breeding networks' (*Borić 2015.158*), underpinned by flows of material into sites and played out in the household settings described above. The culture historical approach has tended to construct a further sense of unifying or coherent group or ethnic identity. We have noted the warning of Voss (*2015.660*) about equating 'ethnonyms' with real ethnicities, and it was normal processual procedure to set that kind of interpretation aside. But it has long been apparent that the Vinča phenomenon was long-lasting and in that sense stable, which the more precise timings set out in this paper serve only to underline. Without removing local differences, there must have been much that was shared throughout the Vinča network, and from widespread, common practices there surely came a shared way of acting in and understanding the world. The virtual absence of formal or archaeologically visible mortuary practice throughout the network and the wide distributions of altars, anthropomorphic figurines (*Tasić 2016*), face-lids and masks, may also speak to widely shared ways of thought. Cumulatively, this perhaps gets us closer

to Voss's (*2015.658,* quoting *Vermeulen, Govers 1994*) very general definition of ethnicity as a "*consciousness of difference*", "*that is negotiated both through external debates about differences between 'us' and 'them' and through internal contests over community self-definition*". But it is far from clear that the Vinča network had rigidly defined or sharp boundaries, even though from Vinča B1 onwards different kinds of ceramics were preferred in southern Hungary, for example. And whether the network at its peak projected "*ideologies of shared and divergent history, ancestry, and tradition*" (*Voss 2015. 658*), in contrast to or opposition to other contemporary cultural groupings, perhaps also remains a moot point; wider connectivity seems to have been at least as important as local or regional self-definition.

Endings

Some of the most intriguing questions raised by our study relate to the Vinča D phase. Though this now appears shorter than frequently suggested in the past, it nonetheless represents overall a substantive continuation of existing practice. Though this was the phase in which some tells began to be abandoned, others, such as Vinča-Belo Brdo itself (*Tasić* et al. *2015; 2016a; 2016b*), continued to rise steadily, until endings perhaps mainly in the 46th century cal BC. Simply on the basis of two well-dated sites, Vinča-Belo Brdo and Uivar (*Drașovean* et al. *submitted*), it could be the case that house burnings became more frequent in the last two centuries or so of the Vinča network. Now there are many ways to interpret house burnings, and there is not the space here to set out again all the arguments for scale and motivation (see *Tasić* et al. *2015.1077–1079*). Suffice it to say that they could be seen as one symptom of changing times and increased intercommunal tensions and aggression. We have already suggested that it seems insufficient to ascribe all putative tensions to the activities of the autonomous late Vinča household, as communal dimensions still seem paramount, for example in contexts like Stubline, though we note the appearance of larger houses in some contexts such as Banjica (*Tripković 2007*).

The situation remains unclear, which the timings given in this paper underline. There are probable tensions, and these and perhaps other factors not yet defined, or a combination of these possibilities, appear to have brought the Vinča network and its associated ways of living to an end. Continuing the theme of tracking the Vinča and Danubian worlds in parallel, the end of the Danubian world was probably staggered across the end of the Vinča network. As with beginnings in the Vinča A phase, we still badly need a much longer list of well-dated late Vinča sites, in order to unpick the sequence and tempo of endings. Another puzzle remains. If the Vinča phenomenon unravelled because of internal tensions (however constituted), this does not seem to have been accompanied by the same kind of material regionalisation as seen for example in the late LBK (*e.g., Pechtl 2015*). Some regionalisation is apparent, and this paper has followed the categorisation of the Turdaș culture in Transylvania as distinct from late Vinča culture (*Drașovean 1996.28, 93–94*). But material culture including ceramics in the Vinča D phase does not appear to project the kind of much tighter regional groupings, perhaps reflective of increasing concern for local identities and interests, which seem to characterise the end of the LBK. We note again, however, the date estimates for a greater overlap between Vinča C and Vinča D ceramics than was apparent with earlier phases, and perhaps this greater variability could be an important clue to follow further at a variety of regional and local scales.

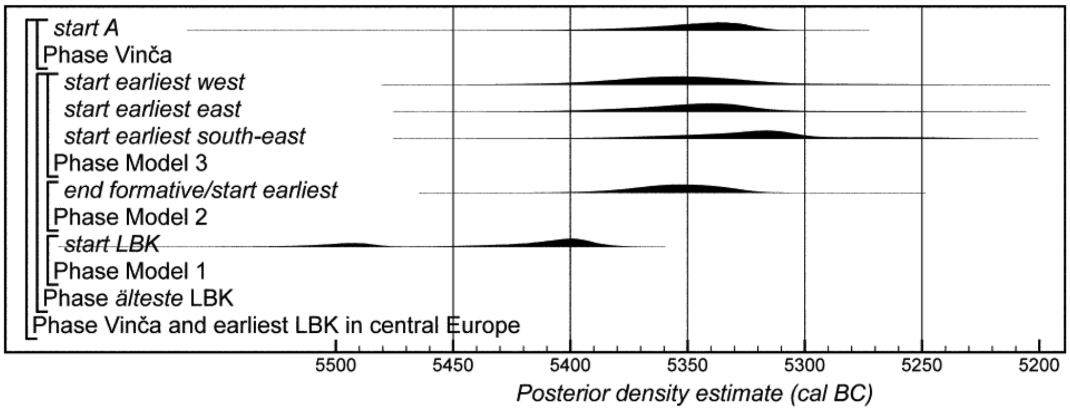


Fig. 41. Earliest Vinča A ceramics (cf. Fig. 25) in comparison to various readings of the dating of the LBK diaspora (*cf. Jakucs *et al.* 2016.Fig 24*).

Conclusions and questions for future research

We conclude that this study indicates much more complex circumstances for the appearance of the Vinča phenomenon than envisaged in most previous approaches; that it sketches a steadily intensifying network, which reached its peak of connectivity already in the Vinča B2 phase, which was maintained through the Vinča C phase and even into the Vinča D phase, though there are some signs of regionalisation in that late phase; and that Vinča ceramics remained relatively stable in the Vinča D phase, even though this is a time widely characterised by many researchers as one of tensions and even crisis. We have used the term network in preference to that of culture; the nature of the network is compatible with widely shared practices and perhaps beliefs, but connectivity rather than exclusiveness is characteristic, and sharp boundaries are not apparent.

Although these conclusions help to redefine the nature of the Vinča phenomenon, our study has raised at least as many questions as answers. In particular, it has highlighted a long list of questions about the circumstances of beginnings and endings, but there are also plenty of unresolved aspects of the long, middle part of the sequence. To answer such questions in future research, a series of challenges need to be met. The typology of Vinča ceramics could be much further refined (with no disrespect intended towards the long list of heroic pioneers and predecessors in this fundamentally important field). Correspondence analysis of the bowls in the upper portion of the Vinča-Belo Brdo stratigraphy needs to be completed, and comparable exercises could be carried out on other key assemblages across the distribution of the network. More sites should and could be radiocarbon dated, using short-life samples of known taphonomy from definable contexts, to avoid age-offsets. All these tasks are feasible, and exploitation of existing archives (as shown in the study of Vinča-Belo Brdo: *Tasić* et alii *2016a*) is at least as important as the application of best practice in new excavations. The scale of new dating, if within a refined system of typology and seriations, need not be massive to be effective. There is every reason to be optimistic that further refinements to the chronology of the Vinča potscape, down to the precision of lifetimes and generations, can realistically be achieved in the next generation or two of research.

The supplementary information for the Vinca_Miloj cic_Model_1.oxcal and Vinca_Milojcic_Model_2.oxcal are available at http://dx.doi.org/10.4312/dp.43.1

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Tab. 1. Summary of radiocarbon dating evidence considered in this review[19].

Site	No. of ^{14}C results	No. of ^{14}C results (excluded)	No. of ^{14}C results (TPQ)	References
Danube upstream of Tisza				
Szederkény-Kukorica-dűlő	41	2		*Jakucs* et al. *2016.Tab. 1*
Versend	68	2		*Jakucs* et al. *submitted.Tab. 1*
Bapska	8	1	1	Table 2
Tisza and Mureş				
Maroslele Pana	5			Table 2
At	4		1	Table 2
Potporanj	3		2	Table 2
Őszentiván 8	4		4	*Kohl, Quitta 1970*
Tiszasziget	1		1	Table 2
Satchinez	1			Table 2
Hodoni	2			Table 2
Uivar	182	27	86	*Schier* et al. *forthcoming.Tabs. 6.2–6.6*
Tărtăria	3	1	1	Table 2
Limba	1	1		*Biagi* et al. *2005.49*
Cauce Cave	1	1		Paolo Biagi, *pers. comm.*
Orăştie–Dealul Pemilor, punct X2	3	3		*Luca 2003*
Cârcea Viaduct	8	8		*Mantu 2000.99; Biagi, Spataro 2005.37*
Miercurea Sibiului-Petriş	4	1	1	*Biagi* et al. *2007.Fig. 3; Luca* et al. *2006.17*
Sava catchment				
Lupljanica	1		1	Table 2
Gornja Tuzla	5	3	2	Table 2
Gomolava	32	3	15	*Borić 2009.Tab. 5; Orton 2012.Tab. 2; Waterbolk 1988.Beilage 1*
Petnica	7			*Borić 2009.Tab. 6; Orton 2012.Tab. 2*
Masinske Njive	3			Table 2
Jaričište 1	1			Table 2
Belgrade area				
Vinča Belo-Brdo	85	2	7	*Tasić* et al. *2016a.Tab. 2*
Opovo	13		2	*Orton 2012.Tab. 2*; Table 2
Banjica	3	1	2	Table 2
Central Serbia				
Grivac	6	1	5	Table 2
Divostin II	11	2	8	*McPherron, Srejović 1988; Borić 2009*
Morava catchment				
Anzabegovo	2		2	Table 2
Belovode	9	1	3	*Borić 2009.Tab. 2*
Pločnik	8			Table 2
Oreškovica	6			Table 2
Selevac	12		7	Table 2
Predionica	1		1	Table 2
Valač	1			Table 2
Beran-Krš	2		2	Table 2
Donje Vranje	1		1	Table 2
Danube downstream of Vinča				
Liubcova	1			Table 2
Gornea	1		1	Table 2
Rudna Glava	14	6		*Borić 2009.Tab. 1*

19 Additionally, five thermoluminescence (TL) ages are reported on sherds from Feature 121 at Divostin II by McPherron and Srejović (*1988.Ch. 4*). These measurements were made using the fine-grain technique (*Zimmerman 1971*), although no checks were made for anomalous fading (*Wintle 1973*) nor radon escape (*Desai, Aitken 1974*). Given the provisional nature of these measurements, no error is quoted for the measurements on each sherd and so they cannot be included in the modelling presented here. Similarly, no error is reported for the average magnetic inclination and declination measurements made from samples from Houses 14, 15, and 16 at Divostin II, two houses from Grivac, and the middle of the Vinča layer at Gomolava, which are also reported by McPherron and Srejović (*1988.Ch. 4*). Again, this prevents these measurements from being calibrated and included in the chronological models.

Tab. 2. Radiocarbon determinations and related stable isotopic measurements for samples associated with Vinča ceramics (all stable isotope measurements were made using Isotope Ratio Mass Spectrometry, except those marked * which were made by Accelerator Mass Spectrometry).

Site	Laboratory number	Material and stratigraphic details	Radiocarbon age (BP)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C:N	References
Bapska	Bln-348	Sample 1, charcoal, *Ulmus* sp. from foundation of house 2-A; 1.4 m in *Dimitrijević 1964* trench associated with a Vinča C vessel	5820±80				*Quitta, Kohl 1969; Dimitrijević 1968.92*
Bapska	Beta-241657a	Charred *Triticum dicoccum* from house 2 associated with Vinča C/D pottery (*Burić 2015.150*)	5710±40	–23.6			*Burić 2015; 2011*
Bapska	Beta-241657b	Carbonised wheat grains from a concentration with traces of a wooden framework from behind house 1	5690±40	–23.6			*Burić, Tezac-Gregl 2009; Burić 2011; 2015*
Bapska	Beta-241659	Charred unidentified animal bone from exterior of house 2 building level associated with Vinča C/D pottery (*Burić 2015.150*)	5660±40	–23.7			*Burić 2011; 2015*
Bapska	OxA-23592	Unidentified animal bone from exterior of house 2 building level associated with Vinča C/D pottery (*Burić 2015.150*)	5714±31	–20.3			*Burić 2011; 2015*
Bapska	OxA-23593	Unidentified animal bone from building level of houses 1 and 2	5715±33	–20.2			*Burić 2011; 2015*
Bapska	Beta-333534	Charred grains from house 2 associated with a Vinča C/D vessel (*Burić 2015.150*)	5700±40				*Burić 2015*
Maroslele-Pana	Poz-28647	Unidentified animal bone from pit 119 containing a few diagnostic sherds, some of which resemble Vinča A1–A2 forms, while others resemble early Alföld LBK material	6290±40				*Paluch 2011.Figs. 115–116*
Maroslele-Pana	Poz-42773	Unidentified animal bone from pit 114 containing diagnostic Vinča A1–A2 pottery and diagnostic early Alföld LBK material	6255±40				*Paluch 2011.Figs. 102–114*
Maroslele-Pana	Poz-28646	Unidentified animal bone from pit 103 containing diagnostic Vinča A1–A2 pottery and diagnostic early Alföld LBK material	6280±40				*Paluch 2011.Figs. 92–101*
Maroslele-Pana	Poz-28645	Unidentified animal bone from pit 102 containing a few diagnostic sherds, some of which resemble Vinča A1–A2 forms	6280±40				*Paluch 2011.Figs. 90–91*
Maroslele-Pana	Poz-28644	Unidentified animal bone from pit 85 containing diagnostic Vinča A1–A2 pottery and a few fragments in early Alföld LBK style	6200±50				*Paluch 2011.Figs. 62–89*
At	Col-3245	Pig mandible from layer 8, base of pit 1, associated with Vinča C/D pottery	5739±41	–21.0*			*Chu* et al. *2016*
At	Col-3246	Unidentified charcoal from layer 11 feature 3. A concentration of fired clay from the oven	5675±43	–24.7*			*Chu* et al. *2016*
At	Col-3248	Right nasal bovid bone from layer 11 feature 2a, from large concentration of ash next to the fired clay in feature 3.	5905±41	–20.0*			*Chu* et al. *2016*
At	OxA-8595	Bone tool from pit 1 associated with Vinča C/D pottery	5660±65	–20.2			*Whittle* et al. *2002*

Site	Laboratory number	Material and stratigraphic details	Radiocarbon age (BP)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C:N	References
Potporanj	MAMS-22666	Unidentified charcoal from last habitation level, after the removal of the house debris in trench 2 associated with Vinča B to Vinča C pottery	6156±30	–18.7*			
Potporanj	MAMS-22667	Unidentified charcoal from the lowest level, house floor level, trench 2 associated with Vinča A pottery	6139±29	–16.8*			
Potporanj	MAMS-22668	Unidentified animal bone from relative depth of 1.64 m in trench 2 associated with Vinča B2 pottery	6211±25	–24.4*		3.1	
Tiszasziget	Bln-1631	Unidentified charcoal from Pit 1 associated with Vinča A pottery (*Horváth, Hertelendi 1994.125*)	6285±60				*Horváth, Hertelendi 1994*
Satchinez	Deb-2579	Antler from pit 4[20] associated with Vinča A pottery (*Mantu 2000.98*)	6270±40				*Mantu 2000*
Hodoni	Deb-1963	Antler from Pit 4 associated with Vinča C pottery (*Draşovean 1994.411*)	5880±60				*Draşovean 1994*
Hodoni	Deb-2018	Antler from Pit 4 associated with Vinča C pottery (*Gläser 1996.196*)	5870±60				*Gläser 1996*
Tărtăria	R-1631	Partial human burial from ritual pit associated with Vinča B1 pottery	6310±65				*Merlini* et al. *2008.156*
Tărtăria	R-1655	Unidentified animal bone from base of pit B2 associated with Vinča B1 pottery	6215±65				*Merlini* et al. *2008.156*
Miercurea Sibiului-Petriş	GrA-33127	Single charred grain of *Triticum dicoccum* from layer IIa in pit 18, which contained diagnostic assemblage of Vinča B ceramics	6475±40	–22.4			*Biagi* et al. *2007.Fig. 3*
Miercurea Sibiului-Petriş	GrA-43076	Charred residue on pottery sherd from pit 18, which contained diagnostic assemblage of Vinča B ceramics	6160±50	–26.1			
Miercurea Sibiului-Petriş	GrN-29053	Cattle calcaneum from house 11, level IIb associated with diagnostic assemblage of Vinča B ceramics	6350±130	–20.8			*Luca* et al. *2006.17*
Miercurea Sibiului-Petriş	GrN-30500	Red deer astragalus from pit 3, level IIb, which contained diagnostic assemblage of Vinča B ceramics	6200±60	–19.1			*Biagi* et al. *2007.Fig. 3*
Lupljanica	M-2455	Unidentified charcoal from 1.3m below ground surface in feature II/1970, the lower building level of Late Neolithic structure in the southwest part of the site, associated with Vinča D pottery (*Breunig 1987.107*)	5600±200				*Breunig 1987.107; Crane, Griffin 1972. 190–191*
Gornja Tuzla	Bln-349	Charcoal, *Quercus* sp. from burnt wooden stucture at 3.63 m in Sonda II/I-8, kop 26 associated with Vinča C pottery (*Quitta, Kohl 1969.233*)	5710±100				*Quitta, Kohl 1969*
Gornja Tuzla	GrN-1974	Unidentified charcoal (charred beam at the depth of 3.5 m) associated with Vinča C pottery (*Vogel, Waterbolk 1963.183*)	5580±60				*Vogel, Waterbolk 1963*
Masinske Njive	OxA-26303	*Bos/Cervus* from Feature 1.31/4, O.S. 12, Sq. ≥8 associated with Vinča B pottery (M. Spasić, pers. comm.)	6211±35	–21.5	8.1		
Masinske Njive	OxA-26304	*Bos taurus* from Feature 1.31/4, O.S. 12, Sq. ≥8 associated with Vinča B pottery (M. Spasić, pers. comm.)	6267±36	–21.2	7.8		
Masinske Njive	OxA-26305	*Cervus elaphus* from Feature 1.31/9, O.S. 05, Sq. Y4 associated with Vinča B pottery (M. Spasić, pers. comm.)	6235±37	–22.6	7.1		

20 Draşovean (*2014.154, fn 10*) reports that this sample came from pit 1. This was, however, a typographical error.

Site	Laboratory number	Material and stratigraphic details	Radiocarbon age (BP)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C:N	References
Jaričište 1	NOSAMS-78623	A singe flax seed from feature 1.137 (pit infill) associated with Vinča A pottery	6260±35				
Opovo	CAMS-4411	Unidentified charcoal from Feature 41 (locus 1861) associated with Vinča C pottery	6030±60	–25.0			
Opovo	CAMS-4413	Unidentified charcoal from Feature 41 (locus 1800) associated with Vinča C pottery	5990±60	–25.0			
Banjica	GrN-1542	Unidentified charcoal associated with Vinča D pottery (*Vogel, Waterbolk 1963.185*)	5710±90				*Vogel, Waterbolk 1963.184–185*
Banjica	GrN-1536	Charcoal/charred grain from House 7, horizon III associated with Vinča D pottery (*Vogel, Waterbolk 1963.184*)	5670±120				*Vogel, Waterbolk 1963.184*
Grivac	Z-1508	Unidentified charcoal from Trench A, level 9 associated with Vinča C pottery	6000±140				*Srdoč* et al. *1987*
Grivac	Bln-868	'Burnt earth' from Trench B, under burnt house associated with Vinča C pottery	6070±100				*McPherron, Srejović 1988.Tab. 14.1*
Grivac	Bln-872	Unidentified charcoal from Trench A, level 4, burnt house floor associated with Vinča C pottery	5915±100				*McPherron, Srejović 1988.Tab. 14.1*
Grivac	Bln-871	Unidentified charcoal from Trench A, level 7 associated with Vinča C pottery	6190±100				*McPherron, Srejović 1988.Tab. 14.1*
Grivac	Bln-870	Unidentified charcoal from a large pit in subsoil, SE corner of Trench B associated with Vinča A pottery (*Bogdanović 2004.500*)	6315±100				*McPherron, Srejović 1988.Tab. 14.1*
Anzabegovo	LJ-2411	Unidentified charcoal from Sq. VIII, unit 55 associated with Vinča B pottery	6070±190				*Gimbutas 1976; Linick 1977*
Anzabegovo	LJ-2329	Unidentified charcoal from Sq. XX, depth 190cm below datum associated with Vinča B pottery	6230±60				*Gimbutas 1976; Linick 1977*
Pločnik	OxA-14685	PL23, *Bos* sp. proximal tibia from burnt building debris: Trench 16; spit 7; 297.79masl; copper chisel found under the debris (07/11/2000) associated with 'Gradac' phase pottery, equivalent here to Vinča C/D.	5765±35	–20.6	5.7		*Borić 2009*
Pločnik	OxA-14686	PL24, *Bos* sp. calcaneus from building floor: Trench 14; spit 10, 297.29masl; amorphous lumps of copper (2000) associated with Vinča B pottery	6046±37	–19.8	4.8		*Borić 2009*
Pločnik	OxA-14687	PL25, *Bos* sp. rib from burnt surface: Trench 14; spit 13, 297.02masl; charcoal, ash and burnt soil (2000) associated with Vinča B pottery	6148±37	–21.4	6.4		*Borić 2009*
Pločnik	OxA-14688	PL26, *Bos* sp. vertebra from bottom of trench: Trench 14; spit 22, 295.87masl (2000) associated with Vinča B pottery	6153±37	–21.0	6.8		*Borić 2009*
Pločnik	OxA-14689	PL28, *Bos*-size bone from Surface V: Trench 15; spit 12; 300.18masl; lumps of thermally changed malachite (02/10/2001) associated with Vinča B pottery	6026±38	–20.4	5.8		*Borić 2009*
Pločnik	OxA-14690	PL29, dog distal humerus from Oven, Surface VII: Trench 15; spit 16, 299.56masl (10/10/2001) associated with Vinča B pottery	6160±37	–19.2	8.5		*Borić 2009*

Site	Laboratory number	Material and stratigraphic details	Radiocarbon age (BP)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C:N	References
Pločnik	OxA-14691	PL30, awl from large mammal long bone from burnt surface: Trench 15; spit 20, 299.09masl, charcoal and ash (11/10/2001) associated with Vinča B pottery	6193±37	–20.1	5.9		*Borić 2009*
Pločnik	OxA-14692	PL31, *Bos* sp. rib from a hearth: Trench 15; spit 26, 298.08masl; hearth dug into the sterile soil (15/11/2001) associated with Vinča B pottery	6181±34	–20.6	7.6		*Borić 2009*
Oreškovica	OxA-31571	Red deer antler tool (S1) from the primary fill (42) of ditch 47 (trench 1) associated with Vinča B pottery	6265±38	–21.9			*Borić* et al. *in prep.*
Oreškovica	OxA-31572	Roe deer metatarsus (S4) from the upper fill (17) of ditch 47 (trench 1) associated with Vinča B pottery	6137±35	–21.5			*Borić* et al. *in prep.*
Oreškovica	OxA-31573	Articulated cattle distal metararsus + phalanx I (S6) from the primary fill (36) of palisade 32 (trench 1) associated with Vinča B pottery	6123±37	–20.3			*Borić* et al. *in prep.*
Oreškovica	OxA-31574	*Sus domesticus* mandible (S8) from fill (62) of pit 18 (trench 2) associated with Vinča B pottery	6224±37	–20.0			*Borić* et al. *in prep.*
Oreškovica	OxA-31575	Cattle horn core (S9) from fill (14) (trench 2) associated with Vinča B pottery	6164±39	–20.7			*Borić* et al. *in prep.*
Oreškovica	OxA-31576	*Lepus europeus* articulated ulna and radius (S10) from pit (61) (trench 3) associated with Vinča B pottery	6206±37	–17.9			*Borić* et al. *in prep.*
Selevac	HAR 3211	Unidentified charcoal from Trench 18, quad. 2, level 9 (BH 77-78: V) associated with Vinča B2 pottery	6050±70	–26.0			*Tringham, Krstić 1990c*
Selevac	HAR 3217	Unidentified wood from Feature 227 in Trench 14 (BH 77-78: VII, VIII or IX) associated with Vinča B2/C pottery	6240±100	–26.3			*Tringham, Krstić 1990c*
Selevac	HAR 3218	Unidentified charcoal from Trench 18, quad. 3/4, level 10 (BH 77-78: IX?) associated with Vinča C pottery	5670±80	–25.3			*Tringham, Krstić 1990c*
Selevac	HAR 3220	Unidentified charcoal from Feature 44, collapsed oven superstructure (BH 77-78: VI) associated with Vinča B2 pottery	6100±70	–27.1			*Tringham, Krstić 1990c*
Selevac	HAR 3221	Unidentified charcoal from Feature 210, ditch related to House 4 (BH 77-78: VII) associated with Vinča B2/C pottery	6050±70	–26.7			*Tringham, Krstić 1990c*
Selevac	HAR 3222	Grain (whole) from Feature 60 (House 7) (BH 77-78: II) associated with Vinča B1 pottery	6230±100	–25.6			*Tringham, Krstić 1990c*
Selevac	HAR 3230	Unidentified charcoal from Feature 220, deep posthole (BH 77-78: VIII or IX) associated with Vinča B2/C pottery	5750±80	–25.7			*Tringham, Krstić 1990c*
Selevac	HAR 3232	Unidentified charcoal lens from Feature 62 (BH 77-78: V) associated with Vinča B2 pottery	6040±70	_25.5			*Tringham, Krstić 1990c*
Selevac	LJ-2521	Grain from Silo A associated with Vinča B1 pottery	6080±70				*Linick 1977*
Selevac	Z-233a	Wheat grain from Silo A	6113±80				*Srdoć* et al. *1975*
Selevac	Z-233b	Wheat grain from Silo A	6152±90				*Srdoć* et al. *1975*
Selevac	Z-233	Wheat grain from Silo A	6366±100				*Srdoć* et al. *1975*

Site	Laboratory number	Material and stratigraphic details	Radiocarbon age (BP)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C:N	References
Predionica	Bln-435	Charcoal, *Quercus* sp. from fire installation in Level 3b at 1.8m associated with Vinča A pottery (*Quitta, Kohl 1969.237*)	6280±80				*Quitta, Kohl 1969*
Valač	Bln-436	Mixed sample of charred acorns and seeds of sf. *Pisum* sp. from charred and ashy infill of a cut feature 0.7m from the surface in sondage P-3 associated with Vinča D pottery (*Quitta, Kohl 1969.237*)	5895±80				*Quitta, Kohl 1969; Gimbutas 1974*
Beran-Krš	Z-491	Unidentified charcoal from context with variable information: Trench III, level 7 (*Srdoć* et al. *1977*) or level 3 or 4 from building horizon IIa associated with Vinča C pottery (*Marković 1985*)	6030±60				*Srdoć* et al. *1977.474*; *Marković 1985.70*
Beran-Krš	Z-492	Unidentified charcoal from context with variable information Trench III, level 13 (base of excavation) (*Srdoć* et al. *1977*) or level 3 or 4 from building horizon IIa associated with Vinča C pottery (*Marković 1985*)	5870±150				*Srdoć* et al. *1977.474*; *Marković 1985.70*
Donje Vranje	SUERC-57927	*Bos* or *Cervus* bone from Pit in KRS1	6206±33	–21.1			*Kapuran* et al. *2016*
Gornea	BM-1124	Charcoal (ref 1974/57); charcoal fragments from Trench 23, sq. 1, Pit 21, spits 4-6 associated with Vinča A pottery (*Burleigh, Hewson 1979.350*)	5871±54	–25.8			*Burleigh, Hewson 1979*
Liubcova	Bln-2133	Charred grain associated with Vinča B2 pottery (*László 1997.260*)	6175±85				*László 1997*

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Ceramics among Eurasian hunter-gatherers: 32 000 years of ceramic technology use and the perception of containment

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ABSTRACT – *We present two parallel and 32 000 years long trajectories of episodic ceramic technology use in Eurasian pre-Neolithic hunter-gatherer societies. In eastern, Asian trajectory the pottery was produced from the beginning. Ceramic figurines mark the western, European trajectory. The western predates the eastern for about eleven millennia. While ceramic cones and figurines first appeared in Central Europe at* c. *31 000 cal BC the earliest vessels in eastern Asia was dated at c. 20 000 cal BC. We discuss women's agency, perception of containment, 'cross-craft interactions', and evolution of private property that that may influenced the inventions of ceramic (pyro)technology.*

IZVLEČEK – *Predstavljamo dve vzporedni, 32 000 let dolgi trajektoriji občasne uporabe keramične tehnologije pri evrazijskih pred-neolitskih skupnostih lovcev in nabiralcev. V vzhodni, azijski trajektoriji, so keramične posode izdelovali že od začetka. V zahodni, evropski, so najprej izdelovali keramične figurice in stožce. Začetek uporabe keramične tehnologije v Evropi je 11 000 let starejši od začetka v jugovzhodni Aziji. Prvi keramični stožci in figurice so se v srednji Evropi pojavile pred 31 000 leti pr.n.št. Prve keramične posode pa so v jugovzhodni Aziji začeli uporabljati pred 20 000 leti pr.n.št. Analiziramo vlogo žensk, pomen shranjevanja in zasebne lastnine ter prenosa znanj in veščin pri razvoju keramične tehnologije.*

KEY WORDS – *Hunter-gatherers; ceramic technology; invention; containment; radiocarbon dating*

Introduction

When he conceptualised the Neolithic as a series of technological, economic and social revolutions in Southwest Asia, Vere Gordon Childe (*1958.76–79*) introduced the premise that pottery making was perhaps "*the earliest conscious utilization by man of a chemical change*" associated with "*thinking of creation*" and "*making form where there was no form*". The result was the ceramic vessel – a tool for more intensive food processing "*made by women and for women*". He suggested that pottery making was one of the steps in the progress of thoughts, knowledge, and skills that humans made as members of society in creating a culture as a kind of mental matrix for action, which allowed man to "*make himself*".

Ceramics soon become broadly considered a key materiality, taken to represent progress in economic, technological, and evolutionary terms. The innovative linking of their plastic medium of clay and pyrotechnology to invent fired clay technology, and to create a solid object, a ceramic container, is still assumed to be a revolutionary step in the development of modern human thought and practice, taken along with agriculture and sedentism (*Gamble 2007. 10–32*).

We show bellow that the earliest step in the development of ceramic (pyro)technology in Eurasia was not the invention of vessels made from fire-hardened clay, but of cones, anthropomorphic and zoomorphic figurines, which were certainly not associated with (pre)existing container or any other food storage technology. The twenty-millennia-long episodic pre-Neolithic trajectory of the fired clay figurine tradition in western Eurasia did not lead to the innova-

tion of ceramic container technologies. In Central Europe the focus in the Palaeolithic was on figurines and cones, followed by the first vessels production in the Pre-Pottery Neolithic in the Near East. In the East Asia, the focus was on vessel making from the outset. The western tradition predates the eastern by about eleven millennia. While ceramic cones and figurines first appeared in Europe at *c*. 31 000 cal BC, the earliest vessels in southeaster Asia are dated to *c*. 20 000 cal BC (see below). Residual analyses show that they were used for food preparation and perhaps for storage tasks.

However, it was suggested recently that man "*did not make himself*" (*Olsen 2010.9–10*). Societies consist of myriads of co-working entities comprised of both humans and non-humans, and 'things', all those physical entities we refer to as material culture, are beings in the world alongside other beings such as the humans, plant and animals, which constitute the very basis of collective action and society. Emile Durkheim (*2005.278*) indeed suggested a century ago that "*... it is not true that society is made up only of individuals; it also includes material things, which play an essential role in the common life. The social fact is sometimes so far materialized as to become an element of the external world*."

The making of pots was suggested to be closely connected with a new understanding of the 'co-dependency of mind and matter' that 'shaped the human intelligence' in the Neolithic. The shaping of ceramic vessels was correlated with conceptual innovations, a true three-dimensional conception of objects. The introduction of a different topology, 'a surface around a void', thus required the conceptual separation of the surface of an object from its volume, and distinguishing between interior and exterior surfaces (*Read, van der Leeuw 2008.1965*).

Pots as bodies

The perception of human dependence on, and mixing with, things at the level of being was embedded in the phenomenology of Heidegger and Merleau-Ponty. Martin Heidegger (*1971.25*) introduced the concept of the 'thing' and the 'thingness of the thing', suggesting that a thing is a totality – "*the unity of a manifold of what is given in the senses*". The jug is a thing, as a vessel, he suggested, made from earth, which stands on its own and takes on the task of containing water and wine, which come from a rock spring or from rain, or from the grape growing from the earth. Pouring can slake human thirst or be a libation to the gods. The jug thus connects humans, gods, earth and sky. It is this "*gathering and uniting*" that makes the jug a thing. The central aspect of the phenomenology of Maurice Merleau-Ponty (*2005*) is everyday practical experience of the world and things. Perception, he suggested, is not a matter of intellectual contemplation, but of active involvement with things – bounded entities that endure through time. It is the perception of the unity of the body that gives unity to the thing. It is through our bodies that, as humans, we are placed in the world, and this bodily being in the world must be understood through tasks and actions that have to be carried out, and through the material possibilities open to the body. So we may hypothesise that the pot has agency and does things for humans (*Gell 1998*), and acts as a "*delegated non-human character*" (*Latour 1992.157*).

It was not only knowledge of the properties of clay and fire, but the perception of containment that marks pots, suggested Carl Knappett *et alii* (*2010*). It was also the blending of pots and bodies. He noticed that, once ceramics were first introduced in Neolithic in Europe and Near East, they were associated with two major forms of 'containment'. The first is that of the vessel and the second of human and animal clay figurines. While in the first the association with containment is obvious at the functional level, in the second it is achieved through the semiotic relation with the human and animal body, which provide metaphors of containment.

Knappett also hypothesised that it was not only the perception of clay vessels capacity to contain, but rather the interactive properties, possibilities, or affordances that emerge because of this capacity of the vessel. Containers are thus not simply vessels, but action possibilities that make possible new forms of mediated action, agency, and material engagement, both in terms of use and manufacture (*Knappett 2004; Knappett, Malafouris 2008*). He introduced the relational concept of 'affordances' of objects, suggesting that information and meaning reside in objects and in the mind, since objects in context afford particular sets of actions to humans. 'Affordances', he suggested, frame, while not determining, the possibilities for human (agent) action in relation to objects (*Knappett 2004.46*). In other words, objects are a "*sort of nexus, where mind, agency and material meet and merge*" (*Knappett 2005.57*). He strictly followed Ian Hutchby's (*2001.444*) notion that "*affordances are functional and relational aspects which frame, while not determining, the possibil-*

ities for agentic action in relation to an object. In this way, technologies can be understood as artefacts which may be both shaped by, and shaping of, the practices humans use in interaction with, around and through them". Hutchby termed his approach the 'third way' in the discussion in sociology of scientific knowledge. He embedded it between technological determinism and constructionism. The perception that new modes of social relations are actively caused by particular forms of technology relates to the first way. The second relates to the perception that technological artefacts are entirely socially shaped, in terms of both their form and meaning.

It is worth remembering that the conceptualisation of affordance (possibilities or opportunities), was introduced by James J. Gibson (*1979.16, 23, 127–143*) in ecological psychology, suggesting that the mind directly perceives environmental stimuli without additional cognitive construction or processing. He criticised the dogma that the human perception of function is indirect, being mediated by cultural representations. He strongly argued that objects held 'potentialities' (*i.e.* affordances) for a 'particular set of actions' that can be observed without categorisation related to actual cultural knowledge. Within the terrestrial environment, affordances were conceived as a "*triad of medium, substances, and surfaces that separate them and where most of the actions are*". The surfaces mark the layouts of objects that afford manipulation. Containers and pots are listed among many others. They all have their technical 'properties or qualities', but "*what we perceive when we look at objects are their affordances, not their qualities*", suggested Gibson (*1979. 134*).

Knappett *et alii* (*2010.585*) later replaced 'affordances' with 'containment', which they suggested is a better term for both 'action possibilities' and 'affordances'.

In parallel studies in anthropology, perceptions of containment were associated with 'bounded object'. They both related to pottery, an archetype for actions of containing, storing, pouring, mixing, and to cooking in the context of domestic technology evolution and food processing. The vessel was conceptualised as "*a necessary extension of the body*" in eating, drinking and other bodily functions, and associated with "*a sensori-affectivo-motor conducts, individual desires and emotions*" in daily household activities (*Warnier 2006.193–195*). Jean-Pierre Warnier linked the body and material culture with "*a major change in the domestic technology of containment*" and "*daily household activities*" that evolve gradually in a "*technology of power*".

In the context of embodied mind theory in cognitive science, Mark Johnson (*1987.21*) suggested that one of the most pervasive features of our bodily experience is our encounter with containment and 'boundedness'. He linked the conception 'of bodily origins of meaning and thought with the intimate awareness of our bodies as 'three-dimensional containers into which we put certain things and out of which other things emerge'. He recognised the human body, and the house, as 'typical schemata for physical containment' that consist of a boundary that demarcates an interior from an exterior.

However, the container metaphor concept and embodied mind theory were linked to our conceptual system, in terms of which we both think and act, and is fundamentally metaphorical in nature (*Lakoff, Johnson 1980; 1999*). They were linked, as well, to our knowledge – we organise by means of structures called 'idealized cognitive models' (*Lakoff 1987*). These both related to Kant's concept of 'schemata' as structures of imagination and cognitive universals. In Kant's theory of perception, the 'schema' is not an image, but 'procedures for constructing images', thus involving perceptual patterns in our bodily experience. It is a nexus between a pure concept and a phenomenon (*Johnson 1987.21*).

In a philosophically oriented discussion of materials, their transformations and affordances, Tim Ingold (*2006; 2007.35*) suggested that there is no inside or outside, and no boundary separating the two domains. Instead, there are relations along which materials flow, mix and mutate. Persons and things, then, are formed in the 'meshwork' of relations between persons and things and things and things along which materials flow, mix and mutate. In 'animic' perception and lines of relationships, it is "*a meshwork of interwoven substances*". It is not that things are entangled in relations; rather, everything is itself an entanglement, and is thus linked to other things by way of the flows of materials that make it up. 'Affordances' were thus related to skill practices. Each generation, he claimed, thus contributes to the next "*by introducing novices into contexts which afford selected opportunities for perception and action, and by providing the scaffolding that enables them to make use of these affordances*" (*Ingold 2000.353–354*).

In more simplistic perceptions of containment, both the human body and the Neolithic pot were considered as containers of fluids and substances which enter and flow out of them, with their orifices, entrances and exits. It was suggested that the surface acts as a human (*Tilley 1996.318, 323–327*) or animal skin (*Mlekuž 2007.273*). A more formal linkage was believed to be provided by the "*occurrence of face pots with eyes*" and clay temper consisting of crushed human bones (*Tilley 1996.318*). These vessels were recognised as food containers linked to feasting and ritual. The pots, although fragile, were hypothesised as representing a highly symbolic items, along with exotic food that would be associated with feasts and ceremonial events to celebrate ancestral forces and powers on the one hand, and to entertain and impress neighbours, and to rise within and between group competition for prestige, fame and power on the other. Pots were believed to act as 'metaphorical vehicles' that link 'notions of time and death to the human body itself through the process of burial ritual' (*Tilley 1996.114*).

The even simpler idea that some pots represent people was introduced by Ian Hodder (*1988.382*). It was based on southeast European Neolithic pots that occur in the form of a female body "*with breasts, arms, and feet, and there are similarities in the decoration used on pots and on female figurines*". Conceptualising the idea of 'entanglement', he explained that "*objects that stand up against humans can only be known by humans through their character as things that gather humans and other things into heterogeneous mixes*" (*Hodder 2012. 13*).

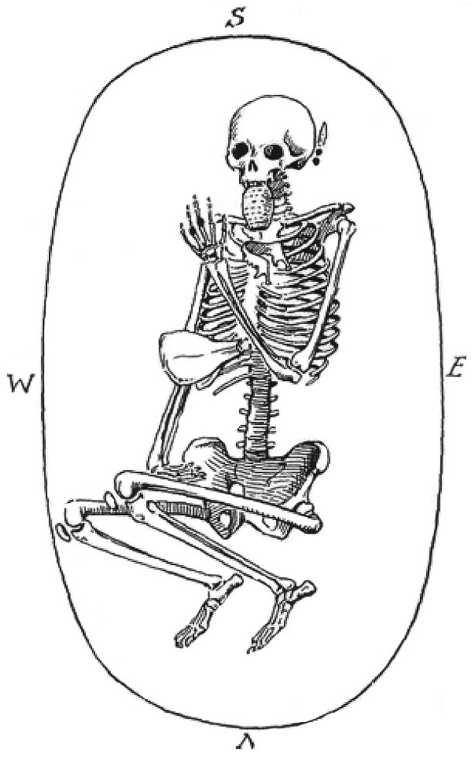


Fig. 1. The Bronze Age burial at Garton Slack. The mandible of the deceased was removed, and a vessel was inserted into the mouth (from* Brück 2006a. Fig. 4*).

Sometimes pots became a part of the human body. In a Bronze Age inhumation burial, the mandible of a crouched inhumation was removed. It was then placed on the deceased's chest and a miniature vessel inserted into the mouth of the deceased (*Brück 2006.84*) (Fig. 1). An early Neolithic vessel modelled in the form of a headless female body contained a fragment of a human skull (*Kalicz 1980.23, Tab. 2*) (Fig. 2). The vessel could be seen as "*mediator in their own right, object as person, whose major concern was the regulation of flows of substance*" (*Fowler 2004.63*) or 'as containers, just as the human head is seen in many societies as the repository of the human soul' (*Brück 2006.84*). We may suggest perhaps that the vessel and the skull fragment metaphorically build a new composite body of the deceased.

John Chapman (*2000a; 2000b*) suggested that pottery is a medium that is 'reliable and effective' for holding persons and groups together "*through the objectification of common traditions often reinforced by symbolic decoration*", and for providing "*a mechanism for symbolism of fission and rupture*". Thus, complete pots may represent group solidarity, integration and successful constitution, whereas fragmented pots represent rupture, cleavage and friction, which lead to dissolution. In Early Neolithic societies, where household and/or local lineage institutions were weakly developed, the only way to maintain social reproduction lay in repeated social practices, including the smashing of pots. Thus, "*the decision to keep pots whole through daily use is a metaphor for maintenance of social relations through continual renegotiation. Just as the associations of its various uses bring and added value to a vessel, so the enchainment of fractal person to a ramifying group of kin brings such people fame and reputation. Conversely, the rupture of those social relations characterising a less sedentary community would have elicited the response of the fragmentation of much valued pottery. But the even more striking collapse of social relations in a seemingly more stable sedentary community's may well have led to the large-scale fragmen-*



Fig. 2. The Early Neolithic 'Gorsza Venus' anthropomorphic vessel portrays a headless female body, and contained a fragment of a human skull (*Kalicz 1980.Tab. 2*).

tation of one of the that community's important symbolic resources-pottery" (*Chapman 2000a.43*). Along with the (fragmented) vessel, which mediates personal relationships between living members of society, human bones are a metaphor for maintaining relations between the living, the deceased and the ancestors (*Chapman 2000a.144; 2000b; Chapman, Gaydarska 2007.53–70*). A social practice of enchainment in this context is believed to comprise the best, and sometimes the only, explanation for the deliberate fragmentation of pots and bones (*Chapman, Gaydarska 2007.203; Chapman 2008.188*). In these readings, the fragmentation of vessels and bodies, and the extraction of parts from wholes and re-articulation of fragments in new units is the major mode of social relations through which people and things are constituted. People are not so much individuals as 'fractal' and 'dividuals'. Who they are and what they do relate to their transactions with each other, with material culture and with the dead (see *Budja 2012.144–147*).

We may hypothesise that the female body was not the only source metaphors of 'containing' through which Neolithic farmers experienced being and understood the world around them, but the animal body too. These appeared in the form of rhytons, four-legged vessels embedded in Neolithic contexts in the Balkans and the Adriatic. They have been seen as stylised representations of the lower body of different species of domesticated animal, especially sheep, goat, swine and cattle (*Perić 1996*). It has also been suggested that they have some iconic resemblance to animals, which is not intended to be representational, but to reveal their hidden properties (*Mlekuž 2007*). Representations of wild animals appeared along with representations of domestic species. Maria Gimbutas (*1989.Fig. 186*) recognised a 'Bear Mother' in one of them (Fig. 3). However, domesticated animals are not only good to share households with (*Haraway 2003*). Neolithic personal experience may have been greatly shaped by the animals that people bred, exchanged and hunted (*Fowler 2001.160*). They were engaged in reciprocal social relations within the household (*Nadasdy 2007*). In communities where personhood is stressed as a feature of the community and where a clan is a person (a family might be another), not all the people in the community are necessarily human, but other social agents, such as animals (for details, see *Morris 2000; Fowler 2004.14–30; Voutsaki 2010.74*).

Pottery and women in ethnographic contexts

Dean Arnold (*1985.128–144*) identifies a number of generalisations about pottery and people based on



Fig. 3. The Neolithic 'bear-legged rhyton' from Smilčić. Maria Gimbutas (*1989.118, Fig. 186*) related its iconicity to 'Bear Mother' goddess.

both ethnographic and archaeological observations. The two of most interest here are the relationship between pottery making and sedentism, and the correlation between pottery as a tool and more intensive forms of food processing. The perception of ceramic vessels as tools for more intensive food processing made by women for women soon became broadly accepted. It was even suggested that 'pottery is one of the few technologies controlled by women for millennia' (*Longacre 1995.278*). The idea that pots represent people has also been demonstrated for north-eastern Africa, where they supposedly act to order the social body there (*Braithwaite 1982; Welbourn 1984*).

The cross-cultural survey in Murdock's Ethnographic Atlas database of preindustrial societies indeed shows 105 traditional societies, 76% of which have female or predominantly female potters, 18% had male or predominantly male potters, and 6% have equal participation of men and women in pottery making (*cf. Skibo, Schiffer 1995.84*). Paradoxically, in the same database, 282 non-sedentary societies were listed, 103 of which made pottery.

However, a number of ethno-archaeological and anthropological studies have pointed out the symbolic links between women and pottery. Studies suggest, "*not only [to consider] woman to be the efficient cause of the clay pot but establish a symbolic identification between the two*" (*Lévi-Strauss 1988.180*). Thus, Jibaro Indians in Ecuador believe that the vessel is a woman, and the Desana in Colombia and Brazil, that a woman's body is a cooking pot. Only women can create and use pottery because the clay, of which they are made, like the earth itself, is a woman. (*Lévi-Strauss 1988.22, 181*). Desana women have to collect the clay from certain places that lie outside their territory, but within the territory of other exogamous groups involved in intertribal marriage exchange. These groups are said to 'cook' their brides before the marriage exchange (*Reichel-Dolmatoff 1978.280–282*).

In sub-Saharan Africa the earth is similarly regarded as female, and potters may have special relations with it. On the other hand, a taboo against women's sculpting in hard materials such as stone, wood, bone, ivory, and metals compounds is suggested. Only men use these materials, and women may work only with soft, materials such as clay, basketry, gourds and leather (*Teilhet 1978.97*). In West Africa, female potting thus widely corresponds with male smithing, the potter being the wife of the blacksmith. Among the Vere, the Dupa and the Dowayo in Cameroon, access to pottery manufacturing is always restricted to the wives of smiths. They are considered both dirty and ritually impure, and therefore subject to numerous taboos. They are marginalised and must live apart and may not enter the huts of others. They cannot share food or even draw water from the same spring, and never eat from the same vessel. Their separation is most strongly maintained by the belief that potters may harm others, as they may cause diseases. They are not allowed to own cattle, because of their "*hot hands*" (*Barley 1994.64; Vander Linden 2001.140; Pankhurst 2003*).

The Ari people in Ethiopia belong to either farmer's (*kantsa*) or craft workers' (*mana*) groups. The latter are socially segregated from the former, and it is taboo for kantsa to marry mana. Although potters, who are predominantly women, and blacksmiths belong to the same group, marriage between them is also prohibited. Potters usually work alone, although daughters are allowed to make pots in the same place as their mothers to learn "*certain finger movement patterns as they play in their mothers' work places*". There are no standardised procedures for pottery making, and each potter goes through trials and errors while creating their pottery. Based on their experience, each potter develops a unique procedure for making pottery (*Kaneko 2007.6; 2009. 387*). It has also been suggested that "*the pots are widely assimilated to the person*", and that the women who make these pots describe the different surface areas in terms of their own bodies (*David* et al. *1988.366; Welbourn 1984.20*).

In Arnold's (*1985.101*) perception of "*the beginnings of pottery as an economic process*", it is suggested that women in hunter-gatherer societies were closely related to the household. He classified pottery production with 'pregnancy, infant care, cooking and other household tasks', because "*pottery making is easily compatible with child care responsibilities*"; it is "*easily accomplished in the home and does not require periods of absence from the home*"; it is "*not dangerous and does not thus provide a hazard for children*", it is "*relatively monotonous and does not require great concentration, can be carried out in spite of interruptions and can be easily resumed*"; and finally "*once the process has begun, it requires almost daily attention and thus it is an ideal craft for females tied to the household*".

Much later, taking a cross-cultural perspective, Randi Haaland (*2009*) similarly argued that vessels become

particularly important in activities associated with women and hearth-centred activities, including childrearing, water carrying, plant gathering, and food preparation.

Parallel to this, cooking technology that used ceramic pots may have resulted in greater equality between individuals in the nutritional value of foods consumed. Meat sharing practices among foragers may be nutritionally and quantitatively inequitable, with women typically receiving less desirable portions, even when pregnant or ill. Preparing a dish of meat and vegetables cooked slowly in ceramic pots could have improved women's access to critical nutrients by equalising the distribution of foods within a group sharing meals from a single vessel. Patricia L. Crown and Wirt H. Wills (*1995a.175–180*) also hypothesised that women preferred ceramic vessels to other containers (*i.e.* bags, gourds, baskets) or cooking pits, because they could achieve an 'economy of scale' in manufacture that was not feasible with other cooking technologies (*i.e.* boiling stones, for cooking clay balls in Çatalhöyük see *Atalay 2005; Hodder 2012.151–195*).

It has been suggested that women produce the tools they use for food procurement and processing, and pottery making might be embedded in a production sequence that involves food gathering, crop tending, harvesting, fetching water, food preparation, and cooking. James A. Brown (*1989.215–216*) argued that pottery has time-budget advantages for partly or fully sedentary groups, because there are women "*who are occupied in a pattern of activities around the base settlement*"; these "*are tasks around which craft production of many types easily fits the odd bits of time left over*", and "*consequently, under these settlement practices, labour has negligible costs*".

Plant cultivation and pottery production were simply added to foraging women's existing workload. However, a behavioural chain analysis of maize preparation among the Hopis in North America in 1900 reveals that women assumed fourteen tasks from harvesting to serving, with seven of these tasks being performed several mornings per week and four tasks performed twice daily. We may agree, therefore, that cultivation and pottery have not fitted easily into women's existing workload, although they depend 'on the time and labour of women' (*Eerkens 2008.320*).

The locus of pottery production shifts from women to men when access to traditional resources decreases and pottery production becomes a more profitable (subsistence) economic activity. A close link also exists between male and the introduction of the potter's wheel, which increased the efficiency of techniques of hand-made pottery (*Stark 2003.205*).

Pottery in the transition to farming

Three general scenarios are available about both the invention and adoption of pottery. The first relates vessels to the use and display of ritual-specific objects made of fired clay and the emergence of specialists, such as female shaman potters. The second suggest the early use of pottery in practical functions, like every day cooking and storage. The third emphasises its role in altering or sustaining social relationships.

Karen Vitelli (*1999.188*) found pots at the earliest Neolithic site in Franchthi Cave in Argolid, but with no evidence of cooking and limited volume capacities, insufficient for food storage. These pots, she argued, had a non-utilitarian function in ceremonies and rituals that may have regulated social conflicts at the onset of sedentism (*Vitelli 1993.217*). She hypothesised that women were probably the inventors and first practitioners of early Neolithic pottery making in Europe. They were "*individuals with shamanic powers*", she suggested, who had knowledge of the "*the seemingly magical transformation that takes place during pottery firing*" on the one hand, and of the "*medical and psychoactive properties of plants and of altered states of consciousness*" on the other (*Vitelli 1995.62*). She estimated an annual production of about 12–13 pots per year divided among five potters at Franchthi (*Vitelli 1989.21*; see also *Perlès 2001.83*). Similarly, in East Asia (China and Japan) and the Russian Far East, the earliest pottery appears only in very small amounts and at a few sites (*Keally* et al. *2003.9; Cohen 2013*). It has been suggested that the vessels may not have been used extensively for everyday food preparation, and that it was a barely sustainable technology that persisted in episodic, low-scale usage. One thus might question how it survived and intensified later (*Gibbs 2012.90; Gibbs, Jordan 2013.20*).

It is worth remembering that Prudence M. Rice (*1999. 1–54*) at the same time introduced a more complex interpretation of the appearance of utilitarian pottery. She thought vessel production could be considered as a trajectory of a series of cultural transformations, beginning with resource intensification, through socioeconomic intensification, to technolo-

gical intensification "*as a prestige technology and a durable good*". There were two different processes, 'initial emergence' ('invention') and 'adoption' ('innovation'), which can be separated by hundreds or thousands of years, she continued. While the 'invention' relates to processes of experimentation and precedents for ceramic technology (clay-lined baskets) and the social contexts in which these inventions appeared, the innovation concerned pottery's "*wider incorporation into the container technology of previously non pottery-using societies*". The innovation thus relates to the social and economic settings in which ceramic containers became 'watertight, fire-resistant' tools widely used for day-to-day cooking, food consumption and storage (originally suggested by *Brown 1989.213–216*). Rice hypothesised that pottery could have been particularly helpful for 'broad spectrum collecting' strategies, which include diverse foods that often might be seasonally available in only small but highly concentrated and highly predictable quantities, which can withstand high harvest rates, such as grains, beans, tubers, shellfish, *etc*. Such food must be cooked and requires sustained simmering or boiling water. Diet can thus be better controlled by preparing meals that included multiple ingredients (meat and vegetables). Boiling and the long-term heating of mixed ingredients improved nutritional intake and allowed an equal distribution of nutrients in a group. An additional advantage is that cooking vessels can be left untended for appreciable periods. She relates the resource intensification to the intensified exploitation of selected highly productive resources, and to the emergence of socioeconomic competition by 'aggrandizing' individuals or groups who competed for power, prestige, and status by means of competitive feasts. Pottery containers seem to have been most important for serving (display) rather than cooking or long-term storage. They became medium, both as prestige technology and containers of new, exotic (*e.g.*, cereals) or perhaps highly desirable foods, for social and power expression.

Ingold introduced (*1983.561–652*) the 'social storage' aspect of food accumulation. This refers to the "*... appropriation of materials in such a way that rights over their future distribution or consumption converge upon a single interest. In this sense, the store has to be considered in its aspect as property or wealth, and storage as a concomitant of social relations of distribution*." It was hypothesised that food containers in this context represented a cultural code by which persons may be identified with their property. On the other hand, social storage represents the direct negation of sharing, which requires a 'practical portable storage, and much stricter calculation' of how much each individual is obliged to make separate provision for bad periods in the 'delayed return' systems of resource exploitation. Vessels offer the possibility of measuring produce in standard units of volume, and calculating how much each individual has given to, or received from, joint efforts. We may assume this distribution was an alternative to a general sharing of food that made possible the ideological transformation from hunting to farming.

However, behavioural ecology theory offers 'prey and patch choice' or 'diet breadth' as an extension of the microeconomic concept of 'opportunity costs' and 'delayed return food production' interpretative models, which suggest that the transition to agriculture "*may have coevolved with incremental shifts from public to private goods*" (*Codding, Bird 2015. 15;* see also *Winterhalder 1983; Bird, O'Connell 2006; Winterhalder, Kennett 2006; Bettinger* et al. *2010*). Hunter-gatherers distribute resources in two different ways. Among immediate-return hunter-gatherers, there is no storage, and the day-to-day uncertainties of hunting and gathering require unlimited and uncontrolled access to territories and their resources, as well as widespread intragroup sharing of harvested resources. Land and resources are public goods, belonging to everyone. Resources should be freely used, redistributed, and shared to equalise disparities. Meanwhile, society should punish hoarders. Delayed-return hunter-gathers, however, accumulate and store some resources for future use and thus place limits on immediate consumption, often by privatisation, making them the property of those who obtain them. Resources thus belong exclusively to those who obtain them, and society should punish those who take resources garnered by others without permission.

These contrasting principles have supposedly had important implications for subsistence intensification. Open access to resources discourages intensive foraging, which is so costly that individuals will not risk it without an assurance that they can keep everything they harvest. This means they need some assurance that the very low returns they obtain will be safe from the claims of individuals who work less, but who always receive the same share as everyone else. If resources must be shared with freeloaders, harvesters of low-return resources may well end up expending more energy than they obtain. For this reason, immediate-return hunter-gatherers "*restrict*

themselves to resources having returns high enough to offset freeloader overhead, using just enough low-return resources to squeeze by and punishing those who hoard them. This keeps population size and density low." (*Bettinger* et al. *2010.12*). Delayed-return hunter-gathers, however, target low-return resources, especially plants that are easily stored. This sustains larger, denser, and more stable resource populations, while reducing the payoffs to individuals who continue to specialise in high-return resources, the use of which can be sustained only by sharing.

Thus it has been suggested that delaying returns restructured prey and patch choice dynamics in a way that becomes contingent on social institutions that solve problems of collective action associated with stored foods, introducing 'farming-friendly property rights', and thus allowing low-level food producers to make the transition to rely completely on domesticates (*Bowles, Choi 2013; Codding, Bird 2015*). Incipient forms of privatisation were hypothesised as being associated with the appearance of storage pits full of uncarbonised broomcorn and foxtail millet in north China (*Bettinger* et al. *2010. 12*). In the Western Great Basin in North America, privatisation was linked to the invention of ceramic vessels, which helps mobile groups to intensify 'wild seed' exploitation, a resource that can be individually acquired, processed and stored privately (*Eerkens 2004*, see below).

Following Pierre Bourdieu (*1984*), on the other hand, we can also see how feasts can convert economic capital into either symbolic power or cultural capital. Brian Hayden (*1990; 1995; 1998; 2009; 2011; 2014*) introduced this perception of feasts into archaeology, strongly emphasising the social implications of early pottery use and exotic food consumption in the context of transition to farming. He thought the association of ceramic containers and feasts may even reflect a universal cultural tradition (*Hayden 1998*). He made a clear distinction between practical and prestige technology. The first is based on the principle of performing tasks in the most efficient and effective fashion possible, which means the less time and work involved, the better. In contrast, prestige technology is grounded on displaying one's wealth, power, or control over labour and resources. Its appearance, he suggested, reflects 'economically based competition' that is possible only when technological advances occur in surplus food production and storage.

Pottery and 'aggrandisers'

To answer the question 'Why clay pots?', Hayden (*2003*) suggested an economically oriented socio-political scenario based on the interconnected concepts of 'private ownership', 'economically based competition' and 'prestige technologies' which appeared among 'transegalitarian' hunter-gatherers. The term 'transegalitarian' refers to societies that recognise private ownership, use prestige items, produce some surpluses, hold feasts or other economically based competitive displays, have restricted sharing, and a range of poor and wealthy families that do not form permanent classes. They differ from societies with permanent classes and political hierarchies on the one hand, and egalitarian societies on the other hand, where sharing is mandatory and there is essentially little or no private ownership or economically based competition. Hayden postulated that feasting constitutes a new kind of human behaviour that probably first emerged in the Upper Palaeolithic, and that it can be "*intimately associated with the first specialized structures, often referred to as communal buildings or ritual structures*", where "*surplus food can be converted into other desirable things or relationships in short spans of time*". Feasting, he continued, provides the 'underlying dynamics for the development of a range of prestige technologies, including new food preparation and serving technologies, including pottery'. In this context, the domestication of plants and animals were "*the most important prestige technologies to have been developed specially for feastings*" (*Hayden 2014.4*; see also *Benz 2015*).

Hayden (*2011*) hypothesised that the transition to private property emerged under conditions of resource abundance, where everyone could have been assured of enough to eat under normal conditions. However, the ability of a technology to extract and store surpluses from environments with abundant resources was required. If not, 'technological bottlenecks' could have occurred in the procurement, processing, or storage of seasonally abundant resources. Storage also led to seasonal, and in some cases perhaps prolonged sedentism, as well as favouring notions of private property, since stored foods represented a supplemental investment of labour by individuals or households for their own benefit, whether in terms of reproduction, power, survival, or standard of living.

He proposed that the development of feasting among hunter-gatherers constituted a new phenomenon

that could have motivated people to develop new technologies. These technologies included not only new extractive devices (such as fishhooks, nets, leisters, sickles and weirs), but also new processing tools (such as grindstones, boiling stones and earth ovens), and new storage technologies. In favourable areas, the cumulative effect of these innovations was to make the production of surpluses relatively reliable. The surpluses were owned by individuals or families and used by them in strategies to enhance their own survival and reproductive benefits (*Hayden 2009*).

These individuals are recognised as 'aggrandisers', or "*triple A personality types: ambitious, aggressive, accumulative, aggrandizing, abrasive people*" (*Hayden 2011.115*). They invented a number of strategies for converting food surplus production into social and political ties through the creation of debt relationships and the display of mutual support. The most common and most important of these strategies include the hosting of feasts with obligatory reciprocity as a way to indebt people, and the creation of wealth (or prestige) objects (such as ceramic vessels) used to validate social transactions with obligatory returns, thus creating debts and forcing people to produce surpluses. The pottery consists of finely-made serving vessels or vessels used to produce special foods. They all exhibit new and prestige ceramic technology to be used to produce prestigious materials and foods to impress guests. Ceramic containers thus became a medium for 'aggrandisers' to build political alliances and court potential followers during public gatherings. Christopher Garraty (*2011*) suggested that these prestige technologies became widely imitated and in time reinvented as practical technologies.

The quantity, shape and size of pots associated with luxury foods formed an important indicator of household status (*Hayden 2001.59; 2003.458–469*; see also *Van der Veen 2003.405–427*). The quantity of pots may indeed signify the use of ceramic vessels as status indicators. Exceptionally large vessels may point to the occurrence of communal feasts. A change from large communal pots and serving bowls to the use of individual plates, drinking vessels and cutlery may indicate a change from eating from a communal bowl to serving portions to individuals and to a shift to hierarchical feasting. The development of social complexity is often viewed as one in which feasting becomes increasingly associated with elites. Paul Halstead (*2012*) thus recognised Neolithic equivalency feasts as a basis upon which Early Bronze Age palatial hierarchical commensality developed.

However, we may assume that hierarchical feasts that evolved from community feasts should not be limited by the assumption that hierarchical feasting replaced all other forms of commensality comprising larger than regular meals, but smaller than the material signatures of very large community feasts (*Twiss 2012; Smith 2012*). In societies undergoing a transition to greater complexity, the functions of solidarity and the creation and demonstration of numerous crosscutting ties would have been of increasing importance to households as well as to emerging elites. Feasts would have been demonstrations "*of individuals' and households' ability to mitigate failure, to demonstrate their resilience in the face of anxiety and stress, and to manage the memory-making of events after the fact*" (*Smith 2015.1230*). Feasts are complex events in which success is far from guaranteed, and the many points of potential 'feast failure' provided an essential opportunity for continuously demonstrating social ties.

Following Hayden (*2003.466*) "*many of the first domesticates in most regions of the world are clearly luxury foods or prestige items*". These foods were "*the rarest, the most difficult to procure or the most-labour intensive to produce, together with labour-intensive preparations*" (*Hayden 1996.137*). His main argument on subsistence intensification does not concern food shortage, but the desire to quickly produce more cereals or animals suitable for feasting to obtain social and political advantages. It was in interests of aggrandisers to reduce the cost of these foods where possible. While this is initially beneficial to them, it changes the status of such foods in the long term and thus their value in prestigious displays (*Hayden 1998*). Exotic foods were desired not so much as foods, perhaps, but as symbols, as 'markers of social distance', and 'status indicators' (*van der Veen 2003.415*).

The competitive feasting scenario was related recently to behavioural ecology theory. Douglas Bird and James O'Connell (*2006*) suggested that 'costly signalling theory' and 'irrational behaviour' can explain the conditions under which high-cost, status-related food production and distribution might be expected to develop. Luxury foods were generally characterised by the cost of acquiring or producing them, and by the notion that they are functionally unnecessary. The cost of producing such foods often limits their distribution to special occasions that can be arranged only by those who can afford them. Those unable to engage in feasting are marginalised, and even forced into slavery. The roles of status, the pro-

duction of costly foods and feasting have been suggested as initiating the development of despotic corporate groups, control over the labour of others, and the evolution of hereditary and inequality in social stratification.

To answer the issue of what kinds of 'meant-to-impress foods' could have been prepared in the earliest ceramic vessels in Incipient Jōmon sites at *c.* 13 100–11 000 cal BC, Oliver Craig *et alii* (*2013*) suggest that freshwater and particularly marine organisms were processed, even though neither site is situated directly on the coast. Similarly, the presence of lipids derived from aquatic organisms in the large number of hunter-gatherers' pottery in north-eastern North America and in Northern Europe show that ceramic vessels developed in this region valued exchange commodities, such as fish oil, at episodic social gatherings during periods of high resource abundance (*Craig* et al. *2011; Taché, Craig 2015*). Similar evidence has been provided by Alexandre Lucquin *et alii* (*2016*). There was little indication that ruminant animals or plants were processed in pottery, although it is evident from the faunal and macrobotanical remains that these resources were heavily exploited.

A recent residue and use wear analysis of grindstones associated with the initial pottery at the Nanzhuangtou site in northern China shows they were probably used to process the seeds of a range of wild grasses (including millets), acorns, and tubers (*Cohen 2013.69*; see also *Liu* et al. *2013*).

It is interesting that Fumiko Ikawa-Smith (*1976*) argued decades ago that pottery was adopted in the initial Jōmon in response to rising amounts of shellfish and other aquatic foods. She suggested that pottery was adopted because it allowed better ways of direct cooking. Some other 'adaptationist' views saw the earliest pottery in the North American Midwest as a specific response to the need for more efficient containers for the extraction of oils from nuts (*Ozker 1982*), or because cooking pots permit a wider range of food resources and techniques of preparing and processing foods to be used (*Reid 1984; Arnold 1985.128–44*).

Pottery and food resource intensification in hunter-gatherer societies

James Brown (*1989.208–212*) suggested, contrary to Hayden, that the earliest pottery 'should be processing vessels' and not 'food-serving containers associated with the tendency for increased economic competition along with more pronounced inequality'. He postulated that early pottery appeared in two separate contexts: sedentary cultivators who used the vessels to process and make digestible cereal grains, and seasonally sedentary hunter-gatherers who used vessels with either direct or indirect heating to extract additional nutrients from animal products or to process seeds and nuts more effectively. The adoption of ceramic vessels thus becomes an innovation, he suggested, in households where 'watertight, fire-resistant vessels are in greater demand than existing sources of supply can deliver'. This demand increases with new processing needs for small-sized seeds and nuts, of which cereal-grain processing is the most demanding of all. On the other hand, sedentary and partly sedentary settlement systems foster the adoption of pottery "*... due to the cheapness of this craft as an alternative to other container crafts when a constraint is approached in the available time that a craftsman has at his or her disposal to dedicate to non-ceramic vessel production. My basic proposition is that pottery, even as a crude technology with limited applications, has an advantage over other alternative containers, even sophisticated basketry, when budgeting time-resources conflicts with or impedes the production of non-ceramic containers.*" (*Brown 1989. 222*). In other words, pottery making is only useful when the demand for vessels is high, and large numbers can be produced in a single firing event. Firing is one of the most time-consuming and energy-consuming steps, and can be done almost as easily for one pot as for many. In economics terms, the per-unit cost decreases with increasing output, a result that is not true of other container technologies, such as baskets, stone bowls, or wooden bowls, where items are made one at a time at the same per-unit cost regardless of total output. As a result, pots, which may be weaker and shorter-lived than these alternative containers, are preferred because large numbers can be produced at once (*Eerkens* et al. *2002*).

Seasonal sedentism at least was required for pottery making. Because of scheduling conflicts, mobile hunter-gatherers may not be able to stay in one place long enough to complete the pottery production sequence, from collecting clay to forming pots, drying and firing them. It can take from several days to several weeks. It is worth remembering that in many parts of the world (like Siberia and the Russian Far East), pottery can be made only in one season of the year because the climate is otherwise too cold and wet (see *Zhushchikhovskaya 2005.36–44*).

On the other hand, it is often said that the adoption of costlier subsistence technology marks an improvement in food procurement. Better tools make the process more efficient: maximising the rate of nutrient acquisition improves health, either by increasing nutrient intake or by reaching some intake threshold more quickly, thus freeing time to pursue other subsistence activities. This is true in the sense that new technology often enables its users to extract more nutrients per unit weight of resource processed or area of land harvested. If we focus on efficiency, and on the cost/benefit ratio as the key criterion, *i.e.* the rate of nutrients gained relative to the effort needed to acquire them, then the use of costlier tools will often be associated with declines in subsistence efficiency (*Bird, O'Connell 2006*).

Jelmer Eerkens (*2004.661–663*) linked pottery innovation among mobile, non-farming groups in the Western Great Basin in North America to the intensification of wild seed exploitation. He related it to a dietary shift from less predictable, frequently shared foods associated with a group-based procurement and cooperation (meat) to more predictable, infrequently shared particulate plant foods that were conducive to individual, or family-based procurement, such as cereal grains, starchy seeds, nuts, kernels, and legumes. Although meat sharing was common among hunter-gatherer groups as a means of reducing risk and garnering social recognition, families were not obliged to share more predictable and readily stored plant foods. Unlike most hunting activities, foraging for these foods did not require collaboration or mutual assistance among group members.

It is also worth mentioning the positive correlation between pot use and the preparation of easily digestible gruels that can substitute for mother's milk. It has been argued that the processing of such gruels facilitates earlier weaning and improves infant survivability, both of which act to increase populations (*Crown, Wills 1995b.248*).

Eerkens (*2004*) suggested that the ethnographic record demonstrates that seeds, which were prepared in pots, were largely considered private goods. However, whether pots were instrumental in the privatisation of seeds or were adopted to process an already privatised resource is unclear. Because pots can be individually made and used inside houses, they are well suited to privatisation. Vessels were differentially used within households, out of view of the rest of the community, and they were not on display. This probably also explains why most pots were not decorated.

Pots make very durable containers resistant to boiling and other hard and permanent use; however, they are less portable and more inclined to break than other containers. Cooking pots are subject to repeated thermal and mechanical stress and, therefore, tend to break and require replacement more frequently than storage and service vessels. Because of conflicts between weight and fragility, bigger storage vessels may have simply not been moved at all. Although it is broadly accepted that hunter-gatherers do carry vessels with them, and that sedentary peoples often transport pottery over long distances, one solution to the weight and fragility problem is simply not to move the pots at all. It has indeed been suggested that 'caching pots' may have been a used to avoid carrying pots during the seasonal round, thus making the technology worthwhile (*Eerkens 2003*).

'Caching pots' or temporary storage strategies may have had major consequences for the lifestyles of hunter-gatherers, since they could not have deposited pots anywhere in a field. Caching would have tied people to particular places on the landscape where they had deposited pots. This results in higher rates of site re-occupation, also referred to as 'occupational redundancy' or 'persistent places' (*Eerkens 2003*). Such ties may have promoted reliance on foods associated with these locations and may have encouraged the notion of land ownership and territoriality. At the same time, it is also likely that 'caching behaviour' would have prompted people to modify pottery technologies to make their products more suitable for storage during the off-season. Thicker and stronger pots may have been a by-product of this behaviour (*Eerkens 2008*).

The early introduction of container technology was based on 'family-by-family decisions' within a context where pottery-using families were living in close proximity to non-using families. Even on a small scale, families might have adopted pottery at different rates and for different reasons. 'Dependent pottery invention' thus marks a process in which households adopt technical knowledge from an external group, but modify or 'reinvent' it in a way that is foreign to the donor population. Households in different areas may have adopted and 'reinvented' pottery in response to different local needs. The appearance of ceramic vessels seems to follow the 'diffusion of innovation principle', with small numbers of early

adopters, followed by a rapid increase in technology adoption, and again with small numbers of late adopters (*Garraty 2011.223; Eerkens, Lipo 2014*).

Pottery may indeed have first been used for storage to better protect seeds from the adverse effects of temperature fluctuations, moisture, and bacteria (*Diehl, Waters 2006.80–81*), but was converted into cooking pots elsewhere after a long period of experimentation. Eerkens (*2008.320*) suggested that baskets which were woven so tightly they could hold water and could be used to cook and serve foods were replaced by ceramic vessels because the boiling of small seeds became a major cooking activity. That is, stone boiling in baskets demands constant attention from women to replace cooled stones with heated ones and to avoid holes being burnt in the bottom of the basket. So pots provided a more efficient boiling container, because they can be set over a fire with less attention and more seeds could be processed.

In most regions in the southwest of North America, most pots were locally made and used. Two or three different pots per house were used during a limited time of the year. Similarly, 'caching pots' were probably only used at certain times of the year (*Eerkens* et al. *2002*).

It is worth noting that maize cultivation preceded pottery making in southwest North America. While cultivation appeared in a 'Pre-Ceramic interval', the initial appearance of ceramic technology was first documented in the 'Early Agricultural Period' at *c.* 2130 cal BC (*Huckell 2006; Mabry 2006*). The introduction of ceramic technology relates to the production of anthropomorphic figurines; at some sites, these are associated with very few, very small ceramic vessels. The latter have been defined as 'incipient plain ware pottery'. They are small, low-fired, and have simple forms. They have highly variable vessel wall thickness, textural surface treatments such as incising, punctuating, and impressing, and the rare use of slips or paint. Individual or small group serving vessels dominate assemblages, followed by and storage and cooking pots (*Heidke 2005; 2006; Mabry 2005; Garraty 2011; Eckert 2014*). Almost half of the early ceramics were deposited in contexts interpreted as having a ceremonial, ritual, or integrative function. Some are associated with 'Big Houses', which are up to three times larger than other structures (*Heidke, Stark 2002*).

The various interpretations mentioned above suggest that pottery technology may have appeared on the one hand in association with temporary storage strategy, seed protection and resource intensification; with the evolution of territoriality and land ownership hunter-gatherers perception; household-level control of resources and private property protection. On the other hand, it may relate to the evolution of culinary practices; 'economy of scale' and women's workloads within households; aggrandising behaviour, competition and individual self-interest to produce surpluses, prestige, power and status.

The origins of ceramic technologies in hunter-gatherer societies

We mentioned above that current evidence increasingly reveals that hunter-gatherer societies developed ceramic technology a millennia before the earliest Neolithic and the beginning of sedentism and agriculture in Europe and Asia.

The invention of fire-hardened clay enabled hunter-gatherers to make durable products, whether ceramic containers or ceramic human and animal figurines. It was recognised as an early step in the development of pyrotechnology. It might have been related to 'cross-craft interactions', a copying of shapes and designs from one material (baskets, ground stone and wooden bowls) to another (ceramic vessels). This kind of transmission is known as skeuomorphism and may occur several times within a similar timeframe, and has been proposed for both ceramics making and copper metallurgy (*Miller 2007. 238; Frieman 2013; Roberts, Radivojević 2015; Radivojević 2015*).

While pyrotechnology is defined as "*deliberate processes utilizing the control and manipulation of fire*" (*McDonnell 2001.493*), the transformation of matter requires not only a working memory and understanding of the separation between different stages of complex production (*Read, van der Leeuw 2008.1965*), but also a shift in perceptions of the natural environment and the 'animate' qualities of soils and minerals, which often relate to 'ritual journeys' for mineral acquisition (*Boivin 2004*).

Benjamin Roberts and Miljana Radivojević (*2015. 300–301*) suggested recently that two processes, invention and innovation, underlie the appearance of pyrotechnologies in prehistory. They both related to ceramic making first, followed by copper metallurgy. Invention is defined as the discovery of a new idea, material or process, deliberately or by chance, and may include a radically new product as much as a

recombination of technological components in a novel manner. An innovation is recognised when "*an invention affects the evolution of the system and is successfully transmitted within a population, and beyond*".

The invention of any novel technology evolved through an accumulation of knowledge of the process's components accumulated through experiment, recombination or reapplication over a period of several decades, or centuries. It may have taken a few generations of people before the invention developed and until it reached a form that functioned for a desired purpose (*Radivojević 2015*). Changes in material culture were thus more likely to have been built up over a certain period, rather than being radical technological breakthroughs (*Shennan 1989*).

To address the question of what motivates invention, John Lienhard (*2006.117–118, 158, 165*) suggested four major stimuli: profit, necessity, pleasure and freedom. He identifies three stages 'in the evolution of any technology': gestation, cradle and maturation. Gestation refers to a fairly long 'run-up period before the invention takes an identifiable form'. It is a period of creating a "*capability that we strongly desire, without knowing what form that capability will take*". During the cradle period, the inventor seeks to understand the invention and alter it in ways that make it serve a purpose. When the invention reaches a form that is no longer dramatically changed, the maturation period begins. The trajectory of technological evolution is very rarely completed during the lifetime of a single inventor. It could take a few generations of inventors, who contribute to the accumulation of knowledge before the invention is sufficiently developed to be broadly adopted. We may note that humans inherited a 'risk-innovative' behaviour, *e.g.*, a capacity to invent and adopt innovations in stressful conditions, when individuals are more encouraged to be inventive in times of economic or environmental uncertainty or strong competition (*Fitzhugh 2001*). In the context of resilience and sustainability theory, a new technological invention can be linked to the ability of society to maintain sustainable development (*Berkes* et al. *2003; Smit, Wandel 2006*).

Indeed, early pots are found only in very small numbers at Palaeolithic hunter-gatherer sites in East Asia. They remained confined to a small number of sites, and persisted in episodic, low- scale usage until the Early Holocene (*e.g., Keally* et al. *2003; Cohen 2013*). There seems to have been a relatively long and gradual 'experimental stage' (for concept see *Jordan, Zvelebil 2009*) that may not have involved significant dispersals of ceramic (pyro)technology and vessels.

The initial pottery in East Asia is chronologically embedded in time spans at 19 286–18 886 and 16 138–15 962 cal BC[1] in the Xianrendong and Yinchuan caves in southern China, and at 10 180–9691 cal BC at the Nanzhuangtou site in northern China; at 14 986–13 839 and 13 855–13 536 cal BC at the Odai Yamamoto 1 and Kitahara sites in Japan; at 14 139–14 297 and 13 735–13 354 cal BC at Khummi and Gasya in the Russian Far East, and at 12 206–12 034 and 12 106–11 688 cal BC in Eastern Siberia in Russia (for radiocarbon dates, see *Wu* et al. *2012. 1699; Cohen 2013.61–70; Hommel 2014.Tab. 30.1; Kuzmin 2015.Tab. 1*).

Some of the earliest pottery fragments from Palaeolithic hunter-gatherer sites in East Asia bear zigzag, stripe or net impressions on the exterior and sometimes interior surfaces. Similar imprints can be made by various techniques for shaping vessels, such as beating out the walls of a hand-modelled vessel with a paddle wrapped in cordage or plant fibres; modelling a vessel inside a hard template or mould, such as a basket; or modelling a vessel inside a semisoft cord mould, such as a woven bag (*Cohen 2013*; for a detailed analysis of 'cross-craft interactions', see *Zhushchikhovskaya 2005.21–23, 59–81; 2009; 2012*). Some incipient Jomōn vessels have a square form that imitates the form of rectangular wooden trays or woven baskets (*Gibbs, Jordan 2013.8*).

It has been suggested that the invention of pottery in Southwest Asia (Near East) was related to pre-existing (pyro)technologies, such as lime plaster production, and the production of ceramic figurines and tokens. Kevin Gibbs (*2015.340*) and Peter Jordan (*Gibbs, Jordan 2016.31*) argued recently that it represented 'a stage of innovation in the development of container technologies 'that was embedded in the evolutionary Neolithic triad of 'sedentism, followed by agriculture and pottery'.

Pots in East and West Asia were 'open fired' or fired in domestic hearths at low maximum temperatures between 450–700°C, although the earliest pots may have been fired at temperatures below 250°C (*Zhu-*

1 All radiocarbon dates in this paper are calibrated with OxCal v 4.2.4 at 68.2% probability.

shchikhovskaya 2009.126; Lu 2011.18; Cohen 2013. 66, 77). Both types of firing produce irreversible changes in the clay body. The earliest invention of ceramic (pyro)technology in East Asia predates its appearance in the Near East by some ten millennia (*Cohen 2013; Kuzmin 2015; Gibbs, Jordan 2016*).

The diffusion of ceramic technologies in Eurasia

Fabio Silva *et alii* (*2014*) and Peter Jordan *et alii* (*2016.590*) recently hypothesised two independent centres of ceramic (pyro)technology innovation in hunter-gatherer societies, one in China and one in Africa, and that "*the earliest European pottery traditions may ultimately find their origins in one or both of these*". They suggested two diffusion zones of ceramic-making traditions out of the main centres. The northern tradition spread from East Asia across Siberia, the Russian plain, and much of the eastern Baltic, Eastern and Northern Europe. In the south, pottery spread with farming from the Near East to Europe, although in the Near East this may not have been the result of an independent local innovation, but may have been influenced by the early pottery traditions of North Africa.

Both corridors are related to modern biomes favouring the rapid diffusion of pottery making. While the northern corridor correlates with the distribution of "*temperate broadleaf/mixed forest' and 'temperate grassland/savannah/shrubland*", the southern corresponds to "*Mediterranean forest/woodland/scrub*". The front speeds of diffusion through these corridors was calculated with regression analysis and statistical modelling of radiocarbon dates from 396 sites, with Xianrendong Cave in China and Saggai in Sudan being taken as the starting points of each diffusion. The rate of spread in the "*Asian-origin diffusion zone is 1.2km/yr*", and 3.3km/yr in the African-origin diffusion zone (*Jordan* et al. *2016. 595–596, 598*) (Fig. 4).

However, as to where ceramic technology first appeared, the answer becomes rather different when we shift the focus from the origin of the earliest ceramic vessels to the origin of ceramic figurine production in hunter-gatherer societies in the Old World. This occurred neither in East Asia, nor North Africa, but in Central Europe.

The earliest invention of ceramic (pyro)technology in the Old World

We suggest that the earliest step in the development of pyrotechnology in Eurasia was not the invention of vessels made from fire-hardened clay, but of anthropomorphic and zoomorphic figurines, which were certainly not associated with (pre)existing container or any other food storage technology. The earliest evidence of burnt clay is available in an Upper Paleolithic Gravettian (Pavlovian) context at Dolní Věstonice, and relates to non-figurative pellets and cones, dated to 30 732–29 956 cal BC (68,2%). They predate ceramic figurines and similar pellets at other sites by two thousand years. They were deposited very close to a central hearth and supposedly unintentionally fired (*Svoboda* et al. *2014.3, 76; 2015.202, Tab. 1*). At later sites, hundreds of these were fired intentionally, with some bearing fingernail imprints (*Händel* et al. *2009*).

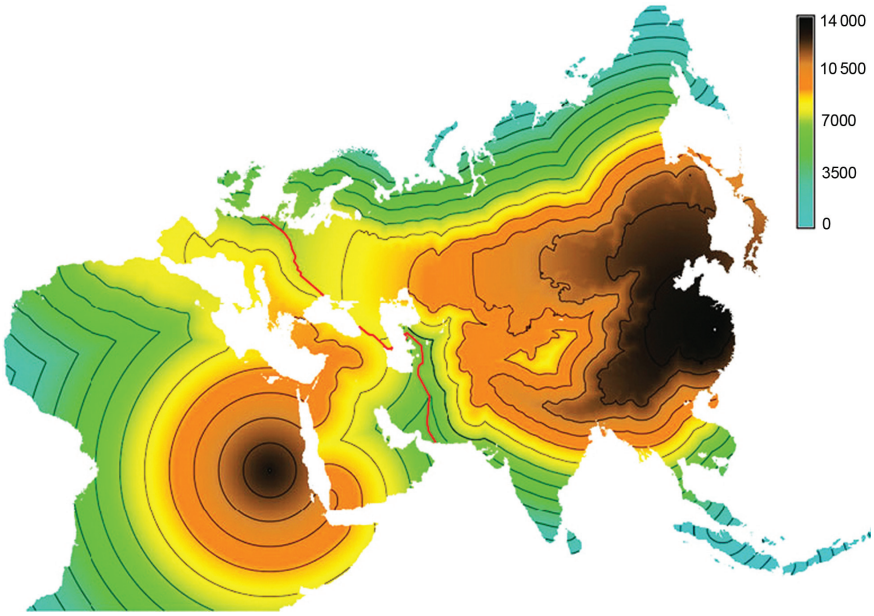


Fig. 4. The Jordan'* et alii *'modelled first arrival times' for the spread of ceramic technology and pottery from the two hypothesised centres of innovation, in Eastern Asia and North Africa. Authors:* Jordan P., Gibbs K., Hommel P., Piezonka H., Silva F. and Steele J. 2016. *Modelling the diffusion of pottery technologies across Afro-Eurasia: emerging insights and future research. Antiquity 90(351), p.599, Figure 4, reproduced with permission Cambridge University Press.

It is well known that some 10 000 ceramic artefacts, among which hundreds of fragments of anthropomorphic and zoomorphic figurines and thousands of pellets and cones, have been found at large Gravettian (Pavlovian) open-air sites in central Europe (*Verpoorte 2001; Králík, Einwögerer 2010; Králík 2011*). These sites show evidence of repeated/episodic occupation, complex hearths, dwelling structures, burials, and innovations in weaving, pyrotechnology and ceramic making embedded in the period *c.* 31 000–27 000 cal BC.

These figurative ceramics were made to be broken, according to Olga Soffer *et alii* (*1993; Soffer, Vandiver 2005.424*). Analyses indeed indicate that almost all the figurines and statuettes were deliberately fragmented, although most of the pellets and cones, which form a large part of the ceramic inventory, were found in an intact state. The analysis of ceramics suggests evidence of intentional thermal shock created by re-wetting air-dried figurines before they were thrown into a hearth. The figurines thus made a loud noise as they exploded, creating a sort of pyrotechnic 'performance', which was the primary social and symbolic significance of these ceramic assemblages (*Vandiver* et al. *1989*). It has also been noted that a relatively large proportion of the well-fired pieces were 'kneaded, compressed, deformed and punctured' already during modelling while the clay paste was still soft and easily reworked if a mistake is made. They were not – and perhaps it was not the intention to make – well-formed figurines (*Králík 2011.243*). In contrast, no fragmentation was found of ivory objects or stone figurines.

While ceramic pellets and cones were identified at almost all Pavlovian settlements, even at small camps, figurine distribution was limited to the sites at Dolní Věstonice I – Pavlov I, Petřkovice, Předmostí and Krems-Wachtberg (*Svoboda* et al. *2015*). The two largest assemblages are from the Dolní Věstonice I and Pavlov I settlement cluster (Figs. 5, 6).

Figurines were made from several small pieces of clay joined together, with heads, limbs, ears and tails shaped separately and then attached to the bodies (*Sofer, Vandiver 1997.383–401*). Rebecca Farbstein (*2013. 28–31*) recently identified different techniques at two neighbouring sites, which she terms 'techno-stylistic traits'. At Dolní Věstonice I, the limbs are 'repeatedly consolidated or compressed' on zoomorphic and anthropomorphic figurines to impart structural stability. The number of joints, which can be weak points vulnerable to breakage, is thus minimised. In contrast, the lack of compressed limbs at the Pavlov I site might support the notion of pyrotechnic 'performance', and the intentional fragmentation and destruction of figurines. These different techniques of making ceramic figurines at two neighbouring sites show not only 'distinct styles of finished figurines', but also mark 'differences in social and embodied practice and knowledge'.

Farbstein (*2011.133–134, 143*) also observed that a carving (distinct from engraving) technique of surface incision in ivory art was broadly adopted at Pavlov I site, but was almost absent from Dolní Věstonice I. Neither technique, on the other hand, was commonly applied to ceramic figurines. All these suggest that the Pavlovian hunter-gatherers did not follow the same *chaîne opératoire* in designing different materials (*i.e.* ivory, bone, and stone). We may assume that the introduction of a new 'soft' medium was not merely the result of 'cross-craft interactions' that became objectified in the production of clay figurine and invention of pyrotechnology.

The analytical focus has recently shifted from ceramic figurines to ceramic 'pellets'. They were considered hitherto as debitage or waste. Some were interpreted as animal legs or 'limb fragments' that broke off from a larger figurine during the intentional pyrotechnic performance of fragmentation. Indeed, some preserve breaks or joints (*Farbstein, Davies 2015.338*). Many others were made in the form of cones or cylinders; the cones have oval or flat bases, with imprints on some (*Králík 2011.217–218, 323, 243*).

Rebecca Farbstein and William Davies (*2015.338*) that the parallel production of pellets and cones

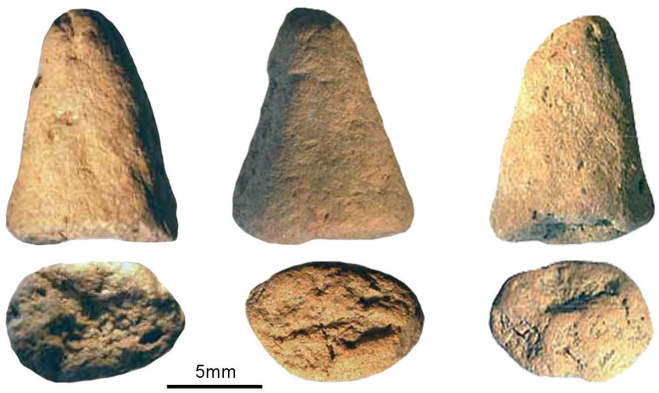


Fig. 5. Upper Paleolithic Gravettian (Pavlovian) ceramic cones from Pavlov VI (adopted from* Králík 2011.Figs. 6, 13, 36*).

reveals 'technical flexibility and experimentation in *chaîne opératoire*' that can be ascribed to 'other social meanings', while Miroslav Králík (*2011.244*) suggested that cones with imprints on their bases are not figurine fragments, but 'final objects' that bear 'meanings'.

What are the 'social meanings' of figurines and cones? In the much later Pre-Pottery Neolithic in the Near East, the 'meaning' of similar ceramic figurines and identical cones (known as geometric figurines) has been contextualised within social and economic frameworks, and the identity of the body. Ian Kuijt and Meredith Chesson (*2004; 2007*) identified a shift in figural representation from naturalistic anthropomorphic images to geometric shapes in the period 11 500–8500 cal BP. They suggested that the transition from naturalistic to geometric images correlates with pressures on community subsistence and social structures. Large and densely populated communities 'struggled with the stresses of overcrowding, sufficient food production and resource depletion around settlements' at the end of the Pre-Pottery period. A new system of ownership, and greater emphasis on the household as a social and economic unit appeared, and because of 'social, economic, and shifts in public and private ritual, people no longer created and employed 'anthropological imagery in significant quantities, and never again produced naturalistic images that were tightly focused on the face and the person' (*Kuijt, Chesson 2007. 226–227*). Perhaps during periods when social, economic, and ritual practices were in contention, and the development of storage technologies, the surplus economy and social differentiation began, 'geometric figurines' were involved in the process of storing, counting and reproduction of goods. Denise Schmandt-Besserat (*1992.168–170*) suggested that they probably served as counters to measure cereals and, as mnemonic devices to store information. They have been found at Mureybet III and Cheikh Hassan, embedded in rectangular granary silos, where they have been identified as tokens.

However, by the end of the Pavlovian, *c.* 27 000 cal BC, ceramic technology disappeared, with no iterations of this technology during the later Gravettian in Central Europe.

Pyrotechnology and ceramic figurines appeared again in North Africa, where at the cave of Tamar Hat (Algeria) a figurine of a wild 'Barbary Sheep' was found. It was dated with a single date in the period 22 486–21 250 cal BC (68.2%) (*Saxon 1976; Bougard 2003*).

A millennia later, they appeared in the central Mediterranean. Ceramic technology was independently invented at 15 338–15 047 cal BC (68.2%) at Vela Spila (on Korčula island) in the Adriatic, and subsequently lost from the socio-technical tradition at this site about two thousand years later at 13 329–12 985 cal BC (*Farbstein* et al. *2012*). The thirty-six ceramic figurines and fragments from Vela Spila are the first evidence of an artistic and ceramic technology tradition in Europe after the Last Glacial Maximum.



Fig. 6. Anthropomorphic and zoomorphic ceramic figurines from the Upper Palaeolithic Gravettian (Pavlovian) sites Dolní Věstonice, Pavlov and Předmosti (from* Verpoorte 2001.Figs. 3. 6, 7, 8, 9, 46, 3.73, 8.1, 54*).

Pyrotechnology was again used to make art rather than functional ceramic containers. Interestingly, neither ceramic nor figurative art is known from contemporaneous sites (Kopačina, Badanj, Crvena Stijena) in the Balkans, suggesting this combined technological innovation and symbolic expression was not shared across the region. Klisoura cave in the Peloponnese is the only site at which evidence of pyrotechnology has been found. Rebecca Farbstein (*2013.33–34*) hypothesised that ceramic innovation did not spread across the social landscape "*because the artefacts did not move throughout the landscape with these people during seasonal migrations*", or perhaps "*groups may not have appropriated this technology, even if they were exposed to it, because it held no social value or significance in their culturally distinct society*".

An almost parallel appearance of ceramic technology was documented more than 7000 km to the East at the Maïninskaya site, on the Yenisei River in Western Siberia at 18 213–17 769 cal BC (68.2%) (*Hommel 2014.666*) (Fig. 7).

Ceramic figurines and vessels first met in the Pre-Pottery Neolithic in the Near East

Ceramic figurine making and vessel production first appeared together in the Pre-Pottery Neolithic in Near East. They were both hypothesised as marking the beginning of the 'Age of Clay' and the advent of 'house societies', because of clay and soil, a 'material and substance that humans became thoroughly dependent on' from the Pre-Pottery Neolithic onwards (*Stevanović 1997; Hodder 2011.165*). Clay and soil are both building materials and substances which enable house construction, hearth and oven structures, plastered skull modelling, figurines and vessel making on the one hand, and agriculture on the other (*Boivin 2008*).

Only a few ceramic anthropomorphic figurines are known from the Pre-Pottery Neolithic, found at Netiv Hagdud, Dhra' and el-Khiam. They are all stylised representations of portions the human body, or of an entire body, and each involves a unique combination of marked features or omissions. Ian Kuijt and Meredith Chesson (*2004; 2007*) suggested that the focus at first was on the stylised human body, mainly the lower. Later, in the PPNB, the focus shifted to 'personhood', which they believe was characterised by realistic representations of human faces. In this period, along with small figurines, many new forms of anthropomorphic ceramic representation appeared, such as full-body anthropomorphic statues, large busts with painted faces, face masks and plastered skulls. The shift in focus correlates with the appearance of large agricultural villages and rectangular residential buildings, and domesticated plants and animals on the one hand, and on the other, it relates to the recognition of the individuality of the deceased, to the idealisation of a collective ancestry, and to the creation of social memories in mortuary practices. The homogeneity of practices, they suggested, "*emphasizes the deconstruction or masking of individual differences and focus on collective identities*" (*Kuijt, Chesson 2007.224*). In the late Pre-Pottery Neolithic B and C, ceramic zoomorphic figurines almost replaced anthropomorphic ones. We mentioned above that replacement corresponds to stresses on community subsistence and social structures, and the erosion of individuality and social differentiation that entered into the negotiation of everyday life.

Pottery has been recovered in very small amounts from Pre-Pottery Neolithic contexts in the Southern Levant and Upper Mesopotamia. At Kfar HaHoresh in the Southern Levant, 23 pottery sherds have been recovered ranging in date from the Early to Late Pre-Pottery Neolithic B, *c*. 8750–7500 cal BC. The appearance of pottery was not an isolated event, but a repeated or intermittent practice, since the pottery fragments were embedded within a time span of more than a millennium. Pottery making was probably very limited, for short-term personal use or for use by distinctive individuals or in certain contexts for very limited purposes (*Biton* et al. *2014*).

The earliest pots at Tell Sabi Abyad in Upper Mesopotamia 'were shaped and finished carefully'. They have regular wall profiles and rims, and an even wall thickness. The vessels were intensively smoothed and burnished, occasionally resulting in somewhat glossy surfaces. Some were decorated with red slip and painting. They may suggest 'prestige' pottery production. Undecorated containers with a more utilitarian function, such as storage or cooking, rapidly replaced them (*Nieuwenhuyse* et al. *2010*).

The use of pottery in Southwest Asia became widespread at the start of the Late (or Pottery) Neolithic, around or shortly before 7000 cal BC. Lipid residue analyses show that vessels became associated with extensive meat (ovicaprids) exploitation during the Early Pottery period, but that this shifted towards the mixed exploitation of meat and milk (*Nieuwenhuyse* et al. *2015*).

Epiloque

We have emphasised that current evidence clearly shows different, but parallel, trajectories of ceramic (pyro)technology adoption and the production of fired clay items, both of which began in the Upper Palaeolithic. In the west, the focus was on figurines and cones in the Palaeolithic, followed by vessels production in the Neolithic. In the east, the focus was on vessel making from the outset. The western tradition predates the eastern by about eleven millennia. While pellets, cones and figurines first appeared in Central Europe at *c*. 31 000 cal BC, the earliest vessels in Xianrendong Cave are dated to *c*. 20 000 cal BC (Fig. 7).

It is unlikely that any single model will ever reveal where ceramic (pyro)technology first appeared or how fast it spread or diffused from hypothesised 'centres of innovation'. The first pottery making in East Asia was confined to a small number of sites, and persisted in episodic, low-scale usage until the Early Holocene.

Residual analyses show that early pottery in East Asia was used for food preparation and perhaps for storage tasks, but small amounts of pottery found at the earliest sites suggest that it may not have been used extensively for everyday activities. It is unlikely it was used to intensify wild seed exploitation, and/or left as 'caching pots' out in the fields. We may hypothesise that it might have marked incipient forms of privatisation, and may have been used as prestigious containers of luxury foods (*e.g.*, fish oils).

We may also hypothesise that the appearance of ceramics probably related to 'cross-craft interactions', such as the lining of organic baskets, but this does not explain why some of the earlier uses of ceramic (pyro)technology in the European Palaeolithic did not lead to the same innovation. However, the widespread and twenty-millennia-long episodic trajectory of the fired clay figurine tradition in western Eurasia did not lead to the invention of ceramic container technologies. Recalling arguments about *chaîne opératoire* techniques, these data may suggest the 'embedded nature' of technological choices and social and ideological practices to which ceramic inventions and innovations were related (see the concept of 'embedded technologies' in *Sillar, Tite 2000*). The makers of Gravettian figurines may have created 'social boundaries' by not sharing all of the same series of technical gestures or related social behaviours, and the intentional fragmentation and destruction of figurines may suggest that the female body did not provide metaphors of 'containing' before the Neolithic.

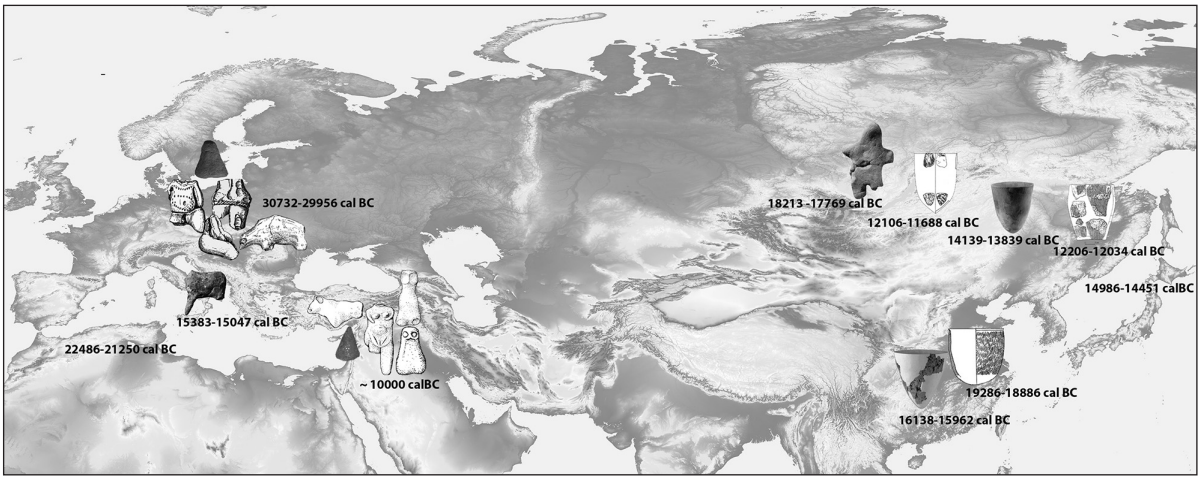


Fig. 7. Parallel trajectories of ceramic technology adoption and burnt clay items making that both started in Upper Palaeolithic. The western focused on figurines and cones making in Palaeolithic, followed by vessels producing in Neolithic. The eastern focused on vessels making from the very beginning. Radiocarbon dates relate to the earliest appearance of ceramic (pyro)technology at Dolní Věstonice, Pavlov, Petřkovice, Předmostí in Moravia, and Krems-Wachtberg sites in Austria (*Svoboda *et al.* 2015.202,Tab. 1; 2014.76*; see also* Verpoorte 2001.86; Einwögerer, Simon 2008.42*); Tamar Hat in Algeria (*Bougard 2003. 32*); Maininskaya site, on the Yenisei River bank in Siberia in Russia (*Hommel 2014.666*); Vela Spila in Croatia (*Farbstein *et al.* 2012.3–5*); Xianrendong Cave and Yunchayan cave in China (*Wu *et al.* 2012. 1699, Tab. 2; Boaretto *et al.* 2009.9596, Tab. 3*); Odai Yamamoto in Japan (*Kuzmin 2015.Tab. 1*); Khummi, Ust Karenga and Studenoe in Eastern Siberia and Rusussian Far East (*Kuzmin 2015.Tab. 1*). The radiocarbon dates are calibrated with OxCal v 4.2.4 at 68.2% probability.

The 'body language' of technical gestures and skills employed to make ceramic figurines may have also been a 'form of silent discourse' with which gendered identity and status were negotiated (*Dobres, Hoffman 1994; Dobres 2010*). However, the intentional breaking of ceramic figurines may have mediated relationships between the members of society (see above, *Chapman 2000a*), but also acted as a symbolic break in social alliances (*Dobres 2010.109*).

In the western ceramic (pyro)technology trajectory, the earliest, 'prestige', pottery making appeared at 8750–7500 cal BC. This was quickly replaced by thick, undecorated, organic tempered vessels that were rather 'entangled' in contexts of domestic food production, processing and storage, separated from the entanglement surroundings of 'wild animals, death and burial' (see the concept of 'entanglement' in *Hodder 2012*).

We may hypothesise in conclusion that the (pre)history of ceramic use in Eurasia relates to neither the Neolithic revolution nor diffusion from a Palaeolithic pottery centre in East Asia, but to two parallel and very long trajectories of episodic ceramic technology use in pre-Neolithic hunter-gatherer societies. In the eastern, Asian ceramic trajectory, pottery was produced from the beginning. The human body was probably not the 'schemata' that marked both containment and the perception of pots as 'bounded objects' (*i.e.* containers) in Asian hunter-gatherer societies. Ceramic figurines, cones and pellets mark the western, European trajectory for the first twenty-two thousand years. Pottery appeared together with domestic food production. However, in East European hunter-gatherer societies, the domestic mode of food production was not the cultural choice.

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The Cretan Mesolithic in context: new data from Livari Skiadi (SE Crete)

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ABSTRACT – *Investigations at Livari (south-eastern Crete) produced a small Mesolithic chipped stone assemblage, whose techno-typological characteristics situate it within an 'early Holocene Aegean island lithic tradition' (9000–7000 cal BC). The material provides antecedent characteristics for the lithics of Crete's founder Neolithic population at Knossos (*c. *7000–6500/6400 cal BC). The idiosyncrasies of the Knossian material can be viewed as a hybrid lithic tradition that emerged from interaction between migrant Anatolian farmers and indigenous hunter-gatherers. Small quantities of Melian obsidian at Livari attest to early Holocene maritime insular networks, knowledge of which likely enabled the first farmers' successful voyage to Crete.*

IZVLEČEK – *Raziskave na najdišču Livari (na jugovzhodnu Krete) so pokazale navzočnost drobnega mezolitskega kamnitega inventarja, katerega tehnološke in tipološke značilnosti ga postavljajo v okvir 'zgodnje holocenske egejske tradicije kamnitih artefaktov' (9000–7000 cal BC). Ta material predstavlja predhodnike tipov kamnitih orodij, ki so značilna za kretsko ustanoviteljsko neolitsko populacijo v Knososu (ok. 7000–6500/6400 cal BC). Značilnosti materiala iz Knososa kažejo na hibridne tradicije v tipologiji kamnitih artefaktov, ki so se pojavile kot posledica interakcije med migranti – poljedelci iz Anatolije in domorodnimi lovci in nabiralci. Manjša količina obsidiana iz Melosa na najdišču Livari pa kaže na zgodnje holocensko morsko omrežje, ki je potekalo med otoki, kar je omogočalo prvim poljedelcem, da so pridobili znanje za uspešno plovbo do Krete.*

KEY WORDS – *Greece; Aegean Islands; Mesolithic; Neolithisation; lithics; Knossos*

Introduction

Until recently, the received wisdom was that Crete (Fig. 1), the fifth largest island in the Mediterranean, had remained unoccupied until the founding of the Initial Neolithic (hereafter 'IN') village at Knossos by migrant Anatolian farmers around 7000 BC (*Broodbank, Strasser 1991; Evans 1994; King* et al. *2008*). Crete was thus something of an anomaly, given that later Palaeolithic populations were known on the islands of Corsardinia (22 000–18 500 BC), Cyprus (11th millennium BC), and Sicily some 30 000 years ago (*Broodbank 2006.205–209*; dates hereafter given as cal BC). Even in the Aegean, pre-Neolithic sites had begun to be reported by this time on a number of significantly smaller islands, including Ikaria, Kythnos, Melos, and Youra (*Broodbank 2006.204–205, 211; Sampson* et al. *2010; 2012*), while a DNA study argued that some modern Cretans embodied traces of a local Middle Pleistocene population (*Martinez* et al. *2007*). In 2008, evidence for Palaeolithic and Mesolithic activity was finally discovered on Crete's

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south-west coast, the former dated to at least 110 000–130 000 BP (*Strasser* et al. *2010; 2011*).

These new data force us to confront a number of questions. Firstly, do they imply Crete's continual occupation from the Middle Pleistocene, or are these traces of intermittent visitations and/or failed colonisations? Secondly, when the migrant farmers arrived at Knossos, did they land on unoccupied territory, or were they confronted by an indigenous hunter-gatherer population? If the latter, what implications does this have for our understanding of early Knossos and the origins and nature of Neolithic society on Crete? Does the material culture of IN Knossos attest to interactions between the two groups? Thirdly, in coming to Crete, did these Anatolian seafaring farmer-herders paddle into unknown waters, or were they drawing on ancient maritime knowledge, taking advantage of pre-existing routes and interaction networks, with the settlement at Knossos being the result of prior reconnaissance trips (*cf. Strasser 1996.327–328*)?



Fig. 1. Location of main sites and regions mentioned in the text.

This paper attempts to answer these questions through detailing a new Mesolithic chipped stone assemblage from Livari Skiadi in south-eastern Crete. The assemblage is contrasted with broadly contemporary data sets from the Eastern Mediterranean to see if Cretan practices can be located within larger regional traditions. We then reflect on the material's relationship to that from IN Knossos. Our work thus employs lithic technology as a means of contributing to debates on the nature and dynamics involved in the Neolithisation of the larger region (*cf. Cauvin 2000; Kotsakis 2003; Perlès 2001; Pinhasi* et al. *2005*).

Livari Skiadi

The existence of a Cretan Mesolithic was first claimed via the publication of stone tools from surveys at Moni Kapsa and Plakias on the southern coast (*Galanidou 2011.224; Strasser* et al. *2010*); one of the latter sites, Damnoni, having since been excavated (*Strasser* et al. *2015*). Here we report on Livari Skiadi (hereafter Livari), the second Mesolithic site to have been dug on Crete (Fig. 1).

Situated on Crete's south-eastern littoral, Livari today comprises a small and relatively flat coastal plain enclosed by low steep hills to the north. It is cut by several streams, two in quite deep gorges, while a spring provides a year-round water supply (Fig. 2). Aeolian and sea erosion has largely removed the Holocene soil deposits, exposing large areas of the natural bedrock, a Miocene conglomerate consisting of limestone, dolomite and chert (*Brandl 2010*). In 2008–2010 the Greek Archaeological Service excavated a small Early-Late Bronze Age cemetery at Skiadi, 50m from the modern seashore (*Papadatos, Sofianou 2015*). While the work's focus was the 3rd–2nd millennia BC burials in a tholos, rock shelter and 'house tomb' (Fig. 3), it subsequently became apparent that there were also traces of Mesolithic occupation. This is not an insignificant claim, and as such requires substantiating.

The evidence for Mesolithic Livari

The evidential basis of Livari's Mesolithic occupation is comprised primarily of chipped stone artefacts (Figs. 4–6). The material derives from thin remnant Holocene soil deposits that were protected from erosion by the rock shelter and Bronze Age tombs (suggesting that most soil was lost after the 2nd millennium BC). It is important to state that the excavators found no stratigraphic distinctions between the material we claim to be Mesolithic and Bronze Age, *i.e.* these were mixed deposits due to the later activities associated with the 3rd– 2nd millennium cemetery. The total lithic assemblage from the excava-

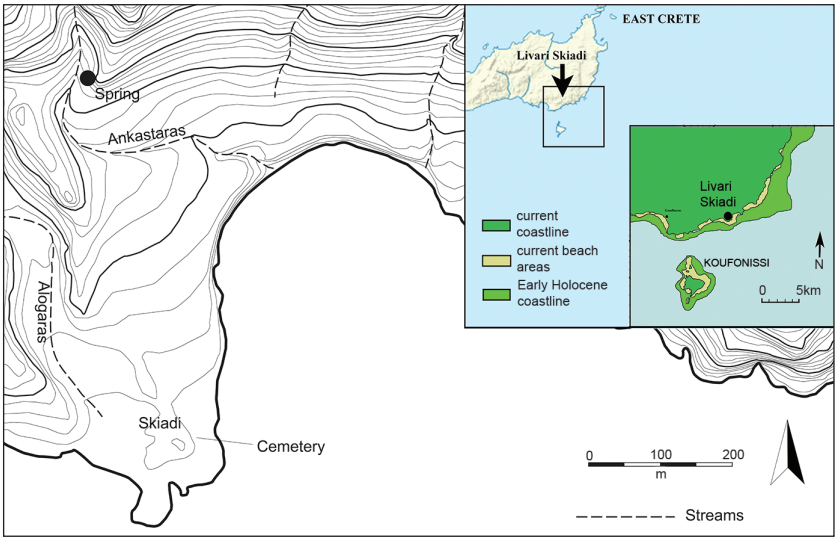


Fig. 2. Map of the Livari plain and early Holocene coastline reconstruction.

tion comprised 469 pieces, of which 251 are identified as Mesolithic. This claim is based on an integrated four-fold approach that considers the role and nature of chipped stone tools in Cretan Bronze Age burial practices/contexts, the techno-typological characteristics of the assemblage, raw material selection, and intra-site artefact distribution. A further posited 20 Mesolithic artefacts were subsequently collected from the site's surface within a 20m radius of the excavation area in 2014.

The Livari chipped stone assemblage is made up of two techno-typologically distinct components. The first comprises obsidian pressure-flaked blades of Bronze Age date (Fig. 4). The second component of the Livari material consists of a microlithic flake-based tradition, most of which were produced using local raw materials (Figs. 5–6); this material, we argue, is Mesolithic.

The Bronze Age assemblage

Just under half of the Livari chipped stone (n = 218/469) comprises fragmentary prismatic blades (Fig. 4). Most of these implements are made of obsidian (n = 215/218, 99%), a raw material that is exotic to Crete, the closest sources being located in the Aegean islands (*Carter 2009*). These fine, razor-sharp blades were pressure flaked, as evidenced by their parallel margins and dorsal ridges, even longitudinal thickness, diffuse bulbs of 'percussion', and small or absent bulbar scars (*Carter 2015.114–115*; see also *Tixier 1984*). Their dihedral platforms, lack of lip and overhang attests to the use of a copper-tipped flaking tool (*Pelegrin 2012.485–490*). The other three pressure blades were made of chert, one greyish- blue, the other two tan in colour (Fig. 4.CS10–C11).

The recovery of obsidian pressure blades from a Cretan Bronze Age cemetery is entirely in keeping with the islanders' funerary traditions of the 3rd–2nd millennia cal BC. This Livari material has numerous parallels. Indeed, Carter (*1998;1999; 2010*) has studied/published over 20 of these data sets from eastern and central Crete. These obsidian-dominated assemblages are highly structured, lacking cores or production debris. The fragmentary state of these implements is likely due to their post-depositional breakage, rather than deliberate fragmentation. The blades' freshness and almost complete lack of use-wear further suggest that they were produced specifically for funerary consumption.

While Crete is known to have small deposits of knappable cherts and other siliceous materials throughout the island (*cf. Blitzer 2004.511; Brandl 2010; Carter 2007.685–688; inter alia*), tools of these raw materials are rarely documented in these burial assemblages. Moreover, such local resources tended to have been ignored by Cretan/southern Aegean Bronze Age populations, with obsidian being the



Fig. 3. View of Livari rock shelter from the south-west. Tholos tomb to the right, 'house tomb' to the left.

raw material of choice for both domestic and funerary products (*Carter 2009.202– 204*).

The Mesolithic assemblage

The remainder of the Livari assemblage is microlithic in character (few pieces >2.5cm), dominated by local chert and radiolarite (*Brandl 2010*), and derived from flake (dominant, n = 220, 88%) and bladelet traditions (n = 31, 12%), with the blanks percussion-knapped from pebble cores (Figs. 5–6). Such material is completely unknown from the numerous Cretan Bronze Age assemblages we have studied (*Carter 2015,* for references). Nor are the artefacts believed to be Neolithic, as Cretan assemblages of this date are almost exclusively obsidian-and blade-based (*e.g., Christopoulou 1989*); only at IN Knossos is there a significant component of flake-tools and bladelets, although here, too, obsidian prevails (70%; *Conolly 2008*). The relationship between the Livari and IN Knossos assemblages is discussed below.

The lithics were recovered carefully, with all soil sieved through a 300 micron-mesh. While the chipped stone all seems to derive from secondary contexts intermixed with Bronze Age burial material (no stratigraphic distinction was noted), we highlight the fact that the distribution of the chert percussion flake/bladelet material does not mirror that of the obsidian pressure-blades (Tab. 1). We believe strongly that this contextual distinction is due to their chronological differences. For instance, the deposition of burials and grave goods (28% of the obsidian blades) deep in the rock shelter is a well-attested practice in Bronze Age Crete (*Branigan 1988.153–154*), yet such a dark, cramped space makes little sense for Mesolithic activity, thus explaining why only 3% of the chert artefacts came from here.

For the flake tradition using local raw materials, we have the entire reduction sequence, with nuclei, cortical debris, and tools. The cores were reduced multi-directionally (Fig. 6.1), although there are a few unipolar cores and three (opposed platform) *pieces esquillèes*, a few being related to on-site percussion bladelet production (12%, n = 31), with cores, platform rejuvenation tablets, and end-products (Fig. 6.2–3).

A high proportion of the percussion flake and bladelet tradition material is modified (n = 110, 44%; Fig. 6.4–16, 18–22; Tab. 2); this is again quite different to Cretan Bronze Age assemblages, which typically have <10% retouched pieces (*Carter 2015. 116*). Most have simple linear modification (Tab. 2), followed by 'spines', *i.e.* pointed tools used as borer/perforators or drills (Fig. 6.8–11), notches, denticulates, composite tools, scrapers (Fig. 6.21–22), blanks with convergent retouch (broader tips than 'spines' (Fig. 6.6–7)), geometrics (Fig. 6.18–20), and backed pieces. There were two burin spalls, but no burins per se. Inverse retouch is common, noted on a third of the modified pieces (n = 34, 33%); this is a characteristically Mesolithic mode of modification (*cf. Perlès 1990.Doc. II.11*), quite distinct from Neolithic or Bronze Age tool-making traditions. Many of the artefacts also display macroscopic use-wear, whether retouched or otherwise.

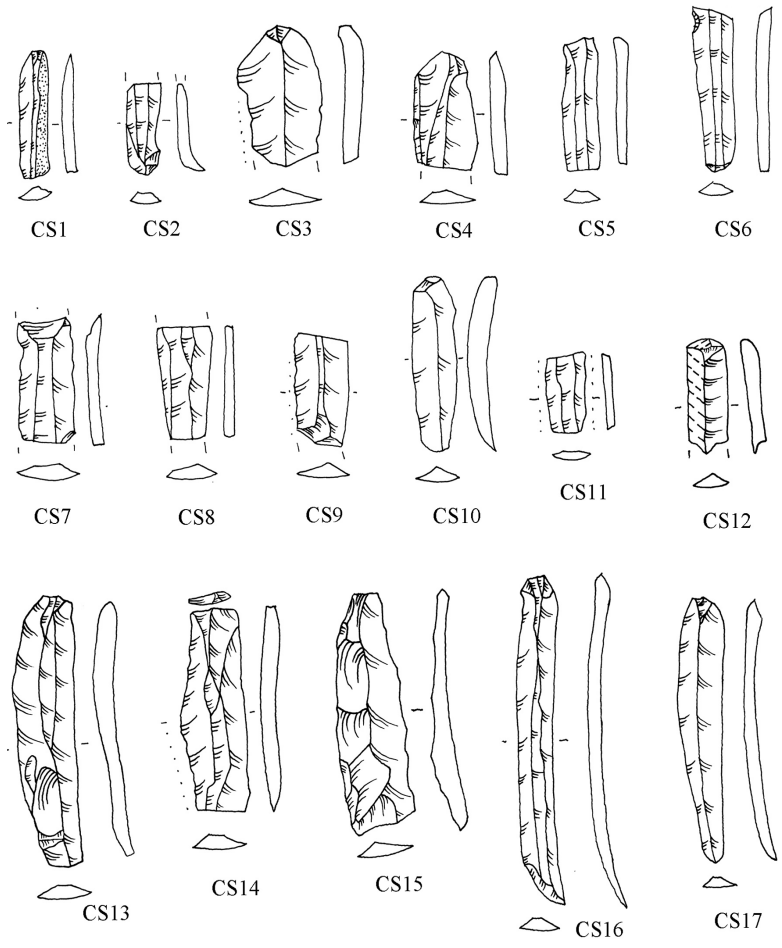


Fig. 4. Bronze Age pressure blades from Livari made of obsidian and chert (CS 10–11).



Fig. 5. Mesolithic artefacts from Livari made of local cherts.

While our claim for early Holocene activity is constituted primarily on the quintessentially Mesolithic character of its chipped stone, Livari also fits the Aegean Mesolithic site-location model forwarded by Runnels (*2009.60–62*) at the "*intersection of woodland and aquatic habitats*". The site is located in front of a rock shelter, offering protection from the strong north winds, with a nearby spring and small caves in the gorge, with the early Holocene coastline approx. 1.5km to the south (Fig. 2). This coastal wetland plain would have provided a perennial water supply, and a rich array of animals, plants, and marine resources for hunter-fisher-gatherer subsistence, a setting directly comparable to the "*foraging coastscapes*" (*Broodbank 2006.211*) enjoyed by the well-documented Mesolithic populations of the southern Argolid (*Runnels 2009*).

Dating the Livari material and its relationship to early Holocene traditions of the Eastern Mediterranean

Given the mixed nature of the Livari deposits, the chert/flake-dominated assemblage can be dated only through reference to comparanda from elsewhere. Perhaps unsurprisingly, the closest parallels come from the Plakias sites 180km to the west (Fig. 1), which are similarly flake-based and microlithic, with 'spines', denticulates, geometrics, notched, and backed pieces (*Strasser* et al. *2010.163–171, Tab. 2*). Preliminary reports of the material from stratified Mesolithic deposits at Damnoni details a directly comparable assemblage to the Livari chert (*Strasser* et al. *2015.278, Figs. 7–9*), an impression that is further strengthened through Danica Mihailović's first-hand study of both data sets (Fig. 7). With absolute dates yet to be published from Damnoni, we need to consider parallels from overseas excavated assemblages in order to offer some thoughts on Livari's chronology, with that from the mainland Franchthi Cave being particularly informative (Fig. 1).

The Livari material has much to compare with the Lower-Final Mesolithic assemblages from Franchthi's lithic Phases VII–IX (Fig. 6; Tab. 3) that span 8500–7000 BC (*Perlès 2001.Tab. 2.1*). These assemblages are similarly microlithic and dominated by flakes (95%) struck from small pebble cores, with notches/denticulates being the most common tools, followed by flakes with simple linear retouch, scrapers, backed pieces, and geometrics inter alia (*Perlès 1990.23–93, Figs. 5–8, 13–19, 21–22*), although Livari has a significantly higher proportion of 'spines' (Fig. 6). The Livari material also includes proportionally more bladelets than at Franchthi VII–IX (12%; v. 4–5%), and instances of inverse retouch (33%; v. 17%); these are both features more characteristic of Final Palaeolithic assemblages (*Perlès 1987*), *i.e.* the Livari material is potentially of earlier Mesolithic date (Phase VII in Franchthi terms, second half of the 9th millennium BC).

While strong links can be established with the Franchthi lithics, Livari is ultimately better viewed as part of the 'early Holocene Aegean Island lithic tradition' (Figs. 1 and 8; Tab. 3). This tradition was first defined by Adamantios Sampson *et alii* (*2010.68–69*) through reference to material from Maroulas on Kythnos in the Cyclades (early-mid 9th millennium BC), the Cave of the Cyclops on Youra in the Spora-

Context	Pressure Blade #	Pressure Blade %	Flake/ Bladelet #	Flake/ Bladet %
Rockshelter	60	28	8	3
House Tomb	51	23	40	15
Tholos Tomb	29	13	143	55
Around the Tholos	78	36	68	24

Tab. 1. Distribution of chipped stone at Livari by context, raw material and technology.

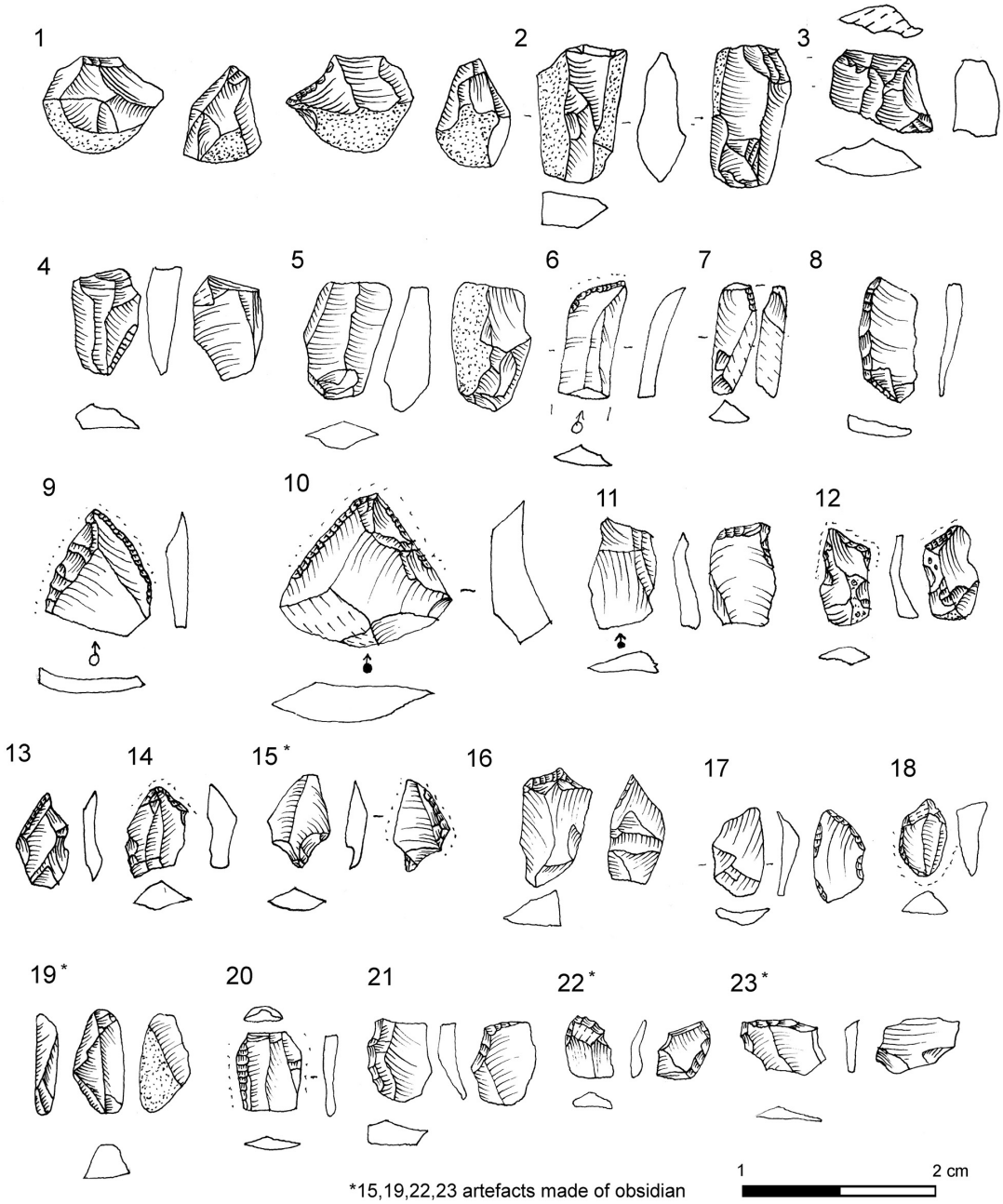


Fig. 6. Mesolithic artefacts from Livari.* 1 *multidirectional flake core/micro chopper with spine,* 2 *bladelet core/*pièce esquillèe*,* 3 *core rejuvenation flake,* 4–5 *unidirectional retouched bladelets,* 6–7 *flakes with convergent retouch,* 8–11 *'spines',* 12–16 *retouched flakes,* 17 *flake,* 18–20 *geometrics with backed elements,* 21–23 *short scrapers on flakes (*14–17 *obsidian,* 18–23 *survey material).

des (*c.* 8600–7800 BC), Kerame 1 on Ikaria in the Dodecanese (*Sampson 2008; Sampson* et al. *2010; 2012*), plus Stélida and Roos on Naxos (*Carter* et al. *2013; 2016; Sampson 2015*). These assemblages are also flake-dominated, with denticulates, notches, perforators, scrapers, and backed pieces, but have few opposed platform cores compared to mainland sites (n = 3/11 at Livari). The Cyclops Cave aside, these assemblages, Livari included, also have notable quantities of 'spines', a further distinction from the Franchthi material (Fig. 8).

The Livari Mesolithic lithics provide further proof of overseas connections through the presence of four pieces of obsidian (n = 4/251, 1.6%) which were characterised by energy- dispersive x-ray fluorescence spectroscopy as being products of the Sta Nychia source on Melos (Fig. 1), 235km away in the Cyclades (*Carter 2016*). These obsidian artefacts can be distinguished easily from the Bronze Age pressure blades on the basis of their technology, form, and size, comprising a retouched bladelet, a 'spine' on a blade-like flake, a retouched part-cortical flake, and

CHERT	Linear	'Spine'	Notch	Scraper	Denticulate	Composite	Convergent	Backed	Geometric
Flake	18	12	12	8	8	10	6		3
Blade-like flake	4	8	1	1	2			2	
Bladelet	1	1	1		1	1		2	
Core				3	1				
Core-tablet				1					
OBSIDIAN									
Flake	2								
Bladelet		1							
TOTAL (n=110)	**25 (23%)**	**22 (20%)**	**14 (13%)**	**13 (12%)**	**12 (11%)**	**11 (10%)**	**6 (5%)**	**4 (4%)**	**3 (3%)**

Tab. 2. Modified tools from the Livari excavation by raw material and blank type.

a denticulated flake (Fig. 6.14– 17). While we believe this to be the earliest Melian obsidian on Crete, the exploitation of these raw materials at distance has an earlier heritage, having been procured by populations from continental Greece during the 11th millennium BC Upper Palaeolithic (*Renfrew, Aspinall 1990*). While mainland hunter-gatherers continued to exploit this material during the early Holocene (9th–8th millennia BC), the primary Mesolithic consumers of Melian obsidian were insular hunter-gatherers with ready waterway access to the Cyclades (Fig. 1); linear distance from source cannot alone explain the distribution patterns (Tab. 4). The tiny quantities of obsidian attested at the Franchthi Cave and Livari suggests that the inhabitants of the mainland and southern Crete likely relied on intermediary exchange to access these Melian resources (*Carter 2016.18*). The obsidian artefacts at all of these Mesolithic sites were made in the same way as tools flaked from local materials, although at Livari there is no evidence for obsidian being worked on-site.

Turning our attention eastwards and southwards, how do the Mesolithic assemblages of the Aegean islands relate to contemporary material from Anatolia, Cyprus, the Levant, or North Africa? Can one document early Holocene supra-regional lithic traditions, *i.e.* common technical practices that developed through close social interaction, such as the establishment of exchange and kin partnerships (*cf. Carter* et al. *2013*)? More specifically, if we can define hunter-gatherer networks linking Cretan populations with their eastern contemporaries, then we conceivably have evidence for the bodies of knowledge through which outsider migrant farmers came to know of particular Aegean destinations and the routes with which to reach them.

If we focus on well-dated excavated assemblages, then the Aegean material bears little resemblance to most Anatolian, Levantine and North African traditions of the 9th–8th millennia BC (Fig. 9). Hunter-gatherer (Epi-Palaeolithic) assemblages of Mediterranean and central Anatolia are bladelet based with geometrics (*Kartal 2009; Baird* et al. *2012.194–195*), while the early farmers of Pre-Pottery Neolithic (PPN) south-eastern Turkey and the Levant had skilled blade industries (*Shea 2013.213–260*). In turn, the lithic traditions of the Western desert and Nile Valley (Quarunian) are bladelet/ geometric in character (*Midant-Reynes 2000.72–74, 77–82*), while those of the Typical Capsian assemblages of North

Site	Date	Flake	Blade(let)	Retouch	Linear	'Spine'	Notch/ Dent.	Compo-site	Scraper	Backed	Geom.	Other
Livari	?M	88%	12%	44%	23%	20%	24%	10%	12%	4%	3%	6%
Franchthi VI	UP	91%	9%	n.d.	9%	–	8%	–	7%	40%	28%	7%
Franchthi VII	LM	97%	3%	n.d.	34%	3%	33%	4%	11%	8%	2%	6%
Franchthi VIII	UM	95%	5%	7%	34%	4%	41%	5%	10%	–	–	6%
Franchthi IX	FM	n.d.	n.d.	n.d.	28%	3%	46%	12%	3%	1%	3%	2%
Kerame 1	LM	97%	3%	n.d.	22%	19%	20%	–	22%	11%	1%	7%
Maroulas	LM	97%	3%	11%	19%	16%	26%	–	24%	3%	4%	8%
Cyclops Cave	L/UM	93%	7%	25%	20%	2%	11%	9%	11%	2%	7%	33%

Tab. 3. Comparing basic blank types (relative proportion) and the retouched component of the Livari percussion flake and bladelet assemblage with late Pleistocene-early Holocene material from the mainland and Aegean Islands (UP = Upper Palaeolithic; L/U/FM = Lower/Upper/Final Mesolithic; Dent. = denticulate; Geom. = geometric; data from* Perles 1990; Sampson 2008; Sampson *et al.* 2010; 2012*).

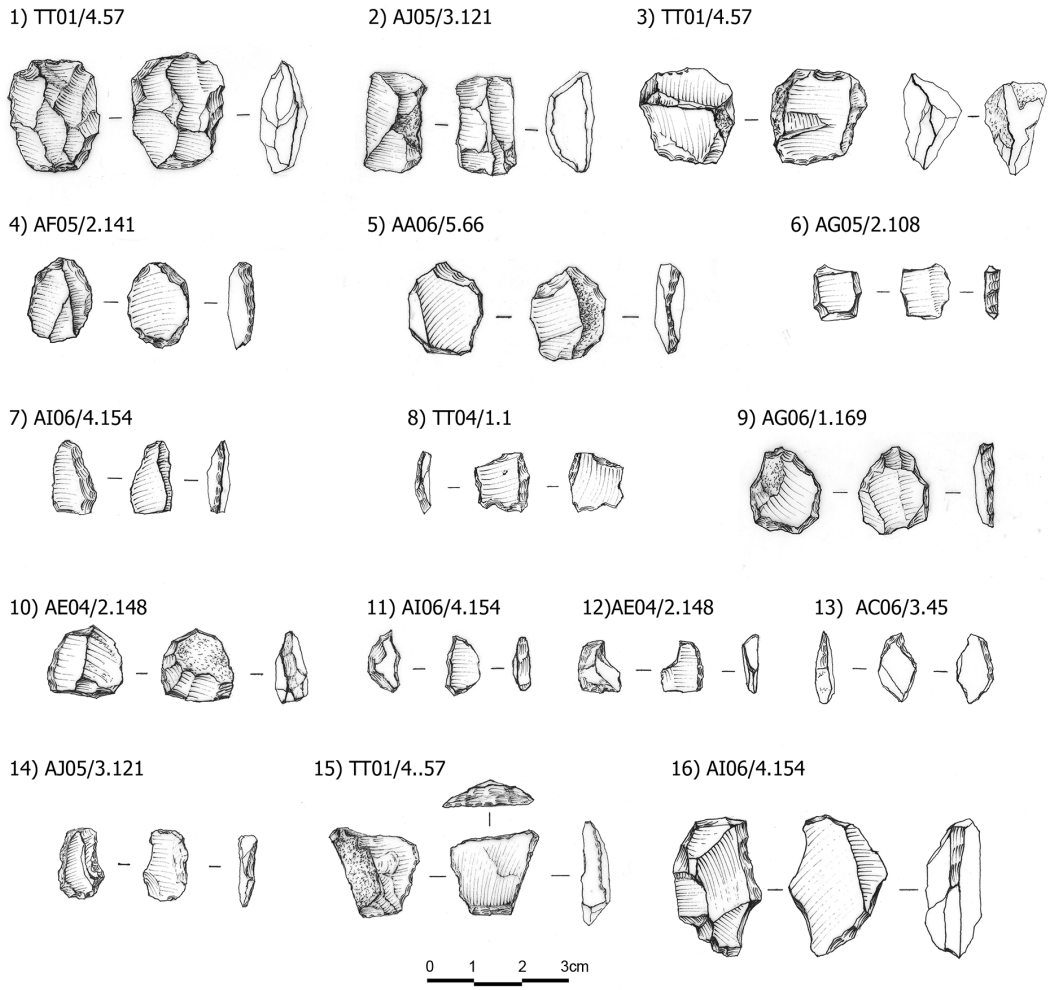


Fig. 7. Mesolithic quartz artefacts from Damnoni.* 1 *multidirectional flake core,* 2 pièce esquillée, 3–5 *flakes with linear retouch,* 9–10 *endscrapers,* 11–13 *'spines',* 14 *notch,* 15 *pseudo-trapeze,* 16 *denticulate.

Africa are blade/bladelet-based with geometrics (*Rahmani 2004.70–75*).

One *possible* connection to the Cretan/Aegean Mesolithic material is Cypriot. While Cyprus of 9000–7000 BC formed part of the PPN world with its fine blade traditions (*Knapp 2013.74–119*), a survey at Nissi Beach (south-east Cyprus) collected material (n = 2225) that allegedly resembles Aegean early Holocene assemblages. The lithics are 'microflake'-based (from pebble cores), with scrapers, backed pieces, and spines, the material purportedly representing the tool-kits of foragers who were either occupying the island during the late Epi-Palaeolithic, or early contemporaries of the earliest Cypriot farmers (*Kaczanowska, Kozlowski 2014.52–55, Fig. 27*). While a tantalising potential link to Mesolithic Aegean populations, knowledge of which may have later been used by migrant farmers venturing westwards from Cyprus (as attested genetically; *King* et al. *2008*), the current evidential basis is insubstantial given the lack of absolute dates.

Finally, there is tantalising evidence for comparable material emerging from archaeological work in south-western and western Anatolia, *i.e.* the obvious continental landfall en route from Cyprus, and/or point of departure for anyone paddling to Crete from Anatolia (*Kartal 2009.Fig. 15; Horejs* et al. *2015.Fig. 15*). The excavation of late 9th/ early 8th millennia BC deposits from the Girmeler Cave in SW Turkey (Fig. 1) produced a 'flint' percussion-knapped flake-based assemblage – with some bladelets – including multidirectional cores and modified forms such as scrapers and perforators, but no classic microlithic types (*Takaoğlu* et al. *2014.112–113, Fig. 6*). The excavators note the materials' distinction from central Anatolian and Antalya region lithic traditions of the period, while also drawing tentative parallels with Aegean Island Mesolithic assemblages (*Takaoğlu* et al. *2014.114*). The second assemblage comes from a survey of the Karaburun Peninsula on western Anatolia, opposite the eastern Aegean island of Chios (Fig. 1). The 116 artefacts of 'white patinated flint' were the products of a non-

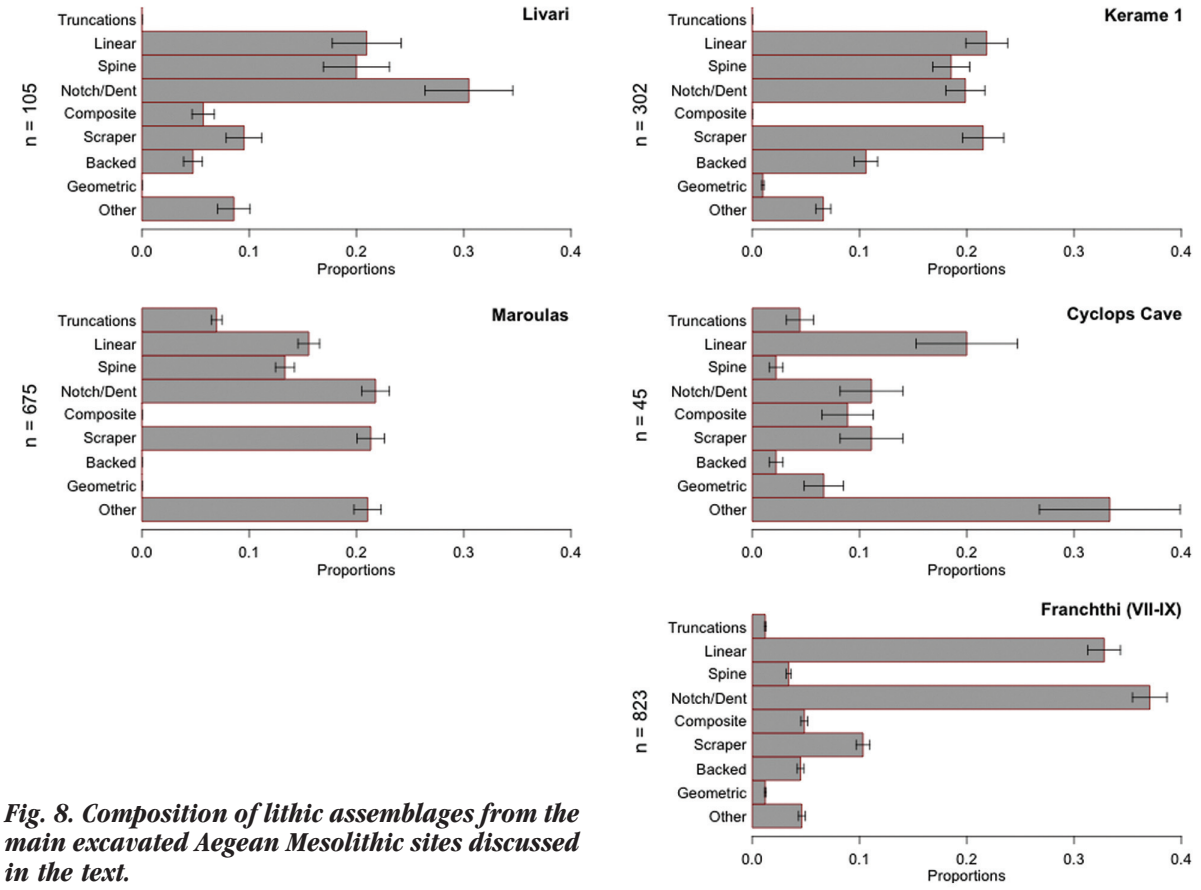


Fig. 8. Composition of lithic assemblages from the main excavated Aegean Mesolithic sites discussed in the text.

standardised flake-based tradition (only three blades recorded), with the few retouched pieces (approx. 10%) including scrapers and notches (*Çilingiroğlu* et al. *2016.3–5, Figs. 4–5*). The survey team clearly contrasts this material with the bladelet- and blade-based traditions of the Epipalaeolithic and Pre-Pottery Neolithic Eastern Mediterranean, instead drawing comparisons with Aegean Mesolithic assemblages (*Çilingiroğlu* et al. *2016.5–6*).

The relationship of Crete's indigenous Mesolithic traditions to Initial Neolithic Knossos

So what impact has the new Cretan Mesolithic finds on how we view IN Knossos? Firstly, we need to be clear about what these data do not change. For instance, we still lack solid evidence for an indigenous hunter-gatherer population inhabiting Crete when the migrant farmers arrived around 7000 BC. With elements of the Livari and the Plakias region sites finding their best parallels from Franchthi Phase VIII of the earlier 8th millennium BC (*Strasser* et al. *2010.164*), there could conceivably be a lacuna in Cretan occupation of at least 500 years until Knossos was founded (*Perlès 1990.46–47*). Moreover, even if the island was inhabited by local hunter-gatherers, it does not change the newcomers' impact on Crete's subsistence economy, as it remains that their agro-pastoral basis was a package of foreign domesticated and proto-domestic plants and animals that they brought with them (*Broodbank, Strasser 1991.236–237; Horwitz 2013; Isaakidou 2008*; although *Sampson 2008.210, 225* argues for some independent Aegean Island domestication processes).

Where the discovery of a Cretan Mesolithic does change the debate concerns how we view the earliest material culture at Knossos. The first detailed study of Knossian IN chipped stone was undertaken by James Conolly (*2008*), part of whose work was dedicated to finding the best overseas parallels in order to locate the settlers' homeland(s) and chart their migration routes. The assemblage comprised 394 artefacts, 70% of which were made from obsidian (in stark contrast to Livari's 1.6%), plus a wide variety of local raw materials. The assemblage was flake based (approx. 80%), with the blanks having been percussion-knapped on-site from multi-platform and bipolar cores/*pièces esquillées* (*Conolly 2008.76–77, Fig. 5.1–5.2*). There was also a small blade component (11 percussion, two possible pressure), but no associated manufacturing debris. A quarter of the assemblage was modified (n = 100), mostly in the form of non-standardised re-

touched flakes. For Conolly, the assemblage's closest parallel came from IN Franchthi Cave (phase X), material of perhaps only slightly later date (*Perlès 1990.84–85, Tab. 5.3, Fig. 5.5; Perlès* et al. *2013*). Both were flake-dominated and included small proportions of more technically advanced blade tools (2% at Knossos and 10% at Franchthi). However, while Perlès (*1990.115–118*) viewed Franchthi's flake component as representing continuity from Mesolithic technical traditions (with the IN the result of 'acculturation' by local (ex-)hunter-gatherers; *Perlès* et al. *2013.1012*), Connolly (*2008.85*) rejected such an implication for the IN Knossian flake material based on the belief that Crete had no indigenous hunter-gatherer population, *i.e.* the entire assemblage had to be the product of a foreign tradition. The assemblages' similarity was instead viewed as the result of the communities' comparable environments, which led to the independent development of functionally analogous tool-kits.

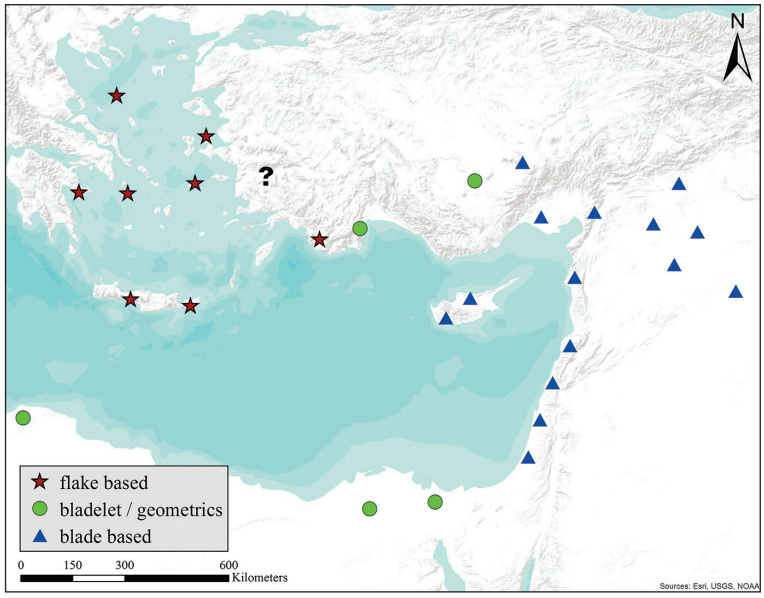


Fig. 9. Lithic traditions of the 9th–8th millennium BC Eastern Mediterranean.

Conolly's interpretations have recently been challenged by Malgorzata Kaczanowksa and Janusz K. Kozłowski (*2011*), whose own study of the Knossian IN material led them to downplay the similarities with IN Franchthi and instead locate Knossos within their early Holocene Aegean Island tradition. In the light of the Livari material, we agree broadly with this position. Ultimately, we believe that the chipped stone from IN Knossos is culturally hybrid. It embodies technical and raw material choices derived from migrant farmer and local hunter-gatherer traditions, which we argue resulted from close population interaction, conceivably through inter-marriage, as allegedly evidenced in the Argolid at Klisoura Cave 1 (*Koumouzelis* et al. *2003.117–118*; although, see *Hofmanova* et al. *2016; Kılınç* et al. *2016* for recent aDNA studies that seemingly argue against forager-farmer admixture). The Livari and Plakias region assemblages now provide the IN Knossos flake-based material, not least the notched/denticulated component, with good Cretan Mesolithic antecedents, while the minority blade component, specifically the pressure blades, provide links to eastern Neolithic traditions. More specifically we suggest that Aceramic Neolithic Çatalhöyük in central Anatolia (Fig. 1) provides not only good parallels for some of the IN Knossian material, but also a conceptual analogy for the site's foundation.

Çatalhöyük's basal levels are dated *c.* 7100 BC (*Bayliss* et al. *2015*), with the population's subsistence based on a range of non-local domestic and proto-domestic animals and cereals that members of this community likely brought with them from the east, possibly Cappadocia, where agro-pastoralism and sedentism was already established (*Hodder 2006.82–84*). The material culture provides further links to this region, with elements of Çatalhöyük's earliest chipped stone forming the westernmost edge of Near Eastern PPNB lithic traditions (*Carter 2011.12*). At the same time, the fauna includes significant quantities of wild taxa (*Russell, Martin 2005.44–46, Fig. 2.3, Tabs. 2.5–2.7*), while the chipped stone contains hallmarks of local Epi-Palaeolithic hunter-gatherer knapping practices with its bladelet technologies, and geometric tool-types (*Carter 2011.11*). Çatalhöyük's earliest material can thus be conceptualised in terms of cultural hybridity (*cf. Bhabha 1995*) due to interaction between indigenous hunter-gatherers and non-local farmers; a century later, we seem to witness a similar situation at IN Knossos.

In terms of actual links between IN Knossos and late 8th millennium BC central Anatolian lithic traditions, both Çatalhöyük and nearby Canhasan III (Figs. 1 and 8) produced numerous exhausted bipolar cores or *pièces esquillées*, plus small quantities of blades, a few of which were pressure flaked (*Ataman 1988; Carter* et al. *2005.492–495, Fig. 11.8a–8b; Conolly*

Site	Region	Period	Date (cal BC)	Obsidian %	Km to Melos
Livari	Crete	Mesolithic	n.d.	1.5	235
Franchthi Cave (VII)	Argolid	Lower Mesolithic	8500 – 8000	0.2	135
Franchthi Cave (VIII)	Argolid	Upper Mesolithic	8000 – 7500	2.8	135
Franchthi Cave (IX)	Argolid	Final Mesolithic	7200 – 7000	0.2	135
Schisto Cave	Attica	Upper Palaeolithic – Lower Mesolithic	10 000 – 9300	0.8	150
Cyclops Cave, Youra	Sporades	Lower – Upper Mesolithic	8600 – 7000	8.4	295
Maroulas, Kythnos	Cyclades	Lower Mesolithic	8800 – 8600	31.1	75
Kerame 1, Ikaria	Dodecanese	Lower Mesolithic	n.d.	26	170

Tab. 4. Mesolithic Aegean sites with obsidian: date, proportion of assemblage, linear distance from source.

2008; Kaczanowksa, Kozłowski 2011). In making these comparisons, one is wary of literalism, as Çatalhöyük is the only well-published central Anatolian site of this date, and differences do exist between their chipped stone assemblages (*e.g.*, the lack of geometrics from Crete); at Knossos this may be partly due to indigenous Cretan influences on migrant Anatolian traditions. To claim Knossian links with central Anatolia is not new, with Arthur Evans (*1994. 5*) positing parallels in mud-brick construction and aspects of the economy, while part of the modern Cretan population's DNA can be traced back to central and Mediterranean Anatolia through the J2a haplotype, whose appearance on Crete is linked to the spread of farming and Knossos' foundation (*King* et al. *2008*).

The state of play

While our understanding of the Cretan Mesolithic remains in its infancy, it still forces us to rethink long-held views concerning the foundation of Neolithic Crete. Through reference to Livari and other Aegean island Mesolithic data, one no longer has to invoke the founder principle to explain the idiosyncrasies of Knossian IN material culture, *i.e.* cultural drift from 'homeland' practices due to the colonists' isolation (*Cherry 1985.26–27*). For us, the Knossian material represents a hybrid product of farmer and hunter-gatherer traditions, conceivably via group interaction on Crete itself (or through forager-farmer contacts in western Anatolia). Moreover, the presence of Melian obsidian on Mesolithic Crete attests to pre-Neolithic maritime networks connecting Cretans with other islanders (*Carter 2016*), the ancestral knowledge of which may have then been employed by those early seaborne farmers as they aimed for the island's north coast (*cf. Broodbank, Strasser 1991.238–239*). The fact we have still to find Early Neolithic sites on the intervening islands between Anatolia and Crete continue to bolster the argument that this was not only a targeted migration, but also a long-range process (*Horejs* et al. *2015.Fig. 15*). In turn, John Cherry's original (*1981*) claim for a 2000-year gap between the establishment of farming on Crete and the Neolithisation of the smaller Aegean Islands remains largely true (an exception being Uğurlu on Gökçeada/Imbros; *Erdoğu 2013*). This suggests that the Cretan-Anatolian dual cereal-livestock subsistence basis was incompatible with smaller Aegean landmasses, which tend to lack sizeable tracts of land suitable for arable development (<10–15° slope). Indeed, the Late Neolithic/5th millennium BC farming economy that eventually succeeded in the Cyclades was underpinned by sheep/goat herding and fishing, having filtered out the cereal and cattle component seen on Crete (*Broodbank 2000.76–85, Tab. 1*).

Other lacunae need to be highlighted. The lack of Mesolithic sites in the southern Dodecanese arguably hampers our claim that Anatolian migrant farmers could have tapped into deep-time knowledge of the sea- and landscapes they were about to encounter via intermediary islanders (though alleged Mesolithic surface finds are documented from Chalki; *Sampson 2010.139*). That said, with the recent discoveries of late Pleistocene-early Holocene insular sites further to the north on Ikaria and Lemnos (*Sampson* et al. *2012; Efstratiou* et al. *2013*), together with the new south-west and western Anatolian evidence (*Çilingiroğlu* et al. *2016; Takaoğlu* et al. *2014*), it is arguably only a matter of time before Mesolithic activity is documented on the islands of Rhodes, Karpathos and Kasos (Fig. 1). Another data lacuna we take more seriously is that of later Palaeolithic island occupation. While Livari has some features that might be viewed as transitional Final Palaeolithic-Lower Mesolithic (proportion of bladelets and inverse retouch), it remains that Crete lacks a well-documented Upper Palaeolithic. This was perhaps to be expected, as most Aegean sites were apparently aban-

doned during the late Pleistocene-early Holocene transition (*Runnels 1995.719, 726–727*). Crete's earlier prehistory might thus be viewed as a series of visitations and/or failed colonisations, rather than a continuous occupation from the Middle Pleistocene. Ultimately, Crete's Mesolithic culture can be viewed as the product of yet another migration and part of a broader wave of supra-regional early Holocene maritime activity that Cyprian Broodbank (*2006. 208*) refers to as the true "*birth of Mediterranean seafaring*".

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Becoming sedentary? The seasonality of food resource exploitation in the Mesolithic-Neolithic Danube Gorges

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ABSTRACT – *In this paper, we investigate whether the Mesolithic-Neolithic sites in the Danube Gorges were occupied seasonally or all year round by looking at animal skeletal remains. The hunting seasons of most important game animals have been determined on the basis of antler and teeth growth, supplemented by looking into the presence of migratory fish and birds. The patterns of food resource exploitation seem to indicate year-round occupation of the settlements, and suggest that a significant degree of sedentism existed in the Danube Gorges prior to, and independently of, the adoption of animal and plant husbandry.*

IZVLEČEK – *V članku na podlagi analize živalskih ostankov raziskujemo, ali so bila mezolitsko-neolitska najdišča na območju soteske Džerdap poseljena sezonsko ali čez celo leto. Na podlagi rasti rogovja in zob smo določili lovno sezono za najpomembnejšo divjad, podatke pa smo dopolnili z analizo selitve rib in ptic. Vzorci rabe raznih virov prehrane kažejo na celoletno poselitev na naselbinah; sklepamo tudi, da se je na območju Džerdapa delno sedentaren način življenja pojavil ločeno od in pred pojavom prvih domačih živali in kultiviranih rastlin.*

KEY WORDS – *seasonality; archaeozoology; sedentism; Danube Gorges; Mesolithic-Neolithic*

Introduction

With their long temporal sequence, spanning between *c.* 9500 to 5500 cal BC (corresponding to the regional Mesolithic, Mesolithic-Neolithic Transformation phase and the Early/Middle Neolithic) (*Borić, Dimitrijević 2009; Borić 2011*), open-air sites in the Danube Gorges (North-Central Balkans) provide great opportunities for studying and understanding various aspects of Mesolithic-Neolithic transition. In particular, intensified building activities in the Late Mesolithic and Transformational Mesolithic-Neolithic phases (*cf. Borić, Dimitrijević 2009; Borić 2011*) have been interpreted as archaeological indicators of increased sedentism resulting from developing social complexity of local hunter-gatherer-fisher communities (*cf. Voytek, Tringham 1989; Chapman 1993; Radovanović 1996; Radovanović, Voytek 1997*) and from merging local traditions with new economic and social practices accompanying 'Neolithic' lifeways (*cf. Borić 2007; 2011; Jovanović 2008*). Obviously, there is no universal mode of hunter-fisher-gatherer existence, as opposed to a presumed sedentary lifestyle of food-producing communities, nor can a clear-cut change from mobility to sedentism be assumed. Moreover, degrees of sedentism are often difficult to assess and divide into neat categories due to the complexity of human lifestyles and residential practices (*cf. Whittle 2001*). One of the starting points, however, most commonly involves determining whether the sites in question were occupied seasonally or year-round. This feature can be addressed by looking at subsistence patterns, *i.e.* the seasons of exploitation of most important animal species, as has been demonstrated by a number of studies, which range from simple observations of the pres-

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ence/absence of seasonally available fauna, to more sophisticated analytical procedures, including the determination of the individual ages and the season of death of exploited animals, skeletochronology, or growth-increment studies (*cf. Pike-Tay* et al. *2004*), or stable isotope balances in teeth and bones (*Blaise, Balasse 2011*).

In this study, we present estimated seasons of capture on the basis of the results of ageing of faunal skeletal elements (teeth and antler) of economically important wild game species, supplemented by quantifications of fish and bird remains (some of them available seasonally and others more or less all year round) from sites at Vlasac, Lepenski Vir, and Padina. By no means exhaustive, this study aims to offer additional data relevant to understanding subsistence and settlement patterns, and to shed more light on the relationship between hunting, fishing and increased sedentism in the Danube Gorges.

Archaeological background

The Padina, Lepenski Vir, and Vlasac sites are situated in the Upper Gorge (*Gospođin Vir*, or Lady's Whirlpool) of the Danube Gorges (Fig. 1), on riverine terraces sloping towards the Danube. The initial rescue excavations of the sites were undertaken in the 1960s and 1970s (*Srejović 1969; 1972; Srejović, Letica 1978; Radovanović 1996; Jovanović 2008*), prior to the raising of the water level due to dam construction, and new revisory excavations of the preserved portion of the Vlasac terrace were carried out in 2006–2009 (*Borić 2006; Borić* et al. *2008; 2014*). The earliest traces of human presence in these locations date to the period of *c.* 9500–7400 cal BC (the Early Mesolithic) (*Borić, Dimitrijević 2009; Borić 2011*), and are manifested by occasional burials (some in a seated position), several stone constructions (*Borić, Miracle 2004; Jovanović 2008*), as well as caches of animal bones originating predominantly from wild game and fish (*Borić, Dimitrijević 2006*), but also from canids displaying mixed wolf and dog features, suggesting that the initial stages of dog domestication took place during this time (*Dimitrijević, Vuković 2015*).

The few and fragmentary traces of Early Mesolithic occupation are mostly due to their disturbance and devastation by later (Late Mesolithic and Transformation phase) building and occupational activities (*Borić 2011*). The Late Mesolithic phase (*c.* 7400–6300/6200 cal BC) is particularly well documented at Vlasac (*Borić 2011*), where numerous burials, several dug-out dwelling structures, stone-lined rectangular hearths and a large number of chipped stone, bone and antler artefacts have been discovered (*Srejović, Letica 1978; Nemeskéri 1978; Kozłowski, Kozłowski 1982; Roksandić 1999; 2000; Borić* et al. *2008; 2014*), as well as an enormous assemblage of animal bones (*Bökönyi 1978*). This phase also produced evidence of large-scale exchange networks, witnessed by occasional finds of good-quality flint of non-local origin, and the occurrence of marine gastropods *Cyclope neritea* and *Columbella rustica* in some of the burials (*Cristiani, Borić 2012; Borić* et al. *2014; Srejović, Letica 1978*).

The Transformation/Early Neolithic phase (*c.* 6300/6200–5900 cal BC) (*Borić, Dimitrijević 2007; Borić 2011*), coinciding with the emergence of the first farming communities in the Balkans, saw the establishment of the first settlements with elaborate trapezoidal-base dwellings, distinctive sandstone sculpted boulders and the introduction of pottery at Lepenski Vir and Padina (*Srejović 1969; 1972; Radovanović 1996; Garašanin, Radovanović 2001; Jovanović 2008*), but with unchanged subsistence strategies dependent on hunting and fishing (*Borić, Dimitrijević 2006*). The first domesticates (apart from



Fig. 1. The Danube Gorges area with relevant sites mentioned in the text. The position of the Danube Gorges within a wider area – the Balkan peninsula shown in the lower left corner. Images from Google Earth.

dogs) make an appearance only after *c*. 6000/5900 cal BC (*Borić, Dimitrijević 2007*), after most of the dwellings had been abandoned and new elements of material culture (domed ovens, ground stone tools, bone spoons), along with certain individuals of non-local origin appear in the area (*Borić 2011; Borić, Price 2013*). Large-scale animal husbandry, however, was never fully introduced into the Upper Gorge; the sites continued to be in use until *c.* 5500 cal BC, but probably for specialised activities, most notably fishing (*Bonsall 2008; Borić 2011*).

The faunal assemblages

The assessment of the nature of animal exploitation and quantification of faunal remains from the Danube Gorges are hindered by several factors, namely the inadequate recovery techniques and selective collection imposed by time constraints during the course of the excavations, and the fragmentary state of faunal assemblages from some of the sites (*Borić 2001; 2002; Borić, Dimitrijević 2006; Dimitrijević 2000; 2008*). The faunal assemblages from the old excavations of Lepenski Vir (1965–1970), Vlasac (1970–1971), and Padina (1968–1970) were collected entirely by hand, using collection grids consisting of 4x4m quadrants. Furthermore, the enormous assemblage from the original excavations of Vlasac, comprising nearly 30 000 identified specimens was discarded after the initial analysis by Sándor Bökönyi (*1978*), with only a small sample of bird (Tab. 5) and fish remains preserved (*Borić 2002.App. 5; Dimitrijević* et al. *submitted*). Part of the faunal assemblage from Lepenski Vir, mainly from first excavation seasons (up to 1969, *cf. Borić, Dimitrijević 2006*) was also discarded after the preliminary analysis by Bökönyi (*1969; 1970; 1972*). The preserved part of the assemblage originated from later campaigns (1968–1970), and consisted of animal bones primarily related to the floors of trapezoidal-base dwellings, and areas between and underneath them (*Dimitrijević 2000; 2008*). Only the faunal assemblage from the new (2006–2009) excavations of Vlasac, as well as the one collected in 1992–1996 at the downstream site of Schela Cladovei (Fig. 1) (*Bartosiewicz* et al. *1995; 2001; 2008*), were collected by water sieving and flotation, in addition to hand collection (*Borić* et al. *2014; Dimitrijević* et al. *submitted*).

The environment of Padina, Lepenski Vir and Vlasac, which were situated on riverine terraces in a narrow belt between the river and the forest, provided both good hunting and fishing conditions. The dense forests surrounding the sites were the natural habitat of various wild game species which were hunted for meat, as well fur-bearing animals which were probably hunted for fur or as vermin. The vicinity of the river and its large whirlpools enabled fishing for both freshwater species (available most of the year) and seasonally available anadromous species, as well as the exploitation of waterfowl.

In terms of wild game at all three sites, the most numerous remains are of red deer (*Cervus elaphus*) which was most commonly hunted, followed by wild boar (*Sus scrofa*), roe deer (*Capreolus capreolus*), and aurochs (*Bos primigenius*) (*cf. Bökönyi 1969; 1970; 1972; 1978; Clason 1980; Dimitrijević 2008*). In terms of fishes, the remains of various cyprinids (Cyprinidae), Wels catfish (*Silurus glanis*), migratory sturgeons (Acipenseridae), and huchen (*Hucho hucho*) have been discovered at all three sites, but in varying quantities (*Živaljević in prep.*). As expected, the hand-collected, water-sieved and flotated sample from new excavations of Vlasac contained many more remains of smaller cyprinids and exhibited the greatest species diversity in comparison to hand-collected assemblages from Lepenski Vir and Padina (Tab. 4). However, in spite of the same collection methods employed at the latter two sites, their faunal assemblages also exhibited significant differences, namely in the absolute predominance of catfish observed at Padina. The Lepenski Vir assemblage contained a significant number of cyprinid, catfish and huchen remains, but also a much greater number of sturgeon remains in comparison to Padina and Vlasac (Tab. 4).

The role of hunting *vs.* fishing in subsistence strategies is difficult to assess on the basis of a straightforward comparison of quantified mammal and fish remains, given the differences in their anatomy and size, and biases affecting their survival and recovery (*cf. Wheeler, Jones 1989; Takács, Bartosiewicz 1998; Bartosiewicz, Bonsall 2004; Borić 2001*). The analyses of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios in human bone collagen have suggested that the Mesolithic inhabitants of the Danube Gorges consumed considerable amounts of fish, with a gradual broadening of the dietary spectrum to include more terrestrial resources at the onset of the Neolithic (*Bonsall* et al. *1997; 2004; Grupe* et al. *2003; Borić* et al. *2004*), whereas the analysis of the sulphur ($\delta^{34}S$) isotope ratio has suggested that there have been significant inter- and intra-site variabilities in dietary practices (*Nehlich* et al. *2010*). On the basis of faunal data, it can be hypothesised that both hunting and fishing made significant contribu-

tions to the diet; the former mainly oriented towards red deer and the latter exhibiting more intrasite (and possibly diachronic) variety.

Apart from a general emphasis on the importance of annual cycles in shaping human lives in the Danube Gorges (*cf. Srejović 1969; 1972*), the subject of seasonality was first addressed by Anneke T. Clason (*1980*) in her study of Starčevo and Padina animal remains. In the description of mammal remains, she specified some specimens as seasonal markers, made some remarks on the seasonal availability of bird and fish, and hypothesised that "*Padina was permanently inhabited during all seasons of the year*", and furthermore, that this was probably also true for Vlasac and Lepenski Vir. A discussion on the influences of seasonal cycles on life in the Mesolithic Danube Gorges is given by Borić in his thesis (*Borić 2002*). Here, and in several later references, seasonal estimates determined on the basis of particular specimens of mammal remains were also noted (*Dimitrijević 2000; 2008; Borić, Dimitrijević 2006; 2009*).

Materials and methods

The seasonal schedule of food resource acquisition in the Danube Gorges has been determined on the basis of skeletal elements which are sensitive to the question of seasonality. This included determining the kill season of red deer and roe deer on the basis of antler growth (*cf. Schmid 1972*), and ageing of red deer, roe deer, fox and wild boar on the basis of tooth eruption and wear (*cf. Habermehl 1985; Brown, Chapman 1991; Carter 2006; Carter, Magnell 2007*) (Tabs. 1–3). Although radiographs were not made, the fragmentary state of some of the mandibles and loose teeth enabled ageing on the basis of root formation stages (after *Brown, Chapman 1991; Carter 2006; Carter, Magnell 2007*). Other mammal species were not taken into account, either because they were not represented by juvenile animals, are not seasonal breeders, or they give birth several times a year. The breeding and reproduction patterns of dogs in particular could have changed significantly as a result of domestication, and could have extended throughout several seasons.

In this respect, the most reliable season indicators are milk and erupting permanent teeth of juvenile animals, given that they follow a fairly standardised schedule, whereas tooth wear does not occur at an even pace (*Bartosiewicz 1989; Pike-Tay* et al. *2004*). Less reliable season indicators are shed antlers; even if they are dropped during limited periods of the year (February-March in the case of red deer and October-November for roe deer, *cf. Schmid 1972*), they could have been collected at any time and/or curated, especially since they were extremely valued as raw material and often structurally deposited.

We assumed that red deer give birth at the beginning of June (*cf. Carter 2006*); similarly, the birthing season of recent red deer populations in the region is described as taking place "*at the end of May – beginning of June*" (*Grupa autora 1991*). Roe deer give birth in May (*Grupa autora 1991; Habermehl 1985; Carter 2006*). The farrowing season of wild swine is seasonally less restricted, occuring in March-April in recent wild pig populations in the Balkans (*Grupa autora 1991*), whereas in Sweden and Germany (*Carter, Magnell 2007*), as well as in Turkey (*Bull, Payne 1982*) it occurs between March and May. Wild sows may breed twice a year, thus substantially widening the farrowing season; however, 65–90% of births occur between March and May, mostly March and April in Sweden and Germany (*Carter, Magnell 2007* and references therein). Similarly, in the Balkans, 85% of births take place in March and April (*Grupa autora 1991*). Fox cubs are born in March (*Habermehl 1985*).

The observations on the hunting seasons of most important game animals were supplemented by looking into the seasonal availability of migratory fish and birds and quantifying their remains (Tabs. 4–5). As noted by László Bartosiewicz and Clive Bonsall (*2004*) and Bartosiewicz *et alii* (*2008*), the presence/absence criteria is highly probabilistic, given that the presence of a certain species might signal occupation during a particular season, but its absence does not imply the lack of occupation at other times. For example, prior to the Iron Gates' dams construction, anadromous sturgeons – beluga (*Huso huso*), Russian sturgeon (*Acipenser guldenstaedtii*), ship sturgeon (*Acipenser nudiventris*), and stellate sturgeon (*Acipenser stellatus*), undertook their bi-annual spawning migrations from the Black Sea at particular times of the year (in early spring and autumn), but with inter-specific and individual differences in the start and peak dates depending on water temperature. Also, the populations migrating in autumn were known to overwinter in the river (*Ristić 1977*). It should be noted, however, that the main sturgeon fishing seasons in the Danube Gorges in more recent times corresponded with their migration patterns, with most catches occurring in spring, followed by autumn (*cf. Petrović 1998. [1941]*; for

different data from Hungary, see *Bartosiewicz* et al. *2008*).

The investigation of the presence of migratory birds as seasonal indicators is also based on the assumption that their behaviour in the past roughly mirrored their present migration patterns. In addition, it should be noted that bird remains at sites could have been accumulated not only by humans and dogs, but wild predators as well, having in mind that no bird bones bore butchering marks. This hypothesis does not seem likely for certain species – particularly birds of prey, which nested in the high cliffs of the Gorges – but cannot be completely ruled out.

Therefore, the data we present here includes the suggested seasons of kill of the most important game animals, which could vary to some extent due to slight or greater variations in the birthing seasons of the species and their ontogeny, as well as the most probable seasons of exploitation of migratory species, assuming their past migration patterns broadly correspond to those observable in more recent times.

Results

Vlasac

As opposed to the 640m² area excavated in 1970–1971 (*Srejović, Letica 1978*), the preserved portion of the Vlasac terrace encompassed by the 2006–2009 excavations (326m²) covered the southernmost peripheral area of the original settlement (*Borić* et al. *2014*), with much less evidence of domestic activities or food preparation and consumption (*Dimitrijević* et al. *submitted*). This feature is certainly manifested in the quantity and preservation of animal remains from the two areas of the site, in particular concerning mammal remains, which are least likely to suffer from bias in recovery techniques. The total number of mammal bone specimens identified to the species/genus/family level from the 1970–1971 excavations equaled 11188 (*Bökönyi 1978*), as opposed to 801 specimen identified to the species/genus/family level and 10955 unidentified mammal remains from the 2006–2009 excavations (*Dimitrijević* et al. *submitted*). In terms of the most important game animals, the NISP (number of identified specimens) of red deer, wild boar and roe deer in the 1970–1971 assemblage equaled 6732, 1185 and 510, respectively (*Bökönyi 1978*), as opposed to their NISP in the 2006–2009 assemblage (209, 86 and 47, respectively) (*Dimitrijević* et al. *submitted*). However, due to more sophisticated collection techniques, the new excavations of Vlasac enabled the recovery of even the most fragile skeletal elements, including the deciduous teeth which were used in this study (Tab. 1), as well as a plentitude of fish remains (Tab. 4).

Most of the mammal remains used in this study originated from the 2006–2009 excavations of Vlasac, and included a fragmented red deer skull, a fragment of a roe deer skull with an antler, as well as deciduous and permanent teeth of red deer, roe deer, wild boar and fox. Given that the largest part of the faunal assemblage from 1970–1971 was discarded, in this study we were able to include only 9 unshed and 31 shed antlers of red deer, and 3 unshed antlers of roe deer, which were originally packed with bone and antler artefacts and thus saved (Tab. 1).

The fragmented red deer skull VL 29/1 (Fig. 2) originated from a young male, and on the basis of partially preserved antlers still on pedicles, it was determined that it was captured between September and February. The skull had been used (possibly, for a significant amount of time), most likely in a series of ritualistic activities, given that it exhibited a number of modifications (numerous cuts and damage to the cranial roof and flattened occipital condyles) which could not be explained by standard butchering practices (*Dimitrijević* et al. *submitted*), and that it had been deposited at the top of a sequence of several inhumations and cremations (*Borić 2010; Borić* et al. *2014.Tab. 1*: the skull is described as originating from context 19). Unshed antlers collected over the course of previous excavations indicate the same broad (autumn-winter) time span, whereas, as

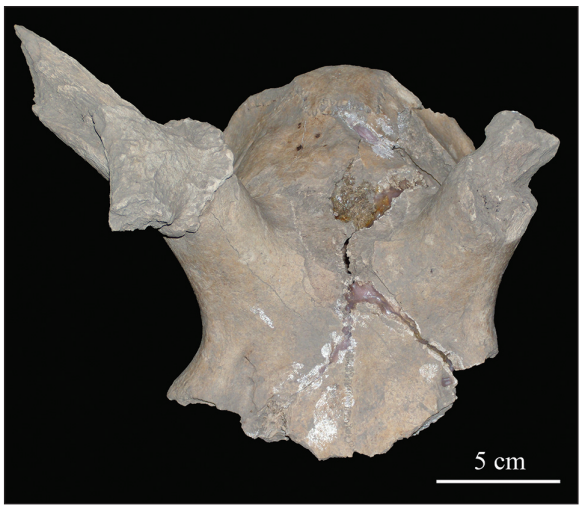


Fig. 2. Fragmented male red deer skull (VL 29/1) from Vlasac, with fragmented antlers attached to pedicles, captured between September and February.

already noted, the use of shed antlers (even though shedding occures within a short time span) as seasonal indicators should be taken with caution, as it is possible they were collected later.

The stages of teeth eruption and wear indicate several seasons of capture of red deer, some with more precision than others. In particular, a 3rd and 4th decidious premolar from a fragmented left maxilla (VL 216/15) (Fig. 3) pointed to an age of 7–8 months, indicative of a December-January capture; whereas a left 3rd permanent incisor with an open root and milk incisors (left and right 2nd and 3rd) and right canine (VL 237/4) (Fig. 4) from a mandible that had not been preserved pointed to an approximat eage of 15–18 months or a kill that occurred between August and November.

A fragment of a roe deer skull with an antler fragment on a pedicle (VL 314 x. 23), as well as three unshed antlers collected in previous excavations indicated that the capture seasons occurred between May and October (*cf. Schmidt 1972*). Assuming the end of May as the season when roe deer give birth (*cf. Habermehl 1985*), one decidious premolar (3/4) (VL 51/1) indicated an age of one month, *i.e.* a June capture.

As already noted, the farrowing season for wild swine is generally from March to April (*cf. Grupa autora 1991; Carter, Magnell 2007*); in our study, the ageing and the estimation of season is given counting from April (Tab. 1). Two teeth – an upper 3rd deciduous premolar (VL 237/5) and an upper 2nd deciduous premolar (VL 282/3) – produced fairly reliable season estimates, an April-May and September-October kill respectively.

Fox teeth (an upper deciduous canine and a germ of the first molar, VL 222/22–23) were included in this study, as they provided a fairly reliable kill season (May), given that this stage of teeth eruption is indicative of a three-month-old individual (*cf. Habermehl 1985*).

Although most of the elements utilised in ageing offered very broad season estimates spanning over several months (Tab. 1), the aforementioned specimens provided fairly accurate and short seasons of death. They signal particular events which took place in December-January, April-May, May, June and September-October, *i.e.* are indicative that hunting did not take place during a limited period of the year. Both the fragment of a roe deer skull with an antler (VL 314 x. 23) and the red deer skull (VL 29/1) have been directly dated, producing a date of 7131–6823 cal BC at 95% probability (OxA-21962) and 6006–5838 cal BC at 95% probability (OxA-16544) respectively (*Borić* et al. *2014*). At the same time, these two dates are currently the oldest and the youngest obtained from the new excavations of Vlasac, thus dating the span of activities in the peripheral zone of the settlement, with Transformation phase activity (post *c.* 6200 cal BC) mainly related to the interment of the latest burials in the successive burial zone closed by the red deer skull (*Borić* et al. *2008; 2014*). A wild boar tooth (VL 282/3) was found in a context (a concentration of artefacts beneath the floor of a dug-out dwelling) dated with two absolute dates: 7034–6692 cal BC at 95% probability (OxA-24809) and 7035–6698 cal BC at 95% probability (OxA-24810) (*Borić* et al. *2014*). From the previous 1970–1971 excavations, encompassing the central area of the settlement, a roe deer skull with antlers found on the floor of Building 2 (*Srejović, Letica 1978*) produced a date of 7047–6699 cal BC at 95% probability (OxA-16216) (*Borić* et al. *2008*). Therefore, it can be concluded that the majority of these events occurred during the last century of the 8th millennium and the first half of 7th millennium BC, and could be taken as representative of Late Mesolithic resource exploitation patterns at the site.

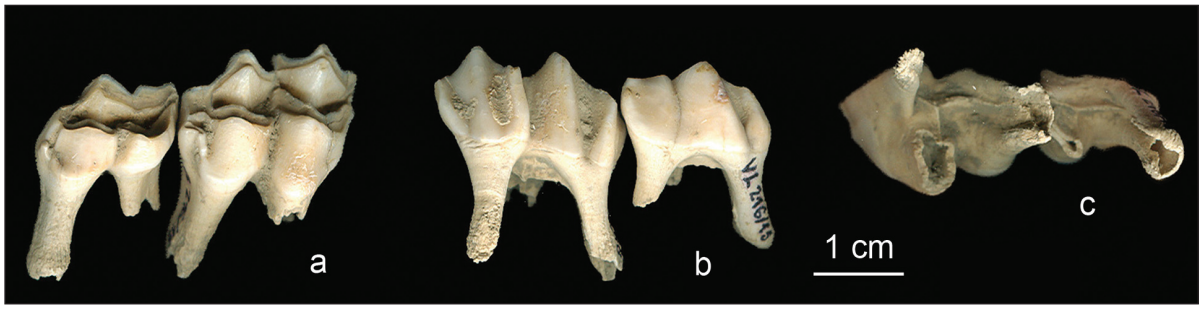


Fig. 3. 3rd and 4th decidious premolar from a fragmented red deer left maxilla (VL 216/15) from Vlasac, indicating an age of 7–8 months or a December-January capture:* a *lingual view;* b *buccal view;* c *roots, apical view.



Fig. 4. Red deer permanent and milk front teeth (VL 237/4) from a mandible that had not been preserved from Vlasac, indicating an age of 15–18 months or an August-November kill:* a *right milk 2nd incisor;* b *right milk 3rd incisor;* c *right milk canine;* d *a germ of the left 3rd permanent incisor;* e *left 2nd milk incisor;* f *left 3rd milk incisor.

Similarly to mammal remains, the fish faunal assemblage from 2006–2009 displayed significant differences in comparison to the one collected in 1970–1971. Only common carp (*Cyprinus carpio*), catfish, pike (*Esox lucius*), unidentified cyprinids and a great number of unidentified fish bones were reported by Bökönyi (*1978*). The absence of sturgeon was clearly a result of author-related bias, given that sturgeon remains were in fact identified in the preserved faunal sample from 1970–1971 (*Borić 2002.App. 5*), as well as in the sample from new excavations of Vlasac (*Živaljević in prep.*) (Tab. 4). Albeit few, the remains of migratory beluga, Russian sturgeon and stellate sturgeon are indicative of spring and autumn fishing at the site, given that sturgeon remains as a rule tend to be underrepresented due to their largely cartilaginous skeleton (*Brinkhuizen 1986; Bartosiewicz* et al. *2008*). The exploitation of anadromous Black Sea shad (*Alosa immaculata*) would have been even more seasonally restricted, as the species is present in the Danube only between the end of March and the beginning of June (Tab. 4). However, the vast majority of fish remains from the new excavations of Vlasac originated from yet another anadromous species – the vyrezub (*Rutilus frisii*) of the cyprinid family, mainly due to the large number of its pharyngeal teeth found in burials, but also in 'loose' contexts. Burials with pharyngeal teeth ornaments, from both the old and new excavations of Vlasac have mainly been related to the Late Mesolithic phase, but have also been found in a Transformation phase burial at Vlasac and settlement deposits at Lepenski Vir (*Cristiani, Borić 2012; Cristiani* et al. *2014; Borić* et al. *2014; Živaljević in prep.*), whereas unmodified vyrezub teeth and bones occur as early as mid-10th millenium BC (Early Mesolithic) at Lepenski Vir (*Živaljević in prep.*). The species has not been reported in the Middle/Lower Danube previously, but it was probably migrating into the river from the Black Sea at least up to the Middle Holocene (*Živaljević* et al. *submitted*). Modern Black Sea populations enter the rivers in October, overwinter in freshwater, and return to estuaries after spawning, which takes place in April and May (*Kottelat, Freyhof 2007*). Therefore, it can be hypothesised that the main fishing seasons at Vlasac corresponded with their autumn migration and spring spawning season, although the possibilities of winter catches should not be excluded. The possibility of opportunistic winter exploitation of freshwater fish should also be allowed, although fishing during this time would have been difficult, as most species take refuge on the river bottom and hibernate until spring. The remains of pike, one of the few species most succesfully caught from January to April (Tab. 4), could be indicative of winter fishing at Vlasac.

The bird faunal assemblage from both new and old excavations of Vlasac contained the remains of aquatic birds and waterfowl, as well as birds of prey and songbirds. Given that bird remains were few even in the hand-collected, water-sieved and flotated sample from the new excavations (Tab. 5), it may be hypothesised that their exploitation was opportunistic. A somewhat greater frequency of imperial eagle (*Aquila heliaca*) and white-tailed eagle (*Haliaeëtus albicilla*) remains (*Bökönyi 1978; Dimitrijević* et al. *submitted*), and the spatial clustering of some of their remains around the area of Late Mesolithic Building 2 (*Borić 2002.190*) could suggest that these birds of prey were possibly held in special regard. Most of the species represented in the 1970–1971 and 2006–2009 assemblage are still resident in the Danube Gorges, and therefore their presence cannot be used as a seasonal indicator. The only exceptions

include the remains of white pelican (*Pelecanus cf. onocrotalus*) which migrates to the area in October-November, black kite (*Milvus migrans*) and imperial eagle which are passage visitors, present from spring to autumn, and fieldfare (*Turdus pilaris*) which overwinters in the area (from November to March) (Tab. 5). In the case of the resident cormorant (*Phalacrocorax carbo*), teal (*Anas crecca*), and mallard (*Anas platyrhynchos*), it should be noted that their populations increase in winter, joined by visitors from Northwestern Europe (*cf. Rašajski, Kiss 2004; Clason 1980.164*). According to Anne Pike-Tay *et alii* (*2004*), teal and mallard are migratory, and are present in neighbouring Hungary in early spring and in autumn (the former used to breed in Hungary), whereas the great white egret (*Egretta alba*) and ferruginous duck (*Aythya nyroca*) leave the area in winter. The data on present populations in Serbia and the Danube Gorges (*Rašajski, Kiss 2004; Grubač* et al. *2013*) suggest that these are resident species, so their past migratory status is less clear.

Lepenski Vir

The hand-collected and partially preserved faunal assemblage from Lepenski Vir contained fewer elements sensitive to seasonality (Tab. 2), but their contextual provenance enables a better understanding of the use of trapezoidal-base dwellings and the site as a whole. At least 13 buildings contained red deer skulls with antlers (*Bökönyi 1969; 1970; 1972*), which were probably deposited on the floors, marking the event of house abandonment (*Dimitrijević 2000; 2008*). Similarly to the structurally deposited red deer skull from Vlasac, these could have been curated over longer periods of time, but in a couple of cases provided a fairly reliable indication of the kill season.

One such example comes from House 28 in the westernmost (upstream) periphery of the settlement, where a red deer skull with unshed antlers (very thin and quite unusual in their asymmetry) had been deposited on the floor (*Dimitrijević 2000.Fig. 16; 2008.Fig. 7*). The skull has been directly dated to a range 6206–5989 cal BC at 95% probability (OxA-16078), which corresponds with the construction and use of the trapezoidal buildings, *i.e.* the phase identified as the Mesolithic-Neolithic Transformation (*Borić, Dimitrijević 2009*). The skull was damaged during excavation, with only the antlers and frontal, temporal and occipital parts of the skull and the upper jaws remaining (*Dimitrijević 2000. Fig. 17*), while fish and gastropod remains were stuck to the crushed skull bones. The age of the animal has been determined fairly accurately on the basis of its upper teeth, which were in the last stages of decidious/ permanent dentition replacement. In both right and left maxilla (LV 273/4), 3rd decidious molars were still holding above the crowns of permanent fourth premolars, and it would have been a matter of days before they fell out. The 2nd and 3rd premolars, and the left 3rd molar were erupting. This stage of dental development is related to an age of 27 months, which would signal that this individual was caught in October (*Dimitrijević 2000; 2008; cf. Brown, Chapman 1991*).

Another example is a red deer skull (LV 261/1–2) deposited on the floor of House 22 (*Dimitrijević 2008.Fig. 3*). At present, only antlers have been preserved, one of which produced a date of 6084–5926 cal BC at 95% probability (OxA-16075) (*Borić, Dimitrijević 2009*), but both the skull (placed upside down) and antlers can be seen in a photograph taken during excavation (Fig. 5). The animal was just about to shed its antlers at the moment of capture; as a result, they parted from the skull when excavated. This occurrence is a fairly reliable indicator that the kill took place in February-March, and the deposition of the skull shortly after. Given that the abandonment of aforementioned House 28 was marked by a red deer skull from an individual caught in October, these two instances indicate that the 'life cycles' of each building were probably unique, ending with similar preparations but at different times throughout the year. It would seem that certain buildings were in use after others fell into disuse; this practice is also suggested by the deposition of sculpted boulders. Most boulders were initially placed in the rear area of rectangular hearths; however, certain dwellings had empty sockets in the floor behind the hearth area, or merely a fragment of an originally larger boulder inserted in the socket, which suggests that some of the boulders were moved from abandoned buildings and inserted at new locations (*Srejović 1969; Borić 2005*). Consequently, the data on seasons of abandonment enables a better understanding of the individual histories of the houses and the occupation of the settlement as a whole.

Another fairly accurate season indicator comes from a context underneath of the floor of House 31, where a cache of animal bones, including a large part of a red deer and a brown bear skeleton, as well as remains of chamois, wild boar, beluga, Russian sturgeon, common carp, vyrezub, catfish, huchen and an unidentified bird bone have been found (*Dimitrije-*



Fig. 5. Red deer skull with antlers (LV 261/1–2) deposited facing the floor of House 22 at Lepenski Vir; the kill took place in February-March. Photo from the archive of the Computer Documentation Centre, Faculty of Philosophy, Belgrade.

vić 2000; Borić, Dimitrijević 2006; Živaljević in prep.). The context has not been AMS dated, but given that the deposition of faunal remains predated the house construction, it can be concluded that the event(s) took place during an early settlement phase. The unity of the assemblage is seen in the large portions of the red deer and brown bear carcasses, which were probably butchered *in situ*. The red deer remains originated from a young individual, given its milk dentition, unfused proximal and distal epiphyses of long bones and porous structure of the short bones. Its age has been determined on the basis of a left mandible (LV bb-30/2) with a 2nd and 3rd decidious molar, alveole for the 4th decidious molar and an erupting 1st permanent molar (*Dimitrijević 2000.Fig. 12*). This stage of dental development and wear indicate a four-month-old individual, suggesting that the kill season was in September (*Dimitrijević 2000; cf. Brown, Chapman 1991; Carter 2006*). If we assume that the whole faunal assemblage underneath House 31 accumulated over a short period, September would correspond with the start of the autumn migration of beluga and Russian sturgeon (Tab. 4), slightly preceding the start of vyrezub migration, if migratory patterns of modern populations are taken into account.

Another red deer mandible (LV bb-14/3) (Fig. 6) from an unspecified context originated from a 13- to 15-month-old individual, judging from the presence of 2nd, 3rd and 4th decidious molars with formed but unresorbed roots (*cf. Brown, Chapman 1991*). This specimen is indicative of a summer kill event that took place between July and September.

An autumn/winter kill is suggested in the case of a red deer left maxilla (LV 1074/5) found in the eastern part of the settlement (sq. a/11-14). The presence of both decidious 4th molar and the 1st permanent molar indicates a 12- to 16-month-old individual (*cf. Habermehl 1985*), captured between October and February. The same season has been determined in the case of red deer maxillae (LV 1296/1) found beneath the floor of House 19. Both left and right maxilla had mixed decidious/permanent dentition (D4, M1; and D3-D4, M1, respectively) (Fig. 7), suggesting they also originated from a 12- to 16-month-old individual (*cf. Habermehl 1985*). In addition, vyrezub pharyngeal teeth were stuck to the right maxilla. The October-February time span corresponds well with the season during which vyrezub migrate to rivers and overwinters, but precedes its spawning season (Tab. 4).

The red deer maxilla with vyrezub teeth, as well as the aforementioned red deer skull from House 28

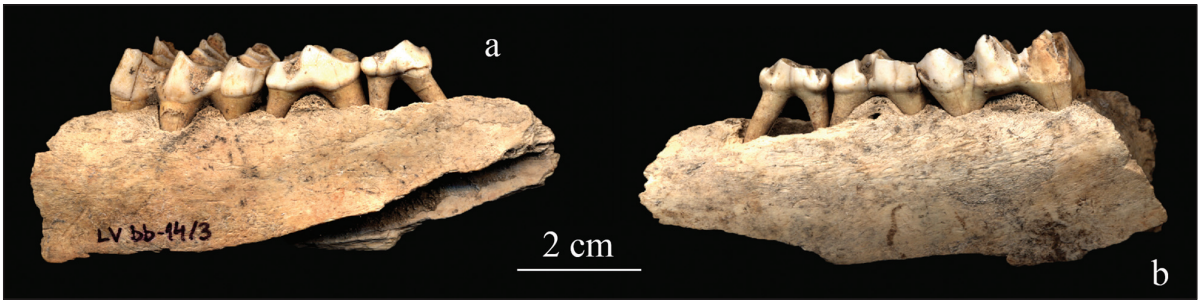


Fig. 6. Red deer right mandible with milk molars (LV bb-14/3) from Lepenski Vir, originating from a 13–15 month old individual, killed between July and September:* a *buccal;* b *lingual.

with small fish bones stuck to it seem to embody quite literally the merging role of wild game and fish. The fish faunal assemblage from Lepenski Vir consisted mainly of cyprinid remains (of freshwater species and anadromous vyrezub), as well as catfish, huchen and a small number of Black Sea shad, pike and pikeperch (*Sander lucioperca*) bones, but also a significant amount of remains of migratory sturgeon. Having in mind their largely cartilaginous skeleton and preservation bias affecting their remains (*Brinkhuizen 1986; Bartosiewicz* et al. *2008*), it is remarkable that sturgeon constitute nearly 20% (in terms of NISP) of identified fish remains at Lepenski Vir (*Živaljević in prep.*); it is also highly significant that some of the sculpted boulders from this site bore a resemblance to sturgeon features (*Radovanović 1997; Borić 2005*). At the same time, the Lepenski Vir assemblage exhibited the greatest diversity of sturgeon species, including the remains of migratory beluga, Russian sturgeon, ship sturgeon, and stellate sturgeon, as well as those of freshwater sterlet (*Acipenser ruthenus*). The first species to enter the Danube is the large beluga, whose spring migration commences in late winter/early spring, reaching a peak in April and ending in late May/ June. Its autumn migration starts by late August, peaking in October/November. The Russian sturgeon starts its spring migration somewhat later than beluga (end of February/March), which peaks in April, and ends mid-May. The second migration starts in August/September, peaks in late September/mid-October and ends by mid-November. The ship sturgeon migrates in spring and autumn, with autumn populations remaining in the river until spawning, which takes place from March/April until June. The stellate sturgeon, the last species to enter the Danube, starts its spring migration in late April/ March, reaching a peak in May. Its autumn run begins by August and ends by September/mid-October (Tab. 4) (*cf. Dinu 2010; Petrović 1998[1941]; Ristić 1977; Simonović 2001; Kottelat, Freyhof 2007; Bartosiewicz* et al. *2008*). Judging from interspecific variations in the migration start and peak dates of sturgeon species, migration pattern of vyrezub, as well as availability of freshwater fish, it might be hypothesised that fishing could have successfully taken place between late winter and late autumn, with particular intensity in spring and autumn. The remains of species active in winter (namely pike) are few, but the possibility of smoking and drying fish (the hearths in particular could have been used for this purpose) and storing it for winter months should not be excluded (*cf. Bonsall 2008; Borić 2002; 2007*). On the basis of fish remains from AMS dated contexts from Lepenski Vir (*cf. Whittle* et al. *2002; Bonsall* et al. *1997; 2008; Borić, Dimitrijević 2009; Borić 2011*), it was determined that fishing patterns remained relatively unchanged throughout the temporal sequence, *i.e.* that the distribution and proportion of species is more or less the same in both Mesolithic and Transformation phase contexts at the site (*Živaljević in prep.*).

Although bird remains have been uncovered at Lepenski Vir (*Bökönyi 1969; 1970; 1972; Dimitrijević 2008*), only a single bird bone found between the superimposed floors of Houses 20 and 33 (context dated to 6231–6056 cal BC at 95% probability (OxA-15998) (*Borić, Dimitrijević 2009*) has been identified to the species level, originating from mallard (*Borić, Dimitrijević 2006*). As already noted, Anne Pike-Tay *et alii* (*2004*) state that the species is migratory, but used to breed in Hungary; whereas Javor Rašajski and Andrei Kiss (*2004*) note that it is

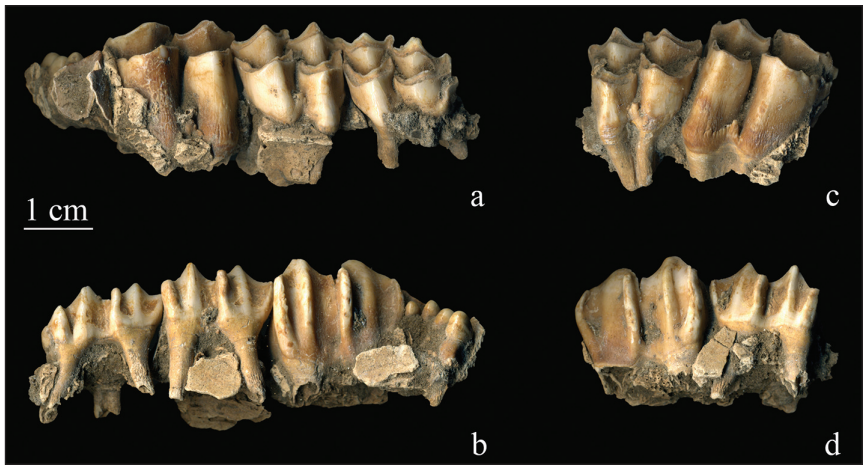


Fig. 7. Red deer left and right fragmented maxillae (LV 1296/1) found beneath the floor of House 19 at Lepenski Vir, originating from a 12–16 month old individual, captured between October and February. A fragment of vyrezub left pharyngeal bone with a row of 4 preserved teeth is attached to the right maxilla.* a *a fragment of the right maxilla with the two milk molars (D3 and D4) and the first molar (M1) in eruption, lingual, attached vyrezub pharyngeal bone at the left;* b *same, buccal view, vyrezub teeth seen at the right side;* c *a fragment of the left maxilla with the last milk (D4) and the first permanent molar (M1), lingual;* d *same, buccal view.

resident in Serbia, with a winter population increase due to migrant populations from the North of Europe.

Padina

The faunal assemblage from Padina, albeit entirely preserved, contained the fewest elements for a reliable estimate of occupational seasons (Tab. 3). Similarly to Lepenski Vir, this was mainly due to the hand-collection of animal bone, particularly biased towards fragile deciduous teeth and fish and bird remains. The majority of elements indicative of seasonality included shed and unshed red deer and roe deer antlers from both Mesolithic and Transformation phase contexts. These indicate kill seasons which occurred between September and February, determined on the basis of unshed red deer antlers, and May and October, on the basis of unshed roe deer antlers. The occurrence of shed antlers of red and roe deer indicate occupation in February-March and October-November, respectively, assuming they were collected shortly after shedding. The only mandible from a juvenile animal (PAD 28.8.69/1) originated from a roe deer, and was found in a Mesolithic occupational context (*cf. Borić 2002.App. 3*). Based on the presence of alveoli for D2-D3, D4 and a fragment of M1 (Fig. 8), it was determined that the animal was between four and eight months old (*cf. Carter 2006*), which suggested that it was captured between September and January.

In terms of fish remains, a specific feature of the faunal assemblage from Padina (even in comparison with other assemblages collected by hand) is the absolute predominance of catfish (69.9% of all identified fish remains, and 77.1% of all fish remains identified to species) and least species diversity (Tab. 4) (*Živaljević in prep.*). Moreover, judging from the species distribution in AMS dated contexts (*cf. Whittle* et al. *2002; Borić, Miracle 2004; Borić 2011*) and in contexts attributed to particular phases on the basis of stratigraphy (*cf. Borić 2002.App. 3*), it was determined that catfish remains become exceptionally abundant in the Transformation phase of the settlement. This could suggest that Padina established itself as a specialised centre oriented towards catching catfish during this time (*Živaljević in prep.*). Catfish is most successfully caught during its spawning season (from May to July) and during summer months, when it feeds most intensely (*Ristić 1977; Simonović 2001; Kottelat, Freyhof 2007; Dinu 2010*); however, given that the species is stationary, and hardly moves from its respective habitat (*Ristić 1977*), it can be hypothesised that it was available for most of the year. During cold seasons, however, catfish populations would decrease in number, as the species requires a water temperature of at least 18°C to reproduce (*cf. Bartosiewicz, Bonsall 2004.Tab. 7*). As already suggested, the harsh winter seasons and periods when the river was covered in ice could be overcome by storing fish by smoking and drying (*cf. Bonsall 2008; Borić 2002; 2007*). In addition, the presence of anadromous sturgeons and vyrezub in the faunal assemblage suggests that freshwater fish exploitation at Padina was supplemented with fishing of seasonally available species, most notably in spring and autumn.

Bird remains are few in the faunal assemblage from Padina, which is suggestive of opportunistic exploitation; however, it is probably also a consequence of the sampling bias. The faunal assemblage consisted of the remains of six resident and three migratory species, some of them available in the Danube Gorges area for fairly short and seasonally limited periods of time (Tab. 5). Such is the case with the shelduck (*Tadorna tadorna*), which is present only in March and September-October, and white pelican, present in October-November. The black-throated diver (*Gavia arctica*) is present in the area from November to March (*Rašajski, Kiss 2004*), whereas in Central Europe it migrates in spring and autumn (*Clason 1980*). As already noted, the numbers of some of the resident populations (such as cormorant) increase in winter (*cf. Clason 1980; Rašajski, Kiss 2004*), which tentatively suggests they could have been exploited more frequently during this time.

Discussion

An important issue to be addressed here is whether permanent, year-round occupation can be distinguished from a series of repeated visits, of varying du-



Fig. 8. Roe deer mandible with alveoli for milk molars (D2-D3), last milk molar (D4) and a fragment of the first permanent molar (PAD 28.8. 69/1) from a Mesolithic occupational context at Padina. The animal was between 4–8 months old, suggesting the capture occurred between September and January.

ration, occurring at different seasons throughout the year? (*cf. Whittle 2001; Conneller* et al. *2012*). This question, of course, remains very difficult to answer archaeologically. The patterns of food resource exploitation at Vlasac, corroborated with archaeological evidence, could be indications of the first scenario. The intensity of occupation in the Late Mesolithic phase (*c.* 7400–6300/6200 cal BC) is evidenced by several dug-out dwellings vaguely resembling the trapezoidal shape in plan, numerous stone-lined hearths which were constructed in the open or were originally incorporated into dwellings that left no trace in the archaeological record, over hundred buried individuals and an enormous assemblage of tools and animal bones (*cf. Srejović, Letica 1978; Nemeskéri 1978; Bökönyi 1978; Kozłowski, Kozłowski 1982; Roksandić 1999; 2000; Borić* et al. *2008; 2014*). The faunal assemblage from the new 2006–2009 excavations of the site, which contained most elements suggestive of kill seasons (namely, erupting teeth of young animals), seems to indicate year-round occupation of the settlement. The exploitation patterns of red deer, the most important game animal, do not suggest any significant seasonal hiatus. Similarly, wild boar and roe deer hunting does not seem restricted to a particular season. Although most elements utilised in this study indicated a relatively broad time span, those that provided most precise and temporally restricted seasonal estimates point to hunting events which took place in all seasons. The fishing activity is indicative of spring and autumn months, judging from the presence of anadromous vyrezub and various sturgeon species, but fishing at other times was certainly possible, given that freshwater species represented in the sample would have been available for longer periods of time. Moreover, the fish could have been stored for winter by smoking and drying.

The hand-collected faunal assemblages from Lepenski Vir and Padina offered much less information for precise season determination, but tentative estimates do not point to a particular season of hunting. Furthermore, it can be suggested that resource exploitation patterns observed in the Late Mesolithic would have continued in the Transformation phase settlements (*c.* 6200–5900 cal BC). Several fairly precise season estimates obtained from specimens related to the construction and use of elaborate trapezoidal-base buildings at Lepenski Vir offer important insights into the life-cycles of particular buildings and, consequently, of the settlement as a whole. It is evident that some of dwellings were abandoned at different times of the year, while others remained in use; this feature is also suggested by the secondary position of some of the sculpted boulders. The significance of both hunting and fishing activities, which took place simultaneously for most of the year, is particularly illustrated by caches of mammal and fish bones stuck together and formed over a short period of time. It remains unclear to what extent the observed differences in preferences for fish species at Lepenski Vir and Padina would influence the nature of occupation of these sites; the latter oriented mostly towards catfish available for most of the year, and the former exhibiting greater species diversity and a significant amount of seasonably available sturgeon. Whereas the environment of Lepenski Vir and other sites would have provided substantial means for occupation lasting throughout the year, the exploitation of seasonally available fish could have been vital in (re)creating memories, events and specific temporal perspectives (*Borić 2002*).

Conclusion

This study offers additional data supporting the hypothesis that a significant degree of sedentism in the Danube Gorges existed already in the Late Mesolithic, prior to, and independently of, the adoption of animal and plant husbandry. Furthermore, recent studies of other Mesolithic contexts in Europe provide evidence of practices involving prolonged stays of human groups in certain locations; for example, the construction (involving a significant amount of time and effort) of substantial timber structures at Starr Car in Britain (*Conneller* et al. *2012*) and large-scale food storage and fish fermentation, implying a delayed-return subsistence strategy, at Norje-Sunnansund in Southern Scandinavia (*Boethius 2016*). Moreover, 'full-scale' sedentism commonly associated with food-producing communities could have also taken many different forms, including shifting cultivation crops or herds, and varying levels of mobility of individuals involved in such practices (*Whittle 2001*). These studies further problematise the relationship of sedentism and subsistence strategies, and add to our understanding of the complexity and diversity of forager and food-producing lifestyle and residential practices. In the Danube Gorges, evidence of Early Mesolithic occupation is relatively scarce, but the presence of several burials and stone constructions indicate a prolonged stay at riverine terraces. The higher resolution of dates, architectural features and artefacts related to the Late Mesolithic occupancy signal that by this time these locations were a home to fairly sedentary populations practicing an exclusively hunter-gatherer-fisher lifestyle.

Their environment enabled the successful exploitation of wild game and fish for most, if not the whole, of the year.

Therefore, it can be argued that the construction of later, Mesolithic-Neolithic Transformation phase settlements at Lepenski Vir and Padina took place in a context where continuous human occupation and relationship with particular locales had been long established. It can also be hypothesised that these settlements, with more elaborate and permanent dwellings, would have followed similar patterns of occupation. Although the changes observed in the Transformation phase largely coincide with the emergence of the first food-producing communities in the region (and contacts with distant communities are evident already in the Late Mesolithic), certain (but not all) elements of Neolithic lifestyles were incorporated only after "*they made sense in local terms*" (*Borić 2007*). Most notably, animal husbandry had fairly little impact on the economy and lifestyle of Upper Gorge communities, with the remains of the first domesticates appearing only after most of the trapezoidal buildings had been abandoned. It can be assumed then, that local traditions, established in a particular environment and involving locally available resources, merged with new cultural elements in the later parts of the sequence, played substantial roles in settlement practices in the Danube Gorges context.

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TAXON	INV. NO.	ELEMENT	WINTER			SPRING			SUMMER			AUTUMN			Reference where the age stage has been defined
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Red deer *Cervus elaphus*	VL 29/1	skull fragment with antlers													*Schmidt 1972*
	/	unshed antler (9)*													*Schmidt 1972*
	/	shed antler (31)*													*Schmidt 1972*
	VL 216/15	maxilla sin. (D3, 4)													*Carter 2006*
	VL 145 x.5	P4 inf. dext.													*Carter 2006*
	VL 204/5	D3 sup.sin.													*Carter 2006*
	VL 209 x.1	P4 inf. dext.sin.													*Carter 2006*
	VL 224/6	D2 inf.dext.													*Carter 2006*
	VL 237/4	I3, Di2, Di3 sin. & Di2, Di3, Dc dext.													*Habermehl 1985*
	VL 264 x.2	D3 sup.dext.													*Carter 2006*
	VL 286/3	M2, M3 inf. dext.													*Carter 2006*
	VL 306/24	P2 inf.sin.													*Carter 2006*
	VL 35/2	P4 inf.sin.													*Carter 2006*
	VL 66 x.2	P4 inf. dext.													*Carter 2006*
Roe deer *Capreolus capreolus*	VL 314 x.23	skull fragment with left antler													*Schmidt 1972*
	/	unshed antler (3)*													*Schmidt 1972*
	VL 51/1	D3/4 sup.sin.													*Carter 2006*
	VL 285/7	D2 sup.sin.													*Carter 2006*
Fox *Vulpes vulpes*	VL 222/22-23	Dc sup.dext. & M1 sup.dext. (germ)													*Habermehl 1985*
Wild boar *Sus scrofa*	VL 133 x.2	max. sin. (D4)													*Carter, Magnell 2007***
	VL 237/5	D3 sup. dext.													*Carter, Magnell 2007***
	VL 282/3	D2 sup.dext.													*Carter, Magnell 2007***
	VL 308 x.9	D4 inf.sin.													*Carter, Magnell 2007*
	VL 242/1	M2 inf.dext.													*Carter, Magnell 2007*

Tab. 1. Tentative kill season of mammals at Vlasac. Dark shades represent the most precise estimation of the season of capture, restricted to 1–2 months. All elements used for estimations of seasonality originate from the faunal assemblage collected in 2006–2009, apart from elements marked with an asterisk (*) which were collected in 1970–1971. **The ageing of wild boar maxillary teeth assuming they follow the same development schedule as mandibular teeth.

TAXON	INV. NO.	ELEMENT	WINTER			SPRING			SUMMER			AUTUMN			Reference where the age stage has been defined
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Red deer	PAD 8.70/279/1	unshed antler													*Schmidt 1972*
Cervus elaphus	/	shed antler (5)													*Schmidt 1972*
Roe deer	PAD 7.70/140/1	unshed antler													*Schmidt 1972*
Capreolus capreolus	PAD 8.69/80/1	shed antler													*Schmidt 1972*
	PAD 28.8/69/1	mandibula sin. (alv. D2-D3, D4, M1)													*Carter 2006*

Tab. 3. Tentative kill season of mammals at Padina.

TAXON	INV. NO.	ELEMENT	WINTER			SPRING			SUMMER			AUTUMN			Reference where the age stage has been defined
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Red deer *Cervus elaphus*	/	unshed antler (8)													*Schmidt 1972*
	/	shed antler (8)													*Schmidt 1972*
	LV 261/1-2	skull with shed antlers													*Schmidt 1972*
	LV 1074/5	maxilla sin. (D4, M1)													*Habermehl 1985*
	LV 1296/1	maxilla dext. (D3-D4, M1) & sin. (D4, M1)													*Habermehl 1985*
	LV 273/4	maxilla dext. (D3, P2-M3) & sin. (D3, P2- M2)													*Brown, Chapman 1991*
	LV bb-30/2	mandibula sin. (D2-D3, alv. D4, M1 bud)													*Carter 2006*
	LV bb-14/13	mandibula sin. (D2-D4)													*Brown, Chapman 1991*
Roe deer	/	unshed antler													*Schmidt 1972*
Capreolus capreolus	/	shed antler													*Schmidt 1972*

Tab. 2. Tentative kill season of mammals at Lepenski Vir. Dark shades represent the most precise estimation of the season of capture, restricted to 1–2 months.

TAXON	VL 2006–2009		LV 1968–1970		PA 1968–1970		WINTER			SPRING			SUMMER			AUTUMN		
	NISP	%	NISP	%	NISP	%	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Russian sturgeon *Acipenser gueldenstaedtii*	9	0,1	54	6,4	13	0,6												
Ship sturgeon *Acipenser nudiventris*	/	/	4	0,5	/	/												
Sterlet *Acipenser ruthenus*	/	/	9	1,1	1	0,0												
Stellate sturgeon *Acipenser stellatus*	5	0,1	7	0,8	16	0,7												
Beluga *Huso huso*	27	0,3	83	9,9	72	3,1												
Black Sea shad *Alosa immaculata*	92	1,1	1	0,1	/	/												
Common carp *Cyprinus carpio*	803	9,5	92	10,9	208	8,9												
Bream *Abramis brama*	22	0,3	/	/	/	/												
Danube bleak *Alburnus chalcoides*	2	0,0	/	/	/	/												
Asp *Aspius aspius*	8	0,1	2	0,2	/	/												
Belica *Leucaspius delineatus*	1	0,0	/	/	/	/												
Chub *Leuciscus cephalus*	/	/	3	0,4	/	/												
Ide *Leuciscus idus*	4	0,0	2	0,2	/	/												
Razor fish *Pelecus cultratus*	21	0,2	1	0,1	/	/												
Vyrezub *Rutilus frisii*	7320	86,4	257	30,5	162	6,9												
Pigo *Rutilus pigus*	2	0,0	1	0,1	/	/												
Roach *Rutilus rutilus*	1	0,0	/	/	/	/												
Rudd *Scardinius erythrophthalmus*	7	0,1	/	/	/	/												
Vimba bream *Vimba vimba*	4	0,0	1	0,1	/	/												
Wels catfish *Silurus glanis*	61	0,7	168	20,0	1806	77,1												
Pike *Esox lucius*	44	0,5	1	0,1	/	/												
Huchen *Hucho hucho*	29	0,3	154	18,3	65	2,8												
Black Sea trout *Salmo trutta labrax*	/	/	1	0,1	/	/												
Pikeperch *Sander lucioperca*	8	0,1	1	0,1	/	/												
TOTAL	**8470**	**100**	**842**	**100**	**2343**	**100**												

Tab. 4. Fish taxa identified to the species level from Vlasac, Lepenski Vir, and Padina expressed in NISP frequencies (after **Živaljević in prep.*****) and their seasonal availability on the basis of migration/spawning seasons, feeding seasons and optimal water temperature. Light shades – availability; dark shades – peak availability (after*** **Dinu 2010.Tab. 2; Bartosiewicz, Bonsall 2004.Tab. 7; Bartosiewicz *et al.* 2008.Tab. 6; Petrović 1998 [1941]; Ristić 1977; Simonović 2001; Kottelat, Freyhof 2007*****).**

TAXON	NISP				WINTER			SPRING			SUMMER			AUTUMN		
	VLASAC		PADINA	L. VIR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	1970–1971	2006–2009	1968–1970	1968–1970												
Black-throated diver *Gavia arctica*	/	/	1	/												
White pelican *Pelecanus cf. onocrotalus*	3	/	1	/												
Cormorant *Phalacrocorax carbo*	3	/	1	/												
Mute swan *Cygnus olor*	/	/	1	/												
Great white egret *Egretta alba*	2	/	/	/												
Mallard *Anas platyrhynchos*	2	/	/	1												
Teal *Anas crecca*	2	/	/	/												
Grey-lag goose *Anser anser*	/	/	2	/												
Ferruginous (?) duck *Aythya nyroca* (?)	1	/	/	/												
Shell-duck *Tadorna tadorna*	/	/	1	/												
Black kite *Milvus migrans*	5 (4)	/	/	/												
Imperial eagle *Aquila heliaca*	6 (16)	2	/	/												
White-tailed eagle *Haliaeëtus albicilla*	27 (0)	/	8	/												
Tawny owl *Strix aluco*	2 (1)	1	/	/												
Jay *Garrulus glandarius*	1	/	/	/												
Magpie *Pica pica*	1	/	/	/												
Raven *Corvus corax*	4	1	2	/												
Rook *Corvus frugilegus*	/	/	1	/												
Fieldfare *Turdus pilaris*	/	2	/	/												
TOTAL	59 (21)	6	18	1												

Tab. 5. Bird taxa identified to the species level from Vlasac (numbers in parentheses represent the revision of the preserved bird faunal assemblage analyzed by* Bökönyi 1978*, after* Dimitrijević *et al.* submitted*), Padina (after* Clason 1980*), and Lepenski Vir (after* Borić, Dimitrijević 2006*) expressed in NISP frequencies, and their seasonal availability on the basis of residency and migration patterns (after* Puzović 2000; Rašajski, Kiss 2004; Grubač *et al.* 2013; Clements *et al.* 2014*).

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Neolithisation of technology: innovation and tradition in the Starčevo culture osseous industry

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ABSTRACT – *The earliest Neolithic cultures in Southeast Europe brought significant changes in many aspects of everyday life, in subsistence, settlement patterns, architecture, and also ritual aspects. Technological changes are also very important – the introduction of completely new technologies, such as clay working, or new techniques in existing industries,* e.g.*, lithic, osseous,* etc*. The osseous industry is especially informative for questions on innovations and traditions, since it was well developed in both the Mesolithic and Neolithic periods. In Starčevo culture, certain Mesolithic traditions may be observed, such as techniques for antler manufacture; however, numerous innovations are also visible, particularly techno-types of Near Eastern origin such as spatula-spoons, the most characteristic bone techno-type of the Early Neolithic in South-east Europe, as well as diverse decorative items. Furthermore, new raw materials (bones from domestic animals) are introduced, and new techniques for manufacture and new tools. It is also interesting to observe that, although osseous materials remain the dominant raw material for personal ornaments, they are no longer used for artistic expression.*

IZVLEČEK – *Najstarejše neolitske kulture jugovzhodne Evrope so prinesle bistvene spremembe v aspektih vsakodnevnega življenja, v gospodarsto, poselitvene vzorce, arhitekturo, pa tudi v ritualne vidike življenja. Tehnološke spremembe so prav tako pomembne – uvajanje povsem novih tehnologij kot je obdelava gline ali vpeljava novih tehnik v obstoječe tehnologije obdelave npr. kamna, kosti itd. Predvsem obdelava kosti je izpovedna pri vprašanjih, ki so vezana na inovacije in tradicije, saj je dobro razvita tako v mezolitiku kot v neolitiku. V kulturi Starčevo lahko tako opazujemo nekatere mezolitske tradicije, kot je obdelava rogovja; kljub temu pa prepoznamo tudi številne inovacije, predvsem pri tehnoloških tipih, ki imajo izvor na Bližnjem vzhodu kot so žlice, najbolj značilen tip v zgodnjem neolitiku jugovzhodne Evrope, isto pa velja za raznorazne dekorativne izdelke. Značilna pa je tudi uporaba novih vrst surovin (kosti domačih živali) in uporaba novih tehnik obdelave in izdelava novih orodij. Zanimivo je, da izdelki iz kosti ne predstavljajo več umetniško izražanje, čeprav ostaja kost poglavitna surovina za izdelavo osebnih izdelkov oz. okraskov.*

KEY WORDS – *osseous raw materials; technological choices; technological innovations; Starčevo-Körös-Criş culture*

Introduction

Although often considered as being completely determined by environmental constraints and ergonomic factors, technology is actually a social phenomenon closely linked with diverse social, cultural and economic aspects (*cf. Lemonnier 1992; 1993*; see also *Killick 2004*). According to Pierre Lemonnier (*1992*), the study of technology should not be limited to its effects on society; technologies must be considered in a general anthropological perspective as social productions that are determined by, and compatible with, other social phenomena. Technologies must not be seen only as constraints; the social aspect of material culture must also be taken into consideration (*Lemonnier 1992; 1993; Pfaffenberger 1992*).

An important characteristic of all technologies is their systemic aspect. Every technique has five relat-

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ed components: matter, the material on which technique acts; energy, *i.e.* the forces which move objects and transform matter, tools or means of work; gestures, which move the objects involved in a technological action, and, finally, specific knowledge, which may be conscious or unconscious. Furthermore, all these techniques form a system, and, within this system, multiple interactions exist between the tools, the material that is being transformed, the actions and the knowledge needed to transformation it. All these elements are interdependent; diverse techniques in a given society can share the same resources, the same knowledge, the same tools and the same actors. One technique may use the products of the others; techniques may share operational sequences or technical principles. This creates multiple relations of interdependence among them; variations in any of the five technical elements causes changes in others, and any alteration within one technology influences modifications in others (*cf. Lemonnier 1986; 1992*).

In terms of the meaning and importance of some technology within a given society, we may group them into practical and prestigious ones (*cf. Hayden 1998*). Practical technologies are used to solve practical problems of survival and basic comfort, such as providing food or shelter, and their most important principle is to perform required tasks in an efficient and effective way. However, there are different kinds of constraints operating in the development of solutions for each problem, such as functional requirements, material properties, availability, and production costs. It is unlikely, therefore, that there will be a single optimal solution for every problem. The criteria used in choosing between alternative technological solutions are how effective and how costly each solution is, but also the choice of the solution that is adopted may largely depend on culture tradition, ideological values, style, *etc*. (*Hayden 1998*).

Prestigious technologies, on the other hand, display power, wealth, prestige, success. Prestigious artefacts are not created to perform a practical, but a social, task, and they play a key active role in the acquisition of status and power. The purpose is to solve a social problem or to accomplish a social task, such as attracting allies, or bonding members of social groups together. Therefore, the logic and strategy for creating prestige artefacts are fundamentally different from the logic and strategy for creating practical ones. Prestige technologies employ as much surplus labour as possible to create objects that will attract and draw attention, status and prestige to the owner (*Hayden 1998*). Analysing the appearance and development of prestigious technologies among hunter-gatherer communities, Brian Hayden (*1998. 17–18*) also argued that many, perhaps even all, of the technological achievements were initially developed as prestige technologies and only later evolved into more practical applications such as pottery, metalworking, domestication of plants and animals, *etc*.

Not only are technological choices influenced, even directed, by cultural and social phenomena, but specific technological traits may be cultural and chronological markers, and the technology itself may be used to display identity, status and/or prestige, to emphasise group identity, for example (*e.g., Wake 1999*). Even a skill itself may be valued (*cf. Sinclair 1995; 1998*), and it may have been used to display or increase the prestigious status of the artisan who produced certain skill-demanding items.

The archaeological background

The Early Holocene in the central Balkan area is marked by a specific Mesolithic culture, labelled after the eponymous sites Lepenski Vir or Lepenski Vir-Schela Cladovei culture. All the sites were discovered in the Iron Gates region, part of the Danube valley and present-day border between Serbia and Romania: Lepenski Vir, Vlasac, Padina, Hajdučka Vodenica and Kula on the Serbian side of the Danube, and on the Romanian side sites at Alibeg, Cuina Turcului, Icoana, Ostrovul Banului, Ostrovul Corbului, Răzvrata, Schela Cladovei, Ostrovul Mare, *etc*. (*Bonsall 2008; Borić 2002; Boroneanţ 1970; 2000; Radovanović 1996*). Absolute dates for the Lepenski Vir site show that the earliest Mesolithic occupation began around 9400 cal BC, while the trapezoidal houses had been abandoned by around 5900 cal BC (*Borić, Dimitrijević 2007*; for more dates see also *Bonsall 2008* and references therein).

Whether these communities were mobile or sedentary is still a subject of research; a certain level of sedentarism, however, may be observed. These communities practiced hunting of the game abundant in the forests in the area, and also fishing, in particular fishing for large migratory fish (*Bökönyi 1978; Bartosiewicz* et al. *2008; Clason 1982; Dimitrijević 2008; Dinu 2010*).

A very peculiar material culture is the hallmark for the Iron Gates Mesolithic, with spectacular non-utilitarian items, which included ornamented stones discovered at several sites, and even sculptures

placed within trapezoidal structures at the Lepenski Vir site. Also, rich and diverse lithic and bone industries were uncovered (*cf. Antonović 2006; Bačkalov 1979; Beldiman 2007; Radovanović 1981; 1996; Vitezović 2011b*).

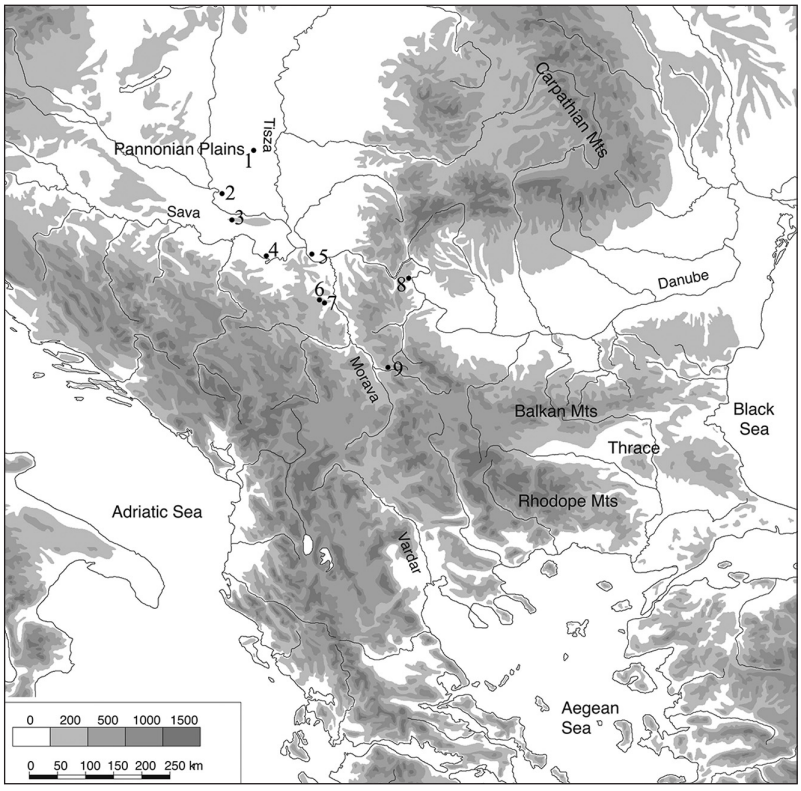
The Early Neolithic introduced numerous innovations – not only farming and animal husbandry, new plant and animal species, but also changes in ways of life and worldviews (*cf. Hodder 1990; Cauvin 1997*). The earliest Neolithic communities in the central Balkan region were part of the Starčevo-Körös-Criş cultural complex (for absolute dates, *cf. Whittle* et al. *2002*). The Neolithic settlers were a new population in the region; however, the nature of their relations with the Mesolithic communities is still not entirely clear (*cf. Bonsall 2008.267–278*).

Starčevo communities were agricultural; they practised farming and animal herding, although hunting and gathering also played a certain role in subsistence (*cf. Filipović, Obradović 2013; Clason 1982; Greenfield 2008*). Settlements consisted of semi-dugout pit-dwellings and huts above ground made from wattle and daub. Their material culture brought in numerous innovations, the most important and most conspicuous being the introduction of clay technology: ceramics were used for daily and storage pots, everyday artefacts such as weights, but also figurines and other cult objects (so-called altars, *etc*.) (*e.g., Vuković 2013*).

Changes in other technologies may be observed as well; lithic and osseous tools are now adapting to new materials and new tasks connected with agricultural activities, life in villages, *etc*. We can assume that perishable technologies changed as well (leather, textile, wood working). In the lithic industry we may note in particular the introduction and more widespread use of polished stone artefacts (axes, adzes, chisels, *etc*.) and ground stone artefacts (whetstones, grindstones, *etc*.) (*Antonović 2003*).

Bone technology in Starčevo culture

Osseous tools had an important role in craft production and daily activities, and also other utensils and personal ornaments were made from these raw materials. The bone industry shows certain traits that can be characterised as Mesolithic traditions, but also numerous innovations, including Near-Eastern influences. The bone industry from the following sites was included in the analysis: Donja Branjevina, Starčevo-Grad, Golokut-Vizić, Obrež-Baštine, Ludaš-Budžak, Divostin, Grivac, Tečić, Drenovac, Ušće Kameničkog Potoka, Knjepište, Velesnica, Bubanj, Pavlovac-Kovačke Njive (*Vitezović 2011a; 2011c; 2012a; 2013a; 2014*) (Map 1). Some of these sites were excavated in the first half of the 20th century and not all of the faunal remains were carefully collected, so the data are not of equal quality, but these assemblages still yielded important information on the osseous industries.



Map 1. Starčevo culture sites mentioned in the text:* 1 *Ludaš-Budžak,* 2 *Donja Branjevina,* 3 *Golokut-Vizić,* 4 *Obrež-Baštine,* 5 *Starčevo-Grad,* 6 *Grivac,* 7 *Divostin,* 8 *Velesnica (Ušće Kameničkog Potoka and Knjepište are located near-by) and* 9 *Pavlovac-Kovačke Njive.

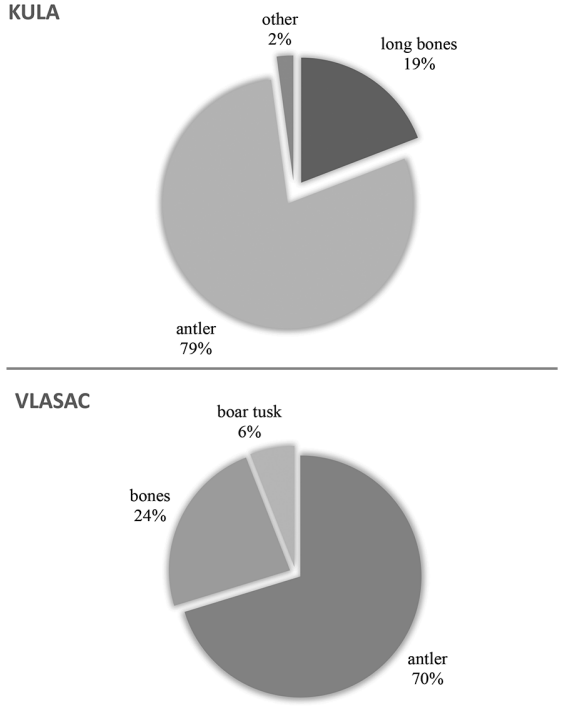
Choice of raw material

Osseous raw materials used for craft production may be acquired directly, obtained either from animals killed for food, or collected (for example, shed antlers or mollusc shells), or indirectly, acquired through trade and exchange (for example, mollusc shells from distant regions). In all prehistoric

communities, locally and directly acquired raw materials comprise the majority within osseous industries. However, this does not imply that all the available skeletal elements were unselectively used, but certain choices among available raw materials were made, directed by their physical and mechanical traits as well as by cultural preferences (*cf. Choyke 2013* and references therein).

The Mesolithic bone industry in the Iron Gates region is marked by the predominant use of red deer antlers (chiefly from killed animals, although shed antlers were present as well) and also diverse bones from hunted animals (auroch, red deer, roe deer), especially large long bones from large mammals used for diverse cutting and burnishing tools, followed by boar tusks and the occasional use of imported mollusc shells (*cf. Bačkalov 1979; Beldiman 2005; 2007; Cristiani, Borić 2012; Vitezović 2011b*; precise numerical data are not available for all the sites; see Table 1 for the data from the sites at Kula and Vlasac, after *Vitezović 2022b* and *Radovanović 1996.253*).

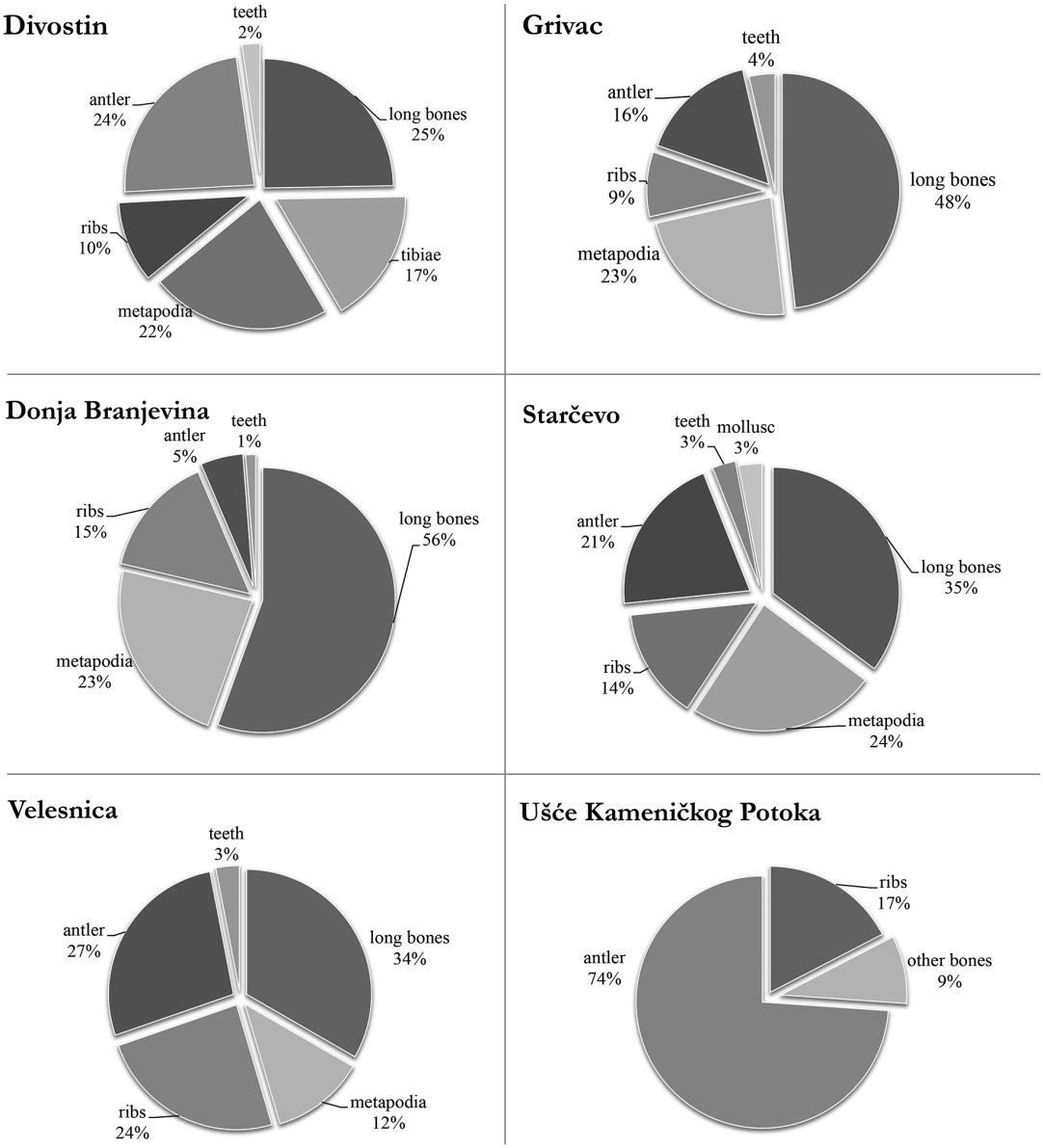
In Starčevo culture, the situation is somewhat different, as the antler ratio decreases and bones are predominant, particularly those of domestic animals prevail (for the antler and bone ratio, see Table 2). We may also observe a strict selection of both skeletal elements and species. Ovicaprine bones (especially metapodia and tibiae) were best represented, followed by cattle metapodia and other ungulate long bones and ribs, mainly from domestic cattle and occasionally aurochs, red deer and roe deer (however, for ribs and some long bone segments, it is not possible to determine the species with certainty, so the percentages cannot be calculated accurately) (*Vitezović 2011a; 2011c; 2013a*). Antlers were mainly from red deer, with the occasional use of roe deer antlers, in most cases shed, probably collected in the relative vicinity of the settlement. There are certain differences between the Starčevo sites in the antler ratio; for example, they are abundant at some of sites, while almost completely absent at others, probably reflecting regional differences in economic aspects (*cf. Vitezović 2011a; 2013a; 2014*). Boar tusks (of wild and domestic pig) were used for tools and decorations, and also diverse teeth of other species, mainly wild (such as red deer canines), served as decorative items (*Vitezović 2012a; 2014*). *Dentalium*, *Spondylus* and *Glycymeris* mollusc shells were present; *Dentalium* beads were found only at Starčevo, while *Spondylus* and *Glycymeris* bracelets and other ornaments were found at the sites of Starčevo, Divostin and Drenovac (*Vitezović 2012a*).



Tab. 1. The use of different osseous raw materials in the Mesolithic. Examples from the sites of Kula and Vlasac.

It is interesting to note that the domestic animal bones were the most prevalent raw material at all Starčevo culture sites (however, as mentioned above, exact ratios cannot be determined), although there is a difference between the sites in the wild/domestic animal ratio. At Golokut, for example, wild animals were predominant, but exploited raw materials do not differ significantly from, for example, Donja Branjevina, where domestic fauna were dominant (*cf. Blažić 1984–1985* and *Blažić 2005.74–76* respectively). At Starčevo site, the ratio of wild pigs is notable (*Clason 1982*), although boar tusks do not stand out particularly in quantity in comparison with other sites.

This prevalence of domestic species in the raw material choices certainly points to cultural attitudes to species. An interesting case study comes from the southern Levant, where the bone tool assemblages from several subsequent periods were analysed, with the focus on the change from gazelle bones to caprinae bones (*Le Dosseur 2010*). During the Natufian and PPNA, gazelle bones were the predominant raw material. During the middle PPNB, an increasing number of caprines is noted in the faunal record, while the gazelle were still the preferred choice of raw material, even though goats were much more



Tab. 2. The use of different osseous raw materials in the Early Neolithic. Examples from the sites of Grivac, Divostin, Starčevo, Donja Branjevina, Ušće Kameničkog Potoka and Velesnica.

numerous in the faunal assemblage. An important change occurred during late PPNB; caprine bones became the main choice of raw material, in particular those of sheep, which also increased in the faunal assemblage. Although some of this change may be purely technological (gazelle bones may be longer and thus more convenient, *etc.*), such a change also includes changes in attitude to the newly introduced animals. This shows that a certain time is needed for domestic animals to be fully adopted and included in all segments of life and in diverse aspects of consumption.

Manufacturing techniques

Most of the manufacturing techniques encountered within the Starčevo culture have much in common with techniques practised throughout prehistoric Europe (*cf. Beldiman 2007; Sidéra 2005; Stratouli 1998, inter alii*). Some of the *débitage* techniques for antler artefacts show certain similarities with Mesolithic technology, in methods of detaching blanks, in shaping cutting tools, *etc*. (*cf. Vitezović 2014*).

Several distinct technological features may be observed in the manufacturing process, including some technical procedures typical of the Early and Middle Neolithic in Southeast Europe.

The main innovation in Neolithic technology was the widespread use of abrasion, directly linked with the introduction and widespread use of abrasive stone tools (*cf. Antonović 2003*). Most of the bone

and antler objects were finished by abrasion; their distal ends are modelled by grinding and burnishing with diverse, coarse- and fine-grained stone tools, or entire surfaces are finely burnished and polished.

Pointed tools (awls, needles) made from small ruminant metapodials present a particularly interesting method of shaping. This tool type was widespread in Europe throughout the Neolithic period (*e.g., Bačkalov 1979; Beldiman 2007; Makkay 1990; Sidéra 2005; Stratouli 1998*). Three distinctive manufacturing methods were in use: (1) manufacture using abrasion only; (2) manufacture by first sawing the metapodia in half and then abrading it; and/or (3) manufacture by first abrading and then by sawing (*cf. Murray 1979, Sidéra 2005*) (Figs. 1, 2).

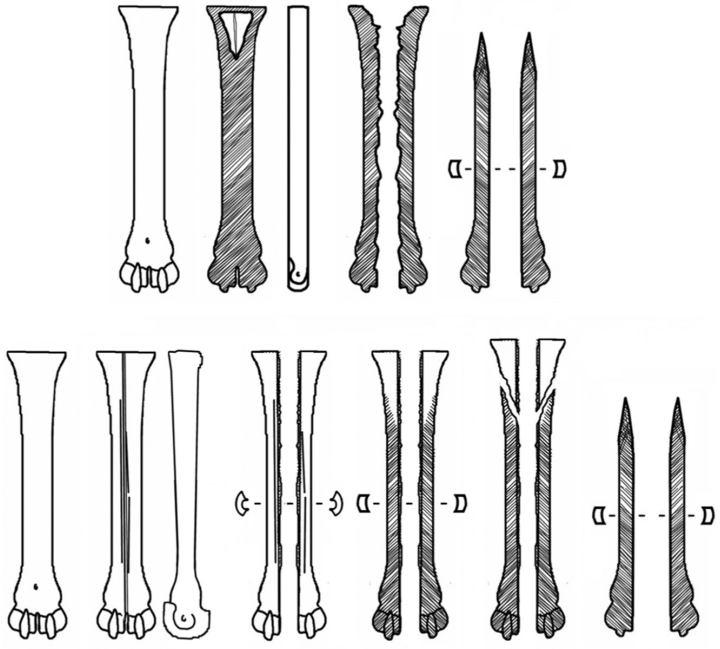


Fig. 1. Reconstruction of methods of making pointed tools from metapodial bones (after* Sidéra 2005*).

All three techniques for shaping were quite well represented in Starčevo-Körös-Criş culture and the Early and Middle Neolithic in the region (*cf. Beldiman 2007; Beldiman, Sztancs 2011; Makkay 1990; Tóth 2012; Stratouli 1998*). In the first and third method, the metapodial bone is first ground with an abrasive stone on both sides (dorsal and ventral) until it becomes flat. It may then be further shaped by abrasion only, or by a combination of cutting with a flint tool and abrasion (Figs. 1, 2). This results in very thin, fine points (Fig. 3). The distal epiphysis, usually preserved at the base, may be reduced to a very small, almost flat knob or simply ground from all sides, thus obtaining a more or less regular square shape. This method allowed more precise shaping, but limited the number of artefacts which could have been fashioned from a single piece of raw material. The second method may enable a maximum of four tools from a single bone, while the results were not so fine, but more resilient, stronger awls. In later periods, methods that included abrasion as the first step disappeared, and the second technique became predominant (*cf. Bačkalov 1979; Russell 1990; Vitezović 2007*).

Also, the method of transversal division into segments was new; this was done by making a groove along the circumference of the bone and then the final millimetre or so of the bone was simply snapped or broken off. A groove could have been made with a flint tool, or by abrasive fibre, or a combination of the two (Fig. 4). The transversal cutting of bones, especially large and thick long bones of large mammals was quite difficult, but this method produced blanks of regular shape, which was not possible by breaking or chopping. This technique was not noted in the Mesolithic and seems to be disappearing with the Late Neolithic period in the region (*cf. Bačkalov 1979; Russell 1990; Vitezović 2007*).

Another specific technique is the method for making large perforations. Besides the widespread method of making perforations by drilling with a flint borer (with sand added) to obtain smaller holes (5–8mm in diameter), there was another method for making larger holes (1–1.5cm in diameter) with a tubular, hollow tool instead (perhaps some sort of reed tube or something similar), with an abrasive substance added (*e.g.*, sand) (Fig. 11; *Vitezović 2013b*). These large perforations leave distinctive debris in the form of small circles, as discovered at several sites of the Starčevo-Körös-Criş cultural com-

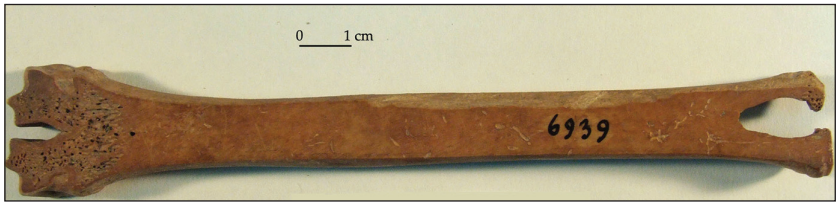


Fig. 2. Ovicaprine metapodial bone, completely ground – blank for producing pointed tools from Starčevo-Grad.



Fig. 3. Fine awls obtained only by abrasion from Donja Branjevina.

plex (*cf. Beldiman, Sztancs 2011; Makkay 1990; Tóth 2012*; see also *Vitezović 2013b* and references therein).

Techno-types

Numerous tools have simple, widespread shapes that are not culturally or chronologically characteristic such as awls from longitudinally split long bones, scrapers from ribs, *etc*. The morphological traits of most antler tools do not differ significantly from their Mesolithic counterparts such as chisels, wedges, axes, adzes, hammers, small punching tools (*cf. Vitezović 2014*). In particular, retouching tools may be considered as result of much longer traditions. Also, some other tools have the same or minimally modified morphology, such as boar tusk scrapers, spatulae and other burnishing tools, *etc*.

Several new techno-types are introduced with the Starčevo culture. According to Isabelle Sidéra (*1998*), Anatolian influences, present in the osseous industries in Southeast Europe, included the presence of some or all of the following techno-types: pointed tools and tools with a cutting edge made from small ruminant tibiae, antler sickles, elaborated fishhooks, needles with perforation made by incision, buckles, crude axes, beads from bird bones, and spoons (*cf.* also *Dekker 2014; Marinelli 1995; Russell 2006; 2012*).

The presence and quantity of these techno-types varies at different Starčevo culture sites; for example, at some, none were identified, while they were relatively numerous at the others (see Table 3 for details).

From Starčevo culture, only one antler sickle has been discovered, a fragmented piece from Ludaš-Budžak (*Vitezović 2014.168*). Needles with perforations made by incision are virtually unknown, with only one being found at Pavlovac-Kovačke Njive (*Vuković* et al. *2016*), while crude axes and beads from bird bones have not been encountered. Elaborated fishhooks are also rare; only a few were discovered at Donja Branjevina (*Vitezović 2011a; 2011c*) (Fig. 5).

Spatulae-chisels from ovicaprine tibiae were discovered at Grivac, Divostin, Rudnik near Srbica and Pavlovac-Kovačke Njive (*Vitezović 2011a; Vuković* et al. *2016*) (Fig. 6). The largest number was noted at Divostin; however, they are not numerous and, in general, not as important as, for example, in Bulgarian Karanovo I–II culture (*cf. Lang 2004*).

The most important techno-types of Anatolian origin among the Starčevo bone artefacts are spatulae-spoons and several decorative items. Spatulae-spoons were widespread in the Near East (*cf. Dekker 2014*), and are abundant throughout the entire Starčevo-Körös-Criş cultural complex (*cf. Beldiman 2007; Beldiman, Sztancs 2011; Makkay 1990; Nandris 1972; Tóth 2012; Vitezović 2011a; 2011c; 2013a*) as well



Fig. 4. Manufacture debris with traces of unfinished transversal cutting, from Starčevo-Grad.

as within Karanovo I–II culture (*cf. Lang 2004; Zidarov 2014*).

Spatulae-spoons were made exclusively from large ungulate metapodial bones, probably all from *Bos*. Although it was suggested by John Nandris (*1972*) that only bones of the wild species *Bos primigenius* were in use, it seems that Starčevo examples were probably all from *Bos taurus*. Spatulae-spoons have elongated handles with cylindrical or oval cross-sections, straight or gently curved, and a bowl at the distal end, usually completely flat or slightly concave. Bowl shapes vary: they may be elongated, leaf-shaped, shorter, triangular, or, rarely, oval (Figs. 7, 8).

Zoomorphic handles, known from Anatolian sites, have not been discovered; however, it should be noted that one projectile-shaped artefact from Donja Branjevina, probably a re-worked spoon, had a zoomorphic base (*Vitezović 2011c.31*). Also from Donja Branjevina, one fragmented piece has a peculiar base, decorated with two rows of incisions (*Vitezović 2011c.Fig. 18/2*), and from Tečić may be mentioned one example with incisions on both sides on basal part of the bowl (Fig. 8). No other decorations were discovered (for example, notches, known from Anatolian sites, *cf. Dekker 2014*).

Spatula-spoons were produced through several stages of cutting, scraping, burnishing, polishing, *etc*. (*cf. Nandris 1972; Sidéra 2013*), and, according to the experimental work of Isabelle Sidéra (*2013.174*), this manufacturing technique demanded a lot of time, over 25 hours of work in total, and also a lot of skill. All these artefacts were used intensively; the bowls show high polish and shine, and at the same time, the bone is flattened, worn out and abraded from use. Edges are sometimes broken or damaged from use, and on some bowl segments it may be seen that they continued to be in use even after the breakage. Also, a high level of polish and shine, as well as fine striations, often spread over entire surfaces, may be noted. Their function is still not clear; the intensive usewear, especially damage, was interpreted as being related to contact with either clay or stone (*cf. Georgiev 1967; Nandris 1972*). They may have been used on special occasions, and their original purpose may have been related to processing different plants, perhaps 'special' plants, such as medicines or spices. They might have also served as cosmetic tools (*cf*. also *Dekker 2014; Russell 2006; 2012*). In Starčevo culture, they were used for a long time and often repaired, so it may be assumed that their original function was rather important (*Vitezović 2011a*). Their final function was probably as



Fig. 5. Elaborated fishhooks from Donja Branjevina.

Sites	Spatulae-chisels from ovicaprine tibiae	Spatulae-spoons	Buckles in shape of open bracelet
Donja Branjevina	/	42 (out of 344 total osseous artefacts)	2 (out of 6 total decorative items)
Starčevo-Grad	/	41 (out of 250 total osseous artefacts)	5 (out of 21 total decorative items)
Golokut-Vizić	/	1 (out of 39 total osseous artefacts)	4 (out of 7 total decorative items)
Obrež-Baštine	/	3 (out of 27 total osseous artefacts)	2 (out of 3 total decorative items)
Divostin	17	1 (out of 96 total osseous artefacts)	/
Grivac	1	1 (out of 58 total osseous artefacts)	2 (out of 6 total decorative items)
Tešić	/	1 (out of 4 total osseous artefacts)	/
Bubanj	/	1 (out of 16 total osseous artefacts)	/
Velesnica	/	3 (out of 39 total osseous artefacts)	/
Ušće Kameničkog Potoka	/	/ (total of 23 osseous artefacts)	/

Tab. 3. The presence of different tool types of Near Eastern origin at Starčevo culture sites.



Fig. 6. Spatula-chisel from ovicaprine tibia from Pavlovac-Kovačke Njive.

some sort of burnisher, as suggested by the presence of the high level of polish and shine consistent with prolonged contact with soft organic materials, such as leather, hide and plant fibres (*cf. Peltier 1986; Maigrot 2003; Legrand 2007*; also *cf.* observations by *Tóth 2012.175*).

Projectile points comprise a very interesting group of artefacts, among which three sub-types may be outlined: two of these show technological and morphological connections with Mesolithic ones, but the third subtype is technologically connected with spatulae-spoons; furthermore, some of these are reworked broken spoons (Fig. 9) (*Vitezović 2012b*).

The new artefact types also include several decorative items. This includes buckles in the form of an open bracelet, all made from long bones of considerable size, from large ungulates, probably *Bos*. Bones were cut transversally by making a groove with abrasive fibre, and then by cutting the bone with a flint tool. All these objects have carefully shaped heads made by cutting with a flint tool, and all the surfaces were carefully polished with some fine-grained stone. However, their original shape is unknown – whether they were in the form of a half-circle or almost full circle – as they are all broken in the middle. This breakage is probably due to use; these peculiar artefacts may have been used as some sort of belt buckle or clasp for clothing (Fig. 10). Similar to those, probably a morphological variation,

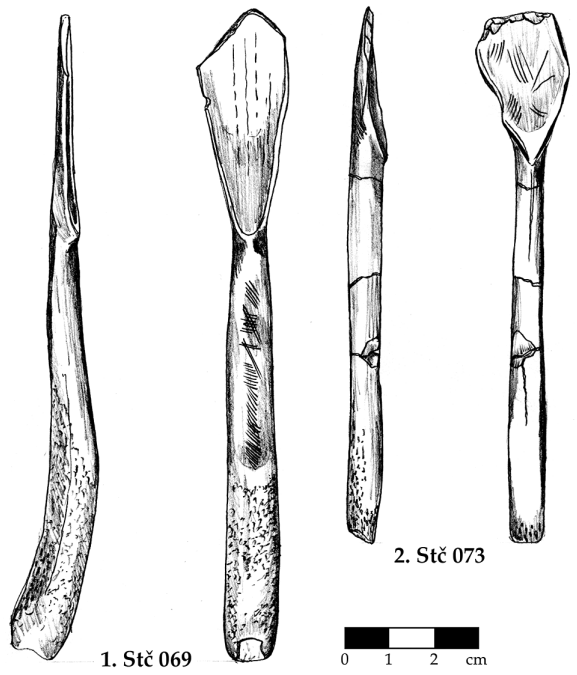


Fig. 7. Spatula-spoons from Starčevo-Grad.



Fig. 8. Spatula-spoon from Tečić.

are buckles in the form of buttons with a rounded head made from a piece cut out from a long bone, finely polished.

Among the region- and culture-specific decorative items rings, disks and rectangular plates with large holes may also be included, all of similar morphology with slight variations, obtained by use of the above-mentioned specific techniques of transversal cutting or making large perforations (Fig. 11). They were made either by transversally cutting large long bones (ring-shaped pieces) or from diverse flat pieces of bones, mainly from diaphyses of large long bones, by cutting, burnishing and polishing and by making large holes with a hollow tool (discs and rectangular perforated plates) (*Vitezović 2013b*).

There is one more trait that shows Near Eastern influences – tools with serrated (denticulated or notched) edges. Different artefact types may have one or more edges with dents or notches that are either purely decorative or may have certain function. Two artefacts from Divostin of unknown function (Fig. 12), as well as several diverse artefacts, spoons, awls, burnishers, have certain parts with wide U-shaped notches or dense incisions that create wavy or denticulated edges. The level of use wear differs in them and it is difficult to determine their function. They may have been used for making decorations on other, soft materials (such as textile); however, no experimental work has been conducted yet. Similar serrated artefacts are encountered in other Pre-Neolithic and Neolithic cultures in the Near East and in Southeast Europe. Several morphologically similar artefacts were discovered at the site of Tell Mureybet with traces of use that cover the range from modest polish up to completely used dents. Several hypotheses on use were offered; however, the experimental work conducted by Rozalia Christidou was inconclusive (*Stordeur, Christidou 2008.522–528*). As for our examples, a small number of finds and large variations in form further complicate the interpretation of the function and must await future new finds and experimental work.

The most important difference in the use of osseous raw materials between the Mesolithic and Starčevo populations in the Balkans is in their symbolic use. In the Mesolithic, decorations may occasionally be found on non-worked skeletal elements (such as antler segments, such as a roe deer antler from Vlasac, *Srejović, Letica 1978.T LXX*) or finished and used tools (such as a possible retouching tool from Vlasac, *Srejović, Letica 1978.T. LXXVI*, and more examples in *Boroneanţ 1970; 2000; Radovanović 1996*). These were mainly incised decorations that formed net, zig-zag or wavy motifs. In Starčevo culture, decoration has not been discovered on any bone artefacts. However, in both cultures, osseous raw materials were widely used for decoration (*Bačkalov 1979; Vitezović 2012a*), as in

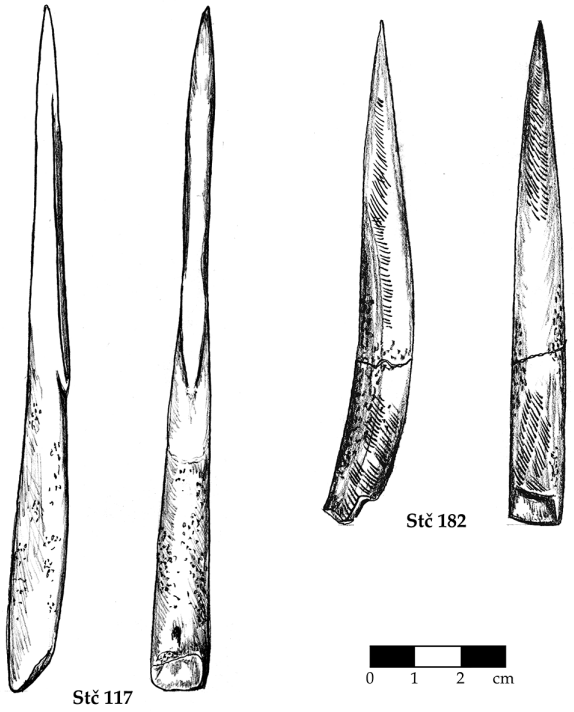


Fig. 9. Projectile points manufactured as spatula-spoons from Starčevo-Grad.

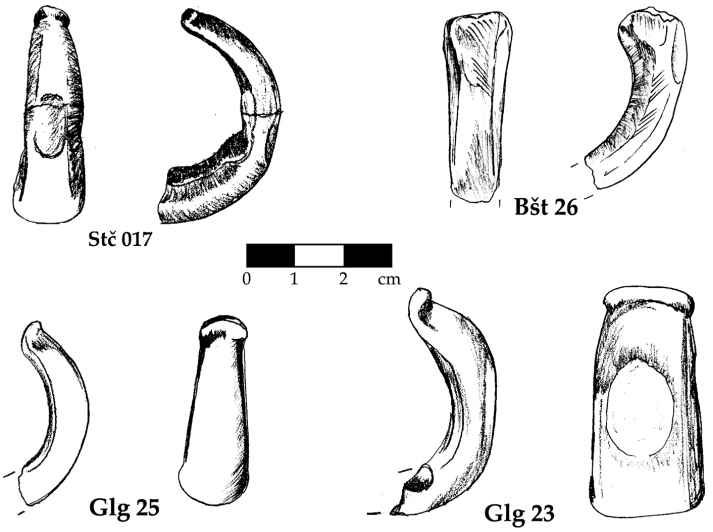


Fig. 10. Buckles in a shape of an open bracelet from Golokut, Baštine, and Starčevo-Grad.



Fig. 11. Decorative rectangular plates with large holes from Grivac.

numerous other prehistoric cultures across Europe and the Near East (*cf. Taborin 2004*).

Discussion and conclusion

The bone industry in the Starčevo culture was a well-developed and important craft, and osseous raw materials were important for producing diverse items, everyday tools and decorative objects. The osseous industry was also closely connected with other technological aspects of Starčevo crafts, displaying innovations connected with the introduction of the Neolithic way of life.

The acquisition and management of raw materials changed significantly as the economy changed. Sheep, goat and cattle bones now prevail, showing that domestic animals had been fully adopted and accepted in all aspects of the economy and consumption, and were not only acceptable, but preferable raw material for most daily tools. The predominant acquisition of shed antlers demonstrates close knowledge of the environment, as the red deer tend to shed their antlers in the same place every year (*cf. Clutton-Brock 1984*).

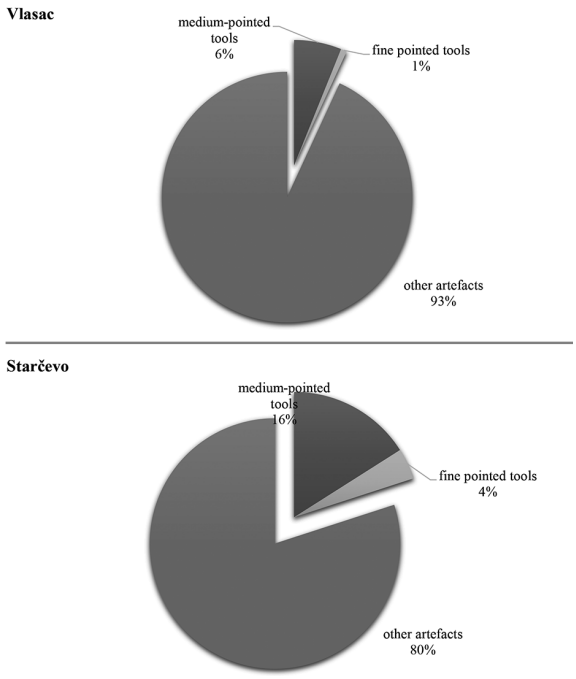
Manufacturing techniques also show innovations connected with modifications in other technologies. The most important change is the adoption and widespread use of ground stone tools for several finishing steps, burnishing and polishing. Furthermore, the application of this new method created technical procedures that may be considered as cultural-chronological markers.

Mesolithic traditions are present to a relatively low extent, and the question of their origin remains open. Some of Mesolithic traits may be considered characteristic of several Mesolithic populations, not only those from the Iron gates region; therefore, the question of contact with the Mesolithic Iron Gates population and its nature remains open.

The increased quantity of fine- and medium-sized pointed tools (needles, awls) (see Tab. 4), including



Fig. 12. Artefacts with notches from Divostin.



Tab. 4. The ratio of fine and medium pointed tools versus other artefacts. Examples from the sites of Vlasac (Mesolithic) and Starčevo (Early Neolithic).

very thin awls obtained through abrasion only, perhaps point to an increased production of perishable technologies, *i.e.* in processing plant fibres, leather, and hides.

Techno-types of Near-Eastern origin were present in most of the bone industries in Southeast Europe, but with significant differences in distribution, importance and technological modifications. In her analysis of new elements of Near-Eastern origin in Eastern Balkan bone industries, Sidéra (*1998*) noted that the style of production changes rapidly from one site to another. In the case of the Starčevo culture bone industry, we may note that only some of the 'package' of Anatolian influences was adopted; furthermore, some of what was adopted had already been partially altered (such as the forms and functions of spatulae-spoons). It is particularly interesting to note that decorative items, probably used to display status and/or prestige, show important Near-eastern influences, but again, in a somewhat modified way.

The most interesting examples are the projectile points, where a symbiosis of tradition and innovation may be observed: subtypes with Mesolithic forms and the introduction of a new subtype closely connected with the most important Near-Eastern artefact type, the spatula-spoon.

The most important difference between the Mesolithic (and earlier Palaeolithic traditions) is in the cultural attitude to osseous raw materials: they are no longer used for figural representations or decorations, while the new material, clay, is now preferred for diverse figural presentations and for objects of possible cultic function. Osseous raw materials are now predominantly used for daily tools, but retained their role for producing personal ornaments (*cf. Vitezović 2012a*).

The Starčevo culture osseous industry shows an interesting mix, preserving some techno-typological traits connected with Mesolithic tradition while introducing new techno-types, mainly of Near-Eastern origin, but somewhat altered during the process of adoption into the new cultural milieu. Technological traditions and innovations are never straightforward, or simply transferred from one culture to another, but must pass through a process of adoption and adaptation to the new economic, social and cultural environment.

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'Neolithisation' in the NE Sea of Azov region: one step forward, two steps back?

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ABSTRACT – *In this paper we present the migratory nature of an initial Neolithisation in the Sea of Azov area on the basis of an analysis of comparatively new and a revision of old materials from the Early Neolithic period. As the 'ancestral land' of elements of the Neolithic package, the region of Zagros Mountains is considered, from where communication with Lower Don across the Caucasian coast of the Black Sea and Sea of Azov or by sea took place in the PPNB period. It seems that infiltration did not lead to a strong Neolithic transformation as seen in other regions 'secondary Neolithisation',* e.g.*, in Europe. The choice of a place for repeated occupation, the organisation of the living area, way of life, subsistence, and perception of the world, for a long time remained typical of the foragers of river valleys, lake, and coastal areas of Europe. This pattern probably continued until the large-scale human movements of the Copper Age.*

IZVLEČEK – *V članku predstavljamo migracijsko naravo začetne neolitizacije v Azovskem morju na podlagi analize relativno novega in revizijo starega materiala iz obdobja zgodnjega neolitika. Elemente neolitskega paketa, ki prihajajo iz območja gorovja Zagros, razumemo kot 'deželo prednikov'; iz tega območja so v obdobju PPNB potekale komunikacije po kopnem ali po morju čez spodnji tok reke Don ter preko kavkaške obale Črnega in Azovskega morja. Opažamo, da infliltracija ni prinesla močne neolitske spremembe kot jo lahko opazujemo v drugih regijah kot pojav 'sekundarne neolitizacije' npr. v Evropi. Izbor prostora za ponavljajočo poselitev, organizacija življenjskega prostora, način življenja, gospodarstvo in percepcija sveta sta dolgo časa ostala tipična za nabiralniške skupnosti rečnih dolin, jezer in obalnih območij v Evropi. Ta vzorec se je verjetno nadaljeval do časa obsežnih premikov ljudstev v času bakrene dobe.*

KEY WORDS – *Sea of Azov region; Middle East; Neolithic; Neolithisation*

The puzzle of Neolithisation in the Sea of Azov area

There are different ways of elaborating the cognitive scientific process. In the most ordinary way, information grows in the framework of a single stable scientific paradigm. Sometimes, new data conflict with old paradigms and a search of the way out of the epistemological impasse ultimately leads to change.

It seems to us that this latter process occurred in the study of the Neolithisation process in the north-east of the Sea of Azov region. The evidence from multilayer Early Neolithic settlements such as Rakushechnyi Yar, Matveev Kurgan I and II, and Razdorskaya 2 (Fig. 1), which was published separately many times in scientific literature (*Krizhevskaya 1991; Belanovskaya 1995; Wechler 2001; Tsybrij 2008; Aleksandrovsky* et al. *2009*) already does not correspond with many parameters with the old prevailing schema of the development of the Early-Middle Holocene cultures of the southern part of East Europe (*Danilenko 1969; Belanovskaya, Telegin 1996; Kotova 2003*). This had many causes.

First of all, according to recent evidence (*Aleksandrovsky* et al. *2009.89–98; Tsybrij* et al. *2013.272–*

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274; Mazurkevitch, Dolbunova 2013.96) we can assume that the first indication of the Neolithic period in the northern area of the Sea of Asov region appeared at *c.* 7200–7000 cal BC, which is much earlier than previously thought. At this time, most of the Mesolithic stage of the elaboration took place in Europe. This raises the question of how such early manifestations of the Neolithic were possible in this area of Eastern Europe.



Fig. 1. Neolithic sites of the North-East of the Sea of the Asov region and of the adjacent areas.

Secondly, a problem of the logical and chronological discordance of different kinds of data appeared. For instance, it is clear that some of the settlements (*e.g.*, Matveev Kurgan I and II, Razdorskaya 2) were aceramic, *i.e.* they did not yield any pottery, although it was found in wide technological and typological diversity at the more or less contemporary settlement of Rakushechnyi Yar nearby (*Belanovskaya 1995; Mazurkevich, Dolbunova 2015*). At the same time, aceramic settlements have miscellanies traces of the use of clay, such as fragments of plaster of 'wattle and daub' constructions, remains of clay oven and other structures, impressions of stakes in burned clay fragments (remains of clay wall plaster?), anthropomorphic, zoomorphic figurines, and geometric tokens. The only probable evidence of wattle and daub constructions was in the Neolithic layers of Rakushechnyi Yar. It is important to notice that the aceramic stage as such has not been observed anywhere in the Mesolithic and Neolithic of East Europe, but was a representative feature of Neolithisation in South-West Asia, especially in the Fertile Crescent.

The data on agricultural subsistence practices at the above-mentioned settlements were also strikingly contradictory.

In contrast to Rakushechnyi Yar and Matveev Kurgan I and II, which after determinations of some archaeozooligists, contained bones of all the staple livestock in the Neolithic (*Krizhevskaya 1991; Belanovskaya 1995*), they were completely absent in the adjacent Rakushechnyi Yar settlement Razdorskaya 2 (*Gorelik* et al. *2013.296*). Here, with the background of the predominant riverine economy, with subsistence based on fish and shellfish, various wild animal bones were also encountered. No assumptions about Neolithic cultivation in the region were confirmed (*Matuzaite-Matuzeviciute 2012.1–21*).

Our paper is intended to characterise our conception of Neolithisation in the Asov Sea region based on the current state of knowledge. Firstly, we address the problem of the emergence of a certain cultural tradition, which are defined by material from Razdorskaya 2, Matveev Kurgan I and II, as well as Rakushechnyi Yar. Furthermore, we analyse different types of subsistence in the region, the general evolving process of material production, including pottery, the role of different aspects of social organisation, and ideology in the specific setting of Neolithisation in this region.

Living space

There are many instances when a certain choice (concept) of living space played an important cultural role in prehistory (*Müller 2013.133–153*). It reflected not only predominant economic strategies, but also, probably, the distinctiveness of the people. The inhabitants of Early Neolithic settlements in the north-east of the Sea of Azov region were uncommonly conservative in their choice of settlement sites. For example, according to the radiocarbon dat-

ing (Fig. 2) precisely the same place in the Lower Don valley was used for some thousands of years. Usually, the preference was for lower topographic levels, wet areas near a river, which flooded in spring and sometimes in autumn (Fig. 3). The predominant riverine economy caused the sedimentation of shell matrix sites in these places. In the northeast area of the Sea of Azov two concentrated or densely populated regions with such settlements are known (Fig. 1). One of these, in the Lower Don valley, features multi-layered sites such as Razdorskaya 1 and 2, and Rakushechnyi Yar at N 47°33'41.03"; E40°31.89'; the second, in the Mius river valley, includes approximately seven campsites near Matveev Kurgan modern settlement at N 47°34'20"; E38°52'20". The main ones are Matveev Kurgan I and II.

Both rivers, Mius and Don flow into the Sea of Azov, which was extraordinarily rich in fish, especially different species of sturgeon (*Janovskiy 2001*). The sites are situated about 100km away from the modern coastline. In the Holocene between (11th–6th millennium BP), the Sea of Azov, as part of the Black Sea basin, underwent a sustained transgression of its surface, which was 3.5 to 4m lower than at present, with an ensuing flood of the coastal shelf (*Balabanov 2007.715*). There are different scenarios of transgression of the Black Sea level, with both a rapid and gradual flooding of the coastal shelf (*Ryan 2007.63–117; Balabanov 2007.711–730; Glebov, Shel'ting 2007.731–773*). 'The Black Sea flood' probably significantly changed the line of the shore; it certainly flooded settlements nearby and the borders of arable land. Apparently, the coastline and the river together with gallery forests became involved in a specific natural framework that became the catchment zone of the populations related to the settlements discussed above. Arboreal vegetation in the Sea of Azov is now almost absent.



Fig. 2. Settlement Rakushechnyj Yar. Profile of the 2008 excavation.

However, at the time of the sedimentation of the cultural layer of Neolithic settlements, based on the anthracological and palynological analysis, pine, black alder, birch, maple, hazel, oak, elm, and ash trees grew in the river valleys and the ravines in insignificant amounts (*Levkovskaya 1992.174–177; Borisova 2011.5–13*). At the same time, it is obvious that steppe vegetation predominated. On the evidence from Olga K. Borisova, throughout the history of the sedimentation of the multi-layered Lower Don settlement at Rakushechnyi Yar, steppe vegetation was preponderant (*Borisova 2011.5–13*).



Fig. 3. Settlement Rakushechnyj Yar. A view on the settlement.

The climate of this region is moderate and continental, with cold and windy winters, and hot and dry sum-

mers. In the Neolithic, it was milder and damper. The coolest conditions are found at the end of the Boreal period and at the beginning of an Atlantic period, *i.e.* contemporaneous with the oldest traces of occupation in this region (Razdorskaya 2 and the oldest levels of Rakushechnyi Yar). This short-term cooling with a reduction in humidity occurred throughout the Azov-Black Sea basin (*Shuisky 2007.262*). In comparison with the later Holocene, this period is marked by the widest distribution of pine and birch forest, with probably a small mixture of oak and elm. The climatic optimum of the Holocene in the Atlantic period was characterised by warming, increasing humidity, and a decrease of continental climate effect. This period saw the spread of mesophyten meadow associations and an extension of broad-leaved woodland. It is possible that the humidity peculiar to this time throughout Europe was considerably increased by the transgression of the Black Sea and the Sea of Azov (*Levkovskaja 1992.175*).

From the perspective of cultural and prehistoric contacts, the North Azov plain was part of the so-called 'circum-Pontic interaction sphere' (cit. after *Whittle 1996.131*). Settlements were located at the confluences of rivers, and pathways that led in almost all periods of history (with a small exception) to the Caucasus, the basin of the Caspian Sea, Central Asia, the Balkans and central regions of the east European plain. The settlements of the Lower Don basin were situated at a special point of the Don which stands out by a confluence of inflows connecting the valley of the river with adjacent geographical areas such as the steppe, which had their own historical and cultural development (Fig. 1). The Severski Donets River flowing from the north connects the Don to the forest-steppe zone between the Dnepr and the Don. The Sal and the Mius rivers, which rise in the Kalmykia steppe, are southern tributaries of the Don. Routes to the dry steppes and semi-deserts of the Lower Volga area and into the North Caucasus could lie along these rivers. There are some outcrops of argillite, carbonic slate, and sandstone, as well as cretaceous Turonian and Coniacian flint in relative proximity to Neolithic settlements. Some of these were already exploited by earlier cultures (*Boriskovskij 1957.135–145*).

The question of emergence

The earliest materials from the group of Neolithic settlements considered have a lot of similar features, not only in the choice of living space, and the character of the cultural layer, but also in the composition of the assemblage. In this respect, they are very different from contemporary sites in the Pontic-Caspian basin. They are culturally identified through numerous artefacts made of argillite, including fishing weights, polished axes/celts, chisels and pendants, predominantly flint artefacts such as scrapers, bores, axes/celts, chisels, and also geometric microliths (Fig. 4). Most of the latter are trapezes, but segments and isosceles triangles were encountered at Razdorskaya 2. The pressure technique of the core-blade technology is worth noting, with knapping on one-side of the wide and flat prismatic detachment surface of the core.

It should be noted that, despite the comparatively large number of radiocarbon dates (Fig. 5), the chronology is still not clear, especially of the earliest manifestations of this cultural phenomenon. There are discrepancies in separate dates compared with the stratigraphic sequence of multi-layered sites, a disparity in the dates taken from one layer, since the samples were obtained from various organic materials, or the same samples yielded different dates depending in which laboratory they were dated, *etc.* (*Tsybrij 2008.52–53; Tsybrij* et al. *2013.272–274*). In many respects, these problems are probably caused by inadequate sampling methods, deficiencies in field research, the influence of the reservoir effect, as well as old wood effect, *etc*. Sometimes the sequence of development of the material culture based on some dates from our field of research do not match the logic and sequence established in some large cultural and historical regions by modern and highly professional research. For instance, in the Middle East, the developmental stage of pottery manufacture was preceded by the use of clay for wattle and daub constructions, and producing tokens and figurines (*Mellaart 1975.53, 62; Kozłowski 1999.33; Thissen 2007.218–219; Özdoğan 2009. 22–43*). The dates of the aceramic complexes at Matveev Kurgan I, excavated in the 1970s-80s, contradict this sequence. They are younger than the pottery layers at Rakushechnyi Yar, having more ancient radio carbon dates. On the other hand, pottery was absent from the assemblage at Razdorskaya 2, which is chronologically close to the pottery layers at Rakushechnyi Yar (*Tsybrij 2008.26–35*).

Nevertheless, despite all the incongruities in the radiocarbon data, it is possible in a very rough form to present the following occupation sequence of the north-east Sea of Azov region (Fig. 5). The emergence of the regional group here (we will call it the Rakushechnyi Yar group or culture, following Tatyana D.

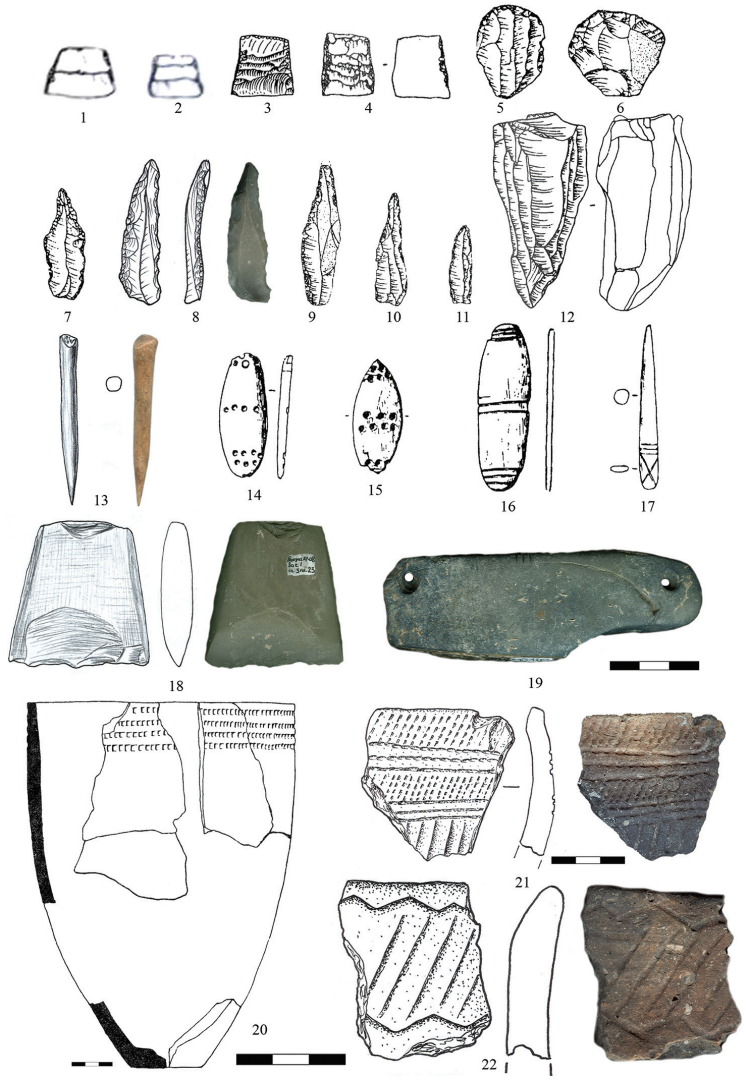


Fig. 4. Rakushechnyj Yar culture. Set of the most characteristic types of artefacts.

Belanovskaya (*1995.173*)) occurred approximately in the range from 7200 to 6500 BC. At the aceramic stage of development, clay was used as a building material and for the production of figurines and tokens. Perhaps since 6500 BC, a ceramic stage of the local Neolithic period had begun, which continued within the framework of a single ceramic tradition occurring, according to the estimates of one group of researchers, at some point prior to 6000 BC (*Mazurkevitch, Dolbunova 2013.98*), or according to the assumptions of others, very roughly prior to around 5500 BC (*Belanovskaya, Timofeev 2003.15; Kotova 2003. App. 1*).

Various considerations have been expressed in the literature concerning the emergence of the Rakushechnyi Yar cultural tradition. According to Liya Ya. Krizhevskaya, who excavated the settlements at Matveev Kurgan I and II and identified the Early Neolithic Matveev Kurgan culture, the main role in its origin was played by former bearers of the Grebenniki culture (*Krizhevskaya 1991.115*). This view was supported in the work of Leonid L. Zaliznyak, who considered that both the Grebeniki and Murzak-koba culture of the Mountain Crimea, as well as Matveev Kurgan I and II were links in proto-Neolithic migration across the sea from the Balkans and Asia Minor in the second half of the 7th millennium (*Zaliznyak 2009. 181*). Belanovskaya, who identified Rakushechnyi Yar culture after the excavation of the multi-layered settlement at the eponymous site Rakushechnyi Yar on the Lower Don, thought its formation was a result of interaction between various cultural influences, such as the Dnepr-Donec cultures in the West from the Sursk side and the Samara und Agidel' cultures in the East from the steppe regions as well as the Ural mountains (*Belanovskaya 1995.176*). Under the influences of the Caucasian traditions, following Belanovskaya, the following features appeared, *e.g.*, rare decorated flat-base vessels, cores flattened in cross-section, polished axes/celts, and chisels, trapezes with a flat dorsal retouch (*Belanovskaya 1995.174, 180–183*).

Viktor V. Tsybrij assumed that materials from Razdorskaya 2, which are situated close to Rakushechnyi Yar, evolved on the same basis as the Matveev Kurgan assemblage, and he suggested continuity between Razdorskaya 2 and Rakushechnyi Yar (*Tsybrij 2008.59*).

Starting with Alexander A. Formozov and Valentin N. Danilenko, many researchers assumed that southern impulses extending from West Asia through the Caucasian coast of the Black Sea in steppe of Pontic-Caspian were significant factors in the Neolithisation of this region (*Formozov 1962; 1965; 1977.47–48; Danilenko 1969.18; Domanska 1990; Wechler 2001. 244–245; Kotova 2003. 7.2.2; Mazurkevich, Dolbunova 2012.149; 2015. 23*).

The value of this hypothesis was supported by a new impulse from the progress of research in archa-

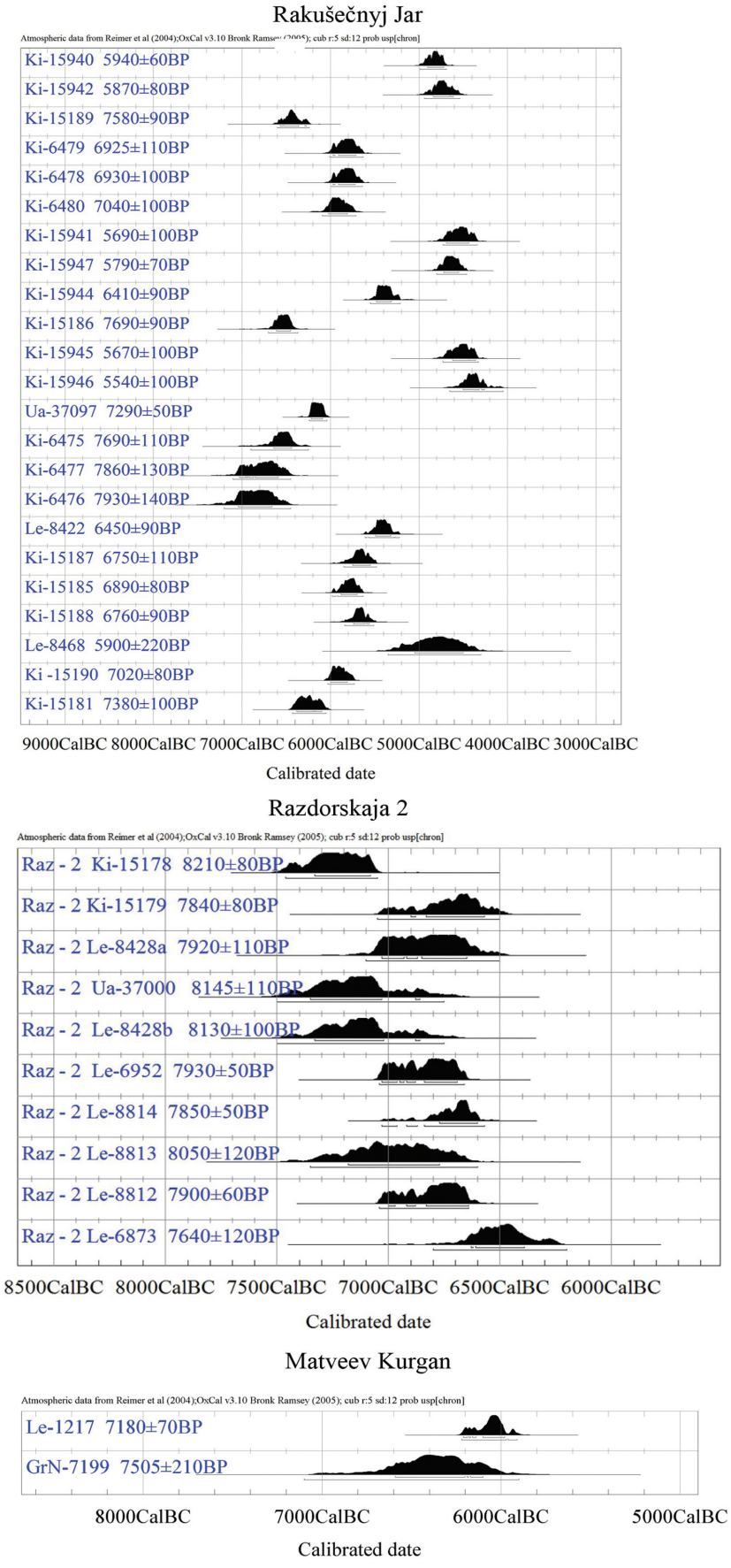


Fig. 5. Graphic image of frequencies of the radiocarbon dates of the main sites.

eozoology and genetics. According to modern paleopopulation genetics, all four species basic to the Neolithic – sheep, goats, pigs and cattle – were domesticated in the Middle East and then spread in different ways, including via the Caucasian route, into Europe (*Scheu 2012.123; Geörg 201.119, 134*).

Some believe that the richest potential of the Caucasian environment lay in possible allochthones, which was a basis for primary Neolithisation in this region, which in turn played the role of a springboard for the secondary Neolithisation in adjacent regions of East Europe (*Vavilov 1965; Munčaev 1975; Amirchanov 1987; Kušnareva 1993; Shnirelman 1989. 83–96; Dolukhanov 1984.323–358; Jacobs 1993. 322*). The current stage of investigations of Early Neolithic settlements in the Sea of Azov area provides an opportunity to clarify our ideas about the emergence of the cultural tradition of the Rakushechnyi Yar group. If we expected the oldest phenomena of this tradition to date to the end of 8th / first half of the 7th millennia BC, according to the chronology of typical shell mounds in the Azov region such as at Razdorskaya 2 and Rakushechnyi Yar, then claims about the decisive importance of the Balkan region for the Neolithisation of the region are very doubtful. The chronology of the oldest Early Neolithic sites in the Balkan region, such as Sesklo, Argissa, Nea-Nekomedea, Francie, *etc*. (*Perles 2001. Tab. 5.3; Thissen 2005.29–40*), indicates that these settlements appeared either roughly at the same time as the Early Neolithic in the foreland of the Azov Sea, or even somewhat later. There are a few features in common between them which could be evidence of their relationship. The assemblages of the Grebenniki culture, according to the newest radiocarbon dates from the Mirnoye site, date to the second half of the 8th millennium cal BC (*Biagi, Kiosak 2010.29–31*). Consequently, they appeared much earlier than the proto-Neolithic in the Balkans, according to the Ukrainian archeologist Leonid L. Zaliznjak, from which they supposedly derived. The first site-camps of the Murzak-Coba culture appeared at just about the same time, judging from the chronology of the Crimean Mesolithic site Laspi 7 (*Biagi, Kiosak 2010.29–31*). The similarities between the assemblages of the Grebenniki and Razdorskaya 2 sites are limited to features which were of transcultural importance around the 7th millennium cal BC (*Tsybrij* et al. *2013.282; Gorelik* et al. *2014.255*).

The other directions of comparison – the Caucasus and Western Asia – seem to us much more promising. It has been established that already from the beginning of the 6th millennium cal BC in Transcaucasia, the Shomutepe/Shulaveri culture expanded, that included classic Near Eastern characteristics such as clay architecture and ceramics, geometrical clay tokens and anthropomorphic figurines, developed agriculture,polished and soft stone industry, and technology of pressure core-blade production (*Lyonnet* et al. *2012.1–190; Nishiaki* et al. *2015.1–28*). As this new cultural complex of the Neolithic period, despite some parallels with northern Mesopotamia, has no full counterparts in Southwest Asia, many researchers believe that the local Caucasian manifestations of an early autochthonous 'Neolithisation' which had occurred still in the 7th millennium cal BC, had an impact on its formation. Materials from the central Caucasian settlement at Chokh, as well as West Caucasian sites at Darkveti and Anaseuli 1, *etc.*, allegedly date to this time. The Neolithic layer of the Choch settlement comprised definite traces of a productive economy: the bones of domestic animals such as sheep and goat and probably cattle as well as grains of several varieties of cultivated wheat and barley (*Amirchanov 1987.145–153*).

Information about the Early Neolithic in Western Georgia is less certain. Allegedly, domesticated animals were represented in layer 4 of the shelter site at Darkveti (*Kushnareva 1993.172–189*), although this was doubted by Victor Shnirelman (*Shnirelman 1989.94*). Moreover, in the Mesolithic and the aceramic layers of the neighbouring cave site at Kotias Klde, modern research has identified only wild fauna (*Meshveliani* et al. *2007*). Recent archaeological investigations in the Black Sea region of Georgia have not revealed any traces of a productive economy at late Stone Age sites (*Matskevitch, Meshveliani 2009; Meshveliani 2013*). Doubts on the emergence of a productive economy in the Caucasus during the period preceding the appearance of the Shomutepe-Shulaveri culture have increased. The voices of optimists, who are still defending the notion of agricultural development (local cultivation of different kinds of millet and rye) already in the aceramic Neolithic of the Western Caucasus (*Nebieridze, Tskwinitidze 2012.62–63*), are confronted by those who consider that there was no Neolithic in the Western Caucasus at all (*Trifonov 2009.84–93*). Nevertheless, regarding Transcaucasia, the probability of discovering traces of a productive economy in the region adjacent to the south-western part of the Caspian Sea region by the end of the 8th or the beginning of the 7th millennia cal BC is considered high (it is highly probable that traces will be found in the near future) (*Arimura* et al. *2010.85; Lyonnet* et al. *2012.*

155, 178). Unfortunately, sites dating to the transitional period between the Mesolithic to the Neolithic in the Caucasus have not been fully investigated, and the time for definitive judgments about cultural development has not yet arrived. One thing we can say for sure: the manufacture of some forms of stone artefacts in the Caucasus had a considerably long tradition, which is why the distribution of these forms outside the Caucasus to adjacent regions might be important for studying ancient communication routes. In particular, geometrical microliths with a distinct bilateral retouching, including segments, trapezes, symmetric triangles, were made in the Caucasus from the Final Palaeolithic period (*Formozov 1965.Fig. 20; Amirchanov 1987.197; Leonova 2009. 105*). Their further development was followed by the Mesolithic of the North Caucasus (*Leonova 2009. 106; Rostunov* et al. *2009.42–74*), Western Caucasus (*Meshveliani* et al. *2007.52*) and Transcaucasia (*Arimura* et al. *2009.Figs. 3, 7, 8*), as well as a little later period, such as probably throughout the 6th millennium cal BC at aceramic Neolithic sites in Western Georgia, such as Odishi-Nizhnyaya Shilovka, and ceramic Neolithic sites, such as Anaseuli 2 (*Nebieridze 1972*). Geometrical microliths with bilateral retouching are widespread in the Mesolithic-Neolithic period throughout the area from Fore-Caucasus to the North Caspian, between the Lower Don and Lower Volga valleys (*Tsybrii 2003.41–55; Gorelik, Cybrij 2007.21–42; Vybornov 2008*). They were encountered in particular in the Lower Don at Razdorskaya 2 (segments, trapezes and triangles) (*Tsybrij 2008.Fig. 43*). This distribution pattern probably reflects different cultural impulses to the south of the east European plain, which were directed from various regions of the Caucasus. Apparently, geometrical microliths spread from Northern Mesopotamia through Transcaucasia and farther on to the Black Sea coast of the Caucasus, mainly in the form of trapezes with a dorsal flat retouch, starting no later than the beginning of the 6th millennium cal BC (*Wechler 2001.252*). Many Neolithic sites on the south of the east European plain contained this type of microliths, especially between the Lower Dnepr and the Lower Volga, and may enlighten us on a different route for this communication (*Formozov 1977; Gorelik 1997*).

There is a whole array of other features in assemblages from the earliest settlements in the Rakushechnyi Yar tradition that were not known around 7000 BC in the Caucasus or elsewhere on the steppe and in the semi-deserts of the Pontic-Caspian, but were observed in the 9th to 7th millennium cal BC in the Neolithic of the PPNB stage in areas located to the south of the Caucasus in the Middle East, in particular in the Zagros mountains on the borders between Iran, Iraq and Turkey (*Gorelik* et al. *2014. 255–278*). For instance, we should mention different kinds of clay artefacts such as geometric tokens, pellets and cylinders, sometimes with graffiti, non-geometric decoration, and anthropomorphic and zoomorphic figurines, which were also discovered together with many fragments of clay plaster from wattle and daub constructions in the inventories of aceramic settlements such as Matveev Kurgan and Razdorskaya 2 (Fig. 6) (*Krizhevskaya 1981.127; 1991; Tsybrij 2008; Tsybrij* et al. *2013*). Also of interest are the stone medallions with a centrally drilled hole, sub-rectangular and bi-perforated pendants made from bone and horn, often with serpentine-like carvings, decorated with grooved stone implements (shaft straighteners), which were also found at Razdorskaya 2 (Fig. 7). It is worth remembering the miscellaneous polished stone axes/celts and pendants (Fig. 8), fragments of stone pots, the pressure technique of core-blade production and so on, which are characteristic features of the Rakushechnyi Yar culture (*Gorelik* et al. *2014.255–278*).

It is important to highlight that the rich pottery assemblage represented in the adjacent Rakushechnyi Yar settlement (*Belanovskaya 1995; Mazurkevich* et al. *2013.27–109; Mazurkevich, Dolbunova 2015*), was completely absent from Razdorskaya 2 and Matveev Kurgan, just like the PPNB settlements of the Middle East. These similarities allow us to suppose that there was some influence from the Middle East, especially the Zagros, in the origin of Rakushechnyi Yar. Of paramount significance is the existence of a package with distinct cultural similarities, which is emphasised to argue for direct links between these two regions.

The assemblage of the Rakushechnyi Yar group is especially familiar to us, due to the materials of the extended M'lefatien cultural group (following S. Kozłowski) (*Kozłowski 1999.51–75*) in the eastern wing of the Fertile Crescent, except for the above-listed features, and also exhibits a distinctive ensemble of geometric microliths. The latter is rarely encountered in the Middle East. For instance, the late aceramic/early pottery layers of the Jarmo settlement dated to the end of the 8th millennium cal BC are characterised by numerous symmetrical trapezes, as well as by a few isosceles triangles and segments (*Hole 1983.237–238*). Developed sets of geometric microliths were also preserved here in the following

7th millennium cal BC in the pottery stage of this group (*Abe 2011*).

This area of the eastern wing of the Fertile Crescent, including the South-East Anatolia and the Zagros mountains played an important role in the domestication of some animals (sheep/goat) and some kinds of staple crops (einkorn, barley and emmer) (*Zeder 2008.266; 2009.30–31, 37*). In approximately the second half of the 8th millennium cal BC, the

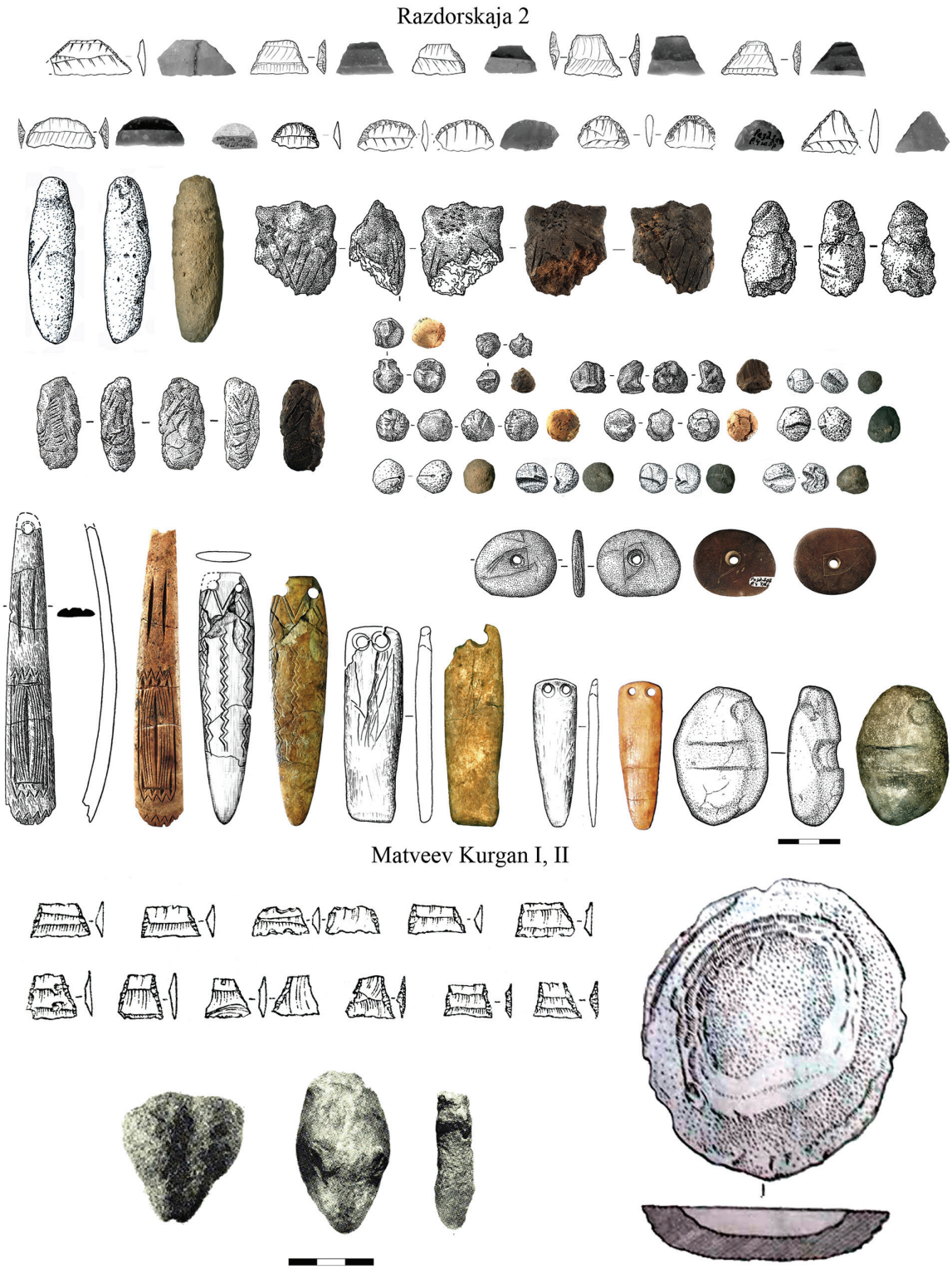


Fig. 6. Settlement Razdorskaya 2: clay plastic tokens, pendants with two symmetric openings and stone medallion. Matveev Kurgan I, II settlements: statuettes, fragment of a figure with image of legs, female image, head of the animal (after* Križevskaja 1981.Fig. 3*).

domestication process of the four principal animals in the Neolithic – sheep, goat, pigs and cattle – reached the stage of early domestication, which is completely different from the preceding stage of animal management (*Scheu 2013.6*). It is known that domesticated sheep appeared in Europe no earlier than in the 7th millennium cal BC, and even in the Central Zagros and Levant their remains could be traced since 7000 BC (*Zeder 2009.36; Geörg 2013.23*). Unfortunately, the Black Sea region of Anatolia is not well researched archaeologically and the Black Sea shores of the Caucasus were flooded during the transgression in the Early Holocene, which is why there is almost no hope of finding any traces of communication between such distant regions. Considerable scales of navigation in the post-glacial period that have been established both for the Aegean (*Perles 2001.59–63*) and the Baltic (*Hartz, Lübke 2000*) allow us to assume the possibility of a maritime route for such contacts. In the drought period in the Zagros Mountains at the end of the PPNB (*Zeder 2008.265*), a search for 'blessed Earth' to the North, may have le populations to travel to the generally more moist regions near the coast.

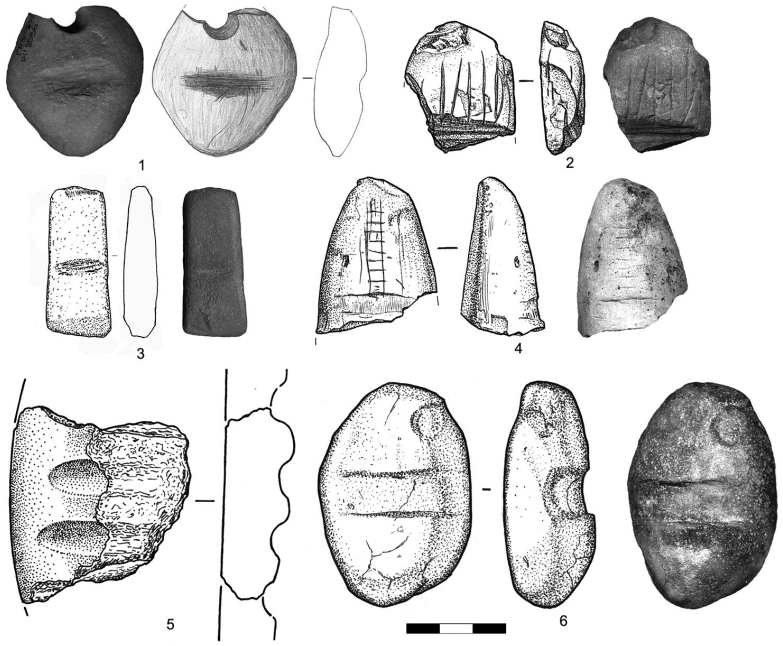


Fig. 7. Settlement Razdorskaya 2. Grooved stone implements.

So, the reconstruction of cultural impulses from the regions of the northern Zagros Mountains, and to some extent from the Caucasus to the Sea of Azov region at the end of the 8th to the mid-7th millennium cal BC has certain scientific arguments behind itself. We can infer a possible migration of small groups by the inland route or also by sea. Obviously, this hypothesis needs to be supported by data obtained by non-archaeological methods. In particular, we rest our hopes on the paleogenetic analysis of animals or human bones, which recently gained great importance in the studying of migration of people and animals.

The contribution of the presumably indigenous population in the formation of Rakushechnyi Yar culture is less clear. At the moment, we can discern some different cultural traditions at the end of the Final Pleistocene in the Lower Don region and in adjacent areas. In the Severskij Donets valley between the modern localities of Rogalik (Petrovka settlement) and Peredelskoye, two different cultural groups were specified, named Rogalik 2-Tsarinka or Osokorovka and Rogalik 7-type (*Gorelik 2001*). It is possible that the other cultural group from this region – Zimovniki – had also taken root in the Final Pleistocene (*Gorelik 2001*). The last one is the Kamennaya Balka industry in the Lower Don (*Leonova* et al. *2006*). Only one of them, Rogalik 2-Tsarinka, suggests that to some extent the microlithic components and core-blade technique at Rakushechnyj Yar culture derived from a local Final Palaeolithic tradition.

It is obvious that we can only infer a very remote similarity, which perhaps is not relevant for historical and cultural analysis. This problem is highly characteristic of the study of the transition from the Final Palaeolithic to the Mesolithic of Eurasia. It could be due either to the insufficient study of the Mesolithic of this region, or by the sparse population in the Mesolithic, as well as by a flooding of possible concentrations of Mesolithic sites in a coastal zone of the Sea of Azov during its transgression or with intermittent characteristics of transition to the Mesolithic. This must be clarified by future investigations.

Foragers or farmers?

The acknowledgement of the definite contribution of the Middle Eastern Neolithic to the emergence of the Early Neolithic in the north-east region of the Sea of Azov raises the question of how presumable

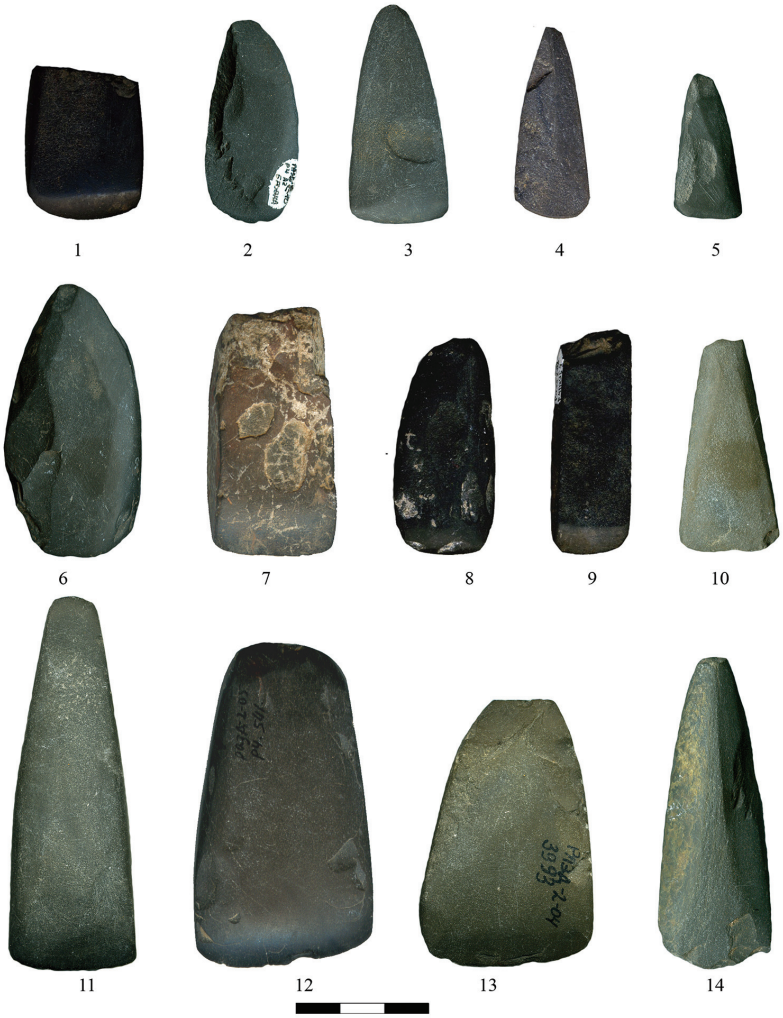


Fig. 8. Settlement Razdorskaya 2. Ground stone celts and adzes.

connections would influence human subsistence in this region?

During the excavations of the settlements Matveev Kurgan I and II, and from the oldest layers of Rakushechnyi Yar, numerous animal bones were discovered, among which there were many bones of domesticated species (sheep/goat, pigs, cattle and dogs), identified by the famous Soviet paleozoologist Valentina I. Bibikova, and by Tatjana G. Belan (determinations of Matveev Kurgan) and Vadim E. Garutt (determinations of Rakushechnyi Yar). The domesticated species present 20% of the bone assemblage in Matveev Kurgan. These data were repeatedly provided in the scientific literature (*Benecke 1997.638; Wechler 2001.132, 145; Shnirelman 1989.176–177*). Unfortunately, they were never sufficiently documented; even the final publications did not include the necessary data on the structure of the different kinds of bones, the minimum quantity of individuals of different animals, their total quantity, or, needless to say, measurements, distinct or features of bone morphology, the distribution of different types of bones in layers, on objects. In comparison with 1970–90, when these identifications were made by modern paleozoology, considerable changes occurred, and some new opportunities appeared which were not available earlier (*Zeder 2009.28*). The question of the correctness of these determinations arose when the data on the fauna of the Razdorskaya 2, a site adjacent to Rakushechnyi Yar, made by an expert on Neolithic fauna of south-eastern Europe, the Balkans and Transcaucasia, Norbert Beneke, were published (*Gorelik* et al. *2013.296*). Unlike his predecessors, he did not confirm the existence of bones of domestic animals, except for one dog, in the fauna at this settlement. The bones of domesticated livestock were not found by Mikhail V. Sablin, who studied the bones found in the oldest layers of the Rakushechnyi Yar settlement in the 2013 excavations. However, the scale of the excavation was too small and limited to provide any detailed information (*Tsybrij* et al. *2014. 207*). It is impossible not to consider the assumptions of David Antony that at both, Rakushechnyi Yar and Matveev Kurgan, the bones of domesticated livestock probably originated from the younger layer, with a radiocarbon date around the second half of 5th millennium BC (*Anthony 2007. 365*). However, this statement contradicts the lack of ceramics, which, in principle, should accompany such a layer.

Here are a few more examples where the domesticated status of animal bones from sites on the Pontic-Caspian steppe dated to the 7th millennium BC was not confirmed. It concerns the corresponding layers of the cave multilayer site at Shan-Koba in the Crimea (*Benecke 2006.12–15*) and especially of the multilayer site at Kammenaya Mogila, north of the Sea of Azov, where numerous bones of domesticated cattle, sheep/goats and horses in the aceramic layers determined by Ivan G. Pidoplichko (*Danilenko 1969.12*) were called into question (*Krizhevskaya 1992.107; Dolukhanov* et al. *2009.105; Gaskevich 2012.49*).

Unfortunately, these obviously wrong determinations were the basis for the generalising research of the Neolithic of Ukraine (*Danilenko 1969; Kotova 2003; 2009*). Typical assumptions of Soviet archeology of the second half of the 20th century about the development of agriculture, of horticulture or at least of the gathering of wild plant foods such as fruits, seeds, and nuts collected from the Azov settlements were also not confirmed (*Matuzaite-Matuzeviciute 2012.1–21*).

Based on the above, it is rather difficult to establish a final conclusion concerning the developed domestication of the Early Neolithic north east of the Azov Sea region, although even today many of our colleagues share this opinion. During a possible new phase of investigations in northeast of the Sea of Azov region, research on the economic aspect should take the central place.

Doubts on the correctness of reconstructions of an early domestication in the north Sea of Azov region amplify also due to the significant forager complex established here. It may be related to the choice of site for settlements with optimal open access to the available wild resources. Most likely, among the Early Neolithic sites of the region concerned, it is possible to distinguish between summer/autumn site-camps and winter settlements (*Gorelik* et al. *2013. 300–308*). Estimated summer or summer/autumn sites are represented by layers of shells of freshwater molluscs, gastropods (*Viviparus diluvianus* or *Paludina*) and bivalvia (*Unio pictorum*) which were accumulated during repeated visits to stratified shell matrix sites (Fig. 9). Sometimes it comprises up to 19 Neolithic layers (*Belanovskaya 1995; Tsybrij 2008*). These layers also contain bones of fish and animals, burnt products, artefacts made of bone, stone/flint and other remains. Sometimes oval depressions with a hearth within them are encountered here (Razdorskaya 2). A typical winter house can be traced in the example of the pit dwellings discovered at the settlement of Matveev Kurgan I (*Krizhevskaya 1991.15*). This dwelling, with an area of 60m², had a wattle and daub floor in the central part and eight hearths within. In its internal space, besides debitage concentrations of dismembered parts of prey – part of wild horse carcass, the bones of terrestrial game such as wild pig, red deer, sajga, auroch, roe deer, hare, fox and bear – were found. At the summer sites, fish bones predominate, sometimes found as complete carcasses in the debris heaps. Fishing was aimed at large, gregarious anadromous fish such as sturgeon, catfish, carp, and pike perches. Perhaps since that time, traditional equipment on the Lower Don such as stable weirs, traps, enclosures is used for fishing. They were set up especially in the narrow places on the river, *e.g.*, between the shore and an island. Judging from the finds of hundreds of fishing weights in the cultural layer of the settlements concerned (Fig. 10), fishing with the use of a seine was also common for the indigenous population. For their maintenance and also for catching big fish, as well for general transport, fishing boats were necessary in the river basin. The miscellaneous and numerous polished stone axes/celts, flint adzes, bores and other much specialised flint/stone inventories (*Tsybrij 2008.Figs. 43–45*) could be regarded in the framework of making boats and other equipment made of wood. More than 50 probably temporary storage pits for fish and shellfish, sometimes with finds of anchor stones and fishing weights, were found at the Razdorskaya 2 site alongside the modern edge of the Don River (Fig. 11). The pits are of different sizes: their diameters are from 0.25m to 1.5m, and depths are from 0.25m to 1.2m.

The materials from the multilayered settlement Rakushechnyi Yar allow us to trace the economic develop-

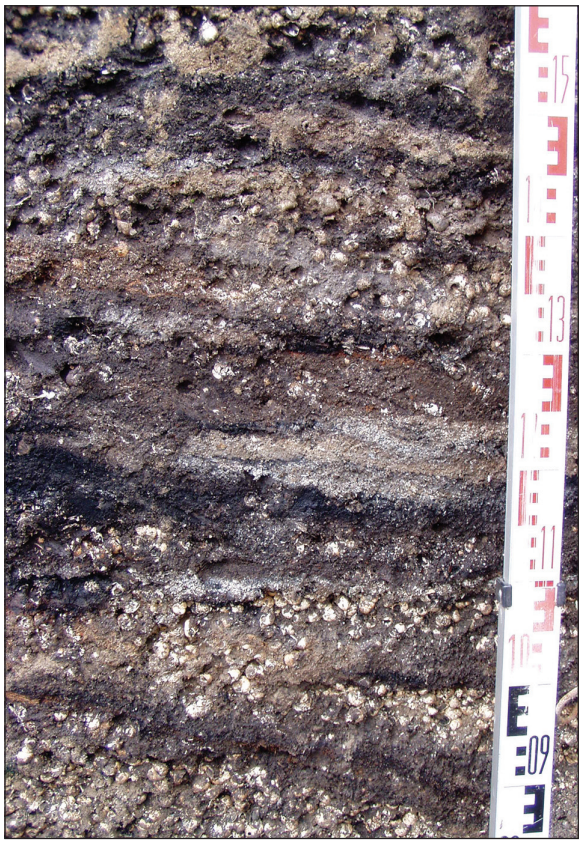


Fig. 9. Settlement Razdorskaya 2. Typical stratigraphy of the shell matrix site.

ment not only during the Neolithic, but also during the Copper-Bronze ages. It is interesting that even in the early Copper age layer (in layer 4) traces of human settlement are noticeable in the form of a shell mound, for example. The younger layers (2, 4, and 5) are thicker than the occupation layers in the Neolithic and contain traces of dwelling structures (*Belanovskaya 1995.12, 16*). Belanovskaya noted that below layer 15, neither hearth pits nor clay floor plastering were observed. These could evidence the short duration of the occupation in the Neolithic period, which became more stable by the time of the transition from the Neolithic to the Copper Age (*Belanovskaya 1995. 17*).

During the excavations in 2010–2012 next to Belanovskaya's excavation pit 1, it was possible with the help of modern archaeological methods to investigate the deposits of the Copper Age layers 2A and B (after Belanovskaya's taxonomy). It appeared that on the square of the site studied, the entire area was not completely occupied. Separate structures were uncovered there: concentrations of animal bones, pieces of coal, artefacts and campfires left by small groups of people visiting the river bank for a short time. According to Vera S. Bajgusheva, in layer 2A, the bones of domestic animals, sheep, horse, and cattle were noticed as determining features. At the same time, the uncovered top of the underlying layer 2B was comprised only of bones of wild animals. Finds of fishbone and mollusc shells were relatively few here (*Tsybrij* et al. *2012.204–206*). In the temper of the ceramics discovered in layers 2 and 4, impressions of domestic cereals (wheat, millet, and barley) and flax were observed (*Matuzajte-Matuzevichute 2012.7–9*). As the layer 4 in Rakushechnyi Yar is already related to the Copper Age (*Belanovskaya 1995*), it is most likely that the transition to farming in the north-east of the Sea of Azov region happened at this time, and not earlier, as it had been previously hypothesised. A find of one clay figurine in layer 4, which is analogous to the settlements of the Early Tripol'e as Bernovo Luka, Luka Vrublevetska, Lenkovtsy, Solonicheny 1, Golerkany (*Belanovskaya 1995.26–27*), could indicate one possible direction of influences for the introduction of agriculture in the Lower Don region. Judging from the chronology of Luka Vrublevetska 1, it could be dated to the first half of the 5th millennium BC (*Rassamakin 2012.46*). There are a couple of different radiocarbon dates from layer 4: one is older than the suggested dating of the statuette; the other two are younger (*Tsybrij* et al. *2013*). It is possible that this layer was accumulated from different occupation episodes, which are quite difficult to differentiate, so there is a need for further research.

What are the reasons for the asynchronicity in perception of the different elements of the 'Neolithic package' in the north of the Azov region and a lag in the development of a productive economy in comparison with many other areas? Why was there



Fig. 10. Settlement Razdorskaya 2. Fishnets and fishnets-shapes pendants in the bulk.

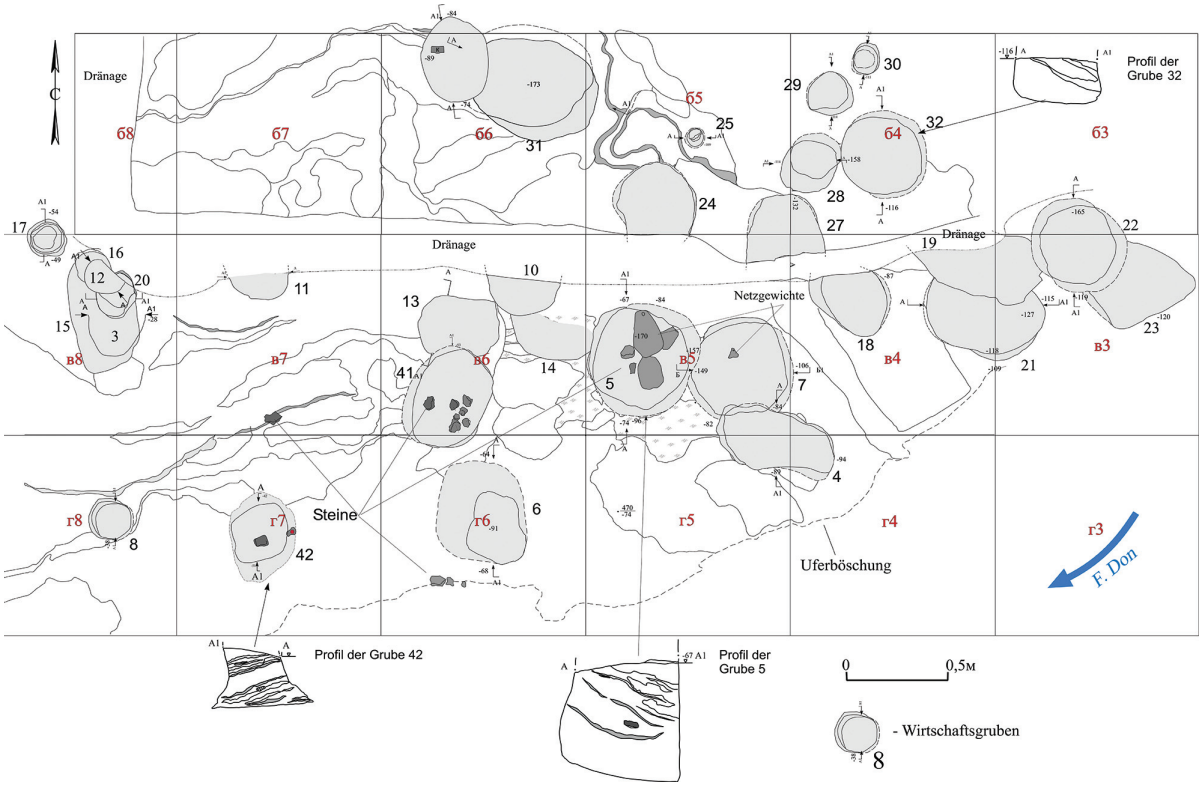


Fig. 11. Settlement Razdorskaya 2. Plan of the temporary storage pits by the river edge.

no significant change in the economic system, the way of life, and ideology as a result of supposed connections with the some areas of West Asia in this region? Why didn't "*the world of the Neolithic villages*" which specifies the Pre-ceramic Neolithic of the Fertile Crescent as well as the Early Neolithic of the Balkans, Central and Western Europe appear here? What are the reasons for the surprising territoriality of the Neolithic population in the Lower Don valley, maintaining exactly the same economic pattern for at least two thousand years, which was expressed in the phenomena of multi-layered settlements or 'tells'?

Social relationships and ideology (beyond typology)

Perhaps the simple answer to questions about traditions of processual archaeology with an appeal to the efficiency of forager subsistence compared to a productive economy in this region and in these climatic conditions is insufficient. Especially in prehistory, the efficiency of one or the other type of economic activity might have a subordinate role in the stability of the whole society (*Sahlins 2004.17–19; Watkins 2010.624*). Furthermore, we might discern different kinds of foraging in synchronous Neolithic cultures of the Northern Pontic-Caspian, with a different pattern of Neolithisation. From our point of view, the distinctive development of the Neolithic in the north Azov region was caused by those aspects of the life of Neolithic communities which are very hard to recognise in an archaeological analysis. It concerns social relationships and ideology.

If we compare the features of the considered settlements of the north Sea of Azov region with those that could be observed among their neighbours, the sites of Sursk-, Donetsk-, Samara-, Platovskij Stav cultures, it would be possible to note that the latter ones were organised differently in many aspects. The level of social and ideological development of the bearers of Rakushechnyi Yar culture seemed to be significantly more complex than that of their neighbours. Such features as multi-level, stratified matrix sites, the continuity of cultural traits, and the same territoriality for millennia, as well as maintaining the same economic pattern all indicate stability and balance in the social system, an evolved complexity of social organisation, and probably at least a semi- sedentary way of life.

The burial of an auroch skull at one of the earliest settlements, Matveen Kurgan II, together with the structure made of clay and a large carefully polished axe could be considered as a semantically important complex (*Krizhevskaya 1991.28–29*). The female figurines made of clay at the settlements of Matveev

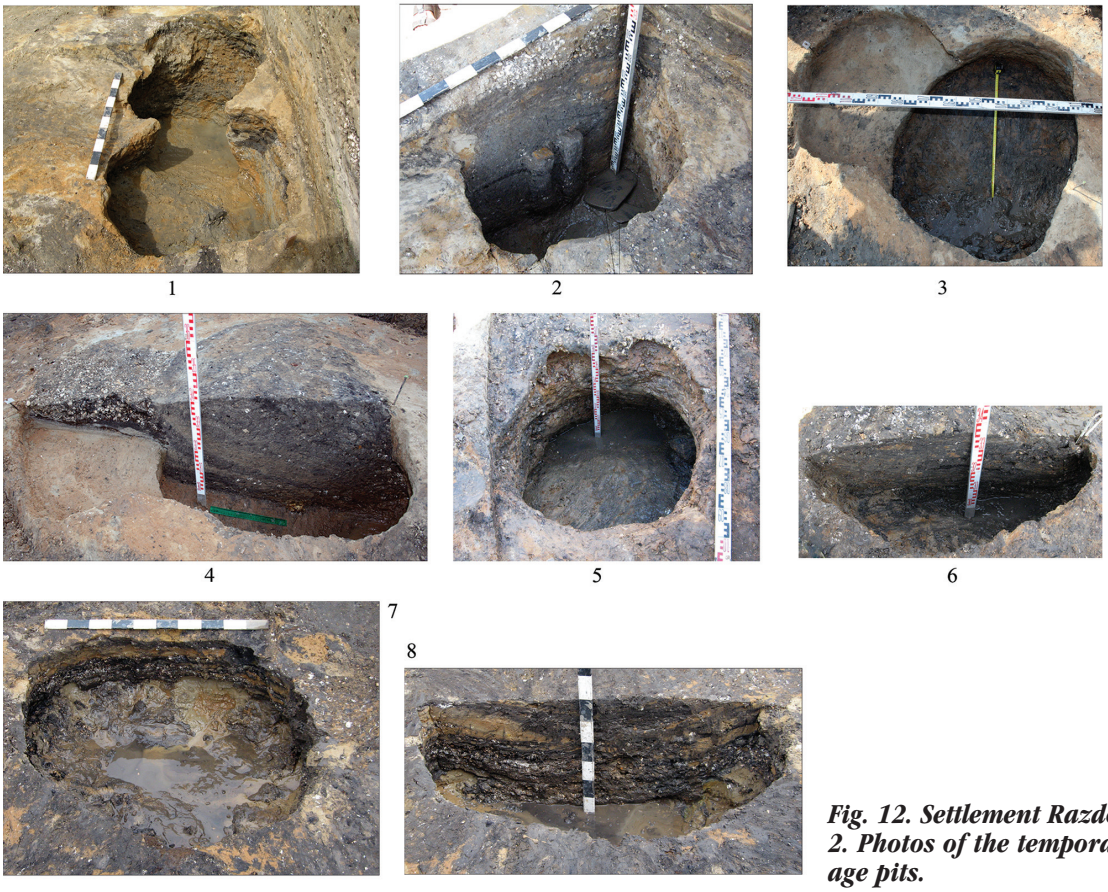


Fig. 12. Settlement Razdorskaya 2. Photos of the temporary storage pits.

Kurgan are of paramount significance. Celt-like pendants along the stone pendants with engravings in the form of fishing weights (Fig. 13) attest to a division between tools, such as celt or fishing weights, and symbolic imitations – that reflect an intention of ideological connotation of the most important dominants of the economic activity. It is symptomatic that one of the celt-like pendants was made from druse of shale with the large transparent rock crystal which grew from it, which had a special symbolical connotation throughout the Neolithic and Copper ages (*Danilenko 1986. 44*).

Different paraphernalia and jewelry from bone and stone, often with engravings, can be interpreted as signs of individuality and self-identification. The array of symbolic status objects with probable male (oxen, axe) and female (figurines) together with zoomorphic and geometric plastic, which are characteristic of the Neolithic world of the Middle East (*Cauvin 2000.32*) were amplified through typical 'forager' engravings, such as wave lines, possible water symbols, nets and serpentine-like engravings. Some of these paraphernalia and jewelry were encountered in the material from Mariupil cemetery, which should be dated to the 5th millennia cal BC (*Makarenko 1933; Telegin, Potekhina 1987*). The grave goods included maces, celts made from flint and porphyries, large pieces of rock crystal, buckles from porphyries, jewelry made of marble and jet. They were found in only a small number of burials. Some typical Mariupol artefacts were found in the second layer of Razdorskaya 1 settlement (*Kijashko 1987. 79*), which reflected the transition from the Neolithic to the Copper Age in the Lower Don basin.

It is indicative that in the Mariupil phase of Neolithic development in the foreland of the Sea of Azov region, which is rather late in relation to the Early Neolithic of Rakushechnyj Yar, we could observe the dominance of strong communal relationships. This is evidenced, perhaps, by the sanctioned placement of burials in a place isolated from the settlement; one trench had a collective burial ground and other burials were placed in rigidly defined rows, and therefore exhibit generally homogeneous burial rites. Strong territoriality, similar to the case of the multi-level/stratified matrix settlements, and continuity with no special attention to preserving the lower layers of graves are characteristic. However, it is possible to divide these graves into two groups, into 'rich' and 'poor' graves based on variations in the quantity and quality of grave goods. In particular, 'rich' children's burials cannot be compared to

the roughly contemporaneous burial grounds at Varna and Durunkulak on the Balkan Black Sea coast in terms of the degree of difference.

In this kind of society, continuity and integration seem to have been more important in the realm of the dead than differences between the living (*Whittle 1996. 169*), although certain differences in social position which were possibly heritable ('rich' children's burials) can be assumed. The lack of ceramics and metal could be interpreted by the fact that these burial rites date as far back as aceramic society. We guess that, in comparison with other Neolithic cultural phenomena of the Northern Pontic-Caspian area, the specific reconstructed traits of social and ideological development in the foreland of the Sea of Azov region also had certain economic causes. The materials from the settlements of the Rakushechnyj Yar culture reflect the specialisation of the economy on fishing and collecting shellfish, most likely on a seasonal basis, which is impossible to imagine without methods for butchering, conservation, and storage.

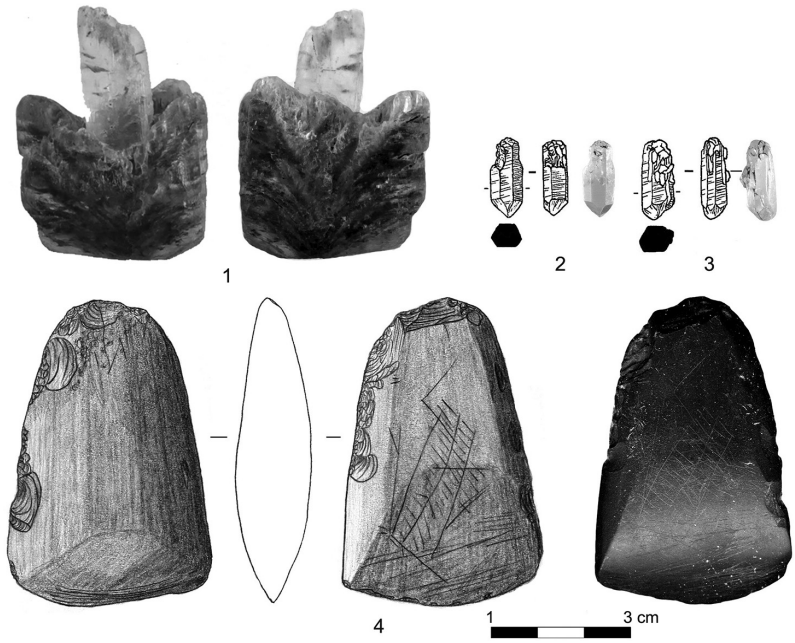


Fig. 13. Settlement Razdorskaya 2.* 1 *celt from the schist with a rock crystal;* 2, 3 *pendants from rock crystal;* 4 *graffiti on the celt.

It is considered by many researchers that a similarly intensive form of resource management without the modification of species' biological or genetic basis was a local stage of pre-domestication already established in the Mesolithic in many parts of Europe (*Zvelebil, Lillie 2000.59*). Specialisation was supposed to have led to a reduction in mobility, a transition to a sedentary/semi-sedentary way of life, and finally, to more complex social organisation and ideology (*Bender 1978.211; Hayden 1981.528*). Finds of Neolithic burials in deposits at Rakushechnyi Yar, and also separate human bones in the shell layers of Razdorskaya 2, give reason to expect positive results from a search for larger burial grounds in this region similar to those in the Dnepr or Danube basins, where fish and shellfish played a leading role in the Mesolithic and the Neolithic (*Zvelebil, Lillie 2000.79*).

Ethnographic material show that such highly specialized production can lead to the accumulation of wealth, and the emergence of power and social control regulating the process of social life and controlling resources (*Bender 1978.213*). Unlike in the preceding Paleolithic and Mesolithic periods, Neolithic communities in which hunting was primary, the value of insured and safe networks of exchange and various intergroup alliances covering considerable territories decreases (*Hayden 1981.527*). Based on research on the Neolithic, the latter hypothesis seems to be true in many respects. The aceramic assemblages such as at Razdorskaya 2 and Matveev Kurgan I and II present many finds and features illustrating cross-cultural communication over long distances. They indicate, as mentioned above, the prime value of the southerly direction of cultural contacts. In assemblages of the pottery Neolithic (Rakushechnyi Yar), these indicators were significantly lost. However, according to some scholars, the earliest pottery traditions in the Lower Don basin were formed under the influence of southern impulses from the Caucasus (*Belanovskaya 1995.174*), Anatolia (*Kotova 2003.7.2.2*), or from Anatolia and the Near East (*Mazurkevich* et al. *2013.91*). We believe, these hypotheses demand more concrete arguments which would exclude the possibility of a convergent emergence of more or less similar types of ceramics (*Budja 2014.27*). Until then, the origin of this distinct pottery tradition in Rakushechnyi Yar remains unclear.

Much more persuasive are cultural links with a smaller range. There is convincing evidence of the distribution of similar patterns of ceramics decoration between the Lower and Middle Don, the Lower Don

and Lower Volga/Northern Caspian area (*Mazurkevich* et al. *2013.91; Vybornov 2008*). The similarities in ceramics from the Lower Don and the Lower Dnepr, in the typology of geometric flint microliths, in stone vessels, as well as in shaft straighteners enable us to consider these also as proof of cultural contacts (*Telegin 1984.42; 1996.44–45; Belanovskaya 1991*). During the subsequent development of Rakushechnyj Yar culture, the value of cultural and historical contacts with the Caucasian and West Asian region was reduced to the recognition of a single form, such as trapezes with a flat dorsal retouch (*Wechler 2001*). It is important to acknowledge the contacts to the east with cultures from the steppe areas, especially from the 5th layer (*Belanovskaya, Timofeev 2003.15*). It seems that connections between the North Caucasus, the Fore-Caucasus, and the Middle East were re-established only with the Majkop phenomenon in the 4th millennia BC.

The narrative of cultural contacts mentioned above could imply that indigenous ruling groups, which apparently dominated the area north of the Sea of Azov for a long time, subsequently managed to eliminate the value of the south-west Asian influences by establishing carefully regulated economic, social, and also, apparently, ideological control.

Conclusions

Despite the much better state of research of the Neolithic in the foreland of the Sea of Azov, compared to other regions of the Northern Ponto-Caspian Sea, the process of Neolithisation here can only be characterised as a sketch, a very probabilistic and speculative model. The need for new, modern, large-scale explorations in this area with broad interdisciplinary integration is obvious. In the light of the latest data which we have, it is possible to claim that the Rakushechnyj Yar cultural unit belongs to the range of the oldest in the Northern Ponto-Caspian region. Apparently, it is one of the oldest cultures in which so many features of the Neolithic package are found: the transition to the wide use of clay, the technology of polishing stone, pressure core/blades technology, the emergence of anthropomorphic and geometrical figurines, and cult practices associated with axes, fishing weights, and bucrania.

Unlike some of our colleagues, who share the concept formulated by researchers from 1970 to 1990 about the origin of an Early Neolithic local centre with a productive economy with developed animal husbandry in the Sea of Azov region, we believe that this is improbable. The cornerstones of this concept were never adequately documented; they were not validated during recent explorations in this region; they are doubtful in the context of modern research of the same field worldwide. It seems that, besides dog, only the presence of bones of domesticated sheep/goat in the Early Neolithic layers of the Azov settlements could be true, because the latter have no wild predecessors in Europe. But this assumption also demands verification.

It is obvious that in the foreland of the Sea of Azov, particularly in the Lower Don, as well as in almost the whole East European plain, sub-Neolithic subsistence was based on different foraging modes. During spring, summer, and autumn fishing was primary, specialising in the art of catching large, gregarious anadromous and settle fish with nets, traps and boats, and the gathering of the shellfish has also been proved. Hunting probably predominated in winter.

The simultaneous emergence in north-east region of the Sea of Azov at an aceramic stage of the whole set of functionally interrelated features of the Neolithic package can be most logically explained by migration. The territory of the Zagros Mountains, the border zone between Iran, Iraq and Turkey (Anatolia), where during Pre-Pottery period B, many parallels with the idiosyncratic features appeared, and assemblages from the Early Neolithic of the south-east European plain could be regarded as a possible 'donor' area. It is possible to assume the two most probable ways of penetration from this region to the Azov's shores: the Black Sea coast of the Caucasus or by sea.

It is impossible to exclude the possibility of numerous contacts and probable participation in this cultural transfer also of the Mesolithic- Neolithic population of the North and West Caucasus. It seems that penetration from West Asia into the foreland of the Sea of Azov of a quite wide set of features of the Neolithic package, apparently in the framework of demic diffusion, did not lead to a deep Neolithic transformation, which took place in other regions' 'secondary Neolithisation', for example, in Europe. The choice of a place for repeated occupation, the organisation of the living area, the way of life, subsistence, and obviously also the perception of the world remained for a long time typical of foragers of river valleys, lakes, and the coastal areas of Europe. Probably this pattern continued until the large-scale movements of people in the Copper Age. We can

speculate further on the reasons for elaborating such a scenario. It is more plausible to suppose that influences from societies more advanced with Neolithisation in the foreland of the Sea of Azov were not significant, in terms of, or at the level of, products or skills associated with a productive economy. The indigenous world absorbed the culture of the newcomers. The sub-Neolithic society with ceramics was indeed socially and ideologically more complex and organised than that of their neighbours, but was based on a foraging economy.

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Initial stages of two Neolithisation models in the Lower Volga basin

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ABSTRACT – *In this paper, two groups of ancient sites located in the Lower Volga River basin are analysed. The first group is linked to the emergence of the oldest pottery in this region, which is one of the most ancient in Europe. The presence of this feature of the 'Neolithic package' can be dated to the middle of the 7th millenium BC. A production economy is a particular feature of the second group of sites, which can be dated to the end of the 6th millenium BC. This is one of the earliest pieces of evidence of the existence of domesticated species in Eastern Europe. These two groups of sites show the initial stages of two Neolithisation models in the Lower Volga basin.*

IZVLEČEK – *V članku analiziramo dve skupini najdišč na območju spodnjega dela reke Volge. Prva skupina je vezana na pojav najstarejše lončenine na tem prostoru, ki je hkrati ena najstarejših v Evropi. Navzočnost lončenine, ki je del t. i. 'neolitskega paketa', lahko datiramo v sredino 7. tisočletja pr. n. št. Pojav produktivnega gospodarstva je značilnost druge skupine najdišč, ki jih datiramo na konec 6. tisočletja pr. n. št. To je eden najstarejših dokazov o navzočnosti udomačenih vrst živali v Vzhodni Evropi. Obe skupini najdišč predstavljata začetne stopnje dveh različnih modelov neolitizacije na območju spodnje Volge.*

KEY WORDS – *Neolithic; Lower Volga; pottery; production economy*

Introduction

The Lower Volga basin lies in a special geographical area (Fig. 1); it connects the northern areas of the forest-steppe/forest zones of the Volga basin and the area of the Don basin with southern areas of the Caucasus and Central Asia. Such a location promoted contacts and interaction between cultures in these regions. The steppe zone of the Volga basin played a particular role in the Neolithisation process, whereby various characteristics of southern cultures could have penetrated farther. The emergence of ceramic production and cattle breeding in the steppe zone from the Dnieper to the Volga River basin can be linked to the region of Western Asia (*Kotova 2002; Yudin 2004*).

The innovations of the Neolithic constitute a 'Neolithic package', which includes a distinct set of components (*Özdoğan 2011*). In addition, the issue of Neolithisation has led to many discussions and questions (*Budja 2013*), including the reasons for, and mechanisms of, the transition to the Neolithic era, as well as regional diversity. Since the publications of V. Gordon Childe (*1958*), a production economy has been considered one of the most important features of the Neolithic. The existence of pottery in the form of storage containers is also related to the appearance of a producing economy. However, no evidences of agriculture or cattle-breeding has been found in the Volga, Don, and Kama basins that date to the Neolithic, a fact which at first sight can be explained by its chronological position. On the other hand, early cases of ceramics appearing in hunter-gatherer cultures are also known today (*Kuzmin 2015; Craig 2016; Gibbs, Jordan 2016*). The term 'ceramic revolution' was coined to denote the oldest pottery remains found in Eastern Europe (*Mazurkevich* et al.

2006). New research on stone age sites located in the Lower Volga basin allowed us to take a new look at the issue of Neolithisation in this region.

Materials and discussion

Kugat IV and Kulagaisi are two of the earliest sites with pottery in the southern part of the Lower Volga basin (Northern Caspian) in the Astrakhan region. Based on the material from the Kairshak III site (*Vybornov 2008*), they are attributed to Kairshak early Neolithic types of site, commonly found in the northern Caspian area. This type of site existed from 6690 BC to 5980 BC (Tab. 1). At that time, blades and blade tools predominated in the stone industry. Geometric microliths – rhomboid and circular segments with a retouched convex edge – are well represented (Fig. 2). These artefacts are typical of the local Mesolithic industry (*Vybornov* et al. *2015*). These testify to the local origin of pottery in this region. Pottery attributed to the Kairshak type was made from silt naturally tempered with the shells of freshwater molluscs. This ceramic technology is thought to be the most ancient in the Volga and Kama basins (*Vybornov, Vasilieva 2013*). The sites in this region are the most ancient of the Kairshak sites, and are radiocarbon dated to 6690 cal BC (*Zaitsteva* et al. *2009*).



Fig. 1. Map of the Lower Volga region.* 1 *Kugat IV;* 2 *Kulagaysi;* 3 *Kairshak III;* 4 *Baibek;* 5 *Tenteksor;* 6 *Varfolomeevskaya;* 7 *Algay;* 8 *Karahuduk;* 9 *Kombakte;* 10 *Kurpezhe molla;* 11 *Oroshaemoe.

The climatic factors which influenced the transition from one period to another present a complicated picture (*Budja 2007*). Extensive aridisation is thought to have occurred between 6400 and 6300 BC in the southern part of the Low Volga basin (*Bolikhovskaja 1990*). This is also verified, according to the ^{14}C dates, by the absence of inhabited settlements at this time. Thus, the beginning of Neolithisation and pottery making in the Lower Volga basin could not have been connected to natural factors. The situation changed after the aridisation ended (6200 BC), and the number of sites increased (Kairshak I–IV, Baibek). Settlements became long-term; living conditions and the economic system changed, and so a great number of household objects, dwellings, artefacts and faunal and fish remains from that time can be found (*Grechkina* et al. *2014*). We can suppose that the initial inhabitants of Kairshak-type sites in this region were more nomadic than the inhabitants of subsequent periods.

With the exception of dogs (*Vybornov* et al. *2015*), the faunal remains found on sites with pottery dated to 6500–5680 BC (Kairshak III, Baibek, Tenteksor, Zhekolgan) were all wild species: saiga, onager, tarpan, auroch, wild boar, wolf, and fox (*Vybornov* et al. *2015*).

The Neolithisation process in the southern part of the Low Volga region during 6500–5500 BC did not include a producing economy. From the point of view of European researchers, sites of this period could be attributed only to the 'ceramic Mesolithic'. In the eastern European scientific world, pottery is regarded as a marker of the beginning of the Neolithic era (*Oshibkina 1996*), which is why these sites were classified as Neolithic.

In the northern part of the Lower (steppe) Volga basin, sites with the earliest pottery are attributed to the Orlovskaya culture. The most important material was found in the lowest layer (3) of the Varfolomeevskaya site (*Yudin 2004*) and the lowest layer of the Algai site (*Vybornov, Yudin 2015*), both of which are located in the Saratov region. The flint industry is represented by blades and blade tools, and

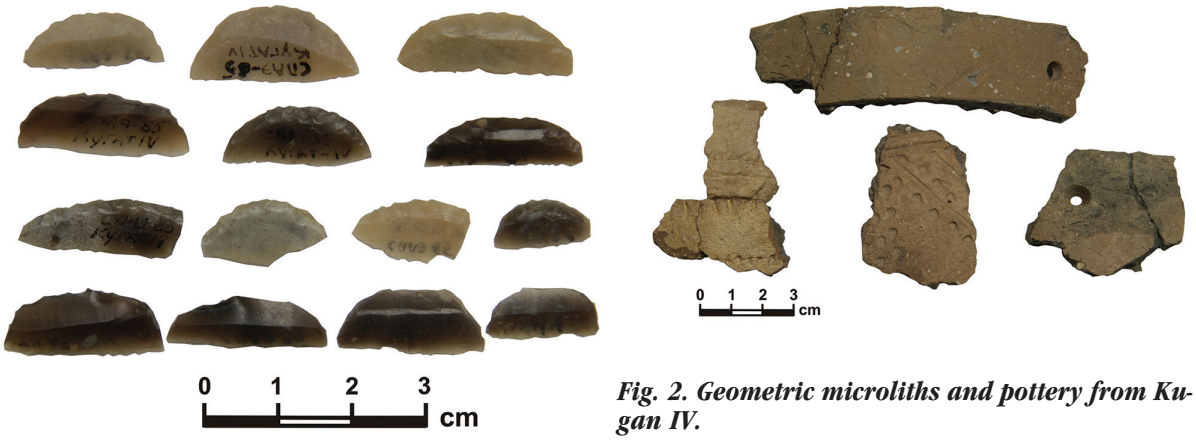


Fig. 2. Geometric microliths and pottery from Kugan IV.

geometrical microliths – circular segments with a retouched arc. These features are typical of the stone industry of the Northern Caspian area. The flat-bottom ware of the Orlovskaya culture was made from silt and silty clay, naturally tempered with the shells of fresh-water molluscs – the same paste recipes as those used in the manufacture of Kairshak vessels. According to the ^{14}C dating, these materials date to 6200–6000 BC (Tab. 1), *i.e.* a period of a wider distribution of sites in the southern part of the Low Volga region. This allows us to suppose that the Neolithisation process in the steppe Volga basin was influenced by bearers of the Kairshak cultural tradition from the Northern Caspian area. The faunal remains in the steppe Volga (sites Varfolomeevskaya, Algai) during this time included saiga, onager, tarpan, auroch, wild boar, wolf, and fox. No evidence of a producing economy has been found at sites in the steppe Volga basin (*Yudin 2004*) or in the North-Western Caspian region (*Koltsov 2004*). Apart from dog, no traces of domesticated species have been found at Neolithic sites in this region (*Vybornov* et al. *2015*). Thus, the Neolithisation model in the southern part of the Low Volga region during 6200–5500 (later than the beginning of Neolithisation in the Northern Caspian) was not connected with a producing economy. This process was not established locally. Neolithic culture was formed in the steppe Volga basin under the influence and by the interaction of some groups of Kairshak inhabitants from the Northern Caspian area with the local Mesolithic population.

Until recently, the appearance of a producing economy in the Low Volga was connected with Khvalynskaya culture sites (Karahuduk, Kairshak VI, Kombakte), which are distributed throughout the whole of the steppe zone. The lithic industry of this culture differs from the flint industry of preceding cultures, as it includes heavy flakes produced by enhanced pressure knapping. Scrapers, knives, points on large blades, and triangular arrowheads with a truncated base predominated. There are also insets on narrow blades. Pottery was made from clay tempered with crushed freshwater mollusk shells. The upper part of the round-bottom vessels is thickened (Fig. 3). The deco-



Fig. 3. Pottery and flint tools of the Khvalynsk culture.

ration and technique of applying it to vessels differs from that found in the preceding Kairshak and Orlovskaya cultures (*Vasiliev 2003*). Domesticated sheep bones were found at Khvalynskaya sites, along with the bones of wild species (kulan, saiga, tarpan). Detailed statistical data can be found in a number of publications (*Kuzmina 1988; Vybornov* et al. *2015*). Khvalynskaya culture sites date to 4900–4600 BC (Tab. 1). There are two hypotheses about the origin of this culture. It has been suggested that it was an autochthonous culture formed on the basis of the preceding Prikaspiiskaya culture. Other researchers suppose that it could have appeared as the result of the migration of tribes from the southern region of the Trans-Caspian area.

It must be mentioned that the earliest copper ornaments were found in Khvalynskaya burials. This is why the culture could not have been involved in the Neolithisation process.

Remains of domesticated animals were also recently found at Prikaspiiskaya sites, preceding Khvalynskaya culture (*Vybornov* et al. *2015*). It is located in the same area as Khvalynskaya culture. Evidence of a quarzite stone industry has been found at Prikaspiiskaya sites (Kurpezhe-molla and Oroshaemoe). Heavy flakes were used as preforms for tools produced by an enhanced pressure technique. Tools



Fig. 4. Pottery and quartzite tools of the Caspian Sea area culture.

Site	Age (BP)	Age, cal BC (2σ)	Material	Lab. No.
Kugat IV	7680±100	6690–6380	Pottery carbon	Ki–14501
Kugat IV	7560±90	6600–6220	Pottery carbon	Ki–14500
Kulagaysi	7380±120	6450–6027	Pottery carbon	SPb–1725
Kairshak III	7190±80	6230–5890	Animal bone	Ki–14633
Baibek	6986±44	5983–5759	Charcoal	Ua–50260
Baibek	6955±80	6002–5708	Animal bone	SPb–973
Baibek	6920±120	6021–5624	Pottery carbon	SPb–1053
Tenteksor	6695±40	5680–5530	Ceramic food crust	Ua–35277
Varfolomeevskaya	7230±90	6250–5890	Pottery carbon	Ki–14368
Varfolomeevskaya	7034±41	6010–5830	Ceramic food crust	Ua–41360
Algay	6800±40	5741–5631	Ceramic food crust	Poz–65198
Algay	6605±32	5617–5487	Charcoal	AAR–21893
Karakhuduk	5980±90	4960–4770	Pottery carbon	Ki–14907
Kairshak VI	5780±90	4880–4600	Pottery carbon	Ki–14910
Burovaya 41	6790±80	5840–5530	Pottery carbon	Ki–14618
Kurpezhe-Molla	6020±80	5150–4770	Pottery carbon	Ki–14832
Oroshaemoye	5806±26	4724–4557	Animal bone	UGAMS–23059

Tab. 1. Radiocarbon dates for Neo-Eneolithic sites in the Lower Volga region.

included scrapers, knives and points on large blades, 'fish-form' arrowheads, as well as insets on narrow flint blades. Flat-bottom pottery was made from clay artificially tempered with shells. The upper parts of the vessels have a thickened external side, called the 'neck-piece'. Pottery was decorated with comb impressions and traced lines (Fig. 4). All of these features are similar to the material from Khvalynskaya culture (*Vasiliev 1981; Vybornov* et al. *2015; 2016*). Domesticated sheep bones were found alongside the bones of wild species (kulan, saiga, tarpan) (*Vybornov* et al. *2015*). The Prikaspiiskaya sites are dated to 5500–4800 BC (Tab. 1). This culture is attributed to the Neolithic period, as no copper artefacts have been found. However, no traces of transition from the Kairshakskaya or Orlovskaya cultures to Prikaspiiskaya culture could be identified. The origin of Prikaspiiskaya culture is reckoned to be connected with the Lower Don region. Some migration from Western Asia could also have occurred. Thus, the Prikaspiiskaya sites in the Lower Volga region represent the second Neolithisation model proposed for this area. The model is connected with the appearance of a producing economy in the milieu of Prikaspiiskaya culture.

Conclusion

Two different Neolithisation models can be proposed for the Lower Volga region. The first could be dated to 6500 BC, and encompasses the appearance of the first sites with the oldest pottery, attributed to Kairshakskaya culture, in the Northern Caspian region. In the Lower Volga basin it could be dated to 6200 BC, and is represented by Orlovskaya culture sites, which appeared under the influence of the southern groups of Kairshakskaya culture. The second Neolithisation model could be dated to 5500–4800 BC, and encompassed the whole area of the steppe Volga basin. It is connected to the incoming Prikaspiiskaya culture, which has yielded reliable traces of a producing economy.

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A network of the steppe and forest steppe along the Prut and Lower Danube rivers during the 6th millennium BC

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ABSTRACT – *The transition from a (predominantly) mobile way of life relying on hunting, fishing and gathering to a (predominantly) sedentary life-style based on farming and animal husbandry is considered in the western Pontic archaeological tradition almost exclusively from a southern, Aegean-Anatolian perspective. Contacts between the steppe and forest steppe of the north-eastern Balkans and the north-western Pontic were seen as linear and unidirectional; 'cultures' were defined almost exclusively on the basis of pottery styles. Not only such traditional viewpoints, but also the political conditions of the 20th century further biased prehistoric research. However, the outer Carpathian region should not be treated as a periphery of the inner Carpathian Criş culture, but as a region of multidirectional exchange networks. Moreover, certain traditions are obviously rooted in the Mesolithic of that area.*

IZVLEČEK – *Prehod od (pretežno) mobilnega načina življenja, ki je temeljil na lovu, ribolovu in nabiralništvu, na (pretežno) sedentaren način življenja, ki je temeljil na poljedelstvu in živinoreji, se obravnava v arheoloških tradicijah na območju zahodnega Črnega morja predvsem iz južne, torej egejsko-anatolske perspektive. Kontakti med območjema stepe in gozdne stepe na severovzhodnem Balkanu in severozahodnem Črnem morju naj bi potekali linearno in enosmerno; 'kulture' so definirane skoraj izključno na podlagi značilnosti okrasa na lončenini. Poleg tradicionalnih pogledov v stroki so tovrstno pristranskost do prazgodovinskega raziskovanja podkrepile tudi politične razmere v 20. stoletju. Ne glede na to, območje zunanjih Karpatov ne bi smeli obravnavati ločeno od notranje karpatske kulture Criş, saj gre za regijo, kjer so potekale mreže izmenjav v različnih smereh. Poleg tega imajo nekatere tradicije očiten izvor v obdobju mezolitika na tem območju.*

KEY WORDS – *Eastern Lower Danube area; Prut valley; steppe; forest steppe; Criş culture; 'Starčevo-Criş IV phenomenon'; exchange networks*

History of research

Traditionally, Neolithic cultures of the forest and coastal steppes of the northern and north-western Pontic regions are known by the names of rivers (Dnepr, Bug, Dniestr), outlining concurrently the geographical area of the respective archaeological culture. This naming was also used for the western-most exclave of the steppe belt, the Alföld, along the Tisza and Lower Körös rivers. In contrast, in the western Pontic area, and the Balkans in general, those sites that were excavated early in the 20th century gave names to cultures covering geographically diverse entities, extending on both sides not only of broad rivers, but also of steep mountains (*e.g.*, Karanovo or Starčevo cultures). This distinct approach might be explained by the fact that in the forest and coastal steppes no metre-high tell-sites with a vertical stratigraphy and only sites with a horizontal stratigraphy developed during the Neolithic, whereas in Southeast Europe it is precisely such sites that have served as chronological backbones for the whole region and beyond, and all subsequently excavated materials, even from distant areas, were related to such sites.

Additionally, modern history shaped the different terminological systems: the vastness of the north-

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ern Pontic area was not divided into several countries during the 20th century, but was covered by the Soviet Union (USSR). In contrast, the Balkans and the Carpathian Basin were divided by many national borders that additionally shifted during the world wars and had to be renegotiated throughout the 20th century. For example, Romania was submitted to many transformations that are also reflected in archaeological approaches. Therefore, some post-war interpretations need re-appraisal, especially when they touch upon the problematic political relationship between Romania and two of its neighbours during the 20th century. On the one hand, the Kingdom of Romania (1881–1947) and with it Greater Romania (1918–1940) as well as the Socialist Republic of Romania (1947–1989) were in strong competition with its neighbour to the west, the Kingdom of Hungary under the regime of Admiral Horthy (1920–1944; Fig. 1), followed by the Hungarian People's Republic until 1989. On the other hand, the tense relationship with the dominant Soviet Union (1922–1991) and, as part of it, the Moldavian SSR (1944–1991) also did not favour cooperative scientific projects (Fig. 2).

1944–1989 in West Romania

Historical events influenced archaeological interpretations during the 20th century essentially. For example, until 1918 Transylvania was part of the Austrian-Hungarian Empire, and afterwards part of Romania; between 1940 and 1944 its northern part was under Hungarian rule, and since 1945 it has again been under Romanian administration (Figs. 1, 2). A child of that period, János Banner (1888–1971), received his PhD in 1911 from the University of Kolozsvár (nowadays Cluj). During connection of northern Transylvania with Hungary, he published his basic book on the Tisza-Maros-Körös area (*Banner 1942*) and led excavations in Hódmezővásárhely until 1944. In the same year, there appeared what is still a fundamental book on the Körös culture by Ida Bognár-Kutzian (1919–2001) (*Bognár-Kutzian 1944*). Thus, the Early Neolithic (henceforth, EN) of eastern Hungary was defined when Transylvania was under Hungarian rule.

The EN Starčevo culture was named after a site near Pančevo (southeast of Belgrade) excavated in the early 1930s (*Fewkes* et al. *1933*). Vladimir Milojčić (1918–1978) included some of the materials in the PhD that he submitted in Vienna (*Milojčić 1944*). Deriving from this study, he published in his influential book on chronology in 1949, in which he established four major phases of Starčevo culture. According to the evolutionist understanding of archaeological cultures of his time, the culture started with a monochrome phase I, evolved through the simple white and later sophisticated polychrome painted phases II–III and ended with phase IV, a phase in decline (the latter being attestable only in northern Serbia (*Milojčić 1949.71*)). Draga Arandjelović-Garašanin in 1954 and Stojan Dimitrijević in 1974 adopted this system with some changes.

Yet, it was not until 1979 that the EN chronology for western Romania was developed in detail by Gheorghe Lazarovici (*1941). He extended the territory of Starčevo culture from Serbia into western Romania and expanded the periodisation by adding new sub-phases. Although in his view the Körös culture cannot be seen as a group in its own right (*Lazarovici 1979.60*), he adopted the same name (Criş is the Romanian name for the river Körös – compare Figures 1 and 2) for the EN culture in western Romania. Whereas the first three phases of the Starčevo-Criş culture were located in the Banat, Transylvania and Oltenia, in phase IV Starčevo-Criş also expanded to Moldova (*Lazarovici 1979.53–55*). Interestingly, he chose to label with 'Starčevo-Criş IV' (written by him in quotation marks in order to differentiate it from the chronological phase IV) a 'phenomenon' (*Lazarovici 1979.55–56*) that is not part of the



Fig. 1. Territories under Romanian administration between 1941 and 1944.

Starčevo-Criş culture, but for which no other name would be necessary, although the pottery of the outer Carpathian area, decorated with incisions in zigzags, ripples and channelling, is strikingly different (see below).

In addition to the impediment imposed by national borders, another shortcoming throughout the 20th century was the perpetuation of methodologically outdated approaches. Namely, the uncritical application of Milojčićs' sophisticated, but, without any adjustments (*e.g.*, absolute data) highly problematic system based exclusively on relative chronology led to partial interpretations. Milojčić was very clear about the requirements the method of comparative stratigraphy based on typological comparability involved: not only pottery shapes, but also figurines, ornaments, burial customs, tools, construction techniques, and settlement patterns must be analysed before establishing a temporal relationship between two sites (*Milojčić 1949.4–5*). These requirements were not always met, either by himself or the generation following him. Instead of describing Starčevo culture based on a detailed analysis of all the elements mentioned above that are essential for the definition of a 'culture', Milojčić used only one of these elements: pottery styles. Moreover, he relied on personal communications from Miodrag Grbič and not on a verified/verifiable analysis (*Milojčić 1949.122, footnote 4*). Thus, his demand to overcome 'scientific intuition' (*Milojčić 1949.1*) as a basis for chronological analysis was hardly being achieved, at least not in the case of Starčevo culture. In many subsequent studies, this key method of pre-radiocarbon dating was narrowed down to a comparison of specific pottery traits, stressing single, exceptional elements (the occurrence or absence of paint) rather than working out and elaborating the basic rules. Even Milojčićs strong rejection for ^{14}C dates seems to have persisted in some recent publications.

As a result, the definition of Starčevo culture, and with it of Criş culture, is not grounded on precise stratigraphic observations; on the contrary, the chronological system is based on subjective interpretations and assumptions. Even less helpful was the transplantation of concepts and results from the Aegean to the Balkans, such as the issue of the 'Monochrome Horizon'. Furthermore, the evolutionist approach, characteristic of that time, led to the interpretation of Starčevo IV as a phase in decline, thereby neglecting its importance. Whereas doubts concerning the 'Monochrome Horizon' have lately been advanced (*Stojanovski 2014; Krauß* et al. *2014; Reingruber in print a*), the poorly defined phase IV (contemporaneous with Vinča A) has never been a topic for in-depth analysis.

1944–1991 in East Romania

It was not until 1983 that materials of the EN in the eastern part of Romania, in the counties of Moldova and Bucovina, were analytically studied and considered to pertain to the Criş culture (*Ursulescu 1984*). Previous interpretations were ignored. Yet, it was Fritz Schachermeyr (1895–1987) who proposed already in 1955 the term 'Glăvăneşti culture' for a specific type of pottery that was first described by Ion Nestor (1905–1974) for the site of Glăvăneştii Vechi near Iaşi (*Nestor 1951*). In this respect, Schachermeyr was supported by Milojčić (whom he thanked in footnote 67). Milojčić, who can be considered as one of the best connoisseurs of Starčevo and Körös pottery of his time, had not identified common elements between Starčevo pottery and the finds from Glăvăneştii Vechi, and he had not advised Schachermeyr to draw comparisons of this sort. Nevertheless, through two articles published by its representatives in the same year of 1958 the Romanian Academy imposed the view that the whole territory of modern Romania had been uniformly covered by the same Neolithic culture. In a harsh critique, Vladimir Dumitrescu (1902–1991) unequivocal-



Fig. 2. Romania (after 1947) and the Republic of Moldova (after 1991).

ly rejected the definition of a separate cultural entity, since the outer Carpathian areas were also occupied by Criş culture (*Dumitrescu 1958*). Mircea Petrescu-Dîmboviţa (1915–2013) also promulgated this view (*Petrescu-Dîmboviţa 1958*). Moreover, Silvia Marinescu-Bîlcu (*1935) insisted that Criş culture had spread not only in Romania, but also in the Soviet Socialist Republic of Moldova (*Marinescu-Bîlcu 1981*).

This latter claim was remarkable, since the generally accepted view in Soviet times was that the Bug-Dniestr culture had evolved in Moldova (*Markevich 1974*). But with *perestroika* and the fall of the Iron Curtain in 1991, almost all sites were redefined as Criş sites instead of Bug-Dniestr (*Dergachev* et al. *1991; Larina 1994.Fig. 2*), except for those sites situated in the Dniestr-valley itself (*e.g.*, Soroca). A more cautious interpretation was given by Klaus P. Wechler (*2001*) who proposed an eastern and western variant of the Bug-Dniestr culture, with strong Criş-influences in the west. Nevertheless, he also accepted the Criş designation, as it is generally still accepted in the archaeological community.

The problems related to research during the 20th century, both during the 'hot' and the 'cold' wars, are manifold. The shifting of national borders and their new negotiations during the 20th century did not favour international research within geographical well-defined entities shared by neighbouring countries. During dictatorships – both rightist and leftist – politically biased research within the confinements of modern states' borders was stimulated, favouring theories and concepts with an inherent and strong national component. History and prehistory were used to legitimise territories repeatedly lost and regained before and after WW II. Certainly, not only in the Balkans, but also throughout Europe, archaeology and nationalism during the last century were "*inextricably intertwined*" (*Díaz-Andreu, Champion 1996.21*). Actually, also discourses of our times, as Yannis Hamilakis (*1996.977*) rightly points out, need careful examination, since subjectivity is inherent in archaeological interpretation.

Apart from the unfavourable historical background, an outdated methodology excluding natural scientific approaches has also led to biased or partial results. The strong focus during post-war research on pottery and stratigraphy, the opening of very narrow but metre-long trenches resulted in mainly limited analysis, further submitted to subjective interpretations. Exceptional painted sherds, always few in the pottery inventories, were used to define whole cultures instead of applying statistical, quantitative ana-

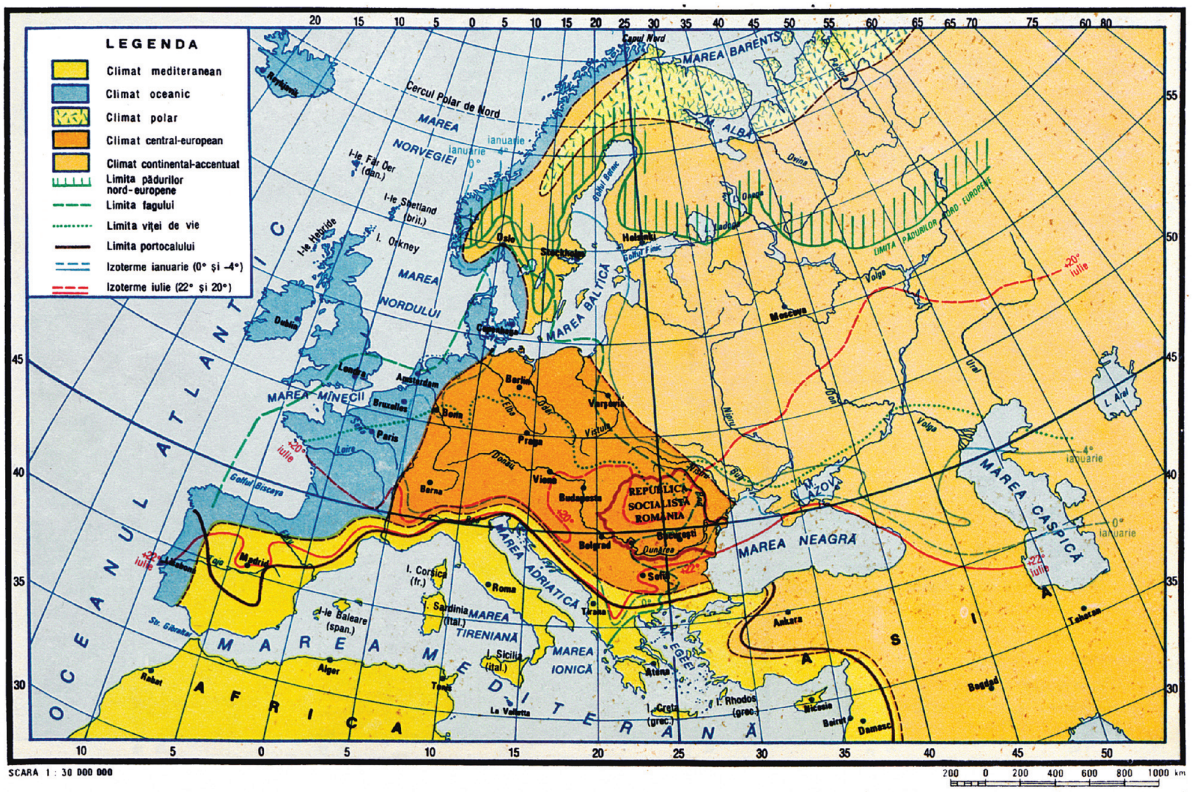


Fig. 3. Map from 1985 showing* "Romania's integration in the climate and natural vegetation of Europe" (Atlas 1985.9*). The red line corresponds approximately to the limits of the steppe in Fig. 4.

lysis. In this way, the qualitative method used in the early days of pottery analysis was perpetuated rather than critically re-evaluated. Natural sciences were only casually applied, so radiocarbon dates are even now few and ambiguous.

Nevertheless, with the application of ^{14}C dates, not only must relative chronological sequences be verified, but also the concept of culture as defined mainly by pottery styles be questioned. In a cross-regional comparative approach, priority should be given not to single decorated sherds and poorly defined assemblages, but to the general climatic, ecological, and geographical setting in which people were living and striving, exploiting the given resources and adapting to the environment and its conditions.

Climatic and ecological zones of the inner and outer Carpathians

During the communist regime in Romania, uniformity was imposed both on society and the economy. Even climate and vegetation were regarded as uniform throughout the territory of the modern state (Fig. 3), so it is not surprising that their advantages and/or disadvantages were not treated in archaeological studies.

Yet, both the climatic conditions and the vegetation cover are diverse, the Carpathian Mountains being a major dividing factor in this respect: they separate the temperate inner Carpathian climate from the more arid conditions of the steppe and forest steppe. Recently reconstructed temperatures for Lake Brazi in the Southern Carpathians accorded with inner Carpathian records (*Tóth* et al. *2015.578*). For the outer Carpathian area, such palaeoclimate reconstructions are still only few (*Mayewski* et al. *2004; Weninger, Harper 2015*). In its western extension, this region is distinguished by the bow described by the Prut and Danube rivers. It is a border region, peripheral to both the arid Pontic steppe farther northeast and to the temperate Balkan zone to the south-west. In Neolithic studies, its connectivity has often been underestimated. Additionally to modern political frontiers, climatic boundaries have also been located between Ukraine and Romania. Generally, only few archaeological maps deal with transfrontier climatic zones, although the *Encyclopedia of Earth* (*Hogan 2013*) considers that the steppe also covers southeastern Romania (compare *Weninger, Harper 2015.Fig. 3*). Even in recent archaeological publications (*Anthony, Brown 2011.139, Fig. 4; Gaskevych 2011.Fig. 2*) does the Pontic-Caspian steppe stop in the west near the Danube Delta (Fig. 4). The assumed antagonism between the steppic nomads and the sedentary farmers of the Lower Danube area appears thus more aggravated than prehistoric circumstances would allow for.



Fig. 4. Extension of the steppe (according to* Anthony, Brown 2011.Fig. 4*).

During the last 100 years, major activities related to deforestation, drainage, river regulation, extensive land use, and overgrazing have changed dramatically both the landscape and vegetation cover. In a region where only few scientific investigations have targeted the reconstruction of the landscape based on drillings and pollen analysis, old maps are especially valuable. Such a map was created by Ellen M. Sanders in 1923, showing the typical mosaic of steppe – wetland – floodplain forest (Fig. 5). Sanders very meticulously describes the

steppe areas with "*no trees*" and with "*some trees*" (*i.e.* forest steppe, a transitional zone of mixed grasslands and temperate broadleaf and mixed forests). It appears that large areas of the outer Carpathian arch belong climatically to the Pontic steppe region, especially those areas close to the Prut and the eastern Lower Danube. Another area of both primary and secondary steppe stretches along the Tisza River (compare also *Tölgyesi* et al. *2015*), in an area inhabited by the EN Körös culture in the Alföld (*Bánffy 2013.Fig. 3*).

On the geographical map of the Lower Danube, the dominant feature is the presence or absence of surrounding mountains (Fig. 6). The western area is enclosed on three sides by mountains and forests (up to the River Vedea), and, in contrast, the eastern part is open towards three sides. This favours different directions of prevailing winds and different quantities of precipitation. Whereas in Oltenia (like in the Banat) the *Austuru* brings warm and dry air from the west at an average of 20–30km/h, in Muntenia, as well as in Moldova and Dobrogea, the *Crivățul*, a strong wind reaching up to 120km/h, sweeps from the east with cold air and blizzards in winter and hot and dry air in summer. Hence, in the western part, precipitation is between 500–700mm/a, whereas in the eastern part, precipitation is less than 400mm/a (*Atlas 1985*). Certainly, this has a strong influence on the vegetation cover: much of the outer Carpathian bow is covered primarily by steppe grasses and open forests of the silvosteppe, interspersed with wet meadows in the river valleys. Therefore, both climate and vegetation are comparable to that of the north-western Pontic steppe region.

That we do not deal in Muntenia with secondary steppe areas is proven by investigations carried out by an interdisciplinary team working in Pietrele, jud. Giurgiu. There, for the 5th millennium BC, the bones of steppe-preferring species such as horses and aurochs, as well as a high percentage of grasses in the pollen record were attested (*Benecke* et al. *2013;* A. Röpke in *Hansen* et al. *2012*).

The Lower Danube Region is thus far from being climatically uniform, but divided into different zones. The zone extending over both the eastern Lower Danube area and the Prut-Siret area is described as arid. The transitional zone between sub-Mediterranean and arid areas runs along the Vedea and Teleorman rivers north of the Danube and the Yantra south of the Danube (*Atlas 1985.28, 42–43*). This line (Fig. 6) can be regarded as an approximate separation between a western area (part of the temperate zone of Southeast Europe) and an eastern one (part of the much more arid zone of the Pontic region).

In the modern era, these zones and their 'ecological biogeography' (*Huggett 2004*) are of little relevance. But populations responding to their physical and living surroundings, to both the abiotic (*e.g.*, temperature, soils, water, air currents) and the biotic environment (different species, parasites, diseases, predators) were dependent on these factors. Differences in ecozones were certainly of major importance in pre-Neolithic times, when Mesolithic communities relied on their biomasses. With the emergence of a producing economy and the import of domesticated species, such dependencies were of less importance. If the view proposed here is accepted, whereby local Mesolithic communities participated actively in the Neolithisation process, then these ecozones should be considered as relevant also for the EN period.

Limits in the definition of archaeological cultures: the case of the 'Starčevo-Criş IV phenomenon'

In the traditional view, the definition of an archaeological culture is based mainly on material culture (*Wotzka 2014.139–144*). Following Philippe Descola (*2014.39*), cultures can be further outlined according to their geographical boundaries. Not only are the remains of Criş culture east of the Carpathians insufficiently described, but also the geographical setting in- and outside the Carpathian Basin, two climatically and geographically quite distinct zones, has hardly ever been discussed. The easternmost stretches of the Pannonian Plain ('Câmpia de Vest', in western Romania) are bounded by the three Criş rivers (Fig. 6), but the sites labelled as Criş are in fact not located in the Crişana, the Criş Basin, but farther east, in the Someş catchment and farther south, in the catchments of the Mureş (Transylvania) and Timiş (Banat) rivers. This, for non-specialists, slightly confusing situation is further impaired by the transfer of the culture's name Criş to the east (the county of Moldova and the Republic of Molodova). As a result, the earliest Neolithic evidence in the outer Carpathian bow, extending as far east as the Dniestr, is named after a river's course from west of the mountains either as Criş or as 'Starčevo-Criş IV' (compare *Lazarovici 1979*, above). Thus it must be possible to ask on what grounds the definition of this culture relies (apart from pottery styles), and how well-founded is its interpretation as a comprehensive cultural phenomenon (apart from the effort to sub-

sume Neolithic cultures occupying the territory of present-day Romania under the same label).

No clear boundaries and no geographically or climatically well-defined area can thus be connected to Criş culture, as it is supposed to have spanned both the inner and outer Carpathian regions. The latter, the Prut-Danube region, is climatically a steppe/forest steppe area. Rather than attaching this climatically, hydrologically, and culturally distinct region to the inner Carpathian basin, it should be envisaged as an important and not interchangeable living environment in its own right. The transition from the Mesolithic to the Neolithic in the Prut-Danube area should not be viewed through results obtained elsewhere, nor should assumptions be built on them, but be described according to the conditions given in the area east of the Carpathians.

Apart from the lack of well-defined geographical boundaries, the temporal limits of the culture are also vague. When one compares ^{14}C dates from different sites of Criş culture, the problematic division into phases and, moreover, the deficiencies deriving from poorly applied stratigraphic comparisons become obvious, even for the heartland of the culture (*Reingruber, Thissen 2016; Thissen, Reingruber in print*). The first phase, Pre-Criş, is presumed to have antedated the 6000 BC margin by several hundred years (*Ciută 2005.124*), similarly to Proto-Starčevo (*Srejović 1988*) and Pre-Karanovo (*Todorova 2003*). These early stages were connected to an allegedly 'Monochrome Horizon'. As has been shown elsewhere (*Reingruber in print a*), this horizon cannot be verified stratigraphically in the whole of the Balkans. Its ^{14}C dates vary between 6000 and 5500 BC (*Reingruber, Thissen 2016*), and cover the whole duration of Starčevo-Criş culture; therefore, monochrome pottery is not limited to a distinct phase, but concomitant with all other phases. Apart from this, the concept of the 'Monochrome Horizon' derives from the Thessalian EN (*Reingruber 2008. 211–213*) and is not directly applicable to pottery from the Middle and Lower Danube area, especially not to the Ludogorie Plateau in north-eastern Bulgaria. There, the pottery of the Koprivets culture (5900–5700 BC) has been linked to the (not only unpainted but also undecorated) Aegean 'Monochrome Horizon' (*c.* 6400 BC), although the vessels from Koprivets are decorated with impressions, incisions and plastic knobs (Fig. 7). Interestingly, incisions and impressions and the absence of paint are characteristic and defining elements of Bug-Dniestr pottery of the early 6th millennium BC (*Wechler 2001*). In the intermediate region of the Prut and Siret rivers again this kind of ornament prevailed in the pottery of the mid-6th millennium BC (Fig. 8). Therefore, rather than claiming direct contacts with distant Aegean regions solely due to the absence of paint, the (also unpainted) pottery inventories of the directly neighbouring Pontic region should be envisaged for comparisons first.

Especially poorly defined is the final stage of the EN. Owing to an evolutionist perception of pottery production and of cultural development in general, the last phase of Criş culture was thought to be one of decline and decay: paint was no longer applied, pots were of rougher appearance (*Ursulescu 1984.31–34, 37*). This interpretation justified the designation of sites from the outer Carpathian bow as Criş, making a more thorough and independent analysis of the material culture seemingly dispensable, even though the (indeed only few) absolute dates pointed not to a co-existence but to a temporal succession between Starčevo-Criş and the 'Starčevo-Criş IV phenomenon'. Starčevo-Criş culture ends in the west, in Serbia, according to ^{14}C dates around

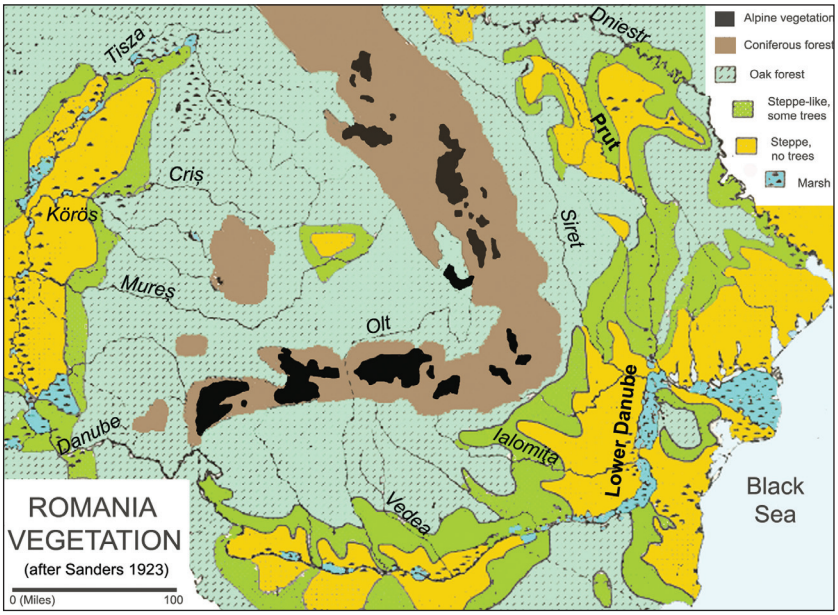


Fig. 5. Climatic map of Romania and neighbouring areas (after* Sanders 1923.387*).

5500 BC (*Thissen, Reingruber in print*). In the outer Carpathian area of Oltenia (southwest Romania) the 'Starčevo-Criş IV phenomenon' has been dated at Cârcea Viaduct and Valea Răii-Copăcelu to 5400–5300 BC *(Mantu 1999–2000.98*). In Moldova, at the Trestiana site (*Popuşoi 1983.36*), the 'Starčevo-Criş IV phenomenon' is assumed to have started around 5500 BC, ending with 'Music Note Pottery', a late variant of Linearband culture (LBK) at *c.* 5300 BC (*Reingruber in print a*). At the moment, we do not possess enough data to characterise these two important centuries, between 5500 and 5300 BC, harbinger of major transformations in both the Lower and Middle Danube areas with the transitions to the Karanovo III and Vinča cultures. Yet the contribution from the Prut-Danube region to the formation of cultures further upstream from the Danube, like Dudeşti at 5500 BC (*Thissen in print*) and Vinča at 5300 BC (*Schier 1996*), should not be underestimated.

The Prut–Danube network of the north-western Pontic steppe: burial rites and stone tools

Hence, a well-founded analytical description of a presumed cultural unity spreading both east and west of the Carpathian Mountains has not yet been provided. Pottery styles would rather point to largely independent, and radiocarbon dates to subsequent, phenomena regarding the Starčevo-Criş cultures in the west and 'Starčevo-Criş IV' in the east. Certainly, pottery styles do display regional variations, but throughout the whole area of the Prut-Danube river system they are (almost exclusively) unpainted and bear decorations that are incised and/or impressed. This is a characteristic that can also be claimed for the westernmost exclave of the steppe belt, the territory of Körös culture, where pottery surfaces were roughened by joining additional clay (barbotine), paint being applied only exceptionally. Recently, Mihael Budja has pointed out, in a wider European context, two major pottery traditions: a northern one, never painted, embedded within a hunter-gatherer context and a southern one, with coloured decoration, connected to early farming communities of Near-Eastern origin (*Budja 2015.546, Fig. 28.5*).

Pottery styles as described above (Figs. 7–8) are only one feature pointing to a network of contacts and exchange. Shared traditions are also traceable in other cultural features. The dominant funerary burial tradition in western Ukraine entailed burial in the supine position (*Gaskevych 2015*), unlike Aegean rites in which bodies were placed out in a crouched, hocker position (*Lichter 2002*). Inhumation in an extended supine position was also a common practice during the Mesolithic of the Iron Gates (*Boroneanț, Bonsall 2012*), but in Lepenski Vir it was replaced after 6000 BC by the hocker position (*Borić 2015*). Along the eastern Lower Danube area and the Black Sea coast (Cernica and Cernavodă, Durankulak and Varna), the supine burial position was used even during the late 6th and 5th millennia (*Lichter 2001.151–152*). For this reason, Lichter concludes that Mesolithic burial traditions in these regions survived until the Copper Age (*Lichter in print*). Furthermore, certain animal sacrificial rites in this area are, according to Valentina Voinea (*2010*), not only of Pontic but even of earlier Mesolithic traditions.

A strong argument for substantiating Pontic traditions and influences in the Balkans are chipped stone tools, especially bullet cores used to produce parallel-



Fig. 6. Topographical map with the mountainous arc described by the Carpathians and its continuation into a southern arc which, with Stara Planina, surrounds the western Lower Danube area.

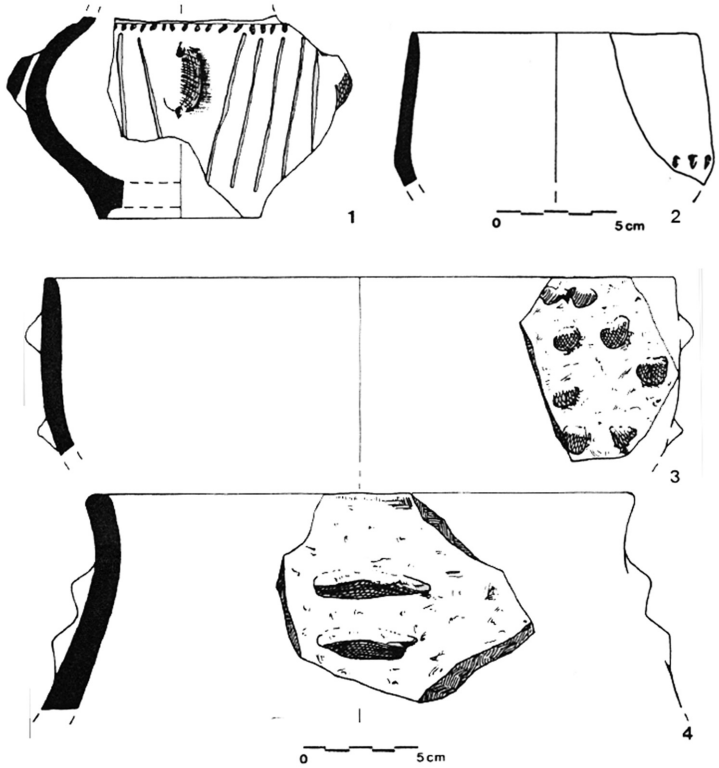


Fig. 7. Pottery from Koprivets (after* Stefanova 1996*).

sided bladelets. Ivan Gatsov recently pointed out that bullet core technology is of Anatolian origin and probably did not continue north of the Sea of Marmara, since in Bulgaria no such items have (yet) been found (*Gatsov* et al. *in print*). One could argue that, generally, very little is known from the Mesolithic in present-day Bulgaria, a period that should especially be targeted in future investigations. As Paolo Biagi and Dmytro Kiosak have shown for areas further north, bullet cores and the fine regular blades obtained from them, are typical of the Mesolithic cultures of south-western Ukraine, especially the Kukrek and Grebenyky cultures, which spread as far west as the Prut (*Biagi, Kiosak 2010.23–24*). From its most important site, Myrne, close to the northernmost Chilia branch of the Danube Delta, geometric microliths (isosceles and rectangular trapezes) and bullet cores were recently dated to 7500–7300 BC (*Biagi, Kiosak 2010.Fig 1, Tab. 3*).

According to some authors, there are no differences between the tools of the Kukrek cultures and the north-western Pontic 'Tardenoisian' of Romania (*Biagi, Kiosak 2010.25*). Also, for northern Bulgaria a century-long use of microliths has been pointed out: in Ohoden, trapezes and segments were in use throughout the occupation (*Gurova 2014.97*), dated to *c.* 5700–5600 BC (*Thissen, Reingruber in print*). Further south, in Kovačevo, they were replaced only in phases Ic–Id (dated to after 5700 BC; *Reingruber, Thissen 2005*) by so-called macroblades.

The macroblade industry prevailed throughout the EN in Thrace. From single-platform cores, big regular blades were removed by punching with a hard hammer; also characteristic is the subsequently applied high and steep retouch (*Gatsov* et al. *in print.Fig. 1*). Interestingly, a specific kind of flint, a high-quality yellow flint with white spots, so-called 'Balkan flint' (henceforth BF) is related to this technique (*Gurova 2008.Figs. 2–12*). The flint most probably derived from the Pleven-Nikopol region in NNW Bulgaria (*Gurova 2014.95*), where it was extracted until *c.* 5500 BC; afterwards, its use declined in the Karanovo III/IV period.

North of Stara Planina, the use of BF started in the so-called Pre-Karanovo period, or rather the Koprivets culture (*Vajsov 2002*), and is attested in the lowest levels of Dzhulyunitsa around 6050 cal BC (*Krauß* et al. *2014*). South of Stara Planina, in the lowest levels of Tell Azmak and Tell Karanovo, its use can be dated to only after 5900/5800 BC. Farther south, in southwest Bulgaria, it does not occur in the earliest Neolithic occupation phase at Kovačevo but only in later ones.

Maria Gurova (*2014.96*) draws our attention to the fact that in north-eastern and northern Bulgaria, no macroblades ('formal tools', in her words) were in use in early contexts (*e.g.*, Ohoden and Dzhulyunitsa). Consequently, Gurova and Clive Bonsall refer to different traditions north and south of Stara Planina (*Gurova, Bonsall 2014.103*). This very limited evidence may, nevertheless, indicate that the Neolithic use of BF began earlier in northern Bulgaria and, one would add, since the sources are in the north, it might be indicative of an exchange network already in use there before it expanded across the Balkan Mountains towards the south.

Discussion: cultures and networks

The elements required to define archaeological cultures were enumerated by, for example, Milojčić (*supra*) in the mid-20th century; their territorial boundaries often coincided with the national bor-

ders of the time. Changes were mainly explained by massive unidirectional migrations, by 'penetrations' from area A into area B (*Ursulescu 1984*). Yet, for an explanation of the complex transformation processes that led, for example, to the Neolithisation of Southeast Europe around 6000 BC or to the transition from the MN to the LN around 5500/5300 BC, such approaches, if they exclude the natural sciences, are insufficient. It is essential to understand transcultural and diachronic networks based on reciprocity and exchange, developing in a given ecological setting and using natural communication and transportation routes. In this perspective, pottery is only one among several elements to be studied: at least as important are studies of raw material sources and their distribution, of animal bones, of human remains. No palaeogenetic or isotopic determinations have been carried out on individuals from the Prut-Danube area, but the studies of human bone material from two Körös sites yielded astonishing results: the genome of a male from the more northerly farming site of Tiszaszőlős-Domaháza (*c.* 5700 BC) displays a hunter-gatherer background, whereas the genome of a female up to 100 years younger from the more southerly site of Berettyóújfalu-Morotva-liget clusters with later Neolithic individuals (*Gamba* et al. *2014.3, Tab. 1*). Although two samples are a very thin basis for drawing any conclusions, it appears that in the steppe area of the Körös region, direct contacts between Mesolithic and Neolithic groups occurred. On a much broader basis, a system of patrilocal residential rules among early farmers was indeed proposed by Anna Szécsényi-Nagy *et alii* (*2015*). This corresponds well with results obtained by Dušan Borić and Douglas T. Price (*2013*) from the Danube Gorges based on isotopic studies in which mainly women were of extra-local origin.

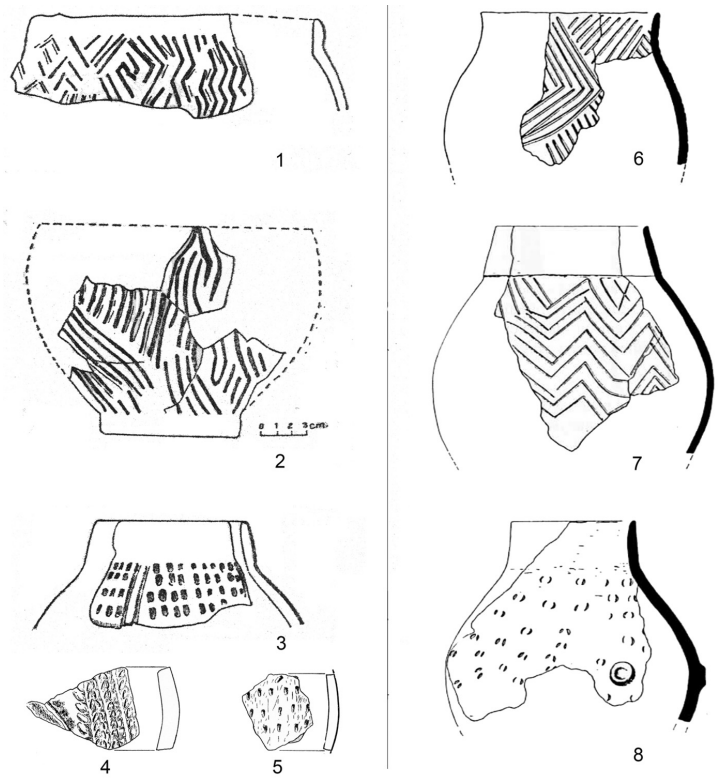


Fig. 8. **1–5** ***pottery from Trestiana (after*** **Ursulescu, Dergachev 1991.Fig. 3; Popuşoi 1983.Fig. 4.12–13*****); 6–8*** ***pottery from Sacarovca (after*** **Dergachev** ***et al.*** **1991.Fig. 4*****).***

In all three interconnected areas of the Prut-Danube river system – the area covered by 1) the Koprivets culture in north-eastern Bulgaria (as defined by Ivan Vajsov), 2) the area of the 'Starčevo IV phenomenon' in Muntenia and Moldova (as defined by Gheorghe Lazarovici) inclusive of Glăvăneşti culture (as it was named by Fritz Schachermeyr, but not accepted in the Romanian literature), and 3) the area of the former Bug-Dniestr culture in the Republic of Moldova (redefined as Criş) – we meet similar characteristics, both climatically, hydrologically, and culturally.

Here, it is plausible that an exchange network existed along the outer Carpathian area. According to the conventions of the terminology used for Neolithic cultures in the steppe, this network should be named after the major rivers of the region, the Prut and Danube. The network was in use already during the Mesolithic (according to evidence from stone tools) and was afterwards enlarged in Neolithic times (according to evidence from pottery). The radiocarbon dates for the sites participating in this network are few and often ambiguous: dates even older than 6000 BC derive from the northern sites west of the Dniestr (*e.g.*, Soroca II-Trifăuţi), but they must be treated with caution (*Gaskevych 2010*). From its central part, the oldest dates are 5900–5700 BC (*e.g.*, Poiana Slatinei – compare *Weller, Dumitroaia 2005. Fig. 6*), and the dates from the southern reaches (the Koprivets culture) are similar. The network can be followed up until at least 5500/5300 BC (*e.g.*, Soroca V and Trestiana) (*Thissen, Reingruber in print*). Subsequently, an expansion along the Danube towards the west is marked by the pottery with *Notenkopf* (Music Note) decoration, which is found in

Pietrele and Vădastra (*Reingruber in print a.Fig. 1*). Therefore, major transcultural networks can be pointed out that developed along the different river systems (highlighted in different colours on Fig. 6):

● operating along the Axios/Vardar-Struma-Morava rivers and Danube-Timiş-southern Tisza-Mureş (*Nikolov in print*) and along the Maritsa-Tundzha and Yantra-Vit-Vedea-Olt (*Reingruber in print b*) is the network that connects the Balkans and the inner Carpathians, comprising roughly the archaeological cultures of Amzabegovo-Vršnik, Karanovo and Starčevo-Criş with, *e.g.*, white painted vessels, hocker burials and with a macroblade technology as well as tell-settlements (in Thrace).

● another network is that of the steppe and forest steppe, comprising the sites both west and east of the river Prut (formerly ascribed to Bug-Dniestr culture or attributed to the 'Starčevo-Criş IV phenomenon') and sites of the eastern Lower Danube catchment. It is characterised by incised and impressed decorations on pots, flat settlements (if tells formed, then only late, after 4800 BC), supine burial positions and simple blade technology.

The different networks are connected in the east-west and west-east directions by the Danube, which facilitated communication and exchange between the regions.

Building upon Richard Huggetts *ecological biogeography*, three zones can be defined for Southeast Europe:

● the First Neolithic of the circum-Aegean zone, starting around 6700/6600 BC (*Reingruber 2015*), covering the *Mediterranean subtropical zone* (*Huggett 2004.102*) between roughly 35° and 42° north;

● the First Temperate Neolithic of the Balkans and eastern Central Europe, between 6000 and 5500 BC (*Thissen in print*) in the *Humid mid-latitude zone* (*Huggett 2004.102*) of SE Europe, north and south of the 45th parallel north;

● the First Neolithic of the western and north-western Pontic steppe and forest steppe of the Arid mid-latitude zone (*Huggett 2004.102*), with an early stage between 5900–5500 BC and a later stage between 5500–5300 BC.

As indicated in Fig. 6, these zones were interconnected by the courses of the different rivers that were essential for maintaining transcultural exchange networks. Especially in present-days north-eastern Bulgaria, a contact zone between the two latter entities emerges: concerning, the white painted pottery of the Thracian tradition appears also on the northern fringes of Stara Planina, whereas in the Ludogorie basically incisions and impressions of steppe traditions were used; on the other hand, the raw material was from the Nikopol region, highly valued also south of Stara Planina.

Conclusions

The Neolithic discoveries west of the Dniestr River are in the opinion of both Moldavian (*Dergachev* et al. *1991*) and Ukrainian archaeologists (*Nadja Kotova, personal comm. 07.11.2015*) indeed different from Bug-Dniestr material culture. According to the above notions, it is also different from the inner Carpathian Criş culture. It is therefore not advisable to speak of Criş culture (in its Starčevo variant) in the outer Carpathian area, in areas of present-day eastern Muntenia and Moldova, since the basic criteria for the definition of a culture are not met, not to speak of the extremely different ecosystem of the inner and the outer Carpathian arch. Yet, for the outer Carpathian area pottery styles, burial traditions, and tool manufacturing attest to a certain degree of exchange, even to perpetuations of traditions from the previous Mesolithic period. Facilitated by the Prut, Danube, and Siret rivers, a network was established in this region that operated simultaneously with those west of the Carpathians or south of the Balkan Mountains (Fig. 6). It certainly deserves more careful and detailed treatment in the future.

The more thoroughly we are able to understand and accept the Prut-Danube area as an interconnected network system of its own, not caught between nationalist and politically motivated approaches, the better are the chances of understanding developments in the broader area between 5900 and 5300 BC. Anatolian-Aegean-centric views do not explain all the transformations appearing after 6000 BC in the northern Balkans, especially not those occurring after 5500 BC. Around the middle of the 6th millennium BC, major transformations have been noted, like the shift to largely unpainted pottery styles and the exploitation of new raw material sources in Karanovo III and Vinča A phases. The beginning of the Dudeşti cultures in Muntenia and Vinča-Dudeşti in Oltenia in particular are poorly defined. In terms of radiocarbon dates, the site of Măgura-Buduiasca near

Alexandria antedates the Vinča tell by *c*. 200 years (*Thissen, Reingruber in print*). These two centuries, 5500–5300 BC, will hardly be understood without acknowledging the contribution and role played by the Prut-Danube area in the formation or expansion of networks in the western Lower Danube area and even farther upstream after 5500 BC. Future interdisciplinary trans-regional and trans-frontier studies will certainly help clarify some of misunderstandings and problems we are confronted with nowadays. The input and importance of this network in transformation processes following the Danube farther upstream certainly will then be better appreciated.

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Neolithisation of Sava-Drava-Danube interfluve at the end of the 6600–6000 BC period of Rapid Climate Change: a new solution to an old problem

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ABSTRACT – *The idea of the Neolithisation of the Sava-Drava-Danube interfluve has undergone very little change since S. Dimitrijević's time. Despite their many shortcomings, new archaeological excavations and radiocarbon dates of Early Neolithic sites have provided us with new insight into the process of Neolihisation of this region. Using the recently published work by B. Weninger and L. Clare (*Clare, Weninger 2010; Weninger *et al.* 2009; Weninger *et al.* 2014*) as a starting point, the available radiocarbon and archaeological data are used to build up a time frame comparable to the wider region of Southeast Europe and climate conditions for specific period. The results fit the model of Neolithisation well (*Weninger *et al.* 2014.9, Fig. 4*), filling in the geographical gaps.*

IZVLEČEK – *Premise o neolitizaciji v medrečju Save, Drave in Donave se od časa S. Dimitrijevića niso veliko spremenile. Nova arheološka izkopavanja in radiokarbonski datumi zgodnjega neolitika so, kljub mnogim pomanjkljivostim, prinesli nove vpoglede v proces neolitizacije na tem območju. Za osnovo pri interpretaciji smo uporabili nedavno objavljena dela B. Weningerja in L. Clarea (*Clare, Weninger 2010; Weninger *et al.* 2009; Weninger *et al.* 2014*), dosegljive radiokarbonske datume in arheološke podatke pa smo uporabili za izdelavo časovnega okvirja, ki je primerljiv s širšim območjem jugovzhodne Evrope in s klimatskimi pogoji za posamezna obdobja. Rezultati dobro ustrezajo uveljavljenemu modelu neolitizacije (*Weninger *et al.* 2014.9, Fig. 4*) ter zapolnjujejo geografske vrzeli v modelu.*

KEY WORDS – *Neolithisation; Starčevo culture; northern Croatia; flooding episodes; Rapid Climate Change (RCC)*

Introduction

The Early Neolithic of Sava-Drava-Danube interfluve, situated on the southern edge of the Carpathian basin, was marked by Starčevo culture. It first appeared in western Syrmia and eastern Slavonia, spreading through Baranja and western Slavonia and further west along the Drava River sometime around or slightly after 6000 BC. Over 100 Starčevo culture sites are known today, but only a handful have been excavated, and even fewer properly published. Data from four sites are used in this paper: Sopot, Zadubravlje – Dužine, Slavonski Brod – Galovo and Virovitica – Brekinja (Fig. 1). The earliest radiocarbon dates can be attributed to features exhibiting the full so-called Neolithic package. The south-east to north-west direction of spread of Neolithisation can be observed through the available radiocarbon dates.

The first relative chronology of Starčevo culture for the region in question was determined by Stojan Dimitrijević (*1969.40; 1979.237–238*). This chronology is still in use, and no attempts have been made to challenge it or to attribute absolute dating to its phases[1].

1 Kornelija Minichreiter added to it Linear C phase for the western Drava region (*1992.54–55*), but she concentrated more on internal chronologies of specific sites than on the absolute dating of Starčevo culture phases in general. The only exception is the attempt to date the white painted Linear A phase at Galovo site (*Minichreiter 2007b*) but without reference to the full problem of Neolithisation.

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In recent years, new interdisciplinary studies appeared that enabled more complex analysis and offered different solutions to the problem of Neolithisation in the wider region from the Middle East, through south-east Europe and beyond. Whether they deal with possible climatic impact on Neolithisation from the climatological point of view (*Perry, Hsu 2000; Migowski* et al. *2006; Weninger* et al. *2006; 2009; 2014; Kuper, Kröpelin 2006; Budja 2007; Clare* et al. *2008; Gronenborn 2009; Berger, Guilaine 2009; Clare, Weninger 2010; Weninger, Clare 2011; Zielhofer* et al. *2012; Reimer* et al. *2013, etc.*) or predominantly from the archaeological point of view (*Jurić* et al. *2001; Bonsall* et al. *2002; Bonsall 2007; Bánffy* et al. *2007; Borić, Dimitrijević 2007a; Bánffy, Sümegy 2012; Bánffy 2013a; Salisbury* et al. *2013; Lespez* et al. *2013; Gurova, Bonsall 2014; Krauß* et al. *2014; Botić 2016, etc.*), they offer answers to some very old questions on this subject.

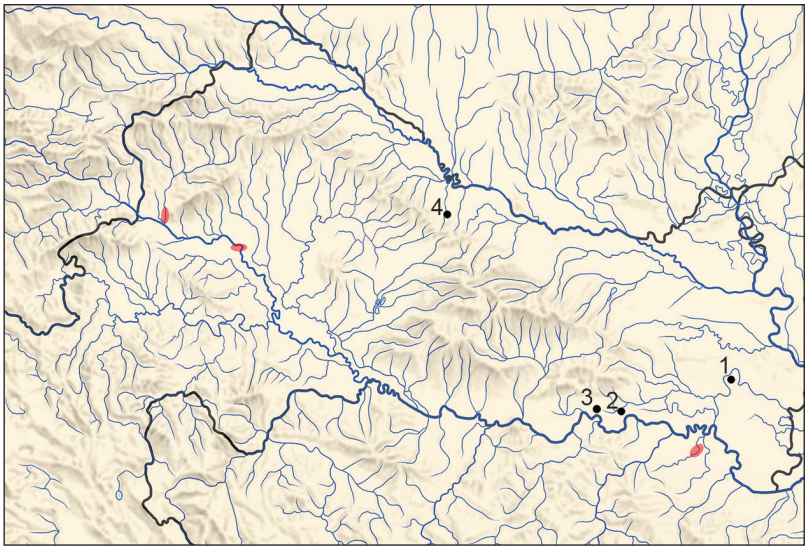


Fig. 1. Starčevo culture sites mentioned in the text:* 1 *Sopot;* 2 *Zadubravlje – Dužine;* 3 *Slavonski Brod – Galovo;* 4 *Virovitica – Brekinja. Sites of sub-fossil wood extraction mentioned in the text (from east to west): Oštra luka; Sava River near Rugvica; mouth of the Krapina River.

Relative chronology of Starčevo culture in northern Croatia

The basic typological periodisation and relative chronology of Starčevo culture in northern Croatia was determined by Dimitrijević (*1969.40; 1979.237–238*) with very few later additions (*Minichreiter 1992. 54–55; Marković 1994.62–63*). Dimitrijević separated Starčevo culture into seven phases: Monochrome, Linear A, Linear B, Girlandoid, Spiraloid A, Spiraloid B and the Final Ždralovi phase (*1969.40; 1979.237–238*). Kornelija Minichreiter later added Linear C phase (*Minichreiter 1992.54–55*), which she considers parallel to Spiraloid A phase in eastern Slavonia and Baranja. Zorko Marković's proposed chronological system was never accepted (*Marković 1994. 62–63*)[2]. No recent attempts have been made to further study the problem of the relative chronology of Starčevo culture, except Minichreiter's internal chronologies of the Zadubravlje – Dužine, Slavonski Brod – Galovo, and Pepelana sites (*Minichrieter 1992; 2007a; 2007b; 2007c*), although the problem of chronological sequences of these phases and their apparent parallel appearance in different regions still waits to be addressed.

An old problem

The process of Neolithisation of the Sava-Drava-Danube interfluve has not been properly addressed since Dimitrijević's time. The development of early Neolithic Starčevo culture was observed by Minichreiter mostly in the light of new excavations carried out at the Pepelana, Zadubravlje and Galovo sites in terms of internal chronology (*Krajcar Bronić, Minichreiter 2007; 2011; Minichreiter 2001; 2007a; 2007b; 2007c; 2010; Minichreiter, Botić 2010; Minichreiter, Krajcar Bronić 2006*) but the process itself was not the focus of Minichreiter's research.

Dimitrijević presumed the existence of an initial Monochrome phase (*Dimitrijević 1969*) even describing pottery finds (*Dimitrijević 1969.40; Minichreiter 1992.7–8*), but sites containing finds from this presumed phase were never documented in northern Croatia (*Minichreiter 1992.41, 54; 2007b.23*), not even after the large-scale rescue excavations on highways, bypasses *etc.* carried out in the last 15 years. Dimitrijević's second presumed Linear phase (*Dimitrijević 1969*), more specifically Linear A (*Dimitrijević 1979.237; Minichreiter 2007b.22–23*),

2 Phases are: Starčevo 1, Starčevo 2-A, Starčevo 2-B, Starčevo 3, Starčevo 4-A and Starčevo 4-B. His phases are parallel to Dimitrijević's.

was confirmed at the Slavonski Brod – Galovo site (*Minichreter 2007a.16; 2007b*) where white painted pottery was found, and at the Zadubravlje site, which had no white painted pottery, although the coarse pottery shows characteristics of this phase (*Minichreiter 1992.35; 2007c.173*): the lack of channelled barbotine decoration and lack of biconical vessel forms. Dark painted Linear B phase (*Dimitrijević 1979.237*) was attested at both the Zadubravlje and Galovo sites, the latter exhibiting white and dark painted linear pottery in all three features mentioned by Minichreiter (*Minichreiter 2007b*)[3]. However, according to Dimitrijević (*1979.242–246*), barbotine and channelled barbotine decoration was introduced in the Linear B phase, which is absent from both of these sites, although some fragments with amorphous relief appliqués appear (*Minichreiter 1992.35, 69, 101, Tab. 19.1; 2007a.93*).

The last campaign at the Sopot site also provided some fragments of white painted pottery, although some fragments were found earlier scattered over the site out of context[4]. How and where the so-called Neolithic package reached northern Croatia and how that affected the Mesolithic way of life remain unanswered question.

There is another problem concerning most of the new and some of the old archaeological excavations: most of the finds were never published. The same holds for the radiocarbon dates obtained from these excavations. They have not been published or are published without any actual context, or perhaps with just a short description of the feature they were collected from. Thus, the view of how and where the neolithisation started in this region is limited. Nevertheless, data available, although limited, can provide a basis for a new interpretation of the beginning of Neolithic in northern Croatia.

^{14}C sequences of four sites

From over hundred Starčevo culture sites only six have been radiocarbon dated[5] and only four of these sites have usable data[6]. From Sopot near Vinkovci (Fig. 1.1), Zadubravlje – Dužine (Fig. 1.2), Slavonski Brod – Galovo (Fig. 1.3). and Virovitica – Brekinja sites (Fig. 14) 37 radiocarbon dates are available, most of them from Galovo (Tab. 1)[7]. Reconstructing a time frame from a limited number of radiocarbon dates per site, the obvious difference in quantity from site to site, the limited information about the context from which the samples were taken, *etc*., is methodologically questionable, but it is the only information available at the moment.

Sopot near Vinkovci (Fig. 1.1)

The Sopot site was systematically excavated from 1996 until 2008 in 13 campaigns (*Krznarić Škrivanko 2015.372*) although there were several previous excavations during the 20th century (*Krznarić Škrivanko 2015.371–372*). The excavations focused on a late Neolithic Sopot culture tell settlement, but during the last campaign in 2008: "*Dug into the pre-sterile layer (prehistoric humus), for the first time at Sopot, a structure was excavated which can be attributed to the Starčevo culture. Pit dwelling SU 519 was dated to the period between 6060 and 5890 BC.*" (*Krznarić Škrivanko 2015.378*) (Fig. 2)[8]. The pit was found on the easternmost side of the excavated area, very close to the summit of the settlement plateau (*Krznarić Škrivanko 2009.90*). The pottery from this pit was coarse, but according to the excavator, fragments of white painted pottery were discovered before, scattered over the site out of context[9]. These finds have not been published yet. The area excavated was 375m^2, several metres in depth (*Krznarić Škrivanko 2011.212; 2015.375*).

Three dates are available, from pit SU 519 (Beta 251910) and two pre-virgin soil layers SU 80 (Beta 251909) and 143 (Beta 251911) (Fig. 3; Tab. 1). All three dates group around 6000 BC or just slightly earlier. These are the oldest dates for Starčevo culture in northern Croatia so far. The existence of two layers into which the Starčevo feature was dug in may suggest one or more episodes of flooding sealing off the Starčevo layer, rather than being layers

3 Pits 9, 205, and 207.

4 See note 9.

5 Only the published data were taken into consideration, with the exception of one unpublished date from Galovo provided by Dr Kornelija Minichreiter, for which we are grateful.

6 Dates from Tomašanci – Palača site were published as a 5660–5300 BC range without details (*Balen, Gerometta 2011.84, note 2*) and for Belišće – Staro Valpovo site the date was published as 6400–5450 BC, a sample being taken from a male skeleton, but with no other information (*Šimić 2007a.34, note 4; 2007b.10; 2012.27*). Both sites were excluded from this paper.

7 Sopot 3 dates; Zadubravlje 8 dates; Brekinja 2 dates; Galovo 24 dates.

8 Krznarić Škrivanko (*2011.219*) mentions two layers (80 and 143) through which this structure was dug in. These two layers were detected over other areas at the site and contained sporadic Starčevo finds (*Krznarić Škrivanko 2009.90*).

9 M. Krznarić Škrivanko, personal communication.

of prehistoric humus. The next occupation level at this site appears almost 1000 years later during the late Neolithic Sopot culture[10].

Zadubravlje – Dužine site (Fig. 1.2)
Rescue excavations on the site were carried out in 1989 and 1990. An area of 6200m² was excavated (*Minichreiter 1992.31; 1993.93; 2001.203, Fig. 4*). Several large and small pits were explored, comprising working and living areas, many post holes, several kilns and a well (*Minichreiter 1992; 1993a; 2001*). No white painted pottery was reported from this excavation, but dark painted linear motifs were found together with coarse pottery characteristic of Linear A phase (*Minichreiter 1992.35, 103, Tab. 21; 2007c.173*).



Fig. 2. Pit-dwelling 519 during and after the excavation (after* Krznarić Škrivanko 2009.91; 2015.378, Fig. 11*).

Eight radiocarbon dates are available from this site (Fig. 4; Tab. 1). The oldest date (Z-2924) comes from a sample taken from the well. It was probably taken from a larger beam or a trunk and may be considered old wood; it was not taken into further consideration in this paper. Most of the dates group between 5900 and 5600 BC (Fig. 4; Tab. 1) with one exception (Z-2925).

Slavonski Brod – Galovo site (Fig. 1.3)
The site is situated about 9 km west of the Zadubravlje – Dužine site. The excavations started in 1997 and are continuing. An area of around 3000m² yielded 11 large pits which are considered burial pits, pit-dwellings and working pits, one above ground structure (*Minichreiter 2010; Minichreiter, Botić 2010.107*), several large fences, a large number of post holes and smaller pits[11]. White painted pottery was found in pits 9, 205, and 207 (Fig. 5) although most of the painted pottery in all three pits exhibit dark motifs (*Minichreiter 2007b*). Here, as at Zadubravlje site, the coarse pottery corresponds to Dimitrijević's definition of Linear A phase (*Dimitrijević 1979.243*).

At the end of its life, the site was covered with an 80cm layer of sediment indicating no later occupation except a late Bronze Age necropolis (*Minichreiter 2007a.33–34*).

Twenty-four dates are available from this site, but some should be excluded. Some samples may have been contaminated by water from flooding episodes[12], while others (Z-3586, Z-3584) may be consi-

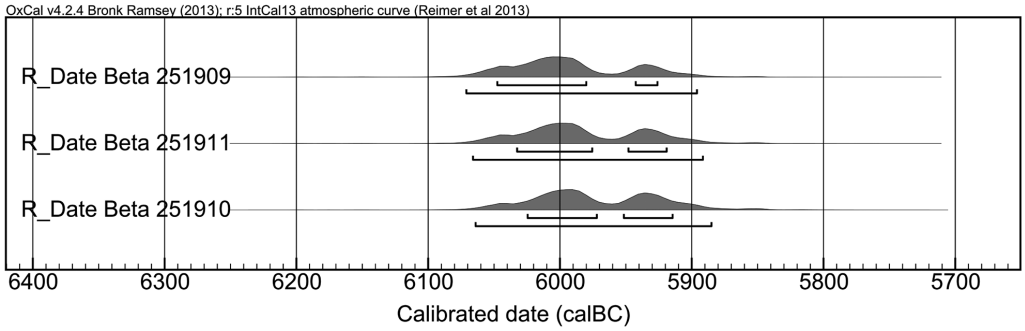


Fig. 3. Sopot ^{14}C dates.

10 The oldest house SU 23 is dated to 6020±100 BP/5050–4780 BC (68.2%) (Z-3139) and 6010±100 BP/5040–4770 BC (66.35%) (Z-3140) (*Krznarić Škrivanko 2011.211, Tab. 1*).

11 The last section excavated since 2010 was only published in short reports (*Minichreiter 2011; 2012; 2013; 2014; 2015*).

12 Most probably samples Z-5043, Z-5044, Z-4879 and Z-4880. The site was damaged by clay exctraction for a brick factory now closed, and there is a large hole to its north-east side. After heavy rains, water sometimes reaches the level of the site. Damage could have been done to unexcavated features with 80 cm of sediment already removed from their top. However, the oldest date from pit 323 (Z-4357) comes from the nearby southern area of the site, which could not have been affected by flood episodes. Further detailed analysis of the material from the southern pits is required.

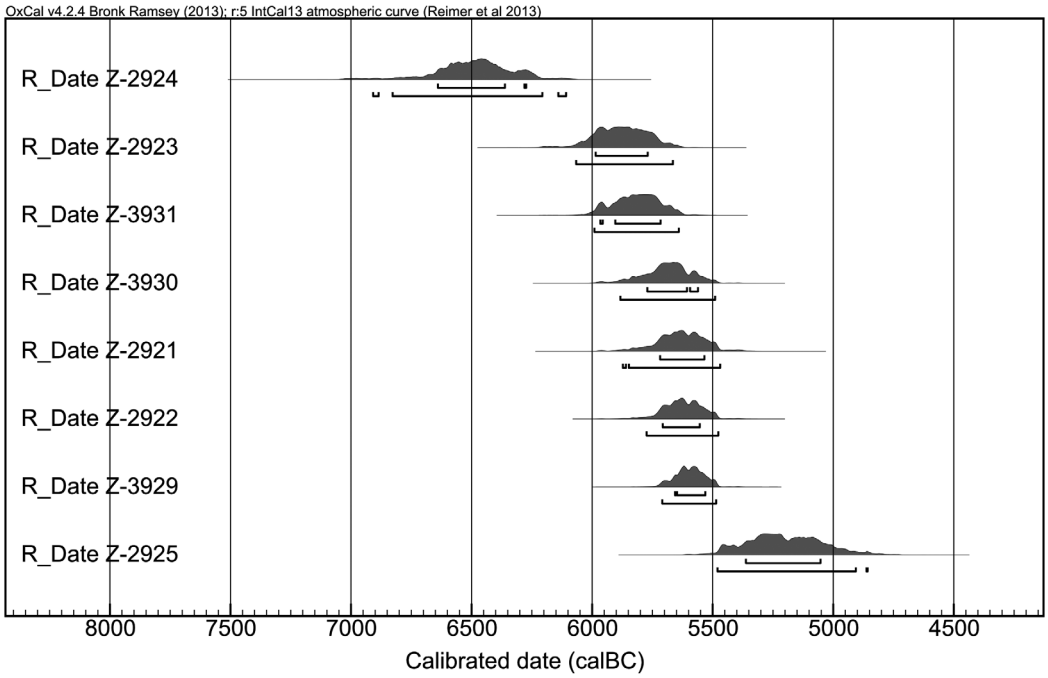


Fig. 4. Zadubravlje – Dužine ^{14}C dates.

dered old wood. Most of the dates group between 5800 and 5550 BC although a younger group of dates can be observed between 5500 and probably 5150 BC (Fig. 6). This group of dates belongs to the part of the feature (Z-3925, the youngest hearth from a pit 9 containing burials) or features (Z-3583, pit-dwelling 37; Z-2935 pit 15 containing male burial) situated on the north side of the site. However, if we consider the possible validity of the three oldest dates (Z-4357, Z-3586, Z-3584), then a third phase of the settlement can be added which would represent slightly younger phase than at the Sopot site and an almost parallel phase at Zadubravlje site.

Virovitica – Brekinja site (Fig. 1.4)
The site was excavated in 2005 on the future western Virovitica by-pass road. An area of 9000m² was explored, but Starčevo culture features were found only on 5400m². Merely the border area of the settlement was excavated, yielding a few partially explored features interpreted as working and residential areas. Most of the finds were fragments of coarse pottery with a barbotine surface. No painted pottery was found. The excavators date this site to the Spiraloid B phase (*Sekelj-Ivančan, Balen 2007*).

Only two dates are available from this site (Fig. 7), but unfortunately no description of the context from which the samples were taken has been published. The dates confirm the late existence of this site, probably between 5500 and 5300 BC.

Time span of Starčevo culture in northern Croatia (Fig. 8)
Although scarce information about Starčevo culture sites is available, it is nevertheless possible to reach some preliminary conclusions about its time span:

❶ Sopot: So far, there are no traces of settlement at this site before 6060 BC (Beta 251909, Beta 251911, Beta 251910). After 5880 BC, early Neolithic life ends and life is renewed only a thousand years later.

❷ Zadubravlje – Dužine: The oldest date 6850–6100 BC from a wooden beam in the well (Z-2924) should not be taken into consideration as the oldest date for this settlement, but the date 6067–5666 BC (Z-2923) could indicate this first phase. The youngest date (Z-2925) corresponds to dates from the Virovitica – Brekinja site.

❸ Slavonski Brod – Galovo: The oldest date is from a small pit 323 from the south side of the excavated area (Z-4357) while the next two dates (Z-3586, Z-3584) are from the two wooden fences. These three samples group just after 6000 BC. The next group of dates is the largest, and groups between 5800 and 5550 BC. The three youngest dates (Z-3925, Z-3583, Z-2935) range from about 5500 to 5100 BC; these samples were taken from pits 9, 15 and 37 situated on the northern side of the site.

❹ Virovitica – Brekinja: Two dates from this site belong to the period between 5500 and 5300 BC[13].

It is worth noting that three of the sites, Sopot, Galovo, and Zadubravlje[14], were at some point covered by one or several layers of sediment. These layers sealed off the sites for a considerable time: at Sopot, for about a thousand years, and at Galovo until the end of the Bronze Age. Life at Zadubravlje site was never renewed.

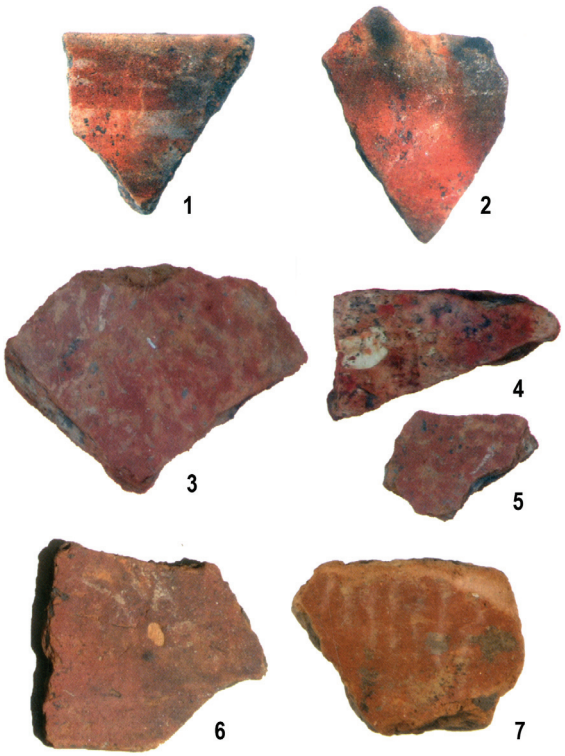


Fig. 5. Slavonski Brod – Galovo, white painted pottery.* 1–2 *working pit 205;* 3–5 *working pit 207;* 6–7 *pit 9 with 3 burials (modified after* Minichreiter 2007b.31, Fig. 4*).

The sum of all the usable dates from all four sites (Fig. 8) shows the existence of Starčevo culture in this area roughly between 6000 BC (or slightly earlier) and 5300 BC. Obvious problems with some dates make it impossible to firmly establish the boundaries of phases, but it is possible to establish a time frame for further discussion in this paper.

The overview of ^{14}C dates provided by Bernhard Weninger *et alii* (*2014*) from central Anatolia to north-east Hungary (Fig. 9) can be complemented with the dates available for north Croatia, filling in the geographical gap. It is also clear that Neolithisation reached northern Croatia just after 6600–6000 BC, following after the Bulgarian and Romanian dates[15], but before the Hungarian dates (*Hertelendi* et al. *1995.242, Tab. 1*). On the territory of Serbia the oldest dates come from southern Serbia[16], while the Iron Gates[17] and Donja Branjevina site (*Budja 2009.127, Tab. 1, 129, Tab. 2; 2013.42. Fig. 1*)[18] show very similar dates to those from northern Croatia.

New solution – RCC 6600–6000 as *terminus post quem*

For a new interpretation of the beginning of the Neolithic in northern Croatia, it is necessary to have a closer look at investigations of the Holocene climate fluctuations of the northern hemisphere. Recent palaeoclimate research has discovered the existence of a distinctly repetitive series of cooling ano-

13 During the preparation of this paper, new ^{14}C dates were obtained for the Našice – Velimirovac, Arenda 1 site (situated north-west of Našice, near Velimirovac). A rescue excavation was carried out in 2011 on the Našice by-pass road. The dates obtained from charcoal samples from a single pit are: 6855±32 BP (DeA-8335) and 6704±39 BP (DeA-8336). However, low temperature combustion yielded 6822±23 BP and 6804±25 BP, showing better results. These are the oldest dates for the Drava region, predating most of the dates at Zadubravlje, half of the dates from Galovo (both in Sava region) and dates from Virovitica – Brekinja site situated further west. The pottery shows traces of black painted motifs on a red surface, the most similar to the Girlandoid phase according to Dimitrijević (*1969.36–37*). Similar finds were collected at the Našice – Brick factory site (*Minichreiter 1992.16; 86, T. 4*) about 4km to the southeast. This is further confirmation of the somewhat later spread of Starčevo culture to the Dravina region. It is still an open question if flooding prevented the advance of the Neolithic to the west along Drava River.

14 K. Minichreiter, personal communication.

15 Similarity of the earliest radiocarbon dates across the Balkans from southern Bulgaria (Dzhuljanitsa, Kovačevo) to Transilvania (*Gurova, Bonsall 2014.100; Krauß* et al. *2014*). See also absolute chronology data for the Starčevo-Criş cultural complex (*Luca* et al. 2011; *Biagi* et al. *2005.44.Fig. 4; Biagi, Spataro 2005.38.Fig. 8a–b; 2008.342–343. Tab. 2*).

16 Blagotin by 6200 BC (*Whittle* et al. *2002.107, 113; Bonsall 2007.55*).

17 Vlasac was occupied before and after the 8.2 ka event (*Borić* et al. *2008.279.Fig. 22*), but at Lepenski Vir there is a gap between 7200 and 6300 BC; the range of dates for the phase with trapezoidal buildings is 6240–5845 BC, while the early Neolithic context has range of dates 6005–5798 BC (*Borić, Dimitrijević 2007a.67, 69*).

18 Dates clearly group before and after 6000 BC, forming a boundary connecting Grivac, Lepenski Vir, Padina before 6000 BC and the disappearance of this boundary after the 6000 BC, indicating two directions of spread of the Neolithic along important rivers: one through Divostin and along the Danube, north-west to Donja Branjevina, and the other to the north-east, along the Tisza and its tributaries to Pannonian Plain and Gura Baciului (*Draşovean 2007.69*).

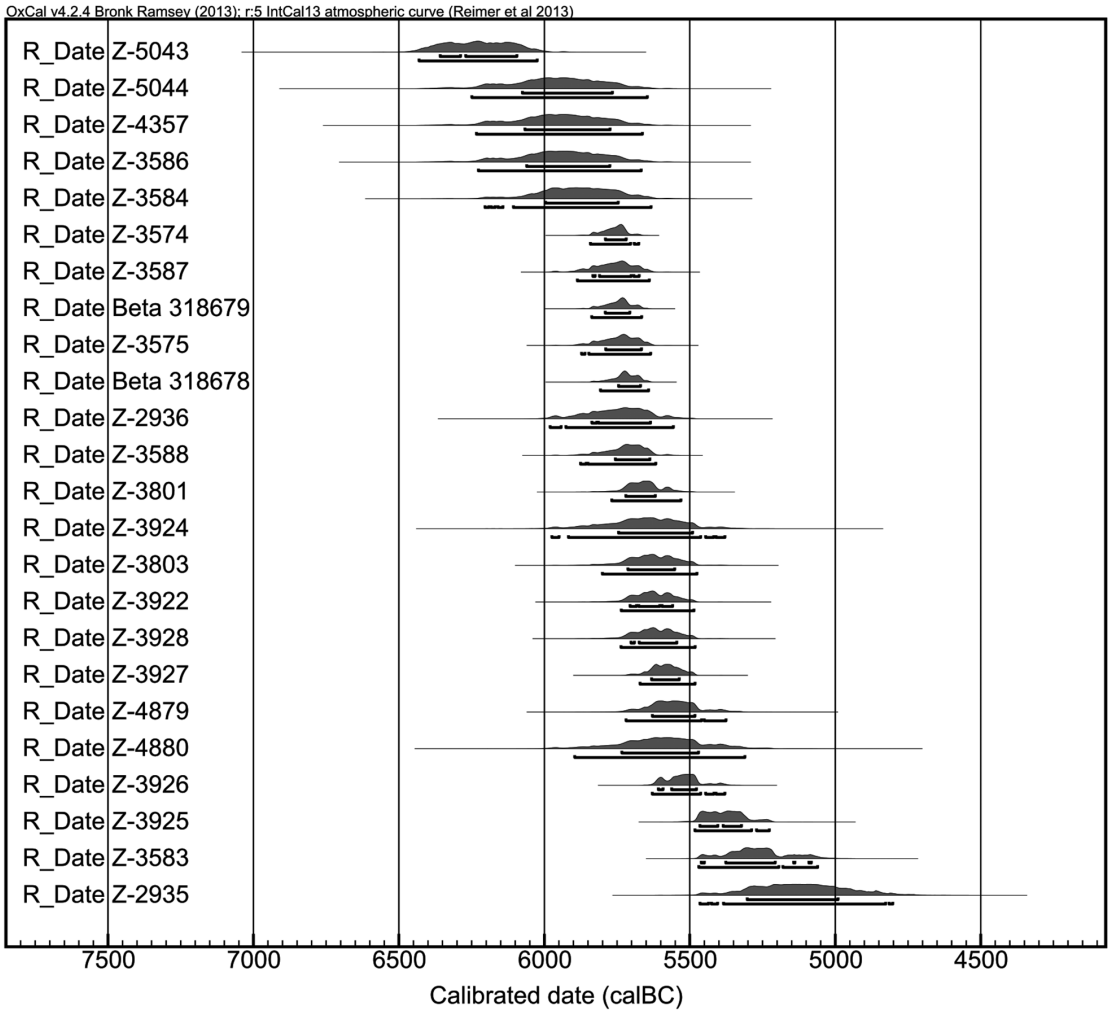


Fig. 6. Slavonski Brod – Galovo ^{14}C dates.

malies during the Holocene (*Weninger* et al. *2009; Weninger, Clare 2011.11*) termed 'Rapid Climate Change' (RCC) events (*Rohling* et al. *2002; Mayewski* et al. *1997; 2004; Clare* et al. *2008; Weninger, Clare 2011.11; Budja 2015*). The RCC intervals are: 9000–8000, 6000–5000, 4200–3800, 3500–2500, 1200–1000 and 600–150 BP, the most recent corresponding to the LIA (*Mayewski* et al. *2004; Budja 2007; Weninger* et al. *2009; 2011; Clare, Weninger 2010*). The main cause of these events, in addition to solar intensity weakening (*Perry, Hsu 2000; Bond* et al. *2001; Mayewski* et al. *2004.244; Marino* et al. *2009.3246*), appears to have been a strengthening of atmospheric pressure gradients between Siberian (High), Iceland (Low) and the Azores (High), conditions supporting an influx of extremely cold air from the polar regions into Europe (*Clare* et al. *2008; Weninger* et al. *2009; Clare, Weninger 2010; Weninger, Clare 2011; Weninger* et al. *2014; Weninger, Harper 2015.478, Fig. 2; Benito* et al. *2015.5*). RCC events correlate with ice-rafted debris (IRD) events (*Bond* et al. *1997*) although not entirely. Furthermore, the North Atlantic Oscillation (NAO) positive phases may have been connected to these cold events (*Bout-Roumazeilles* et al. *2007.3212*).

The most severe of these events was the 8.2 ka event (6600–6000 BC) (*Alley* et al. *1997; Magny* et al. *2003; Alley, Ágústsdóttir 2005; Thomas* et al. *2007; Clare* et al. *2008; Gronenborn 2009; Marino* et al. *2009; Weninger* et al. *2009; Weninger* et al. *2014*) during which temperatures in the North Atlantic region dropped over the course of the subsequent 160 years (*Thomas* et al. *2007.75; Weninger* et al. *2009.11*). This cooling event was amplified between 8.2 and 8.0 ka calBP by the collapse of a remnant Laurentide ice-dome and subsequent drainage of large amounts of melt-water from the Hudson Bay into the North Atlantic (*Bauer* et al. *2004; Budja 2007.191; Marino* et al. *2009.3246; Weninger* et al. *2009.11–12; 2014.8; Weninger, Clare 2011.17*) resulting in one of the most extreme climate anomalies of the entire Holocene (*Weninger* et al. *2014.10*). Marine Core LC21 from the southeast Aegean to the east

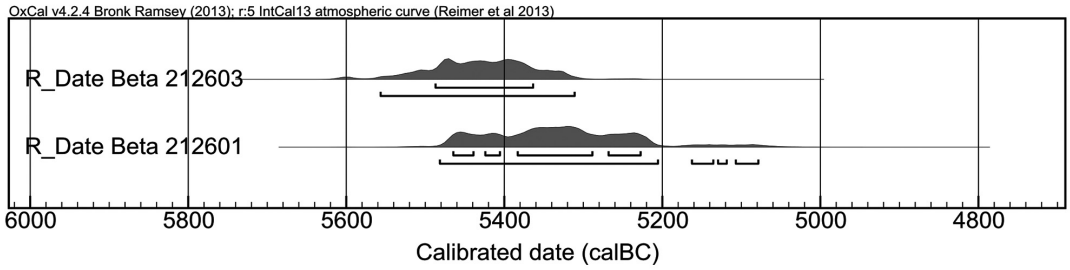


Fig. 7. Virovitica – Brekinja ^{14}C dates.

of Crete showed rapid sea-surface temperature variations resulting from the rapid movement of extremely cold air masses over the surface of the Aegean Sea over a distance of some 700km over short periods of time during winter and early spring (*Weninger* et al. *2009.10; 2014.10; Weninger, Harper 2015*). Cold and dry air flowing rapidly over a warm ocean surface caused evaporation (*Weninger* et al. *2009.11*), which in turn could have provoked intensive precipitation (*Weninger* et al. *2009.33*). Similar cooling events were documented for the Adriatic Sea (*Siani* et al. *2013; Budja 2015.172*). However, in Eastern Mediterranean periods of extreme drought were documented, such as the low levels of Dead Sea (*Migowski* et al. *2006; Budja 2007.194; Weninger* et al. *2009.15–16*) (Fig. 10.H), during which 'flash-flood' events would have had devastating results on the environment and human occupation (*Weninger* et al. *2009.33*). Weninger *et alii* (*2014. 14*) distinguish two phases: an earlier phase at 6600–6200 cal BC (RCC only) and a later phase at 6200–6000 cal BC (RCC amplified by Hudson Bay impact).

Northern Africa was arid until 8500 BC, when an abrupt arrival of monsoon rains created savannah-like environmental conditions, which prompted the swift population of the area by 7000 BC; conditions changed back to arid after 5300 BC (*Kuper, Kröpelin 2006.806.Fig 3*). Nile River sediments record an enhanced riverine contribution between 8600 and 5500 calBP, indicating enhanced precipitation in north-east Africa (*Magny, Combourieu Nebout 2013. 1449*). The aridity in North Africa, southern Near East and Middle East is due to the reduced northward migration of the Intertropical Convergence Zone (ITCZ) in summer (*Berger, Guilaine 2009.41*). Southern Europe shows similar records, indicating that it should be integrated into the same climatic zone during the 8200 calBP event (*Berger, Guilaine 2009.41*).

In Europe during the 8.2 ka event, low latitudes were affected by colder and more arid conditions, especially in winter (*Alley* et al. *1997; Alley, Ágústsdóttir 2005; Berger, Guilaine 2009.35.Fig. 3*). German oak tree-ring records show a distinct low (Fig. 11) (*Alley, Ágústsdóttir 2005.1127; Budja 2007.192; Berger, Guilaine 2009.37; Weninger* et al. *2014.15. Fig. 9*), implying poor growing spring and summer conditions (*Alley, Ágústsdóttir 2005.1127; Budja 2007.193; Berger, Guilaine 2009.37; Čufar* et al. *2014.1275*).

In southern-central Europe, pollen spectra show a sudden disappearance of *Corylus avellana* (hazel) and rapid expansion of *Pinus* (pine), *Betula* (birch) and *Tilia* (lime) and an invasion of *Fagus sylvatica* (beech) and *Abies alba* (fir). This change in vegetation is thought to relate to annual temperature decreasing by about 2–3°C and increased moisture availability. The rapid retreat of drought-adapted *Corylus* was probably caused by taller and longer-lived trees (*Pinus, Betula, Tilia, Quercus, Ulmus, Frayinus excelsior, etc.*) (*Tinner, Lotter 2001; 2006; Budja 2007.194; Nafradi* et al. *2015. 14, Dörfler 2013.322*). Research conducted at Prokoško jezero in central Bosnia, the closest to our region of interest, showed similar trends: from 7360 BC until 5500 BC a distinct change occurred, when Fagus increased rapidly and became the dominant species in subalpine woodlands, closely followed by *Abies*, while *Corylus* greatly decreased; *Betula, Quercus* and *Tilia* values diminish, while *Carpinus orientalis* (oriental hornbeam) and *Picea* slightly increase (*Dörfler 2013.325*). The difference in vegetation is noted for north-western Greece (Rezina marshes – *Willis 1992*, and Boras Mountains – *Lawson* et al. *2005*): the spread of thermofilic trees starts with *Quercus, Abies* and *Carpinus orientalis*, followed after some 1000 years by *Corylus* and *Ulmus*, and after another 1000 years by *Tilia* (*Dörfler 2013.329*). *Fagus* and *Abies* values are very low in the Rezina marshes (*Dörfler 2013.329*). In north-west Romania (Preluca Tiganului and Steregoiu) pollen-based analysis showed a drop of 1.5–2°C in mean annual temperature, 2–4°C in mean temperature of the coldest month, and an increase in mean temperature of the warmest month, while precipitation shows a de-

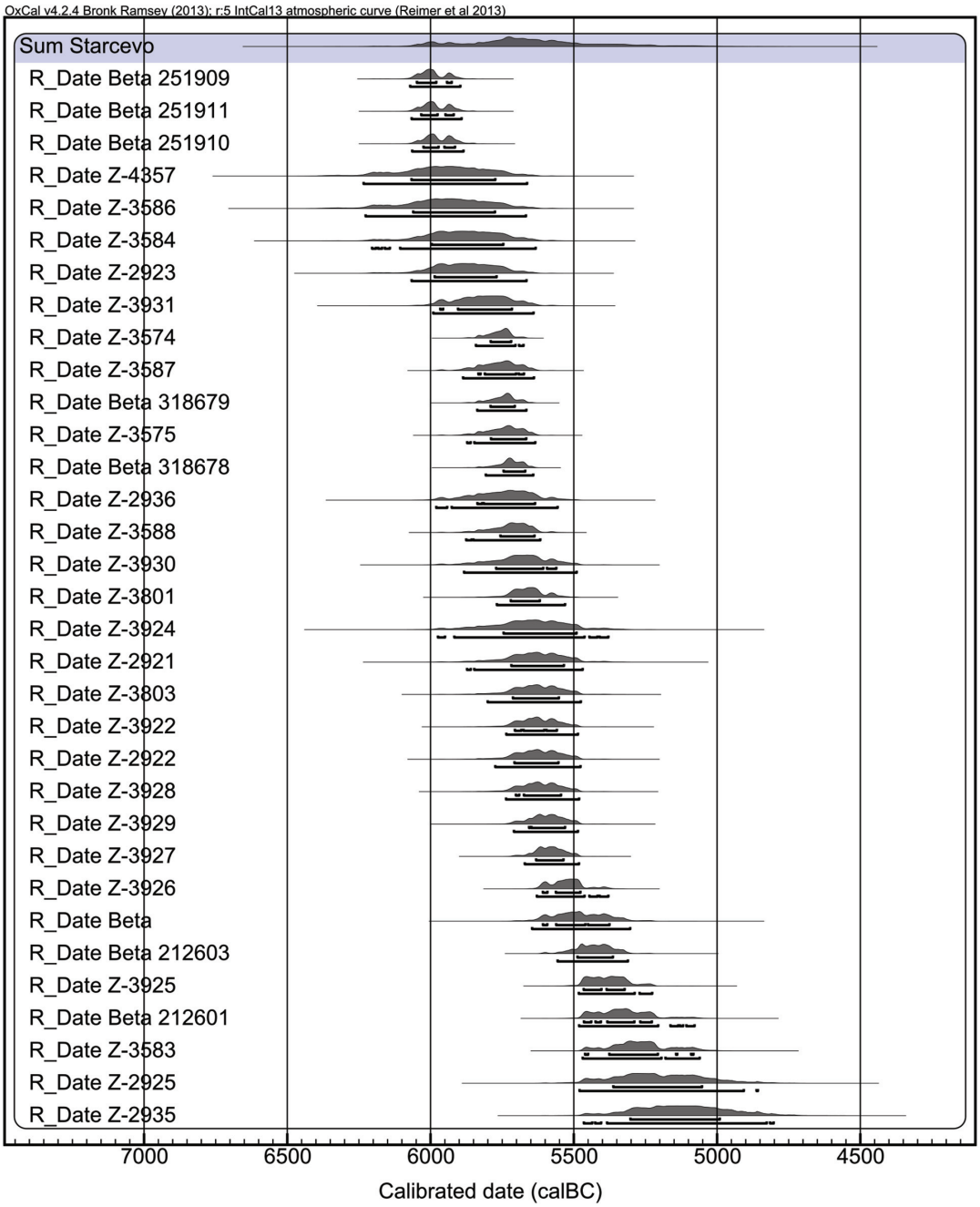


Fig. 8. Sum of ^{14}C dates for Starčevo culture in northern Croatia.

crease of about 200mm. This suggests an intensification of seasonality and continentality (*Feurdean* et al. *2008.500*).

European mid-latitudes between 43° and 50°N underwent wetter conditions in response to cooling, while northern and southern latitudes were marked by drier climate (*Magny* et al. *2003.1593; Alley, Ágústsdóttir 2005.1128; Budja 2007.194; Berger, Guilaine 2009.37, 40.Fig. 6*). Increasing cyclonic activity over mid-latitudes consecutive to a southward displacement of the Atlantic Westerly Jet and a strong thermal gradient between high and low latitudes could have been the cause of hydrological tripartition of Europe (*Magny* et al. *2003.1592.Fig. 2, 1593–1594.Fig. 3; Budja 2007.194–195.Fig. 3; Berger, Guilaine 2009.41*). Lake sediment and palaeobotanical records from Alpine region indicate cooler and wetter conditions between 8500 and 7800 cal BP (*Haas* et al. *1998; Bonsall* et al. *2002.2; Magny* et al. *2003.1592; Berger, Guilaine 2009. 37; Budja 2015.172*) while wet winters and wet summers are documented in southern regions below 40°N (*Budja 205.172*) marked by sea surface salinity lowering and reduced deep-sea convection during the sapropel S1 phase between 9.3 and 7.4 ka (*Magny, Com-*

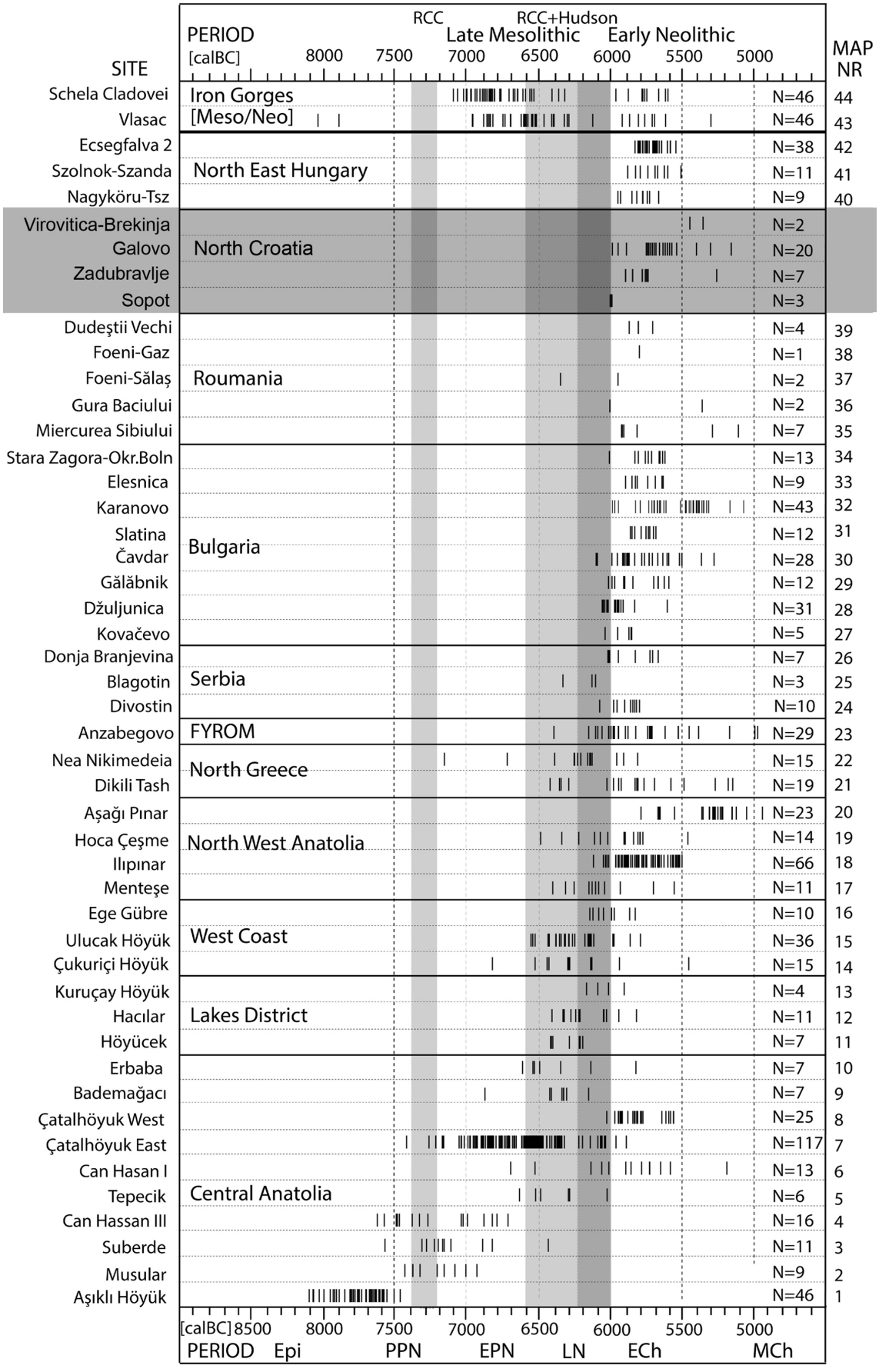


Fig. 9. Overview of ^{14}C-ages (modified after* Weininger *et al.* 2014.9.Fig. 4*).

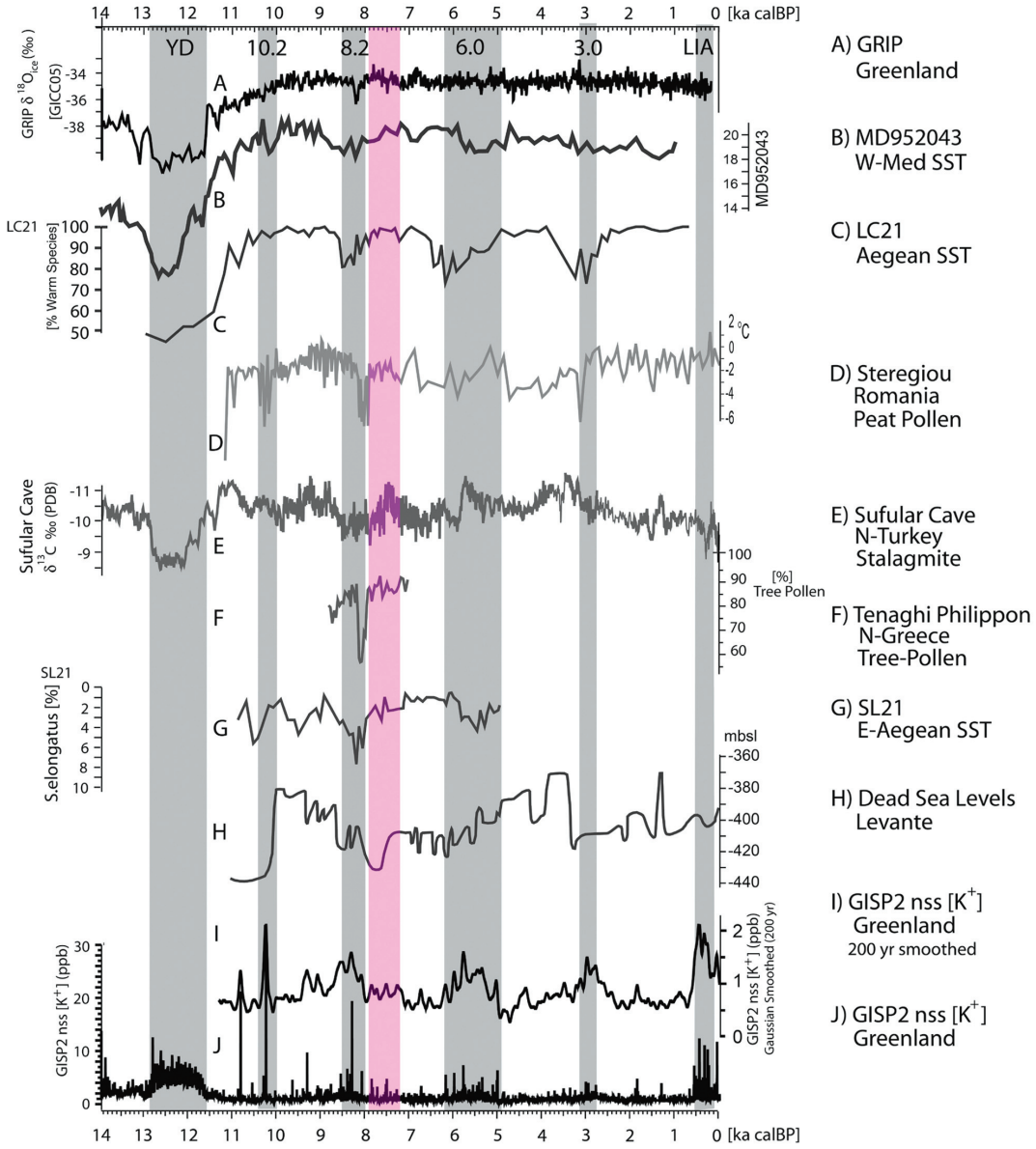


Fig. 10. Northern Hemisphere Palaeoclimate Records showing Holocene Rapid Climate Change (RCC). The purple line marks the duration of the early Neolithic in northern Croatia (modified after* Weininger *et al.* 2014.11.Fig. 5*).

bourieu Nebout 2013.1449; Siani et al. *2013.510*). There is also evidence for a major period of flooding in several parts of Europe, *i.e.* central Europe (fluvial episode associated with a massive accumulation of tree trunks in the Rhine Valley between 8500 and 8000 cal BP – *Berger, Guilaine 2009.37–38*), Britain, the Danube delta and specifically the French Alps between 8250 and 7950 BP (*Bonsall* et al. *2002.4*). A recent study by Gerardo Benito *et alii* (*2015*) combines more than 2000 ^{14}C and OSL dated flood units from 12 regions in Europe and North Africa (*Benito* et al. *2015.2, Fig. 1*), but unfortunately this study does not include data from regions between the Alps and the Black Sea including the entire Carpathian basin[19]. Studies have shown that intensive runoffs of the Po, coastal Italian, Apennine and Albanian rivers may have had an impact on lowering salinity during the middle part of the Holocene in the south Adriatic Sea (*Magny, Combourieu Nebout 2013.1449; Siani* et al. *2013.505*).

19 It is, however, interesting to note an increase in flooding after the 8.2 ka event, first in temperate European regions and slightly after in Mediterranean regions (*Benito* et al. *2015.4, Fig. 3*). These flood episodes in both regions correspond to IRD 5b, *i.e.* to the period between 5700 and 5100 cal BC (*Gronenborn 2009.100; Benito* et al. *2015.4.Fig. 3*), adding to our understanding of climatological conditions during the early Neolithic in northern Croatia and especially during its end.

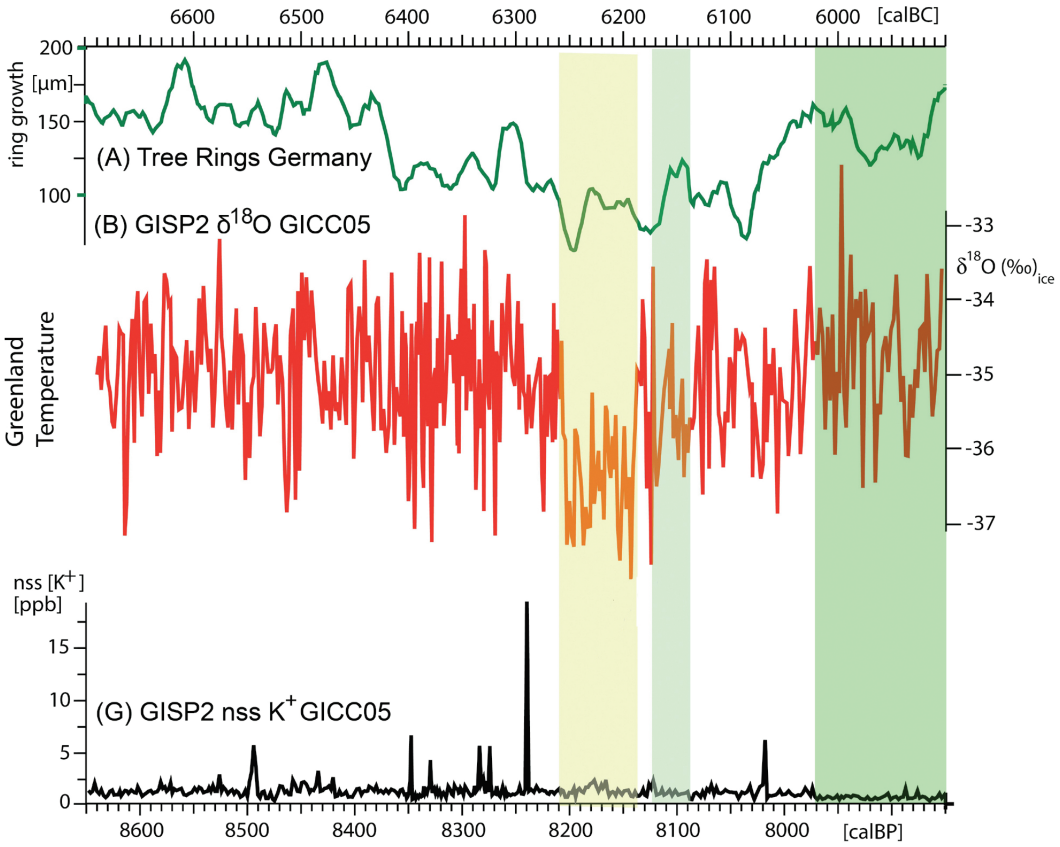


Fig. 11. Timing and structure of the 8.2 ka calBP event on a global scale. The relevant time frame for the beginning and duration of early Neolithic in northern Croatia is marked in darker green (modified after* Weininger *et al.* 2014.15.Fig. 9*).

The end date for the 8.2 ka event (*Weninger* et al. *2014*) falls at 6000 BC, or slightly before. The available radiocarbon dates from the early Neolithic period from the Sava-Drava-Danube interfluves fall within the same time range. Thus, the end of the RCC 6600–6000 BC can be taken as a *terminus post quem* for the appearance of the early Neolithic in this region. It is important to stress that the full 'Neolithic package' is present at all the above-mentioned sites[20].

Discussion

Several studies published in the last 15 years or so (*Perry, Hsu 2000; Migowski* et al. *2006; Weninger* et al. *2006; 2009; 2014; Kuper, Kröpelin 2006; Budja 2007; Clare* et al. *2008; Gronenborn 2009; Berger, Guilaine 2009; Clare, Weninger 2010; Weninger, Clare 2011; Zielhofer* et al. *2012; Reimer* et al. *2013, etc.*) were dedicated to the observation of the 8.2 ka event impact on Neolithisation processes with some regard to archaeological evidence from the Middle East across the Eastern Mediterranean, northern Africa, and southern and central Europe. Others (*Jurić* et al. *2001; Bonsall* et al. *2002; Bonsall 2007; Bánffy* et al. *2007; Borić, Dimitrijević 2007a; Bánfy, Sümegy 2012; Bánffy 2013a; Salisbury* et al. *2013; Lespez* et al. *2013; Gurova, Bonsall 2014; Krauß* et al. *2014; Botić 2016, etc.*) take the archaeological context more into consideration but recognise the possible climatic influence on Neolithisation process from the Middle East to central Europe or at least deal with ecological/environmental conditions that could have enabled or prevented the spread of Neolithisation at specific point in time. These studies seem to indicate a halt in Neolithisation advances caused by the 8.2 ka event, which led to unfavourable conditions across certain European regions, mainly the Carpathian basin and other regions of temperate Europe.

20 At the Sopot site, only a partial pit was excavated, but it contained coarse pottery and an altar (*Krznarić Škrivanko 2015.Fig. 12*). White painted fragments were collected at similar depths across the site, but out of context and radiocarbon dates come from teeth (*Krznarić Škrivanko 2011.223, Tab. 3*), although it is not clear if the teeth are from animals and if they are from domesticated species.

Eszter Bánffy and Pál Sümegi (*2012*) discuss the role of the Central European-Balcanic Agro-Ecological Barrier (CEBAEB)[21] in the Carpathian Basin as a zone of interaction between immigrant farming communities and the local forager population, although the reasons for the existence of the barrier were manifold: the climatic conditions on the southern side of the boundary were favourable, but the soil was sandy and unsuitable for long-term settlement and crop cultivation (*Bánffy, Sümegi 2012.59*), especially given the limited agricultural knowledge of immigrant communities adapted to different conditions in south-eastern Europe; the specific climatic conditions in Carpathian Basin due to the basin effect (*Bánffy, Sümegi 2012.59*) which could trigger a unique transformation in vegetation and soil types; wet habitats and sandy ridges more suitable for a Mesolitic population based on hunting and foraging (*Bánffy, Sümegi 2012.60*) *etc*. The German oak tree-ring record[22] (Fig. 11) shows another low between 6000 and 5900 BC, possibly indicating unfavourable climate conditions such as excess of precipitation that could have caused large-scale and unpredictable floods (*Bonsall* et al. *2002; Bonsall 2007*) representing impenetrable barriers, although their intensity could have been less pronounced than in the previous 8.2 ka period. However, some of the barriers recognised, such as the one in the Kalocsa area and Tolna Sárköz region (the southern Danube region in Hungary), are difficult to explain using ecological/environmental arguments (*Bánffy 2013b*). Borić (*2011*) does not see the gap in the settlement of the area between the late Mezolithic and early Neolithic in the Iron Gates gorge; gaps can be seen at certain sites, while others were settled during that time. Borić also does not agree with Bonsall (*Bonsal* et al. *2002; Bonsall 2007*) that large-scale floods were the reason for discontinuity of occupation of sites, but considers different economic strategies to be the reason for that. It is also clear in the Iron Gates gorge that Early/Middle Neolithic (5950/5900–5500 BC) settlements are at least to a point situated in different environments and on different soils (such as Aria Babi) (*Borić 2011.183*).

The question is whether some kind of ecological barrier existed in the Sava-Drava-Danube interfluve, influencing the emergence and spread of Neolithisation in this region or whether this spread was dictated by some other reasons, such as in the Tolna Sárköz region. So far, specific environmental analysis compared with archaeological data has not been done for the Sava-Drava-Danube region, and only circumstantial data are available which might give an insight into the climatic conditions of this region during the Neolithic. In a recently published paper (*Pearson* et al. *2014*) two sub-fossil wood samples are of interest for the region discussed here. Samples 25 from Oštra Luka near Orašje and 151 from the mouth of Krapina River near Zagreb yielded very interesting dates (Fig. 12–13). The date for sample 25 from Oštra Luka is almost identical to three dates from Sopot (Fig. 3) and the date for sample 151 from the Krapina River coincides with the beginning of flood episodes (*Benito* et al. *2015.4, Fig. 3c*), which in turn coincide with IRD 5b (*Bond* et al. *2001.2131, Fig. 2; Gronenborn 2009.99, Fig. 2; Benito* et al. *2015.4, Fig. 3b*). As the extreme flooding in spring 2014 showed, extremely high precipitation in the central Bosnian mountain region can provoke extreme episodes of flooding of the Vrbas, Bosna and lower flow of the Sava rivers. This scenario may have happened around 6000 BC or slightly after; debris could have sealed off the Sopot site for the next 1000 years[23,24].

Interestingly, in the Prokoško jezero pollen record, a significant drop in the *Corylus* record and a rapid increase of *Fagus* are noted around 6000 BC (*Dörfler 2013.322, Fig. 11*). This episode could have been provoked by increased precipitation.

21 CEBAB: an ecological–palaeoecological–mathematical model based on the combination of archaeological and the palaeoenvironmental evidence (*Bánffy, Sümegi 2012.57–58*).

22 The positive correlation between tree-ring widths and amount of summer precipitation in different months, the ambiguous effect of summer temperatures (*Čufar* et al. *2014.1268*). The sub-regional climatic signal should be taken into consideration because there is clear evidence that the eastern part of the Sava-Drava-Danube interfluve shows a different climatic signal from the western part (*Čufar* et al. *2014.1272.Fig. 3*).

23 The date for sample 151 from Krapina river may indicate climatic conitions just before the appearance of the Našice – Velimirovac, Arenda 1 site in Drava region (see note 13). The Krapina and Drava rivers respond to increased precipitation in pre-Alpine region, while the lower flow of Sava river responds to precipitation in the central Balkan region. Quite often, floods of the Krapina, Drava, Kupa and upper flow of the Sava rivers do not correspond to floods in the lower flow of Sava river because of this dual source of excess precipitation.

24 As mentioned above, this is all circumstantial evidence; nevertheless, the closeness of dates is striking. Bearing in mind that Starčevo culture was more extensive and more intensive presence in western Hungary can only be documented from around 5700–5550 cal BC (*Bánffy 2013a.17*), this circumstantial evidence carries even more weight. In this respect, the temporal map of the spread of Neolithisation from the Middle East to Europe (*Gronenborn 2014*) needs to be modified.

The early Neolithic in Sava-Drava-Danube interfluve shows all the characteristics of full Neolithic package. White painted motifs on some fragments from the Galovo and Sopot sites suggest the earliest Linear A phase, although these fragments are accompanied by fragments with black painted motifs. The percentage of both white and black painted pottery is very low in the overall amount of pottery from all sites. There is a difference of opinion as to whether a Monochrome phase of early Neolithic existed throughout south-east Europe preceding the 'developed' Neolithic (*Stojanovski* et al. *2014.24*): Lolita Nikolova (*2007.91*) puts Hoca Çeşme 4–3, Krajnitsi 1, Divostin 1, Koprivets 1, Dzhulyunitsa, and Smurdesh 1 sites in this phase, dating it to ?6300–6200/6100 cal BC, while Krauß (*2011*) argues that the amount of painted pottery during the whole early Neolithic in south-eastern Europe is notably below 10%, and that painted pottery was present from the very beginning in this region[25]. This latter can be applied to Sava-Drava-Danube region: the amount of painted pottery is well below 10% at observed sites and it is already present in the earliest dated sites. So far, no traces of Starčevo Monochrome phase have been found in our observed region (*Minichreiter 1992.54; 2007b.23*). Nevertheless, some sites in the Balkans were attributed to that earliest Monochrome phase: Krajnici, Koprivec and Poljanica-platoto in Bulgaria; Divostin, Donja Branjevina and Grivac in Serbia; Pešterica, Rudnik and Grnčarica in the Republic of Macedonia (*Krauß 2010.41; Stojanovski* et al. *2014*), Foeni-Sălaş and Gura Baciului in Romania (*Drașovean 2007.70, Fig.2–4; Luca, Suciu 2007.79; Krauß 2010.36*).

The question of the transition from late Mesolithic to early Neolihic is also open for discussion for Sava-Drava-Danube region, because no Mezolihic sites are yet known from eastern Slavonia, which may be the result of later floods covering earlier sites or the state of current research. In the surrounding areas, the best-preserved and explored sites exhibiting the transition from Mesolithic to Neolithic are situated in the area of the Iron Gates (*Krauß 2014.194*). There, among other periods, the Late Mesolithic (*c.* 7400–6200 cal BC) and Transformation period/Early Neolithic (*c.* 6200/6300–6000/5950 cal BC) can be distinguished (*Borić 2011.161*). There are several well-documented Mesolithic sites in this region: Hajdučka Vodenica, Icoana, Kula, Ostrovul Banului, Ostrovul Corbului, Ostrovul Mare, Padina, Schela Cladovei, Velesnica, and Vlasac (*Borić 2011.163, Tab. 2; Borić* et al. *2014*). In the Transformation/Early Neolithic period only Hajdučka vodenica, Padina and Vlasac show uninterrupted occupation, while new sites appear: Ajmana, Alibeg, Lepenski Vir[26] and Stubica (*Borić, Dimitrijević 2007a.69, Tab. 2; Borić* et al. *2008.279; Borić 2011.163, Tab. 2; Borić* et al. *2014*)[27]. In the following Early/Middle Neolithic (*c.* 5900–5500 BC) occupation continues in Ajmana, Hajdučka Vodenica, Icoana, Lepenski Vir, Padina, Schela Cladovei, Velesnica, and Vlasac and new sites appear: Ari Babi, Cuina Turcului, Donje Butroke, and Lepenski Abri (*Borić 2011.163, Tab. 2*).

In southern Banat, a part of the Iron Gates region, only two sites are known: Hoţu Cave, near Steierdorf (Anina) and Băile Herculane-Hoţilor Cave (*Krauß 2014.195*). These sites are situated a few kilometres north of the Iron Gates in the hilly parts of the southern Carpathians, while in the northern part of the Banat, the Mesolithic is as yet unknown (*Krauß 2014.195–196*). In Bačka, Mesolithic sites are documented at Hajdukovo close to Subotica and at Bačka Palanka, west of Novi Sad; the sites are located exclusively on the banks of the alluvial plains of the rivers (*Krauß 2014.196*). In Transdanubia, the Regöly 2 site was recently explored, but there are some older finds from the vicinity of Győr, from the Sárrét bog, Csór-Merítőpuszra, next to the village of Nádasdladány and from a sand dune on the flood plain of the Kapos River at Kapshomok (*Krauß 2014.196*). In Alföld, excavations were carried out at two sites in the Sződliged/Vác area, together with intensive survey in the Jászság area. The sites at Sződliged are situated close to the Danube and are compared to Iron Gates sites by the excavators (*Krauß 2014.201*). Extensive surveys were carried out in Jászág Basin, the large flood plain between the upper Tisza and Danube rivers, and two Mesolithic sites were found: Jászberény I and Jásztelek I (*Krauß 2014.201–202*). Five more sites from the Alföld have been mentioned in the literature, some of them situated on the sandy dunes of the floodplains or close to major rivers (*Krauß 2014.212*). In the Sathmar district of north-west Romania Ciumeşti II site is also situated on a dune (*Krauß 2014.212*).

25 In Dzhulyunitsa, the oldest layer contains black painted pottery, while only the second layer presents white painted pottery (*Krauß* et al. *2014; Dzhanfezova* et al. *2014*). It is also clear from a preliminary archaeometric study (*Dzhanfezova* et al. *2014*) that all the pottery was locally made and that the presumed south-eastern imports do not exist.

26 For the non-existent Late Mesolithic period at Lepenski Vir (see *Borić, Dimitrijević 2007b.51, Tab. 2; 2007b.69, Tab. 2; Borić 2011.169*).

27 Note the change in view of the Mesolithic-Neolithic transition at Vlasac in papers by Borić *et al.* (*2008.279; 2014*).

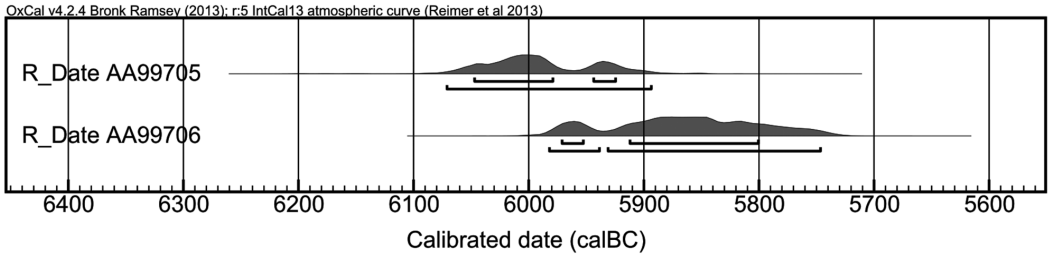


Fig. 12. ^{14}C dates for two sub fossil samples: AA99705 = sample 25 and AA99706 = sample 151 (after* Pearson *et al.* 2014.S54, Tab. 2*).

Maria Gurova and Clive Bonsall (*2014*), comparing known data for Upper Palaeolithic and Late Mesolithic sites in the Balkans, show the peripheral distribution of latter sites within the Balkans. In their assessment, most of the sites are located within 50km of the sea or the Danube. One of the reasons for Mesolithc peripheral site distribution could have been the change in vegetation cover – from semi-desert steppe and forest-steppe ecosystems to a major expansion of temperate forest during the early Holocene. Dense forests protected animals, thus reducing hunting productivity and they have also "*posed significant challenges for inter-group communication and participation in viable mating networks*" (*Gurova, Bonsall 2014.98*). Edible plants in temperate forest ecosystems are found on the forest margins, such as upland tree lines, recently burned areas or along sea, lake and river shores. Aquatic resources became an essential substitute for the lack of animal biomass (*Gurova, Bonsall 2014.97–98*).

Bearing in mind the specific site positions on dunes near large rivers or at elevations near floodplains, the change in resources due to the change in the environment and appearance of dense temperate forests, it is clear that the lack of Mesolithic sites in the Sava-Drava-Danube region, specifically eastern Slavonia, was partially due to environmental change at the beginning of the Holocene. The only large river in this area is the Danube, while the Sava and Drava plains experienced regular seasonal flooding, but were also covered by dense forests. Mesolithic settlements can nevertheless be expected on the high right margin of the Danube and Đakovo-Vinkovci loess plateau. However, intensive occupation of these regions from the Late Neolithic to modern times reduces the hope of finding surviving Mesolithic sites.

Conclusion

The appearance of the early Neolithic, *i.e.* Starčevo culture in the Sava-Drava-Danube interfluve can be placed around 6000 BC or just slightly before, as current research and radiocarbon dates show. The earliest dates and finds come from the Sopot site situated in the south-eastern part of Slavonia. After a short period of settlement during this initial Neolithic phase, an episode of flooding probably sealed off the site for the next 1000 years. Shortly after the abandonment of Sopot site, the Zadubravlje and Galovo sites situated in the Sava valley to the west were settled. Both sites show traces of flooding, which was probably the reason why both sites were abandoned and never resettled (except for the late Bronze Age necropolis at the Galovo site). Most of the dates from Zadubravlje and Galovo group after 5850 BC,

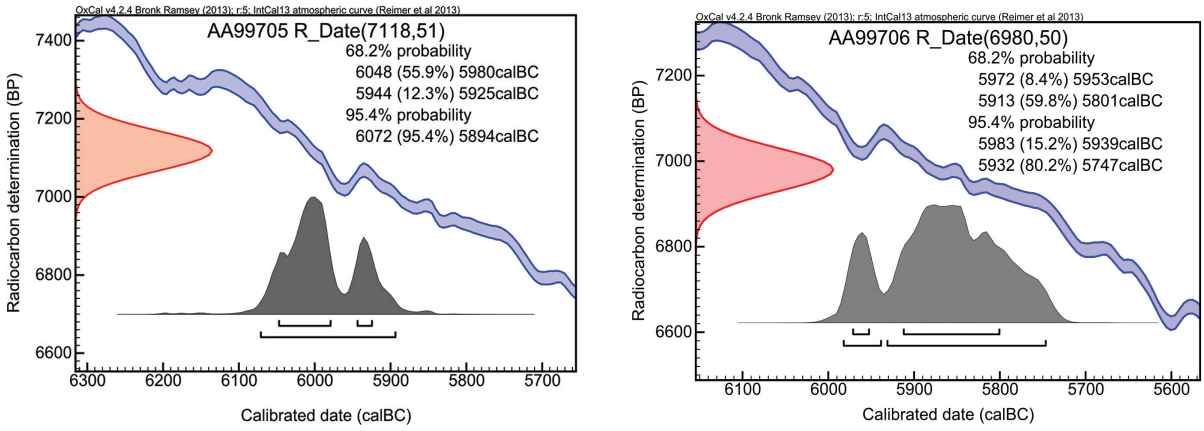


Fig. 13. ^{14}C dates for two sub-fossil samples: AA99705 = sample 25 and AA99706 = sample 151. OxCal v4.2.4 (*Bronk Ramsey *et al.* 2013*); IntCal 13 atmospheric curve (*Reimer *et al.* 2013*).

although two older dates, slightly younger than the Sopot dates, come from the Zadubravlje site and four dates from the Galovo site. The youngest group of dates can be observed at the Galovo and Virovitica – Brekinja sites (with one date from Zadubravlje) starting after 5500 BC. The end of Starčevo culture can be expected before 5100 BC. Radiocarbon dates also indicate the north-western spread of Starčevo culture to the Drava valley around 5750 BC and later.

Taking climatological/ecological data into consideration, the beginning of Starčevo culture can be linked to the end of the 6600–6000 BC period of Rapid Climate Change (8.2 ka cal BP) but it cannot be expected earlier than 6100 BC. Similarly, the end of Starčevo culture can be linked to the 7.1 ka calBP event (5300–5100 BC).

There is circumstantial evidence of climatic instability in this region, *i.e.* excess of precipitation that can probably be linked to flooding responsible for sealing off the Sopot site and for the unfavourable conditions prior to the Drava region settlement around 5750 BC.

The white painted pottery found at Sopot and Galovo sites shows the connection to other regions of south-east Europe in the Neolithisation process. This connection is also visible in available radiocarbon dates. Weninger *et alii* (*2014.6*) give the best summary of the process: "*The moment the Neolithic left the Aegean basin, which appears to have occurred not earlier than 6100 cal BC, it apparently took little more than 100 years to become established at sites in Serbia, Bulgaria, and Romania, and little more than around 200 years even to have reached the Pannonian Basin.*"

Although the climate was not the primary reason for cultural change, and in some cases played almost no role in it (*Budja 2015; Flohr* et al. *2015*), it is worth noting that radiocarbon dates from early Neolithic sites of the Sava-Drava-Danube interfluve fit well between documented RCC periods; further archaeological, geoarchaeological and palaeoenvironmental research is needed to firmly establish a cultural, climatological and environmental connection. The term archaeological climatology or archaeoclimatology, introduced by Fabian Welc (*2016*) describing a subdiscipline within geoarchaeological science, can be applied to this future interdisciplinary research.

Epilogue

During spring 2016, a small scale geoarchaeological survey in eastern Slavonia was conducted by Zagreb Institute of Archaeology and the Institute of Archaeology, Cardinal Stefan Wyszynski University in Warsaw with the cooperation of the Faculty of Geology, University of Warsaw. The survey consisted of geological sampling and a geophysical survey and was conducted at, among other places, at Slavonski Brod – Galovo and Sopot sites. At the Galovo site, a core of 9m was taken, while at the Sopot site the depth of the core was 3.6m. Magnetic susceptibility preliminary results show an episode of drought followed by an episode of extreme wetter conditions just at the end of life at the Galovo site, while the cultural layer at Sopot site was sealed off by a pronounced wet episode. The interchange of dry and extremely wet conditions can be compared to the eastern Mediterranean periods of extreme drought during which 'flash-flood' events occurred (*Weninger* et al. *2009. 33*). The full results of this survey will be published in the future.

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Site	Lab code	Material and context	^{14}C Age (BP)	δ^{13}C/ ^{12}C (‰)	cal BC (2σ)	Reference
Sopot	Beta 251909	tooth from SU 80 (sq. J25): layer before sterile ground	7120±50	–20.0	6072–5897	*Krznarić Škrivanko 2011.215, Tab. 3*
Sopot	Beta 251911	tooth from SU 143 (sq. J37): layer before sterile ground	7110±50	–19.7	6067–5892	*Krznarić Škrivanko 2011.215, Tab. 3*
Sopot	Beta 251910	tooth from SU 519 (sq. K35): pit-dwelling	7100±50	–20.5	6065–5886	*Krznarić Škrivanko 2011.215, Tab. 3; Burić 2015.145, Tab. 2*
Zadubravlje – Dužine	Z-2924	charcoal from well 11 (sq. C/19; 3.90–4.10m depth)	7620±140		6850–6100	*Obelić* et al. *2002.620; Krajcar Bronić* et al. *2002.18; Minichreiter, Krajcar Bronić 2006.14, Fig. 5; Minichreiter 2001.207; Krajcar Bronić 2011.183,185, Fig. 5; Krajcar Bronić , Minichreiter 2011.47, Fig. 3*
Zadubravlje – Dužine	Z-2923	charcoal from south-east part of the pit-dwelling 10 (sq. D-E/15)	6995±115		6067–5666	*Obelić* et al. *2002.620; Krajcar Bronić* et al. *2002.18; Minichreiter, Krajcar Bronić 2006.14, Fig. 5; Minichreiter 2001.205; Krajcar Bronić 2011.185, Fig. 5; Krajcar Bronić, Minichreiter 2011.47, Fig. 3*
Zadubravlje – Dužine	Z-3931	charcoal from working pit 19 – workshop for stone tools and weapons production (sq. D/11)	6919±102		5991–5641	*Krajcar Bronić 2011.185, Fig. 5; Krajcar Bronić, Minichreiter 2011.47, Fig. 3*
Zadubravlje – Dužine	Z-3930	charcoal from working pit 12 that contained several kilns (sq. A/20-A/21)	6770±110		5884–5491	*Krajcar Bronić 2011.185, Fig. 5; Krajcar Bronić, Minichreiter 2011.47, Fig. 3*
Zadubravlje – Dužine	Z-2921	charcoal from pit-dwelling 6 (sq. A/14-A/15)	6710±115		5873–5470	*Obelić* et al. *2002.620; Krajcar Bronić* et al. *2002.18; Minichreiter, Krajcar Bronić 2006.14, Fig. 5; Krajcar Bronić 2011.185, Fig. 5; Krajcar Bronić, Minichreiter 2011.47, Fig. 3*
Zadubravlje – Dužine	Z-2922	charcoal from southwest part of the pit-dwelling 9 (sq. A/18)	6705±95		5775–5477	*Obelić* et al. *2002.620; Krajcar Bronić* et al. *2002.18; Minichreiter, Krajcar Bronić 2006.14, Fig. 5; Minichreiter 2001.203; Krajcar Bronić 2011.185, Fig. 5; Krajcar Bronić, Minichreiter 2011.47, Fig. 3*
Zadubravlje – Dužine	Z-3929	charcoal from the south pit-dwelling 10 (sq. E/15)	6673±75		5710–5486	*Krajcar Bronić 2011.185, Fig. 5; Krajcar Bronić, Minichreiter 2011.47, Fig. 3*
Zadubravlje – Dužine	Z-2925	charcoal from working pit 12 (sq. A/20–21)	6260±130		5481–4858	*Obelić* et al. *2002.620; Krajcar Bronić* et al. *2002.18; Minichreiter, Krajcar Bronić 2006.14, Fig. 5; Minichreiter 2001.204; Krajcar Bronić 2011.185, Fig. 5; Krajcar Bronić, Minichreiter 2011.47, Fig. 3*
Slavonski Brod – Galovo	Z-5043	charcoal from burial pit 2013, sq. J/6a	7358±114		6431–6025	*Minichreiter 2013.27* (only partial date published; BP age first published here)

Tab. 1. Starčevo culture ^{14}C dates in northern Croatia. OxCal v4.2.4 (*Bronk Ramsey *et al.* 2013*); IntCal 13 atmospheric curve (*Reimer *et al.* 2013*).

Site	Lab code	Material and context	^{14}C Age (BP)	$\delta^{13}C/^{12}C$ (‰)	cal BC (2σ)	Reference
Slavonski Brod – Galovo	Z-5044	charcoal from burial pit 2013, sq. J/6a	7076±158		6250–5647	*Minichreiter 2013.27* (only partial date published; BP age first published here)
Slavonski Brod – Galovo	Z-4357	charcoal from a small pit 323 (sq. J/10-a,b, I/10-c,d) under the hearth SU 1681 (sq. J/10-b)	7067±152		6234–5664	*Minichreiter, Botić 2010.120, Fig. 14; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Z-3586	charcoal from the western cult structure 89 (sq. F/12-d)	7060±150		6227–5668	*Minichreiter, Krajcar Bronić 2006.8, Fig. 2; Minichreiter 2007a.192, Fig. 1; Krajcar Bronić, Minichreiter 2007.716; Minichreiter, Botić 2010.120, Fig. 14; Krajcar Bronić 2011.182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Z-3584	charcoal from the western cult structure 149 (sq. E/11-a)	7000±140		6205–5634	*Minichreiter, Krajcar Bronić 2006.8, Fig. 2; Minichreiter 2007a.192, Fig. 1; Krajcar Bronić, Minichreiter 2007.716; Minichreiter, Botić 2010.120, Fig. 14; Krajcar Bronić 2011.182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Z-3574	charcoal from pit-dwelling 205/kiln 752 (sq. I/13a,c)	6875±35		5842–5676	*Minichreiter, Krajcar Bronić 2006.8, Fig. 2; Minichreiter 2007a.192, Fig. 1; Krajcar Bronić, Minichreiter 2007.716; Minichreiter, Botić 2010.120, Fig. 14; Krajcar Bronić 2011.182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Z-3587	charcoal from the western cult structure 389 (sq. G/12-a)	6865±65		5887–5640	*Minichreiter, Krajcar Bronić 2006.8, Fig. 2; Minichreiter 2007a.192, Fig. 1; Krajcar Bronić, Minichreiter 2007.716; Minichreiter, Botić 2010.120, Fig. 14; Krajcar Bronić 2011.182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Beta 318679	charcoal from SU 2243 (sq. I/6b), fill of the burial pit	6860±40	–24.8	5838–5666	*Minichreiter 2012.20* (only partial date published; BP age first published here)
Slavonski Brod – Galovo	Z-3575	charcoal (loom beam) from pit-dwelling 205 (sq. I/13a)	6850±60		5873–5635	*Minichreiter, Krajcar-Bronić 2006.8, Fig. 2; Minichreiter 2007a.192, Fig. 1; Krajcar Bronić, Minichreiter 2007.716; Minichreiter, Botić 2010.120, Fig. 14; Krajcar Bronić 2011.182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Beta 318678	charcoal from kiln SU 258 (sq. I/13-b,d) in pit-dwelling SU 205	6840±40	–23.8	5808–5642	first published here

Tab. 1. continue

Site	Lab code	Material and context	^{14}C Age (BP)	δ^{13}C/ ^{12}C (‰)	cal BC (2σ)	Reference
Slavonski Brod – Galovo	Z-2936	charcoal from kiln 032, pit-dwelling 9 (sq. C/3), contains 3 skeletal burials	6835±110		5981–5557	*Obelić* et al. *2002.616; Krajcar Bronić* et al. *2002.18; Minichreiter, Krajcar Bronić 2006.8, Fig. 2; Minichreiter 2007a.192, Fig. 1; Krajcar Bronić, Minichreiter 2007.716; Minichreiter, Botić 2010.120, Fig. 14; Krajcar Bronić 2011.182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Z-3588	charcoal from pit-dwelling 155 (sq. G/13a)	6820±70		5876–5618	*Minichreiter, Krajcar Bronić 2006.8, Fig. 3; Minichreiter 2007a.192, Fig. 1; Krajcar Bronić, Minichreiter 2007.716; Minichreiter, Botić 2010.120, Fig. 14; Krajcar Bronić 2011.182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Z-3801	charcoal from a kiln SU 181 (sq. G/12-a, G/13-b) in pit 155	6750±70		5769–5531	*Krajcar Bronić* et al. *2010.495, Fig. 3; Minichreiter, Botić 2010.120, Fig. 14; Krajcar Bronić 2011.182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Z-3924	charcoal from a burial pit 9 (sq. C/4)	6726±147		5975–5380	*Krajcar Bronić* et al. *2010.495, Fig. 3; Minichreiter, Botić 2010.120, Fig. 14; Krajcar Bronić 2011.182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Z-3803	charcoal from pit-dwelling 207, bottom near the kiln 794 (sq. H/13-d), PU548	6710±100		5801–5476	*Krajcar Bronić* et al. *2010.495, Fig. 3; Minichreiter, Botić 2010.120, Fig. 14; Krajcar Bronić 2011.182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Z-3922	charcoal at the bottom of a working pit 291 (sq. K/11-a)	6709±82		5736–5486	*Krajcar Bronić* et al. *2010.495, Fig. 3; Minichreiter, Botić 2010.120, Fig. 14; Krajcar Bronić 2011.182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Z-3928	charcoal from pit-dwelling 153 (sq. E/13d)	6700±86		5737–5482	*Krajcar Bronić* et al. *2010.495, Fig. 3; Minichreiter, Botić 2010.120, Fig. 14; Krajcar Bronić 2011.182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Z-3927	charcoal from pit-dwelling 108 (sq. G/11c)	6659±61		5672–5483	*Krajcar Bronić* et al. *2010.495, Fig. 3; Minichreiter, Botić 2010.120, Fig. 14; Krajcar Bronić 2011.182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Z-4879	burial pit 2243, sq. I/6b	6620±102		5720–5376	*Minichreiter 2012.19–20* (only partial date published; BP age first published here)
Slavonski Brod – Galovo	Z-4880	burial pit 2243, sq. I/6b	6600±162		5896–5311	*Minichreiter 2012.20* (only partial date published; BP age first published here)

Tab. 1. continue

Site	Lab code	Material and context	^{14}C Age (BP)	δ^{13}C/ ^{12}C (‰)	cal BC (2σ)	Reference
Slavonski Brod – Galovo	Z-3926	charcoal from hearth near the kiln SU 31 in burial pit 9 (sq. C/4)	6567±66		5630–5380	*Krajcar Bronić* et al. *2010.495, Fig. 3; Minichreiter, Botić 2010. 120, Fig. 14; Krajcar Bronić 2011. 182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Z-3925	charcoal from a burial pit 9 (sq. B/3)	6398±67		5483–5227	*Krajcar Bronić* et al. *2010.495, Fig. 3; Minichreiter, Botić 2010. 120, Fig. 14; Krajcar Bronić 2011. 182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Z-3583	charcoal from pit-dwelling 37 (sq. b/10-c)	6300±80		5470–5061	*Minichreiter, Krajcar Bronić 2006.12, Fig. 4; Minichreiter 2007a.192, Fig. 1; Krajcar Bronić, Minichreiter 2007.716; Minichreiter, Botić 2010.120, Fig. 14; Krajcar Bronić 2011.182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Slavonski Brod – Galovo	Z-2935	charcoal from pit-dwelling 15 (sq. D/2), contains 1 skeletal burial	6185±130		5466–4803	*Obelić* et al. *2002.616; Krajcar Bronić* et al. *2002.18; Minichreiter 2007a.192, Fig. 1; Krajcar Bronić, Minichreiter 2007.716; Minichreiter, Botić 2010.120, Fig. 14; Krajcar Bronić 2011.182, 184, Fig. 4; Krajcar Bronić, Minichreiter 2011.46, Fig. 2*
Virovitica – Brekinja	Beta 212603	charcoal	6470±70		5557–5312	*Sekelj-Ivančan, Balen 2007.24*
Virovitica – Brekinja	Beta 212601	charcoal	6350±80		5482–5079	*Sekelj-Ivančan, Balen 2007.24*

Tab. 1. continue

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New theoretical discourses in the discussion of the Neolithisation process in South Scandinavia during the late 5th and early 4th millennium BC – an identification of learning processes, communities of practise and migrations

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ABSTRACT – *In this paper, it is argued that agriculture is a very complex technology, which takes a long time to learn, thus making it very difficult for agrarian practises to spread as ideas. Instead, based on a detailed survey of primary agrarian evidence (direct ^{14}C dates of cereals and domesticated animals) and secondary evidence of material culture (polished axes and pottery), it is claimed that the expansions of agrarian practises in South Scandinavia are associated with the migration of farmers who were related to the Michelsberg Culture. These incoming farmers had the appropriate skills and the ability to teach the indigenous hunter-gatherer populations about agriculture by establishing communities of practice, a fact which supports the theory of integrationism. The engagement in these communities of practise changed the identity and material culture of the immigrating farmers, as well as the indigenous hunter-gatherers, thus creating new agrarian societies in South Scandinavia which were interconnected in a regional as well as larger European network.*

IZVLEČEK – *V članku razpravljamo o tem, da je poljedelstvo zelo kompleksna tehnologija, za učenje katere potrebujemo veliko časa, kar pomeni, da se znanje o poljedelskih praksah težko širi le kot ideja. Nasprotno – na podlagi raziskav primarnih agrarnih podatkov (neposredno ^{14}C datiranje žit in domačih živali) in sekundarnih podatkov o materialni kulturi (polirane sekire in lončenina) trdimo, da je širitev poljedelskih praks v južni Skandinaviji povezana z migracijo poljedelcev, ki so bili v sorodu s kulturo Michelsberg. Ti prihajajoči poljedelci so imeli potrebne spretnosti in možnost poučevanja domorodnih lovcev in nabiralcev o poljedelstvu, tako da so ustanovili vadbene skupnosti, kar podpira teorijo integracije. Srečanja v takšnih skupnostih so spremenila identiteto in materialno kulturo imigrantskih poljedelcev kot tudi domorodnih lovcev in nabiralcev, kar je povzročilo nastanek nove poljedelske skupnosti v južni Skandinaviji, ki je bila vključena v povezane regionalne in širše evropske mreže.*

KEY WORDS – *Neolithisation; South Scandinavia; agrarian expansions; knowledge exchange and migration*

Introduction

The purpose of this article is to integrate some new discourses of learning and migration theories into the discussion of how, when and why agrarian societies spread from Central Europe to South Scandinavia during the late 5th and early 4th millennium BC, as no consensus has been reached (*e.g., Becker 1947; Troels-Smith 1954; Lichardus 1976; Jennbert 1984; Larsson 1984; 2013; Fischer 1982; 2002; Zvelebil, Rowley-Conwy 1984; Nielsen 1985; 1987; 1994; Rowley-Conwy 1985; 2004; 2011; Madsen 1987; Solberg 1989; Price 2000; 2016; Skak-Nielsen 2003; Hartz, Lübke 2004; Klassen 2004; Sørensen 2005; Hartz* et al. *2007; Andersen 2008; Hallgren 2008; Brinch Petersen, Egebjerg 2009; Terberger* et al.

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2009; Sjögren 2012; Sørensen, Karg 2014; Sørensen 2013; 2014; 2015) (Fig. 1). Currently, there seems to be agreement on a 1500-year period of standstill, which lasts from approx. 5500 cal BC to 4000 cal BC, in the agrarian expansion from Central Europe towards South Scandinavia (Fig. 2). What could explain the static border during the Ertebølle Culture (5400–4000 cal BC), and what caused the swift or gradual change towards the emergence of agrarian societies during the Early Funnel Beaker Culture (4000–3300 cal BC)? Was the introduction of agrarian practises the result of migration or gradual adaptation through a process of diffusion? New theoretical approaches together with novel discoveries from excavations and investigations of key artefacts will be presented in this article in order to discuss the questions raised above and to present a new hypothesis of the Neolithisation process in South Scandinavia.

Curtural Epoch	cal BC
Late Ertebølle	4500–4000
Early Neolithic Ia	4000–3800
Early Neolithic Ib	3800–3500
Early Neolithic II	3500–3300
Middle Neolithic I–II	3300–3000

Fig. 1. Chronology of the Mesolithic and Neolithic transition in South Scandinavia.

Definitions of agrarian practices

The appearance of the first agrarian societies in South Scandinavia is often defined as an economic and ideological change from a hunter-gatherer society. But in prehistoric times, hunting, fishing and gathering were practised by both hunter-gatherers and agrarian societies. In my opinion, what separates farmers from hunter-gatherers in a transitional situation in South Scandinavia is crop cultivation and managing animal husbandry all year round. However, I do not see any problem with the fact that hunter-gatherers could have kept a few domesticated animals for meat reserves and prestige reasons. The managing of a few domesticated animals could be interpreted as initial and experimental herding activities by communities that still lived mainly as hunter-gatherers.

Why do agrarian societies expand?

Generally, the reasons for the adoption of agrarian practises and their expansion in South Scandinavia can be narrowed down to three lines of argumentation, concentrating on population growth, resource availability caused by climate changes and social changes within societies, or a combination of all three (see *Sørensen 2014.27–29*). However, researchers tend to prefer one explanation over another, emphasising either the advantages of the agrarian subsistence strategy, or the social, ideological and power-related benefits of the adoption of agriculture. Therefore, the perception of who the primary bearers and movers of agrarian knowledge and practises were varies with each of the proposed hypotheses (see *Sheridan 2010; Thomas 2013*). To attempt to establish the identity of the primary carriers of agrarian practises, it is necessary to investigate the processes behind agrarian expansions.

How do agrarian societies spread?

In general terms, the discussion regarding the transition from hunter-gatherer to farming communities has concentrated on three competing hypotheses: migrationism, indigenism and integrationism (*e.g., Rowley-Conwy 2011*). The three hypotheses characterise not only discussions of the Neolithisation process in southern Scandinavia, but throughout Europe. The migration hypothesis argues that agriculture was introduced by a swift process of a smaller or larger migration, where it is the migrating farmers who are the primary bearers of agrarian technologies. The hypothesis of indigenism and diffusion argues that the introduction of agrarian technologies is a gradual process, lasting several hundred years. Here, hunter-gatherers are the primary bearers of agrarian technologies, which spread as an idea between humans. The integration hypothesis is a combination of the first two hypotheses, but here there is still no consensus about who introduced agrarian practises, and how big a role the local hunter-gatherers played in this spread of agrarian technologies (*e.g., Sørensen, Karg 2014*). Previous studies of the Neolithisation process in South Scandinavia (*e.g., Klassen 2004; Rowley-Cowy 2011*) have suggested that migrating farmers expanded from Central Europe towards the North by leap-frog punctuated migration (*e.g., Moore 2001*). A similar model has also been presented for the rapid expansion of agrarian societies in the Mediterranean region (*e.g., Zilhão 2001; Horejs 2015*). These mobility models of agrarian expansions have been combined with Marek Zvelebil's and Peter Rowley-Conwy's (*1984*) availability and agricultural frontier model in order to explain the geographical setting of where the actual Neolithisation process occurred. However, these models fail to discuss how the actual 'fields' (*e.g.,*

Bourdieu 1977) of social meetings and structures between humans occurred during the process. Within the investigation of whether agrarian technologies spread as an idea or by migrating farmers, a central issue has often been overlooked, which concentrates on how easy or difficult it is to learn the agrarian technologies in question (see *Sørensen 2014.30–44*). This view focuses on how people, particularly indigenous hunter-gatherers, learn agrarian technologies, and which processes are included in this, which then can contribute to a more nuanced picture of the primary bearers of agrarian practises and technologies.

Learning about livestock and cultivation practices

Cultural evolutionist theories suggest that the learning of domestication practises is the result of the emergence of complex hunter-gatherers combined with either an optimal foraging strategy or niche-constructing behaviour (*Bird, Connell 2006; Zeder 2015*). The term complexity was defined as the product of an evolutionary process in prehistoric societies, in which hunter-gatherer groups went from small- to large-scale societies, thus making it more likely they wished to, and were able to, adopt agrarian practices. However, in periods of low yields, within the experimental domestication phases, populations would have switched back and forth between strategies dominated by foraging activities, or combined foraging with more or less agrarian activities (*Codding, Bird 2015*). The learning processes behind the domestication of livestock and crops was thus a longer process of experimentation and optimising yields and reproductive success with agrarian practises, which was initiated in several areas of the Fertile Crescent around 10 000 to 8500 cal BC (*Fuller 2008; Larson* et al. *2014*). Fully developed agrarian practises thus constitute a very complex technology, which requires detailed knowledge exchanges between different actors.

The management of stockbreeding practises is probably the least difficult technology to be adopted by a hunter-gatherer society. Several ethnographic studies have documented that animal husbandry practices could be integrated in a relatively short time into a hunter-gatherer subsistence pattern (*e.g., Nicolaisen 1975; Gregg 1988.53; Xavier* et al. *2008.1ff; Sadr 2013*). So it is possible that animal husbandry practises could have spread without any significant exchange of knowledge between hunter-gatherers and farmers in boundary areas, where domesticated animals could have been received in exchange, stolen or escaped from farmers. However, keeping domesticated animals all year round is not an easy task, and requires planning, which might have been an obstacle when compared to the traditional hunter-gatherer subsistence strategy. New skills had to be learned about domesticated animals and their behaviour, regarding their life cycles, breeding patterns, feeding and nutrition, in order to gain permanent and acceptable meat and milk yields. Furthermore, grazing, browsing and fodder requirements had to be calculated, with particular attention given to the storage of fodder during the winter. It would also be important to calculate the minimum number of animals required in a herd and to compare it with the feeding capacity of a given region. One method to control the size and composition of herds would be to systemise breeding patterns and thus regulate when a yield could be expected (*e.g., Mackinzie 1980; Perry 1984; Gregg 1988*).

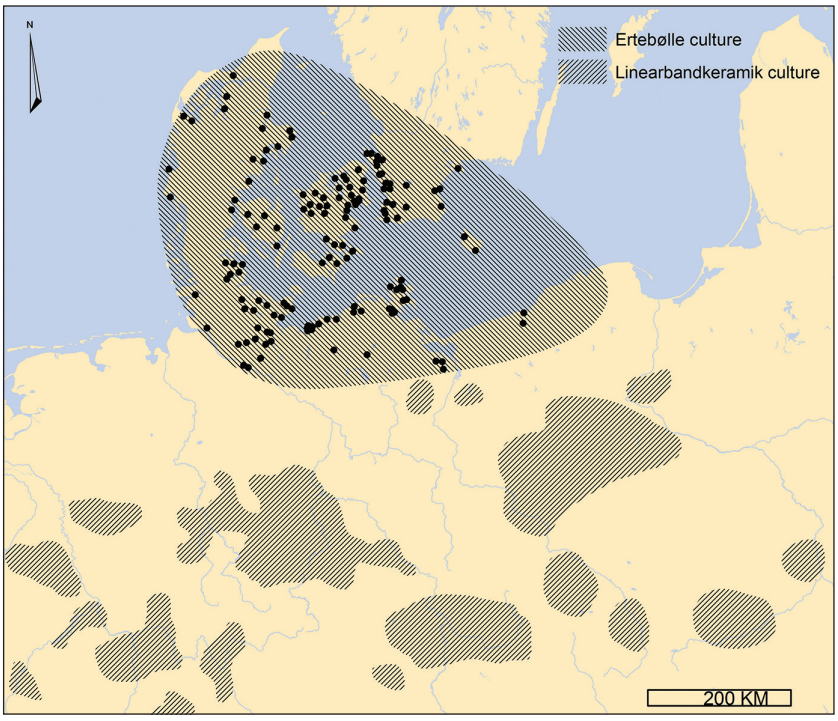


Fig. 2. The distribution of the Linearbandkeramik Culture and the Ertebølle Culture (after* Hartz *et al.* 2007*).

Crop cultivation is an even more difficult agrarian activity to master than animal husbandry, which is documented in several ethnographic and experimental studies (*e.g., Steensberg 1979; Nicolaisen 1975; Lee 1979; Yin 2006; Freeman 2012*). The cultivation of crops has limited room for trial and error, as it is only possible to sow and harvest crops once a year in Europe. In order to have initiated cultivation practices, it would have been necessary to obtain domesticated crops and obtain skills and knowledge relating to the properties of the crops, thus minimising mistakes. Cereal cultivation is associated with a long, knowledge-based process, involving accumulated experience of understanding the landscape, soil, climate, seasonal changes, and plant properties, thus creating a different perception of nature compared to that of hunter-gatherers. Soil fertility is a crucial matter when cereals are grown repeatedly in the same place, thereby exhausting the soil. Cultivation experiments have shown that yields would be relatively high during the first two to three years after a forest clearance using the slash-and burn strategy (see *Lüning, Meurers-Balke 1980; Schier 2009*). One solution could be to supply the soils with nitrogen oxides by implementing a manuring strategy using domesticated animals. The manuring method is most efficient when combined with a fallow strategy, which allows the regeneration of the soil's organic content. Grass fallow is faster, taking a few years; bush fallow takes less than a decade, whereas forest fallow can take up to several decades. The use of manuring can be tested by investigating the nitrogen content of charred cereals from the Early Neolithic, while fallow strategies can be tested by studying pollen analyses in South Scandinavia, which can be used in the discussion of how advanced the first pioneering agrarian societies actually were in South Scandinavia.

The new categories of food resources from agrarian products would have led to new cooking practices and new material culture. This change can be seen in the emergence or introduction of new types of pottery suited to new food sources, and the more complex use of foodstuff storage and food production, including slow heating of stews, porridge, broth and weaning foods. In connection with milk and the ability to store this type of food, it would have been necessary to incorporate bacteria into the production process to make cheese, curd, whey, and yoghurt. The handling of new ceramic vessels would have involved new cooking, storage, and consumption practises, which could have transformed the rhythms of social life (*e.g., Parker-Pearson 2003*). Generally, the use and implementation of these agrarian technologies requires the ability to plan several years ahead, which means that the learning processes could take decades.

Learning practices

Generally, agrarian technologies can be associated with many practises which are articulated and especially unarticulated, thus making it difficult to learn. When an individual has learned agrarian technologies, they tend to become routine practice, which are more or less repeated every year according to the preferred strategic choices in the breeding of animals, cultivation of crops, and securing of winter fodder, or foraging activities. The repeated patterns of agrarian strategies can be interpreted as routine practices (*e.g., Giddens 1984*). According to Anthony Giddens, routinisation is fundamental to daily social activities from which learning processes could emerge. The routines are repeated modes of activity by agents who do not need to consciously think or speak about them, so they are not articulated. The code of such actions makes it unnecessary for the agents to engage in constant negotiations. This might be knowledge about combining certain cereal types with an individual soil type, thus optimising the growth pattern, or laying out a field in accordance with the sun and wind directions, or controlling the breeding patterns of domesticated animals. It is precisely these untold routine practises that make agrarian activities so difficult to learn, as there are over 30 processes associated with possible unarticulated, routine information relating to cultivation or animal husbandry practises (*e.g., Gregg 1988*). Furthermore, the time frame of when to initiate certain actions in agrarian practises is very long and could potentially last several years. Moreover, in critical situations, the unspoken conventional and social codes would change and new ones would emerge. These new codes of action could also be unspoken and based on previous experience. There could be several pieces of information that are not expressed in the transferred exchange of knowledge. Furthermore, the amount of information required to explain the different processes of agrarian activities could make it easy to forget certain important details. Information exchange through oral communication makes it even more difficult to grasp all of the details. Such unarticulated or forgotten details are vitally important in practise. The knowledge process would be challenging even if the actors spoke the same language, because the learning of agrarian practises requires a detailed understanding of many technical words.

And if knowledge exchange occurred when the different actors, in this case hunter-gatherers and farmers, spoke different languages, then the learning process would have been even more difficult. Colin Renfrew (*1987*) and Peter Bellwood (*2005*) have argued that the expansion of agrarian societies around 7500 cal BC also involved the spread of Indo-European languages into Europe during the Neolithic period. Words like wheel, cart and traction have been associated with Indo-European languages (*e.g., Mallory 1989*). However, these technologies did not exist before 4200–3700 cal BC, thus suggesting a later spread of Indo-European languages into Europe (*e.g., Rowley-Conwy 2011*). The expansion of agrarian societies into South Scandinavia began around 4000 cal BC (*e.g., Sørensen, Karg 2014*), thus making it possible that an exchange of knowledge could have taken place in two different languages spoken by the indigenous hunter-gatherers and farmers.

Learning about farming is a social process which requires years and possibly decades of active participation in order to implement agrarian technologies and have consecutive years of positive yields (Fig. 3). Prehistoric people who wanted to learn this had to engage in social relations with certain individuals or groups who had the right skills and knowledge to teach other individuals. Such dynamic and active participation in exchanges of knowledge could have flourished in what Jean Lave and Etienne Wenger (*1991*) defined as a community of practice.

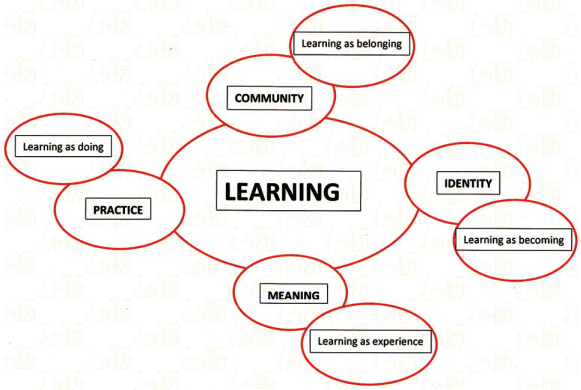


Fig. 3. Components of a social theory of learning (after* Lave, Wenger 1991*).

Communities of practise

According to Lave and Wenger (*1991*), the concept of communities of practise is a system of relationships between people, activities and the world, which develops over time and in relation to other overlapping communities of practise, in which exchange of knowledge and experience can be developed (Fig. 4). Within communities of practise, knowledge is negotiated through a process of participation and reification, and thus they are important places of learning, meaning, identity and power (*e.g., Wenger 1998*). Some characteristic features have been identified in connection with communities of practise. Firstly, members interact, thus establishing norms and relationships through mutual engagement. Secondly, members are bound to one another by an understanding of a common goal. In addition, members accumulate a shared knowledge of history and routines over time, which leads to increased competences in learning practices. Wenger (*2000*) also distinguishes between three modes of belonging to a community of practise. Engagement is important and can be achieved by initiating activities with other members of the community. Imagination is creating an image of an individual and his or her community in which they can become orientated and explore new possibilities. Alignment involves activities being aligned with other processes and thus becoming effective beyond their own engagement. Being part of a community of practise also involves the learner progressing from peripheral to more centrally-orientated learning practises, depending on the types of activities and the length of time spent in the community of practise (Fig. 4).

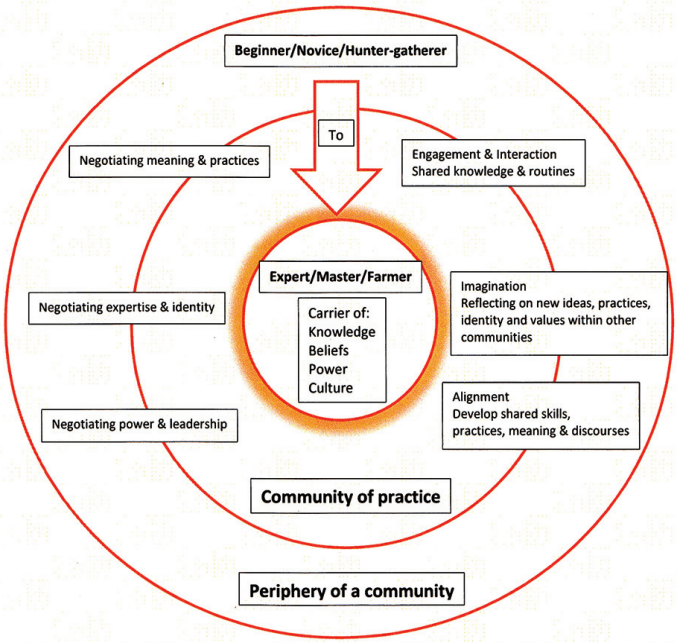


Fig. 4. Community of practise: a system of relationships between people, activities and the world (after* Lave, Wenger 1991; Wenger 1998; 2000*).

Studies of communities of practise have shown that learning does not occur through isolated processes, but by active participation and interaction (*e.g., Lave, Wenger 1991*). Hunter-gatherers could have engaged in such communities by moving to agrarian societies or by visiting for long periods. If farmers and hunter-gatherers had direct social relations, perhaps as neighbours, then such communities of practise could have emerged. However, this would have depended on the farmers' and the hunter-gatherers' desire to teach and learn the knowledge of agrarian practises. In addition, it also depended on how to produce the material culture – such as axes, pottery and houses – associated with agrarian practises. If a large part of an indigenous population decided to participate in such communities of practise with farmers in order learn agrarian practices, then this would be shown by a rapid change in material culture, as well as social and ideological behaviour. The archaeological evidence of such communities of practise could be associated with a rapid change in material culture and subsistence practices. A different scenario could entail limited interaction between farmers and hunter-gatherers who chose to live in isolated groups. Here we should expect to identify a synchronic cultural duality of hunter-gatherer and farming societies living as neighbours, thus showing a slow change in the material culture. Such a scenario could be applied to hunter-gatherers who wanted to participate in these communities of practise and had to give up some of their power vis a vis the farmers, because the latter were the bearers of agrarian knowledge, beliefs, ideology, culture, long-range networks and taboos. At first, the hunter-gatherers had to submit themselves within the community of practise on the periphery of the community until they had accumulated enough knowledge to attain a higher status. In this process of knowledge exchange and learning agrarian practises, the hunter-gatherers would have changed their identity towards becoming farmers (Fig. 3). These newly emerged farmers could then set up new communities of practise, where they were the bearers of ideological and cultural power. For some hunter-gatherers, their surrender of power in communities of practise could have been seen as intimidating, especially for individuals of high rank in their societies. But if submission meant that you, your children or the juveniles in your society would have the chance to attain an even higher status within an agrarian society, this could have been a motivating factor. In addition, farmers could give the leading hunter-gatherers more influence within the communities of practise, so that the rest of the group would follow into the agrarian communities of practise. It would then have been easier to create alliances with other hunter-gatherer societies, thus creating a domino effect of hunter-gatherers joining agrarian societies and communities of practise.

Integrating local hunter-gatherers could very well have been a necessary and deliberate strategy for the first pioneering farmers in South Scandinavia, because they needed manpower to clear the dense and thick forest in order to create arable land. Such a project would require the commitment of many more people, whereby the hunter-gatherers could have played an active role. Over time, the formation of several parallel and simultaneous communities of practise could have helped to create a larger network which would have been closely linked through social relationships and alliances. The prime movers of agrarian practices were thus people who, in a long-term learning process, acquired a detailed knowledge of, and skills in, agrarian practices. Agrarian expansion to different regions was most likely related to the migration of farmers and the willingness of indigenous hunter-gatherers to adopt agrarian practises, possibilties which support both migrationism and integrationism.

The structure of migration

Migrations and the processes behind them are subject to certain rules and structures that can be characterised as part of a larger process in which migration is a type of behavior carried out by a sub-group within a group (see *Anthony 1990*). The first phase would include several scouting expeditions to possible destination areas, which could be contemporary with the appearance of push factors at the place of origin. The scouting expeditions resulted in exchanges of certain prestigious objects, cereals or domesticated animals between agrarian scouts and local hunter-gatherers. The scouts would be searching for optimal arable locations and pull factors in connection with future migrations. Most ethnographic parallels indicate that the scouts would have been men, although it cannot be ruled out that women may also have been involved in these scouting expeditions. The strategy of initiating these expeditions may not have been a deliberately controlled process from the beginning. However, the aim was to return to the place of origin with valuable information about the potential destination area (Fig. 5).

The second phase would be the actual immigration of pioneering farmers of men, women and children,

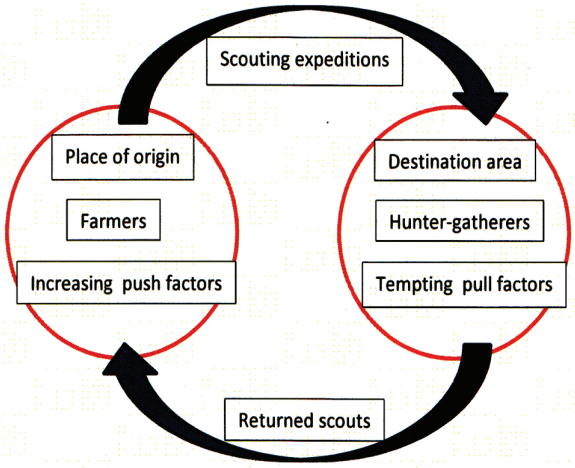


Fig. 5. The first phase of migrations would include several scouting expeditions to possible destination areas, which could be contemporary with the appearance of push factors at the place of origin.

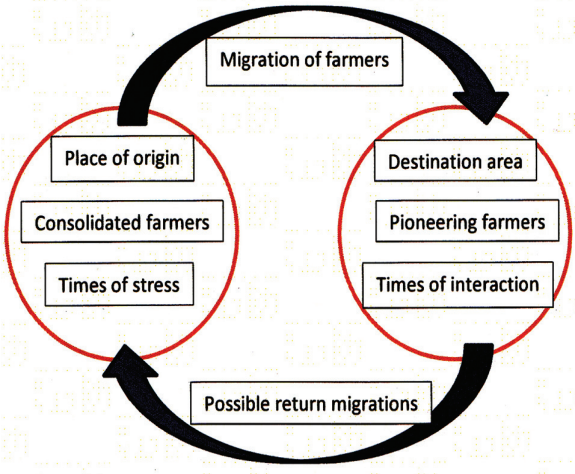


Fig. 6. The second phase of migrations would be an actual immigration of pioneering men farmers, which could be followed by return migrations to the place of origin.

carrying a complete knowledge of farming, who would settle in clusters located in optimal places for establishing an agrarian tribal society. One of the aims might be to engage and integrate the indigenous population into communities of practise, thus improving the possibilities of creating a more permanent agrarian society in foreign lands. Such a transition would be expected to have resulted in a swift change in the material culture and the emergence of new behavioural patterns, together with an increased social and political hierarchy in these newly established agrarian societies. As early as the pioneering phase, there may have been attempts to initiate return migrations back to the place of origin, unless there were continuous push factors at the place of origin. Additionally, there would have been active engagement in larger networks by the pioneering farmers (Fig. 6).

The third phase can be characterised as a consolidation stage, in which the pioneering farmers expanded their territories and settled in more marginal areas within the settled region. Such regional expansions may have resulted from population growth or other immigrations from neighbouring agrarian societies. Such behaviour may have created the need to construct territorial markers in the landscape in order to maintain contemporary power structures and to prevent any major conflicts. But the intensified usage of the landscape may have resulted in yet another push effect, thus leading to new scouting expeditions and migrations. The migrations could in fact have become an embedded tradition within these pioneering agrarian societies, where juvenile groups were expected as part of their rite of passage to actively take part in scouting expeditions and migrations to new regions (Fig. 7). The main contribution from these studies compared to earlier expansion and colonisation models of Zvelebil's and Rowley-Conwy's availability model and Zilhão's pioneer colonisation model (*e.g., Zvelebil, Rowley-Conwy 1984; Zilhão 2001*) is the identification of a scouting phase in the centuries before the actual agrarian expansions. The scouting phase does not result in any agrarian practices for the indigenous hunter-gatherers, but gift exchanges of objects from agrarian societies. However, the second pioneering and third consolidation phase overlaps with Zvelebil's and Rowley-Conwy's availability model and Zilhão's pioneer colonisation model (*e.g., Zvelebil, Rowley-Conwy 1984; Zilhão 2001*).

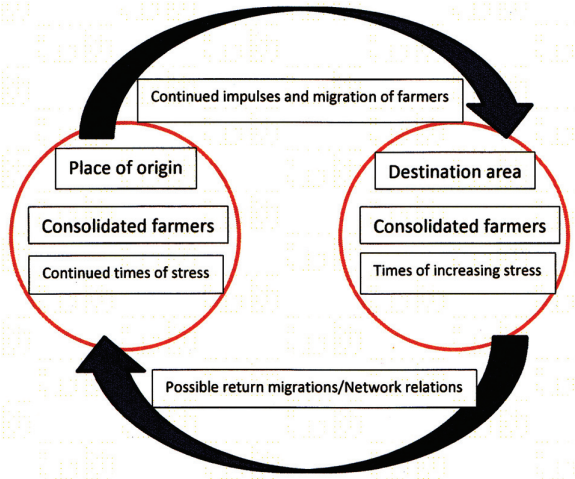


Fig. 7. The third phase of migrations can be characterised as a consolidation stage in which the pioneering farmers expanded their territory and continued to receive impulses and possible immigrants from the place of origin.

Turning to the archaeological data

In the following, the theoretical hypothesis will be tested in order to identify migrations and the establishment of communities of practise by studying material culture during the transition between the 5th and 4th millennium BC in South Scandinavia.

Evidence of scouts in the archaeological material

There are some important finds in southern Scandinavia which may be interpreted as material evidence from groups of scouts that originated from Central European agrarian societies. The first example is from the inland site of Flintbek in Schleswig-Holstein, where a pit was filled with short- necked funnel beakers, flake cores and scrapers (*e.g., Zich 1993*). Charcoal pieces from the pit were ^{14}C dated between 4300 and 3900 cal BC, making it one of the earliest discoveries of funnel beaker ceramic in northern Germany. Signs of contact between agrarian scouts and coastal hunter-gatherers could also be interpreted in connection with the few bones from domesticated animals found at contemporary Late Ertebølle coastal sites at Wangels and Neustadt, which were located approx. 30km from Flintbek.

The second example is from the inland site of Oxie 50:1 in Scania, which consisted of a pit where some undiagnostic Neolithic sherds and a fragment of a polished axe were found together with several charred cereals. One of the cereals was ^{14}C dated between 4200 and 4000 cal BC, which indicates that the material in the pit could be evidence of agrarian scouts (*e.g., Brusling 2003*). Scania also has signs of contact between these scouts and local hunter-gatherers, which is expressed in the famous finds of grain impressions on Ertebølle ceramics from the sites of Löddesborg and Vik (*e.g., Jennbert 1984*) (Fig. 8).

A third example of scouting is observed in the pollen analysis from South Scandinavia. Some pollen analysis, especially from the inland parts of Scania, claims that cerealia pollen has been found stratigraphically below the elm decline in South Scandinavia, thus indicating that crop cultivation was practiced during the Late Mesolithic (see *Sørensen 2014.84*). However, the few examples of cerealia pollen from these pollen diagrams are problematic, as they are probably from wild grasses, thus suggesting smaller openings in the forest. Hunter-gatherers could have cleared the forest and created open spaces in order to improve their hunting of grazing animals such as red and roe deer. But then we should expect a repeated pattern

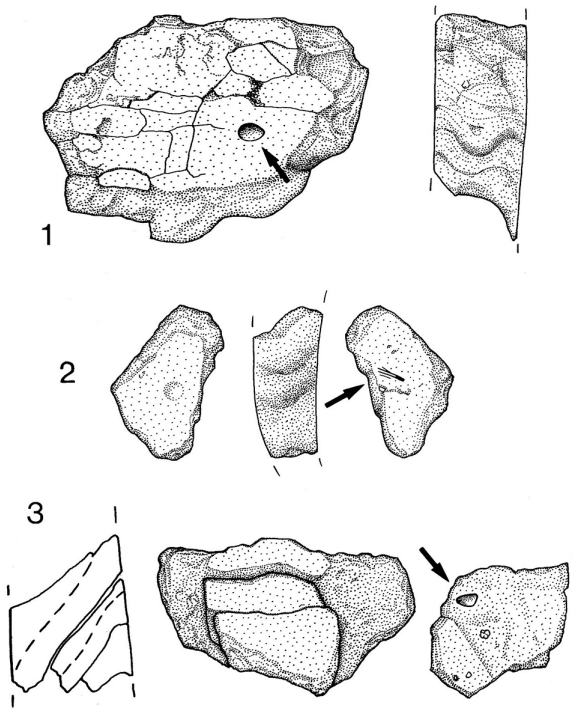


Fig. 8. Drawings of Ertebølle sherds with grain impressions from the settlements at Vik and Löddesborg in Scania.* 1 *Sherd with impressions of wheat (*Triticum compactum*);* 2 *Sherds with impressions of a barley grain (*Hordeum*);* 3 *Sherd with impression of einkorn wheat (*Triticum monococcum*) (after* Jennbert 1984; Koch 1998*).

going back to the Middle Mesolithic, which is not the case. Instead, most of the wild grasses are found just below the elm decline, which could be interpreted as evidence of scouts preparing the landscape for future farming. Perhaps the scouts were involved in preparing the landscape for farming by creating smaller clearings and making fields, so that the first pioneering farmers could begin cultivating just after they arrived.

A fourth example can be observed within the earliest axe deposition in South Scandinavia, which consists of two shoe-last axes and a pointed-butted axe, all made of amphibolite found at Udstolpe on Lolland (see *Lomborg 1962*) (Fig. 9). Such axe deposits are usually observed in Central European agrarian societies and could have been a symbolic offering made by scouts searching for new lands in the North. A similar example is the appearance of jadeite axes, which could also stand for several deposits made by Central European agrarian scouts (*e.g., Klassen 2004*) (Fig. 10). Perhaps the depositions of these exotic axes could have been associated with embedded symbolic practices relating to the establishment of new farming community in southern Scandinavia. The importation of the shoe-last axes has been inter-

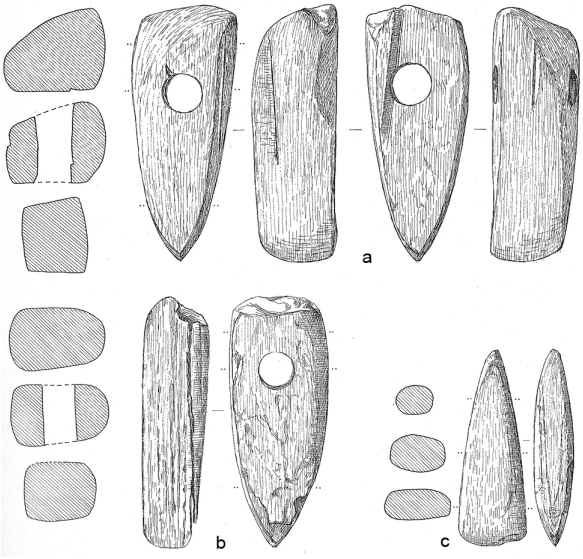


Fig. 9. Deposition of two shoe-last axes and one pointed-butted amphibolite axe from Udstolpe, Lolland (after* Lomborg 1962*).

preted as evidence of direct contact between Central European agrarian cultures and Ertebølle hunter-gatherers, where ideas of agrarian practises could also have been exchanged. But often the shoe-last-axes show signs of heavy usage on the neck and most were found in ordinary waste layers (see *Sørensen 2012*). So it is likely that the original ideas behind these exotic axes as status and prestige symbols were lost in a hunter-gatherer contact network. In such a more-or-less indirect network of agrarian societies and hunter-gatherers, it would have been difficult to initiate detailed knowledge exchanges about agrarian practices, which could explain why the border between Central European agrarian societies and Mesolithic hunter-gatherers in South Scandinavia was almost static for 1500 years from 5500 to 4000 cal BC.

How complex were agrarian practises during the Early Neolithic?

Clear evidence of agrarian practises is first documented on a broader scale from 4000 cal BC onwards, which was documented by investigating all the known ^{14}C dates of charred cereals and domesticated animals in South Scandinavia (Fig. 11). But how complex and advanced were the first agrarian practises? New research indicates that they were already very advanced from the beginning of the 4th millennium BC, which indicates that highly skilled people were involved in the process.

Pollen analysis has yielded some of the empirical data, especially from the Ystad project in Scania. Here, high concentrations of charcoal dust appear in the pollen diagrams around 4000 cal BC, thus indicating the use of slash-and-burn agriculture (*e.g., Digerfeldt, Welinder 1989*). Other pollen diagrams from South Scandinavia show higher pollen concentrations of ribwort plantain (*Plantago lanceolate*) and birch (*Betula*) around 4000 cal BC, which indicates the use of a short- and long term fallowing strategy. However, most of the pollen analysis show an absence of cerealia pollen from the beginning of the Early Neolithic. Unfortunately, most pollen samples in Scandinavia have been taken from larger bogs or lakes, thus showing that environmental changes to the landscape covered a radius of 5–10km (*e.g., Sørensen 2014*), so pollen from cereals is rarely detected, because wheat and barley are self-pollinating species, which means that the pollen does not spread over long distances. The phenomenon has been confirmed: an experiment has shown a very low dispersal of wheat pollen just 10m away from the crop field (1.4%) and a greater amount (26.6%) at the ac-



Fig. 10. Alpine jade axes from South Scandinavia.* 1 *type Chelles, jadeitite, Zealand, unknown find location;* 2 *type Puy, jadeitite, Zealand, unknown find location;* 3 *type Durrington, eclogite, Højgård, Tulstrup parish, Eastern Jutland;* 4 *type Durrington, amphibolite, Danmark, unknown find location;* 5 *type Durrington, jadeitite, Lolland-Falster, unknown find location;* 6 *type Puy, eclogite, South Funen, unknown find location;* 7 *type Durrington, jadeitite, possibly South-western Scania, unknown find location. Photo: Louise Hilmar, Moesgćrd Museum, Aarhus University (after* Klassen 2013*).

tual threshing site (see *Diot 1992*). Fortunately, some other pollen samples in connection with the Ystad project in Scania have been taken from much smaller bogs which had higher concentrations of cerealia pollen around 4000 cal BC (*e.g., Berglund 1991*). Furthermore, new research of ^{15}N values of charred cereal grains from different sites dating from the later part of the Early Neolithic (EN II) to the Iron Age has confirmed a long-term increase in manuring intensity in relation to emmer cultivation (*e.g., Kanstrup* et al. *2013*). The result indicates that cultivation and animal husbandry practises were interacting factors in the same system already from the beginning of the Neolithic in South Scandinavia. Additionally, another argument can be proposed when measuring the sizes of cereal grains from the Early Neolithic and Middle Neolithic in Denmark. The results document that the average size of emmer kernels increased by 59% over a period of only 400 years, between 3500 and 3100 cal BC, thus indicating that emmer was cultivated in the Early Neolithic (*e.g., Westphal 2005*).

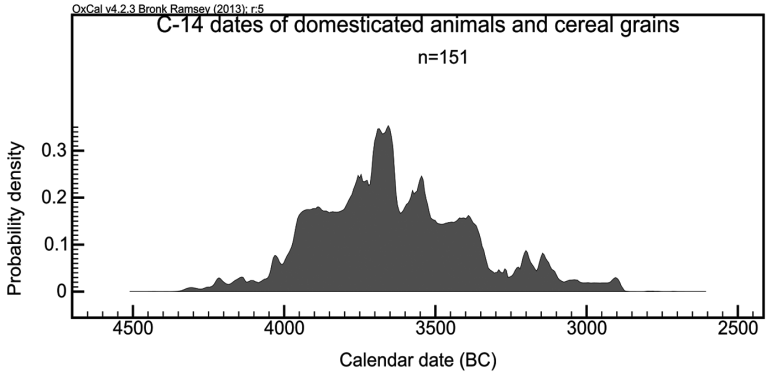


Fig. 11. Graph showing distribution of all ^{14}C dates of charred cereals and domesticated animals from the Early Neolithic in South Scandinavia (after* Sørensen 2014*).

The fact that cultivation was efficient and covered larger fields can also be documented by new and old finds of plough marks. Plough marks have been found below the long barrow at Højensvej 7, near Egense on Funen, where the furrows covered an area of 85m^2 (see *Beck 2013*). Some plough marks were cut by a pit, which was dated by a burnt hazelnut shell to 4900±40 BP (3770–3637 cal BC, POZ-28068), thus providing a very early date and making them the earliest from Northern Europe.

Recent research has also argued for complex cattle husbandry methods during the Early Neolithic. The most recent study was based on a strontium isotope-analysis of Early Neolithic cattle teeth from the sites at Almhov in Scania and Havnelev on Zealand. The results indicated some variation in the local origin of the animals. But both sites also yielded at least one individual showing strontium isotope ratios indicating movement over water by boat between Zealand and Scania, thus documenting that exchanges of cattle occurred already during the Early Neolithic (*e.g., Gron* et al. *2016*). Another study based on the analysis of δ^{18} on cow teeth also from Almhov, demonstrated that cattle calved in more than one season. The implication of this study means that breeding was artificial manipulated to produce calving and milk throughout the year. Calving throughout the year, especially in winter, must have demanded for extra fodder and long-term planning for these Early Neolithic farmers. It would also have produced a higher milk yield and thus stimulated the need to produce longer-lasting products such as cheese and yogurt, which changed the material culture (*e.g., Gron* et al. *2015*).

Changes in diet were also confirmed when Henrik Tauber measured the ^{13}C values of human bones from the Ertebølle and Funnel Beaker cultures (see *Tauber 1981*). His results revealed a very clear change from a marine diet during the Mesolithic period to a terrestrially dominated diet in the Early Neolithic in South Scandinavia. The abundance of fish bones from Mesolithic sites changes around 4000 cal BC, which is synchronous with the transition to the Early Neolithic. In general, there is an absence of fish bones from Early Neolithic sites located near the coast or inland lakes. It has been argued that in the transitional process of becoming farmers, the indigenous hunter-gatherers changed their view of marine food resources, which came to be regarded as less prestigious than agrarian products (*e.g., Milner* et al. *2004*). Such an interpretation could explain the sharp shift from a marine to a terrestrial diet, as indicated by isotope values (*e.g., Tauber 1981; Fischer* et al. *2007*). Nevertheless, these analyses lack data from the Early Neolithic remains of humans who lived in the coastal sites, thus indicating that people did exploit marine food sources (see *Pedersen 1995*).

Contemporary with the introduction of advanced agrarian techniques, some clear changes occur around 4000 cal BC. Firstly, the Late Ertebølle pottery, adzes, T-shaped antler axes disappear, and the emergence of new material culture can be observed in the form

of short-necked funnel beakers, clay discs, clay spoons, pointed-butted flint axes and battle axes from the Funnel Beaker Culture (Fig. 12). New constructions such as two-aisled houses and flint mines also emerged around 4000 cal BC, a feature unknown in Ertebølle Culture (*e.g., Sørensen 2014; 2015a*). The symbolic behaviour behind the material culture also changed, because many pointed-butted axes and short-necked funnel beakers were deliberately deposited, which is a characteristic feature observed in Central European agrarian societies. Such symbolic depositions of material culture are almost non-existent within Ertebølle Culture, thus documenting a physical as well as symbolic change in the material culture beginning around 4000 cal BC. All these data suggest that early agrarian societies in South Scandinavia were so advanced that migrating farmers from Central Europe must have been involved in the Neolithisation process.

Evidence of pioneering farmers and colonies in the archaeological material

The settlement pattern also changed during the transition from the Late Ertebølle Culture and the Early Funnel Beaker Culture, because a new type of inland site located on arable soils emerges. However, investigations of the settlement pattern from the Early Neolithic are often biased, because they are unevenly distributed on the basis of various rescue excavations, thus making it difficult to document any possible clusters or colonies of pioneering agrarian societies. However, a recent survey of pointed-butted axes dated from 4000 to 3700 cal BC reflects the early expansion of pioneering agrarian sites in South Scandinavia (*e.g., Sørensen 2014*) (Fig. 13). Their distribution clearly illustrates that agrarian scouts did manage to find suitable areas for founding smaller colonies of pioneering agrarian societies in areas characterised by arable soils (Fig. 14). These areas are also characterised by a small number of sites associated with Late Ertebølle Culture. Such a pattern can be interpreted as if the pioneering agrarian societies had established their colonies in areas where they could expect the least possible conflict with local hunter-gatherers. Some of the most obvious concentrations of pioneering colonies are also located in the vicinity of flint-rich areas in Scania, Stevns and Thy. Here, pioneering farmers quickly established flint mines and systematic axe production. The increased production of pointed-butted axes, particularly in Scania and Stevns, was used to establish a large network of agrarian societies further north in regions poor in flint on Bornholm and Gotland and in Västergötland, Östergötland and Närke (Fig. 14).

The visible patterns emerging from the distribution of pointed-butted axes was tested by integrating the results from a 10 x 6km survey near Risø and Hedehusene on Zealand (Fig. 15). The survey was conducted over a 38-year period, from 1978 to 2016, by amateur archaeologists Hans Sørensen and his son Klaus Sørensen. They collected and plotted over 14 000 flint artefacts from the Mesolithic, Neolithic and Bronze Age in that particular area. The distribution of the artefacts presents a totally unique picture of the changes between the Late Ertebølle and Early Funnel Beaker Culture, thus indicating the huge research potential of such long-term surveys. The distribution clearly illustrates the location of Late Ertebølle kitchen middens near the coast and the location of Early Funnel Beaker sites located further inland on sandy and easily cultivated areas. Furthermore, it is possible to observe a few core axes with specialised edges at agrarian inland sites, which are characteristic archetypes of Late Ertebølle Culture (*e.g., Sørensen 2014*). These finds could indicate the possible integration of migrating farmers and indigenous hunter-gatherers engaging in new agrarian communities of practice.

Population duality or commuting farmers?

The sudden changes in the settlement pattern appear at the same time as the disappearance of Ertebølle Culture. However, some of the kitchen middens contain layers from the Late Ertebølle and Early Funnel Beaker cultures. On the one hand, these sites indicate a clear break in the material culture, and on the other hand continuity, because some sites continued to be settled during the Early Neolithic (see *Johansen 2006; Andersen 2008*). There is continuity in the economic exploitation of the sea and forest, as fishing, gathering and hunting activities continued into the Neolithic in South Scandinavia (*e.g., Andersen 2008*). Such behaviour is only natural, because Central European agrarian societies also continued to fish and hunt, as such activities are compatible with agrarian activities (*e.g., Hachem 2011; Höltkemeier 2011*). Often the busiest time of the year for agrarian endeavours is in early spring during and late summer, which leaves time for hunting, fishing and gathering during the period between sowing and harvesting activities. But how should we understand the settlement continuity of coastal settlements, as these sites have been used to argue for cultural duality?

The theory argues that one population lived near the sea and lived mainly as hunter-gatherers, but

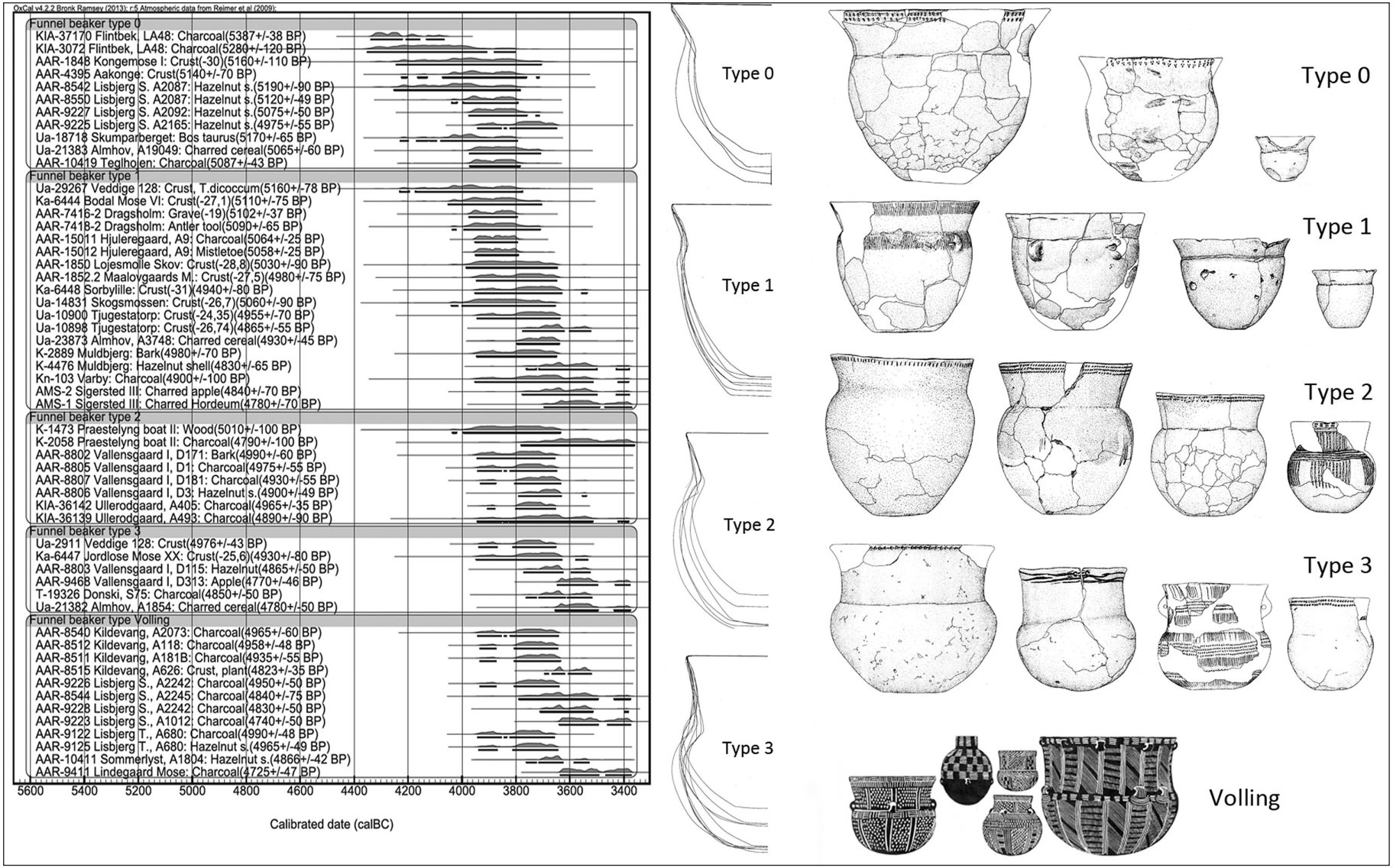


Fig. 12. ^{14}C dates of various types of funnel beakers (type 0, I, II, III and Volling vessels) in South Scandinavia (after **Koch 1998***).*

changed their material culture and supplemented their economy with domesticated animals and the cultivation of gardens. The other population lived as farmers on the easily cultivated land. It was around 3500 to 3300 cal BC that these coastal settlements were first abandoned, and the real agrarian process begins contemporaneously with the building of megaliths (*e.g., Andersen 2008; Ebbesen 2011*). The theory has been questioned by some researchers, and an alternative hypothesis suggested (*e.g., Skaarup 1973*) which argues that the coastal and inland sites were populated by the same agrarian population, who commuted between the coastal and inland areas during various seasons. This hypothesis is supported by the fact that the faunal evidence lacks the winter indicators of Early Neolithic kitchen middens, thus arguing for the seasonal exploitation of these coastal sites. However, detailed studies of the Early Neolithic kitchen middens show the same accumulation of layers as during the Late Ertebølle, indicating that these sites were not short-term seasonal settlements (see *Andersen 2008*). But the Late Ertebølle kitchen middens also lack faunal winter indicators, suggesting that they too were exploited in specific seasons and for special reasons, which continued during the Early Neolithic. Nevertheless, empirical studies of Early Neolithic kitchen middens have shown that most of the layers dated to 4000 to 3700 cal BC contain very limited evidence of charred grains, clay discs (interpreted as baking plates) or grindstones (*e.g., Sørensen 2014*). These studies can support the commuting hypothesis, because people could have specific tasks at seasonal sites not associated with agrarian practices. But the studies could also support the theory of population duality, where groups of people were more conservative and continued to hunt and fish, supplemented with some herding activities, and thus representing a slower transition and integration into the legitimate periphery of an agrarian community of practise. Generally, the lack of evidence of cultivation practises in these kitchen middens could also be due to current archaeological visibility. Perhaps the actual fields and other agrarian activities were located behind some of the kitchen middens. Unfortunately, few excavations behind Early Neolithic kitchen middens have been conducted. However, at the Bjørnsholm kitchen midden, located in northern Jutland, a large long barrow was discovered behind a midden where cultivation practices were identified (see *Andersen, Johansen 1992*). To move forward in this ongoing discussion, it is necessary to conduct surveys and excavations behind the middens and to carry out DNA, ^{14}C and ^{13}C analyses of the human bones found at these Late Mesolithic and Early Neolithic kitchen middens and inland sites.

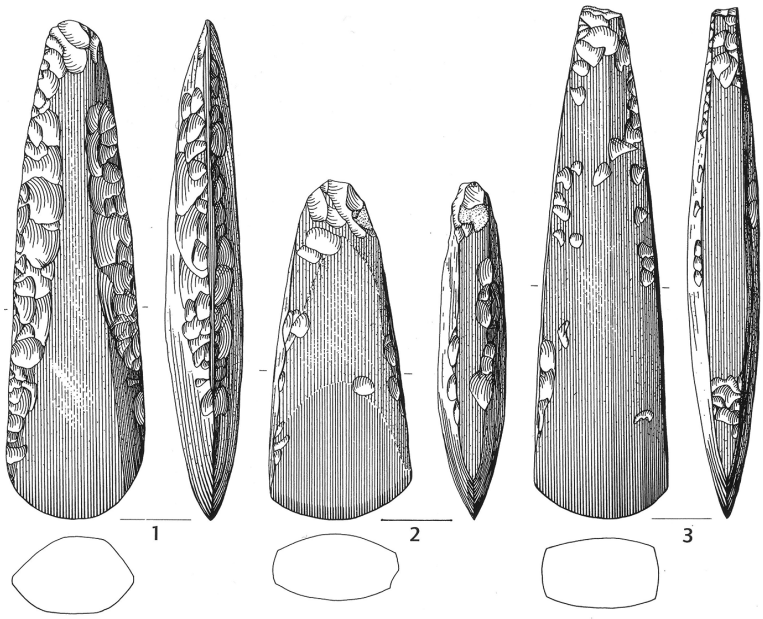


Fig. 13. Drawing of pointed-butted flint axes of type* 1, 2 *and* 3. *Type* 1 *has an oval cross section. Type* 2 *has a three-sided cross-section. Type* 3 *has a four-sided cross section (after* Nielsen 1977*).

One DNA study of humans from the Funnel Beaker Culture is not from the actual transition, but several hundred years later. The problem has been exemplified by Pontus Skoglund *et alii* (*2012*), who were able to extract mtDNA from a female skeleton found in passage grave Gök 4 at Falbygden, Sweden. The woman was ^{14}C dated to 4341±44 BP (3090–2889 cal BC, AAR-10235) and carried haplogroup H, which is associated with Middle Neolithic agrarian groups in Central Europe dated from 4600 to 3500 cal BC (*e.g., Sørensen 2014.105–109*). The result suggested that agriculture was introduced to South Scandinavia through a process of migration in which the Falbygden area, known for its many passage graves, may be interpreted as an enclave displaying very little integration between migrating farmers and local hunter-gatherers. However, the haplogroups of people living in the Mid-Funnel Beaker period could also be the result of later immigrations and do not necessarily have anything to do with the adoption of agriculture during the Early Neolithic (*e.g., Skoglund* et al. *2012; 2014*). No DNA analysis has been undertaken on human bones dated to the transition

between the Late Ertebølle Culture and Funnel Beaker Culture in South Scandinavia. Such investigations are underway, and preliminary results can be expected in the next couple of years (*e.g., Sørensen 2015b*). Nevertheless, mtDNA analysis has been conducted in Central Europe on human remains dated between 4600 and 3600 cal BC from the agrarian Rössen, Schöningen, Michelsberg and Baalberg cultures, which are important in connection with agrarian expansion to South Scandinavia (*e.g., Bramanti* et al. *2009; Deguilloux* et al. *2010; Adler 2012; Bollongino* et al. *2013; Brandt* et al. *2013; Lizaridis* et al. *2014; Lee* et al. *2014*). These investigations showed a few individuals carrying the U5 haplogroup, which is normally associated with Palaeolithic or Mesolithic populations of Europe. The data indicate that there was some genetic mixture between hunter-gatherers and farmers, perhaps through marriage alliances. A similar result could perhaps be anticipated in connection with the agrarian expansion to South Scandinavia.

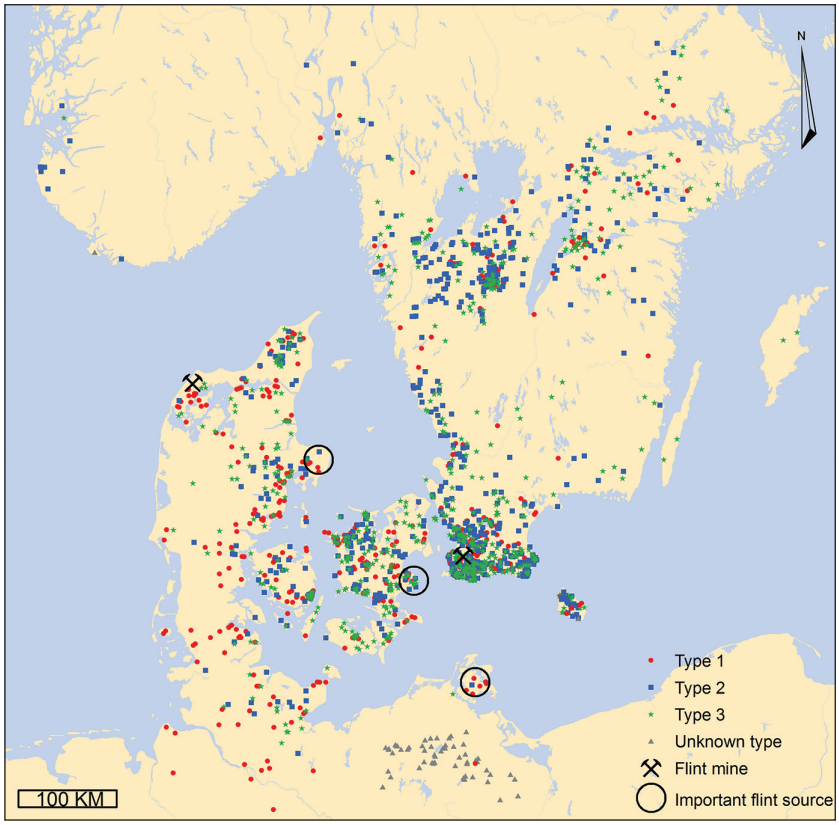


Fig. 14. Distribution of pointed-butted flint axes, flint mines and important flint resources in South Scandinavia and northern Germany (after* Sørensen 2014*).

One of the earliest farmers in South Scandinavia is the Dragsholm man, found in a burial on Zealand, who showed terrestrial ^{13}C values and was dated to 4000–3800 cal BC (5102±37 BP, 3973–3798 cal BC, AAR-7416) (5090±65 BP, 4035–3712 cal BC, AAR-7418) (*e.g., Brinch Petersen 1974; 2008; Price* et al. *2007*) (Fig. 16). The burial of the Dragsholm man contained some significant finds, including a short-necked funnel beaker (Oxie/ type 1) (see *Koch 1998*), a polygonal battle axe of type F III (*e.g., Zápotocký 1992*), teardrop-shaped amber beads, flint blades and a wrist guard, thus connecting the man with status and power. The Dragsholm man is therefore an important piece of evidence in the discussion of the expansion of agrarian societies and the adoption of a new ideology. The grave goods and terrestrial isotope values support the theory that he could have been one of the pioneering farmers who during the earliest phase of the Early Neolithic tried to establish new agrarian societies at specific places in South Scandinavia. He may be an example of a 'big man' who had the skills and the ability to disseminate information about agrarian practices (*e.g., Brinch Petersen 2008; Nielsen, Nielsen 2017*). The fact that he was buried as a warrior at a coastal site could indicate that he and other immigrating farmers were engaged in a community of practise together with the indigenous population in this region. The Dragsholm man was probably from the first or second generation of pioneering farmers, but where did he and his ancestors come from?

Origin of scouts and pioneer farmers in South Scandinavia

The cultural impulses creating the Early Funnel Beaker Culture were influenced by pioneering farmers who were either directly or indirectly connected to the large-scale network of the Michelsberg Culture in the transition between the 5th and 4th millennium BC. It was these groups of migrating pioneering farmers who, together with the indigenous hunter-gatherers, established new agrarian communities of practices in connection with the expansion towards South Scandinavia. The integration of practises in these communities created the foundation and emer-

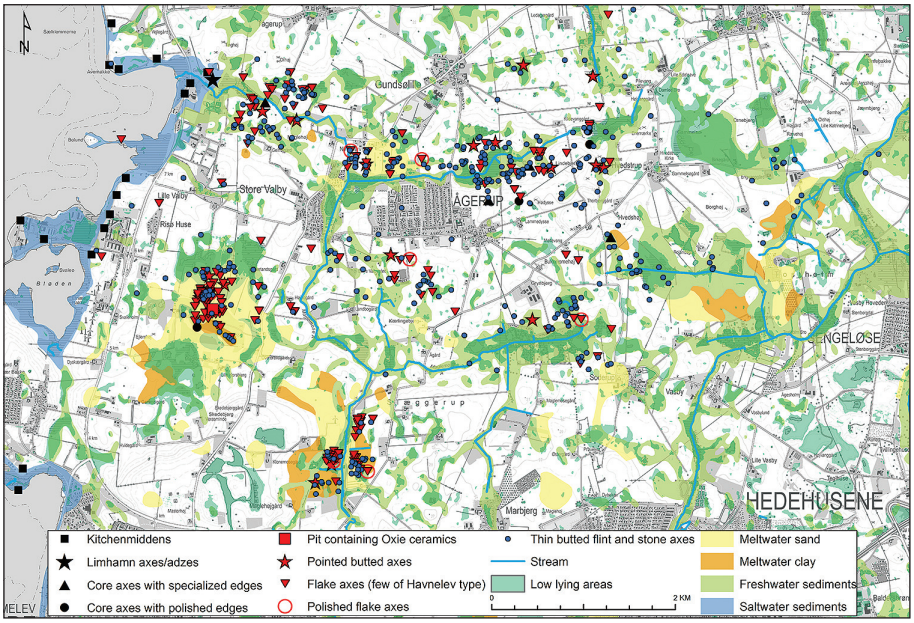


Fig. 15. Distribution of flint artefacts, showing the transition from Late Ertebølle to Early Funnel Beaker cultures in the area near Risø Zealand. The survey was conducted from 1978 to 2016 by amateur archaeologist Hans Sørensen and his son Klaus Sørensen.

gence of Funnel Beaker Culture. Investigations into the material culture, structures and types of sites of Early Funnel Beaker Culture clearly demonstrate the Michelsberg network influences on the first farmers who came to South Scandinavia. These newly established pioneering agrarian societies in South Scandinavia also expanded their network, not only towards the Michelsberg Culture, but also towards Eastern Europe, which can be documented by the appearance of copper axes, battle axes and thin-butted axes (*e.g., Todorova 1981; Zápotocký 1992; Klassen 2000; Klimscha 2007*). The widely dispersed material culture associated with impulses from the Michelsberg Culture or Michelsberg-affiliated cultures can also be associated with agrarian expansions during the centuries around 4000 cal BC into the British Isles (*e.g., Sheridan 2010; Rowley-Conwy 2011*), the Netherlands (*e.g., Willms 1982; Louwe Kooijmans 2007; Raemaekers* et al. *2012*), central and northern Germany (*e.g., Brandt 1967; Lüning 1968; Hartz* et al. *2007; Vogt 2009*) and northern Poland (*e.g., Lichardus 1976; Czekaj-Zastawny* et al. *2011; Papiernik 2012*), thus making this spread of material culture and people a northern European phenomenon.

Typical Michelsberg sites demonstrate many similarities with Early Funnel Beaker sites. They are both located on easily worked arable soils and characterised by a small number of pits containing objects, including short-necked funnel beakers, clay discs, clay spoons, pointed-butted axes, flake axes, ordinary blades, disc-shaped flake scrapers, transverse arrowheads and flake perforators (*e.g., Nielsen 1985; Vermeersch 1988; Vanmontfort* et al. *2008*). It has previously been suggested that the type 0 funnel beaker may be a transitional shape of vessel between the Ertebølle and Funnel Beaker cultures, thus indicating an inde-

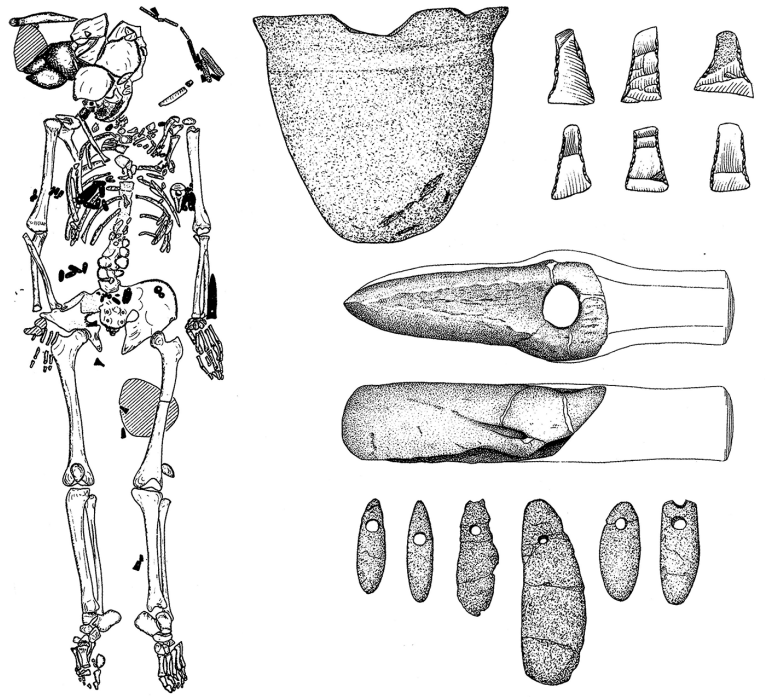


Fig. 16. The burial of the Dragsholm man, containing a short-necked funnel beaker, a polygonal battle axe, teardrop-shaped amber beads, transverse arrowheads, flint blades and a wrist guard (after* Brinch Petersen 1974; 2008*).

pendent evolution of funnel beakers (*e.g., Koch 1998; Andersen 2008*). However, type 0 has parallels with short-necked funnel beakers from the early stages of Michelsberg Culture, dated to 4400 to 4000 cal BC (Fig. 17). It is therefore probable that funnel beakers came to southern Scandinavia through direct or indirect contacts with agrarian groups around 4000 cal BC (see *Lüning 1968*). The new practice of disposing of ceramics in pits also points to a contact associated with pioneering farmers who were interconnected with people from the Michelsberg Culture (*e.g., Becker 1954; Biel* et al. *1998; Jeunesse 2011*).

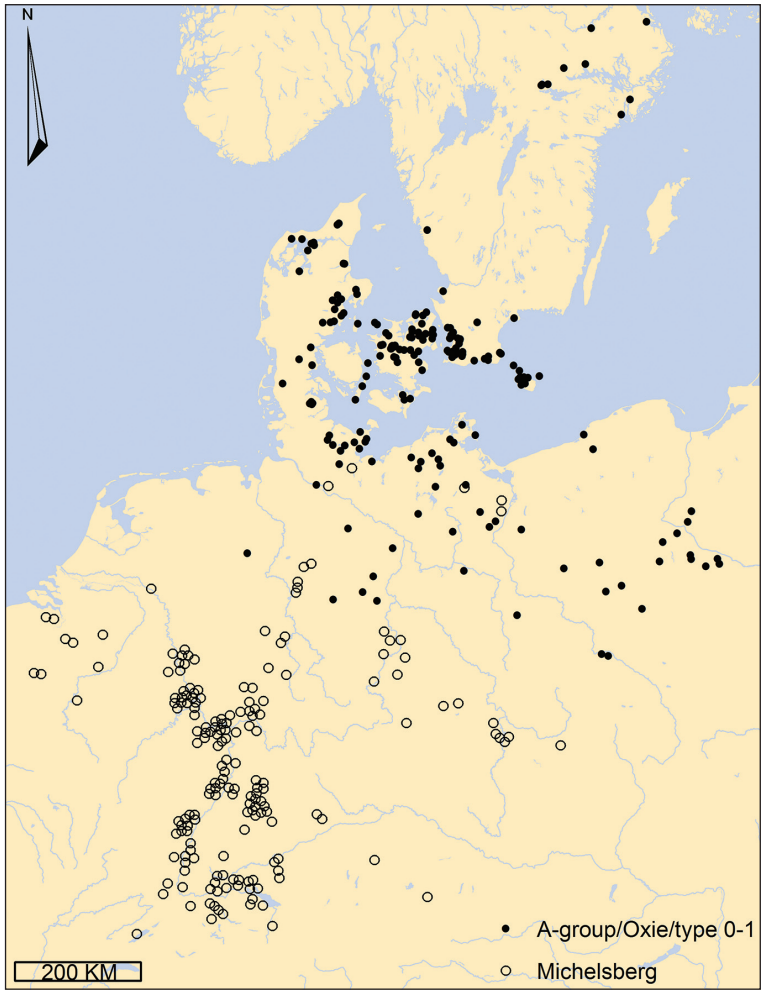


Fig. 17. Map of Michelsberg sites in Central Europe and localities containing short-necked funnel beakers in South Scandinavia, northern Germany and northern Poland (after* Lüning 1968; Sørensen 2014*).

The flint assemblages from the Early Neolithic in South Scandinavia have also been used to argue for a continuity from Late Ertebølle Culture (*e.g., Nielsen 1985; Stafford 1999*). It has been stated that flake axes and blade knapping technology are typical features of Ertebølle Culture. But flake axes are also very common in Michelsberg Culture, because polished flake axes similar to the Havnelev type have been found at Michelsberg sites at Schorisse-Bosstraat and Thieusies in Belgium in contexts ^{14}C dated to between the late 5th and early 4th millennium BC (*e.g., Mathiassen 1940; Nielsen 1985; 1994; Breunig 1987; Vermeersch 1988; Vermeersch* et al. *1991*). Furthermore, polished flake axes of the Havnelev type have also been identified from South Scandinavia in pits at the Almhov site, which have been ^{14}C dated to between 4000 and 3800 cal BC (see *Rudebeck 2010*). It is therefore clear that the tradition of polishing flake axes may have come from pioneering agrarian societies that were influenced by Michelsberg Culture.

Jade axes also reached South Scandinavia from scouting visits or pioneering farmers during the Early Neolithic (4000–3500 cal BC), an assertion supported by local imitations found in ^{14}C-dated contexts, thus making their introduction synchronic with the introduction of agriculture (Fig. 18). A pointed-butted flint axe imitating a Durrington type jade axe was found at Lisbjerg Skole in pit A2247, together with Oxie ceramics and threshing waste from cereals, which was dated to the earliest part of the Early Neolithic (see *Skousen 2008*). Other local imitations of jade axes from South Scandinavia include Durrington, Chelles, Bègude, Bernon, Saint Michel, Rarogne, Altenstadt, and Chenoise types, which were made from local raw materials such as flint, diabase, basalt, porphyry and slate (Fig. 18). The typological classification can be debated, of course, but some of the imitations of jade axes with splayed edges (Saint-Michel and Rarogne) clearly suggest imitations of specific jade axes found in Central Europe. Another characteristic type of axe is the pointed-butted axes with a perforation in the butt, which also show similarities with the contemporary Zug type, which is concentrated in Switzerland (see *Klassen 2014a*).

Jadeite may have been difficult to acquire, as it is only found in a few places in the Italian Alps, and because the supply of this raw material decreased during the late 5th and early 4th millennium BC (*e.g.,*

Pétrequin et al. *2012*). The result would have been an increased focus on exploiting more abundant raw materials, such as flint. Jade axes were already being imitated in flint in the Michelsberg Culture during the period from 4300 to 4000 cal BC, which is shown by the emergence of the Glis-Weisweil type (*e.g., Gallay 1977; Pétrequin* et al. *2006; 2010*) (Fig. 19). This may be one of the reasons why several flint mines were established at almost the same time, around 4200 to 3800 cal BC in northern France, Belgium, and the Netherlands (*e.g., Bostyn, Lanchon 1992; Becker 1993; Collet* et al. *2004; Grooth* et al. *2011, Giligny* et al. *2012; Baczkowski 2014*). If certain territorial rights were connected with the exploitation of flint, then this, in association with other cultural or social factors, could have generated migration to other areas rich in flint sources. Such a scenario may explain why some of the earliest agrarian sites in both Britain and South Scandinavia have been found near contemporary flint mines, which have been ^{14}C dated to the beginning of the 4th millennium BC (*e.g., Olausson* et al. *1980; Rudebeck 1986; Becker 1993; Barber* et al. *1999; Stevens, Fuller 2012; Sørensen 2012; Sørensen, Karg 2014*) (Fig. 19).

The Michelsberg Culture is also characterised by large hall buildings, enclosures and long barrows, which have not been found in the first centuries of the Early Neolithic from 4000 to 3800 cal BC in South Scandinavia (*e.g., Marolle 1989; Andersen 1997; Raetzel-Fabian 2009; Rzepecki 2011; Klassen 2014b; Sørensen 2014*). The lack of these monumental structures could be because it was more important for the first pioneering farmers to invest most of their time in clearing the forest for large areas suitable for arable farming. However, the first monumental long barrows and enclosures do appear in South Scandinavia in the consolidation phase during the following centuries, from 3800 to 3500 cal BC, thus showing that there was a continuous network exchange of people, ideas and knowledge either directly or indirectly with the Michelsberg Culture.

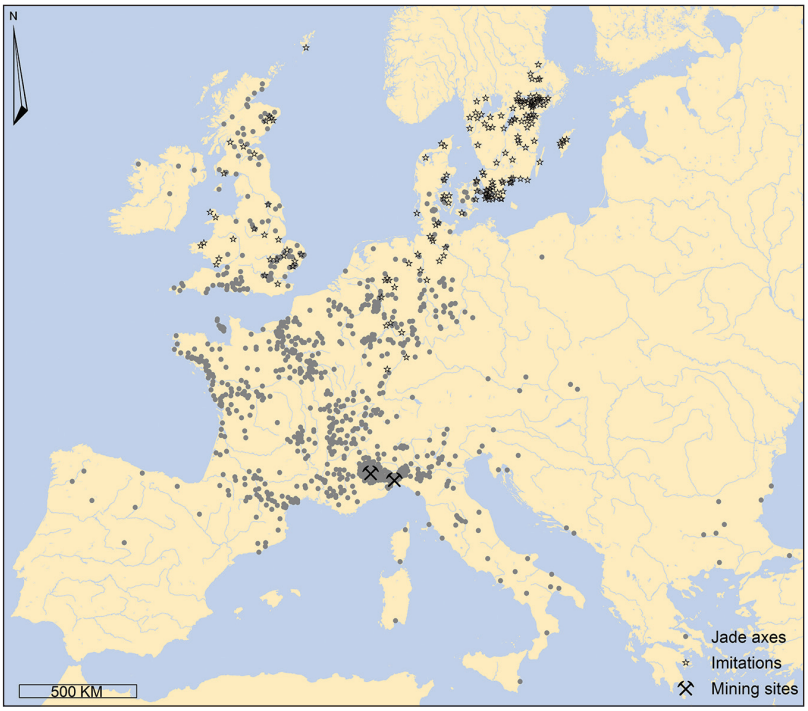


Fig. 18. Distribution of jade axes and imitations in Northern Europe (after* Sørensen 2014*).

Why did agrarian groups connected to the Michelsberg Culture migrate?

The reasons for the expansion of Michelsberg Culture have been interpreted as a combination of population pressure and climatic change to drier conditions, meaning that better environments for growing crops were located in the Northern European plains, thus explaining both the push and pull effects, as natural resources for agricultural activities were unexploited in South Scandinavia (*e.g., Leuschner* et al. *2002; Gronenborn 2007; Shennan 2009; Müller 2011*). The distribution of Michelsberg and Linearbandkeramik sites in Belgium shows interesting patterns (see *Vanmontfort* et al. *2008*). The Linearbandkeramik sites are clustered in areas with the best and thickest loess soils, whilst the Michelsberg settlement is concentrated in between and in former Linearbandkeramik areas, thus showing more widespread exploitation of the landscape from around 4400 cal BC (Fig. 20). Such a pattern may be explained by population growth or the emergence of new cultivation methods, which allowed people to exploit an increasing amount of land, including more marginal areas. This resulted in increased territorial demands, thus leading to the construction of causewayed enclosures from around 4400 cal BC, which may have served as structures of refuge in times of stress and conflict (*e.g., Christensen 2004; Gronenborn 2010*). Continuous conflicts in Michelsberg society over territorial rights and

the struggle for arable land could have served as a push effect, which may have led to the contemporary migration of pioneering farmers to the British Isles, Netherlands, northern Germany, northern Poland and South Scandinavia around 4000 cal BC (*e.g., Louwe Kooijmans 2007; Hartz* et al. *2007; Sheridan 2010; Rowley-Conwy 2011; Papiernik 2012; Sørensen, Karg 2014; Sørensen 2014*) (Fig. 21).

Concluding remarks

In this paper, it is argued that agriculture is a very complex technology which takes a long time to learn, making it very difficult for agrarian practices to spread as an idea. Instead, it is suggested that expansions of agrarian practices in Scandinavia were associated with migration. These migrants had the appropriate skills and the ability to teach the indigenous population about agriculture by establishing communities of practise, a fact which supports the theory of integrationism. Engagement in these communities of practise would have changed the identity and material culture of the immigrating farmers, as well as the indigenous hunter- gatherers, thus creating new agrarian societies.

The results presented in this paper suggest that the immigration of pioneering farmers from Central Europe to South Scandinavia began with a scouting phase during the centuries before 4000 cal BC. The scouts searched for suitable agrarian areas. The information retrieved from these scouting expeditions would have laid the foundations for where the pioneering societies should settle. The pioneering migrations began around 4000 cal BC, based on the appearance of a complete agrarian technology and a quick expansion of farming activities all the way up to Central Sweden. The pioneering agrarian societies established their colonies in areas where the density of the indigenous population was low, with an abundance of easily worked arable soil and access to flint sources, which is evidenced by the distribution of pointed-butted axes. The rapidity of the process changed the material culture, thus supporting the argument that both the immigrating farmers and the indigenous population were involved in creating agrarian societies in South Scandinavia. The engagement of the indigenous population in agrarian communities of practise could explain the swift change in the material culture, as well as the emergence of new depositional practices at habitation sites and in wetland areas during the early stages of the Funnel Beaker Culture.

These immigrating individuals brought with them know-how relating to agrarian technology, and a new material culture and ideology. The question of what happened to the local hunter-gatherers is still

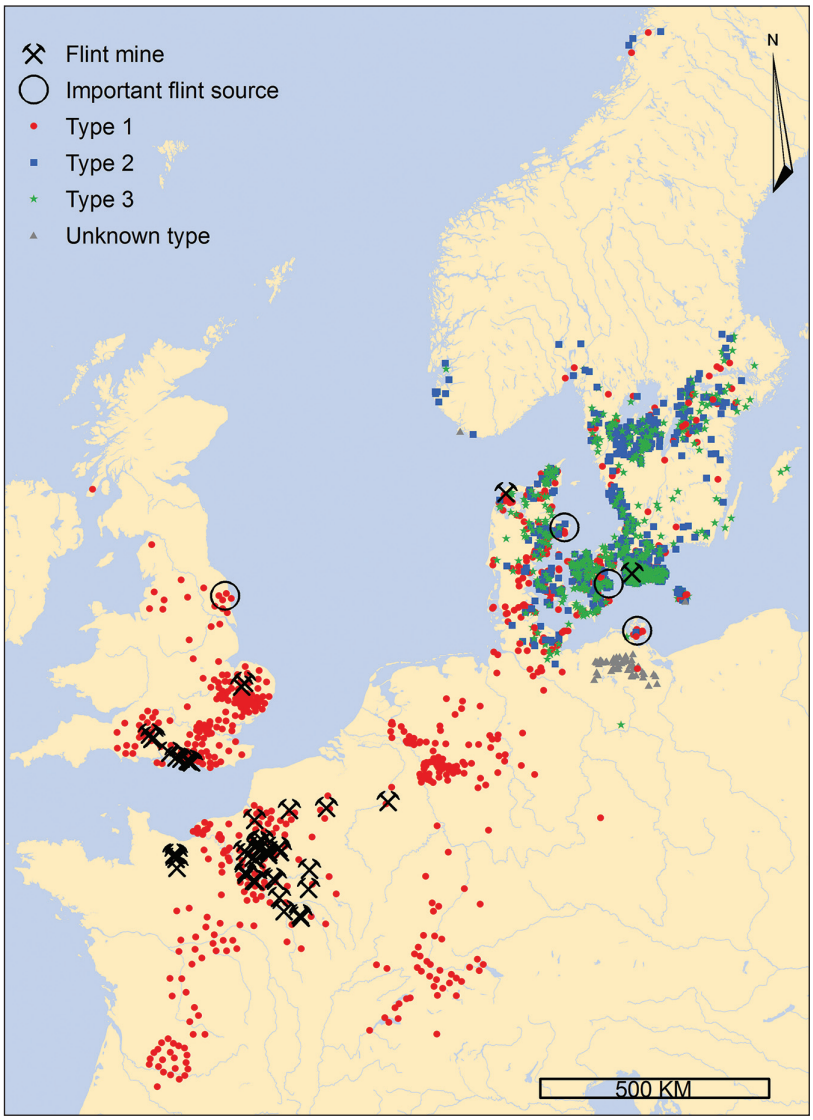


Fig. 19. Distribution of pointed-butted flint axes, flint mines and important flint resources in western Europe (after* Sørensen 2014*).

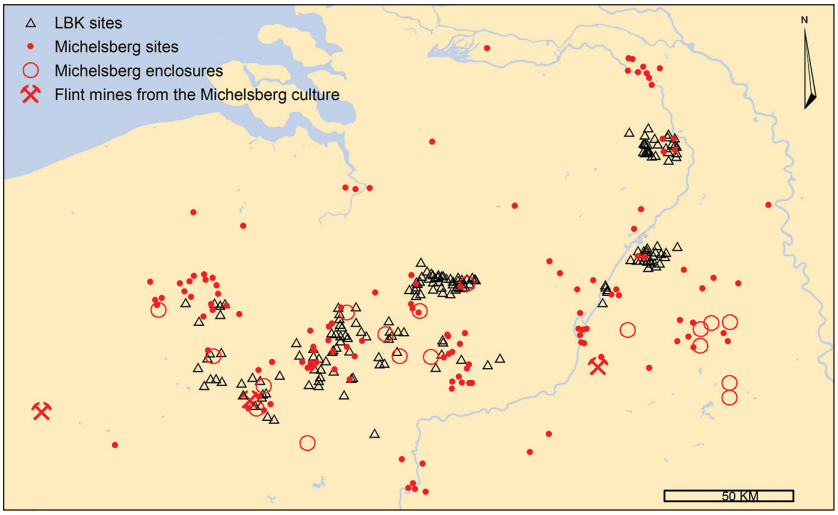


Fig. 20. Distribution of Linearbandkeramik Culture sites, and Michelsberg Culture sites, causewayed enclosures and flint mines (after* Vanmontfort *et al.* 2008*).

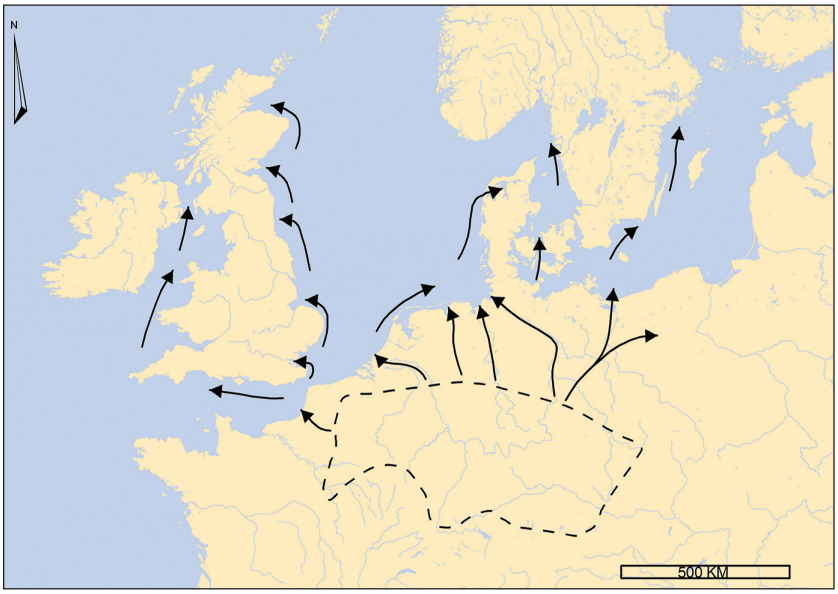


Fig. 21. The expansion of Michelsberg Culture to the British Isles and South Scandinavia around the transition between the late 5th and early 4th millennium BC (after* Sheridan 2010*).

open for discussion: perhaps they became farmers within one or two generations. This could explain the synchronism of inland and coastal sites, where both agrarian and natural food resources were exploited. Involvement in these communities of practise would not only change the material culture, but also the habitus, identity, ideology, symbolic behaviour and power relations of the participating immigrating farmers and the indigenous hunter-gatherers, and in the process, a new tribal agrarian society would evolve. A consolidation phase from 3800 to 3300 cal BC followed the pioneering phase, with the building of territorial markers such as long barrows and causewayed enclosures, which indicates continuous network exchange with Central European agrarian societies.

The immigrating farmers coming to South Scandinavia probably came from the Michelsberg Culture, or were connected with it, which is confirmed by similarities in the material culture, symbolic practices, types of site and monumental structures. The reasons for the expansion are still uncertain, but a combination of growing population pressure in the Middle Neolithic cultures of Central Europe, unfavourable climatic conditions and easily accessible flint resources may have motivated some farmers to move north. These groups of pioneering farmers migrated not only to South Scandinavia but also to the British Isles, the Netherlands, northern Germany and northern Poland during the centuries around 4000 cal BC.

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Keep on walking: the role of migration in Linearbandkeramik life

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ABSTRACT – *Migration played a central role throughout the LBK culture. After summarising the motivations for migration in the earliest LBK, the article outlines how some of these factors remained relevant in later phases. Beyond continued west- and eastward expansion, at regional and site levels migration to better one's social position provided an alternative to patrilineal land inheritance. The main change between the earliest and later phases is the role of material culture after migration events. Initially a means of creating long-distance connections, it later stressed difference from other groups. This process of ethnogenesis is invisible genetically. Overall, migration emerges as a salient behaviour even in 'sedentary' Neolithic societies.*

IZVLEČEK – *Migracije so imele osrednjo vlogo čez celotno obdobje kulture LTK. V članku povzemamo motivacije za migracije v času najzgodnejše LTK, nato pa se osredotočamo predvsem na načine, kako so nekateri motivacijski dejavniki ostali pomembni tudi v kasnejših fazah. Poleg stalne širitve od zahoda proti vzhodu predstavlja migracija zaradi izboljšanja osebnega družbenega statusa na regionalnem nivoju in na ravni najdišč pomembno alternativo patrilinearnemu dedovanju zemlje. Glavno razliko med zgodnimi in poznimi fazami kulture LTK vidimo v vlogi materialne kulture po migracijskih dogodkih. Sprva je bila materialna kultura sredstvo za ustvarjanje povezav na dolge razdalje, kasneje pa so se s pomočjo materialne kulture posebej izpostavile razlike med posameznimi skupinami. Ta proces etnogenete je neviden za genetske raziskave. Na splošno se migracije pojavijo kot glavni vzorci obnašanja tudi v 'sedentarnih' neolitskih skupnostih.*

KEY WORDS – *Linearbandkeramik (LBK); migration; aDNA; ethnogenesis; social status*

Introduction

As the first Neolithic culture over vast areas of central and western Europe (Fig. 1), the Linearbandkeramik (LBK) has long been in the spotlight. The question of its initial spread has been particularly controversially discussed, with opinion oscillating from population movement (*Childe 1929; Lüning 1988*) to indigenous adoption as the main driver (*Barker 2006.361–363; Whittle 1996.363–364*) and back again to a model of leapfrog colonisation, whereby small groups of colonists create isolated pioneer sites, inspiring locals to follow suit (*e.g., Anthony 1990.902–903; Gronenborn 1999*). In the last few years, archaeogenetic studies (*e.g., Brandt* et al. *2013; Haak* et al. *2012; Szécsényi-Nagy* et al. *2014*) have altered our perception yet again, indicating very strongly that LBK expansion was effected by large groups of colonisers, genetically very different from the European hunter-gatherer population, with whom they appear to have interbred surprisingly little.

Even though this scenario is now gaining more widespread acceptance, the role of group migration – *i.e.* a permanent shift of residence of a social unit larger than an individual – after initial colonisation events is still barely discussed. It is acknowledged that individuals could move, and that some covered longer distances. Based on isotopic studies, it seems that LBK women were more likely than men to have been born away from the place in which they were buried, a pattern interpreted as indicating patrilocality (*Hedges* et al. *2013.367–368*). In other cases, small temporarily mobile groups have been postu-

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lated, but have been seen as effectively tethered to, and based in, permanent settlements. For instance, non-local isotopic signatures reflecting the movement patterns of boys in their teens could be connected to longer periods spent away from settlements, perhaps for seasonal herding (*e.g., Bentley* et al. *2003*).

This paper argues that, in addition to these kinds of mobility (here defined as episodes of movement by groups or individuals which are ultimately centred on a fixed place of residence), migration had an important part to play in LBK society beyond the initial earliest LBK spread. Using selected ethnographic analogies to open a new perspective on the archaeological evidence, it is argued that migration events took place at various spatial scales throughout the duration of the LBK, and that this behaviour left profound traces in LBK worldviews.

Appreciating the role of continued migration events has several consequences. First, it highlights that alternative lifeways and possibilities of gaining status and renown existed in Neolithic societies. Our (generally quite rigid) social models should take into account the flexibility and tension resulting from this, as well as the likely regional and chronological oscillations in the importance of migration. Second, while archaeogenetic results have put the relationship between migration and ethnicity back on the agenda, we must appreciate that migration episodes which took place within the LBK area will be largely indistinguishable at a molecular level. Identifying ethnicity and other identity groups is thus largely an archaeological task, and they cannot be simplistically correlated with haplogroups or isotopic signatures. Finally, the continued importance of physical relocation in what we call Neolithic 'sedentary' societies must be appreciated anew. This involves developing a perspective that does not automatically equate any form of mobility or migration to a 'Mesolithic' heritage[1].

Background

Migration as an explanation for material culture patterns has had a patchy history in archaeological interpretation in general, fading in and out of fashion (*e.g., Anthony 1990; Burmeister 2000; Chapman, Hamerow 1997; Härke 1998*). In particular, the link between migration, past ethnic identity and the heuristic device of 'archaeological cultures' has been repeatedly questioned (most recently, *e.g., Hu 2013; Siegmund 2014; Sommer 2003*). This is not the place to repeat these arguments in detail, but as all these scholars have developed different agendas and approaches, a few words are necessary to situate the line taken in this paper.

Two broad themes emerge from the literature. On the one hand, the problem is how to identify migration archaeologically and distinguish it reliably from other processes (*e.g., Andresen 2004; Burmeister 2000*). In the end, this identification can only proceed contextually and in terms of greater or lesser probability (*Sommer 2003*). The second main strand is to understand migration as a cultural behaviour and to reconstruct how it is embedded in a given social formation. This broadly ties in with a wider 'mobility turn' in the social sciences, which has increasingly criticised 'sedentarist' assumptions of stability, centred on dwelling in a fixed place. Yet rather than just replacing this with narratives of an all-pervasive fluidity, the goal is to investigate the factors encou-

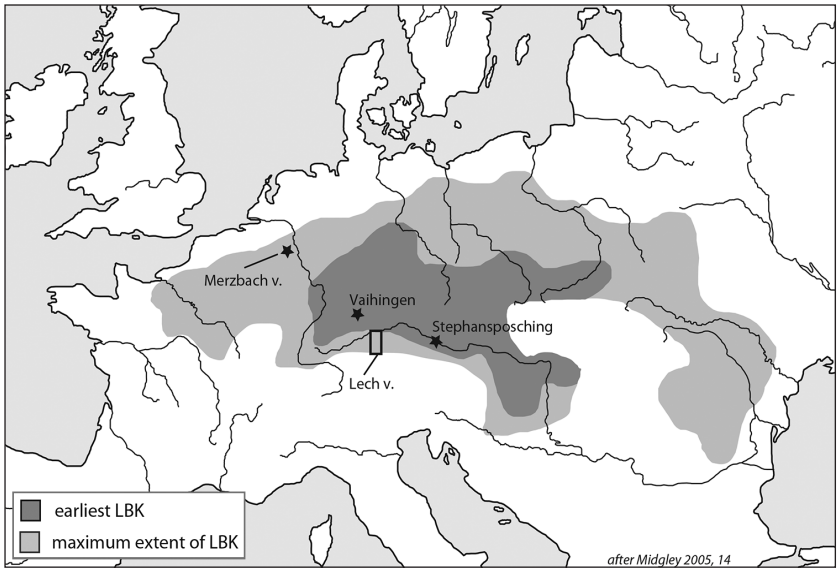


Fig. 1. Map of LBK distribution, showing main sites and areas mentioned in the text. Base map after Midgley (2005.14).

1 This is why the relations between LBK famers and Mesolithic hunter-gatherers, although an important research area that has seen considerable new information emerge recently (*e.g., Bollongino* et al. *2013*), are not the focus of the present article.

raging particular kinds of movements of people, goods and information, the ways societies deal with distance and travel, practices of creating 'home' in mobile contexts, the changing constitution of places and paths, and the varied access to, or exclusion from, the opportunity to move (*e.g., Hannam* et al. *2006; Kaufmann* et al. *2004; Urry 2007*).

In the LBK situation, evidence from ancient DNA has now established that in all likelihood, a large-scale migration did take place in conjunction with the appearance of LBK material culture (for discussion of the remaining uncertainties, see *Hofmann 2015*). It has also been shown that the new LBK-related genetic make-up, which is very different to known hunter-gatherer genomes dominated by U haplogroups, is closely related to Neolithic populations in Hungary (*Szécsényi-Nagy* et al. *2014*), confirming the source area previously suggested on archaeological grounds (*e.g., Bánffy 2004.353– 358*). The main problem is thus no longer how to identify migration, and this paper instead focuses on the second of the themes discussed above, which has so far hardly been tackled for the LBK. This includes the social mechanisms involved in migration events, both in terms of organising and carrying out a given migration episode, and in terms of the interactions and adjustments necessary at the new settlement location. It also covers processes of ethnogenesis, or the creation of new group identities partly connected to a shared origin or history, and what the role of material culture was in these circumstances. In these contexts, the continued importance of migration as a culturally valued behaviour may have had a longer-lasting impact than has previously been recognised, even though such movements within a shared LBK gene pool cannot yet be traced with aDNA[2].

A comparative perspective can be useful here and has been adopted for this paper. Although only few analogies have been selected, they have been chosen from societies which present similarities with at least some of the social constellations postulated for the LBK (*i.e.* inheritance of land in the male line and/or the importance of clans or lineages as units of decision making) and where these similarities are structurally related to aspects of migration. After briefly exploring the possible motivations behind the earliest LBK migration, the bulk of the paper discusses how these factors may have retained a longer-term relevance in later LBK phases, fuelling continued long-distance expansion as well as shorter-distance relocations of various social units.

The hows and whys of earliest LBK migration

For David W. Anthony (*1990.897–899*), trying to understand the causes of migrations is too challenging a question, as one would first have to establish at which social level (household, lineage, or larger group) factors promoting migration were actually operating. Causes are also likely to have been complex and multi-layered, and to have included both economic and ideological factors (see also *Burmeister 2000.543*). Yet, given that the LBK is a comparatively well-investigated archaeological culture, some suggestions can be made.

In general terms, people often migrate because their original homeland has become uninhabitable, for instance as a result of climatic deterioration and resulting food shortages; natural catastrophes; continued warfare and raiding; because of population increase squeezing the resource base; or a combination of these (*Anthony 1990.900; Burmeister 2000.543–544*). While examples can be found for the importance of all these factors, none of these suggestions seem to be the main factor in the LBK. Evidence of large-scale violence is a feature mainly of the end of the LBK (*e.g., Gronenborn 2006.17–20*), while efforts to link initial LBK expansion to climatic fluctuations (*e.g., Strien, Gronenborn 2005.136–139*) rely on rather uncertain correlations between climatic data and archaeological events, based on untenably early dates for the earliest LBK. Similarly, while the transition to a Neolithic way of life would almost certainly have caused population increase as the 'Neolithic demographic transition' took hold (*Bocquet-Appel 2008*), site density in the earliest LBK is thin on the ground in putative areas of origin, so that this is unlikely as the only explanation (*e.g., Bánffy 2004. 388; Kalicz 2010.249*). This is not to say that long-distance migration, even at an early date, would not have helped to buffer risks (*Bogucki 1988.93–128*). Yet, even if factors like climatic deterioration, population increase and (perceived) land shortages did play some part in migration events, they are unlikely to provide the full picture, particularly as they cannot explain the very large

2 As whole ancient genomes can now be retrieved (*e.g., Gamba* et al. *2014; Mathieson* et al. *2015*), it is possible to identify close biological relatives. However, given the nature of the archaeological resource and the likely extent of sample coverage that can be achieved, the chances of finding close relatives on sites far apart from each other, thereby directly tracing migration routes, are very remote indeed.

distances covered from the word go, or why settlement needed to be quite so thin. In the search for alternative possibilities, it is worth considering explanations which take into account the particular social conditions prevailing in the LBK and the way settlement communities, households and individuals may have tried to act within them.

Prestige-driven migration

Several researchers have pointed out the considerable risks, necessary resources and logistical challenges of migration, in particular as the earliest LBK settlements were often located far from their parent sites and each other, and hence from any immediate support network (*e.g., Van de Velde 2008; Zimmermann* et al. *2005*). To begin with, suitable sites would have to be scouted for, generally in territories occupied by hunter-gatherers. Once a spot had been chosen, surplus food for the journey and for surviving the initial weeks at the new settlement would have to be accumulated, alongside enough seed corn and viable herds of domesticates (*e.g., Zimmermann* et al. *2005.4–6*). Especially the latter may have taken some time, as in prehistoric conditions the growth of cattle herds in particular is thought to have been slow (*Ebersbach 2002.143–144, 161*). In sum, a colonisation venture certainly did not come cheap and would have needed sponsors. Debts or obligations were undoubtedly called in and new ones created. The investment was so high that migration has been seen as the main vehicle of status competition in an otherwise rather undifferentiated earliest LBK context: in the absence of lavish graves or elaborate architecture, it seems any surplus at hand was used to found distant daughter settlements (*Frirdich 2005.99–103*).

A successful colonisation, in turn, would have resulted in considerable renown. This may have provided a strong motivation, particularly for those excluded from large inheritances, for instance by birth order. The colonisations of the Pacific, initially by Lapita groups and then reaching even the remotest islands of eastern Polynesia in the first millennium AD, provide interesting parallels here. In the Lapita context, it is believed that the younger sons of chiefs and leaders, for whom there was little opportunity for wealth and glory at home, were instrumental in attracting followers and resources to drive forward the high-risk discovery and colonisation of new islands (*Spriggs 2016.486–487*). The benefit to them was obvious: rather than remain in a subordinate position at home, they could become the founders of new lineages elsewhere, as also recorded for the later east Polynesian cases (*Richards 2009*), while their departure certainly also helped to protect more senior members from discontent and intrigue.

Alongside this political dimension, migration was intimately bound up with people's identity, both in their personal quest for greater standing and in terms of their worldview. The colonisation of new islands formed a large part of Pacific heroic mythology and group founding myths, so that by re-creating these journeys the travellers were perpetuating a fundamental aspect of their value system (*Richards 2009; 2010*). The main point here is to appreciate the heady mix of pragmatic choice, personal opportunity and embeddedness in myth and history which characterised these ventures. Being so deeply engrained in the cultural fabric, colonisation formed a core value of Pacific societies at this time.

There are of course differences between this situation and the LBK, if only because the colonisation of uninhabited islands did not require interaction with prior inhabitants. Nevertheless, the models of patrilocality and lineage inheritance recently invoked for the LBK (*Bogaard* et al. *2011; Hedges* et al. *2013*, and see below) make it plausible or even likely that similar structural conditions promoting the migration of younger siblings were at work.

How long any daughter settlements, once established, would retain ties with their origin sites is an interesting topic for further research, as is the subsequent development of these sites. If it was important to cover large distances, then the earliest LBK sites close to one another, or even households on the same site, may have been founded by rival lineages or clans, eager to flaunt their successes to each other (*Frirdich 2005.105*). In this model, related households or sites would have established lines of solidarity across the landscape, with their closest allegiance to people far away. In contrast, Jörg Petrasch (*2003.510–511*) suggests that sites established early in the LBK sequence often developed into central places later on, forming a core around which smaller, perhaps dependent hamlets clustered, as has also been suggested for Austria (*e.g., Pieler 2012.212–213*). In this scenario, first arrivals in a new area would take on a leading role, forming what Anthony (*1990.904*) has termed 'apex families' to whom later newcomers owed deference. This would result in a pattern of clusters of closely linked sites, some of which may have stood out through particularly lavish material culture or buildings (Fig. 2).

This has, for instance, been suggested for Nieder-Mörlen, an early LBK foundation in Hesse with traces of a possible ritual building (*Lüning 2009.130–136*), an impressive spectrum of figurines and other unusual artefacts, and pottery denoting long-distance ties (*Schade-Lindig 2002; Schade-Lindig, Schade 2010*). These alternatives – clusters versus chains of related sites – could be tested further in the future, and indeed elements of both scenarios could have coexisted. Here, I would like to focus on how this kind of prestige-driven migration would have influenced further events. New regions were colonised and new settlements established. And then what?

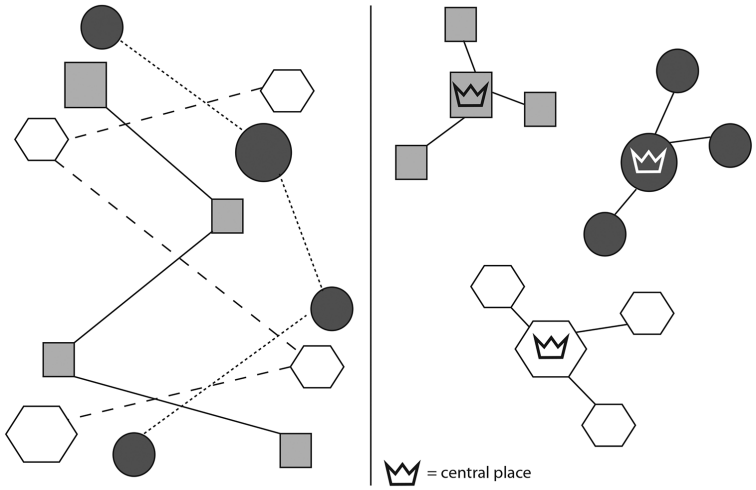


Fig. 2. Schematic representation of the two models of earliest LBK settlement. Different shapes represent different lineages or clans. Left: Frirdich's model of linear solidarity; right: Petrasch's model of settlement clusters.

What happens next

Scenario 1: we like it here

There is still comparatively little debate surrounding the transition between the earliest LBK, during which initial large-scale migration took place, and the following LBK phases. Probably the most influential model is that developed by Christiane Frirdich (*2003.546–547*). She suggests that with increasing settlement density, migration became a less viable option[3]. Elders, who had previously sponsored migration events for younger generations and used this as the basis for social control, now lost their authority, as their promises could no longer be fulfilled. New ways of expressing prestige and social distinction had to be developed, and various avenues were tried out, including larger and architecturally more complex buildings and the deposition of wealth as grave goods in newly established cemeteries. For Ulrike Sommer (*2001*), too, the diversification of later LBK material culture is the result of a reduction in group migration events, after which material culture signalled belonging not at the culture-wide, but at the settlement and household level. A similar pattern of increasing regionalisation has also been recognised in other case studies of migration, for instance in the Pacific (*Spriggs 2013*).

There is much to commend this view. Although variations exist in earliest LBK material culture (*Lenneis 2005; Strien 2009*), the later LBK represents a step-change in diversity in almost all areas of life. This happens at the same time as the landscape is progressively infilled, with site density increasing considerably in all regions.

The pervasive idea, then, is that once LBK groups reached a new location, they would settle and remain there, making the best of where they were. However, with increasing population density, the best would soon have turned sour. By the latest LBK, several regions, notably along the Rhine and in Hessen, may have seen a catastrophic collapse of some sort (*e.g., Schade 2004.221–223; Zimmermann* et al. *2005.33*). It is still debated whether the reasons for this were primarily environmental (*e.g., Strien, Gronenborn 2005*) or social (*Zeeb-Lanz 2009*), but in either case it is implied that increasing territoriality, limiting access to land and resulting in exclusive definitions of identity, played a crucial role.

The importance of land inheritance may also be indicated by isotopic evidence. As Robert Hedges *et alii* (*2013.367–369*) have shown, there is an association between local isotopic signatures and males buried with polished stone adzes. This means that where an individual grew up had an impact on treatment at the time of death, a pattern which can plausibly be read as implying inheritance down the male line (*Bentley* et al. *2012; Hedges* et al. *2013*). That this inheritance involved land has been argued on the basis of evidence from Vaihingen, an LBK settlement in south-west Germany (Fig. 3). Here, as elsewhere,

3 This could also be related to a strong hunter-gatherer presence and/or a lack of appropriate soils and climatic conditions, limiting further expansion in certain directions (*e.g., Lüning* et al. *1989; Hartz* et al. *2007.570; Thomas 1996*).

households and groups of households defined on the basis of material culture preferences tended to rebuild their houses in the same area of the site. In addition, detailed archaeobotanical studies have shown that some groups invested far more time in tending their crops than others. Looking at the weed assemblage, Amy Bogaard *et alii* (*2011*) identified neighbourhoods where inhabitants manured and weeded their crops, while others did not. This has been interpreted as high status groups having laid claim to the parcels of land closest to the site, while others had to make do with plots further away, which could not be tended as carefully. As a result, it is argued, those lower status groups eventually left the site (*Bogaard* et al. *2011*), although this particular causal relationship is only one of several possibilities (see below).

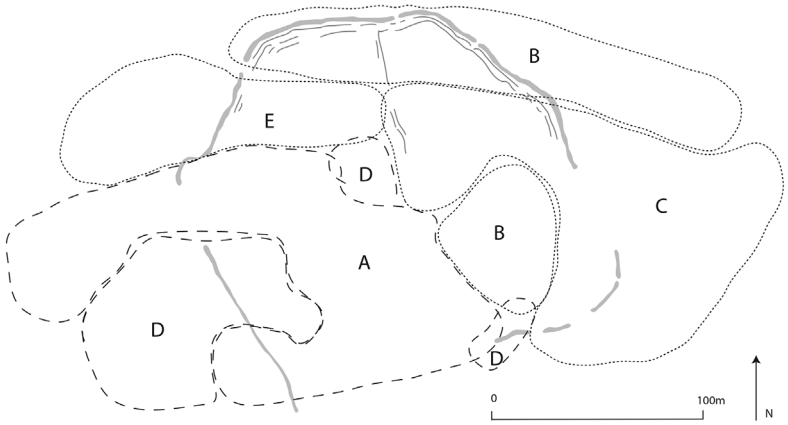


Fig. 3. Schematic outline of Vaihingen, showing the enclosure (gray) and the location of different 'clan groups' (A–E) defined on the basis of material culture preferences and economic choices. Dashed line: groups of the Middle Neckar tradition (who remain at Vaihingen); dotted line: groups of the Unterland-Kraichgau tradition (who eventually move away). Data after Bogaard et alii (2011) and Strien (2005).

In short, after the earliest LBK, effort was invested in putting down roots, and there is evidence for the importance of a person's origin and its link to land inheritance. Yet the question remains whether this behavioural pattern replaced migration quite so wholesale. Here, following Anthony (*1997.29*), I suggest that migration as a behaviour so strongly connected to status and prestige, and so bound up with group identity, did survive, albeit not unchanged. This could also help us to re-think some of the social models suggested for the LBK.

Scenario 2: the grass is greener on the other side

The evidence for the importance of genealogical ties in the LBK is convincing, but there has been an unhelpful tendency to see its link with land as the only means of obtaining social position. Yet things are rarely as clear-cut as that, and in day-to-day life the benefits and obligations derived from ties of descent from (male) ancestors would have to be balanced against other relationships, such as those structuring co-residence. Similarly, the standing of a household in relation to others could have been open to negotiation, shifting allegiances and political power plays.

For instance, in the Amazonian villages studied by Kaj Århem (*2001*), descent from known ancestors is an arena for status competition, particularly between men. This aspect is drawn upon in initiation rituals, but also in the daily consumption of valued items such as coca and snuff. Yet it coexists with practices centred on the sharing of food and drink between co-residents and across the village, again on both daily and ritual occasions. Here, status differences between individuals are denied and common identity is stressed through commensality, although people do keep an eye on whether everyone contributes as much as they can. In both spheres, then, there is potential for dissonance and conflict. In a case such as this, status and renown could be achieved in several ways. On the one hand, through contributing resources, dissipating tensions and stressing conviviality, a community of many residents could be held together, creating a site of some renown. However, if hierarchies within the group became unbearable or were overplayed, people in junior positions within the lineage could improve their lot by convincing others to form a breakaway settlement elsewhere, one in which their status would be increased. This kind of village fission is regularly observed ethnographically (*e.g.,* also *Bandy 2004; Barrier, Horsley 2014; Metcalf 2010.252*). In such a case, archaeologically, we would expect to see communities of varying duration, whereby longer-lasting ones could fluctuate in size over time.

Migration does not only happen when relations break down. In the Hopi Pueblos of the American Southwest, clans defined themselves by the chain of prior migrations in which they had been involved, generally relocating every two or three generations. In a given settlement, people with very different

histories would thus live side by side, but these were never planned as long-lived communities (*Bernardini 2005.7–8, 30*). In the 15th century AD, villages in this arid region could reach impressive sizes and a greater degree of permanence, but nevertheless most shifted every few generations (*Fowles 2001*). Pragmatic reasons, such as soil exhaustion or resistance to Spanish colonisation, can be cited. However, to reduce Pueblo migration to these push factors alone misses an important aspect, namely the way migration was strongly interwoven in Hopi cultural values to the extent that it was considered a fundamental aspect of group identity. In the several decades in which a given Pueblo was settled, the importance of migration remained present through ritual dances, in myths and stories, and through the initiation rites of young men, who were sent to faraway locations, returning with exotic goods and knowledge of the wider landscape (*Fowles 2001.49–52*). Moving on was not a failure, but the normal course of existence, to the extent that the Hopi have been characterised as 'urbanized nomads' (*Fox 1967.24*), or as engaged in serial migration (*Bernardini 2005.7–8*). Simply because groups spent a few generations in one place does not mean that migration as a behaviour had become unimportant to them.

These case studies show that societies could exist in various 'modes' – stressing one or the other aspect of relationships, or being more or less settled at a given point in time. This presents people with alternative strategies that could be variously drawn upon. At a general level, migration, and the recombination of social groups in that process, thus remains an option even in many societies generally classified as sedentary, and these decisions were often taken at the level of clans, lineages or households. With these possibilities in mind, it is time to return to the evidence for continued migration in later LBK phases.

Continued migration in the LBK

In this section, I outline the role of migration events in later LBK phases, looking at three exemplary, but almost certainly not exhaustive, settings. The first is continued migration beyond established LBK settlement areas. This is archaeologically the most obvious, but may have been a viable choice particularly in those areas close to the shifting margins of the LBK. The second is shorter-distance migration within or at the edge of established LBK settlement regions, founding new sites and 'filling in' the landscape. This choice was most likely viable throughout the LBK distribution for several generations, although it was not universally taken up, remaining only one among several possible strategies. Finally, echoes of the migration process may also be visible in other cultural practices, such as house renewal, which were performed on virtually all LBK sites over the entire duration of this culture.

Moving west: more colonisation

While site density in areas already settled in the earliest LBK continued to increase, migration also continued to the east into what is now Romania, Moldova and Ukraine (*e.g., Dębiec, Saile 2015; Kotova 2003; Larina 2009*)[4], as well as westwards across the Rhine. LBK groups reached the Paris Basin probably by the end of the sixth millennium, and Normandy soon after (*Billard* et al. *2014.337–338*). Yet what is notable is the changing role of material culture in this process. Earliest LBK material was similar over large distances, ostensibly to create a network of solidarity between widely spaced sites. In contrast, the newly established communities further west emerged at a time when this initial unity had begun to fragment, and they drove that process of diversification further. Thus, while the Paris Basin LBK can broadly be considered part of the Rubané du Nord-Ouest group (*e.g., Lefranc 2007.27*), there are also local peculiarities in pottery design and in burial customs, which are limited to settlement burials and focused on the provision of shell jewellery and ochre (*Constantin* et al. *2003; Hofmann, Bickle 2011; Jeunesse 2009*).

One way to interpret these differences has been to stress the greater likelihood of hunter-gatherer involvement in these western areas, introducing behaviours which transcended or challenged LBK norms (*e.g., Jeunesse 2009*). However, an alternative explanation is possible. At least in certain cases, emerging regional pottery groups within the LBK correlate with other aspects of material culture and behaviour and have been interpreted as ethnic boundaries (*e.g., Pechtl 2016*). People may have chosen to define a group identity based on shared ancestry, or on a shared origin and history, and to express this by distinguishing themselves from their neighbours. The stylistic innovations found in the Paris Basin could be part of such a process of ethnogenesis. For colonists perhaps drawn from several parent communities or lineages, material culture which resem-

4 These areas will not be treated in greater depth here, as large-scale excavations are still rare.

bled no one existing tradition too closely would have been well suited to signal a new social formation, while the migration movement itself could have provided a shared experience as the basis for a new group identity[5].

Overall, then, the link between an end to migration and the diversification of material culture, as suggested by Frirdich (*2003*) and others, is only part of the story. As long as the LBK lasted, migration never really stopped entirely. What appears to have altered is how groups saw their allegiance once migration was over, and the role material culture played in these transformations. In the earliest LBK, widespread similarity in all aspects of material culture ensured that people could find their way around whichever community they were currently in, creating a far-flung, island-like pattern of similar sites where people made similar choices. By the late LBK, this unity had disappeared, and migration may have been one more means by which to differentiate oneself from others at the group level.

In future, it will be interesting to think further about whether these changing aftermaths of migration, from similarity to differentiation, went hand in hand with a changing organisational backdrop. For instance, are we witnessing a shift from migrations sponsored by elders to migrations of discontent? And what does this say about the role of lineages or clans, as opposed to territorially defined groups? For now, I would like to turn to evidence that even away from the LBK's ever-shifting western and eastern frontiers, migration remained a viable choice.

Moving around, not necessarily far

The continued importance of migration even within established LBK settlement regions goes well beyond seasonal rounds of mobility or one-off residential changes by individuals. Households or larger sections of communities could also take the decision to relocate. We have already encountered the idea that at Vaihingen, disadvantaged social groups were pushed out of a settlement in which they were only ever accorded marginal lands. However, seen from a perspective in which migration may not be equivalent to failure, and bearing the example of the Hopi Pueblos in mind, one could also develop another explanation. The suggested neighbourhoods or clan groups are not only distinct from each other in terms of weed assemblages, but also concerning the animal bone spectrum. According to archaeozoological evidence (*Schäfer, Arbogast forthcoming*) and isotopic measurements on cattle teeth (*Knipper forthcoming*), cattle dominate across the site, but the households which invested more time in maintaining their plots grazed their animals in uplands and river valleys, and also kept comparatively more pigs, probably closer to home. In contrast, groups with less well maintained plots in turn grazed their animals on loess and kept more of the potentially more mobile sheep and goats. This fits with the existing evidence for diversity in economic choices within LBK communities (*e.g., Hachem 2000; 2011*). As

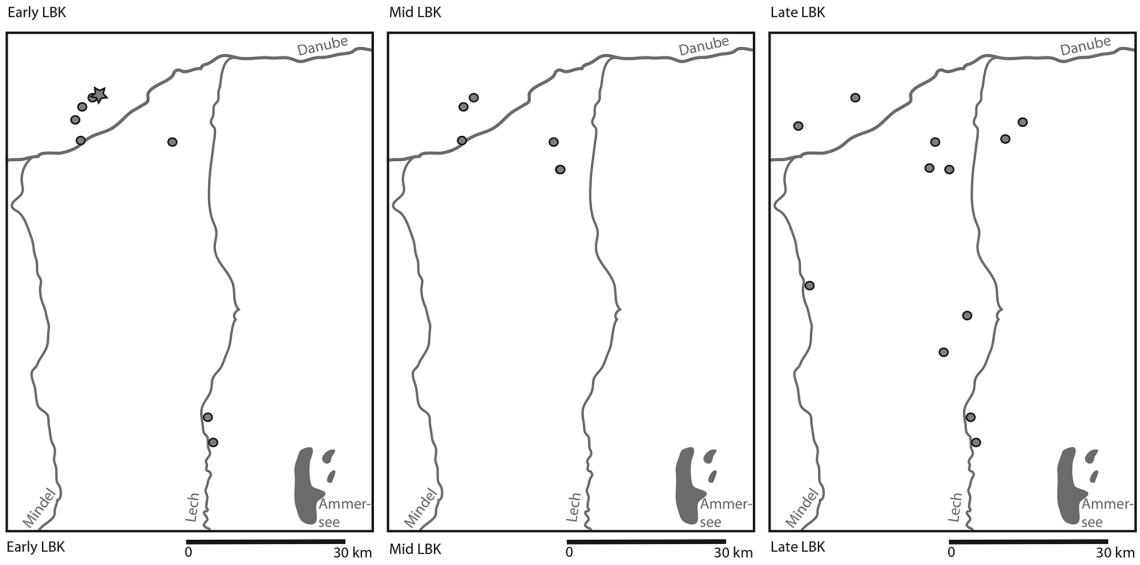


Fig. 4. Phases of colonisation of the Lech valley. Only dated LBK sites are shown. The star symbol denotes the only site also settled in the earliest LBK. After Pechtl (*2011.Fig. 2*).

5 This is not to deny that foragers could have participated in these events. However, as the observed material culture changes are very strongly rooted in the LBK, forager involvement is unlikely to be the sole, or indeed the main, mechanism active here.

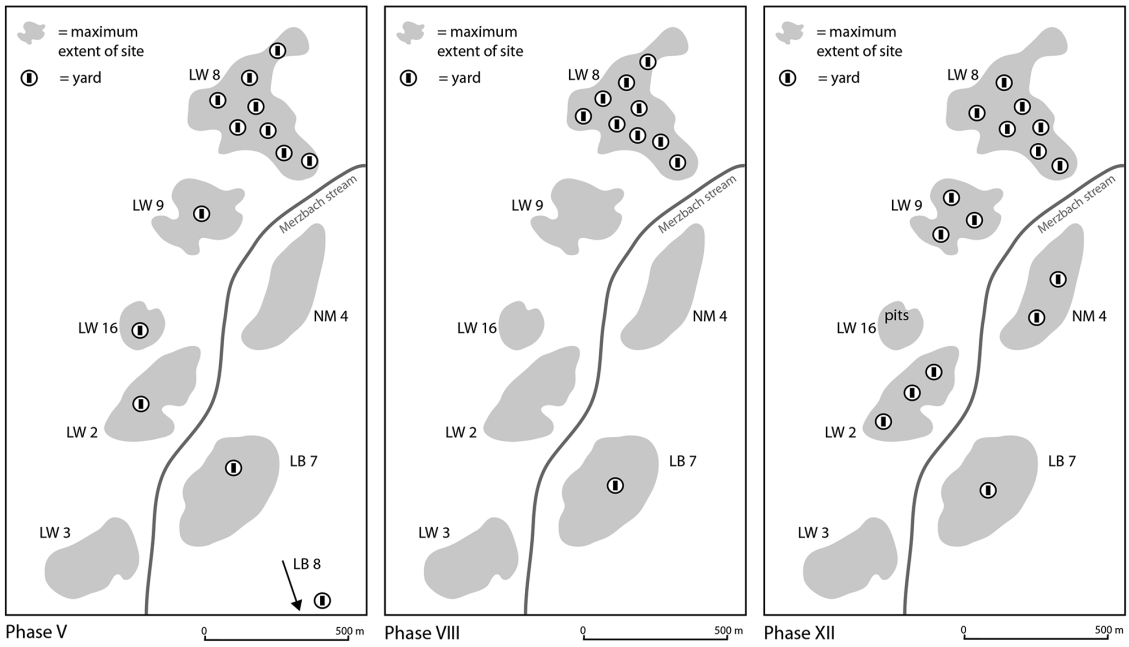


Fig. 5. Number of yards on sites in the middle Merzbach valley in phases V, VIII and XII. Location of sites within yards is schematic only and does not correspond to their real position.* LW *Langweiler;* LB *Laurenzberg;* NM *Niedermerz. After data and base map in Stehli (*1994*), with corrections by Münch (*2009*).

wealth on the hoof, cattle in particular could have provided an alternative way to gain social standing (*e.g., Parker Pearson 2000; Russell 1998; Whittle 2003.80*), meaning that status need not relate exclusively to controlling agricultural land.

This importance accorded to cattle keeping, in conjunction with a less important role for pigs, could have enabled households to remain more mobile in the medium and longer term. Settling in any one place for longer than a few generations and investing in enduring plots may simply not have been high on the agenda for these groups. Instead, they kept different choices open and remained able to react to promising opportunities pulling them along a new path. In this case, community fissioning every few generations could have been the rule rather than the exception.

Indeed, looking closer at situations with detailed evidence for settlement sequences, there is a lot of fluctuation in settlement biographies. Frequently, it appears that people took the first possible opportunity to move into a new area. For instance, in his detailed study of settlement patterns in the Lech valley, south of the Danube in western Bavaria, Joachim Pechtl (*2011*) has shown that sites were repeatedly established closer to the Alpine foreland in periods of favourable climatic conditions, and abandoned when they became untenable (Fig. 4). It is tempting to see the origins of these Lech valley settlers in one of the larger sites with early foundation dates along the Danube, although this will need to be verified by further directed study[6]. Irrespective of their origin points, these people clearly were strongly motivated to establish new sites, rather than expanding existing ones.

The Merzbach valley in the Rhineland provides another example and is particularly interesting because several adjacent sites could be fully excavated, giving a picture at the level of the settlement cell. The definition of phases (or 'house generations') has been criticised in its details and in the rigidity of its application (*e.g., Rück 2009; Schwerdtner 2007*), but broad patterns are reliable. One can observe probable expansion out of the founding settlement, Langweiler 8, in some phases (Tab. 1; Fig. 5; *Stehli 1994*), when sites in the immediate vicinity were established, but Langweiler 8 remained the same size.

However, in phase VIII, most of the smaller sites are again abandoned, and there are gaps at individual sites during other phases. Where these households moved to is another question, but continued migration beyond the Merzbach valley is a likely scenario. Population peaks in later phases are also largely reached, because the smaller sites, rather than Lang-

6 A project led by Joachim Pechtl is in progress.

weiler 8, are growing. Interestingly, while Langweiler 9 had initially shown strong links to Langweiler 8 in pottery decoration, this is no longer the case after the phase VIII hiatus (*Frirdich 1994.356*). If pottery decoration is a reliable indicator for close connections at the household and lineage level (and this is admittedly a big 'if'), then this would suggest that the re-settlement of Langweiler 9 was not undertaken by the same social group that first established the site, further stressing the degree of fluidity in settlement choice.

Phase	LW 8	LW 9	LW 16	LW 2	LW 3	LB 7	LB 8	NM 4	Total
I	4								4
II	7		1			1			9
III	7	1	1	1		1			11
IV	7	1	1	1		1	1		12
V	8	1	1	1			1		12
VI	8	1	1				1		11
VII	9	2		1			1		13
VIII	9					1			10
IX	7	1		3		1			12
X	7	3	P	3		1			14
XI	7	3		2		1		2	15
XII	7	3	P	3		1		2	16
XIII	6	E		3		1		2	12
XIV	4, E	E?/P		2	E?/P			2	8
XV		P			E				

Tab. 1. Number of yards in use at settlements in the middle Merzbach valley.* E *enclosure;* P *pits only;* LW *Langweiler;* LB *Laurenzberg;* NM *Niedermerz,* AL *Aldenhoven. After data in Stehli (*1994*), with corrections by Münch (*2009*).

Fluctuation can also be traced in settlement sequences on individual yards. The partially excavated settlement of Stephansposching (Lower Bavaria) has been tentatively divided into ten settlement phases, using a combination of ceramic sequencing and house overlaps (*Pechtl 2009.502–504*). After an initial three generations in which the number of yards increases quickly, there is a period of stability between phases IV and VII, followed by relatively rapid decline (Fig. 6). However, a more detailed look at individual phases reveals an undercurrent of fluctuation even in some of the 'stable' phases, as some yards are abandoned while others are established anew. Several caveats remain, particularly the fact that the site is incompletely excavated and the phasing method used tends to overestimate house numbers in the middle phases, while underestimating them at the start and end (*Pechtl 2009.492*). Nevertheless, it is clear that there was a certain level of coming and going, in which some households were attracted to Stephansposching, while others preferred to move on.

Certainly, then, there was enough flexibility in any system of land tenure to allow for the departure of households, and perhaps even for their re-integration elsewhere, especially if there were lineage or other pre-existing connections. This is now visible in several regions of LBK settlement, and is likely to become more evident as detailed site narratives increase[7]. Yet in all these cases, it seems that several generations of settling in one place separated instances of migration of greater or smaller parts of the population. On the one hand, this indicates that abandonment of a given site (much like establishment) was sometimes a phased process of some duration, with the decision to leave taken by small groups of households. On the other hand, it begs the question of whether, as in the Hopi case above, we can identify mechanisms which would have acted to keep migration salient as a valued cultural choice, even over longer episodes in which a given social group stayed put.

Memories of migration

The re-creation of ancestral journeys in ritual and myth could be a mechanism here, as it is for the Hopi (*Fowles 2012.53*). Yet while long-term absences by youngsters could potentially be tracked isotopically, in detail it remains difficult to differentiate between scenarios such as herding, stays with foster families or as migrant labour, or indeed long-distance exploratory journeys (*e.g., Gronenborn 2010. 566–567; Knipper 2011.348*).

A more ubiquitous and longer-lasting practice is the rebuilding of LBK houses in every new generation. Longhouses could technically have been used for many decades (*Lenneis, Trebsche 2013; Schmidt* et al. *2005*), but this suggestion has not yet been backed up by a plausible phasing framework. The ebb and flow of houses, and in some cases the over-

7 Also, there is a trend to assign houses undated by pottery to phases in such a way that gaps in the overall settlement sequence are minimised (*e.g., Boelicke* et al. *1988.900–901; Pechtl 2009.496*). As such, fluctuations in house numbers are very likely underestimated.

lapping of house plans on more densely settled sites, suggest instead that that the model of generational replacement, while perhaps sometimes too rigidly applied, holds true in general. This means that people frequently rebuilt their longhouses not because these had become structurally unsound, but for social reasons. In this context, the resources and labour that needed to be invested in a new longhouse were vehicles for displaying wealth and connections, competing for status in a potentially fluid social situation (*e.g., Hofmann 2012; 2013*). Yet in addition, and to further bolster status claims, re-establishing a house, even if just some tens of metres away, can also be read as a re-creation of the group's first settlement at a given site, most likely hedged about with origin myths or heroic tales.

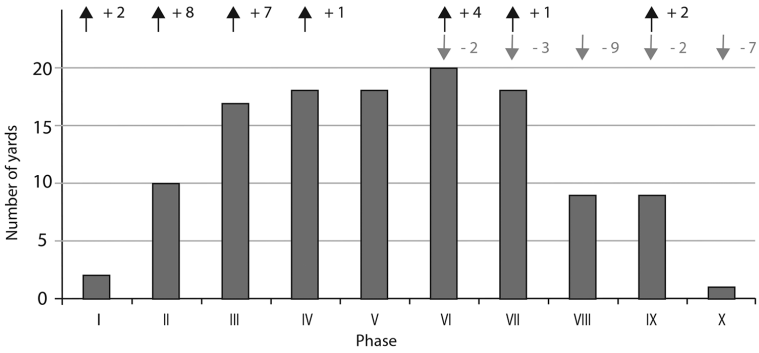


Fig. 6. Fluctuation of settlement size at Stephansposching. For each phase, arrows pointing up show the number of new yards established; arrows pointing down show the number of yards abandoned. Generated from data in Pechtl (*2009.502–504*).

Most interesting in this respect are the so-called 'founding buildings' now excavated at several western LBK sites, particularly in Belgium. Here, the chronologically earliest house to be identified, generally a quite substantial building, did not form the origin of a later yard, *i.e.* of an area in which houses were replaced in following generations. Instead, this building remained isolated, and later dwellings, this time grouped into several yards, were established some distance away: within the enclosure at Darion, or 50 to 130m away at Fexhe and Remicourt, for example (*Bosquet, Golitko 2012; Bosquet* et al. *1998*). Occasionally, founding buildings are associated with peculiarities in material culture such as non-LBK ceramics (Limburg and other traditions) at Fexhe (*Bosquet, Golitko 2012. 94*). These sorts of buildings, then, could have formed a kind of collective origin point for the whole community, a visible reminder of the migration of the founders to a new site, re-created in a small way by all successive house-building generations. Yet even where such 'founding buildings' do not exist, new houses seemingly referenced earlier structures. As Jens Lüning (*2005*) has argued, this happened either by forming lines of successive buildings ('father principle'), or by referencing their predecessor's predecessor ('grandfather principle'; Fig. 7). In either case, there was evidently a desire to express one's connection to a genealogical line, even while re-locating the longhouse.

Although these suggestions remain speculative, they outline how migration could have remained a salient and actively performed cultural behaviour even in longer periods in which there was no larger-scale or longer-distance migration at all. While commemorating and re-enacting migration was very likely not the only function these practices fulfilled, tying migration to behaviours which were also socially relevant in other ways, such as status competition, reaffirmed it as a valued cultural choice, experienced at the personal scale of household and community politics.

Conclusions and outlook

In sum, there are indications that LBK society witnessed group migration even beyond the earliest phases. At a macroscale, the continued importance of colonisation remains undisputed. Taking this as a starting point, this paper has shown ways in which such large-scale undertakings were embedded in the LBK cultural fabric as a whole by being performed and re-created as viable cultural choices at the level

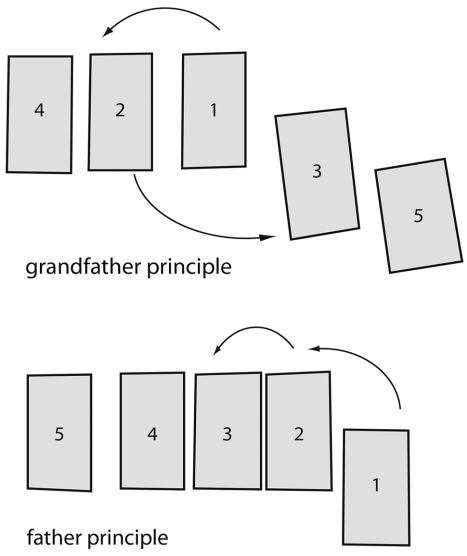


Fig. 7. Alternative modes of house replacement on LBK yards. After Lüning (*2005.Figs. 59–60*).

of communities, households and individuals. The decision to move could be taken at several levels, from groups of yards at Vaihingen and along the Lech to sometimes single households at Stephansposching. Migration was most likely connected to a hope for better opportunities elsewhere, as well as to a group's sense of a shared way of life. It could have functioned as a counter-balance to a social logic of patrilocality and land inheritance, so far stressed in most archaeological accounts, and may have been backed by economic choices enabling a greater degree of mobility and group migration. In this way, according a key role to migration suggests new, plausible connections between many different spheres of life, involving economic choices, status display and even founding myths. It is at these levels that the foundations for longer-range colonisation ventures were laid. The changing character of these migrations, in terms of possible motivations, the decision-making groups involved and the relationship to (ethnic) identity, must be investigated further in the future.

Migration was not of course the only possible option. Indeed, the basic make-up of LBK social structure seems to have been sufficiently flexible to accommodate a wide range of settlement patterns. In some instances, mechanisms to reduce community fissioning were apparently found, creating sites with greater settlement densities. For instance, preliminary research at Vráble-Vel'ké Lehemby suggests that models of settlement organisation changed over time, and that a large community of several tens of contemporary houses could have existed in some phases (*Furholt* et al. *2014.250–254*). Similarly, it has been suggested that the limited opportunities for migration in the Alföld LBK led to alternative strategies, notably the faster establishment of social stratification (*Domboróczki 2009.122–123*).

Whether migration was considered a viable choice would hence have differed depending on where and when one asked this question. This is also the case for the consequences of migration. In the earliest LBK, it resulted in long-distance networks, while later on more effort went into stressing the creation of boundaries. This process of ethnogenesis, *i.e.* the creation of new identity groups based on a belief of shared descent or history, and defined in opposition to others, will not be amenable to biomolecular study. Especially in the later LBK, when relocations may have taken place within established settlement regions, aDNA (and indeed isotopes) will be a poor guide for tracing the precise origins of migrants. Increasing territoriality as expressed in material culture boundaries took place between genetically largely identical populations, most of whom had grown up on loess soils. For these instances, then, defining migrations remains as challenging as it has ever been: reasons, group size and composition, distances travelled and so on will have to be reconstructed largely on the basis of detailed archaeological work.

However, in spite of these difficulties, the problem merits close attention. If the earliest LBK expansion left its traces not just on the distribution maps of archaeologists, but also in the attitudes and behaviours of later LBK communities, then the migration of larger social groups must be added to our research agendas alongside the identification of tethered mobility and individual relocation. This contributes to the impression that the LBK, in spite of its monumental wooden longhouses, was far from settled, with mobility and migration possible, and practised, at various scales. This should not be read as sign of a 'Mesolithic' heritage. Instead, such behaviours were specifically Neolithic, carried out for new kinds of reasons (such as personal renown) and embedded in an entirely new set of social circumstances. It was never too late to move on.

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Genomic approaches and their contributions to understanding the European Neolithisation

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ABSTRACT – *The contribution of ancient DNA to the understanding of past events has been increasing exponentially in recent years. This is mainly due to the synergy of technical advances, such as the molecular technique of high-throughput DNA sequencing, which has allowed for the reconstruction of complete genomes as old as 750 000 years. Another step toward the cost-effective characterisation of ancient genomes is the sampling of petrous bone, which has allowed sequencing of the first ancient African genome. Here I review the significant contribution of ancient genomics to our understanding of the European Neolithisation process.*

IZVLEČEK – *V zadnji letih se je eksponentno povečal prispevek stare DNK k razumevanju preteklosti, kar je predvsem posledica sinergije tehničnih napredkov, npr. molekularne diagnostike visoke zahtevnosti DNK sekvence, s katero lahko rekonstruiramo celoten genom tudi do 750 000 let starih vzorcev. Drug korak k stroškovno učinkovitejši karakterizaciji starega genoma je vzorčenje kosti skalnice v lobanji, s katero smo lahko dobili sekvenco prvega starega afriškega genoma. V članku nudim pregled nad glavnimi prispevki raziskave starega genoma k razumevanju evropskega procesa neolitizacije.*

KEY WORDS – *ancient DNA; palaeogenomics; Neolithic*

Introduction

The field of ancient DNA was 30 years old in 2014, and the anniversary was celebrated with an international conference at the Royal Society of London entitled "*Ancient DNA: the first three decades*" (*Hagelberg* et al. *2015*). This conference was dominated by the most recent results in the field, including an extensive genome-wide proof of Neanderthal interbreeding with modern humans (*Sankararaman* et al. *2014*). However, ancient DNA has entered the 'genomic era' only very recently, with the first ancient human genome published in 2010 (*Rasmussen* et al. *2010*), the first scattered genomic data from a Neolithic sample in 2012 (*Skoglund* et al. *2012*), and the first Near Eastern Neolithic genomes only very recently (*Mathieson* et al. *2015*).

Before the 'genomic era', the field advanced thanks to the complicated and low-success recovery-rate of small DNA fragments, mainly from mitochondrial DNA (mtDNA). The mitochondria are cell organelles that govern the energy supply, in several copies per cell. They contain one or more small circular molecules of DNA; therefore, 1000 to 10 000 copies of mtDNA can be counted in a cell, as compared to only two copies of maternally and paternally inherited nuclear DNA (nuDNA) (*Robin, Wong 1988*). This has made mtDNA the preferred target for ancient DNA studies, given >1000 higher probability of recovering DNA after the environmental degradation that affects cells and molecules after death.

The first mtDNA sequence from ancient material was isolated in 1984 from the dried muscle of an early 1900s quagga, an extinct equid (*Higuchi* et al. *1984*). Since then, a wide range of other ancient samples and tissues have been analysed, especially ancient bones and teeth, the most frequently preserved tissues in ancient samples, with the seminal work of

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Hagelberg and colleagues (*Hagelberg* et al. *1989*). Other tissues such as hair (*Gilbert* et al. *2004*), coprolites (*Poinar* et al. *1998*), and arctic sediments (*Willerslev* et al. *2003*) were also successfully investigated in the first two decades of the aDNA field.

In the specific research on the Neolithic transition in Europe, several studies based on short mtDNA sequences were published, with the pioneering work of Wolfgang Haak and colleagues (*Haak* et al. *2005*) on Neolithic LBK (samples from Central Europe). This study was the first population survey of an ancient Neolithic group to help us understand the Neolithisation process. The authors showed an ancient Neolithic genetic composition very different from the current European population, including variants virtually absent nowadays (*i.e.* haplogroup N1a). Several other mtDNA works followed, including a comparison of contemporaneous farmers and hunter-gatherers in Northern Europe ion the 3rd millennium BC (*Malmström* et al. *2009*), revealing a genetic break. For the Iberian Peninsula, Cristina Gamba and colleagues (*Gamba* et al. *2011*) also showed an important component of new incomers at the beginning of the Neolithic.

The jump to the second-generation or the 'genomic era' has allowed a quantum leap in retrieving genetic information from ancient specimens. After the first ancient human genome to be sequenced, a 4000 years old specimen from Greenland called 'Saqqaq' after his culture (*Rasmussen* et al. *2010*), many other ancient genomes followed. Most of the studies included one or very few samples, due to the high cost of high-throughput DNA sequencing (HTS) of whole genomes (3 billion base pairs for the human genome – around 200 000 times longer than the whole mtDNA). This is especially true for degraded samples with endogenous DNA below 5%, the other 95% being mostly co-purified microbial DNA from the environment and, unfortunately, as costly as the endogenous DNA fraction. Basically, to sequence the genome of an ancient sample costs at least 20 times more than a modern one, restricting the whole-genome sequencing of ancient sample to a few highly funded laboratories and to very well-preserved specimens.

Ancient DNA challenges and validation

In order to understand aDNA data, it is essential to understand the challenges involved in performing a molecular analysis based on degraded material. Firstly, the DNA starts to degrade immediately after the organism dies due to the action of microorganisms in the depositional environment, enzymes released from the cells themselves and chemical reactions due to the presence of oxygen and water (*Hofreiter* et al. *2001*). The main outcomes are DNA fragmentation and chemical changes. The first implies that only short sequences can be retrieved from ancient samples, and a sequence is informative only above 25–30 base pairs, because below this length the probability of a precise match between the DNA fragment in different locations of a genome or even in different genomes significantly increases, making the genetic data uninformative.

The main chemical DNA modification known to date is the deamination at cytosines, one of the four nucleotide bases composing the DNA, which implies their transformation into uraciles (usually only found in RNA and not in the DNA of living organisms), and ultimately into thymines through the amplification process, which is necessary for sequencing DNA (*Hofreiter* et al. *2001*). This means that we detect a thymine, which was originally a cytosine, which renders misleading the genetic information retrieved. This happens mainly around DNA breaks, thus at the beginning or end of DNA fragments. Consequently, the deamination might lead to confusion concerning the correct retrieval of genetic information, unless many fragments from the same genomic region are analysed and compared (high coverage), given that deamination should happen randomly.

On the other hand, detecting deamination provides a unique signature of DNA degradation and has been largely used as a criterion from ancient DNA (*Ginolhac* et al. *2011*). Interestingly, there is an experimental way to eliminate these miscoding lesions from the DNA strands, by using an enzyme (UDG, Uracil-DNA-Glycosylase) that can remove the majority of the uracils from ancient DNA before amplification, making downstream analysis less noisy (see *e.g.*, *Rohland* et al. *2015*).

Another significant weakness of aDNA, especially before the HTS era, is its susceptibility to contamination from fresh genetic material, either from the depositional environment or introduced after an excavation during manipulation of the sample. This undermined many of the first aDNA studies, which claimed to recover sequences from material millions of years old, such as a magnolia leaf claimed to be 17–20 million years old (*Golenberg* et al. *1990*), amber-preserved bees, termites and plants (*Cano* et al. *1993; DeSalle* et al. *1992; Poinar* et al. *1993*), and

even fossil bacteria (*Cano* et al. *1994*). These studies were later shown to be fallacious, as only contaminant DNA of modern origin was actually retrieved (*Poinar* et al. *1998; Yousten, Rippere 1997*).

All these million-year studies revealed the high risk of combining a highly sensitive technique, such as PCR, with the study of scarce and degraded ancient molecules. This led to outsiders taking a very sceptical view of the field, especially archaeologist and palaeontologists unwilling to destroying precious samples in order to obtain unreliable results.

However, this was an important turning point in the aDNA field, highlighting the importance of authenticating and validating results. The so-called 'authenticity criteria' were formalised for the first time by Matthias Krings and colleagues through the validation of the DNA results obtained from the first Neanderthal specimen analysed (*Krings* et al. *1997*), followed by several comprehensive reviews of all the criteria needed to validate results (*Cooper, Poinar 2000; Pääbo* et al. *2004*). Despite its controversial beginnings, ancient DNA can now be considered a well-established scientific discipline, with greatly improved standards, especially since the development of HTS.

A highly valuable piece: the petrous bone

Recently, Gamba *et alii* (*2014*) demonstrated that the densest area of the petrous bone, part of the temporal bone, could provide very high levels of endogenous DNA, up to 180-times more than other bone pieces from the same individual, preserving up to more than 80% of the ancient endogenous DNA of the specimen. This implies a sequencing cost only slightly higher than modern genomes, which are currently systematically generated by the hundreds. This is linked to the high density of this bone in mammals (*Lam* et al. *1999*), which might be responsible for the low penetration of bacteria during the decomposition processes of the body. After this seminal study, different parts of the petrous bone were shown to provide lower amounts of DNA (*Pinhasi* et al. *2015*) than the densest part chosen in the first case (*Gamba* et al. *2014*).

In the latter study, the closest samples to the petrous bone in terms of DNA preservation were the molar roots, only 3-times less efficient (*Gamba* et al. *2014*). In another study, Peter B. Damgaard and colleagues demonstrated that the cementum of teeth is where the best-preserved genetic material is harboured (*Damgaard* et al. *2015*). However, although especially well-preserved teeth can also have very high levels of endogenous DNA, on average they do not perform nearly as well as petrous bone (Fig. 1).

Thanks to the specific sampling of the petrous bone, it became possible to retrieve and sequence the genome of a sample from an especially degrading environment such as Africa for the first time (*Gallego-Llorente* et al. *2015*), and more recently, even a handful of the first farmers from the Near East (*Broushaki* et al. *2016; Gallego-Llorente* et al. *in press; Lazaridis* et al. *2016*)

Palaeogenomics and the Neolithic transition in Europe

Ancient genomes from prehistoric Europeans have provided highly valuable insights into the understanding of the population dynamics of the past. This

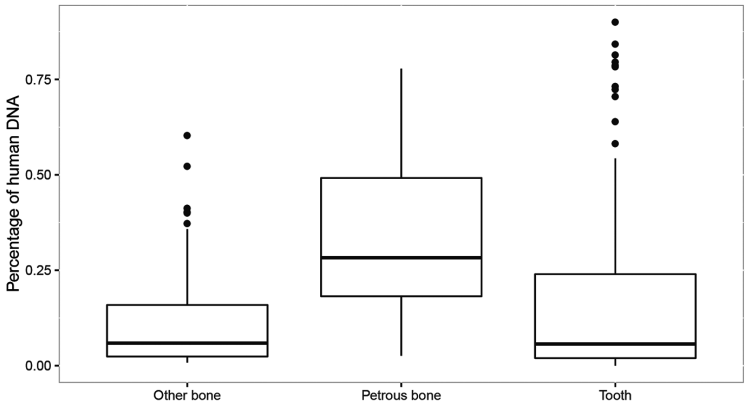


Fig. 1. Boxplot representing the percentage of endogenous human DNA retrieved from the petrous bone versus other skeletal elements retrieved from ancient specimens. The bottom and top of the box refer to the first and third quartiles; the band inside the box is the median, while the ends of the whiskers represent the 5th and 95th percentiles. Outliers are represented as points. Database from Mathieson and colleagues (*2015*), which also includes data (*Allentoft *et al.* 2015; Gamba *et al.* 2014; Haak *et al.* 2015; Keller *et al.* 2012; Lazaridis *et al.* 2014; Olalde *et al.* 2014) completed with these data (*Cassidy *et al.* 2016; Günther *et al.* 2015; Jones *et al.* 2015; Omrak *et al.* 2016; Skoglund *et al.* 2014; Broushaki *et al.* 2016; Gallego-Llorente *et al.* in press). Only data at a minimum coverage of 0.025x were included. Plot realised in R (*Core Team 2014*) using the library ggplot2 (*Wickham 2010*).

is especially true for the Neolithic period, for which many complete genomes or genome-wide data are now available (Fig. 2).

The Neolithisation of Europe has been thoroughly investigated by different disciplines (*i.e. Bocquet-Appel, Bar-Yosef 2008; Pinhasi, Stock 2011*) which showed the relative contribution of demographic movements and the transmission of ideas and new practices that accompanied the economic revolution (*Zvelebil 2001*).

Investigations of this process with modern DNA data has yielded contradictory results (see *Jobling* et al. *2013.Ch. 12 and references therein*) because of the specificity of the genetic markers studied and the important genetic reshaping of the European genetic pool after the Neolithic, recently directly detected through ancient genomics (see *Mathieson* et al. *2015* and references therein). However, it seems that now this long-lasting debate on the mechanisms of Neolithic expansion has been resolved thanks to ancient genetics and genomics. Ancient genomes support the first studies based on mtDNA (*Bramanti* et al. *2009; Haak* et al. *2010; Brandt* et al. *2013; Szécsényi-Nagy* et al. *2015*), pointing to a genetic break between the Mesolithic and the Neolithic periods in Europe, with the arrival of new incomers from the Near East.

The first clue to the genomic landscape of Neolithic Europeans was provided from the complete sequencing of a frozen mummy from the Copper Age (5300 BP) found in the Italian Alps (*Keller* et al. *2012*). The so-called Iceman surprisingly showed high genetic affinities with modern-day Sardinians, despite their geographic distance. These data suggested for the first time that (1) major genomic reshaping occurred after the Neolithic and (2) Sardinians might be relics of the original Neolithic population, because of the late peopling of the island and the implicit geographic isolation.

Understanding palaeogenomics

Molecular approaches

Palaeogenomic analyses start in the laboratory, where a sample, usually a piece of bone, is ground and the DNA extracted. The short DNA molecules retrieved are then built into so-called *libraries* by attaching to each side of the DNA strand two sequences, the *adapters*, which contain well-known DNA stretches compatible with further processing. The library is then amplified and (usually at this stage) short unique DNA, including unique *indexes*, are attached to the adapters to tag each sample differently and to allow the sequencing machine to distinguish between samples. The amplified libraries are then either sequenced or enriched. In the first case, the whole DNA molecules extracted from the sample are sequenced. This method is called *shotgun sequencing*, because there is no selection of the DNA to be sequenced, and then, apart from the endogenous DNA of interest, also DNA from the environment (contaminant DNA) is co-sequenced. In the second case, the amplified library is firstly combined with a set of DNA sequences, so-called *probes*, which *capture* regions of interest, while all the other molecules are washed away. In this case, principally these regions are selected, *enriched* and then sequenced, reducing sequencing costs while increasing the coverage of these positions of interest. The drawback of this second approach is that the genome to be sequenced needs to be well characterised in order to produce specific probes for DNA *enrichment*.

Analytical approaches

Given the massive amount of sequences retrievable from HTS machines, *bioinformatic* tools should be applied to the data analysis and interpretation. The first step is to align the sequence retrieved to a *reference genome*, whenever available. Sometimes, a reference genome is not available, *e.g.*, in the case of species not characterised or extinct; therefore, the genome should be *assembled* from scratch. For human samples, a very well characterised genome is available and constantly improved. So the first step consists of *aligning* the sequences to the human reference genome, followed by *quality filtering*, which takes into account how well a genome is aligned to the reference (*mapping quality*) and how confidently each base was identified during the sequencing (*base quality*). This is followed by *genotyping*, mainly focusing on the identification and analysis of punctual genomic variants, also called *SNPs* (Single Nucleotide Polymorphism), which are positions in the genome that vary among different individuals and populations. Further filters can be applied, such as the setting of a minimum *coverage* (how many times a position has been sequenced), which reflects

Further genomic data from northern European farmers and hunter-gatherers extended to much higher latitudes and much later periods (~5000 years old) showed the affinity of ancient farmers with modern-day southern Europeans (*Skoglund* et al. *2012*). On the other hand, northern hunter-gatherers showed genetic discontinuity with farmers, falling outside the genomic variability of modern Europeans (*Skoglund* et al. *2012*). Despite the very low amount of genomic data retrieved, covering only ~10% of the genome, this study allowed for the correlation of two different genomic backgrounds with two differentiated cultural groups: farmers and hunter-gatherers, suggesting the arrival of new incomers with the advent of the Neolithic.

Later studies showed the same pattern at lower latitudes, such as the characterisation of two high-quality genomes, one Neolithic farmer from Germany and one Mesolithic hunter-gatherer from Luxembourg, further supported by eight lower-quality genomes from Swedish hunter-gatherers (*Lazaridis* et al. *2014*).

The study of a time series from the Early Neolithic to the Iron Age in Eastern Hungary (*Gamba* et al. *2014*), provided a pool of nine new Neolithic genomes (one high-quality, NE1), including two early Neolithic individuals associated with the Körös culture. One of them, KO2, showed affinities with the Neolithic pool, close to modern-day Sardinians, with some Near-Eastern influence. Surprisingly, the other Körös sample, KO1, fell outside modern-day variability, clustering together with hunter-gatherers' genomes, despite the Neolithic cultural context. This finding points to possible admixture between hunter-gatherers and farmers at the beginning of the Neolithic. The following investigations mainly focused on genome-wide informative markers (*Haak* et al. *2015; Mathieson* et al. *2015*), allowing for the characterisation of more than one hundred Neolithic genomes to date.

how confidently the genotyping was assigned. *High-quality* or *high-coverage* genomes usually refer to genomes that have been sequenced with an average coverage of the whole genome of 20x and above. Specific filters that take into account post-mortem deamination reactions are frequently applied to ancient genomic data, *i.e.* considering only SNPs that involve transversions (from C or G to T or A and *vice versa*), which cannot derive from deamination events.

The genomic variability can be summarised and compared to other individuals with *Principal Component Analyses* (PCA), relying on those components that best explain the diversity between samples.

So-called *admixture plots* are also frequently used to visualise with stacked ancestry components in barplots. The number of these components is set *a priori* and can identify portions of ancestry related to geographic distributions, temporal periods or ethnicities shared among different individuals.

Relationships between individuals can also be drawn by adopting phylogenetic approaches. One of the most interesting approaches used in palaeogenomics relies on whole genome data and allows for the representation of a phylogenetic tree including arrows between branches, pointing to possible admixture events (*e.g.* interbreeding between species or inbreeding between unrelated populations).

Many methods have been specifically developed to identify admixture events among populations or species including ancient DNA. These rely on different statistical tests, such as so-called D-statistics and the f-statistics.

Adaptation to the environment and the selection of advantageous variants (positive selection) can also be tested at a population or species level, and rely on the comparison between patterns of genetic variability (such as FST, which provides a measure of population differentiation).

All the genomic analyses described above can also be implemented on either *genotype likelihood* or *imputed genotypes* (genotype likelihood incorporating information from available databases), which provide *genotype probabilities* instead of observed genotypes. This is especially interesting for ancient genomes, usually showing few data mined by molecular damage, which are not suitable for extensive genotyping.

Further reading

For a review of aDNA molecular methods see Shapiro, Hofreiter (*2012*), and for an updated and comprehensive review of aDNA analytical tools see Leonardi *et al.* (*2016*).

Within the Neolithic pool, there is a Southeast-Northwest cline, with a decreasing Near-Eastern affinity, pointing to a dilution of the original gene pool along with the expansion. The same trend can be detected in modern European populations, overlapping with an East-West gradient due to the influence of Bronze Age incomers from the Steppe (*Mathieson* et al. *2015*) at later stages.

It is worth noting that the Neolithic cluster also includes a Spanish genome associated with the Cardial Neolithic cultural expansion, the first Neolithic incomers into Mediterranean regions, suggesting a common origin with the LBK Neolithic culture, which spread in parallel into Central Europe (*Olalde* et al. *2015*). Moreover, it was possible to identify an eastern European hunter-gatherer component in this Cardial genome (*ibid.*), reinforcing the hypothesis of a certain admixture of hunter-gatherers and farmers at the beginning of the Neolithic expansion.

Similarly, Zuzana Hofmanová and colleagues (*2016*) detected a low-level admixture of migrating farmers and local hunter-gatherers in the earliest stages of the Neolithic, consistent with sporadic occurrences.

The admixture with local hunter-gatherers increased substantially at later stages (*Haak* et al. *2015; Hofmanová* et al. *2016*) at the transition to the Middle Neolithic across Europe, while Late Neolithic and Bronze Age periods were characterised by increasing input from steppe populations (*Haak* et al. *2015*).

The analysis of north-western Anatolian Neolithic samples from the Marmara region in Turkey (*Mathieson* et al. *2015*), which also clearly cluster within the ancient Europeans' Neolithic pool, confirmed that the source of the agricultural incomers reached Europe through northern Anatolia, and probably followed a route across Greece to Europe (*Hofmanová* et al. *2016*).

However, until very recently, there were no genomic data directly linked to the first appearance of Neolithic culture in the Fertile Crescent. Only short sequences from mitochondrial DNA were available from Pre-Pottery Neolithic samples (*Fernández* et al. *2014*). However, recently, whole genomes and genome-wide data from the Fertile Crescent region have become available, giving a first glimpse of the Near-Eastern genetic pool through time and space (*Broushaki* et al. *2016; Lazaridis* et al. *2016; Gallego-Llorente* et al. *in press*). The analysis of samples from such warm areas has now become possible thanks to the recovery of relatively high endogenous content from the petrous bone, used as the main DNA source in all three studies (see section above).

Four Early Neolithic (EN) genomes from Zagros in Iran show a distinct genetic signature from both European hunter-gatherers and farmers, close to modern Pakistanis and Afghans (*Broushaki* et al. *2016*). In this study, the authors suggested that the affinities of Zagros Neolithic individuals to modern pop-

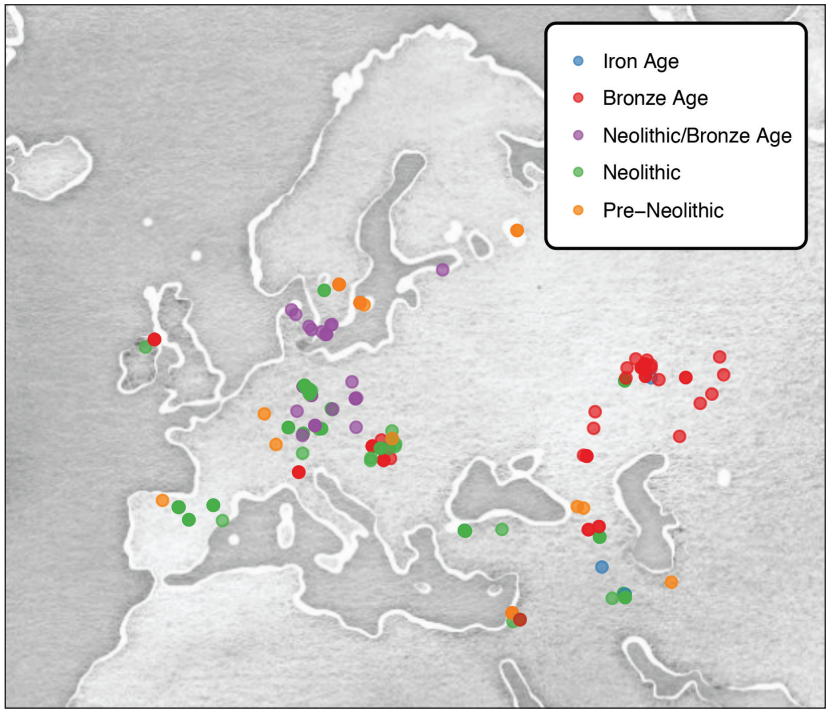


Fig. 2. Location of ancient human genomes sequenced at a minimum coverage of 0.025x (database* Mathieson *et al.* 2015 *which also includes data from* Allentoft *et al.* 2015; Gamba *et al.* 2014; Haak *et al.* 2015; Keller *et al.* 2012; Lazaridis *et al.* 2014; Olalde *et al.* 2014*; this database is completed with data from* Cassidy *et al.* 2016; Günther *et al.* 2015; Jones *et al.* 2015; Omrak *et al.* 2016; Skoglund *et al.* 2014; Broushaki *et al.* 2016; Gallego-Llorente *et al.* in press; Lazaridis *et al.* 2016*). Plot realised in R (*Core Team 2014*) using the libraries ggmap (*Kahle, Wickham 2013*) and ggplot2 (*Wickham 2010*).

ulations of southern Asia can be related to the spread of Indo-Iranian languages or Dravidian languages, along with the demographic expansion of farming into the region (*Broushaki* et al. *2016*). This study also pointed out that the European Neolithic migration probably had a different genetic source than the eastern Fertile Crescent.

Iosif Lazaridis and colleagues (*2016*) tried to answer to this question by analysing serial samples from different regions of the Near East, mainly from two areas, the Levant (Israel and Jordan) and Iran, for a total of 44 samples (also including some from Armenia in the Caucasus, and one from Turkey) spanning from the Epi-Paleolithic and Natufian (pre-Neolithic) to the Chalcolithic periods. The results retrieved from the Iranian samples supported the study by Farnaz Broushaki and colleagues (*2016*) and highlighted the high genetic differentiation of those samples not only with respect to the European Neolithic, but also to the Levantine pool. Interestingly, they also detected genetic continuity in both regions from pre-Neolithic to Neolithic periods, suggesting a major cultural spread of the Neolithic throughout the Near East (*Lazaridis* et al. *2016*).

The populations of the Levant in the Neolithic are genetically closer to the European and Anatolian Neolithic pool than the Iranian Neolithic, but nevertheless cluster separately (*Lazaridis* et al. *2016*). The authors identify the Levantine population as a good proxy for East African ancestry, pointing to the fact that the source population of the Neolithic expansion into Europe still remains to be identified (*Lazaridis* et al. *2016*). Further analysis from such crucial areas and periods will improve our understanding of the dynamics that influenced the initial development of the Neolithic period and its subsequent multidirectional expansion.

Although palaeogenomics data have significantly contributed to deciphering the mechanisms involved in European Neolithisation, this field would benefit from deeper interaction and integration with related disciplines, such as archaeology and anthropology.

Positive selection and phenotypes during the Neolithic

Genomic research is sufficiently advanced to allow the identification of the genes involved in several phenotypic attributes – including complex traits such as eye and hair colour – controlled by several genes. European hunter-gatherers had quite dark skin, dark hair and, interestingly, light-coloured eyes, while the incoming farmers typically had lighter skin and dark eyes (*Gamba* et al. *2014; Lazaridis* et al. *2014; Mathieson* et al. *2015; Olalde* et al. *2014*).

A recent study specifically focused on detecting the positive selection of phenotypes through time (*Mathieson* et al. *2015*) identified several candidates. The authors investigated the temporal progression of allele frequency of those genes for spotting the selection timing and consequences.

A strong signal of selection was detected for the light skin pigmentation variant of the gene SLC45A2 (SNP rs16891982), now almost fixed in Europeans, significantly increasing in frequency through time. Another gene, SLC24A5, also associated with light skin pigmentation, was not identified as under selection in the analysis, but the selected allele frequency increased at the beginning of the Neolithic in Europe, probably due to the migration pattern from the Near East.

The primary determinant of light eye colour is linked to the gene HERC2/OCA2 (SNP rs12913832). This has been found in all European hunter-gatherers, while at later stages up to the present, the allele associated with light eye colour increases with high latitudes, suggesting selection due to the environment.

Interestingly, the derived allele of the SNP rs3827760 in the gene EDAR, almost absent in present-day Europeans, was detected with high frequency in Scandinavian hunter-gatherers from Motala in Sweden (5898–5531 cal BC). This gene, which affects tooth morphology and hair thickness, is highly frequent in East Asian and Native Americans and has previously been suggested to have originated in East Asia (*Kamberov* et al. *2013*), but a different scenario emerge from these ancient data.

However, the strongest signal of selection was retrieved from the LCT gene (SNP rs4988235), associated with lactase persistence, which allows to adults to digest milk. The authors confirmed previous results (*Gamba* et al. *2014; Burger* et al. *2007; Allentoft* et al. *2015*) pointing out the late occurrence of this allele, which appeared for the first time only around 4000 years ago, much later than the advent of the Neolithic. The earliest date for lactase persistence is from a central European Bell Beaker sample dated to 2457–2142 cal BC (*Mathieson* et al.

2015). Other variants in genes associated with diet have been identified, suggesting components of adaptation to a variety of diets (fatty acid), different food sources and environments (vitamin D) and others possibly linked to coeliac disease (*Mathieson* et al. *2015*).

In this study, Iain Mathieson and colleagues (*2015*) were also able to investigate an even more complex trait which depends on hundreds of variants: height. A North-South cline in Europe is evident, with height decreasing in modern Europeans, probably linked to selection processes that occurred in the past reflecting better adaptation to the environment. Based on 169 genomic variants, the authors explained this gradient by detecting a significant signal of selection of reduced height in Iberian Neolithic and Chalcolithic samples, as well as increased height in steppe populations relative to the central European Neolithic. This suggests that the height gradient detected now is mainly due to the increased steppe ancestry of northern Europeans and selection for lower height in Southern Europe.

New perspectives in ancient genomics

Despite the short history of the aDNA field, the genomic boom has resulted in an explosion of ancient genomes from many species, including humans, archaic hominids, animals, and plants. Also, other satellite approaches are attracting more and more attention, providing new ways to study ancient genomics, such as ancient metagenomic and ancient epigenomic analysis. The first refers to the analysis of the whole sequencing output, the exogenous DNA, that vast amount of unused sequencing obtained through shotgun approaches, especially vast in those samples with very low amounts of endogenous DNA. Why should we be interested in such DNA portion? Because it might contain other interesting organisms, which might come from the depositional environment, from manipulation, or from other organisms, such as pathogens, that were inhabiting the specimen. Recent work has demonstrated that it is possible to collaterally detect and fully characterise Yersinia pestis, the agent of the plague, in ancient samples (*Rasmussen* et al. *2015*), pushing back the presence of this pathogen at least 3000 years before any historical record.

A very interesting substrate for metagenomic analysis is the dental calculus (*Adler* et al. *2013; Warinner* et al. *2014*), allowing for the investigation of ancient oral microbiomes, clearly detecting shifts correlating with dietary changes during the Neolithic and the Industrial revolutions (*Adler* et al. *2013*).

On the other hand, epigenomics studies DNA modifications that do not imply changes in the sequence, but only reversible modifications to the genetic material that mainly influence gene expression (*i.e.* how the genetic information coded in the genes is differently expressed in cells). One of the most common epigenetic modifications is DNA methylation, which is the addition of a methyl group to a nitrogenous base in specific genomic contexts. Recent studies have demonstrated that it is possible to retrieve this information from ancient genomes, by using either direct techniques (bisulphite sequencing, which is difficult to apply to ancient specimens, as it requires a large amount of DNA) (*Llamas* et al. *2012*), or by analysing patterns of molecular damage directly linked to methylation rates (*Gokhman* et al. *2014; Pedersen* et al. *2014*).

The applications of both epigenomics and metagenomics to ancient substrates pinpoint the progressive incorporation of new approaches to palaeogenomics, the result of a continuously updated multidisciplinary field.

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Diversity and homogeneity among the early farming communities of Western Anatolia

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ABSTRACT – *Our knowledge of the Neolithisation of Western Anatolia has increased considerably in recent years. Being located beyond, but on the border of the formative zone of Neolithisation, the region has acted as a buffer in the dispersal of the Neolithic way of life farther to the west. Recent research in Western Anatolia has shown that Neolithic sites appeared in the second quarter of the 7th millennium BC and had become widespread by the second half of the same millennium. There is now adequate data available on both the distribution of sites and the material culture in some sub-regions. In this context, this article will focus not on the Neolithisation process, but on the characteristic features of the sub-regions and the interaction between them.*

IZVLEČEK – *Naše vedenje o neolitizaciji zahodne Anatolije se je v zadnjih letih znatno povečalo. Glede na svoj položaj onstran, a vseeno na meji formativne cone neolitizacije, je ta regija delovala kot ločitveno območje pri širjenju neolitskega načina življenja proti zahodu. Nedavne raziskave na zahodnem delu Anatolije so pokazale, da so se tam neolitska naselja pojavila v drugi četrtini 7. tisočletja pr. n. št., razširila pa so se v drugi polovici istega tisočletja. Trenutno imamo že dovolj dostopnih podatkov o širitvi najdišč in materialne kulture v nekaterih podregijah. V članku se tako ne osredotočamo na proces neolitizacije, temveč na značilnosti v teh podregijah in na njihovi medsebojni interakciji.*

KEY WORDS – *Neolithic; Western Anatolia; Secondary Neolithisation*

Introduction

The origin of Neolithic societies in Europe, which solidified connections between the Near East and the Aegean, has been discussed for over a hundred years. However, through time, not only what is implied by the term Neolithic but also the conceptual framework for approaching the problem has been considerably modified; as more data became available, not only our vision of the Neolithic, but more significantly, the questions being asked had to be reformulated.

The emergence and dispersal of the Neolithic way of life from the core area of its origin to the borders of Central Europe and the western coastal areas of the Mediterranean has been seen as a long multifarious process covering the period between the 10th and 6th millennium BC; evidently, depending on the questions being asked or the modalities of our approach, there would be different ways to look into this vast territory, particularly in defining spatial boundaries. This paper will be concerned mainly with two distinct entities; the first area encompasses the geographical region where the Neolithic way of life first appeared and developed its main features. Different terms have been used to describe this region, such as 'the origin of civilisation', 'the Fertile Crescent', 'the primary zone of Neolithisation', 'the core area' or 'the formative zone' *etc*. (see *Bailey, Whittle 2005; Özdoğan 2008; 2011; Asouti 2006; Zeder 2011*). There are remarkable differences between these terms, not only in their meaning, but in the geographic and chronological boundaries of the region. In this paper, the main area where the basic features of the Neolithic way of life were form-

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ed will be referred to as the '*Formative Neolithisation Zone*'. This is the main area where the first Neolithic communities appeared by the 10th millennium BC and where cultural and technological developments occurred gradually in a dynamic process. This wide geographical area includes sub-regions such as the Levant, northern Mesopotamia/the Tigris and Euphrates Basin, the Zagros Mountains (?), Central Anatolia and Cyprus; even further distinctions can be made on the local level.

The second area is where the components constituting the Neolithic way of life appeared without precedent, although these same elements, sometimes contemporarily but generally earlier, emerge in the formative zone. The beginning of Neolithisation in these secondary areas, including western Anatolia, the Aegean, Greece, the Balkans, the Adriatic, Central Europe, the western Mediterranean, North Africa, and even the Caucasus, extends from the beginning of the 7th to the end of the 6th millennium BC. Here it is worth noting that the areas of secondary Neolithisation cannot be considered as a uniform entity; on the contrary, it comprises several distinct entities, each having its particular modalities. Direct or indirect connections to the formative zone, and the continuity of that relationship, the distribution of Neolithic components, the contribution of local elements to the Neolithic way of life, and/or the adaptation of Neolithic elements to a new natural/cultral environment all played a role in this process; due to the cultural and environmental variables and differences in Neolithisation processes, designating this area as a whole with a categorical name is rather difficult. In this respect, based on the presence of advanced Neolithic elements that evidently derived from the formative zone after being fully developed there, it seems proper to address them as the '*Secondary Neolithisation Zone*'. Even if grouping all of the regions noted above under this term is questionable, it seems proper to use it at least for western Anatolia, Greece, and the Balkans, regions that not only constitute the borderlands of the formative zone, but had sustained interaction with it.

The Neolithisation process in these secondary areas has been discussed since the first half of the 20th century (*Childe 1929; 1939; Milojčić 1949; Garašanin 1954; Renfrew 1987; Price 2000; Lichter, Meriç 2005; Gatsov, Schwarzberg 2006; Krauß 2011*). Many of the debates surrounding their emergence have arisen out of the conflict between diffusional and anti-diffusional approaches; nevertheless, trends have been changing since the 1990s, developing a multi-dimensional holistic approach to looking at the problem (see *Harris 2003*), and considering both cultural and demic movements in the westward expansion of the Neolithic way of life (*van Andel, Runnels 1995; Zilhão 1997; Zvelebil, Lillie 2000; Zvelebil 2001; Bogucki 2003; Perlès 2003; Özdoğan 2011; Budja 2009; 2013*). As will be elaborated below, recent work in western Anatolia not only reveals apparent similarities between the formative and secondary zones, but also presents direct evidence of interregional connections.

Research in western Anatolia in the last two decades has demonstrated that the Neolithic way of life emerged almost simultaneously in Western Anatolia and Greece, expanding to the Balkans just a short time later. Although this was a rapid process in secondary areas, Neolithic settlements in the initial phase of dispersion seem to have been sparse. In the second half of 7th millennium BC, this dispersal gained momentum, but the massive expansion of the Neolithic way of life took place at the end of the same millennium or the beginning of the next. Thus the apparent leap of dispersal from Central to Western Anatolia is part of a more complex picture, which must be examined in accordance with the dynamics behind Neolithic dispersal from the formative zone (*Brami 2015*).

In the course of recent decades, with the onset of new excavations, our knowledge of the material assemblages of Western Anatolia has increased considerably; it now is possible to detect several components that indicate a close relationship with the formative zone. It seems that demic diffusion played an imported role in the Neolithisation of Western Anatolia, Greece, and the Balkans. In this respect, significant contributions have been made by archaeogenetic studies, gradually providing ample new data to answer questions relating to the Neolithisation process. At the present point of research, although there has been a number research projects, some still ongoing, based on genome studies to understand the interaction between the sub-regions of the Formative Zone and the area of Secondary Neolithisation, mainly due to the geographic and as well chronologically uneven distribution of samples, some considerable controversies still need more time to be resolved. On the other hand, evidence of the contribution of early Near Eastern farmers to the European gene pool is gradually increasing (*Pinhasi* et al. *2005; Thomas* et al. *2013; Fort 2015; Mathieson* et al. *2015; Lazaridis* et al. *2016; Hofmanová* et al. *2016*).

A recent DNA project which compares the genes of contemporary populations in Northwestern Anatolia with samples from the Neolithic layers of Barcın and Neolithic sites in Greece has revealed certain genetic connections between these two regions (*Hofmanová* et al. *2016*). However, genetic studies, especially from Anatolian sites, are still extremely few. Barcın is the only Neolithic site in Western Anatolia to compare to the whole of Europe. As well as questions about the genetic composition of Western Anatolia, there are many more questions about the differences between the Neolithic societies of Western and Central Anatolia and the unknown Mesolithic populations. The genetic connection between Anatolia and the Near East has also not been ascertained thoroughly. Therefore, given the present state of genomic research, it is difficult to define clear routes for Neolithic expansion; moreover, the results of genetic analysis have to be correlated with the archaeological evidence. In this respect, there is a significant discrepancy between the archaeological evidence and the genome studies noted above; a recent assessment of the archaeological evidence of Northwest Anatolian Neolithic sites clearly reveals a difference between sites in eastern and western parts of Thrace, indicating that the Barcın-related assemblages stopped in the area of Istanbul without expanding into Thrace (*Özdoğan 2014a*). Thus, the archaeological and genomic results have somehow to be considered together before making conclusive remarks. Contrary to the differences between the Neolithic assemblages on the eastern and western sides of the Sea of Marmara, similarities with mainland Greece are evident, which could be interpreted either as evidence of a direct connection between the two regions or an indication of their common origin.

Although there are similarities, cultural differences can be discerned between large cultural areas and at the local level. Thus, it is difficult to envisage an identical process of Neolithisation for the whole area or to confirm the same mechanism for the process. Detailed studies of micro-regions, as well as enabling the summarising of local developments, more significantly provide the means to develop supra-regional perspectives; otherwise, as exemplified above, what seems similar in an overview, either in a cultural or genetic analysis, may give way to new controversies.

Research in Western Anatolia has shown that there are cultural differences within the region itself. This paper aims to present the differences and similari-



Fig. 1. Sites mentioned in the text.

ties between the adaptations of Neolithic elements in various areas of this region, although some areas still remain undocumented.

Studies of the Neolithic in Western Anatolia

Western Anatolia has three areas with distinct Neolithic features: the Lakes District/Southwest Anatolia, Central-west Anatolia and Northwest Anatolia (Fig. 1). The Lakes District was a priority for archaeological investigations from the very beginning of Neolithic research in Anatolia. The first studies began in the 1950s with James Mellaart's work at Hacılar, and continued in the years immediately after from 1957 to 1960 (*Mellaart 1970*). Hacılar and Çatalhöyük in Central Anatolia were again excavated by Mellaart between 1961 and 1965, both revealing the first evidence of Neolithic communities on the Anatolian plateau, the existence of which had been ruled out (*Mellaart 1967*). The Hacılar excavations in the 1950s were a turning point not only for knowledge of the region's western areas, but also in the history of archaeological research in Anatolia. With the excavations at Hacılar, the Near Eastern chronological denominations were transferred to Anatolia, mainly deriving from Tarsus Gözlükule; the stage at which painted vessels intensified at Hacılar was seen to be contemporary with Halaf culture, so it was termed the Early Chalcolithic. Later, with the excavations at Çatalhöyük, this chronology was also adapted to the interior regions of Anatolia (*Schoop 2011.151–152*). Thus, these first studies were instrumental in defining the chronology and terminology still used for Anatolian prehistory.

After Hacılar and Çatalhöyük, excavations at Erbaba (1964–1965) and Suberde (1969–1978) on the outskirts of the Beyşehir and Suğla lakes were conducted by Jacques Bordaz (*Bordaz 1973*). For a long time, however, the definition of the Neolithic cultures of Anatolia was based mainly on the evidence from Hacılar and Çatalhöyük, and usually disregarded results from other sites. In this respect, with the excitement triggered by the finds at Çatalhöyük and Hacılar, the quest to look for the origins of the European Neolithic in the Near East until 1980s were mainly confined to comparisons based on the material evidence from these two sites. Research in the Lakes District resumed in the 1980s, beginning with some soundings on the periphery of the Hacılar mound between 1985 and 1986 by Refik Duru (*1989*), who also excavated Kuruçay from 1978 to 1988 (*Duru 1994*) and Höyücek from 1989 to 1992 (*Duru, Umurtak 2005*). Between 1993 and 2010, Duru also worked at Bademağacı with Gülsün Umurtak (*Duru 2008*). In addition to these excavations, surveys were conducted by Mehmet Özsait (*1993*), illustrating the intensity of settlement during the Neolithic and Early Chalcolithic.

Neolithic research in the northwest began at the same time as the research in the Lakes District. Located on the eastern side of the Bosphorus, Fikirtepe was excavated by Kurt Bittel and Halet Çambel between 1952 and 1954 (*Bittel 1969*). Researching a site contemporary with Fikirtepe, Şevket Aziz Kansu took some soundings at Pendik in 1961 (*Kansu 1963*). Edibe Uzunoğlu began a salvage excavation at Pendik in 1981 (*Harmankaya 1983*), which was continued by Alpay Pasinli in 1992 (*Pasinli* et al. *1994*) and Zeynep Kızıltan between 2012 and 2013 (*Kızıltan 2013*). The assemblage revealed there was similar to Fikirtepe in terms of pottery, architecture, and burial customs (*Özdoğan 1983*). Due to the conventional assumption that Neolithic settlements did not exist in this region, the dating of these sites long remained controversial. In 1979, Mehmet Özdoğan dated materials from the Fikirtepe excavations in his PhD thesis (*Özdoğan 1979*) and concluded that the Neolithic societies in and around the Bosporus were part of a single cultural group, the 'Fikirtepe Culture', due to the distinctive features observed at Pendik and Fikirtepe (*Özdoğan 1983*). After the beginning of excavations at Ilıpınar at the end of the 1980s, the Fikirtepe material could finally be radiocarbon dated. Despite differences in architecture and subsistence pattern, the pottery of layers X-IX at Ilıpınar is similar to assemblages of other sites labelled as '*Fikirtepe Culture*', so the date of the sites could be securely established to the beginning of 6th millennium BC (*Özdoğan 1999*).

The architectural remains and material culture at Fikirtepe and Pendik are quite different from those at contemporary settlements in the Lakes District and Central Anatolia. The architecture of these sites consists of simple huts, and the faunal evidence points to intensive fishing and mollusc gathering; likewise, finds such as grindstones and flat axes, which are usually the markers of agricultural communities, are few in number (*Özdoğan 1979*). In addition to these features, the presence of microliths and relatively small bullet cores led Özdoğan to define the costal settlements like Fikirtepe and Pendik as descendants of local Mesolithic communities known from surface surveys (*Özdoğan 1999*). The architecture, subsistence patterns, and chipped stone technology reminiscent of Mesolithic traditions suggest

continuity between Mesolithic communities and Fikirtepe-related sites. The pottery assemblages also support this assertion, given the predominance of simple cooking pots for domestic use and mostly dark and matt surfaced wares, which are unlike the red-slipped ware known from Neolithic sites in western Anatolia.

Following the excavations of Ilıpınar from 1987 to 2002, the same team under the direction of Jacob J. Roodenberg, continued their work at Menteşe from 2000–2005 (*Roodenberg, Alpaslan-Roodenberg 2013; Roodenberg* et al. *2003*). With the excavation of Aktopraklık (*Karul, Avcı 2013*) and Barcın in 2004 (*Gerritsen* et al. *2013a*), knowledge of the Neolithic communities of the southern and eastern parts of the Sea of Marmara considerably increased. The basal layers of Barcın, Aktopraklık, and Menteşe are dated to the second half of the 7th millennium BC, revealing pottery assemblages similar to, or slightly different from, that of the 'archaic phase' of Fikirtepe; it thus seems evident that the initial stages of 'Fikirtepe Culture' began in those regions at a much earlier date.

There are significant differences among the excavated sites in Northwest Anatolia, demonstrating the effect of local environments and traditions. Coastal settlements like Fikirtepe and Pendik and mountain threshold sites like Aktopraklık show features reminiscent of their local Mesolithic communities, whereas Ilıpınar, Menteşe and Barcın predominantly feature elements typical of agricultural villages (*Karul 2011*). Yenikapı, excavated between 2008 to 2013 on the western side of the Bosphorus, and Yarımburgaz Cave at the northern end of Küçükçekmece Lagoon also have significant localised differences (*Kızıltan, Polat 2013; Özdoğan 2013*).

Due to apparent changes in the topography of the coastal areas of Western Anatolia and the heavy alluvial fill that has accumulated in the valleys and plains, the Aegean littoral is an area where localising Neolithic and Early Chalcolithic settlements is rather difficult. Therefore, the area has long remained in obscurity. An initial reconnaissance of the area, although not intensive, was conducted by David French (*1965*) in the 1960s and by Recep Meriç (*1993*) in the 1980s. Despite some small-scale research following these studies, until recently it was still an area where no Neolithic excavations had taken place. Knowledge of the Neolithic in this region began to emerge with the excavation of Ulucak beginning in 1995 (*Çilingiroğlu* et al. *2004; 2012*). Following this initial work on Neolithic communities in the eastern Aegean, excavations were conducted at Dedecik in 2003, Ege Gübre and Yeşilova in 2004, and Çukuriçi in 2007 (*Lichter, Meriç 2012; Sağlamtimur 2012; Derin 2012; Horejs 2012*). All of these sites, being located by the alluvial valleys of the Gediz and Menderes rivers, were buried under thick alluvial deposits. In the southernmost area of these sites, rock shelters in the Beşparmak/Latmos mountains have revealed rock paintings dating back to the Late Neolithic-Early Chalcolithic (*Peschlow-Bindokat, Gerber 2012*). Although there are some difficulties regarding the dating of these paintings, they have some features reminiscent of similarly dated painted pottery and figurines from the Lakes District.

Far fewer studies have been made in the northeastern part of the Aegean. The site of Coşkuntepe discovered by Jurgen Seeher in 1990 on the southwestern edge of Biga peninsula, and Uğurlu located close to the coast on the western side of Gökçeada/Imroz, shows that this region has been inhabited since the Early Neolithic period (*Seeher 1990; Erdoğu 2013*). It is also possible to assess Hoca Çeşme as a northern Aegean site due to its location on the Maritza River (*Özdoğan 2013*). Having been inhabited since the second half of 7th millennium BC, the early phase of this settlement was closely connected with developments in the Aegean, but from the 6th millennium onwards it shows closer similarities with the central parts of Thrace, mainly with those known as the Karanovo assemblages.

Neolithic chronology and pottery assemblages

The earliest dates on the appearance of Neolithic elements outside of its formative zone are not earlier than the second quarter of 7th millennium BC, according to newly calibrated dates (see *Reingruber 2015* and *Weninger* et al. *2014*) from sites including Ulucak, Çukuriçi, Knossos, and Franchthi Cave, located respectively on the western and eastern side of the Aegean. These data demonstrate that the first leap of the Neolithic to the 'west' did not take place along a frontier line, but occurred dynamically across a wide area (Fig. 2). In this respect, it is of interest to note that the excavators of these sites, based on certain analogies, have pointed to the different regions of the formative zone. In this regard, Ulucak, for example, located along the eastern end of the Gediz valley, which provides a natural route connecting the Aegean littoral with inner Anatolian plateau, has revealed red-coated floors and the subsequent pottery tradition (*Çilingiroğlu, Çakırlar 2013*).

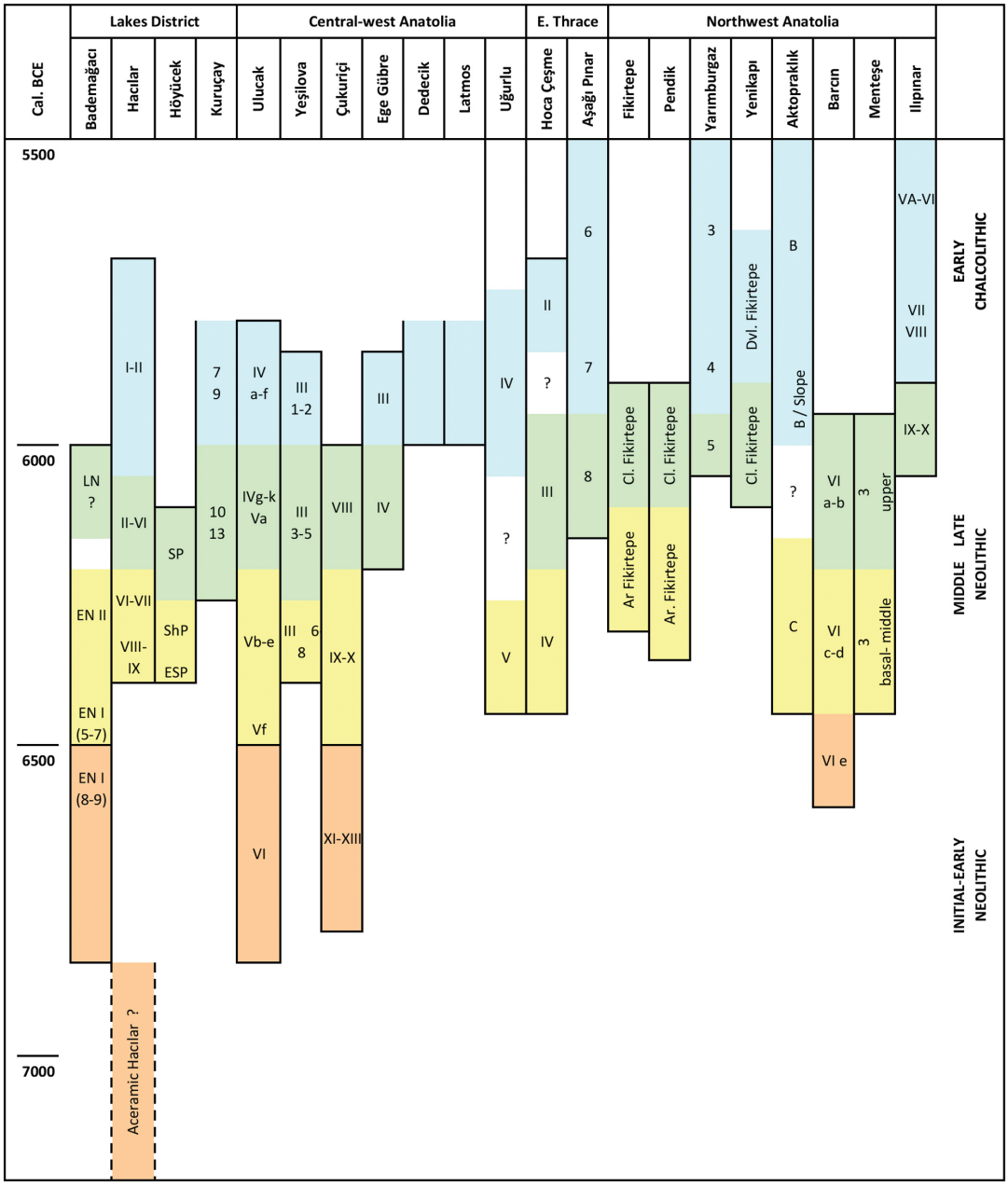


Fig. 2. Chronological table of sites in Western Anatolia.

On the other hand, the newly exposed early layers in Çukuriçi, located in the same area as Ulucak, have been associated with the Neolithic assemblages of the Levant and northern Mesopotamia, due to the presence of lithic tools and some other stone implements that bear the characteristic features of the PPN tradition (*Horejs* et al. *2015*). It is also often noted that Knossos and Franchthi had connections with the Eastern Mediterranean and the Levant (*Perlès 2001; Efstratiou 2013*). Likewise, the Neolithic assemblage of Ege Gübre, which dates to a slightly later period, has been compared to the contemporary sites in the Eastern Mediterranean and Cyprus, mainly concerning the presence of impresso decoration and to features of the architectural remains at the site (*Sağlamtimur 2012*). The relationships between different areas of the formative zone show that the expansion of the Neolithic was more complex than previously assumed.

In recent years, in characterising the period in the newly Neolithised regions outside the formative zones, a number of different suggestions have been made (see *Reingruber 2015*). Pottery, seen as one of the most characteristic elements of the westward expansion of the Neolithic, and has been at the centre of these debates. However, the present data suggest that in the earliest stages of expansion, pottery

was not among the 'unavoidable' components of the Neolithic way of life. Pottery emerged on the Anatolian Plateau at the end of the 8th millennium BC, and was rarely used until approx. 6700–6600 BC. It then existed mostly as coarse, plant-tempered, thick-walled and simple ware (*Özdoğan 2009*). Pottery from this period in Central Anatolia is defined as 'Early Tradition' by Serap Özdöl, and defined in detail by Suberde and Çatalhöyük (*Özdöl 2012*). Therefore, the existence of little pottery or none at the earliest Neolithic settlements in the Aegean or in Western Anatolia is consistent with the central and eastern parts of the peninsula. Layer VI in Ulucak, where no pottery has been encountered, is also consistent with this picture (*Çilingiroğlu* et al. *2012*). Recently discovered layers at Çukuriçi present a similar situation; although no detailed published description of the pottery vessels is available yet, the excavators note that pottery is insignificant in the material assemblage of layers XI-XIII of the mound (*Horejs* et al. *2015.305*). Aceramic Hacılar and Bademağacı ENI 9-8 present a coherent picture, although the dates of both sites and the presence of pottery in Aceramic Hacılar are quite controversial (see *Brami, Heyd 2011; Özdoğan E. 2015*).

While pottery from layer VIe at Barcın in Northwest Anatolia is slightly later than the earliest pottery in Central Anatolia, dating to 6600 BC, the presence of fewer coarse and simple wares is remarkable. At Barcın, the pottery assemblage includes simple plant-tempered thick-walled spherical vessels, baked at low temperatures (*Gerritsen* et al. *2013b.Fig. 11–14*). Based on this, pottery production in Northwest Anatolia is therefore reminiscent of the 'Early Tradition' in Central Anatolia, although with later dates.

The scarcity of early Neolithic settlements, the diversity displayed in the quality and quantity of pottery types recovered is remarkable; thus we termed this stage as the 'initial phase' (*Özdoğan E. 2015.51*). As far as can be understood, there is evidence of village life at all the settlements, as well as full adaptation to agriculture, animal husbandry, and their associated technologies. Thus, the presence or absence of pottery relates to the process of adapting to the newly emerging technology of pottery production rather than to the expansion of the Neolithic. In terms of the first pottery with these coarse and simple features, no trace has yet been encountered in the Lakes District or Central-west Anatolia. It seems that pottery appeared in these areas when it was more developed or, alternatively, it represents a process independent from the Central Anatolian early pottery tradition.

From the mid-7th millennium BC, consistent with the increase in the number of new settlements, pottery became a common commodity. Defined as the DFBW (dark-faced burnished wares) group or the 'Middle Tradition' by Özdöl (*2012*), the pottery from this period shows some differences from region to region. The early pottery in Central-west Anatolia includes simple thin-walled spherical vessels in brown, cream and red tones known from Ulucak Vf, which is reminiscent of the DFBW tradition. The published assemblage from Ulucak Vf-b, Yeşilova III8-6, and Çukuriçi X-IX indicates that S-profiled bowls and the use of a red slip increases over time (*Çilingiroğlu* et al. *2012; Derin 2012; Horejs 2012*) Although rather rare, vertical lugs and small horizontal handles with flat- or disc-shaped bases are distinctly characteristic of these assemblages. The pottery assemblages of the Lakes District present a similar picture; cream, brown and red tones dominate the pottery of Bademağacı ENI-II, Höyücek ESP-ShP[1], and Hacılar IX-VIII (*Duru 2008; Duru, Umurtak 2005; Mellaart 1970*). In this area, bowls and open forms with thin walls and flat bases have been found over a wider area. The number of vertical lugs and the use of red slip also increase over time.

Although there seem to be some stylistic difference between the Uğurlu and Hoca Çeşme assemblages, both dating to the latter half of the 7th millennium BC in the northeast Aegean, it is possible to see highly burnished, thin-walled, high quality ware in vibrant tones of red and black, especially in Hoca Çeşme (*Erdoğu 2013; Karul, Bertram 2005*). The vessels are generally small and have sharply cut S-profiles. Contemporary with the aforementioned Hoca Çeşme ware, in other parts of Northwestern Anatolia what has been termed 'Archaic Fikirtepe' ware predominates, mainly at sites including Barcın VId-c, Aktopraklık C, and in the basal layers of Menteşe, Fikirtepe, and Pendik; this material features small and simple closed shapes, mainly bowls and hole-mouth jars (*Gerritsen* et al. *2013a-b; Karul, Avcı 2011; Roodenberg* et al. *2003; Özdoğan 2013*). These are in cream, light tones of red, dark brown and different shades of grey. Vertical tubular or horizontal lugs, and flat bases are common; the quality of craftsmanship improves through time, with the walls of the vessels becoming thinner. Disproportio-

1 ESP is the Early Settlement Phase, ShP is the 'Shrine Phase' and SP is the 'Sanctuaries Phase'.

nately large horizontal lugs are among the most characteristic features of 'Fikirtepe Culture', mainly at Pendik and at Fikirtepe (Fig. 3), although they are dated to a slightly later period than other sites in the southern part of the Sea of Marmara.



Fig. 3. Globular jars from Fikirtepe (after* Özdoğan 2013.Fig. 7*).

In the last quarter of the 7th and the beginning of the 6th millennium BC, pottery groups show remarkable differences and more variety in form. Certainly, the distinctive feature of this period is the style of decoration; the different noteworthy pottery traditions include vessels decorated with light on dark paint in the Lakes District (*Duru 2008; Mellaart 1970*), monochrome red slipped wares in Central-west Anatolia and vessels with a dark, matt surface without decoration or, rarely, with narrow incised decoration in Northwest Anatolia (*Çilingiroğlu* et al. *2012; Derin 2012; Sağlamtimur 2012; Horejs 2012; Özdoğan 2013*).

The percentage of painted pottery revealed in Hacılar V (Fig. 4) increases after Layer VI in the Lakes District (*Mellaart 1970*). Together with the painted wares' sharper S profiles, the emergence of carinated bowls is observable. The painted pottery of Central Anatolia had been associated with Halaf painted pottery by Mellaart, mainly due to the presence in both regions of open bowls and necked jars with painted decoration. In Central-west and Northwest Anatolia, painted decoration (Fig. 5) is seen very rarely. However, red-slipped vessels are quite frequent and S-profiled vessels tend to increase over time. One of the changes in this area is the appearance of impresso decoration in the late 7th millennium BC (*Çilingiroğlu 2016*). This type of decoration is frequently seen at all the settlements in the area, especially at Ege Gübre (*Sağlamtimur 2012*). While impresso decoration appears almost simultaneously in the Lakes District, where the percentage of impresso is relatively quite low, its appearance being almost as infrequent as the painted ware in Central-west Anatolia (*Duru 2008*). Impresso decoration emerges in the early 6th millennium BC in Northwest Anatolia, at Aktopraklık B (Slope), Ilıpınar VIII, and Yarımburgaz 5 (*Karul, Avcı 2013; Thissen 2001; Özdoğan 2013*). In all three regions, the pottery tradition continues by retaining its former features during the 6th millennium BC, but a range of new forms are added, in particular necked jars and large storage vessels. There is an increase in the number of incision-decorated vessels, particularly among the 'Classical Fikirtepe' stage in Northwest Anatolia, and painted ware in the Lakes District. In general, with the exception of the ware with sophisticated decoration of the Lakes District, pottery of the 6th millennium BC in most other regions is coarser compared with pottery in the earlier stage.

Similarities and differences in the material assemblage

Subsistence strategies

Animal husbandry and agriculture had been fully adopted by the initial stages of the Neolithic in Western Anatolia. Recent studies have demonstrated that domestic sheep and goat were present in the central



Fig. 4. Painted vessels from Hacılar V (after* Mellaart 1970.Tabs. 277, 279*).



Fig. 5. Painted pottery from Aktopraklık B, Aktopraklık project archive.

and western parts of the Anatolian Plateau from the early phases of the Neolithic, but cattle and especially pig were domesticated through different processes (*Arbuckle 2013; Ottoni* et al. *2013*). Intensive wild cattle hunting seen from the Aceramic phase onward in Central Anatolia and the presence of bull symbolism in the area is known from Çatalhöyük; however, the appearance of domesticated cattle is dated to the middle of the 7th millennium BC. This is a thousand years later than the domestication of sheep and goats, which took place in the 8th millennium BC. Domestic cattle remained uncommon in the region, and auroch hunting continued until the 5th millennium BC (*Arbuckle 2013.1808*). More striking data are available for pigs; Central Anatolian Neolithic societies hunted pig very infrequently, and the emergence of domestic pigs in the region dates to after the Neolithic. Domestic pigs existed in the northern part of the region in the middle of the 5th millennium BC, while in southern parts, evidence of domestic pig is only found in the Bronze Age (*Arbuckle 2013.1809*). In the periphery of Central Anatolia, however, domestic cattle are present from the early stages. Likewise, it is understood that domestic pigs are encountered at the first Neolithic settlements in the Lakes District and Central-west Anatolia and that local pigs were also domesticated. It has also been suggested that the existence of domesticated pig dates to the early 6th millennium BC in Northwest Anatolia, and the method and impetus for the domestication of pig then passed through Central-west Anatolia (*Ottoni* et al. *2013; Arbuckle* et al. *2014*). The appearance of domesticated pig is not the only novelty in Northwest Anatolia in the early 6th millennium BC. At the same time, impresso decoration and mud brick architecture has been encountered at Aktopraklık B (Slope) (*Karul, Avcı 2013*); shortly after Aktopraklık B, both impresso pottery and mud brick architecture seem to have dispersed to the regions north of Bursa, as evidenced at Ilıpınar (*Roodenberg, Alpaslan-Roodenberg 2013*). Although both the presence of domesticated pig and impresso decoration shows ties with Central-west Anatolia, the tradition of mud brick walls with buttresses indicates sustained interaction with the southern parts of Central Anatolia and the Lakes District. Another important feature of Northwest Anatolia in terms of subsistence patterns is the diversity of data on fishing and mollusc gathering. Although there is some evidence of the use of marine or lacustrine sources at sites within the Central-west Anatolia and Lakes District, the consumption of marine fauna is remarkably high in Northwest Anatolia, especially at coastal settlements. Here, mollusc gathering and open-sea fishing were important activities in the food economy, together with the hunting of game animals (*Boessneck, von den Driesch 1979*). Dairy products are also characteristic of the region; residue analyses from different sites in Northwest Anatolia show that the use of dairy products dates from the late 7th millennium BC (*Evershed* et al. *2008; Thissen* et al. *2010*).

Architecture and village patterns

Different traditions regarding building materials and plan-types, as well as settlement patterns are to be seen in Western Anatolia during the Neolithic period. From the earliest stage, some structures with terrazzo-like and red-coated floors have been recovered, mainly at sites such as Ulucak VI, Bademağacı EN 8, and the so-called Aceramic Hacılar (*Çilingiroğlu* et al. *2012; Duru 2008; Mellaart 1970*). Despite our limited knowledge of the settlement layout, the presence of wattle and daub structures has been attested at Ulucak, while structures with mud brick walls exist at Hacılar. In the Lakes District, mud brick architecture is a characteristic feature of the Neolithic and Early Chalcolithic periods and, as known from Kuruçay and Bademağacı, stone foundations are also to be seen in some layers. The use of wattle and daub architecture seems to have continued from the earliest layer up to the end of Layer V at Ulucak (*Çilingiroğlu* et al. *2004; 2012*). On the other hand, as revealed at Çukuriçi, buildings with stone foundations were also built in the region (*Horejs 2012*). However, later mud brick architecture with stone foundations replaced the use of wattle and daub, as indicated at Ulucak IV, Ege Gübre and Yeşilova (*Çilingiroğlu* et al. *2012; Sağlamtimur 2012; Derin 2012*).

Different traditions were also in present at the same time in Northwest Anatolia. While there are simple

wattle and daub huts in coastal settlements and Aktopraklık, which is located in a mountain threshold area, settlements like Barcın, Menteşe and the early layers of Ilıpınar (X-VIII) have a well-organised rectangular village pattern with wattle and daub or mud-slab structures (*Özdoğan 2013; Karul, Avcı 2013; Gerritsen* et al. *2013a; Roodenberg* et al. *2003*). But the most important difference between these two groups lies not in the structural plans, but in the functions of these structures. In settlements with rectangular plans, the organisation of the interior of the structures shows that these buildings bore the characteristic features of 'Neolithic dwellings' in terms of installations, storage facilities, the distribution of finds and the multi-functional purpose of the house as shelter, storage space, and living space, whereas structures in coastal settlements remain relatively simple huts. The huts at coastal sites appear as simple shelters compared to the concept of the house that existed during the Neolithic in Anatolia. With the 6th millennium BC, architecture and settlement plans were subject to strict rules in Northwest Anatolia (*Karul, Avcı 2013*). In Aktopraklık B and Ilıpınar VI-VA, buttressed buildings with mud brick walls are organised adjacent to one another in a curvilinear or circular pattern. Built according to the same dimensions, structures are organised around a large central courtyard. This architectural pattern, specific to this region, developed with time, its earliest examples being the wattle and daub structures built adjacent to one another at Barcın in level VId (*Gerritsen* et al. *2013a.95*). Here, open spaces in front of the houses are used as open courtyards where the activities of everyday life took place. A more or less similar pattern consisting of structures in lines around a large courtyard (Fig. 6) is also characteristic of the Lakes District. Structures in two clusters in Hacılar VI are referred to by Mellaart as part of a settlement pattern with a circular plan similar to the rectangular layout of Hacılar II and the round layout in Hacılar I (*Mellaart 1970.10–11, 28–29, 77*). Mud brick walls with buttresses also appeared in the early 6th millennium in the Lakes District; the structures in Hacılar I and Kuruçay 7 (with stone foundations) are buttressed (*Mellaart 1970.Fig. 35; Duru 1994. Fig. 24*). Almost contemporaneously, mud brick architecture also appears in Ulucak, but here the layout of the settlement is different, as the buildings were separated from each other by narrow streets; still, closed courtyards are present, not as shared spaces, but as parts of specific structural units (*Çilingiroğlu* et al. *2012.Fig. 3*). This settlement pattern is currently attested only in this region, and specifically in Ulucak IV. Layer III at Ege Gübre in the same region presents a different picture; here, structures were placed around a wide open space, seemingly an open courtyard (*Sağlamtimur 2012.Fig. 2*).

Burial customs

During the Neolithic, one of the differences between the sub-regions in western Anatolia is the burial customs. In the formative zone of the Neolithic, early in the period, intramural burial was the common practice. Along with simple inhumations in pits, there was a diversity of burial practices, such as skull removal and, occasionally, treatment of skulls, collective burials, and secondary burials, or post-burial practices *etc*., but all taking place within the settlement (*Erdal 2015*). One of the most significant chan-

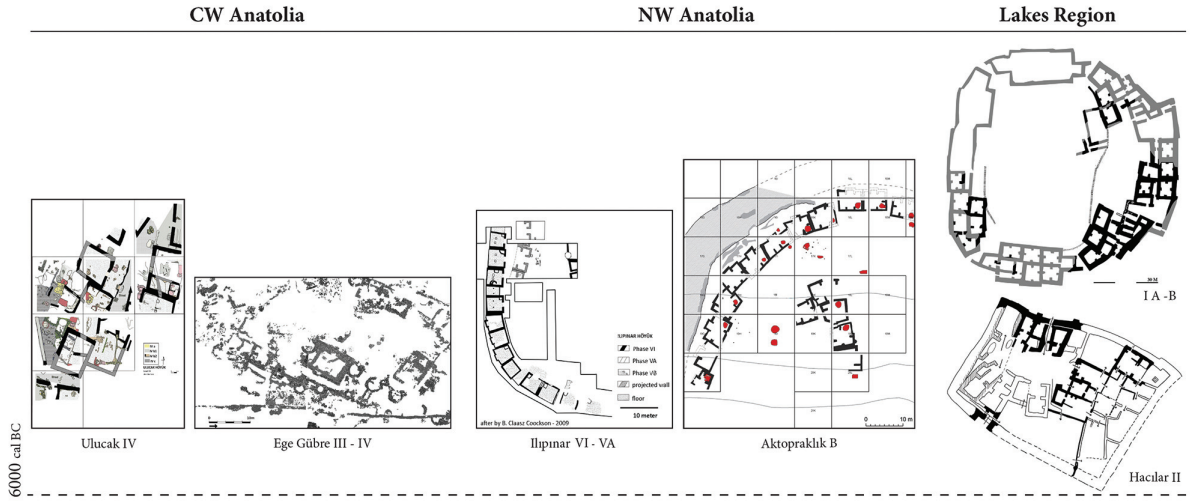


Fig. 6. Ulucak IV (after* Çilingiroğlu *et al.* 2012.Fig. 4*); Ege Gübre IV-III (after* Sağlamtimur 2012.Fig. 3*); Aktopraklık B (after* Karul, Avcı 2013.Fig. 14*); Ilıpınar VI-VA (after* Roodenberg, Alpaslan-Roodenberg 2013.Fig. 2*); Hacılar II and I (after* Mellaart 1970.71, 89*).

ges that took place with the onset of the Pottery Neolithic, still within the Formative Zone, was the custom of extramural burials. Although known extramural cemeteries are extremely rare, it is possible to surmise their presence from the almost total absence of burials within the settlement areas (*Campbell 1995*). On the other hand, Central Anatolian, is one of the few places where intramural burial customs continue up until the end of the 7th millennium BC, as extensively documented at sites such as Çatalhöyük, Tepecik-Çiftlik and Köşk Höyük (*Boz, Hager 2014; Bıçakçı* et al. *2012; Öztan 2012*). Additionally, at Köşk Höyük, skull practices continue into the 6th millennium BC (*Özbek 2009*).

In Northwest Anatolia, burial customs show parallels with Central Anatolia. Intramural burials or burials under house floors are common at sites during the 7th millennium BC (*Özdoğan 2013; Lillie* et al. *2012; Alpaslan* et al. *2013; Roodenberg, Alpaslan-Roodenberg 2013*). Most burials are in the hocker position and buried with grave goods such as bone spoons, whole pots, or polypod vessels. However, by the 6th millennium BC, burials had moved out of the settlement to graveyards (Fig. 7), as seen at Aktopraklık (*Karul, Avcı 2013*).



Fig. 7. Early Chalcolithic burial with grave goods from Aktopraklık graveyard in Area C (after* Karul, Avcı 2013.Fig. 6*).

The cemetery of the Early Chalcolithic settlement (Area B) is about 200m north of the site in Area A which contains the remains of a Late Neolithic settlement. However, in spite of the development of special cemeteries by the first half of the 6th millennium BC, the practice of intramural burial continued, as evidenced at Aktopraklık and Ilıpınar. Examples from Aktopraklık include single or double burials in extraordinary positions excavated beneath the central courtyard of the settlement (*Karul, Avcı 2013. 50*). Some human bones have also been found mixed with stones. At Ilıpınar, burials are also found in various positions, sometimes found lying on a wooden plate; however, most of the intramural burials at this site are small children and newborn babies (*Roodenberg, Alpaslan-Roodenberg 2013*).

Intramural burials and their associated customs are phenomena also found in the Lakes District, although not as frequently as in Northwest Anatolia. A number of human skulls were discovered in structures at Aceramic Hacılar, which is considered to be the earliest settlement in the region (*Mellaart 1970.6*). Remains in a hocker position were found in pits at Bademağacı EN I and II, Hacılar IV, III, and Kuruçay 11, although there are few in number (*Duru 2008. 51; Mellaart 1970.Fig. 43; Duru 1994.18*). At Höyücek, a single child's grave was found in an area dating to the ShP or SP phase (*Duru, Umurtak 2005. 26*). Unlike in the other two regions, there are no burials at sites in Central-west Anatolia or the northern Aegean, with the exception of Ege Gübre, where one individual was found buried in a hocker position (*Sağlamtimur 2012.32*).

Material culture and symbolism

The early stages of the Neolithic, particularly in the northern parts of the formative zone, are exemplified by the extensive presence of symbolic elements, monumental communal buildings, and the use of special crafts that require sophisticated technologies and elaborate workmanship; however, with the transitional stage to the Pottery Neolithic, there is a clear decline in almost all of these (*Rollefson, Köhler-Rollefson 1989; Özdoğan 2014b*). The Aceramic Neolithic in Central Anatolia shows parallels with the Pre-Pottery Period in the east in terms of features like public buildings, painted floors, and intramural burial customs, *etc*. (*Özbaşaran 2011*). However, contrary to the decline in east, symbolic ele-

ments in Central Anatolia increase during the Pottery Neolithic, as best known at Çatalhöyük, Tepecik-Çiftlik and Köşk Höyük (*Hodder 2012; Bıçakçı* et al. *2012; Öztan 2012*). Although symbolic expressions are far more limited in Western Anatolia, some need to be described nevertheless.



Fig. 8. Anthropomorphic vessel from Hacılar I (after* Mellaart 1970. Fig. 525*).

The distribution of symbolic elements in Western Anatolia is not uniform; some elements are found in some districts, while other elements exist in other regions. For example, in Central-west Anatolia and the Lakes District, anthropomorphic (Fig. 8) or zoomorphic vessels occur, while in Northwest Anatolia they are absent. Bull symbolism is notably present in Central Anatolia, and is found on vessels in the form of relief decoration, mainly in the Lakes District and Central-west Anatolia (and sometimes in the form of painted decoration, see Kuruçay *(Duru 1994.Fig. 56)*), but in Northwest Anatolia, it seems to appear only as a variation of horizontal lugs, and very rarely (*Karul, Avcı 2011*). Additionally, polypod vessels known from Central Anatolia exist both in the Lakes District and Northwest Anatolia, but these are not present in Central-west Anatolia (*Schwarzberg 2005*). Polypod vessels are far more common in Northwest Anatolia (Fig. 9) and are considered a characteristic feature of the 'Fikirtepe Culture'.

Human figures, mostly depicting females, are quite common both in the Lakes District and in Central Anatolia (*Duru 2008.Fig. 152, 157–162, 164–168*). On the other hand, in Central-west and Northwest Anatolia these are less common than in the Lakes District (*Gerritsen* et al. *2013b.Fig. 17*). Some anthropomorphic figures in Central-west Anatolia can be found on vessels in the form of appliqués, which strongly resemble the three-dimensional examples found in the same region (*Çilingiroğlu* et al. *2012. Fig. 8; Sağlamtimur 2012.Fig. 17*).

Northwest Anatolia is particularly different from the other two regions with regard to the distribution of symbolic elements. In addition to the scarcity of figurines, objects such as pintaderas, stone vessels, and high-quality stone finds such as amulets or pendants *etc*., did not exist – especially not in the 7th millennium BC – in this region, as they did in the Lakes District and Central-west Anatolia. Although sling missiles are common throughout Western Anatolia, arrowheads are non-existent in Northwest Anatolia in contrast to other regions (*Özdoğan 2002*). On the other hand, finds such as bone spoons (Fig. 10), hooks or fine bone tools are present in all three regions, but bone tool technology; bone spoons and spatulas are notably more common at Northwest Anatolian sites (*Özdoğan 2013; Gerritsen* et al. *2013a; Karul, Avcı 2013*).

Conclusion

One of the most typical features of the Western Anatolian Neolithic is the continuity of settlements. After the establishment of settlements in the region, most survived until the Early Chalcolithic period, but only a few until the end of the Neolithic (Fig. 2). However, in Northwest Anatolia, some coastal settlements lasted for a relatively shorter period, such as Fikirtepe and Pendik. It might also be appropriate to add Höyücek, Kuruçay and Ege Gübre to the list of settlements that lasted for a more limited time. The continuity of the settlements is a reflection of overall regional continuity, and thus it is seen not only in the stratigraphy but also in the material culture. The features that characterise each region seem to have emerged immediately after this initial phase, shaped by local dynamics.

Intensive interactions can be traced between different areas of the formative zones and other sub-re-



Fig. 9. Polypod vessel from Fikirtepe (after* Özdoğan 2013.Fig. 9*).



Fig. 10. Bone spoons from Northwest Anatolia,* a-e *from Fikirtepe and Pendik (after* Özdoğan 2013. Fig. 14*); f from Aktopraklık B (after* Karul, Avcı 2013.Fig. 22*).

gions in Western Anatolia. Painted pottery being common in the Lakes District, in the southern parts of Central Anatolia and as well along the Mediterranean coastline and in northern Mesopotamia it is extremely rare in the western and northern parts of the Anatolian Plateau. Instead, there seems to be a tradition of red-slipped pottery in the Central-west, while, in northwestern parts it is supplanted by dark monochrome ware. Impresso decoration appears in the last quarter of the 7th millennium BC in Central-west Anatolia, and at the beginning of the next millennium in Northwest Anatolia, probably the result of interaction with Mediterranean and Aegean sites. Western Anatolia has some connections with the formative zones, as well as with networks emerging in the Aegean and Mediterranean; in addition to pottery traditions, the presence of Aegean and Central Anatolian obsidian is among the main evidence for these connections (*Milić 2016*). Likewise, female figurines, red-slipped ware, bull representations, mud brick architecture, intramural burial customs *etc*., are all indicators of strong parallels with Central Anatolia.

The continuity of cultural elements in Western Anatolia, the Aegean, and Greece suggest that the expansion of the Neolithic did not extend along a defined frontier line, but must have been a massive phenomenon. Nevertheless, it is more evident that the expansion of the Neolithic way of life was a multifarious event that cannot be explained by a single model. Accordingly, it has to be taken case by case, each having its own particular modalities defined by local conditions and relationships with different parts of the formative zone. Furthermore, all three sub-regions in Western Anatolia sustained interactions with Central Anatolia. They had their own distinct interrelations; thus, the features that the Lakes District had in common with Central-west Anatolia and Northwest Anatolia are greater than the similarities between the latter regions.

It is possible to categorise the cultural changes that took place in Western Anatolia in distinct time frames (*Özdoğan 2008; 2011*). The earliest Neolithic settlements outside of the formative zone had begun to appear by the second quarter of the 7th millennium BC, and their number seems to have increased in the middle of the same millennium. Following the formation of the first few early settlements, there must have been a massive movement, subsequently leading to the establishment of new settlement sites. In the next stage, approximately at 6200–6000 BC, with the spread of painted pottery and impressed decoration, significant changes take place in the cultural setting. During this stage, newly Neolithised areas beyond the formative zone began taking on a role as new or secondary cores. Thus, by this stage, the Mediterranean, the Aegean, and/or Western Anatolia can be regarded as new cores.

In this respect, the expansion of the Neolithic way of life into the Balkans must have been through different routes and networks of interaction, as elements were carried on from different regions through Anatolia, the Aegean and Greece. A substantial increase in the number of settlements in the Balkans took place between 6000 and 5900 BC. This expansion, as the settlements appeared over a wide area, must have been associated with some global fluctuations rather than the internal dynamics of sub-regions. On the other hand, these dates fit the climatic events suggested recently by Bernhard Weninger and his colleagues (*Weninger* et al. *2015*).

The beginning of the 6th millennium BC is conventionally considered as marking the chronological division between the Late Neolithic and Early Chalcolithic periods; however, no significant changes can be observed in the cultural assemblages of the sites in the western and southern coasts of the pen-

insula. On the other hand, in Central and Northwest Anatolia, marked changes took place during that time. In addition to the change observed in material culture, the location of the Neolithic settlement at Aktopraklık moved 200m south, the settlements at Menteşe and Barcın ended, and new settlements like Ilıpınar emerged. New settlements such as Kanlıtaş and Orman Fidanlığı located along the valley of the Sakarya River connecting the Marmara region with inner Anatolia, and Gelveri in Central Anatolia (*Türkcan 2015; Efe 2001; Özbudak 2012*) define the formation of the Chalcolithic as far back as the early 6th millennium BC. The changes taking place in this period can especially be seen at Çatalhöyük West and Canhasan in the southern part of Central Anatolia (*Biehl, Rogasch 2013; French 2005*). During this period, interaction between Central and Northwest Anatolia seems to have accelerated. Appearing first at Aktopraklık and then at Ilıpınar, the tradition of building structures with buttresses and mud brick walls reflects the same traditions as at Canhasan or at Çatalhöyük. However, over time the mud brick structures in Northwest Anatolia came to be built with circular plans, continuing the layout of the previous period. These structures are arranged in adjacent lines at Barcın VId, an entirely different design from the agglomerate settlement pattern of Central Anatolia. The same phenomenon has also been evidenced in the Lakes District at Hacılar I and Kuruçay 7, where the structures have mud brick walls with buttresses. Although construction techniques and the other features show many similarities between the areas and prove the existence of interaction between the regions, it is difficult to say that the features in each region were transferred wholesale from one to another. Local adaptation processes seem to have played a major role in each sub-region in Western Anatolia, while incorporating new elements.

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A social perspective on the Neolithic in western Iran

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ABSTRACT – *While the Neolithic revolution caused gradual basic changes in different dimensions of human life, including social structure, western Iran has so far mostly received attention in terms of the emergence of domestication and sedentarisation. Generally speaking, some evidence, such as architectural elements, burial goods, clay tokens, and scarce artefacts such as obsidian pieces and marble objects not only determine an inter-regional interaction, but also suggest craft specialisation. It is believed that sedentary life and private food storage paved the way for property ownership and that a gradual change from egalitarian to non-egalitarian societies can be seen in the Neolithic of western Iran.*

IZVLEČEK – *Medtem ko je neolitska revolucija povzročila postopne osnovne spremembe v različnih dimenzijah človeškega življenja, tudi v družbeni strukturi, je območje zahodnega Irana deležno pozornosti predvsem zaradi pojava domestikacije in sedentarizacije. Posplošeno, nekateri podatki, npr. arhitekturni elementi, grobni pridatki, glineni žetoni in redki artefakti iz obsidiana in marmorja, ne določajo le med-regionalne interakcije ampak tudi specializirane obrti. Verjamemo, da sedentarni način življenja in privatno shranjevanje hrane predstavljata osnovo za privatno lastništvo, in da lahko v času neolitika na območju zahodnega Irana opazujemo postopen prehod med egalitarno in neegalitarno družbo.*

KEY WORDS – *Neolithic; social structure; initial complexity; western Iran*

Introduction

Since the time when Gordon V. Childe (*1936*) referred to the transition from the late Pleistocene to the early Holocene as the 'Neolithic revolution', this issue has primarily received attention in the light of changes in subsistence, *i.e.* foraging to farming. In the 1960–70s, processualist archaeologists focused on the interaction of humans with the environment which moved forward the economic dimension of the most crucial revolution in human history, as Ofer Bar-Yosef (*2001*) puts it. The Neolithic revolution, however, was not only a change in subsistence from foraging to farming; it also affected the social structure of those people who took the first steps into a new world that had never been experienced before. In archaeological theory, the central importance of the social emerged mainly over recent decades (*Hodder 2007*). Social archaeology is the archaeology of society, and so encompasses a very wide range of topics (*Dark 1995. 88*). Basic questions posed by the social archaeologist concern social order, reproduction and social change (*Shanks 2005.179*). It could be expected that alongside subsistence, social structure was changed by the onset of the Holocene, when new ways of life emerged; nevertheless, the economic results have been acknowledged much more than other dimensions of the Neolithic revolution. However, some investigations have recently begun to explore the nature of changes in social organisation in this period. Therefore, archaeologists are now directing new attention to the social context of Neolithic life at the household, community, and regional scales (see *Pollock* et al. *2010; Byrd 1994; 2000; 2005; Flannery 1972; Voigt 2000; Kuijt 2000; Kuijt,*

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Goring-Morris 2002; Goring-Morris 2000; Bar-Yosef, Belfer-Cohen 1991; Cauvin 2000). Collectively, these investigations offer an alternative perspective on the Neolithic transition by shifting the point of debate from questions of how and when plant and animal domestication occurred to what the nature of Neolithic social organisation was throughout this period, and how might these social frameworks have been linked with new systems of food production (*Kuijt 2000.311–312*). On the one hand, the examination of the social structure of early Neolithic societies is restricted mainly to the Levant (see *Flannary 1972; Byrd 1994; 2000; Kuijt 2000; Kuijt, Goring-Morris 2002; Ali 2010*) and Anatolia (*Rosenberg, Redding 2000; Bleda, Marciniak 2006; Pearson* et al. *2013; Wright 2014*), since the data set for the region is the strongest across the Near East. On the other hand, some other areas, like western Iran, have been very poorly targeted in this regard, although new evidence sheds new light on the Neolithisation process in the region (see *Darabi 2012; 2015; Matthews* et al. *2013a; 2013b; Riehl* et al. *2012; 2013; 2015*). In western Iran, however, previous investigations mainly focused on the subsistence issue and, thus, the social consequences of the Neolithisation process are largely overlooked. This resulted from the fact that the region was initially targeted by researchers who concentrated primarily on early domestication (see *Braidwood 1960; 1961; Braidwood* et al. *1961; Hole* et al. *1969; Mortensen 1974; 2014; McDonald 1979; Smith 1972; 1976; Pullar 1990*), while it should be seen as a geographic-cultural zone wherein early socio-cultural developments were established as an inter-connected 'whole' in the early Neolithic.

Therefore, this article should be regarded as an introduction to the social consequences of Neolithisation and the social indications of Neolithic societies in western Iran. This is dealt with on a general regional scale, so the elucidation of the social daily life of any particular Neolithic site – as already applied to Toll-e Bashi, Fars (see *Pollock* et al. *2010*) – is not attempted here. In fact, a social interpretation of some archaeological finds from Neolithic contexts is discussed in order to investigate the social structure of Neolithic communities in western Iran. Chronologically, the period under discussion coincided with the Transitional Neolithic through the late Neolithic, *c.* 9500– 5500 BC. As taking a regional social perspective is difficult, the targeted archaeological finds might seem to be limited. However, I attempt to present those archaeological data that are interpretable in investigating social structure at the regional level.

Archaeological evidence

As archaeologists, we are concerned with how social structure extends into material culture, what types of materials are usually targeted, and to what extent. In this regard, many types of data and different attitudes have been employed to try to reconstruct social structure: burial, settlements, artefacts, and human remains (*Dark 1995.88*). However, within a regional context, different materials could be taken into account. Moreover, each archaeological period may require a particular artefact assemblage. Therefore, settlement patterns, human burials, architectural remains, and artefacts such as tokens, figurines, stone tools, and marble objects are briefly discussed here. In addition, subsistence will also be partly addressed. It is believed that all these, and possibly more, evidence should be investigated as an 'inter-woven whole' to gain insights into the social structures of societies living in the early Holocene era (Fig. 1). To better understand the diachronic change and continuity of social structure, one might prefer to place the issue within chronological

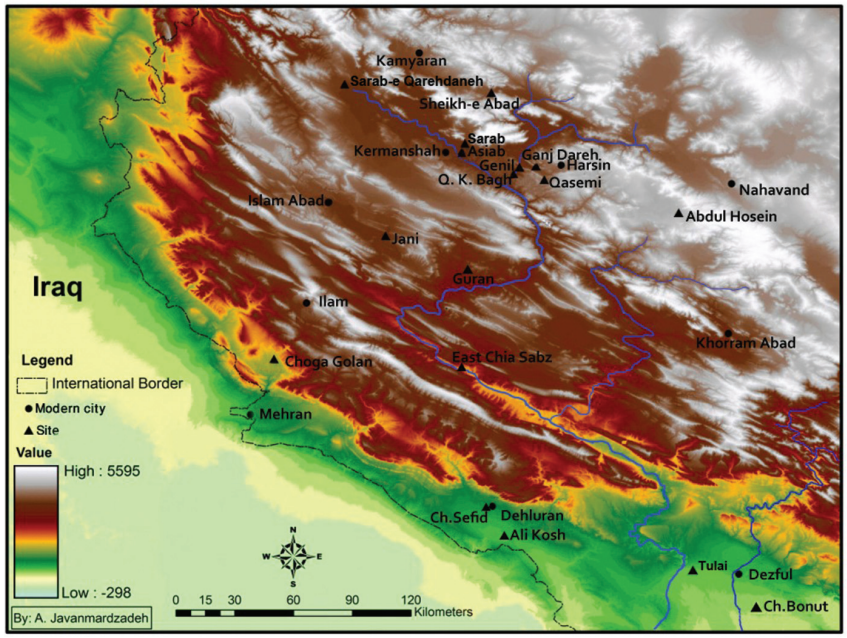


Fig.1. Map showing the location of the main Neolithic sites in western Iran.

(sub)periods. However, it should be noted that Neolithic archaeology of the region explicitly suffers from limited archaeological evidence, especially in terms of the social dimension. This obliges us to discuss the issue in details from the Transitional Neolithic (*c.* 9500–8000 BC) through the Neolithic period (8000–5500 BC). However, some archaeological evidence concerning these periods is presented below.

Although any examination of the transitional period requires attention to the preceding Late-Epipaleolithic time, our information is mostly restricted to the lithic tradition which limits our understanding of social structure. In general, we may assume the hunter-gatherer groups were 'small bands' mostly occupied with economic concerns (see *Bender 1978*).

The evidence associated with the Transitional Neolithic period is limited in western Iran. The time span that we are concerned with involves a gradual change from a migratory to semi-sedentary lifestyle from the mid-10th millennium BC onward, when the climate improved at the end of the Younger Dryas (*Darabi 2012; 2015*). The scarcity of evidence might be the result of the seasonality of occupations, which left shallow deposits, or they were buried by later sediment or occupations. However, it seems that some sites, such as Sheikh-e Abad and Chogha Golan, were seasonally inhabited in the mid-10th millennium BC. By the early 9th millennium BC, some new occupations, including Asiab, East Chia Sabz, and possibly Sarab-e Qareh Daneh, came about. In addition, Ganj Dareh E and basal Jani might have been given attention. This may indicate some kind of population increase. Although insufficient data remains the main obstacle to debating the social structure of the period, some evidence may be helpful.

From the mid-10th millennium BC, settlements changed from circulating annual movement to circulating semi-permanent (*Mortensen 1972; 2014; Darabi 2012; 2015; Weeks 2013*). Archaeological data indicate a sort of 'food resource management' in the Transitional Neolithic period (*Darabi 2012; 2015*). Some particular plant species, including two-row barley, emmer wheat and lentil were cultivated during the 9th millennium BC (*Riehl* et al. *2012; 2013; 2015*). At the same time, goats were also herded (*Zeder 2008; 2011*). Although a gradual change in subsistence is estimated, data on social structure are still hidden. However, we presume that changes in settlement and subsistence patterns must have occurred alongside changes in social structure.

As a result of changing from seasonal occupation to semi-sedentism, an increase in population must have occurred in the early 9th millennium BC. Therefore, the environmental resources were not sufficient to feed the whole population in the small valleys or intermountain plains such as Konjan Cham or Kurtavij, where Chogha Golan and Sheikh-e Abad were respectively established. This resulted in the diversification of people across western Iran in a way that led to an increase in the number of sites. However, later pressures on resources paved the way for an alternative solution, *i.e.* food management and, subsequently, the beginning of the Neolithic period. However, the area of the sites is not determined. At Asiab, the surface finds suggested that the site might have extended over an area of approx. 2ha (*Howe 1983*). As Asiab seems to have also been reoccupied during a later period, perhaps the late 8th millennium BC, the precise area of the Transitional Neolithic occupation is unclear. In addition, the site might have been horizontally extended through time. Excavations at Asiab, however, revealed different finds, such as bone objects, stone tools, stone implements, obsidian tools, marble objects and human burials. Some of these might date to a later phase; however, recent excavation at the site can be helpful in this respect.

One of the most important signatures characteristic of the Transitional Neolithic period are pits, usually dug into virgin soil at the basal levels of sites such as Asiab (*Howe 1983.115*) and Ganj Dareh E (*Smith 1972b.193; 1976.12*). Other sites have not yet been excavated sufficiently. At Asiab, a large oval expression found in the lowest layers is regarded as a refuse pit and also a possible semi-subterranean structure. However, the pits seem to have been used for storing food supplies or even parching grain[1]. This arrangement allowed people to remain in one place for a longer period, resulting in population growth. No evidence of privacy or property is seen during the transitional period, although the numerous pits might indicate that each family had separate storage facilities. The first presence of grindstones shows an increasing emphasis on plants. People lived in huts built from perishable materials such as wood and reeds. Therefore, no solid trace of architecture has been found adjacent to the pits. This prevents an estimate of the possible mean population at both home and site levels and how densely populated each site was. If pits indicate an initial property, they probably paved the way for private property or ownership, which is seen in the succeeding early

1 In some areas of the region, such pits were even used until some decades ago, mainly by nomadic people for storing grain.

Neolithic period, during which several changes seem to have occurred in western Iran: the emergence of morphologically domestic species; the emergence of true villages with solid rectilinear architecture; standardisation of stone tools; development of places for rituals; production of some new objects, such as clay tokens; and the introduction of obsidian tools and marble objects. These innovations can be useful for an investigation of social structure.

In the Neolithic period, *ecotones* were still the environmental priorities for occupation; especially places close to fresh water or with fertile cultivable soil. It seems that most houses were built of different available materials, including mud (*pisé*), mud-brick and stone. Buildings are rectilinear in plan, with a small area. They might be seen as the earliest architectural remains; although recent excavation at Tapeh Asiab seems to tell us something different on the circular pise walls, the Neolithic architectural remains must have mostly been preceded by the application of perishable materials. Excavations at upper Sheikh-e Abad and Ganj Dareh D revealed cellular rooms which were linked together to form a complex building. No evidence of foundations is mentioned until the second half of the 7th millennium BC, when some walls were founded on stone in the Deh Luran Plain (*Hole* et al. *1969; Hole 1977*). Two-storey houses have also been attributed to Gnaj Dareh D (*Smith 1990*). The emergence of public or ritual buildings alongside residential sites is of interest. At upper Sheikh-e Abad, two kinds of architectural traces were found, known as Buildings 1 and 2 (*Matthews* et al. *2013a*). Building 1 comprises an irregular agglomeration of several rooms made of clay. The rooms are generally rectilinear and oriented south-west/ north-east. The dimensions of rooms are small, ranging from approx. 1.8 to 2.5m. Outside the buildings, some features were also excavated which have been considered as activity areas or sometimes animal pens. Building 2 comprises a single major room built from shaped mud-bricks, as well as occasional indistinct lumps of *pisé*. The walls, at approx. 80cm, are thicker than the walls of building 1, which are generally 30 to 36cm thick. The interior area has a T-shaped plan with, similar to building 1, with no remains of an entrance. The most important material in the building included skulls, horn-cores, and the maxillae of five wild herbivores (four goats and one sheep) arranged in two pairs with a single sheep skull placed behind the eastern pair (Fig. 2). Traces of red ochre were clearly evident on the maxilla and cheek of a skull positioned in the eastern front part of the assemblage, and as spots on the surface of the floor under the skulls. The distinctive architecture and internal features such as *in situ* skulls suggest a ritual area at the site (*Matthews* et al. *2013a*).

A ritual site was also discovered at Ganj Dareh D (Fig. 3). Here, a pair of wild sheep skulls had been carefully fixed inside one of the portholes. The architectural features of Ganj Dareh D are so prominent that they have been regarded as 'a futureless innovation' (*Smith 1990*). Although the evidence that explicitly indicates ritual/non-domestic buildings is confined to these two sites, as recently seen from Tapeh Asiab, more is expected across the region. Some architectural remains indicate an intra-site difference between the houses that have been excavated so far. At Genil, walls were built of large mud-slabs and plastered with mud or white lime, also sometimes used for floors. A large domed structure filled with stones was also discovered (*Smith, Mortensen 1980*). In one case at Abdul Hosein (*Pullar 1990.9–10*), a floor had been re-plastered seven times, sometimes with red ochre. However, more prominent evidence comes from Tapeh Guran, where excavations have shown that almost all the floors in levels K, J, and H consisted of a mixture of clay and lime with a large number of white pebbles. These floors were made in a kind of 'terrazzo-technique' with large pieces of chalk-spar carefully laid in a solid mortar of ochre-coloured clay (*Mortensen 2014.28*). Based on the radiocarbon dating and pottery styles, these levels could be dated to around 6000 BC. In the lowlands, some mud-brick platforms were un-

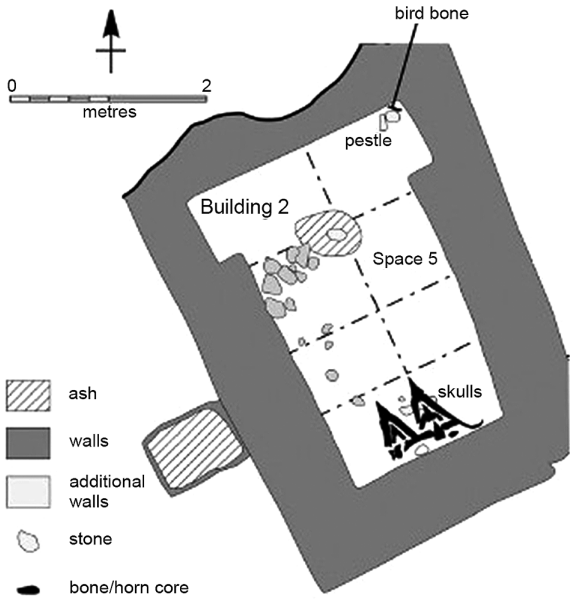


Fig. 2. A ritual building recovered from upper Sheikh-e Abad (adapted from* Bendrey *et al.* 2013. 153, Fig.12.2*).

covered at Chogha Sefid which measure approx. 7×10m in size, standing about 1.8m high, founded on large stones; they were built of standard mud-brick, 60×30×10cm in size (*Hole 1977*).

In addition to the architectural remains, other artefacts such as obsidian tools and marble objects may provide us with informative data. The emergence of obsidian pieces in the region is archaeologically remarkable. Across the Near East, obsidian pieces are entirely attributed to sources in Turkey and the Caucasus (*Renfrew 1969; Renfrew, Dixon 1977; Abdi 2004*). It seems that the late 8th millennium BC witnessed the first appearance of chipped obsidian tools in western Iran (*Darabi, Glascock 2013*). This phenomenon might have been associated with the transhumant communities which were moving across the region and perhaps transported the obsidian blanks. This indicates that obsidian was indirectly transported in western Iran. However, the emergence of obsidian, along with marble objects, could indicate an indirect inter-regional contact.

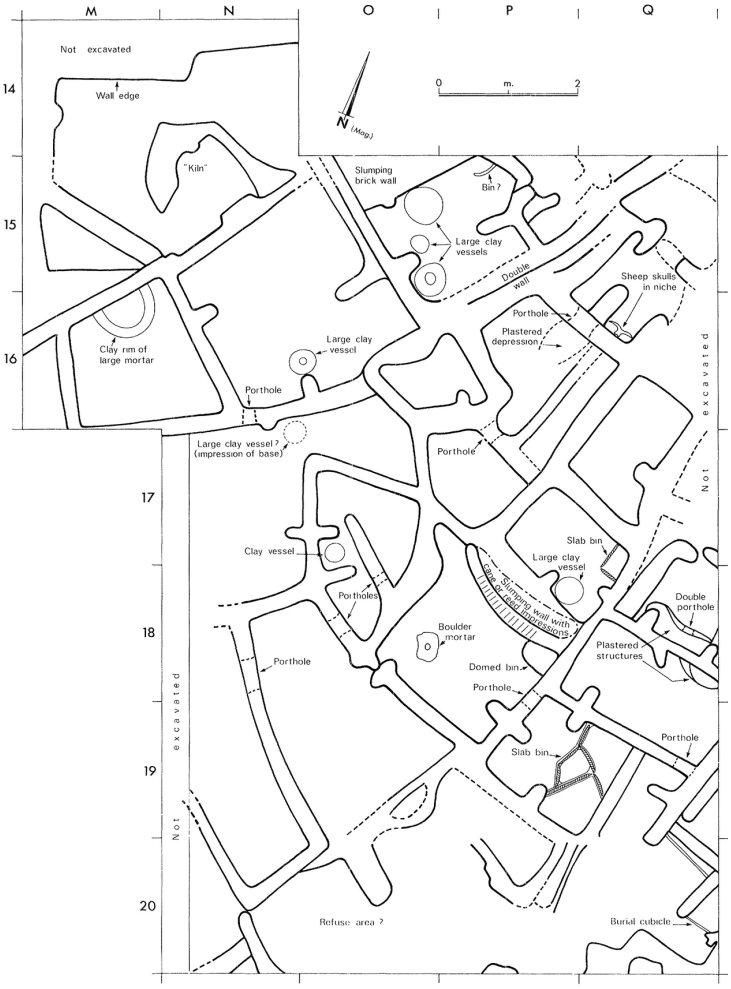


Fig. 3. Rectangular cellular buildings from Ganj Dareh (after* Smith 1990.327, Fig. 1*).

Although the most regularly used approach to reconstructing social structure is perhaps the use of burial evidence (*Dark 1995.90*), this type of evidence is quite rare in western Iran. In general, burial traditions show continuity through time, with flexed or crouched positions being predominant. In this regard, some samples are accompanied by burial goods. Unlike in the Levant or Turkey, however, individuals were buried entire under floors, and no signs of 'skull removal' or 'skull cache' have been found. As a result of excavations at Asiab, two burials were found, one in a crouched and another in an extended position. Ochre seems to have been applied in association with the latter (*Howe 1983.115*). At upper Sheikh-e Abad, six burials were found under floors. They had no distinct grave cuts and were accompanied by no obvious grave goods; however, two skeletons seem to have ochre stains. In addition, the remains of a reed mat are also believed to be connected with one find (*Cole 2013*). In two cases, the burial cut through the walls. This may date the burials to a period later than the architectural remains, including the so-called 'ritual building'. Excavations at Ganj Dareh revealed a notable number of human burials in two crouched and extended positions. They are associated with ages varying from infant to adult. In one case, a multiple burial consisting of three individuals in a clay coffin was discovered from level D (*Smith 1972.193; 1976.17*). One burial was accompanied by many stone and shell beads. Also, the remains of a reed mat were discovered with one skeleton. Of the two burials found during the first season of rescue excavation at East Chia Sabz, one was accompanied by goods, including a stone bead and a necklace made from perforated land snail shells (*Darabi* et al. *2011; 2013*). A combination of crouched and extended burial customs is also seen at Abdul Hosein, where a stone vessel was found adjacent to a single burial. Moreover, four skeletons were found which, in Judith Pullar's view, might have been buried as the result of a roof collapse (*Pullar 1990.10*). At Genil, two bodies were buried under the floor in a tightly flexed position and one with possible signs of cranial deformation (*Mortensen, Smith 1977; 2014; Smith, Mortensen 1980.511–*

512). Cranial deformation has also been reported from Ganj Dareh and Ali Kosh. In the Ali Kosh phase, some burials were wrapped in a reed mat (*Hole* et al. *1969.248*). In addition, one burial was entirely coated with red ochre. From the succeeding Mohammad Jaffar phase (zone A1), several burials were found, sometimes accompanied by shell and turquoise jewellery, stone beads, and labrets (*Hole* et al. *1969.47*). No evidence of mat-wrapping was detected in this phase. However, one of the burials had been given more attention, with the most elaborate grave goods, including turquoise beads, a labret of turquoise, a bracelet of white shell beads, strings, and a bell-shaped stone pendant. In addition, the body was completely coated with red ochre (*Hole* et al. *1969.254*). The use of red ochre and reed mats is also seen in the later phase, at the site at Chogha Sefid (*Hole 1977*). At Guran, a heap of human bones was found in the lowest level. Furthermore, beads have also been reported as burial goods at the site (*Mortensen 2014*), and two tokens seem to have been used as grave goods (*Schmandt-Besserat 1992*). Clay tokens have been discovered, but not as grave goods, from other Neolithic sites, such as Ganj Dareh, upper Sheikh-e Abad, upper Asiab, Ali Kosh, Chogh Bonut, Chogha Sefid, Tulai, Sarab, and Abdul Hosein (Fig. 4). They appear from the early 8th millennium BC, when the true Neolithic period began in the region. This period roughly coincided with the development of clay animal and human figurines, as seen from the above-mentioned sites.

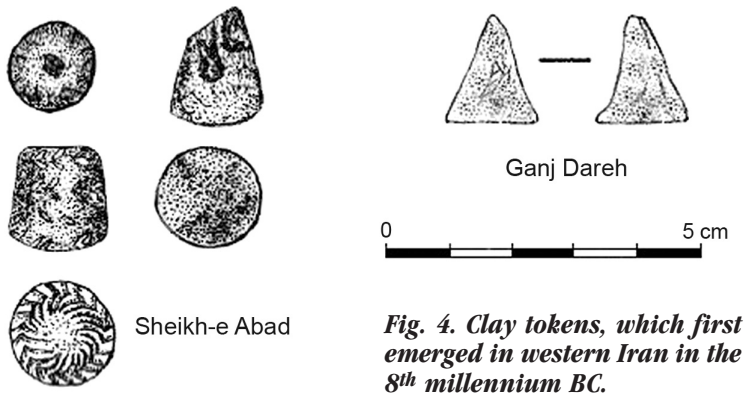


Fig. 4. Clay tokens, which first emerged in western Iran in the 8th millennium BC.

All these innovations occurred along with the emergence of new chipped stone types. As the most numerous Neolithic artefacts, stone tools display some standardisation and even craft specialisation. Although the chipped stone industry seems to have derived from the preceding Zarzian tradition (*Kozłowski 1994; 1999; Olszewski 1994; 1996*), the most prominent change was the beginning of the M'lefatian industry in the Early Neolithic, during which a combination of retouched, backed, and truncated pieces, including bladelets, blades, and sometimes flakes, along with blade/let cores, are prevalent. However, this industry more or less continued through the Neolithic period (Fig. 5), in which flint-knapping became 'domestic'. In fact, 'the domestication of flint' is an idea suggesting that, unlike in the Paleolithic, the preparation of tools, like a number of other daily activities, was entirely an on-site task inside or outside houses (*cf. Mortensen 1988.199; 2014.123*). This might be evidence for a specialised task, as seen by standardisation in stone tool production.

Discussion

In order to assess social structure, a theorisation of material culture is required. Although the social typology of band, tribe, chiefdom, and state has had a tremendous influence on social archaeology (*Sahlins 1968; Service 1964*), this paper does not attempt to place the Neolithic societies of western Iran in any



Fig. 5. M'lefatian industry and standardisation of chipped stone tools in Neolithic western Iran (after* Darabi 2015.89, Fig.7.10*).

of these individual evolutionary models. Instead, the discussion is based on the archaeological evidence that may offer hints of social structure. Architectural structures and settlement patterns form an important source for considering social structure. The architecture of buildings has been seen as representing functions related to specific social divisions, or symbolising social position or relationships (*Dark 1995.97*). Prior to the emergence of the earliest solid buildings that may indicate sedentary life, societies appear to have used perishable materials periodically. Therefore, the layers of ash which usually form the lowest layers of Neolithic sites could be the result of using perishable materials. This type of housing mostly indicates a transition to the Neolithic period, during which some kind of primary food storage might have been in use. If so, each community attempted to own the surrounding resources to feed its members. But as food resources were depleted, camps were separated locally, and resources were hidden from other members of the camp. Therefore, initial storage practices must have been the result of attempting to find alternative food supplies, *i.e.* predomestic cultivation and animal husbandry. In fact, food storage is known as a means of risk management (see *Kuijt 2009*). As Marion Benz (*2004.28*) pointed out, population growth and thus reinforced social differences may have led to territorial commitment in the Transitional Neolithic period.

In western Iran, population increases can only be estimated according to an increase in settlement numbers until further research. Although the basic steps, food resource management in particular, were taken during this long period spanning from *c.* 9500 to 8000 BC, the social structure will not be known until further evidence is discovered. But it is during the succeeding Early Neolithic that some changes are seen; in particular, architecture, burials, clay tokens, stone tools, and the introduction of some materials made of obsidian and marble are of interest.

The earliest known architectural remains include cellular rooms with a rectilinear plan. Rectilinear buildings with subdivisions offered less communality than circular rooms into which access is direct. This may strengthen privacy. It has been suggested that the appearance of these buildings coincided with the appearance of private or individual storages (*Flannary 2002*). This could be taken as an indicator of private ownership or property, which might have paved the way for an initial hierarchy in the Neolithic period.

Kent Flannery (*1972*) identified two site types in the archaeological literature – circular hut compounds and rectilinear house villages – and examined the ethnographic literature for insights into the social structure of these settlement types. Based on his considerations, early clusters or compounds of circular buildings during the Natufian and Pre-Pottery Neolithic A (PPNA) were hypothesised as representative of patrilineal, polygamous families. Each building was typically occupied not by a family, but by one or sometimes two people (typically a man or one of his wives). In later Neolithic villages, in contrast, "*rectilinear buildings are designed to accommodate families, rather than individuals*". These buildings of the Pre-Pottery Neolithic B (PPNB) were hypothesised as being occupied by families of three or four people. Thus, the transition from circular to rectilinear buildings coincided with a shift in residential units from polygamous to monogamous households. Nuclear households or simple households generally comprise spouses and their children, while extended families or complex households include two or more co-resident married siblings or additional adult members (*Byrd 2000.66*). However, the remains of circular houses are not seen in Neolithic western Iran and, as mentioned, the earliest solid houses seem to have been rectilinear in plan, which may suggest a kind of monogamous extended household in the early Neolithic period.

In general, two types of building have been defined at Neolithic sites in western Iran: residential and ritual. The former is distinguished by the nature of the internal features, the presence of *in situ* artefacts for food processing and preparation, and the production and maintenance of tools and other domestic equipment. It was also facilitated by storage. The two ritual buildings which have so far been discovered in the region are clearly indicated by the style of building – usually different from domestic buildings – the associated features and objects, such as animal skulls, and also the energy expended in their construction (for the criteria of Neolithic ritual buildings see *Byrd 1994*). These criteria have been employed by archaeologists to infer the proper ritual or symbolic function of the buildings (*Smith 1990; Matthews* et al. *2013a*).

Gary O. Rollefson (*1998; 2005*) has divided ritual buildings into 'shrines' and 'temples'. In his view, shrines were smaller, because they might have been used by smaller groups (lineages), while temples were larger and more complex and might have served the entire community. The ritual buildings

found in western Iran, however, indicate a tendency for sacred places to have been used by a single community or even by several settlements located close together across a geographically separated valley or plain.

The latter issue might remind us of a sort of 'ritual centrality', perhaps similar to Göbekli Tepe in southeastern Turkey (*Schmidt 2005; 2011*). Ritual buildings do not automatically signify inequality, but raise questions about corporate authority (*Wright 2014. 7*). A ritual area was not necessarily located inside the settlement. A particular sacred area close to the village might have been targeted to enact rituals. If so, it is almost undetectable archaeologically. It should also be kept in mind that a few locations, such as Ganj Dareh and Sheikh-e Abad, might have been ritually central to the surrounding settlements. Such centrality probably offered a higher status across the region.

Perhaps ritual centrality in the Neolithic period could be compared somewhat with contemporary religious centres or sacred places; each is primarily revered by particular groups of people. In western Iran, some Neolithic settlements included buildings that seem to have been more elaborate than the rest. The most costly buildings would have been the most important. According to the rank-size rule, the bigger a building, the higher was its rank. If so, ritual areas at Sheikh-e Abad and Ganj Dareh, and some other notable buildings such as those found at Guran and Chogha Sefid, may hint at rank or differentiation within the social structure of some communities. The size and height of the platforms discovered at Chogha Sefid and their standard mudbricks (see *Hole 1977*) could indicate a non-residential or public function.

Across the Near East, public buildings have been discovered at different Neolithic sites, such as Jerf el-Ahmar (*Stordeur 2000*), Mureybet (*Cauvin 1977*), Hallan Çemi (*Rosenberg 1999; 2011*), Çayönü (*M. Özdogan 1999; A. Özdogan 2011*), Göbekli Tepe (*Schmidt 2005; 2011*), Jericho (*Kenyon 1953*), Beidha (*Byrd 1994*), Ain Ghazal (*Rollefson, Kafafi 1997*), and Wadi Faynan 16 (*Mithen* et al. *2005*). Although we are not sure about the ritual function of some of these buildings, ritual behaviours functioned to reduce tension in times of environmental stress within farming societies (*Rollefson 1998; Verhoeven 2002*). In addition, Ian Kuijt (*2002*) believes that ritual behaviours were a means of gaining authority in farming societies. Therefore, the role of ritual areas and those who were responsible for ritual matters might have been of importance in organising societies. This comes to the fore when we consider the co-emergence of public buildings and clay tokens, which may indicate the economic role of ritual areas. However, an intra-site spatial analysis can yield valuable information on the function of architectural remains, and one should examine the arrangement of space within building interiors, focusing on the location and function of internal structural features, and the nature and spatial distribution of the associated artefacts (*Byrd 2000.66*).

In the so-called open area at Sheikh-e Abad (*Matthews* et al. *2013a*), close to the ritual building, a large amount of animal bone was found, presumably a hint of consumption beyond household needs. This area could also indicate a site of activity where various objects such as stone tool and bone objects were made. However, Bar-Yosef (*2002.119*) believes that common buildings indicate an increase in the level of social structure.

In addition, the application of lime or gypsum in architecture is also regarded as a mark of initial specialisation and social complexity (*Kingery* et al. *1988*). As a result of her ethno-archaeological investigation, Carol Kramer (*1979.148*) stated that variation in the frequency and quality of floors suggests differential access to source materials and perhaps socio-economic status. However, if multi-roomed rectilinear structures indicate extended families consisting of various members, for example, grandparents, uncles, aunts *etc*. (*Flannery 1972; Byrd 2000*), they might indicate that economic activities were shared by genetically related households. These households had a tribal kinship system (see *Bender 1978*); although they would have shared storage facilities, situated either within only one building or as smaller adjacent storage structures (*Byrd 2000.87*), individual storage was emerging. Kin affiliation, however, was highly important in Neolithic villages that consisted of relatives. In the case of Sheikh-e Abad, where very small grindstones were discovered, a kind of shared area for food producing or processing may have been identified, although this may also indicate an abandonment which was not the result of a sudden event. It should be noted that reconstructing the function of prehistoric buildings is extremely difficult. The function of buildings may change over time, and the archaeological evidence may imply only the ultimate use of a building or include a compilation of signatures from a sequence of functions (*Byrd 2000.67*).

It seems that household size did not radically change during the entire Neolithic period (*c*. 8000–5500 BC). However, a trend toward the greater use of internal space for domestic activities, storage, production, and the increased size of settlement populations is assumed. This could result in the building of some larger spaces through time; buildings of various sizes are seen in Neolithic western Iran. Perhaps smaller structures indicated smaller population numbers, seasonal use, and less reliance on domesticated plants and, hence, less need for storage and processing locations.

Beyond the intra-site level, spatial analysis could also be informative regionally. In the region, no settlement layouts have been found that are comparable in size to the mega-sites known from other areas of the Near East. It seems that variation in size resulted from the carrying capacity of the environmental resources around the sites across western Iran. Compared with a maximum of 0.5 to 1ha as the average size in the region, however, some sites like Chogha Golan must have reached approx. 3ha in the 8th millennium BC. As noted above, this variation in settlement size seems to correlate with resource abundance (see *Hole 2000*) and the ensuing population growth at the some sites, while some other settlements maintained their small area based on the available resources. This shows an adaptation to the surrounding environmental resources to support enough people in one place. However, this fact does not mean 'centrality', as proposed for the Levantine PPNB, with sites exceeding 10ha in area (see *Rollefson 1998; Simmons 2007*). Generally speaking, fundamental cultural changes have been attributed to the onset of the PPNB period, *c*. 8500–7000 BC, while the preceding PPNA period, *c*. 9500–8500 BC, witnessed a transition in multiple aspects of social life.

Apart from buildings and settlement layout, some artefacts could give hints on social structure. The simplest way in which artefacts are used by archaeologists to form the basis of their conclusions about social structure is by ordering them according to their value or significance as perceived by the archaeologists concerned. Artefacts may be ranked on the grounds of their materials, their scarcity, or the amount of effort required to produce them (*Dark 1995.95*). An artefact type may have had special value: (1) if it is made of material imported from a considerable distance; (2) if there were difficulties associated with importing; and (3) if manufacture was unusually labour intensive (*Wright 2014.12*).

In this regard, some objects made of obsidian and marble deserve attention. These two groups of material seem to have contemporaneously emerged around the late 8th millennium BC in western Iran. It seems that obsidian was not equally valued in all places – some sites indicate higher usage than others. In the light of natural obstacles, including the mountains and deep valleys in the region, villages appear to have been unable to import obsidian directly from the sources. Therefore, some kind of intermediary trading must have been established which resulted in obsidian distribution across the region. Unlike in western Zagros, high amounts of obsidian tools were not used in the Neolithic occupations. Therefore, an indirect relationship could be assumed between south-eastern Turkey and western Iran. Here, the most probable route to import the obsidian must have been through western Zagros (*Darabi, Glascock 2013*). Stefan Karol Kozłowski (*1999. 63*) believes that a highly specialised obsidian mining and processing system (mines and workshops) appeared in another region, perhaps in Turkey. Regarding the presence of clay tokens and public or elaborated buildings at some sites, an administrative organisation might be inferred.

Inter-regional relationships are not reflected only in obsidian trading, but also in marble, which was used to produce various objects such as ornaments and vessels. Marble objects have been found at different Neolithic sites, such as East Chia Sabz, Asiab, Genil, Guran, Ali Kosh, *etc.* These materials became important inter-regionally and used from *c*. 7200 BC onward across the Near East (*Kozłowski, Aurenche 2005*). Furthermore, it seems likely that finely-walled stone vessels were also produced at the same time. However, the mechanism of production and exchange organisation is unknown. Perhaps these scarce objects were used as prestige goods in Neolithic society. If so, they may reflect social differentiation, which is also detectable in some burials.

The pioneering work of Arthur Saxe (*1970*) and Lewis Binford (*1971*) opened up the analysis of mortuary practices as a primary means of investigating past social systems. Archaeologists have recently devoted considerable attention to mortuary and ritual practices as a way to reconstruct broader Neolithic social organisation and the existence of some degree of social differentiation (*Kuijt 2000. 317*). In western Iran, burials could help us find clues to the social structure of Neolithic people. Did the varying mortuary practices signal particular social units in society? Collective burials could indicate a collective

identity for the society. However, finds of such burials have so far been limited to a few cases recovered from lower Guran, Abdul Hosein, and Ganj Dareh D. In addition, plastered skulls or skull removal, which is reported from sites in the Levant and Turkey, is not seen in Neolithic western Iran, where burials are mostly found underneath floors in a tightly flexed position.

As mentioned above, however, some individuals were treated differently. Perhaps some burials that were accompanied by grave goods, or wrapped in a reed mat or coated with red ochre indicate initial social ranking. In this regard, the richest example, from the Mohammad Jaffar phase, is of interest. However, diachronic changes are not clear through time, and burial traditions indicate a kind of more or less regional homogenisation of community members at the time of death.

In addition to ritual buildings and burial customs, rank is also indicated by the presence of clay tokens. Neolithic clay tokens have been widely analysed by Denise Schmandt-Besserat (*1982; 1992; 1996*), who attributed their emergence to around 8000 BC, describing them as the precursor of a writing system. She believes that Neolithic tokens were associated with an agricultural economy to record goods, functioning as symbols for them. In western Iran, the earliest known examples, from Ganj Dareh and Asiab, are dated to around 8000 BC (*Schmandt-Besserat 1992*). Although the later part of the Neolithic period yields more clay tokens, their emergence in the Early Neolithic could indicate a sort of counting system contemporaneous with the beginning of sedentary life and ritual buildings. These innovations perhaps suggest a kind of initial administrative system and political power which relied upon controlling real goods. However, there seems to have been an inter/intra-site counting system, which outlines a regional and interregional bureaucratic relationship. Schmandt-Besserat (*1992.198*) determined two stages of clay systems: plain and complex. In her view, these stages correspond to two phases in the evolution of social structure. The plain tokens seen in the Neolithic period imply a ranked society, and counting was an indicator of privilege. Perhaps rituals areas functioned as places for the administration of economic activities in agricultural societies. If so, the 'temple-based economy' dates back to the beginning of the Neolithic period.

In addition to tokens, clay was also used to produce figurines (see *Schmandt-Besserat 1974*). It seems that the emergence of figurines should be given attention in relation to a new economic strategy based on agriculture. As more individuals could create a bigger food supply and provide better security for themselves, a higher population would become a preference. This signals the importance of higher birth rates and, therefore, females found higher social positions in society. The fact that female figurines were mostly show protrusions could mean they were fertility symbols, and an emphasis on producing more children (*Voigt 2000*). In addition, perhaps some particular figurines, such as seated females, were status symbols of some kind (Fig. 6). Therefore, specific symbols might have corresponded to specific ranks. In his discussion on the ritual and social structure of Ain Ghazal, Rollefson (*2000. 184*) believes that certainly some of the PPNB animal figurines belong in a 'toy' or analogous category, but others (particularly human and cattle figurines) appear in contexts that indicate controlled ritual usage (and perhaps production by certain shamans or other ritual practitioners). Regardless of the possible function of figurines in the Neolithic context, their spatial and temporal distribution should be considered in association with inter-related aspects of the society, including subsistence, rituality and social organisation.

While some artefacts, such as those made of marble and obsidian, may indicate inter-regional contact, some others, such as chipped stone tools, suggest local standardisation and craft specialisation. During the transitional Neolithic, a combination of Zarzian, along with the earliest signs of M'lefatian tradition, which is here referred to as 'Pre-M'lefatian tradition', is seen (see *Kozłowski 1994; 1996; 1999; Olszewski 1994; 1996*). By the beginning of the Neolithic period, however, the M'lefatian tradition became prevalent. Although very gradual change can be traced in the Neolithic chipped industry in western Iran, stan-



Fig. 6. A seated female figurine with protrusions from Tapeh Sarab (after* Vahdati Nasab, Kazazi 2011.4, Fig. 2*).

dard tools such as blades and bladelets at some sites such as upper Sheikh-e Abad (*Vahdati Nasab* et al. *2013*) could indicate some kind of domestic specialisation. Kozłowski (*1999*) argued that a high-value black flint might have been traded across the region as a desirable raw material. This, alongside the standardisation of stone tools, might hint at craft specialisation, although this issue requires further investigation.

Concluding remarks

Although population numbers are difficult to reconstruct and verify, we may assume that population increase caused an increase in site numbers in western Iran. As a result, people were confronted with food shortages and, therefore, they had to manage food resources in the 9th millennium BC. Perhaps storage pits were used in this regard in the transitional period. In addition, this might have resulted in restricted access to resources and, therefore, territoriality (for the role of territoriality, see *Gebel 2014*). Archaeologically, territoriality is perhaps shown by different styles of artefacts, although some were shared at a regional or inter-regional level. For example, we may observe the presence of particular objects such as some distinct pottery styles in many areas, while others were restricted to a specific area. These ideas address both local 'micro-packages', each formed by a combination of local natural, social, and cognitive environments, and regionally-shared 'macro packages' in Neolithic western Iran. In the Neolithic period, however, the long-term storage of grain paved the way for private property and a reduction in reciprocity. In other words, some degree of property implies a departure from the generalised reciprocal sharing typical of mobile hunter-gatherer societies. Therefore, seasonal surpluses, when coupled with private storage and increasing agriculture, laid the foundation for the earliest steps toward social complexity. Generally speaking, the transition to agriculture probably coincided with a transition from common property to the earliest signs of private property.

At a regional level, archaeological evidence shows the emergence of fully domesticated species around 8000 BC, when the true Neolithic period began. This period witnessed the first signs of sedentism, with solid architecture, ritual or common buildings, clay tokens, and inter-regional contacts. It should be noted that at least some minimal level of social complexity is present in virtually any sedentary society (*Rosenberg, Redding 2000.39*). Increasing emphasis on agriculture was consistent with the increased use of grindstones (*Wright 1994*). If grindstones are found within domestic spaces, they may indicate self-sufficient food production and a kind of private property. On the other hand, if they are found in a non-domestic or common area, we may take them as indicators of their communal use or even collective food production. Although clusters of milling tools have been regarded as indicators of mass food preparation (*Asouti, Fuller 2013; Hayden, 2009; Wilcox, Stordeur 2012*), we are not sure this happened at some particular sites such as Chogha Golan, which have yielded amounts of grinding stones.

Private storage and food production signal ownership in the Early Neolithic. However, the possible role of ritual places should not be overlooked. Consideration of Neolithic architecture, mortuary practices and ritual actions collectively brings researchers to the point where we can start to reflect on how ritual and civic leadership might have been organised in different Neolithic communities (*Kuijt 2000.317*). Ritual buildings seem to have appeared in the early Neolithic at the same time as clay tokens. The authority of ritual practitioners should be economically and ritually placed within an intra/inter-site framework. If these ritual centres, along with clay tokens, indicate an initial administrative system, they may be regarded as a sort of preliminary to institutionalisation. Perhaps the presence of clay tokens at some settlements shows an inter/intra-site redistributive system organised by ritual practitioners. Therefore, the two-fold role of ritual places might indicate a kind of 'temple economy'. Ritual activities were structured at three levels inside a community: individual, household, and intra-community (*Verhoeven 2002*). In addition, an inter-site level was also possible. A few sites contain evidence indicating ritual areas in western Iran. This may suggest a 'regional centrality' in the way that each centre, such as Sheikh-e Abad, was regarded at an inter-site level. Besides ritual buildings, some other elaborate architecture, such as at Guran or Chogha Sefid, could be evidence of social differentiation. Generally, social differentiation may be identified by two processes: one related to trade, exchange and societal interaction, and another to the intensification and specialisation of production of agriculture and crafts and subsequently their management and control. The emergence of some scarce artefacts, including obsidian pieces and marble objects, indicate inter-regional interaction since the late 8th millennium BC onward. We are not in a position to say whether these objects were used by individuals in specific

areas or times or used as common material. The regional circulation of prestige goods is not clear. If the materials found within buildings are similar, they may mean the community was self-sufficient; if not, it would indicate cooperation and sharing, or inequality of access (*Wright 2014.16*). Intra or inter-site inequality of access to resources affects the social status.

In the Levantine PPNB period, stable isotope data from burials revealed possible differential food consumption patterns and may indicate social complexity (*Pearson* et al. *2013*). Different access to food resources could pave the way for social conflict. Social conflicts have not yet been inferred, although it has been supposed that Ganj Dareh D might have been burnt as the result of such an event (*Smith 1976; Bar-Yosef 2009.206*). In this regard, Frank Hole (*1987.33*) stated that some hunters maintained their ways of life alongside the early villagers for a considerable time in some areas and they must have been mutually influential, some cooperatively, some antagonistically; in the latter case by poaching herds or stealing crops stored in the villages. This may have stimulated the nucleation of settlements and eventually the construction of defensive structures. If this was the case, the thick clay wall discovered at Sheikh-e Abad may be meaningful, hinting at a kind of fortified occupation in the 8th millennium BC. It should be noted that fortified Neolithic villages have already been found across the Central Plateau of Iran (see *Malek Shahmirzadi 2006*) and Northern Mespotamia (*Matthews 2000*). This suggestion, however, could open a new window into further invaluable information on the social structure of Neolithic societies in western Iran.

Social, economic, political and religious territories might have been established within Neolithic societies, although they have always been intertwined. In fact, through artefacts people recreate their material world and their social relations. Material culture is known as a principal means of identification and distinction from 'the others' (*Balossi Restelli 2006*). For instance, to discuss the pottery found from the Neolithic site of Toll-e Bashi, Southern Zagros, Bernbeck *et alii* (*2003.78*) believe that the strong focus on one motif may have served a social function, unifying members of the community and setting them apart from neighbouring ones. However, people tended to perceive themselves as individuals differently from adjacent regions across the Near East. It seems that Neolithic people attempted to manifest their particular identity through making the particular artefacts seen in different archaeological sites in western Iran. At the same time, they shared some common artefacts or ideas which might have been produced by each group separately or, but with the same popular tradition, traded throughout the region. Small variations in burial customs, therefore, may show religious differences between those buried, or those burying them, or differences between local customs across the region. Moreover, some burials may be expressions of social status. This discussion explicitly concerns the two kinds of synchronous micro/macro-packages in Neolithic western Iran mentioned above.

Finally, it should be emphasised that, despite the fact that some archaeological evidence such as buildings, burials, and other artefacts hint at the social structure of Neolithic western Iran, our information is obviously limited. This prevents us from taking steps in more detail in this area of research until further information becomes available.

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Tools tell tales – climate trends changing threads in the prehistoric Pannonian Plain

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ABSTRACT – *This study of prehistoric textile production on the Pannonian Plain is based on indirect evidence dated to the period between the 5th and 2nd millennium BC; the study of technological trends and changes that occurred in manufacturing traditions concentrates on fibre processing and production. The functionality analysis of spindle-whorls served as a basis for comparing textile production trends with the results of the climate change model. Climatic changes in the area were simulated by means of a moderate-resolution Global Circulation Model (GCM). The simulation covered the mid-to-late Holocene, from 7000 years BP to the pre-industrial period.*

IZVLEČEK – *Predstavljamo študijo izdelave tkanin v prazgodovini na območju Panonske nižine, ki temelji na posrednih dokazih, ki datirajo v čas 5. in 2. tisočletja pr. n. št.; pri študiju tehnoloških trendov in sprememb, ki so se zgodile v tradicijah izdelave tkanin, se osredotočamo predvsem na procesiranje in izdelavo vlaken. Analiza funkcionalnosti predilnih vretenc nam je služila za osnovno primerjavo med proizvodnjo tkanin in rezultati modela klimatskih sprememb. Klimatske spremembe na tem območju smo simulirali s pomočjo svetovnega modela cirkulacije (ang. GCM) pri srednji resoluciji. Simulacija pokriva čas med srednjim in poznim holocenom, torej od 7000 let pred sedanjostjo do časa pred industrijsko revolucijo.*

KEY WORDS – *textile production; spindle-whorls; functional analysis; climate forcing; climate modelling*

Introduction

Reconstructing the resources

Textile fibres can be roughly divided into two main categories, vegetal and animal. At least according to the textile evidence from both Europe (*Barber 1991; Rast-Eicher 2005; Médard 2006; 2012*) and the Near East (*Schick 1988; Alfaro 2002; Burnham 1964; Helbaek 1963*) flax (*Linum usitatissimum L.*) and tree basts were the most frequent sources of textile fibre during the Neolithic period. Although most of the direct findings suggest that the early raw materials used in textile production were mainly of vegetal origin, their preponderance should be considered with caution. Despite the fact that animal fibres are made of protein and therefore are more resistant to decay than vegetal ones, which are composed of cellulose, one should keep in mind that linen preserves better in alkaline conditions, while animal fibres such as wool require acidic environments for preservation (*Cybulska, Maik 2007*). The fact that they are not found in the contexts investigated might not account for a genuine absence, but rather for the fact that the conditions for preservation were not met.

From the plant

The wetland settlements of the Alpine region facilitated the investigation of fibre from the flax plant (*Linum usitatissimum*) and its use in textile production, revealing details of both the plant's development and its dynamics. However, since animal fibres cannot survive in the alkaline soils of circum-Alpine dwellings, the possibility of wool use in these rich contexts remains elusive. Flax has been defined

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as one of the 'founder crops' that started agriculture in the Near East (*Zohary 1996*). Its early and simultaneous use for linen fibre production already in the 8th millennium BC has been attested by textile remains from Nahal Hemar cave in Israel (*Schick 1988.31*). In Central Europe, linseed specimens from the Jevišovice site at Hundssteig (3100–3010 cal BC) in Lower (eastern) Austria were incidentally found within a row of loom weights (evidence of the oldest in situ weaving loom in Austria. Although there is certainly a long way to go between seed-bearing flax plants and the fibres woven on a loom, this coincidence might well point to the use of flax in textile production (*Kohler-Schneider, Cannepele 2009. 67*). The earliest surviving linen cords from the circum-Alpine area of Europe attest to its use for textiles in the 4th millennium (*Barber 1991.11–15; Médard 2012.386–9; Rast-Eicher 2005.118–20*), although the earliest flax seeds in the same area predate the textile finds by almost two millennia.

However, the importance of flax in Eneolithic contexts within the investigated area of South East Europe has also been well documented in more recent reports (*Reed 2016*). In several studies based on differences in linseed sizes, archaeobotanists have made an effort to clarify the dynamics and patterns of its exploitation (*Maier, Schlichtherle 2011; Herbig, Maier 2011*). Since it is possible to distinguish between domestic and wild flax seeds (*Linum bienne*), mainly on the basis of features such as seed size (*Herbig, Maier 2011; Zohary* et al. *2012.101*), a similar methodological principle is used to distinguish between the two different varieties of domesticated flax.

Ancient Near Eastern seeds have a length of approx. 4.0 to 4.7mm and a width of approx. 2.3 to 2.7mm, their size remaining unchanged from 5000 BC to 1800 BC (*Helbæk 1959.109, Tab. 1*). Interestingly, in Central Europe, flax seems to have split into two varieties at an early stage, one with the large seeds used for linseed oil, and another with smaller seeds specialised for making textile fibres.

An extensive study of 4th and 3rd millennium waterlogged flax seeds from a series of wetland settlements in the Alpine region revealed that in the early phase (4000–3700 BC) seeds were significantly larger in comparison to samples from the ensuing periods (*Herbig, Maier 2011.529*). This difference in size cannot be correlated with natural or climatic variations and, according to the research, two flax varieties may be considered as possible proof of fibre specialisation. In the early phase, a flax type with larger seeds was cultivated for both oil and fibre production, similarly to the Near East (*Maier, Schlichtherle 2011.571*). At the same time, already in the middle of the 4th millennium BC (around 3400–3300 BC) a small seed fibre type appeared, which was introduced and cultivated to fit the needs of textile production (*Herbig, Maier 2011.529*).

The effects of osmotic stress on long fibre flax (*Chemicosova 2006; Dash* et al. *2014*) and its preference for colder and wetter conditions could offer an explanation as to why this new fibre variety of improved length and quality became the primary resource in Europe. Indeed, a central European 'flax-boom' (*Herbig, Maier 2011.531–532; Maier, Schlichtherle 2011. 571*) occurred at the end of the 4th millennium BC, when textile production intensified.

Spindle-whorls, spindles, loom weights, and finished fragments of netting and fabric allowed for the reconstruction of textile techniques throughout the wetland settlements. Well-preserved layers like those at Arbon-Bleiche 3 and Pfyn-Breitenloo contain the remains of flax processing, which provided valuable information on its preparation and handling. There is sufficient evidence to show that certain villages focused on growing it and processing the fibres (*Schlichtherle 2009*). Furthermore, the spatial distribution of textile tools within settlements points to the organisation and specialisation of textile work (*Maier 2001; Lauzinger, Rast-Eicher 2011.539–540*). Archaeological and botanical evidence suggest that in addition to the division of labour, certain socioeconomic differences developed whereby goods and economic factors, including flax, were not available to the same extent to all inhabitants (*Schlichtherle* et al. *2010*).

To the animal

Although the intensified use of animal fibres, namely wool, in textile production, was initially discussed in the context of Sherratt's model (*Sherratt 1981*), new evidence for milk consumption (*Evershed* et al. *2008; Bartosiewicz 2007; Craig* et al. *2005; Vigne, Helmer 2007*) and animal traction (*Fabiš 2005; Isaakidou 2006; Johannsen 2005*) does not support a big time lapse between the initial domestication, focused mainly on meat consumption, and the later use of secondary animal products. No such arguments for the early use of wool have been established so far, since the first woollen textiles are exceptionally rare and appear only from the 4th millennium BC (*Rast-Eicher 2014; Shishlina* et al. *2003*). Further-

more, linguistic research suggests a common root for the word 'wool' in Indo-European languages, pointing out that the notion of its soft and spinnable characteristics appeared prior to its departure from west-central Asia around 4000 BC (*Barber 1991; Chantraine 2009*).

Some attempts to place the beginnings of wool use earlier (*Rooijakkers 2012*) focus primarily on the Near East. New zooarchaeological investigations of sheep husbandry in Northern Mesopotamia (*Vila, Helmer 2014*) point to fleece exploitation shortly after initial domestication (around 6500 BC), suggesting that several breeds were involved in the selection process. Thus multi-origins and trade are considered important factors for the cross-breeding process.

Although the first use of wool was suggested to be parenthetical in the context of fibre production and processing, at least as far as spinning is concerned, it does account for the early knowledge both of the resource and its properties. It is thus considered plausible that sheep fleece developed new desired properties gradually (*Rast-Eicher, Bender Jørgensen 2013*), as a cumulative result of animal selection, involving out-breeding and cross-breeding practices by shepherds. Already developed and established Mesopotamian wool economies in the 3rd millennium BC, known from the numerous cuneiform sources (*Charvát 2011*) raise the argument that wool's first appearance should be dated much earlier.

An analysis of textile tools from Arslantepe (*Laurito* et al. *2014*) proposed household wool spinning already in the 4th millennium BC, and ethnological research in Greece showed that unspecialised herding can, and did, account for an ample amount of spun thread (*Rokou 1994*). In addition, both 'Neolithic' and 'Bronze Age' wool types occur in Iron Age contexts. Sheepskins and textiles from Hallstatt in Austria (dated to the 1st millennium BC) show a range of fleece qualities, with a selection of finer wool for weaving (*Ryder 1990a; 1990b; 1992*). This direct evidence confirms that the development from 'hair' to coarse wool and finally to fine wool in sheep was successive. Consequently, a definition of a single temporal horizon for the introduction of woolly sheep can be considered unconvincing (*Halstead, Isaakidou 2011*). Considering that multiple genes account for fleece development (*Ryder 1982*), Paul Halstead and Valasia Isaakidou proposed that the better fleece qualities might have been selected unintentionally and on diverse occasions (*Halstead, Isaakidou 2011. 67*).

Moreover, an important argument that additionally supports the idea of the multiple origin of the desired traits was a consequence of the dynamic gene flow – rather than of developed wool economies focused on increased production – is based on the fact that the better qualities of wool, regarding its finesse, are often found in places and periods remote from those interpreted as more specialised and established[1].

And 'back to the roots'

The definite separation of farming and foraging has been fairly criticised, and it is plausible that both strategies were practiced simultaneously (*Cummings, Harris 2011*). The use of foraged plant fibres before, during and beyond the Neolithic is supported by the substantial amount of direct evidence attesting to the common use of indigenous plants, including reeds, grasses and bast fibres from trees (*Harris 2014*). The best examples from the Pannonian Plain region were found at the Ljubljansko Barje dwellings in Slovenia, with preserved fibres of the grass family (*Poaceae*) (*Pajagič-Bregar* et al. *2009*) and leaf fibres of lesser bulrush (*Typha angustifolia*) (*Greif 1997.41*). Nonetheless, the result of the plant macro remains study of the late 4th millennium Stare Gmajne lakeshore settlement at Ljubljansko barje, should be mentioned, since they revealed that, besides poppy (*Papaver somniferum*), flax was the highest represented oil plant, which could also have been used for its fibres (*Tolar, Velušček 2009; Tolar* et al. *2010*).

Fabienne Médard concluded that, overall, there are more preserved cords, threads and cloth made from tree bast fibres than those made from flax (*Médard 2010.57*). She noticed that tree bast fibres (predominantly lime) were used mainly for twined cloth,

1 Commenting on Bronze Age wool quality, Michael Ryder compared contemporary Scandinavian and Egyptian produce: "*The wool in North Europe was naturally brown, while that in Egypt was white. Surprisingly, however, the Egyptian wool was coarser. This theme of finer wool in more primitive areas, or in earlier periods, is repeated throughout subsequent history*" (*Ryder 1974.110*). Subsequently, this was explained by experts (*Rast-Eicher, Bender Jørgensen 2013*) as indeed a finer wool quality from 'Nordic' sheep (genetically different from central European and Near Eastern sheep breeds). The Bronze Age 'Nordic' type wool of superior fibre quality to that of contemporary Egyptian production thus provoked a revaluation of the 'improvement through intensification' principle.

whereas flax was used mainly for woven textiles. (*Médard 2012.368*). This led to the conclusion that most of the tree bast fibres from the Neolithic lake dwellings in Switzerland were spun without a spindle, a technique characteristic especially of spinning long vegetal fibres (*Médard 2006.99–102*).

The use of both early wool and flax for textiles could be considered in this category. Collected wool tufts and wild flax fibres were probably competitive with the aforementioned plant resources, along with other materials, such as frequently disregarded goat hair (*Frangipane* et al. *2009*). Wild flax fibres were identified in a series of Upper Paleolithic layers at Dzudzuana Cave in Georgia (*Kvavadze* et al. *2009*), indicating that prehistoric hunter-gatherers were already using its fibre to make thread. There was certainly a substantial time lapse in sequential adaptations of fibre use before it become a primary resource for textile production.

Finally, if considered in a wide-scale process that involved gradual modifications and a refinement of practices, it is extremely difficult to decide when and where these secondary products were first recognised and exploited. Although Hans Helbæk suggested that flax was initially used for its seeds and then for its fibre (*Helbæk 1959.104; McCorriston 1997*), linen evidence is direct proof of its early use for textiles. Preserved textiles confirm that flax was used for its fibre already in the Early Neolithic in the southern Levant (*Schick 1988.31*).

Alternatively, the quality of early wool could have been controlled to a certain degree through fibre preparation. Sampling and manual sorting of fleeces and tufts could have resolved its hairiness and coarseness, resulting in a selection of spinnable material. This selection practice has been demonstrated with an analysis of Bronze Age skins and textiles from Hallstatt (*Rast-Eicher, Bender Jørgensen 2013*), revealing how a skilled wool-sorter could identify and categorise a range of wool qualities even with a flock of highly mixed sheep.

Due to gradual specialisation and the secondary product character ascribed to these fibres, it is extremely difficult to investigate the origin of their use and dynamics of their development. On the other hand, following their importance and representation in textile production, it is to some degree possible to determine when, where and why they became a primary resource, as their intensified exploitation was more culturally and environmentally dependent.

Theory and time

Apart from investigating the biological origins and developments of both wool and flax fibres, social and technological changes connected to their intensified exploitation could be approached through cultural historical narratives and theoretical frameworks. The economies of prehistoric communities across the Pannonian Plain would alter with specialisation in either of the resources, transforming fibre material into a commercial good, possibly involved in export and exchange. Both strategies, if intensified, would imply an increased anthropogenic factor. Maintaining large herds calls for opening the primeval forest vegetation in parts of Europe, where forest cover is not limited by climatic factors. The high water and high-quality agricultural land requirements of flax suggest direct competition with food crops. Thus, the benefits of developing traditional technologies and production as sub-branches of the fragile and not fully formed economies of the period seem even more reasonable.

The processual archaeology approach would argue that this next step was determined by a successful cultural adaptation to climatic and environmental conditions (*Binford 1968*), while the opposing post-processual approach would focus on explaining all changes in the past as a result of human agency (*Hodder 1986*). Regardless of the approach, the fact remains that developments of the technological aspect were the main determinant of 'success'.

Andrew Sherratt assembled different strands of evidence from archaeology and zooarchaeology into a consolidated model of the Secondary Products Revolution (*Sherratt 1981*). By suggesting that the main by-product of domesticates (traction, riding, milk and wool) occurred simultaneously, first in a narrow time span in the 4th millennium BC, he conceptualised them as economic achievements that developed several millennia after primary, meat-focused consumption. In this model, the main commodity, namely meat, was the objective of Neolithic herders, against the full range of exploitation, an achievement of the Eneolithic. Consequently, the model addressed the secondary products' potential for cultural evolution and social complexity in the transition from the 4th to the 3rd millennium BC. Interestingly, it is not the main postulate of the theory which is criticised, but the contemporaneous occurrence or intensification of different types of exploitation (*Vorsteen 1996; Halstead, Isaakidou 2011*). One of the biggest supporters of Sherratt's model, Haskel Greenfield, argued for a revision of the con-

temporaneity of its parts (*Greenfield 2005*), underlining the importance of intensification in scale, rather than origin of use. The initial critique of the model contributed to further questions on causality: were these 'innovations' a cause or a consequence of social and economic developments, did they influence each other, and finally, how?

The economic importance of secondary products, even if known for a long time, as proved in the case of milk (*Evershed* et al. *2008; Bartosiewicz 2007; Craig* et al. *2005; Vigne, Helmer 2007*), increases during the 4th millennium BC, which further shaped our research objectives. The 'competition of fibres' found its place in the paradigm due to the contemporaneity of the specialisation of both resources and the influence on economic factors that accompany their intensified use.

The wide time frame of our investigation, which encompasses two millennia, gave us the opportunity to pattern technological trends and changes on a large scale, rather than addressing culture-specific questions and particular inter-site dynamics. The focus on 4th and 3rd millennium BC textile production in the Pannonian Plain placed the research within the context of three periods: the Middle Eneolithic, Late Eneolithic and Early Bronze Age. The transformation from Middle to Late Eneolithic and from Late Eneolithic to Early Bronze Age societies in the Pannonian Plain from the final 5th to the ending of the 3rd millennium BC, and the role of local and exogenous influences, remain controversial. Further, all three periods are characterised by a number of partly overlapping 'cultures' whose definition is based primarily on pottery inventories and burial rites, so they do not necessarily represent social or economic communities. The 'Chronological framework for the Copper Age cultures of the Carpathian Basin and neighbouring territories' outlined by Pál Raczky (*1995.60, Fig. 1*) was chosen as the basis for the periodisation of investigated textile tool samples.

The chronological division we used placed spindle-whorl samples from the 1st half of the 4th millennium BC in the Middle Eneolithic and samples from the 2nd half of the 4th and the very beginning of the 3rd millennium in the Late Eneolithic assemblage. Samples from the advanced 3rd millennium contexts thus entered the Early Bronze Age assemblage. The classification of the investigated cultural-historical groups within these three periods remains arbitrary, especially due to the transitional character[2] of the particular 'cultures'.

Changing threads

In the process of hand spinning, the spinner continuously rotates the spindle and the spun yarn attached to it. As the tool rotates, the hands are used to draft the prepared fibres, while the weight of the tool pulls them, and its rotation twists them into a yarn. Tension and speed are the two main factors affecting the transformation from fibre to yarn. Smoother and shorter fibres call for a shorter, lighter draft and more twist to enter the fibres fast enough, while on the other hand, coarser and longer fibres allow for longer and heavier down-pull and less twist without causing a break.

As textile tools for fabricating yarn, spindle-whorls are the most commonly preserved evidence of fibre processing and production practices found in prehistoric contexts. The same proved to be the case with the sites studied in regions of South East and East Central Europe. Fortunately, they are also the most efficacious of textile tools for studying the differences of fibres. It has been widely accepted within the respective field of textile archaeology that the morphological features of the spindle-whorl relate to its functionality. A good number of reports from experimental archaeology have supported this dependency (*Grömer 2005; Mårtensson* et al. *2006; Verhecken 2010*). Nevertheless, the real impact and conditioning of these determinants continue to be questioned and investigated (*Kania 2015; Laurito* et al. *2014*).

As mentioned above, both whorl size and weight account for the rotational properties, while determining the tool's moment of inertia. Perforation diameter and position are two other features that have a significant influence on rotation, later also accoun-

2 Despite its integration with the Boleráz group (*Stadler* et al. *2001.543*) and mainly due to its transitional character (*Horváth 2001. 83*), typological fusion with Lasinja and Furchenstich (*Horváth 2009.105*), its stylistic affiliation with the 'stab and drag' or 'Furchenstich' decoration complex (*Kalicz 2001*) and absolute dates that cluster between 3700 and 3500 BC (*Horváth 2009.104*), the Proto- Boleráz sample recorded from the Abony site was placed within the Middle Eneolithic assemblage together with Lasinja and Furchenstich spindle-whorls. The Vučedol sample recorded from the Gomolava and Slavča-Nova Gradiška sites was placed within the Early Bronze Age assemblage together with Somogyvár-Vinkovci spindle-whorls. Mainly because the big sample recorded from the Ljubljansko Barje-Ig site, which is only relatively dated (*Korošec, Korošec 1969*) to the 3rd millennium BC, did not permit finer classification according to the particular cultural-historically defined phases.

ting for the whorl's stability during the process. Perforation is to some extent indicative of the spindle on which the whorl was used, thus its dimensions and properties have to be considered, since they also influence rotation.

In the context of the proposed functionality, the moment of inertia and weight of the whorl are given the central role, mainly because they are connected with both the raw material (*Verhecken 2010*) and the properties of the spun thread (*Bohnsack 1981; Crewe 1998*). It is generally accepted that lighter weights would be preferred for thinner and lighter threads and heavier for thicker and heavier yarns (*Andersson 2015.47*). This quality standard is thus taken as the parameter which has the most influence on the end products and their characteristics. The fact that the fibre flax plant would have provided fairly long fibres, especially compared with the much shorter length of wool expected for the early woolly sheep, is the main reason this distinction of raw materials resonated in the dichotomy between spindle-whorl types, with an emphasised contrast between big and heavy and small and light categories.

Climate trends

In recent decades, the media have taken a great interest in future climate change and its possible impact on society. Adaptation and mitigation policies have become main discussion topics in scientific research. Analyses of past events are often referred to for predictions of future developments, so archaeological and historical data substantially contribute to our understanding of the effects of climate change and its influence on culture and society. Most importantly, the way civilisation reacted or adapted to different environmental conditions in the past could give us vital information on how to respond to the effects of renewed climate stress (*Riede 2014*).

In order to interpret altering technologies by distinctions between fibres and their reliance on cultural and environmental contexts, our research analysed Eneolithic and Early Bronze Age textile tools in the light of the results of a climate simulation for the period of interest. This comparison of the two sets of data revealed that climate changes might have significantly influenced the observed dynamics of production traditions. Thus, our approach is a valuable interdisciplinary case study that incorporates bi-univocal examples of the suitability of archaeological analysis, firstly, regarding its use as a comparison data frame for climate modelling results and, secondly, for evaluating the effects of past climate change on culture, particularly innovation and technology.

The results of climate model simulations are particularly suitable for analysing cultural and technological dynamics, since they reveal trends which can explain certain continuities, as well as changes at a higher temporal resolution. This means they enable a wider understanding of the climate's impact on prehistoric societies, since their coverage builds an environmental context for the study of both adaptation processes and their consequences.

Materials and methods

Scope of the study

In order to avoid the absence of contextual data and uncertainties regarding 'cultural' and chronological assignments, the choice and collection of material used in this research focused as much as possible on recent excavations, with the exception of several sites[3]. A textile tool database was created that comprises spindle-whorls from over 20 archaeological sites[4], which gave a presentable transect from the northern slopes of the Central Balkan Mountains in the south and the Danube River in the east to the foothills of the Carpathian Mountains and the South East Alps in the north and west (Fig. 1).

The period of interest, beginning with the Middle Eneolithic (Lasinja spindle-whorl sample representing the earliest tools) and ending with the Early Bronze Age (Somogyvár-Vinkovci spindle-whorl sample representing the latest tools) falls roughly between the middle of the 5th and the end of the 3rd millennium BC. Within the geographically defined region, changing environmental conditions were investigated with the use of moderate-resolution climate simulations. In the investigation of change and possible innovation in fibre production and processing, both climate information and the recorded archaeological evidence were considered, analysed, compared and finally discussed for possible correlations.

3 Ljubljansko Barje-Ig and Dobanovci were excavated during the 1880s and the 1960s, while Gomolava and Slavča-Nova Gradiška are the only systematically excavated sites included in the study.

4 Kostolac: two sites (172 tools), Classical Baden: eleven sites (147 tools), Boleráz group: two sites (32 tools), Furchenstich complex: ten sites (205 tools), Lasinja: six sites (47 tools), Proto-Boleráz: one site (37 tools), Vučedol: two sites (38 tools), Somogyvár-Vinkovci: four sites (17 tools), Late Vučedol/Somogyvár-Vinkovci: one site (141 tool).

The results of the comparative analysis present the impact of dynamic climatic conditions on two changes in textile production which influenced spinning technology: firstly, through the adaptation of the fibre material resources, and secondly, through the modification of final product demand. Both trends, occurring in the 4th and becoming more pronounced in the 3rd millennium BC, were mainly quantitatively observed and discussed as the adjustment of tools' morphological, and thus functional features. Therefore, both their typological and functional variability were addressed.

The recorded trends in tool assemblages presented in this paper can be attributed to more than two suggested factors that may be equally culturally and environmentally promoted. Nonetheless, from the technological point of view, they are the most frequently discussed and considered in the framework of archaeological textile research as being the factors responsible for determining a tool's functionality (*Loughran-Delahunt 1996; Grömer 2005; Mårtensson* et al. *2006; Verhecken 2010*). The approach presented here draws attention to prehistoric textiles in the archaeological record, which enables a closer insight into manufacturing traditions and production technologies that can benefit our understanding of social and cultural realities and their changed economic strategies.

Our main objectives were intended to:

❶ Explore and detect trends of change within the Pannonian Plain textile tool sample.
❷ Elucidate the chronological, cultural-historical and, to some extent, environmental context of these trends.
❸ Model and interpret the main climate change trends within the geographical and chronological range of the research.
❹ Correlate both sets of trends and consider their connection.
❺ Explore the idea of climate conditions within the spatio-temporal context of the textile production structures.

Spindle-whorl analysis

The metrical standards outlined above have to be considered cautiously, because the spinning process is influenced by a combination of many factors. In fact, recent extensive spinning experiments (*Kania 2015*) designed to shed more light on how fibre and yarn depend on the tool's weight and moment of inertia revealed how both of these variables have little to no influence when compared to the human

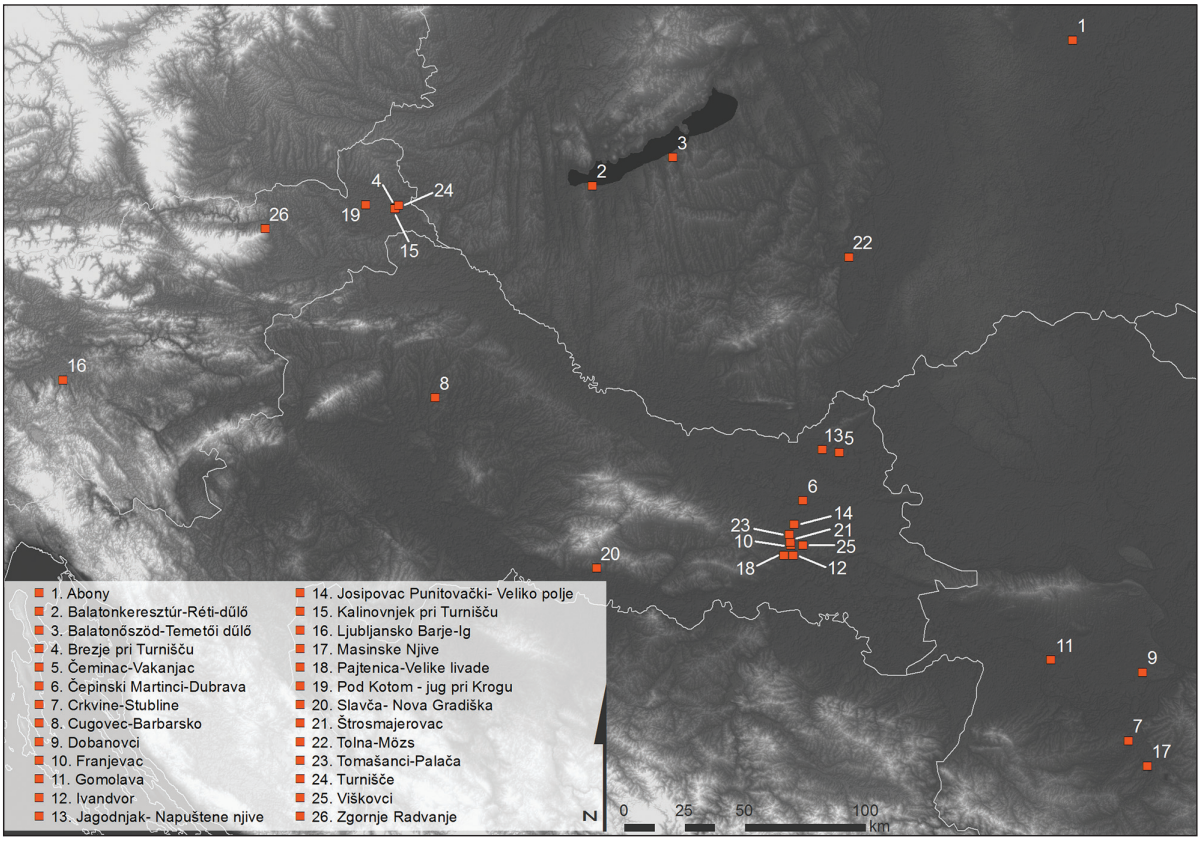


Fig. 1. The distribution of the sampled sites.

factor. In other words, a skilled spinner can spin a variety of fibres with a variety of spindle-whorl types and produce a proportional variety of different yarns. In addition, Karina Grömer's experiments (*Grömer 2005*) showed that although very heavy suspended spindle-whorls (120–140g) were not suitable for very fine yarns and light whorls (8–20g) were not efficient for thicker yarns, a medium weight (40g) would be suitable for almost every thickness documented in prehistoric Europe.

Although the influence of the tool's weight and its moment of inertia can to a certain degree be overcome by the spinner's skill, the substantial difference in tensile strength between the two fibres investigated (fibre flax and early wool) should be distinguishable, if not in the distribution of medium spindle-whorl types, then in the distribution of extremely different tool categories. The functionality analysis was thus chosen as appropriate with regard to the big size of the considered sample and big difference in tensile strengths of the raw materials investigated. The sampling method accounts for the robust patterning; its purpose was to reveal interpretable trends in textile technologies within a broad chronological context. Although moderate spindle-whorl types are especially difficult to interpret, the significant difference between the distributions of extremely different tool types should be considered as an indication of substantial differences in spinning technologies.

During the three-year study, 1152 spindle-whorls were recorded in a textile tools database. Initially, the study included tools from 34 archaeological sites, but subsequently the final analysis was conducted on a limited sample of 836 spindle-whorls[5]. Each investigated cultural-historical group was documented at two or more sites, with the exception of the Proto-Boleráz group. Middle Eneolithic tools account for 34.6% (289), the Late Eneolithic for 42.0% (351) and Early Bronze Age for 23.4% (196) of the entire sample of spindle-whorls. The recording protocol was based on four main measurements (whorl diameter, perforation diameter, height and weight) and by calculating weight/diameter and height/diameter ratios. The ranges and mean values for all the recorded variables are given in the chart (Fig. 2).

The analysis segment of this paper reports on 328 whorls which were completely preserved, 163 whorls preserved in half, 223 partially preserved whorls and 122 whorls that had small fragments (less than 10%) missing[6]. All spindle-whorls in the database were documented in order to provide three separate categories of information: contextual, morphological and illustrative. Not all specimens provided equal amounts of information, and for the purpose of the functionality analysis a minimum criteria was applied: reliable chronological assignment, typological determination and the above-mentioned measurement standard.

In order to investigate the change in the metrical features of the spindle-whorls, the tools were divided into height-diameter and weight classes. This kind of typology served as a basis for their functionality analysis. The entire sample (836 spindle-whorls) was divided into three main weight types (light, medium, heavy) and height types (flat, high, and steep), according to the distribution of the spindle-whorl's height-diameter ratio and weight values (Fig. 3).

Additionally, due to the extremely high values, a fourth weight type was defined. The weight values

Valid Number 836	Min.	Max.	Mean
diameter	26.00	96.00	56.4011
height	5.00	77.60	25.5841
perforation diameter	3.50	17.00	7.9317
weight	6.39	317.70	68.3354
height-diameter ratio	0.10	1.32	0.4559
weight-diameter ratio	0.14	4.25	1.1400

Fig. 2. Table showing ranges and mean values for all the recorded variables in millimetres and grams.

5 The sample standard was set at a minimum of three recorded spindle-whorls with complete metric data and chronological placement. Furthermore, the Neolithic spindle-whorl sample was not included in the study. No Early Eneolithic spindle-whorls were recorded in the database, thus no continuity or change in textile production could be thoroughly investigated. Also, the climate simulations did not cover a substantial part of the period.

6 The weight values of the spindle-whorls in the sample were documented in four different reliability categories depending on their preservation status. The weights of complete samples were documented in the complete weights category; weights of almost complete samples with small fragments missing were documented in the estimated weights category (estimated weight ≈ weight if not complete); weights of samples preserved in half were documented in the calculated weight category (calculated weight = weight if not complete doubled), and finally, weights of partially preserved samples were documented in the reconstructed weight category (reconstructed weight = density x volume). Volume and density variables were provided from virtual (three-dimensional) models created for the partially preserved spindle-whorls.

N	836	height/diam. (mm)		(g)	weight
(%)	10	0.20		22.00	
	20	0.23	FLAT	27.40	LIGHT
	30	0.30		33.00	
	40	0.35		41.30	
	50	0.43	HIGH	56.00	MEDIUM
	60	0.52		68.00	
	70	0.60		82.00	
	80	0.68	STEEP	104.40	HEAVY
	90	0.80		**140.00**	**(>VERY HEAVY)**

Fig. 3. Table of height-diameter ratios and weight classes with considered values.

of very heavy spindle-whorls are generally connected to substantially long fibres and plying (*Barber 1991.52; Hochberg 1979.21*) heavier thick yarns or ropes (*Vakirtzi 2014.53*). Represented in 10% of the entire sample, spindle-whorls weighing above 140g were considered appropriate for the addition of the very heavy weight type, making this class associable with very long, presumably plant fibres and plying (Fig. 4).

As already mentioned, early wool was expected to have shorter fibre lengths, thus the 33g upper limit for light spindle-whorl category was considered reasonable (making this weight type associable with wool)[7].

Model simulations

To our knowledge, the results of climate simulations have not been employed so far to investigate changes in climatic conditions for a chosen region and determined period. The decision to adopt this particular approach as support for our analysis was made for several reasons. Firstly, the model allows full coverage of the area investigated for the entire period in question. Furthermore, the temporal resolution of such analysis allows us to focus on different temporal scales, leading to the representation of inter-annual to millennial climate variability. But, most importantly, besides allowing the simulation of possible changes of different climatic parameters, the model also allows us to find plausible physical interpretations for them. Nonetheless, as support for the conclusions based on the model results, we additionally address several studies which rely on proxy reconstructions.

A transient continuous climate simulation was performed with the coupled atmosphere-ocean circulation model ECHO-G, composed by the ECHAM4 (*Roeckner* et al. *1996*) and the ocean model HOPE (*Wolf* et al. *1997*), at a spectral resolution of T30 (_ 3:75o_3:75o). The model was driven by changes in the Earth's orbital configuration calculated by Andre Berger and M. Loutre (*2002*), changes in solar activity as reconstructed by Sami K. Solanki *et alii* (*2004*) and variations in GHGs concentrations deduced from air trapped in ice cores (*Flückiger* et al. *2002*). Further information on the simulation realisation is provided in Sebastian Wagner *et alii* (*2007*). The results of the aforementioned simulation have been used in different studies: within these Wagner *et alii* (*2007*) used the model results in order to investigate the Mid-Holocene hydrological climate in Southern Patagonia. Bijan Fallah *et alii* (*2015*), Jonas Berking *et alii* (*2013*) and Emanuele Russo *et alii* (*2016*) used the model's outputs in order to run a time-slices experiment for different areas and periods of study.

The region considered in our analysis extends from longitude 14W to 21W and from latitude 42N to 48N, covering most of the Pannonian Plain region from the southern borders of Serbia in the south to Northern Hungary in the south. The analysis covered the period between 7000 BP and 3000 BP, taking into consideration the different variables that were particularly relevant for plant growth, such as near surface temperature, humidity balance (*i.e.* precipitation minus evaporation) and rising temperature



Fig. 4. Late Eneolithic spindle-whorl (from the Kostolac context) beside a Late Neolithic loom-weight from the Sopot context found at Slavča-Nova Gradiška, demonstrating the large size of the very heavy spindle-whorl type.

7 Compared to wool, plant fibres are more often considered to be spun with heavier weights Barber (*Barber 1991.25*). Very heavy whorls, respectively 100g and above, could be connected with full-length flax or long-staple wool of later specialised breeds, while this amount of tension is supported only by very long fibres. For spinning medium to heavy wool more moderate weights would be more adequate, at around 30g, respectively (*Gleba 2008.103–106*).

of days with above 5 degrees (*Masson* et al. *1999*). Sea level pressure anomalies were also considered.

Results

Adapting technologies

Regarding the robust period to period comparison, the observed differences in spindle-whorls' weight and diameter distributions pointed to a significant increase through time in values for both variables. The lowest weight variability is obvious in the earliest (Middle Eneolithic) and the highest in the latest (Early Bronze Age) assemblage. Nevertheless, in the case of Early Bronze age tools, it is noticeable that the previously wide distribution of the Late Eneolithic values was limited to a noticeable degree in the frequency of the large diameter sizes (Fig. 5).

A similar trend can be observed regarding the correlated height-diameter and weight categories. In the earliest, Middle Eneolithic assemblage, light and medium weight types are convincingly predominant, and appear to be clustered in only one height group: the lowest category or the flat spindle-whorl type. Almost the opposite distribution is evident in the latest, Early Bronze Age assemblage. Here, again, most of the tools cluster in one height group, but this time in the highest category of the steep spindle-whorl type. Although in this period all four weight groups appear to be more evenly distributed in this category, heavy and medium spindle-whorls are the most represented. The Late Eneolithic assemblage seems to fit the transitional period between these two extremes. First, because it shows the increase in the amount of heavy weight types, a trend which displayed continuity in regard to the Early Bronze Age period. Second, because the category of medium weight spindle-whorls revealed the most balanced distribution across all three different height groups, with the highest frequency occurring in the moderate (high type) height group (Fig. 6).

When analysed in the context of shape variability, the largest weights (heavy and very heavy spindle-whorl types) are mostly represented in the biconical and conical groups, those of the moderate size (medium weight spindle-whorl types) in biconical, conical, convex and discoid groups, while, finally, the

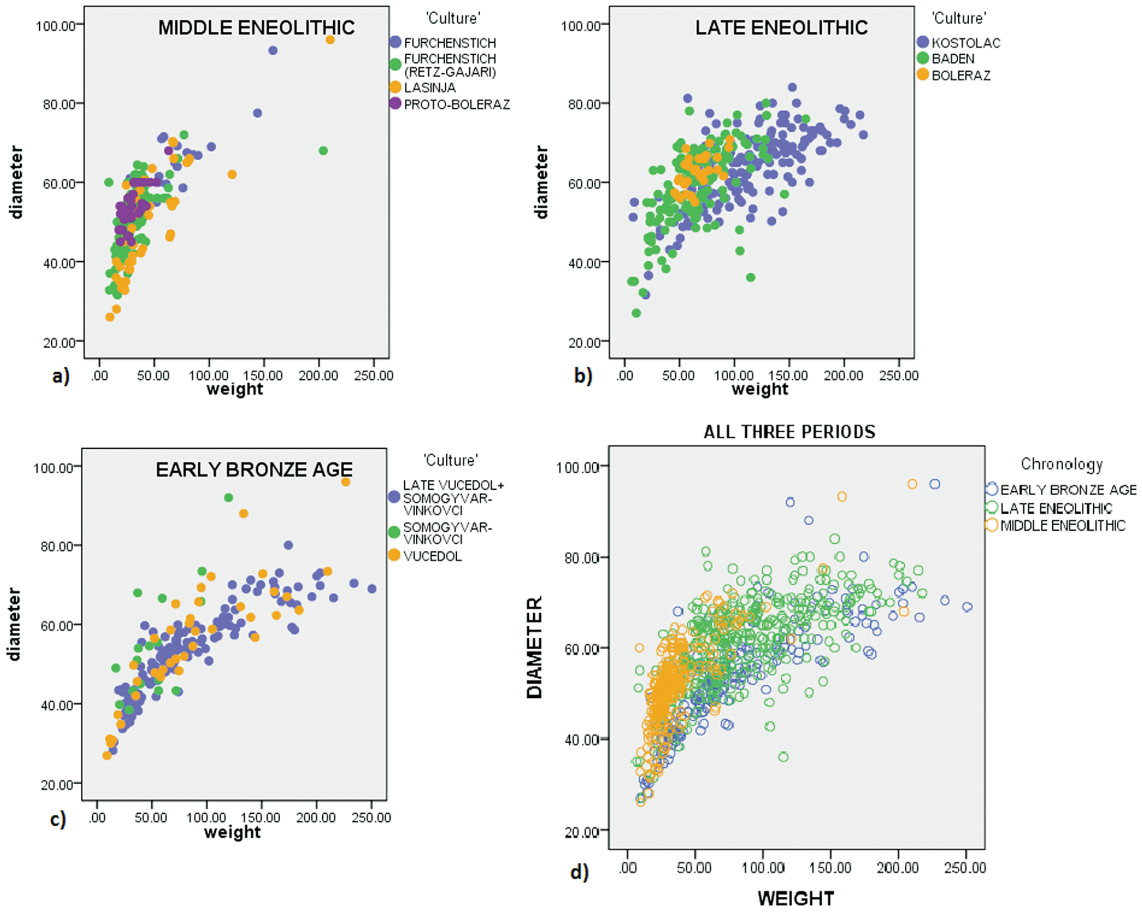


Fig. 5. The weight-diameter distribution for each period separately (*a, b *and* c*) and diameter-height distribution chart shown for all respective periods together (*d*).

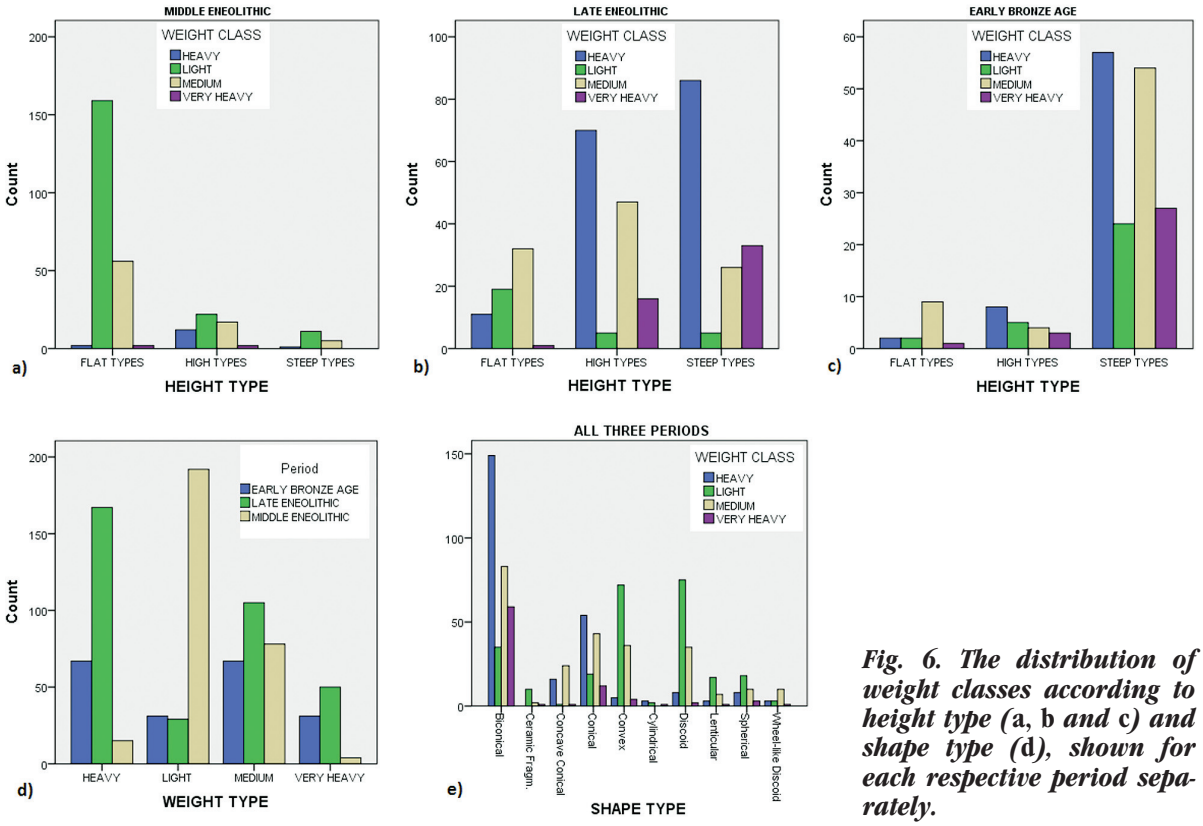


Fig. 6. The distribution of weight classes according to height type (a, b and c) and shape type (d), shown for each respective period separately.

smallest weights (light weight spindle-whorl type) appear to be characteristic of the discoid, convex, and, again, biconical groups. Finally, it is obvious that biconical and conical spindle-whorl shapes account for the greatest weight variability in the sample (Fig. 6). Both types are most represented in the Late Eneolithic sample, while the biconical type is the single predominant type in the later, Early Bronze Age assemblage. Convex, followed by discoid types are convincingly the groups most typical of the earlier Middle Eneolithic assemblage (Fig. 7).

Although the maximum diameter and perforation diameter variables seem to behave quite proportionally to one another, it is possible to distinguish some preferences and tendencies when comparing periods. Smaller maximum diameters and smaller perforation diameters seem to be more typical of the Middle Eneolithic period, while the Late Eneolithic values cluster towards the higher spectrum in the case of both variables. Early Bronze Age values show the greatest variability in their distribution, but even in this case, the inspected variables still correspond proportionally (Fig. 7). This parameter was primarily tested for samples with significantly non-proportioned correlations, since they would influence the ensuing assumptions, attributing a greater influence of spindles to the tools' rotation. These would substantially change generalisations regarding rotational properties, which are based solely on the whorls' morphological and weight parameters.

If we consider how the spindle-whorl's rotational characteristics, particularly its moment of inertia, depend on the tool's geometry and weight, a heavier whorl of significant height could have similar rotational properties to a much lighter tool of smaller height and bigger maximum diameter. The principals of this approximation, presented by Tomasz Chmielewski and Leszek Gardyński (*2010*), were used to compare widely defined height and weight categories of tools, not specific objects and values[8].

8 Corresponding correlations were suggested by Chmielewski and Gardyński (*2010.876*): "*the height-diameter ratio corresponds quite accurately with the modulation of the basic technical parameters of the tool that is its weight and angular mass. Changing both of the qualities influences the functional characteristics of a given spindle-whorl. For the increase in the angular mass of the tool, in order to slow down its rotational speed, it is purposeful to increase its maximum diameter (whereas this parameter will be characterised with the higher variability). On the other hand, if a high increase in the mass moment of inertia is undesirable (due to the use of shorter fibres that require more twist), but is needed to enlarge the mass of the spindle itself in order to create better yarn tension, the height of the spindle-whorl will increase rapidly, whereas diameter variability will be reduced.*"

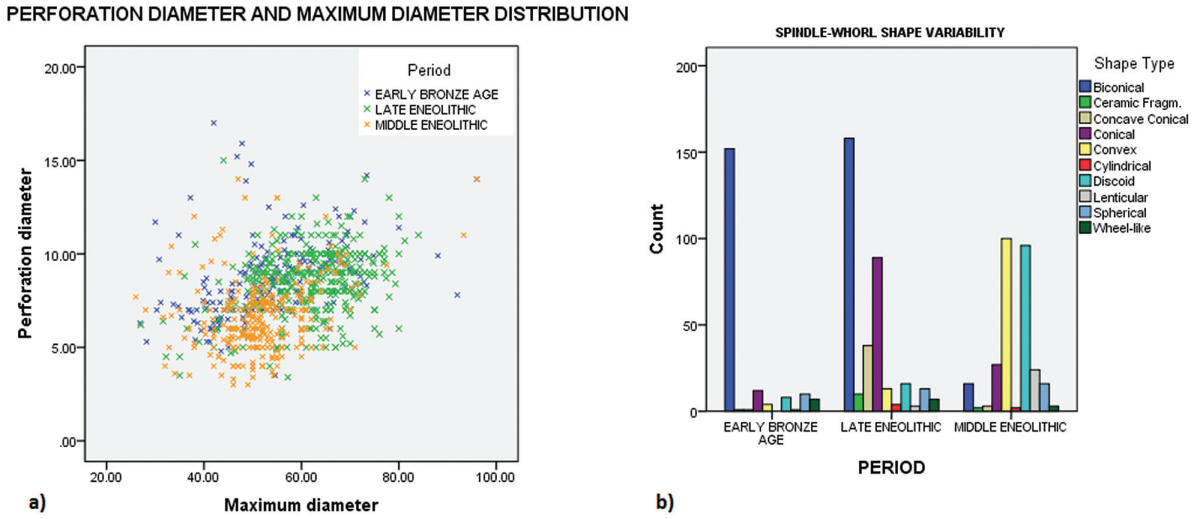


Fig. 7. The distribution of spindle-whorl maximum diameter and perforation diameter values (a). Histograms presenting their ratio variable distribution against period (b). The spindle-whorl shape type distribution for all three periods separately (c).

The differences in geometry among recorded spindle-whorl shapes enabled only rough comparisons and general assumptions. These were based on the expectation that a substantial increase in the spindle-whorl's height (Fig. 8) would lower the tool's moment of inertia if its weight remained constant.

Acceptance of this relational principle allowed further correlations between different weight and height types (medium-steep with light-high type, medium-flat with heavy-high type, heavy-steep with medium-flat type and light-flat with medium-steep type), based on their comparatively corresponding or rather similar rotational traits. If we consider these assumptions in the fibre material context it becomes obvious that the medium weight type from the middle-high height class is the most 'flexible' among all groups of spindle-whorls, presumably affording a comparable twist or tension performance with the greatest number of different category types (Fig. 9).

This accounts for the Late Eneolithic transitional character in the technological sense, since it shows how the most 'flexible' spindle-whorl category is highly represented in its assemblage when compared to samples from the other two periods (Fig. 6). The greatest height type variability in the Late Eneolithic assemblage could be interpreted as the intentional manipulation of the tool's height properties, possibly due to the avoidance of a drastic increase in the spindle-whorl's mass moment of inertia. This kind of tool adaptation is desirable, for example, in processing shorter and lighter fibres which require more twist, while the enlargement of the mass of the spindle itself is intended, for instance, to obtain better yarn tension (*Chmielewski, Gardyński 2010.876*).

During both the Middle and Late Eneolithic period, light steep types of spindle-whorls are under-represented, but in the case of the light high types, the Middle Eneolithic shows an increase in frequency, which could be associated with wool spinning. Additionally, the recently reported results of a technological analysis of 4th and early 3rd millennium BC textile tools from Arslantepe in Turkey (*Laurito* et al. *2014*) support this conclusion. Furthermore, the above-mentioned spinning experiments were designed to prove that the wider hemispherical and heavier spindle-whorls (comparable to the light high type) were the most efficient tools in terms of quantity and quality of yarn. Also, this category proved to be proficient in processing both vegetal and woollen fibre and suitable for all thread thicknesses[9]. Interestingly, the single bone spindle-whorl in our sample[10] closely resembles (in shape, method of production, and recorded size and weight values) the aforementioned 4th millennium bone tools from Arslantepe, proposed for spinning wool (Fig. 10). It

9 Surprisingly, it has been suggested that the smaller and lighter clay spindle-whorls from Arslantepe were unsatisfactory for spinning wool. Furthermore, authors explain how their moment of inertia was too small for short animal fibres, pointing out that wool used in the experiment had presumably longer fibre lengths than early wool. They do propose that metal spindles might have been used to increase the moment of inertia of the small whorls, making them suitable for spinning animal fibres (*Laurito* et al. *2014*).

10 Bone spindle-whorls are very rare in the Pannonian Plain during this period, and the particular find was initially published as a bone pendant (*Čataj 2009.31*).

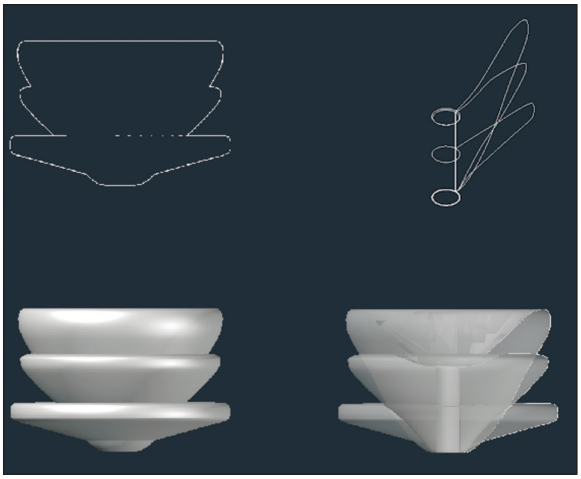


*Fig. 8. Reconstructed three-dimensional models of a flat, high and steep spindle-whorl type, based on published conical spindle-whorls found at the Balatonoszod-reti dulo site (***Horváth 2013***).*

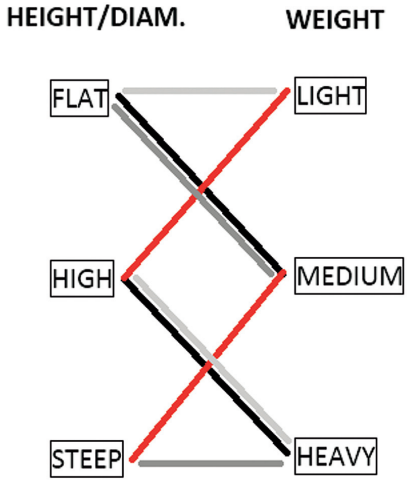


Fig. 9. Diagram of corresponding height and weight types.

should be mentioned how the results of another recent analysis (*Vakirtzi 2014*) of North Aegean Early Bronze Age tools from Thasos also suggest that this particular spindle-whorl weight class was used for spinning wool.

Both light high and light steep tool categories become significantly more represented in the course of the 3rd millennium, as shown by the Early Bronze Age assemblage. These types, including the medium steep type (if we accept the approximated comparisons explained), which is more substantially represented in the Late Eneolithic sample, and the second most frequent type in the Early Bronze Age sample, could be appropriate for spinning shorter fibres, presumably wool (Fig. 6). These medium steep types, although heavier, are expected to have a significantly lower moment of inertia due to their geometry, or more precisely, their higher height-diameter ratio.

On the other hand, heavy and very heavy types could be connected to processing long plant fibres. Although they have larger height-diameter ratio values and tend to cluster in the high and steep height groups, their weight leads to significantly larger moment of inertia values (too big for processing short or even moderately long fibres that call for more twist). Additionally, their weights alone are too big for the lower tensile strengths of animal fibres. Thus they can be considered appropriate for spinning long plant fibres such as full-length flax. These spindle-whorl types become predominant in the late 4th millennium and continue to be highly represented in the ensuing 3rd millennium assemblage, as shown by the distribution charts for the Late Eneolithic and Early Bronze Age samples (Fig. 6).

The technological development did not reveal a linear process leading 'from plant to animal' fibre production. As shown by the trends in maximum height-maximum diameter and maximum height-weight correlations, the dynamics of the use of fibre material was more complex (Fig. 11). The greatest height value variability apparent in the Late Eneolithic period is lowered in the 3rd millennium BC sample. Frequency of the lowest height values is decreased, while the maximum diameter distribution clusters towards the lower values.

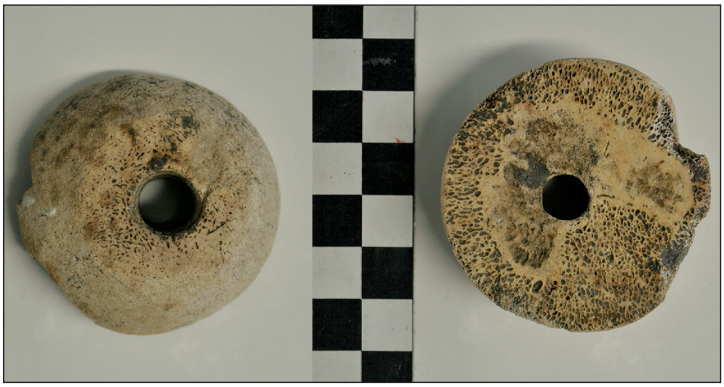


Fig. 10. A convex spindle-whorl made from the head of a cattle femur bone, weighing 24.6g, from a Furchenstich (Retz-Gajary) context found at Josipovac Punitovački-Veliko polje, dated to the 1st half of the 4th millennium BC (Middle Eneolithic period).

Climate conditioning

The climate of the Holocene was highly variable, and multiple controls must have been responsible for this variability (*Mayewski* et al. *2004*). According to Heinz Wanner *et alii* (2009), the Holo-

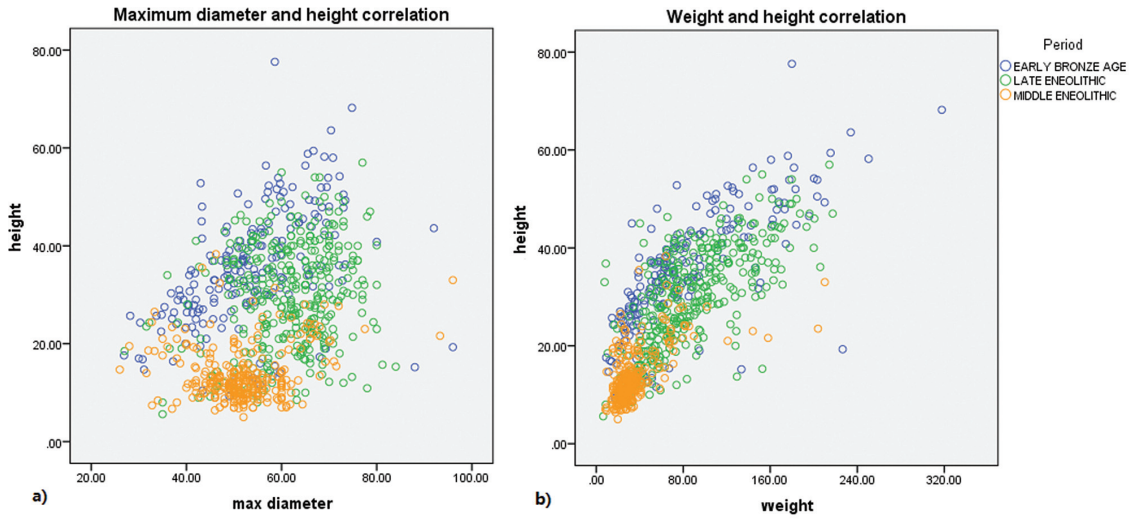


Fig. 11. The distribution of correlated:* a *maximum diameter and height values;* b *weight and height values, for the three period assemblages together.

cene climate was dominated by the influence of summer season orbital forcing; our results are in accordance with this interpretation. In particular, our model simulations revealed that from the 7th millennium BP, summer climatic conditions started to deteriorate in the middle latitudes of the Northern Hemisphere (NH), mainly due to a decrease in summer insolation, which reached its maximum at around 9000 BP (not shown). For all the simulated climatic parameters, a pronounced trend is evident for the summer season, which resembles one of a complete decrease in insolation (Fig. 12), although the humidity balance reveals an opposite, increasing trend, mainly due to the effect of evapotranspiration as a consequence of the enhanced insolation in the mid-Holocene.

Such conclusions are also supported by other studies based on proxy reconstructions for the investigated area and its surroundings. In particular, by analysing Holocene conditions through pollen reconstructions from several lakes, in Southern to Northern Italy and the Alpine region, Michel Magny (*Magny* et al. *2012*) concluded that the mid-Holocene summer precipitation regimes appear to have been opposite between the south- and north-central Mediterranean: a maximum was present in Sicily and a minimum in north-central Italy. Later, Magny *et alii* (*2013*) analysed a time series of wetness for the Lake Ledro basin in Northern Italy spanning the last 10 000 years: while the early and mid-Holocene periods show relatively low flood frequency, the late Holocene, from *c*. 4500 cal BP onwards is characterised by an increase, which is in full agreement with the reconstructions from neighbouring Lake Iseo. The pattern of contrasting mid-Holocene summer precipitation regimes was confirmed by Odile Peyron *et al.* (*2013*) on the basis of pollen-inferred quantitative estimates and a multi-method approach that revealed minima (maxima) of summer precipitation and lake levels to the north (south) of *c.* 40° N. Summer temperature showed a similar partition for the mid-Holocene in the central Mediterranean, with warmer (cooler) conditions to the north (south). Mónika Tóth *et alii* (*2015*) presented a Holocene summer air temperature reconstruction based on fossil chironomids from Lake Brazi, a shallow mountain lake in the Southern Carpathians, with results suggesting that from *c.* 8500 cal BP, chironomid-based summer temperatures decreased in the area. In particular, the period between 6000 and 3000 cal BP was characterised by cooler temperatures in comparison to the earlier period.

Conversely, winter-time model results do not show a clear trend and the data are characterised by significant multi-decadal to inter-centennial fluctuations (Fig. 13). For winter, the trend of insolation during the mid-to-late Holocene at the mid-latitudes of the NH is not particularly pronounced (Fig. 13). The behaviour of the simulated data is probably a result of the system's internal variability. In winter, climatic conditions in Europe are mainly driven by changes in atmospheric circulation (*Hurrel 1995; Hurrel* et al. *2003*). In particular, the first mode of winter atmospheric variability over the North Atlantic is represented by the North Atlantic Oscillation (NAO), which explains one third of the total variance in the sea-level pressure (SLP) field over the area (*Hurrel* et al. *2003*). A positive phase of the winter NAO is associated with an increase in strength and a northward shift in westerly winds. This results in moist

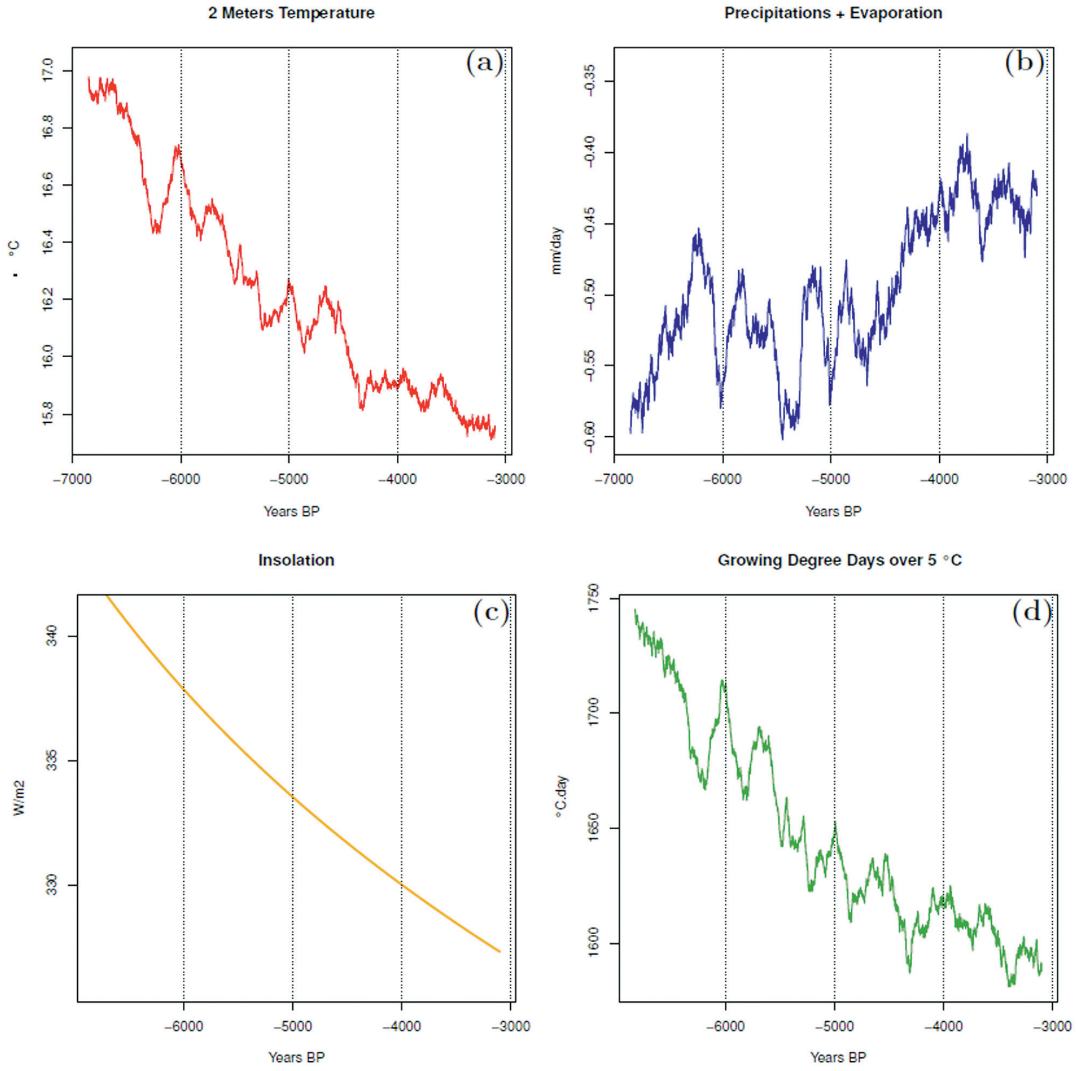


Fig. 12. Graphs presenting:* a *summer temporal evolution of near-surface temperature regional mean computed over the area of study;* b *time series of summer precipitation + evapotranspiration calculated in mm/day;* c *insolation changes over the period of study;* d *time series of rising temperature days above 5 degrees. All the time series are smoothed using a 200-year running mean.

and warm air advection from the Atlantic to Northern Europe (55°–70° N) and, consequently, in drier and colder conditions over Southern Europe. Conversely, the negative phase of the NAO is accompanied by weaker and southward shifted (35°–50° N) westerlies, responsible for wetter and warmer winter conditions over Southern Europe. The use of the NAO index (Fig. 12.a), which is based on the principal component time series of the leading Empirical Orthogonal Function (EOF) of the winter SLP anomalies (*Hurrel* et al. *2003*), allows us to speculate that the oscillations of the simulated winter temperature and precipitation are caused by the variability between positive and negative phases of this atmospheric pattern. The simulated winter temperature, and particularly humidity, present an extremely high anti-correlation (~ –0.7) with the calculated NAO index.

Different studies hypothesise that at around 6000 BP the NAO was in a more pronounced positive phase in comparison to present-day conditions (*Bonfils* et al. *2004; Braconnot* et al. *2007a; 2007b; Davis* et al. *2003; Mauri* et al. *2014; Russo* et al. *2016*). This is not directly evident in our results and seems to be a problem characteristic of climate models. Nevertheless, the changes in the simulated winter conditions can be considered physically consistent: the model simulates a reasonable and internally consistent climate (*Goosse 2012; Von Storch 2004*). Other events often reported in studies that are based on proxy-reconstructions are the so-called Rapid Climate Changes (RCC) (*Mayewski* et al. *2004; Budja 2015; Weninger* et al. *2009; 2015; Wanner* et al. *2011*). They are abrupt cooling events, lasting from a century to millennia, for which large drifting ice debris has been registered. The complexity of our model

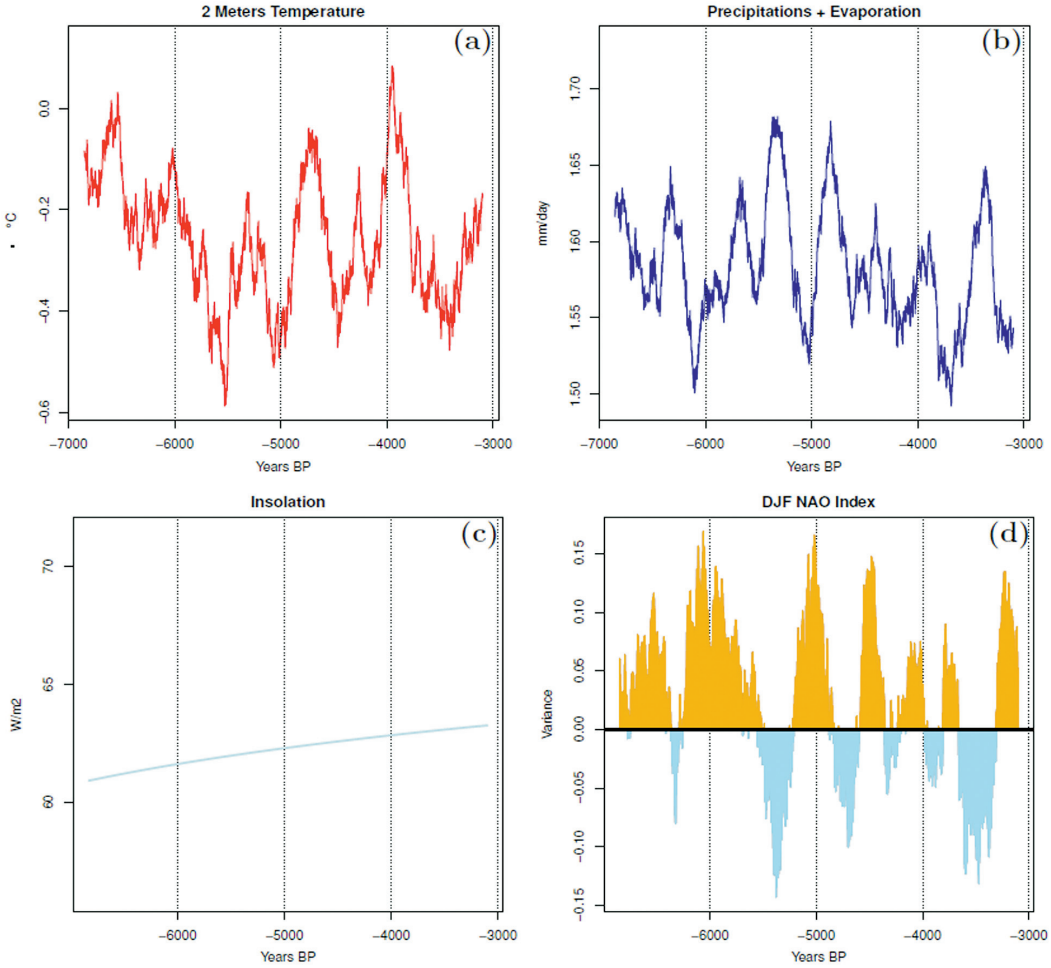


Fig. 13. Graphs presenting:* a *winter temporal evolution of near-surface temperature regional mean computed over the area of study;* b *time series of winter precipitation + evapotranspiration calculated in mm/day;* c *insolation changes over the period of study;* d *DJF NAO index over the period of study. All the time series are smoothed using a 200-year running mean.

does not permit a precise reproduction of such events. Additionally, even if evidence supporting them seems clear, their cyclic occurrence and causes are still highly debated, as well as the impact they had on a regional scale (*Wanner* et al. *2011*). This is one of the main reasons we focus our attention on long-term trends and the relevance of abrupt oscillations in the context of population adaptability.

Nonetheless, in our discussion, we take into consideration one particular example of RCC and the possible impact it had on the life of Eneolithic communities inhabiting the area. Although in the case of winter, no distinct trend is evident in our simulations, and the model results do not display the same level of correspondence with the other studies (as they do in the case of summer, particularly temperatures and moisture balance), the evident oscillations are physically plausible. Thus, acknowledging the possibility of the effects of RCCs during the simulated period does not contradict the model results at all. On the contrary, it means that if those events occurred, they only contributed to the evinced deterioration in climatic conditions.

Discussion

The period between the mid-5th and the end of the 3rd millennium BC, in which the spread of both fleece-bearing sheep husbandry and new fibre flax in South East and Central Europe probably occurred, was characterised by profound social changes and has been studied so far in terms of intensified contacts and mobility (*Anthony 2007; Leary 2014*), environmental change (*Binford 1968; Barker 1985*) and economic transformation (*Sherratt 1981; 1997; 2006; Greenfield 1988; 2005*). This provided the entire contextual framework and theoretical background for the present investigation of textile production trends and their climate dependency in the aforementioned regions. Apart from the extensive research on textile production in Romania (*Mazare*

2014) and Bulgaria (*Petrova 2011*), which took into consideration indirect archaeological evidence from larger and confined geographical sections, the textile tools and production of the period have not yet been systematically approached in the Pannonian Plain contexts. Narrowing the focus on the particular region enabled us to raise specific questions regarding textile fibre raw materials and final product demand through their dependence on the changing climate. The declining summer trend in temperatures and the corresponding rising trend in moisture content might have caused the cultural-historically defined groups of the Post-Neolithic inhabiting the area to be more sensitive to possible climatic fluctuations like the simulated winter oscillations. Such events could have acted as a trigger for shifts in fibre procurement practices, resulting in a broadening of resources and, especially, in intensified selection in favour of their fitness.

Evidence has shown that the period between 6000 and 5000 BP, normally referred as a Rapid Climate Change event, was generally characterised by globally colder conditions (*Weninger* et al. *2009; 2011; Mayewski* et al. *2004*). In this case, the effects of the proposed scenario of a deterioration in climatic conditions would eventually have been amplified, and abrupt changes could have had even more drastic effects on the 'cultural groups' under consideration. Through a complex causal network, this could have led to substantial perturbations within human societies, as suggested by changes in the archaeological material in Central Europe (*Arbogast* et al. *1996; Berglund 2003; Magny 2004*). Weninger *et alii* (*2009*) found that at different times in the 6–5ka RCC period, there were abrupt abandonments of various settlements in Romania, Bulgaria, and Greece. During the same period in the Alpine region, abrupt oscillations on the scale of decades or a century seem to have caused changes in hunting and farming patterns (*Schibler 1997*).

The high-quality organic preservation at Sipplingen, an Alpine lakeshore settlement on the northern shore of Lake Constance in south-west Germany, enabled comprehensive dendroarchaeological, archaeobotanical and zooarchaeological investigations that revealed the adaptive character of the settlement and its subsistence strategies in response to changes in climate, environment and cultural influences over time (4000–2800 BC) (*Styring* et al. *2016.103*). Obvious economic changes that occurred during the 4th millennium BC, which have been attributed to climatic deterioration (*Schibler* et al. *1997*), reveal a dramatic cycle of establishment, expansion and reduction, or even abandonment of settlements around Lake Constance (*Billamboz, Köninger 2008*). A great deal of evidence of flax cultivation has been found from lake dwellings north of the Alps, (*Jacomet 2009*). In particular, the find densities of flax rise considerably during the second half of the 4th millennium BC (*Brombacher, Jacomet 1997.249*).

It is most likely that during the Middle Eneolithic period, which marked the turn and the first centuries of the 4th millennium BC, animal products, presumably including fibres, started to be more important as a result of deteriorating climate conditions. All the scarce textile evidence favours wild plant species, but the functional analysis of the Furchenstich and Lasinja spindle-whorls suggests that during this, apparently, intensive foraging period, animal fibres should not be disregarded. Faced with an environmental challenge due to the whimsical climate in the following centuries of the 4th millennium BC, in the context of intensified textile production, foraged plant material and possibly the old variety of flax might have been partially substituted with a new fibre fax in order to meet the growing demands of textile production. It is premature to conclude this, but the above-mentioned archaeobotanical research supports this idea.

The earliest direct evidence of wool, respectively woollen finds from Germany (*Rast-Eicher 2014.16*) and the North Caucasus (*Shishlina* et al. *2003*), when observed in the framework of changed herding strategies revealed in the contemporary contexts of South East and Central Europe[11], intensified sheep husbandry recorded at some sites[12] and the spin-

11 Regarding Central Europe, analysed faunal evidence from the Bronocice site in South Eastern Poland (*Pipes* et al. *2014*) suggest that sheep rearing intensified during the second half of the 4th millennium BC (Funnel Beaker horizon). Indeed, the increased herd sizes reported from the site revealed that the majority of animals were slaughtered as adults. In the case of South Eastern Europe, analysis of Late Eneolithic faunal samples from the Bubanj and Mokranjske Stene-potkapina sites in Serbia suggests the predominance of sheep husbandry (*Bulatović 2012; Bulatović, Milošević 2015*). Furthermore, analysis of the age profiles from the Mokranjske Stene-potkapina sample attributed to the Kostolac-Cotofeni horizon (late 4th to early 3rd millennium BC) revealed that the adult age group was the most represented.

12 Intensified sheep husbandry was recorded at the Middle Eneolithic Furchenstich site at Pod Kotom – jug pri Krogu I/II *(Šavel 2009*), at the Middle to Late Eneolithic Proto-Boleráz site at Abony (*Fábián 2008; 2012*), and at Late Eneolithic Boleráz/Baden sites at Balatonőszöd-Temetői dűlő (*Horváth 2010*) and Balatonkeresztúr-Réti-dűlő (*Fábián 2014*).

dle-whorl analysis results, push the presence of wool in the context of fibre production already into the 4th millennium BC.

Following the results of our analysis and according to the aforementioned studies, it is very likely that the middle of the 4th millennium BC (characterised by the appearance and spread of Baden culture in the Pannonian Plain) was a period of major climatic stress. Such pressure probably promoted further mastering of both fibre resources, thus influencing their specialisation. Intensified sheepherding is usually connected to this cultural group (*Maran 1998.514–516*), and many authors propose its acquaintance with wool (*Horvath 2010; Bondar 2012; Struhar* et al. *2014*). On the other hand, the level of flax pollen in samples from lake-shore settlements in Switzerland indicates intensive flax production, more recognisable in the frequent textile remains (*Capitani* et al. *2002. 115–120*). This allows us to speculate that, during the course of the second half of the 4th millennium BC, both fibre materials gained in importance.

By the beginning of the 3rd millennium BC, such strategies had already been mastered and spread, since textile production does not seem to have slowed down at this point. On the contrary, judging by the increase in the amount of spindle-whorls from the end of the Eneolithic period, it seems it even intensified. More organised fibre material resources had to have been acquired and established by that period. Both the changed environmental and cultural conditions resonated further in the new demands for specific types of textile products, which quite possibly corresponded to the intensified use of transport and traction. The predominance of very large tools, probably used for plying plant fibres or their filaments in order to make thick and strong threads and ropes which could have been used for harnessing animals, would support this scenario. Mobility and the transport of goods would also have promoted the trend. The increased variability of Late Eneolithic spindle-whorl assemblages in favour of a balanced distribution of moderate weight types between three main height categories is something that might reflect this kind of broadened fibre assortment, both in regard to the raw material resources and demand for end products, although the obvious predominance of heavy and very heavy types of tool, particularly in high and steep height categories, greatly accounts for longer plant fibre preferences. This trend is particularly pronounced at the turn of the millennium, and continues in the Vučedol and Somogyvár-Vinkovci phase. There is a possibility that this reflects the appearance of specialised fibre flax and its intensified use in the plying tradition of the late 4th and the following 3rd millennium BC. Impressed plied cord decoration (*Grömer, Kern 2010; Leghissa 2015*) representative of the Early Bronze Age Corded Wear complex (widespread in the Pannonian Plain) could attest to the growing importance of plied cordage in the course of the following centuries.

Conclusions

Three main trends are evident in the spindle-whorl sample. First, the Middle Eneolithic assemblages suggest more intensive animal husbandry, which led to the first exploitation of animal fibres. Second, on the basis of the Late Eneolithic tools, continued use of wool may be argued, which was substantially accompanied by the intensified production of long plant fibre, presumably flax. And third, the results of the analysis of Early Bronze Age spindle-whorls reveal a specialisation of fibres, most probably due to the refinement of both textile fibre resources and demand for final products.

Despite the large textile tool sample on which this research is based and regardless of the climate conditions that support the outlined timeline for the introduction of both sheep wool and the new fibre flax, already during the Eneolithic in the Pannonian Plain, further zooarchaeological and archaeobotanical evidence is required to understand and explain the dynamics of these processes in finer detail. The exploration of the new fibre resources occurred simultaneously in remote contexts and could have been provoked by both cultural and environmental conditions.

Numerous interacting factors were probably responsible for the intensification of their exploitation and, to some degree, their further development, which might not have been as linear as we thought. Thus their evolutional character is contrary to the revolutionary scenario. They gradually developed from ordinary foraged fibres into occasional and then into common secondary products. Due to the intensification of their use, they finally became primary and specialised resources for developed textile production. It is plausible that, due to different factors in different areas and periods, similar reasons promoted fibre production as those that later contributed to their specialisations. Although the earliest direct evidence for wool in the studied region dates to the 2nd millennium BC (*Grömer* et al. *2013;*

Rast-Eicher, Bender Jørgensen 2013), its much earlier presence must be considered.

There are two possible reasons why in Europe the scant textile evidence sample from the 4th and 3rd millennium lacks woollen examples: first, its underrepresented use in comparison to flax and other plant fibres, and second, the fact that the European climate is not conducive to its preservation conditioning (*Ryder 1964*). Regarding resources for fibre production, the Middle Eneolithic could mark their initial exploitation phase, while the Late Eneolithic, with evident technological change which gradually resulted in greater tool standardisation in the Early Bronze Age, marks their second exploitation phase. The exploration phase for both resources might have already started in previous periods, and so future textile research of Early Eneolithic tools might clarify this dynamic. The results of the analysis suggest that in the studied region of South East and Central Europe, wool was probably already being exploited in the 4th and certainly the 3rd millennium BC, although on a smaller scale, first in comparison to flax, and also in comparison to the established wool economies of contemporary urban centres in the Near East.

The continuous deterioration in summer climatic conditions in the Pannonian Plain region during these two millennia would still have provided conditions congenial to fibre flax. Areas with less favourable conditions for cultivating it might have focused their developing textile production on other resources, causing them to specialise in alternatives. This is a question of difference in fibre specialisations, which so far have been interpreted as indications of use, creating an unacceptable dichotomy in the period of intensified mobility and contacts. A growing demand for raw materials, and metal in particular, resulted in intensified trade that could support this kind of fibre competition through division in specialisation during the 4th millennium, while textiles, and presumably fibres, may have been substantially involved in both short- and long-distance trade. Metal objects were certainly accountable for far-reaching cultural contacts, possibly facilitating breed mobility, which then accelerated the gene flow and the evolution of both fibres. Copper axes from burial mounds at Moravian TRB-Boleráz sites were wrapped in flax textiles, which could account for a combination of two luxury goods (*Baldia* et al. *2008.264–265*). Sherratt (*Sherratt 1997; 2006*) connected both the animal traction and wool with social stratification, explaining them as symbols of elites. Quite possibly, this connection should be to some extent related to inequalities between animals and plants reflected in the people who had privilege to select among them. Although wool's appearance and origin were for a long time considered within the textile economies of the urban revolution package in Bronze Age Mesopotamia (*McCorriston 1997; Kimbrough 2006*), the oldest finds, genetic evidence, and the analysis of the prehistoric textile tools pushed its early appearance on the fibre scene into a new and much wider framework regarding its theoretical (SPR), geographical (Fertile Crescent), chronological (Bronze Age) and social (stratified organised systems) context.

On the other hand, archaeobotanical research on the flax plant, taken in consideration with the processed textile evidence from circum-Alpine pile dwellings, place the fibre evolution in the same period of the thriving copper trade in the 4th millennium BC, suggesting that both resources were exploited in the production of Eneolithic textiles. Although both scenarios were connected to many cultural and environmental trends, climate change was certainly accountable, if not for their evolution, then for influencing the dynamics of their exploitation.

During the late 4th and early 3rd millennium BC, an interesting example of a technological shift occurred, one which accommodated to both new options of presumed raw material resources, and new demands for a seemingly greater variety of end products. The moderate weight types of spindle-whorls significantly represented in all height classes during this technological phase suggest that all of the fibres considered could have been used. This was evidently accomplished through a gradual change in tool properties, while assemblages were consecutively adjusted.

Although the boom in heavy and very heavy types of spindle-whorls is more obvious and easier to connect with long plant fibres, and the appearance of smaller sizes in the Early Bronze Age is something we search for when we expect wool use, the modest, ordinary, average, hard-to- interpret type of tool revealed the biggest evolution: craftsmens' slow and gradual accommodation to the world around them. Technology's potential to be modified is mainly reflected in the outlined tools' flexibility. Although its moderate and gradual transformation does not account for a high degree of specialisation, it does reveal our ability to combine tradition and innovation in altering and, more importantly, challenging circumstances.

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Tell communities and wetlands in Neolithic Pelagonia, Republic of Macedonia

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ABSTRACT – *Pelagonia is the biggest valley in the Republic of Macedonia, positioned in its mountainous southwestern area. It was first inhabited around 6000 BC by agricultural societies, which established the tell settlements in the region. Their villages were densely concentrated in several regional centres located near wetlands and rivers. These farming communities produced a variety of ceramic household items with pronounced features of a distinct identity, such as white painted pottery, anthropomorphic house models, figurines, tablets and stamps. The particular landscape and isolated network of Early Neolithic tell societies in Pelagonia remained unaffected until the Late Neolithic, which was an outcome of the idiosyncratic and strong relationship between the environment, dwellings and human body. Therefore, the paper discusses the first farming communities in Pelagonia, as well as the process of how identity was manifested in regard to the wetland environment and networks.*

IZVLEČEK – *Pelagonija je največja dolina v Republiki Makedoniji in leži v jugozahodnem goratem predelu. Poljedelske skupnosti so regijo prvotno poselile dolino ok. 6000 pr. n. št. in postavile t. i. tell naselbine. Njihove vasi so bile zgoščene v številnih regionalnih centrih, ki so bili omejeni predvsem na območja močvirij in rek. Te poljedelske skupnosti so izdelovale različne keramične hišne izdelke z izrazitimi značilnostmi, ki kažejo posebne identitete kot so belo slikana lončenina, antropomorfni hišni modeli, figurine, plošče in žetoni. Značilna pokrajina in izolirana mreža povezav zgodnje neolitskih tell naselbin v Pelagoniji so ostale nespremenjene do poznega neolitika, kar je rezultat značilne in močne povezave med okoljem, naselbinami in človeškim telesom. V članku se zato ukvarjamo tako s pojavom prvih poljedelskih skupnosti v Pelagoniji kot tudi z načinom, kako se je glede na vlažno okolje in mreže povezav oblikovala njihova identiteta.*

KEY WORDS – *Pelagonia; Neolithic; wetlands; networks; chronology*

Introduction

The Balkans played a significant role in the introduction of agriculture and new ways of life in Europe. This process started in the middle of 7th millennium and continuously modified a large number of societies and landscapes on the continent. In this dynamic prehistoric environment, a particular group of communities inhabiting a valley in Pelagonia significantly contributed to the integration of new economic, social and symbolic practices (Fig. 1). The elongated valley, oriented north-south, lies in the Republic of Macedonia and Greece, incorporating the towns of Prilep, Bitola and Florina. Since prehistory, this basin has provided solid subsistence and so it has been continuously settled until the present. The fertile alluvial soil near wetlands was the major feature that prompted numerous communities in the Neolithic to build the first dwellings on the artificial mounds they created. The calibrated dates based on radiocarbon analysis from the 1970s indicate that the region was occupied around the beginning of the 6th millennium BC, although some dates with high standard deviation reach back to the middle of the 7th millennium (*Srdoć* et al. *1977; Valastro* et al. *1977; Naumov 2016a*). New AMS radiocarbon analysis will determine the precise dates of earliest sites, but nevertheless the process of Neoli-

thisation was synchronous with that in the neighboring regions. The large scale excavations in the 1970s supports this argument, as numerous finds are similar to those unearthed in the Korçë basin (Albania) and Amindeon area (Greece).

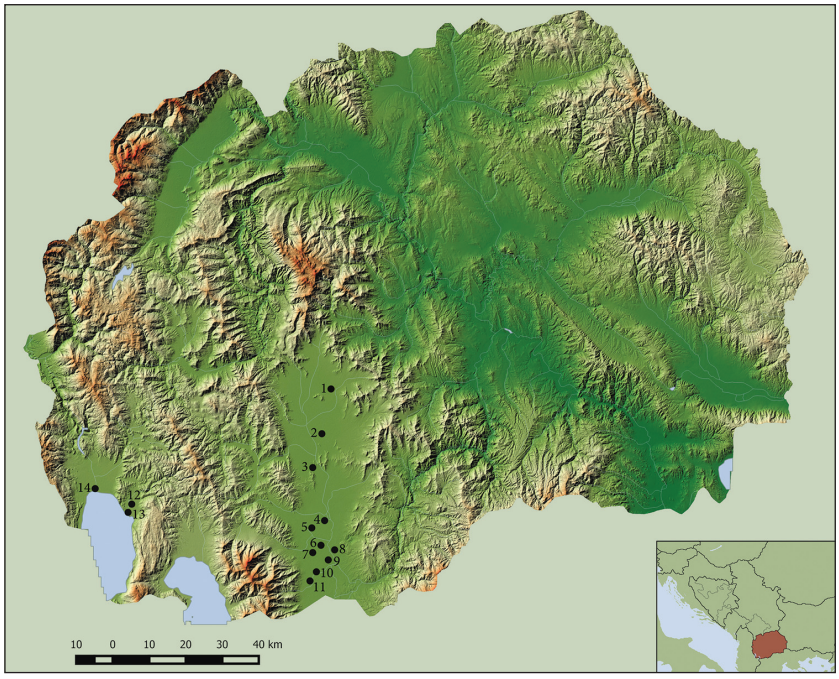


Fig. 1. Map of the Republic of Macedonia with location of sites discussed in paper. Pelagonia:* 1 *Senokos;* 2 *Slavej;* 3 *Topolčani;* 4 *Radobor;* 5 *Mogila;* 6 *Trn;* 7 *Karamani;* 8 *Dobromiri;* 9 *Optičari;* 10 *Porodin;* 11 *Veluška Tumba. Lake Ohrid:* 12 *Dolno Trnovo;* 13 *Ohridati;* 14 *Ustie na Drim.

Interest in the prehistory of Pelagonia started during the First World War, when several Paleolithic sites were researched (*Malez 1979; Kuzman 1995*). Thereafter, some campaigns by different teams commenced, including those of American institutions directed by Vladimir Fewkes and by British archaeologists guided by Walter A. Heurtley (*Fewkes* et al. *1933; Heurtley 1939; Galović 1964*). These were smaller-scale excavations and mainly prospections which recorded the first Neolithic sites and indicated the character of settlements as tells. It was a significant step forward in introducing Pelagonia as a region where numerous communities established villages in the Early Neolithic and chose the wetland area as an integral part of their lives. Furthermore, the interest in the Neolithic of Pelagonia increased after the Second World War, when more thorough excavations were performed, but an apparent boost in research was initiated in 1970s, when a number of excavations were executed on sites at Porodin, Mogila, Dobromiri, Karamani, Radobor, Trn and Topolčani (*Simoska, Sanev 1976; Todorović* et al. *1987; Sanev 1995; Naumov 2009a*).

These campaigns provided most of the data which even today is the main source for understanding Neolithic societies living on this valley. After the research boom in the 1970s, archaeological interest in Pelagonia suddenly decreased, with the exception of excavations at Vrbjani and Optičari in the 1980s (*Kitanoski* et al. *1990; Simoska, Kuzman 1990*). Nearly three decades passed without any thorough research in this region, until the 2000s, when excavations at Senokos, Mogila, and Vrbjani began, as well as geophysical scanning, GIS mapping, the calibration of chronology and archaeobotanical research of Neolithic tells in Pelagonia (*Temelkoski, Mitkoski 2006; Naumov* et al. *2014; Naumov, Stojkoski 2015; Naumov, Tomaž 2015; Naumov* et al. *in print*). Although still modest, the current data obtained from the research in 1970's and that of the last decade, provide elementary information on Neolithic communities, their dwellings, material culture and environment. There is still much to be done for a thorough understanding of the social setting and interaction with nature in Neolithic Pelagonia, but the available data allow for the initial reconstruction of the landscape and settlements and how they were integrated in the wetland environment.

The geography of wetlands

Pelagonia is an elongated valley in the geographic region of Macedonia, in Southeast Europe. The valley is nearly 5000m^2 in area, with a length of approx. 80km and width of 35km. Geologically, it dates to the Pelagonia horst anticlinorum and consists of a neotectonic basin structure initiated in the Middle Miocene (*Arsovski 1997; Dumurdzanov* et al. *2004*). The wider region is built from Precambrian and Paleozoic metamorphic rocks developed by the peripheral mountains surrounding Neogene lake sediments. To the North is Mt Dautica, eastward are Babuna and Selečka, southernmost are Nidje and Neredska, while to the west are Baba, Plakenska, and Buševa (*Trifunovski 1998*). The valley is formed on

Neogene lake sediments including saline sandstones, clean siltstone, clay, sandy clay, and gravel (Fig. 2). Quaternary lake sediments consist of coarse sandy gravel fraction and marshy sediments, proluvial and diluvial deposits from roughly clastic sediment of silty-clay, sands and gravels (*Mirčovski* et al. *2015*). The graben itself is developed on Precambrian gneiss and schist and Paleozoic schist and granite of the Pelagonian tectonic unit. This unit was formed in the Late Miocene and contained lacustrine environment from the Late Miocene until the end of the Pliocene and Pleistocene. The Miocene-Pliocene section is covered by 5–15m of Pleistocene alluvial-proluvial sediments (*Dumurdzanov* et al. *2004*).

The environment deposited a thick layer of alluvial and Neogene lake sediments which affected the quality and fertility of the soil (*Puteska* et al. *2015*). This was one of the primary motives for the dynamic inhabitation of Pelagonia since the Early Neolithic and its continued exploitation. Also, the abundance of underground waters and rivers contributed to soil fertility. The Crna Reka River is one of the biggest in the region and is used as a main waters ource in the agriculture. The Crna Reka's branches, such as the Dragor, Šemnica, and Eleška rivers, also contribute to irrigation. Hydrogeological complexes distributed swampy sediments (*Mirčovski* et al. *2015*), and the flooding of rivers and appearance of underground waters caused by melting snow creates large areas of wetlands. In the period of heavy rains or snow melting, the rivers overflow their banks and in combination with underground waters create several smaller marshy lakes which were used throughout the year for fishing, hunting birds and providing resources for house building and weaving. These marshy lakes were intentionally and systematically dranied in the early 1960s, but were often exploited for subsistence economy, communication and boating (*Trifunovski 1998*). The recent floods confirmed that the marshes are again being created in the particular areas where swampy lakes existed before being drained, which indicates that their surroundings were preferred even in the Neolithic (*Naumov, Stojkoski 2015*).

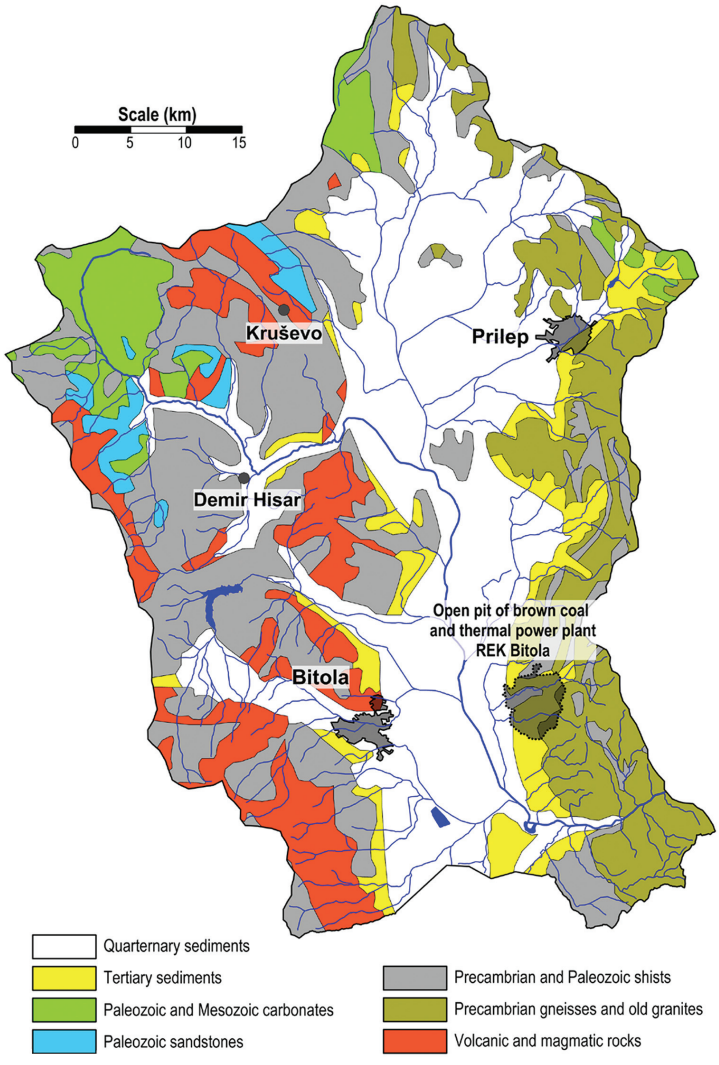


Fig. 2. Geological map of Pelagonia (*Puteska *et al.* 2015.Fig. 2*).

Without new hydrogeological research in Pelagonia, it is hard to specify the environment at the end of 7th millennium BC. Although it could be expected that the landscape did not significantly change in the last 10 000 years, sampling is still necessary in order to understand thoroughly the climate and processes concerning waters and sediments in the central alluvial plain. Geographical maps from the end of 19th and first half of 20th century indicate that there were several isolated areas with marshes which were the same size or perhaps bigger in prehistory. Medieval sources even indicate that there was a smaller lake in Pelagonia and an island near the site known as Staroselo and Katarsko (*Chausidis 2003*). The frequent floods and dynamic underground waters probably affected the quantity and extent of the wetlands which were changing in various eras until their final drainage in the 1960s. The climate had an important role, as the one in Pelagonia is considered as modified continental and moderate continental, with hot, dry summers and cold, wet winters. Wide temperature fluctuations are frequent with a

maximum of 40°C and minimum –30°C in summer and winter, respectively. Annual precipitation is approx. 915mm, which, along with river floods, allow constant watering of the soil and the cultivation of cereals (*Puteska* et al. *2015*).

Nevertheless, archaeological research in the 1970s asserts that Pelagonia in the Neolithic was mainly wetland area and therefore later inhabited by the first agricultural communities (*Kitanoski* et al. *1980; Naumov 2009a*). This is also indicated by the calibrated dates of several sites in Pelagonia, which are somewhat later than those from Neolithic settlements in Ovče Pole, a region north-east of Pelagonia (*Naumov 2015a; 2016a*). In spite of recent chronological and hydrogeological results, archaeological excavations confirm large number of sites in this wetland area next to the Crna Reka and marshes (*Simoska, Sanev 1976*). The fertile fields attracted larger groups of communities to establish settlements near wetlands, which is also supported by similar radiocarbon dates from several Neolithic villages (Fig. 3). This process began around 6000 BC, but continued throughout the entire millennium, with a number of tell sites appearing and vanishing after several centuries of intensive occupation.

Chronology of tells

The date of the establishment of tells is still under debate as the proposals are based mainly on relative chronology, *i.e.* on comparison of material culture (*Sanev 1995*). There were few dates from radiocarbon analysis of samples unearthed at sites in Pelagonia, but they were not used in Macedonian archaeology. They have recently been incorporated into the research of tells in this region and provided an entirely new perspective on the initial stages of the Neolithic and its progress in the 6th millennium BC (*Naumov 2009a; 2015a; Naumov in print*). Several tells in Pelagonia were dated in the 1970s in two laboratories at the Ruđer Bošković Institute in Zagreb and the University of Texas in Austin (*Srdoć* et al. *1977; Valastro* et al. *1977*). Although this was a few decades ago, they remain the only reference for the prehistoric chronology of Pelagonia. There are high standard deviations among the provided dates, but some could be used as a reference for a chronological framework.

The earliest date so far is from Topolčani, which dates to the middle of the 7th millennium (Fig. 3). This quite early date is under discussion due to sev-

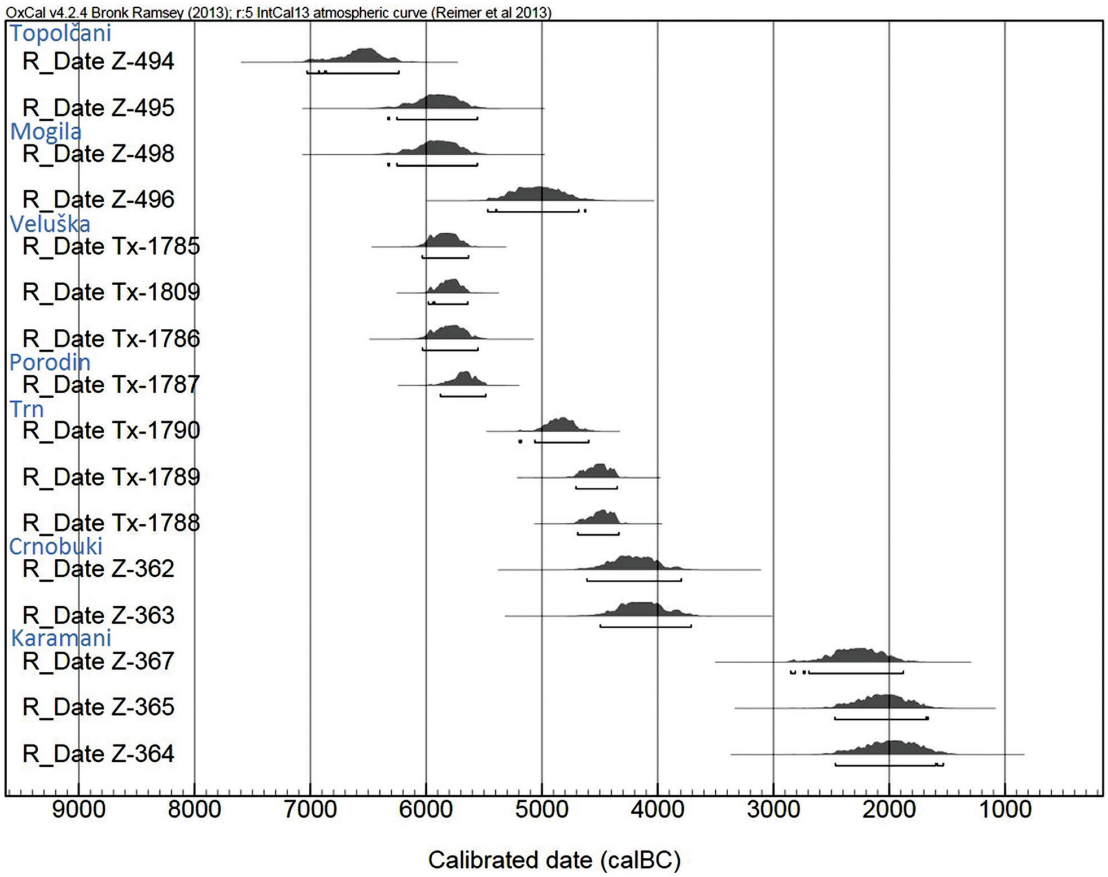


Fig. 3. Calibrated radiocarbon dates from tell sites in Pelagonia (after* Naumov 2016a.Fig. 10*).

eral problems. First, there is high standard deviation in the result, which currently is not considered in archeological research as adequate information. Also, the sample could come from organic material which is much older than the period of its use at the Neolithic settlement at Topolčani. But if some dates from northern parts of Greece and Central Albania are considered, then such early date is not uncommon for the Balkans (*Reingruber 2011; Karamitrou Mentessidi* et al. *2013; Bunguri 2014*), and they are sometimes associated with the first farming pioneers exploring and later settling this peninsula (*Perlès 2001*). The second date from Topolčani corresponds more with the chronology of other tells in Pelagonia, although with a high standard deviation in the result, which is much later and could be set at the very beginning of the 6th millennium BC.

Several dates from Mogila, Veluška Tumba, and Porodin are close to this one from Topolčani, and therefore could be proposed as more referential for the initial Neolithic stages of tell sites in Pelagonian wetlands. New dating and detailed chronological sequences are required in order to propose more complete dates for Pelagonia, although currently this should be considered as the only precise reference[1]. In regard to the very end of the Neolithic period in Pelagonia, the tell at Trn provides several dates from the first half of the 5th millenium BC. Both dates and material culture are common for the Late Neolithic in the Balkans and therefore could be proposed as the current chronological reference for the last Neolithic stage in Pelagonia (*Simoska, Sanev 1977; Naumov 2016a; in print*). This temporal range indicates that Neolithic tells appeared and were abondoned over a period of approx. two millennia. Some of these settlements were occupied for only a few centuries, while others were reused in later periods (Chalcolithic and Bronze Age) and even as an area for Roman villas rusticas in the Classical Period or necropolises in the Middle Ages.

Settlements in wetlands

The first Neolithic villages were established according to the environment and natural conditions. Wetlands and the surrounding fields were chosen as fertile ground able to provide a subsistence economy. Although paleoecological research has not been undertaken for Neolithic Pelagonia, a survey from the neighboring regions indicates progressive reforestation after the Pleistocene and a densely forested landscape with oak, pine, elm, hazel, *etc*. (*Demoule, Perlès 1993*). Both the alluvial plain and hills around it were preferred locations for Early Neolithic settlements, but the highest number of villages has been recorded in the flatlands (*Simoska, Sanev 1976*). The majority were close to marshes due to the well-watered soil and proximity of resources for food, building, plaiting and basketry. Recently, the marshes were considered as source of a malaria, but current research shows that particular communities developed cultural, dietary and behaviour adaptations and reduced the risk of death (*Sabattani* et al. *2010*). Therefore, the Pelagonian wetlands could be considered an ideal landscape for siting some of the first agricultural villages in the region.

Most of the settlements are tell sites, although some sites are positioned on the hills near the valley. Considering that most of the valley is flatland, it was necessary to establish artificial mounds close to marshes. The first agricultural communities in Pelagonia used small natural humps on which they constructed wattle and daub houses (*Simoska, Sanev 1976; Kitanoski* et al. *1990; Tolevski 2009; Naumov* et al. *in print*). Tells were dispersed all over the valley, but the majority around the marshy lakes (Fig. 4). Recent research indicates that Neolithic societies in Pelagonia used the principal water resources, so that many of them are close to marshes and along the Crna Reka. Although the total current number of documented tells in Pelagonia is more than 120, in its central part alone 93 sites have been recorded, most of which are tells (*Naumov, Stojkoski 2015*). There are major bigger tells all over the valley, with a number of smaller tells established in their vicinity. Until thorough excavations and further dating, it remains open as to whether these clusters of tells were synchronous and related to each other. In some areas there are groups of 3 to 8 tells, which indicates several scenarios: 1) they could have been established in different periods, although pottery at some neighboring sites is quite similar; 2) a single tell could be the area's centre, while a few others could be peripheral, consisting of communities not incorporated within the centre or belonging to a group of newcomers willing to be integrated into the society (*Naumov, Stojkoski 2015*). Nevertheless, such a high density of tells in a particular area indicates more complex social processes in the Neolithic and a division of both status and space.

1 Few months ago ^{14}C analysis on seeds unearthed from tells at Porodin and Optičari was done at The University of Bern. These still unpublished dates indicate that the initial occupation of the sites was at the very beginning of 6th millennium BC and partially correspond with the dates from 1970s.

In regard to the division of space, geophysical scanning at a few tells shows practices common to well-organised societies. At the tell at Dobromiri, a number of dwellings are disposed in lines, while the centre consists of constructions organised around an empty circular area (Fig. 5a). The entire village is enclosed with a ditch and a few entrances apparently divided the tell from its surroundings (*Naumov* et al. *2014*). This ditch could be to protect the inhabitants from attack, from wild animals and fires, but it could also be a symbolic border between the domus and agrios, *i.e.* domesticated and wild world (*Hodder 1990; Bradley 2005; Harding* et al. *2006*). In spite of this, at other sites the geophysical scanning does not show a similar division of space. The tell at Trn is later, has no ditch enclosing the village and has one massive building at its very centre (Fig. 5b). These differences could relate to dissimilar social practices or to diverse communities inhabiting sites divided only by the wide Crna Reka. That they belong to different chronological and cultural Neolithic levels could be a further explanation, although this does not always consider diverse societies, but sometimes the absorption of new cultural features (*Naumov* et al. *2014*).

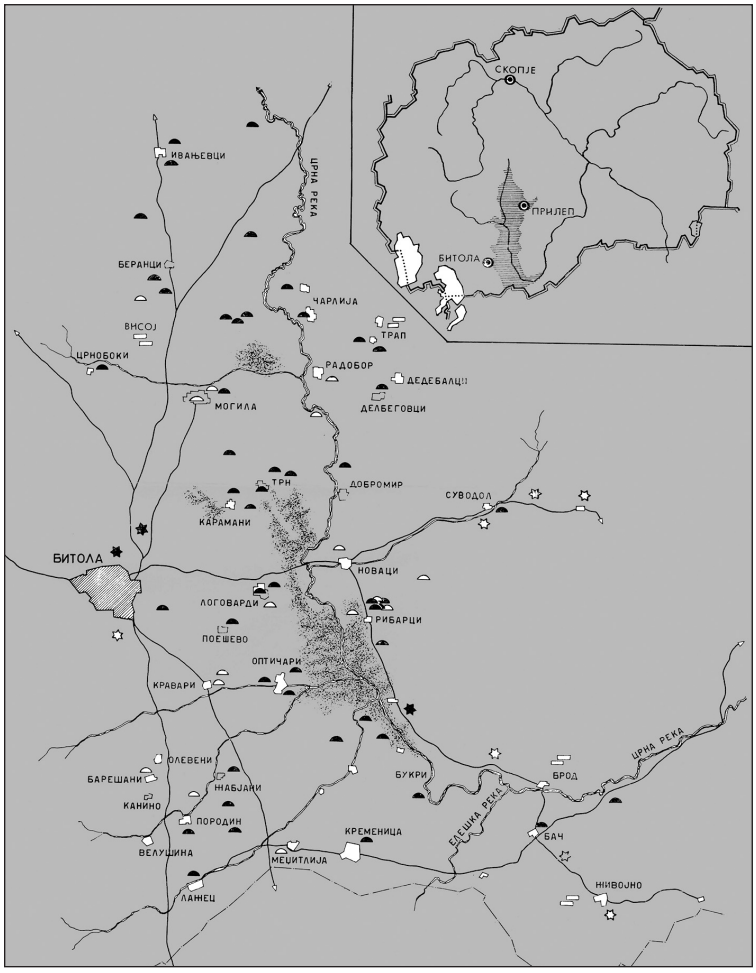


Fig. 4. Location of tell sites around wetlands in central Pelagonia (after* Simoska, Sanev 1976.Map 1*).

The buildings in the Neolithic villages of Pelagonia are mainly unified, with only a few exceptions. Most of the architecture consists of rectangular dwellings made of wattle and daub, with posts and triangular roofs covered with straw (*Tolevski 2009*). The dwellings at Veluška Tumba and Tumba at Porodin have feature common to the Neolithic houses in the Balkans, while at many other sites no outlines of structures are confirmed (*Grbić* et al. *1960; Simoska, Sanev 1975*). The dwelling at Slavej has the same plan (Fig. 6), but differs from the others in having an enormous elongated structure consisting of one main large container and four smaller disposed laterally (*Mitkoski 2005*). There are different explanations of this structure, with some stressing cultic aspects and others focusing on its economic features symbolically intensified by the applied patterns on the walls (*Kitanoski* et al. *1990; Mitkoski, Naumov 2007*). Recent excavations at the same site indicate another dwelling in the vicinity of this one. The concentration of many structures within one dwelling for processing cereals (platforms, ovens, fire places, grind stones, grinders, *etc*.) indicates an area with intensive economic dynamism (*Naumov* et al. *in print*). Considering these two large buildings in the central part of the tell it could be proposed that a huge quantity of wheatflour and bread was produced there. They could be communal buildings for the public provision of bread, which has already been proposed for some other sites in the Balkans (*Budja 2003*).

The pit houses at the Pešterica and Senokos sites, with banches and platforms in their interior, are exceptions to common Neolithic architectural traditions (*Kitanoski* et al. *1980; Temelkoski, Mitkoski 2006*). A specific structure is confirmed on a tell at Mogila, where a building with a dense concentration of posts but without the remains of daub in its vicinity was recorded (*Naumov, Tomaž 2015*). This structure is on the very periphery of the tell, which indicates the building of pile dwellings in Pelagonia

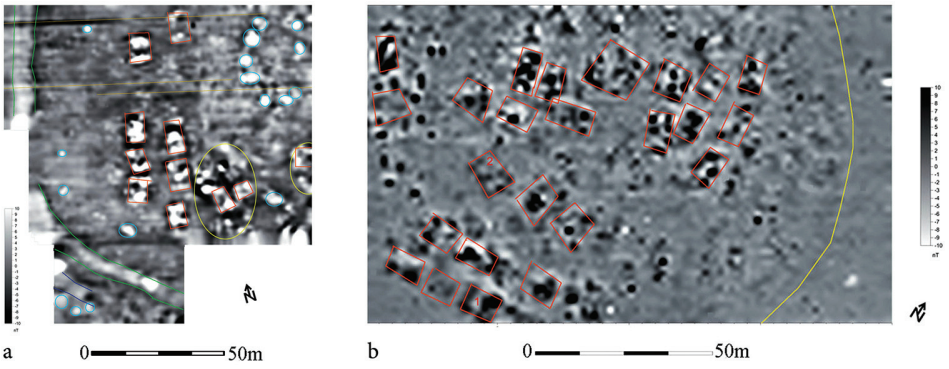


Fig. 5. Geomagnetic maps from geophysical scanning of tells at Dobromiri (a) and Trn (b) (after* Naumov *et al.* 2013. Fig. 11–12*).

due to the presence of water beside and below the site. The building of structures on posts was a common practice in Pelagonian villages even in the 20th century. Many were used for economic purposes in order to protect food resources from waterlogged ground and were sometimes used as huts for fishing, seasonal work or ritual purposes (*Chausidis 2009*).

With regard to pile dwellings or structures on wooden posts, house models should be an indication of the presence of such buildings in Pelagonia. House models are a common feature of the Balkan Neolithic, and there are several variations in shape (*Nikolov 2007*). Those in Pelagonia have particluar features which accentuate architectonic details, and have so-called 'legs' on the bottom (*Naumov 2011*). The study of house models has mainly focused on their symbolic aspects (*Temelkoski, Mitkoski 2005; Chausidis 2009; Naumov 2011*), but the social and architectonic features have also been considered (*Tolevski 2009; Naumov 2013*). The majority have 'legs', without a hearth or oven in the interior, and could be stylised representations of pile dwellings or buildings used to store cereals, vegetables, meat, *etc*. (Fig. 7a, c). The model found at Porodin has a broken bottom and a house interior, so it could be interpreted as a wattle and daub ground-level dwelling. But recent finds at Lemnochri II in the Amindeon basin (Greece) confirm the wider production of almost identical models which are thought to be representations of two storey houses (*Chrysostomou* et al. *2015*). Such houses have not been documented in Pelagonia so far, but given the proximity and similar environment of these regions, similar buildings could be expected in Pelagonia as well.

Material culture

The house models produced at Neolithic sites in Pelagonia are an appropriate introduction to the material culture of the societies living in the wetlands of this region. Regarding the amount of house models and its architectonic details, Pelagonia is one of the rare regions in the Balkans with such a focus on house representations. It indicates that the communities producing these models were focused on the social and symbolic significance of the house and its importance within Neolithic life (*Naumov 2013*). An emphasis on the house throughout material culture was related to the stylised portrayal of dwellings, but also integrated these miniature rerpesentations of buildings into more complex symbolic realm. Besides their specific visual features, associated with variety of semiotic atributes, the models also have a shallow container not designed to store a large amount of material. There have been different observations on how and why this part was used, but archeologists are mainly united on the ritual function that these models could have had (*Temelkoski, Mitkoski 2005; Nikolov 2007; Chausidis 2009; Naumov 2011*). The remains of fire suggests that something was burnt in their interior, although further chemical analysis could trace the ma-

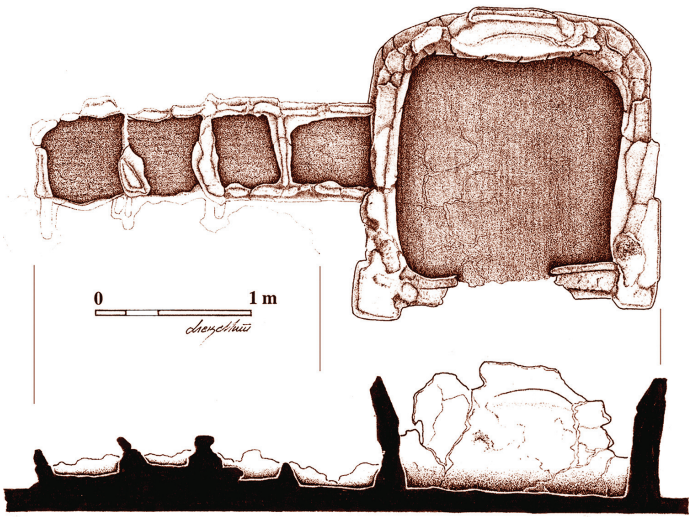


Fig. 6. Large clay structure (granary) inside a Neolithic house in 'Vrbjanska Čuka' at Slavej (after* Mitkoski 2005.Pl. 1*).

terials which were used in these practices. The deposition of figurines, stones and organic materials (flour, vegetation, liquids, *etc.*) should certainly not be excluded as composite parts of symbolic activities associated with these artefacts in the Neolithic.

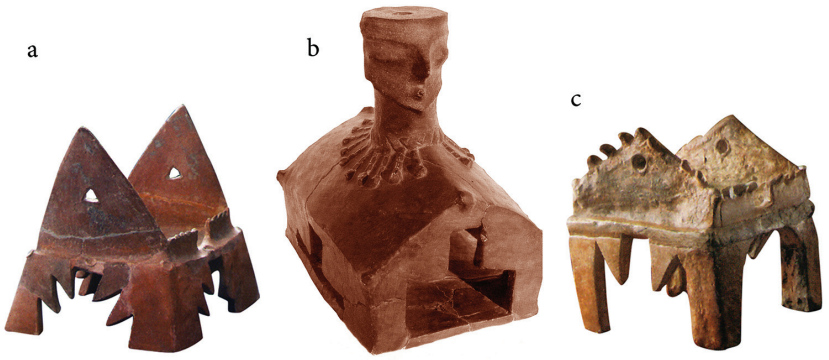


Fig. 7. Neolithic house models from 'Tumba' and 'Veluška Tumba' at Porodin:* a *no scale (*Vasileva 2005.40*);* b *height 25cm (*Kolištrkoska Nasteva 2005.Fig. 43*);* c *no scale (*Vasileva 2005.40*).

The symbolism within the house models was not only applied to their ritual use, but also to the more complex semiotic identification of the house and the human body. From the last stages of the Early Neolithic in Pelagonia anthropomorphic house models were produced (*Simoska, Sanev 1976; Sanev 2006; Chausidis 2007*). They comprise a cylinder with a representation of a human face and house model instead of the lower half of the human body (Fig. 7b). Although similar artefacts were produced in neghbouring regions north and north-east of Pelagonia, those particular to this region have apparent features of dwellings, in spite of others which consisted of a box instead of a house model. Such apparent identification of humans with houses is not common in the wider region, so discussions raised the question of who or what was manifested through these artefacts. Alhough they were speculatively interpreted as 'Great Mothers' (*Sanev 1988; Zdravkovski 2006a*), still more thorough observation indicates that they probably represented the individuals associated with the house, such as the family head (paterfamilias), an ancestor, deceased person, distinguished individual, *etc.* (*Naumov 2013*). Nevertheless, the anthropomorphic house models attest to the symbolic relationship with communities and their dwellings, which was particularly emphasised among the Neolithic villages within the wetlands of Pelagonia. It is in accord to Hodder's concept of domus and the accentuation of the domestic sphere in the Neolithic (*Hodder 1990*), but also emphasises the idea of the domestication of human body as a process synchronous with the domestication of animals and cultivation of plants.

The prominence of symbolic features of the human body in Pelagonia was not only manifested in this hybrid relationship between man and house, but also in the production of figurines. The figurines were miniature representations of bodies, and stressed particular segments of corporeality and embodiment (*Joyce 2000; Lesure 2011*). In spite of other regions where sexless figurines prevail, in Pelagonia most of the figurines are female, with an apparent focus on the buttocks and genital area (Fig. 8). Corporeality employed body gestures which often includes hands on the abdomen or genitalia and also covering of genitalia with particular round applications (*Naumov 2014*). Animal figurines were also found in Pelagonia, but in significantly smaller numbers compared to human representations (*Temelkoski, Mitkoski 2001; Vasileva 2005*). The interpretation of figurines ranges from individuals to deities (*Gimbutas 1989; Bailey 2005*), but although their meaning is hard to grasp, it is indicative that they were intended to represent features of a human body. The characteristics that were represented bear the apparent features of humans and thus reflect regional identity and the understanding of embodiment in that particular region.

In terms of regional identity, pottery is one of the most distinguished representatives. Not only typology, but patterns painted, applied, and incised on the vessels are indicators of regional preferences in pottery production (Fig. 9). Along with the first extensive excavation of Neolithic tells in Pelagonia, pottery was regarded as a cultural and chronological marker. Thus, the types of vessel and their decoration were primarily determinants for the archaeological culture identified with Pelagonia (*i.e.* the Velušina-Porodin group) and consequently the reference for each Neolithic phase (*Simoska, Sanev 1976; Garašanin 1979*). Particular shapes and patterns were associated with the Early, Middle or Late Neolithic, although further analysis demonstrate that such an archaeological division of decoration is not always accurate and was thus modified (*Sanev 1995; Naumov 2009b; 2015a*). Nevertheless, besides its chronological, economic and technological engagement pottery also has complex social features.

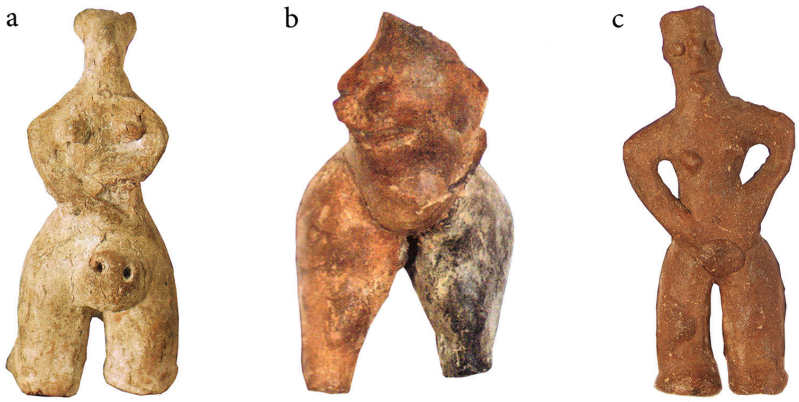


Fig. 8. Neolithic anthropomorphic figurines from 'Tumba' and 'Veluška Tumba' at Porodin:* a *height 7cm (*Kolištrkoska Nasteva 2005. Fig. 7*);* b *height 12cm (*Kolištrkoska Nasteva 2005.Fig. 26*);* c *height 6cm (*Kolištrkoska Nasteva 2005.Fig. 5*).

The majority of Early Neolithic white painted patterns or Late Neolithic incrustations were not only an aesthetic expression of communities inhabiting Pelagonia, but also markers of their identity. Most of the patterns on vessels were common mainly in Pelagonia, but not in the surrounding regions. This indicates that as a geographically encircled area, Pelagonia was inhabited by communities which developed a distinct identity mainly manifested in pottery, but also in other elements of material culture (*Naumov 2010*), which includes figurines, models, stamps, and tools, which besides their general characteristis also have authentic features unique to this region. Nevertheless, although geographically isolated, the communities in Pelagonia established dynamic networks mainly with those to the southwest, while northerly regions were apparently omitted. A number of painted vessels, anthropomorphic house models, 'altars' and stamps found at Neolithic sites in the Lake Ohrid basin are almost identical to their counterparts in Pelagonia (*Kuzman* et al. *1989; Kuzman 2013; Naumov 2016b*). Although geographical obstacles were not prominent between these two regions, networks were intensified in the Early and Late Neolithic, despite less intensive interaction with other northern areas (*Naumov in print*).

Tools comprise the final group of material culture incorporated in this review of Pelagonian wetlands in the Neolithic, although more objects should be included in an extensive review. Regarding regional specifications, ceramic projectiles should be mentioned, as they are absent or rare in neighbouring regions (*Grbić* et al. *1960; Mitkoski 2005*). They are found in large numbers at Pelagonian sites, which suggests they were more frequently used in hunting and fighting than for other purposes. Arrowheads are almost absent, thus confirming the preference for clay sling missiles for both hunting and fighting. Also their use in stockbreeding and controlling pasturing flocks or herds has been proposed (*Perlès 2001*), and the accuracy of sunbaked projectiles in combat has also been emphasised (*Runnels* et al. *2009*). In contrast to arrowheads, flint blades are more frequent and vary in shape and function, as well as a number of polished axes (*Simoska, Sanev 1975; 1977; Kitanoski 1977; Simoska, Kuzman 1990; Kitanoski 1989; Naumov, Tomaž 2015; Naumov* et al. *in print*). Bone tools are also very rare, perhaps because of the excavation methodology or chemical features of soil, as animal bones from the Neolithic are rarely present or reported. Ornaments are not within the scope of tools and are more concerned with decoration and identity. Bracelets and necklaces of stone, bone or shell are almost absent at Pelagonian sites, but their presence on human representations such as figurines and anthropomorphic house models indicate they were composite parts of an emphasised individual or communal identity (*Naumov 2015b*).

Wetlands and networks

Due to the vast bodies of water, wetlands were considered as areas consisting of unrefined and conservative societies incapable of producing a sophisticated material culture or establishing more complex spatial organisation within settlements and land-



Fig. 9. Neolithic pottery from 'Tumba' and 'Veluška Tumba' at Porodin:* a *height 48cm (*Fidanoski 2009.Pl. 66/7*);* b *width 23cm (*Fidanoski 2009.Pl. 66/5*);* c *height 17cm (*Fidanoski 2009.Pl. 67/3*).

scapes. But more thorough research on excavated finds and contexts, as well as the integration of science and theory within wetland archaeology, has provided a new understanding of these areas and the communities living there (*Van de Noort, O'Sullivan 2006*). The first agriculturists in the wetlands of Pelagonia are a remarkable illustration of how societies inhabiting such areas were far from unrefined or unskilled at crafts. The brief overview of material culture presented above indicates that the Neolithic wetlanders in Pelagonia and in many other similar areas of the Balkans were exceptional manufacturers, rational exploiters and meticulous organisers of living space. Moreover, they engaged their cognition in a sophisticted way in order to incorporate hybridism and embodiment within material culture or to geometrically organise the scrupulous white painted patterns on the curved surfaces of vessels. Although this blossoming of art, symbolic visualisation and patterning of space appear as a kind of sudden 'explosion' in Pelagonia, it was gradually integrated in a long-term process developed by many generations in diverse regions.

The wetlands in the valley within the encircled landscape of mountains in Pelagonia were even more of a challenge to newly arrived farmers or to the indigenous population that rapidly absorbed Neolithic ways of life. Constant access to fertile fields, confrontation with floods and isolation from other regions by high mountains enabled a solid focus on local identity and particularly a genuine understanding of the human body and the landscape. Therefore, the spatial organisation of tells around marshy lakes, the conception of corporeal hybridism or incorporation of geometry within pottery decoration were advanced as achievements not similar to, or at least modified, further north of Pelagonia. The material culture associated with these principles was exceptional, made with a high level of expertise and quality and attractive to communities in neighbouring regions.

Although developed within an area enclosed by mountains, Pelagonian societies were not preserved in regional isolation. Its aesthetic and symbolic features reached other farming communities in the vicinity. Some of them absorbed or exchanged only parts of this Pelagonian 'culture', while others were established thorough networks. In terms of material culture, Pelagonian societies were more southerly oriented, and did not favour strong relationships with those to the north or east. The painted patterns of vessels, figurines' features, model houses and anthropomorphic cylinders significantly differ from what was produced by the so-called Amzabegovo-Vršnik, Starčevo, and Karanovo cultures (*Garašanin 1979; Todorova, Vaisov 1993; Sanev 1994*). There are surely glimpses of Pelagonian artefacts in regions defined by these 'cultures', as witnessed by the anthropomorphic lanterns, figurines and the few painted patterns in the Skopje and Ovče Pole region (*Naumov 2010*). More evident elements of the Pelagonian Neolithic are present in the very close region of Raec across Mt Babuna and in the Polog valley northwest of Pelagonia (*Sinadinovski 2016; Zdravkovski 2006b*). The similarities are mainly in the white painted patterns on vessels from the Middle Neolithic levels of a few sites in Pelagonia. Therefore, it can be proposed that contacts were firmly established later, although communication between these regions in the Early Neolithic should not be excluded.

The solid networks of Pelagonia with other areas are most apparent in the Lake Ohrid basin. From the Early Neolithic, settlements produced white painted pottery, anthropomorphic model houses and 'altars' almost identical to those in Pelagonia (*Naumov 2016b; in print*). This is evidenced at Dolno Trnovo, which is on the alluvial plain close to the lake (*Kuzman* et al. *1989*). Some painted patterns are also present in Korçë basin in Albania, but anthropomorphic house models are entirely absent there (*Ruzi 2009; Bunguri 2014*). Intriguingly, the Pelagonian features are not so apparent or present at Neolithic sites south and south-east of this valley, like those in the Amindeon, Servia and Giannitsa regions in Greece, which are more like the pottery produced by communities in the Korçë basin and even in the Ovče Pole valley than in Pelagonia. Future research on Early Neolithic data could provide a model different from the one proposed, but current research and published material suggest the lack of a strong relationship with the south, in spite of firm networks with the south-west, *i.e.* Lake Ohrid basin.

The firm networks between Pelagonia and the Lake Ohrid basin were maintained in the Late Neolithic as well when an abrupt change in material culture appeared synchronically in both regions (*Naumov in print*). Black polished pottery with white incrustation and stamps with identical patterns have been unearthed at sites at Ohridati and Ustie na Drim (*Kuzman 2009; 2013*). In the Late Neolithic levels of Ohridati, an anthropomorphic cylinder was found that has apparent similarities with those previously produced in Pelagonia, but utterly absent in later pe-

riods. This cylinder indicates that some Pelagonian elements were retained in the Lake Ohrid basin even when they were abandoned among communities in Pelagonia. Nevertheless, the recently published results of a dendrochronological analysis of piles in Ohridati provide Middle Neolithic dates around 5500 BC (*Westphal* et al. *2010*). This indicates that some social processes were synchronous in these two regions, so some earlier features from Pelagonia do not have to be considered as Late Neolithic in the Lake Ohrid basin.

Regarding the apparent geometrical incrustations on pottery, it was previously suggested that such Late Neolithic novelties were introduced from Adriatic communities (*Benac 1979; 1989; Sanev 1995*), but recent research indicates that the same features on pottery were present quite early in Western Turkey and gradually transposed to the Balkans, including Pelagonia and the Ohrid area (*Özdoğan 1993; 2011; Steadman 1995; Naumov 2016b*). The networks between Ohrid and Pelagonia continued in later prehistoric periods as well, as witnessed by the similar pottery, jewelry, burial masks, weaponry, *etc*. (*Mikulčić 1966; Mitrevski 1997*). This connection was probably interrupted at the end of the Iron Age, when novel cultural features dominated and the ethnic reorganisation of territories became more dynamic.

Although these two regions were divided by high mountains – Baba, Galičica and Bigla – the Neolithic and later prehistoric communities inhabiting the separated valleys established and maintained solid contacts, economic exchange and a shared common identity. In spite of this, regions which were closer to Pelagonia and easier to approach were culturally more distant and material culture was not very similar to what was found in the Lake Ohrid region. Future research will provide new data for a more thorough understanding of the motives for having strong networks between these geographically divided regions and elaborate the integrated processes within social relationships and symbolic practices. Until then, it may be proposed that similar wetland environments and the proximity of a lake as resource and symbolic landscape were major reasons for intensive communication and shared identity manifested in pottery, models, 'altars' and stamps.

Conclusion

The particular focus on tell sites has attracted more attention in recent decades than hitherto. Although many tell sites have been partially excavated in Southeast Europe, they have rarely been regarded as architectural and social entities (*Kotsakis 1999; Perlès 1999; Rosenstock 2009; Hofmann* et al. *2012*). Recent research indicates that tell sites are complex settlements with highly intensified social and infrastructural dynamics, which is manifested in their outline, building patterns, material culture, rituals, *etc*. The Neolithic tells in Pelagonia have similar features and require further exploration in order to specify the dynamics within these specific agricultural settlements. They were excavated mainly in the 1970s, but a thorough understanding of their social, architectural, economic, and symbolic spheres was never extensively explored or proposed. Given their authenticity, they can provide a novel insight into the establishment and development of these specific settlements in the Balkans.

Most Pelagonian tells are located on alluvial flatlands, while the surrounding mountains slopes mainly consisted of flat settlements on hilly areas. This concentration of vast numbers of tells on flatlands was intentional rather precarious due to frequent flooding, therefore the first agricultural communities in this region have deliberately chose small bulky mounds made of Neogene lake sediments. These were the fundamental basis for the villages which gradually developed into tells. This bulky and sandy ground has been found to be the lowest level at many tells in Pelagonia where the first dwellings were established (*Simoska, Sanev 1975; Simoska* et al. *1979; Naumov, Tomaž 2015; Naumov* et al. *in print*). In this way, the first Pelagonian farmers interacted with the wetland environment and evaded the rising underground water after heavy rains, flooding of the Crna Reka and snowmelt water from the surrounding high mountains. The forests on the mountain slopes provided plenty of wood for wattle and daub houses, but also for pile dwellings on the periphery of sites. Such constructions are recorded in Early Neolithic levels of the tell at Mogila, while a wooden post was unearthed from the Krušeanska Čuka tell (*Naumov, Tomaž 2015; Todorović* et al. *1987*).

Regarding the successful management of settlements in various climatic conditions, the wetland environment in the valley was not an obstacle to the appearance of a large number of Neolithic villages. On the contrary, the frequent floods and marshy lakes provided more resources used for subsistence, architecture and communication. Consequently, many tells were established in the initial Neolithic phases and many continued in use at later stages and even in the Chalcolithic and Bronze Age (*Simoska, Sanev*

1976). They were mainly concentrated around marshy areas and next to riverbanks, so a pattern of tells distribution in Pelagonia is identifiable. There are discussions on the density and absence of tells in particular regions. For the Thessalian tells, it is proposed that farming communities living there intentionally avoided particular areas or these were used as buffer zones (*Perlès 1999; Runnels* et al. *2009*). In Pelagonia, such avoidance could be due to marshy areas, as partly documented by geographic research (*Naumov, Stojkoski 2015*), or could be the result of using these areas for raising crops. Consequently, the majority of tells tend to be densely clustered close to marshy lakes and riverbanks, *i.e.* near the most fertile soil.

There are larger tells, which were probably economic centers, and few smaller ones were erected in their vicinity at the same time, but some were established later. The question remains as to whether the later tells were founded by the same communities living on neighbouring tells or settled by newcomers. There are cases, such as Çatalhöyük in Anatolia, where the community from the East Mound in the Late Neolithic established the West Mound, which was continuously occupied in the Chalcolithic (*Biehl* et al. *2012*). The Pelagonian tells at Trn and Slavej could have the same site history, as they both have very closely positioned tells with phases of the Early and Late Neolithic accordingly (*Simoska, Sanev 1977; Naumov* et al. *in print*). Future detailed research will determine whether there the material culture was shared with neighbouring tells and thus elaborate resettlement from one place to another.

Another question is why life on one tell was interrupted and did not continue on the same tell, but the same or different community later established a new tell, in some cases only a few metres from the earlier one. The height and general occupation area of tells is not that great, especially compared to those in Anatolia and Near East, so capacity was not an obstacle to the continuation of life in the same settlement. Some Neolithic tells were even reoccupied in the Bronze Age, such as those at Karamani and Radobor (*Simoska* et al. *1977; Todorović* et al. *1987*). Thus a reduction in resources or climate changes could be a further reason for tells to be abandoned and for the later establishment of new ones nearby. The space in the central area of tells was not used to expand the site, such as in the Great Hungarian Plain or at Sesklo in Thessaly, which were parts of larger horizontally extended settlements (*Kotsakis 2006; Parkinson, Gyucha 2012*). The vertical extension of the settlement was common at tells in Pelagonia, although there are exceptions, such as the site at Slavej, where there no buildings were above or below the house level at the very centre of the site (*Naumov* et al. *in print*).

The reuse of a central place for occupation resulted in the rebuilding of new houses on existing ones, which further affected the creation of an artificial mound. This process was not only social, *i.e.* with a concentration of elites at the very centre, but was also a symbolic manifestation of a continued relationship with previous occupants. In the Balkans, this tradition began in Thessaly, as reflected not only in architecture, but also in material culture and burial rituals (*Kotsakis 1999*). The deceased were buried below houses which were later reoccupied or rebuilt and house models were also produced in order to maintain a link with ancestors, relatives, or those who built the first houses. Although no burials have been found inside Pelagonian settlements, the occupants produced a large quantity of house models, especially those with human representations (Fig. 7). Such anthropomorphic models are powerful representations for the identification of dwellings with particular individuals and the human body in general (*Naumov 2013*). In this sense, the rebuilding of houses and massive production of models indicate strong liaison between several generations within these agricultural communities and the accentuation of dwellings as focal points for the establishment of lineages.

According to the proposed dates, most Early Neolithic tells in Pelagonia were constituted around 6000 BC, probably as a Thessalanian tradition, *i.e.* at the beginning of the Middle Neolithic in Thessaly (Fig. 4). Therefore, such transposition of practices and traditions is not surprising, although it is not frequent or common in other regions in the Republic of Macedonia. These habitual and symbolic traditions were further modified and localised throughout novel building techniques, spatial organisation and the production of more advanced house models, *i.e.* identified with the human body. This was also manifested in other spheres of material culture such as pottery, stamps, figurines, 'altars', ornaments, *etc*. This localised production of the Neolithic 'inventory' was synchronic with the initiation and further development of novel identities evident in pottery decoration, figurine details, stamp patterns, house models, features, *etc*. (*Naumov 2010; 2015a*). It was reflected in the understanding of the landscape, settlements and inhabitants as particular groups that

are differentiated from others in surrounding regions. In such a vibrant isolated environment encircled by mountains, the numerous tells in the flatlands had a significant role in the establishment of social and symbolic relationship with human made and natural features of Pelagonia. This is evident both within tells themselves and their spatial organisation in the valley and thus can be further explored by means of advanced archaeological methods and more thorough research.

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Marine shell hoard from the Late Neolithic site of Čepin-Ovčara (Slavonia, Croatia)

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ABSTRACT – *The focus of this paper is the ornament hoard from the Sopot culture site of Čepin-Ovčara in eastern Slavonia (the Republic of Croatia). The hoard contained pendants and beads made of shells of marine clam* Spondylus gaederopus *and scaphopod* Antalis vulgaris*. The paper analyses the context and use wear of the objects in the hoard. The results form a basis for: the reconstruction of the role of some of the items and the ways in which they were worn; the premise that the dynamics and mechanisms of acquisition of ornaments made of the two Mediterranean mollusc species could have differed; and the identification of a cross-cultural pattern of deposition of ornament hoards.*

IZVLEČEK – *V članku se osredotočamo na zakladno najdbo z nakitom iz časa sopotske kulture na najdišču Čepin-Ovčara v vzhodni Slavoniji (Republika Hrvaška). Depo vsebuje obeske in jagode, izdelane iz lupin morskih školjk vrste Spondylus gaederopus in polžkov vrste Antalis vulgaris. V članku analiziramo kontekste in sledove uporabe teh izdelkov. Rezultati nam nudijo osnovo za: rekonstrukcijo vloge nekaterih izdelkov in načinov nošenja nakita; premiso o različnih dinamikah in mehanizmih pridobivanja okrasov iz dveh sredozemskih vrst mehkužcev; in za prepoznavanje medkulturnih vzorcev odlaganja zakladnih najdb z nakitom.*

KEY WORDS – *Late Neolithic; Sopot culture; marine shell hoard;* Spondylus*;* Antalis

Introduction

Objects made of marine animal shell discovered at sites on the European mainland are important not only because of their basic and symbolic function; they are also evidence of contacts and exchange with communities that lived by the sea. The importance of these objects is reinforced through their exotic origin, their often highly meticulous manufacture, as well as their deposition in graves and hoards (*Chapman 2000; Müller 1997*). However, the distribution and ubiquity of such ornaments across the European continent have been considered primarily for objects made of *Spondylus* shell. In contrast, there are no sufficient data on areas and periods in which ornaments made from shell of other marine animals occur.

The distribution map of spondylus items (as shown in *Müller 1997; Dimitrijević, Tripković 2006; Todorova 1995; Willms 1985; Windler 2013*) shows that the territory of eastern Slavonia (the Republic of Croatia), bordered by the rivers Sava, Drava, and Danube, lies in the centre of an area in which the ornaments have been sporadically documented since the beginning of the 20th century (*Brunšmid 1902; Dimitrijević 1968*). The number of sites investigated in the region has significantly increased in the last decades, thanks primarily to rescue excavations that preceded the construction of major roads (see *Balen, Hršak and Šošić-Klindžić 2014*). Ornaments made from *Spondylus* and other marine species were found in graves and settlements from different phases of

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the Neolithic. However, a single ornament hoard was discovered, at the Late Neolithic Čepin-Ovčara site, and this is the focus of this paper.

Method and terminology

For the taxonomic identification of shells in the Čepin hoard, preserved shell morphology was used according to the criteria provided in Walter Fischer *et alii* (*1987*) and Raymond Moore (*1969*) as well as the online source *Seashells collections* (*Caro 1997–2011*). The taxonomic nomenclature follows CLEMAM – Check List of European Marine Mollusca (*Le Renard 1994*).

Besides the scientific names of species, and also of higher-ranking taxa from which the shells used for the ornament manufacture derived (*Spondylus gaederopus, Spondylus, Antalis vulgaris*, Scaphopoda), common names are also used here. These are the names most often used by archaeologists to denote these kinds of objects, regardless of whether a taxonomic identification has been carried out or not: 'spondylus', for objects made of shell of *Spondylus gaederopus* and/or other species, and 'dentalium', for objects made of scaphopoda shells. The scientific names are given in italics, as is customary, and hence differentiated from the common names.

The morphological characteristics of the shells were observed with the naked eye, whereas the structure of the shell visible in cross-section was examined under a binocular magnifier with x45 magnification. The criteria (stated in *Dimitrijević, Tripković 2006*) were applied in order to exclude the possible use of fossil shells in the manufacture of the ornaments. The dimensions of the objects were taken with a calliper to 1mm precision. The weight was measured on digital scales to 0.1g precision.



Fig. 1. The site of Čepin-Ovčara (photo Museum of Slavonia).

The reconstruction of the function, *i.e.* the way in which shell items were worn, was performed through a macroscopic analysis of the incisions created by the strings on which individual pieces of ornament were originally placed. Traces of accidental damage on the objects resulting from their use were also observed microscopically by x45 binocular magnifier.

The Čepin-Ovčara site

Čepin is a village settlement located in a micro-region within the Drava-Danube lowlands of the eastern Croatian plain, 12km from the town of Osijek. The Ovčara archaeological site is situated on the outskirts of Čepin, immediately adjacent to the road to Djakovo, on a prominent hillock extending in the northwest-southeast direction (Fig. 1). The immediate surroundings of Čepin are in the area of an alluvial plain comprised of different landforms – the Drava river terrace and the Vuka river valley. This is swampy land interspersed with loess ridges (locally known as '*praporne grede*'), in the form of elongated areas of high ground that remain dry even in seasons of maximum water table. This land is now used for intensive agricultural production, and the region is characterised by long-lasting continuous habitation (*Roglić 2006.134*).

From 1997 to 2006, systematic archaeological investigations of a 300m^2 area were carried out by Jasna Šimić. A late medieval building (from the 13th to the 14th century), an early medieval cemetery of the Bjelo Brdo culture, and a Neolithic settlement of the Sopot culture were discovered (*Šimić 2006a.10; 2007b. 41; Rajković 2014*). The presence of a medieval building furnished with an apse affected the planning of the fieldwork, as the walls of the building determined the shapes of the excavation trenches. Thus each room of the building had a separate excavation trench. The remains of the Neolithic settlement include an array of diverse habitation elements, such as semi-subterranean structures, traces of above-ground architecture, postholes, pits and wells. Due to the disturbed stratigraphy and numerous burial pits, the relationships between individual stratigraphic units could not be clearly defined, and the excavation layers in different trenches could not be interconnected; this makes the entire interpretation of the sites' stratigraphy very difficult.

Based on observations made so far, the Neolithic settlement comprises several building horizons (*Šimić 2006a; 2006b; Rajković 2014*). In the earliest horizon of Neolithic occupation, variously shaped pits made for different purposes were uncovered, as well as part of a large, irregularly shaped dug-out structure with traces of thick posts, which has been interpreted as a pit-house (*Šimić 2006a; 2006b*). These features were dug into the virgin soil. The earliest settlement phase was overlain with a layer consisting of the remains of rectangular above-ground buildings oriented northwest-southeast (Fig. 2). A total of 18 floors were detected, generally constructed from baked soil placed on top of a wooden construction sitting on a layer of hard-packed clay. In some trenches, more floor levels were noticed, probably pertaining to different building phases (*Šimić 2006b. 41*). Due to the small size of the areas excavated within the walls of the Late Medieval building, no single above-ground Late Neolithic structure could be investigated in its entirety, which constrains a wider interpretation of the excavated features.



Fig.2. Čepin-Ovčara, sector 4: building SJ–75 (photo Museum of Slavonia).

A large quantity of diverse materials was recovered from the site. In addition to the usual products of pottery manufacture, one should mention a high number of animal bones, clay balls, spindle whirls made of potsherds, chipped stone, obsidian, and an anthropomorphic clay figurine (*Šimić 2007b.13*). The vessel types include pots of different outline decorated with modelled bands filled with fingerprints, biconical and conical bowls, cups with a foot, miniature vessels, and ceramic strainers. The ceramic ware is mostly grey and black, while some of the fragments are decorated with red paint. The typological characteristics of the pottery, stone and chipped stone from the Late Neolithic layer indicate the middle and later phases of the Sopot culture, *i.e.* phases II and III according to Dimitrijević (*Dimitrijević 1968.41, 48–49*).

Four radiometric dates were obtained for the Neolithic occupation of the site (Tab. 1). The date Z–3750 on charcoal places the earliest investigated cultural layer of the site in the period from 5054 to 4730 cal BC (at 95.4% probability). This horizon would cor-

Laboratory code	Sample	Radiocarbon age (BP)	Calibrated date
Z–3750	charcoal; cultural layer (Sj 62) between houses Sj 47 and Sj 60	6010 ± 60	68.2% probability 4986 (68.2%) 4836 cal BC 95.4% probability 5054 (93.7%) 4765 cal BC 4758 (1.7%) 4730 cal BC
Z–3751	charcoal; layer Sj 69 (ashy layer with some charcoal)	5940 ± 70	68.2% probability 4902 (14.2%) 4863 cal BC 4856 (54%) 4725 cal BC 95.4% probability 5006 (94.6%) 4679 4636 (0.8%) 4619 cal BC
Z–3264	charcoal; semi-subterranean structure Sj 28/29	5900 ± 90	68.2% probability 4908 (67.2%) 4684 cal BC 4630 (1.0%) 4624 cal BC 95.4% probability 4996 (95.4)% 4547 cal BC
Z–3263	charcoal; floor of the house Sj 16/17	5500 ± 90	68.2% probability 4452 (54.3%) 4314 cal BC 4301 (13.9%) 4261 cal BC 95.4% probability 4537 (87.5%) 4223 cal BC 4207 (4.0%) 41594070 cal BC 4018 (0.1%) 3998 cal BC

Tab. 1. Radiocarbon dates from Čepin-Ovčara. Dates were calibrated using OxCalv4.2.4 Bronk Ramsey (2013); r5; IntCal 13 atmospheric curve (Reimer et al. 2013).

respond with the earlier part of the classical period of Sopot culture (between 5000 and 4500/4400 cal BC, according to *Balen, Čataj 2014*; phases IB–III after *Dimitrijević 1968*). Somewhat later, but still during the classical period of Sopot culture, are the dates Z-3751 and Z-3264, which range between 5006 and 4619 cal BC and between 4996 and 4547 cal BC, respectively (at 95.4% probability). The latest date (Z-3263) for the settlement, obtained from charcoal recovered from the floor of an above-ground structure, indicates the period from 4537 to 4070 cal BC (at 95.4% probability). This range falls mostly within the Eneolithic sequence of Sopot culture (*Balen, Čataj 2014*) which so far has not been reported for the site. It is thus clear that the radiometric dates point to the continuity of the Neolithic settlement through several phases of development, but a stronger correlation between absolute and relative chronology is yet to be established.



Fig. 3. Čepin-Ovčara, marine shell hoard:* a *broader context,* b *detail (photo Museum of Slavonia).

The marine shell hoard

The hoard of objects made of sea shells was discovered in 2006 on the south side of a burnt house (sector P4, SJ-75), covered by its remains (Fig. 3ab). The remains of the structure derive from the final occupation horizon of the Late Neolithic settlement. The floor of the structure was not fully excavated, and one part of it extends into the north profile of the trench. The dimensions of the area of the exposed portion of the floor are 2.80 x 0.70m. The floor consisted of 10–15cm thick burnt soil, under which was a layer of charred wood comprising the remains of a substructure assembled from planks placed on top of a layer of compact clay. The overall thickness of the floor was 30cm (*Šimić 2007a.66–68; 2007b.13*). On the basis of the burnt remains, it can be assumed that this building was destroyed by fire, as was the case with other buildings at the site. The archaeological material found in the floor includes a fragment of a stone quern and another complete quern, a worked antler and a microlith; pottery was not recorded.

The hoard comprised 15 oval and trapezoidal pendants, one elongated pendant, 58 beads made of spondylus, and 386 tubular dentalium beads (Figs. 4–5). The total weight of the objects is 166g. The pendants and beads were deposited in the largest of the pendants, created from a whole valve of the clam (*Šimić 2007b.13*). The objects in the hoard probably formed three composite ornaments. The spondylus pendants each have two stringing holes, and it is assumed that they were parts of a single piece of adornment – a belt – while the spondylus beads were probably strung on a thread for one necklace, and the dentalium beads for another. In the text that follows, these composite decorative objects are described separately.

The belt

Fifteen objects made of spondylus shell, each fitted with two holes for stringing, can be interpreted as pendants or, as we prefer for this particular set, as

segments of a single belt. The largest piece was created from a left valve, whereas the remaining 14 represent circular, oval and polygonal cut-outs from the shell. The morphological elements of the valve indicating the type of shell from which the pendants were made are preserved only on the largest of the segments, on the inner surface of the valve; the outer surface of the valve and the hinge line have been worked and significantly modified. The original natural ornamentation of the valve is not preserved. The valve margins were trimmed and rounded, and the hinge area smoothened and flattened so that there are no traces of the ligamental grooves or the hinge teeth. Based on the shape and size of the valve, as well as the appearance of the hinge mechanism and the position of the ligament, it can be concluded that the largest segment was from the left valve of a shell of the genus *Spondylus*; its dimensions suggest that it is *Spondylus gaederopus*. The valve is oval, and appears elongated in vertical cross-section. On the inside of the valve, the scar of a large adductor muscle and the pallial line are clearly visible. The preserved height of the valve is 85mm, and its preserved thickness, measured in the centre of the valve, is 6mm. Among the species of the genus *Spondylus* that occur in European seas (*Clemam*

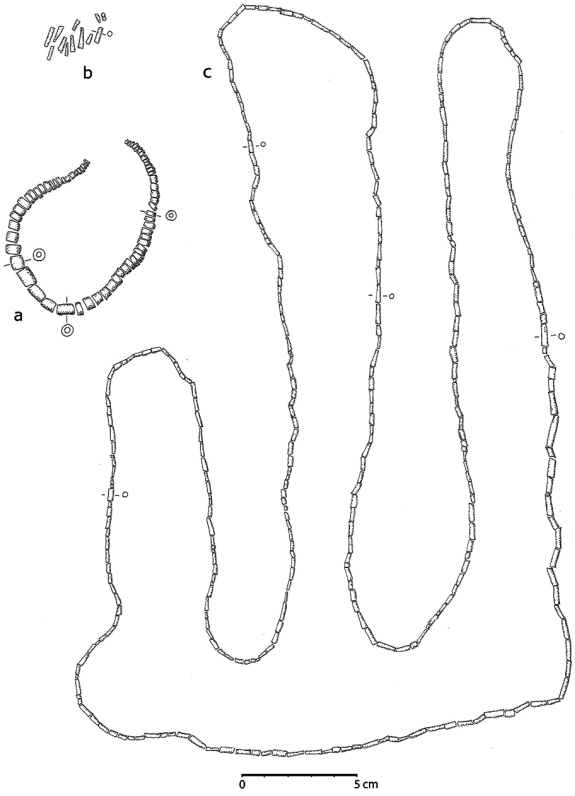


Fig. 5. Čepin-Ovčara hoard:* a *spondylus beads arranged in a string,* b *few loose dentalium beads,* c *dentalium beads arranged in a string (drawings by D. Radman).

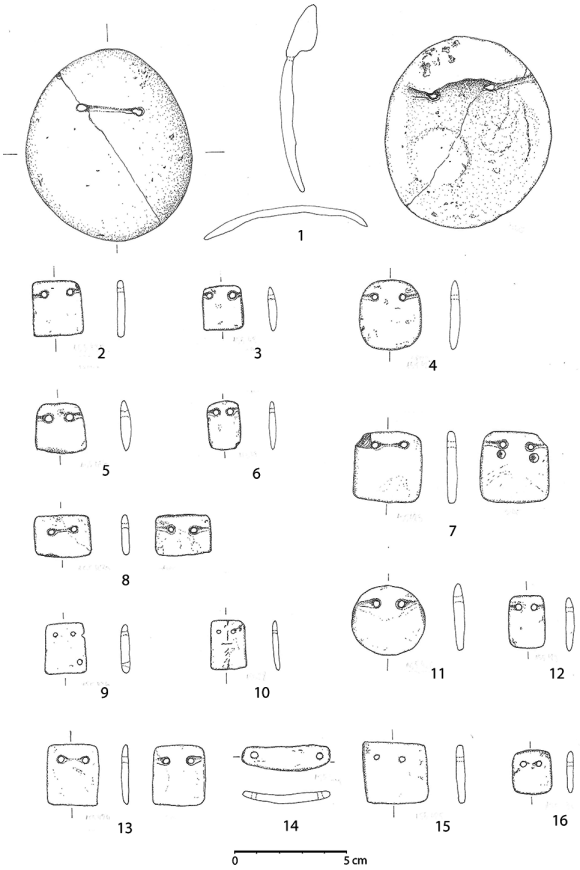


Fig. 4. Čepin-Ovčara hoard: spondylus pendants (drawings by D. Radman).

2014), only *Spondylus gaederopus* attains these dimensions. On the outer and inner surfaces of the valve the interior structure is visible in places, and is particularly clear in the area of the hinge. It is characterised by alternating transparent and opaque white laminae, *i.e.* growth lines whose frequency and curvature varies depending on the angle at which the valve is cut. The lines extend in the form of a wave of variable amplitude. The growth lines were also sporadically noticed in other segments (for example, segments No. 1 in Table 2, Fig. 8.c, and No. 14, Fig 8b), along with a rare trace of the valve's morphology. For instance, in the central part of one item (Fig. 4.15, No. 15 in Table 2) there is a shallow depression remaining from the scar of the adductor muscle that was flattened out through polishing. In another one (Fig. 4.5, No. 8 in Table 2), in the area above the stringing holes there is a dimple, which is either from the scar of the adductor muscle or is an irregularity on the inner surface of the valve.

The largest pendant or belt segment is ovoid in outline, and has one smooth convex surface which can be defined as the outer face, which was created by shaping the outer surface of the valve (Figs. 4.1; 6).

There are two holes near the upper margin set 20mm apart. The impressions of the string are visible in the area between the holes. The opposite, inner face of the object, which is the inner surface of the valve, was most probably turned towards the body. The hinge was flattened through polishing; its upper parts, initially rectangular, were trimmed to obtain the rounded, ovate outline of the whole object. The remainder of the inner face consists of the concave inner surface of the valve whose central part was not worked, and thus it preserves the scar of the adductor muscle and the pallial line. The flattened hinge and the trimmed, flattened and rounded edges of the valve are all in the same plane, *i.e.* they lean almost perfectly against the background. It is very probable that when the pendant was worn, its inner side faced the body and the convex side was visible, because if the pendant had been turned the other way, it would have been uncomfortable to wear it, given its large size, and would also result in deep incisions made by the string. On the inner surface of the pendant, the holes for stringing are located immediately below the hinge. The impressions of the string extend horizontally from the holes towards the lateral sides of the object, and are tilted slightly upwards. It is thus clear that this is not a pendant or an amulet worn around the neck, since if it were, then the use wear on the inner surface would extend vertically from each of the holes and upwards, rather than horizontally sideways.

For the remaining 14 pendants, *i.e.* belt segments, it can also be assumed which side was turned toward the body and which side was readily seen. These pendants are shaped as small plates with an oval, trapezoid or rhomboid outline (Fig. 4.2–13, 15–16). In most of them, one side is slightly convex while the other is flat. Usually, the slightly convex surface looks glossier, *i.e.* it appears more polished than the flat side. Also, in most pendants, this better polished surface is covered with fine scratches oriented in various directions, probably due to wear when the pendants were used. There are fewer of these marks on the other, flat side.

The imprints of the string in the area between the holes are in all pieces located on the convex, better polished surface; the string marks that extend from the holes towards the lateral sides of the objects are visible on their flat surface. Similar to the largest of the pendants, here it can also be assumed that the slightly convex, smooth surface was the front side, while the less carefully worked surface was the back and was turned towards the body. The pendants



Fig. 6. The largest pendant made of left* Spondylus gaederopus *valve, Čepin-Ovčara hoard (Museum of Slavonia, inventory no. 155438).

were all strung in the same way, and hung on a string tied around the body and sitting approximately horizontally. This leads to the assumption that the objects served as segments of a belt.

However, we cannot be entirely sure. For the majority of decorative objects, the way in which they were worn can only be ascertained when they are discovered on the body of a burial, or if they are explicitly shown in depictions. However, this, should not impede the examination of the characteristics that the 15 objects share or recognising the strong possibility that they were parts of a whole, or attempts to reconstruct the way they were worn. The pendants were probably not attached to a piece of textile or some other kind of material. If they had been, the impressions of the string would have remained in the area between the holes and the edges on the flat side of the pendants, because the string would have been run through the fabric immediately under the holes. The string imprints are deeper and more pronounced on the flat back side than on the front. This is probably because on the front side the string was firmly fixed between the two holes, whereas it was relatively loose between the segments and could move. There are no traces along the edges to indicate that two neighbouring segments rubbed against each other, so it can be supposed that there was some space between the segments.

The largest of the pendants, made from left valve of the shell, is at least 2.5 times higher than any other pendant in this group, and its weight is 6.5 times greater (Tab. 2). Hence it can be safely assumed that it was placed in the centre, because its weight would pull the belt downwards. There are 14 other segments, of which seven were probably placed on each side of the central piece (Fig. 7). They were probably arranged in descending order of size, from the largest piece placed next to the central pendant,

down to the smallest, *i.e.* of the smallest height, placed at the end of the row. The traces left by string in the area between the holes and the lateral sides can, to some extent, help infer whether an individual piece was placed to the left or right of the central pendant. In most segments, the string imprints on either the left or the right extend somewhat obliquely upwards. This could be due to the central pendant pulling the string of the belt downwards with its weight, which means that the other belt segments were slanted, and the intensity and angle at which the string made marks on the surface to the left and to the right of the holes were variable. Clearly, the arrangement of the individual segments could have been different, and almost certainly changed during use, given the traces of modifications and repair on some of the pieces.

#	Museum inventory	height/lenght (cm)	width (cm)	thickness (cm)	diameter of holes (cm)	weight (gr)
1	155423	3.2	2.9	0.4	0.3	11
2	155424	2.7	2.4	0.4	0.3	7
3	155425	2.7	2.8	0.4	0.3	7
4	155426	3.2	3	0.5	0.4	9
5	155427	3.2	2.8	0.5	0.3	7
6	155428	2.2	1.7	0.3	0.2	2
7	155429	2.4	1.6	0.3	0.3	3
8	155430	2.7	2.3	0.3	0.4	4
9	155431	2.5	2.3	0.4	0.3	4
10	155432	2	1.7	0.3	0.3	2
11	155433	1.8	2.5	0.4	0.3	4
12	155434	2	1.8	0.3	0.3	3
13	155435	2.2	1.4	0.3	0.3	2
14	155436	2.3	1.9	0.3	0.2	3
15	155437	3.9	1	0.4	0.3	3
16	155438	8.5	7.3	0.5	0.4	71

Tab. 2. List of spondylus pendants from the Čepin-Ovčara hoard.

As well the two usual holes, one of the segments (Figs. 4.9; 8.b; No. 14 in Tab. 2) has another complete hole and a portion of a hole positioned on the lateral side. Initially, a larger object was created with a pair of holes. It seems that the object was used for a short time before it was fractured across one of the holes. After it got broken, a pendant of different orientation was made, two new holes drilled, and the lower edge of the primary trapezoid was cut so as to again obtain a trapezoid, but this time one of smaller dimensions. The two new holes bear the usual string marks, only now the incisions are somewhat shallower compared to those in the other pendants in the collection.

Pendant No. 11 (Figs. 4.8; 8.a) is trapezoidal, but unlike all the other examples, its height is less than its width. Moreover, the lower edge is curved and damaged. The damage is the most likely reason for 'shortening' the originally regularly shaped trapezoid of which the height is greater than the width. There are traces of two holes – the drilling of which had started but was soon abandoned – under the

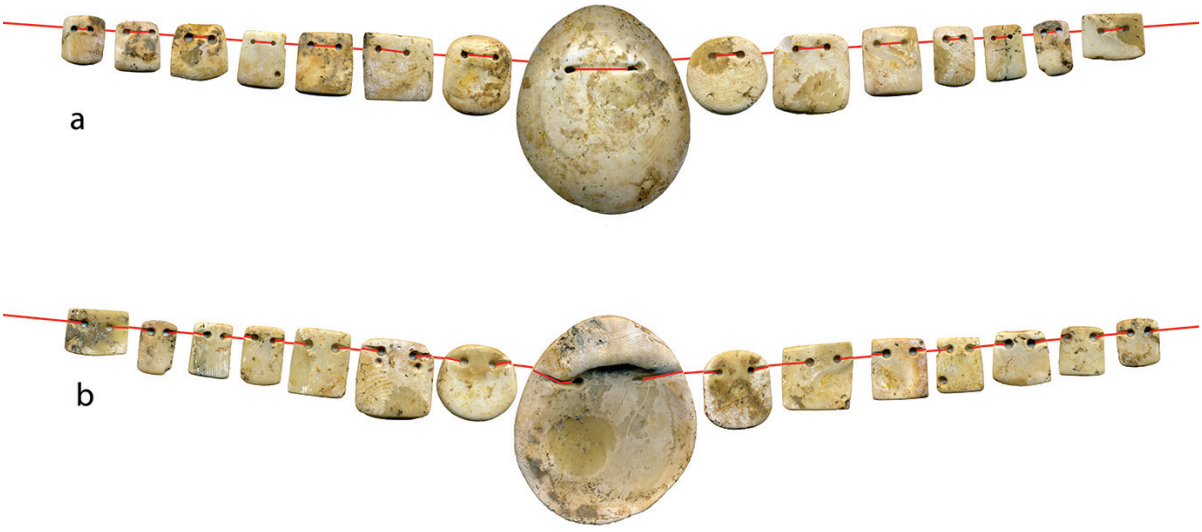


Fig. 7. Reconstruction of the belt made of spondylus pendants:* a *outer surface, turned away from the body,* b *inner surface, facing the body.

perforations on the flat back side of pendant No. 1 (Figs. 4.7; 8.c). This initial drilling was probably attempted prior to opening the holes that were actually in use, but was abandoned because the position of the drilling was too far from the upper edge.

In all the segments, drilling into the convex front side alternated with drilling of the same hole on the back, flat side. Drilling into the back would expose three quarters of the height of the hole, and the hole would then be completed by drilling into the front. This order of drilling procedure is also documented on pendant No. 1 (Fig. 8.c) where two unfinished holes are preserved.

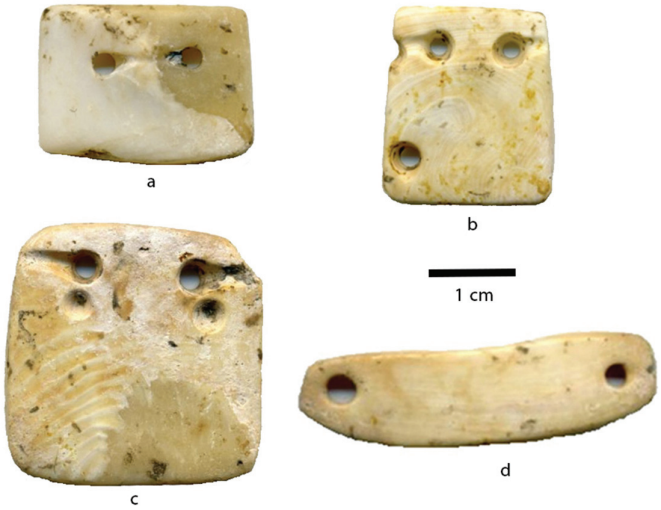


Fig. 8. Examples of spondylus pendants, Čepin-Ovčara hoard (specimens No. 11, 14, 1 and 15 in Table 2).

Finally, it should not go unnoticed that the beauty of this exclusive composite ornament lies in the similarity between the segments in the proportions and the location of the holes, but that despite this, each segment is unique. This beauty in the contrast between similarities and differences between the pieces is greatly enhanced by the material from which the pieces were created. The material gives them all a translucency and pretty, bright, ivory colour, but it also renders them unique, since the different irregularities of the shell surface and the different exposed sections of the internal shell structure renders each pendant distinct. Above all, and certainly not of least importance for the aesthetic, but also symbolic perception of the individual pendants, is their remotly anthropomorphic character, achieved by placing the string holes in such a way that they remind one of human eyes.



Fig. 9. Spondylus beads arranged in a string. Čepin-Ovčara hoard.

The pendant shaped as an elongated oval (No. 15 in table 2; Figs. 4.14; 8.d) could have been an element of the belt and served as a kind of a safety pin; or it could have had a similar purpose, but as an element of one of the necklaces; but it could have also been worn on its own. The holes are located at the edges, and no string marks are visible on either the outer or inner surface. However, the areas around the holes appear polished, and it is possible that the string was pulled through both of the holes. The string could have been tied into a not on the convex outer side of the pendant, and sown onto a textile or some other kind of material.

The string of spondylus shell beads

The string consists of 58 discoid beads of various dimensions, diameters and heights (Figs. 5.a; 9). The majority of beads (79.3%) are up to 4mm, and as many as 91.3% are 6mm long (Fig. 10). They are made of the same material used for the pendants of the belt. Alternating wavy growth lines characteristic of the different sections through the spondylus shell valves are also visible on the beads. The diameter of the stringing holes is 0.3cm and is uniform in all the beads. The standardised diameter of the stringing holes indicates that the beads belong to the same necklace. When they are string together, the length of the string is 19cm.

The string of dentalium shell beads

The cylinder-shaped beads made of significantly thinner shell than that of spondylus were probably also strung as a single item (Figs. 5.b–c; 11). There are 386 of them, and when strung, the length of the string is 128cm. Scaphopods shells[1] were used for making these beads. These animals are characterised by a cylindrical shell open at both ends, which can thus be used as a pendant or a bead without modification. Large amounts of these shells have been found at archaeological sites dated from the Palaeolithic onwards (*Zilhão 2006; Bar-Yosef Mayer, Gümüş 2010; Ivanova 2012*) and a number of their possible uses have been recorded in traditional communities (*Sprague 2004; Barton 1994*). In the archaeological literature, these shells or, rather, ornaments made from them, are commonly referred to as dentalium, after the best-known genus *Dentalium*.

The beads from Čepin are 1.5–14.2mm long (their average length is 6.3mm), whereby 69% of the beads are 4–8mm long (Fig. 12). The thickness of the shell is about 0.2mm; it is smooth, ivory in colour and translucent (Fig. 13). This shows that the shells are modern, not fossilised[2]. None of the shells is complete; instead, all the beads were produced from transversely broken shells. On the beads made from the back, tapered end of the shell, one can observe fine longitudinal lines that gradually become faint towards the very end and blend into the smooth surface. This type of shell surface pattern is characteristic of *Antalis vulgaris*[3]. No traces of cutting were detected. The rounded edges of the beads suggest that, instead of complete shells and subsequent transverse cutting to obtain beads of the desired length being used, already broken shells were collected and used. However, this hypothesis should be tested by observing the shells under greater magnification than the one used for this study. In the vast majority of beads, the edges were routinely rounded, *i.e.* smoothed and rounded naturally. A number of beads have spout-like protrusions around the edge, which indicates that they were broken along the growth lines[4]. They were probably collected on beaches where the waves leave shells of decomposed organisms; as waves roll ashore, they crush the shells and sand smooth their edges. The presence of tiny dimples on the surface of some shells confirms this impression; these occur as a result of the activity of so-called drilling organisms[5]. Given that scaphopods live buried in mud, these organisms inhabit the shell only if it is empty.

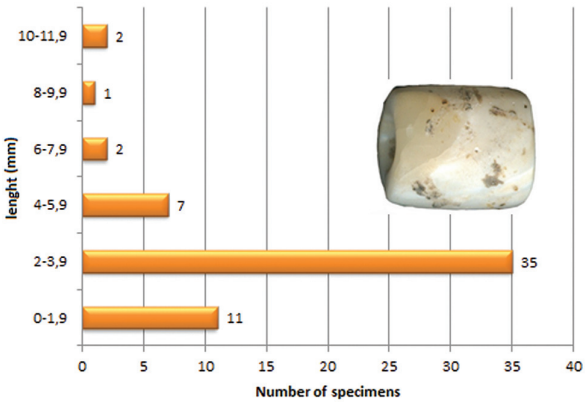


Fig. 10. Distribution of lenghts of spondylus beads. Čepin-Ovčara hoard.

The Čepin hoard in a regional context

In Europe, Spondylus shell ornaments were in use between the 7th and 4th millennium BC, whilst their distribution was widest – from the Aegean Sea to the Paris Basin – between the mid-6th and mid-5th millennium BC (*Müller 1997; Seferiades 1995; Windler 2013*). Over the three millennia, the ornaments were manufactured exclusively from contemporary shells. The results of previous (*Shackleton, Renfrew 1970; Schakleton, Elderfield 1990*) and new stable isotope analysis (*Bajnóczi* et al. *2013*) suggest that the shells were sourced in the eastern Mediterranean, *i.e.* from the Aegean and/or the Adriatic Sea. Based on the archaeological data from the coastal zone, researchers agree that the Aegan region was an important shell source throughout this period, and that both jewellery and shells were transported from here to the mainland of the Balkan Peninsula, and later all the way to the west coast of the

1 Scaphopoda means 'shovelfoot' (scapho = shovel, poda = foot) and the term refers to the organ located at the wider end of the shell and which serves for burrowing in sand or moving through sea sand and mud. They are also commonly known as 'tusk shells' because their shells are conical and curved, making them look like miniature tusks (*Dimitrijević, Tripković and Jovanović 2010*).

2 See the description of differences between fossilised and modern shells in Dimitrijević and Tripković (*2006*). The paper describes decorative objects made of modern shells (*i.e.* coeval with the archaeological finds) *Spondylus* and *Glycymeris* and of Miocene dentalium shell.

3 *Antalis vulgaris* Da Costa, 1178, formerly determined as *Dentalium vulgare*.

4 Naturally broken and rounded fossil dentalium shells used as beads at the site of Vinča – Belo Brdo had a similar shape (*Dimitrijević, Tripković and Jovanović 2010*). Also, based on the similar taphonomical characteristics of shells, Bar-Yosef Mayer (*2008*) concluded that in the prehistory of the Levant, primarily in the Natufian, shells collected on beaches were used as beads.

5 Primarily Bryozoa (moss animals).

Black Sea. From the mid-6th century, items made of spondylus were frequent at sites along the Danube and its tributaries; this led to the conclusion that the Danube corridor was the main route for transporting and exchanging goods in the central part of the European continent (*Chapman 1981*). The interfluves of the Sava, Drava, and Danube formed an integral part of the continental route, which may explain the origin of the ornaments in the Sopot culture settlement.

Still, there are different opinions on the origin of the ornaments found in continental Europe. For instance, spondylus items discovered in Central Europe and the Carpathian Basin have characteristics documented region-wide; however, the frequently found large belt buckles are absent from the Aegean and the eastern Balkans. This led to the assumption that ornaments from central Europe was manufactured from shells obtained from a different source, *i.e.* from the Adriatic (*Müller 1997*). As has recently become increasingly evident, the Neolithic communities of the eastern Adriatic undoubtedly used and created spondylus ornaments (*Batović 1979; Kukoč 2012*). They probably established and maintained communication with communities in the hinterland (*Batović 1979*). The best evidence for these contacts derives from the settlements in central Bosnia, Obre I from the Early Neolithic (*Benac 1973*) and Obre II from the Late Neolithic (*Benac 1971*), where the material culture bears numerous characteristic of the Adriatic cultural circle, and where spondylus items were also documented (Fig. 14.a). This indicates that the inhabitants of the central Bosnian settlements possibly mediated the northward distribution of valuable objects from the Adriatic. The closest areas in the neighbourhood, and located on this route, are the interfluves of the Sava, Drava, and Danube.

Unlike spondylus, for the manufacture of dentalium beads, both fossil and contemporary shells were used. The regional distribution and ubiquity of objects made of dentalium are still not well understood. According to the available data, in the middle Danube area and the Carpathian Basin, the beads occur most frequently during later prehistory; these are chiefly examples of the use of fossil shells (*Todorova 1995; Dimitrijević, Tripković and Jovanović 2010; Girić 1971; Sümegi 2009; Sztancs, Beldiman 2010*). They are relatively common at the Lengyel sites in south-eastern Transdanubia (*Siklósi 2013*) and at the Vinča-Belo Brdo site in Serbia (*Dimitrijević 2014*). As regards the Vinča site, it was established that the shells were procured from a Miocene outcrops in the vicinity of the settlement (*Dimitrijević 2014; Dimitrijević, Tripković and Jovanović 2010*).



Fig. 11. Čepin-Ovčara hoard. **Antalis vulgaris** ***beads arranged in a string.***

Beads made from contemporary shells, such as those in the Čepin-Ovčara hoards, have not been documented at other sites in the Slavonian and Srem regions, and are also very rare in the wider area (*Dimitrijević, Tripković and Jovanović 2010*). However, they are frequently found in the Aegean (*Karali 1999; Nikolaidou 2003*) and along the Black Sea coast, while they are especially abundant at the necropolises at Durankulak and Varna (*Todorova 2002; Avramova 2002*). Given that scaphopods do not live in the Black Sea, it is assumed that people in this region acquired them through sea trade, probably with the Aegean, and that the subsequent exchange was confined to the local coastal areas (*Ivanova 2012*). The scaphopod shells that are the focus of this paper could have originated from the Adriatic, which is 300km away as the crow flies from the Čepin site. However, they could as well have originated from other parts of the Mediterranean Basin such as the Aegean.

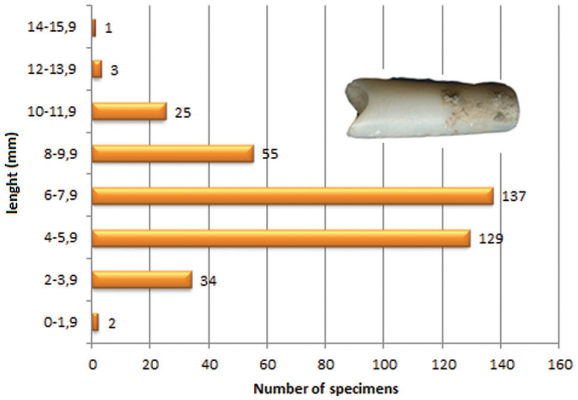


Fig. 12. The distribution of lengths of* Antalis vulgaris *beads. Čepin-Ovčara hoard.

Considering the variations between Neolithic sites in the distribution and ubiquity of adornments made of spondylus and dentalium, it is possible that they were acquired in different ways. Spondylus items exchange was a matter of cultural routine in the Neolithic, and a number of people were involved in its production, procurement, use, and re-working. This is supported by the long use-period of the objects in the Čepin hoard. The lack of evidence in the wider region of the use of contemporary scaphopod shells might suggests that the bead necklace from the hoard was not obtained via the same communication route used for obtaining objects made of spondylus. Furthermore, very few intermediaries or, rather, acquisition directly from the source of the raw material, perhaps better explain the mechanism by which the beads were obtained.

Distribution and use of the ornaments

During later prehistory, objects made of shells of marine organisms were commonly used as ornaments. Those made from a complete valve of *Spondylus* shell are particularly ubiquitous in the Carpathian Basin and central Europe (*Müller 1997; Kalicz, Szénászky 2001*). They are frequently found in graves; based on their find location near the abdomen of the deceased, and/or the traces of use, it was determined that they were used as belt buckles (*Nieszery, Breinl 1993*). This type of ornament, more than any other, demonstrates that regions and cultures had specific requirements in terms of the manufacture, appearance and use of the objects. Thus the clasps with V-shaped opening were made exclusively from the right valve of the shell, and the opening served as part of the buckling mechanism. These are typical of the Linearbandkeramik culture of central and western Europe and were usually found only in male graves (*Müller 1997; John 2009*). They very rarely occur in other regions; in the southern Balkan Peninsula they are known only from the sites at Dispilio (*Ifantidis 2009*) and Alepotrypa Cave (*Papathanasopoulos 1996*) in Greece. In contrast, pieces with two perforations, identical to the example from the Čepin hoard, were manufactured from the left valve of the shell. These are particularly common in female graves in the Carpathian Basin during the period of Alföld Linear Pottery and the early Tisza culture (*Kalicz, Szénászky 2001; Siklósi 2004; 2013*). The reconstruction of their use suggests that they represented the central part of a belt (*Nieszery, Breinl 1993*). A specimen of spondylus valve, that is most probably belt buckle with multiple perforations, was recently discovered in a grave 476 (unsexed adult, aged 18–20 years) at the Sopot culture site Alsónyék-Bátaszék (*Oross* et al. *2016*). Date OxA-28246 obtained on human rib places the grave in the period from 5135 to 4995 cal BC (at 93% probability). Besides in Čepin hoard, no other finds of spondylus valves have been found at the Sopot culture sites in the Sava-Drava-Danube interfluves. Some 40 km to the east of the site, however, a similar object was discovered at Mostonga near Odžaci (Serbia) in a grave dating from the early Vinča culture (*Karmanski 1977.Pl. 7*).

In the Sava-Drava-Danube interfluves (Fig. 14.b), other objects made of marine shells are encountered throughout the Neolithic. Yet, their number increases through time and particularly towards the final Neolithic. From the Early Neolithic (Starčevo culture), a small pendant with two perforations made of spondylus was discovered in the settlement at Tržnica-Vinkovci, in the grave of a child placed in a flexed position (*Dimitrijević 1979.241; Burić 2009.Fig. 24*). At Zlatara near Ruma, three spondylus beads were recovered from the grave of a woman of 40–45 years of age (*Leković 1985*).

The largest number of objects made of marine shells from the Sopot culture, is from the Čepin-Ovčara site. Besides the finds in the hoard, three more pendants

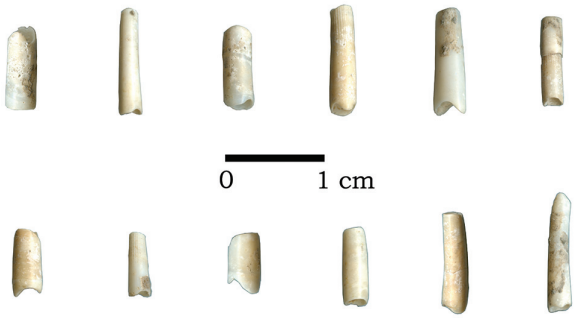


Fig. 13. Examples of* Antalis vulgaris *shell beads. Čepin-Ovčara hoard.

and nine fragments of spondylus bracelets were discovered elsewhere in the settlement[6]. Pendants and fragmented bracelets found in the settlement at Gradac-Bapska (*Burić 2009.22, 47, Fig. 5, 46, 66; 2011; 2014.9*), two pendants with perforations from Sopot-Vinkovci (*Dimitrijević 1968.47, Pl. XVI/1, Pl. XX/7; 1979.267, 292; Balen 2006.28–29*), and ornaments from Štrbinci near Djakovo (*Dimitrijević 1979.292*) derive from the same period. Also, at least 19 spondylus items were unearthed at Filipovica/Hermanov vinograd near Osijek, including mainly rectangular and oval pendants with two perforations, fragments of bracelets and a bead (*Šimić 2006.40; 2008.34–35*).

The regional assemblage of marine shell ornaments is completed by the objects from, probably, graves found by chance at Željeznička stanica (a bracelet and beads) and Lijeva Bara (three bracelets) in Vukovar, dated to the Neolithic/Eneolithic (*Brunšmid 1902.63–64, Fig. 20; Kukoč 2012; Chapman, Gaydarska and Balen 2012*). Furthermore, three cylindrical beads of various sizes and unknown provenance are today kept at the Museum of Slavonia in Osijek (Inventory no. 896). Lastly, a pendant and an elongated cylindrical spondylus bead were discovered within an early post-Vinča culture horizon at Gomolava in eastern Srem (Serbia), in a layer that yielded a combination of material associated with the Sopot and Tiszapolgar cultures (*Brukner 1981.24–25*).

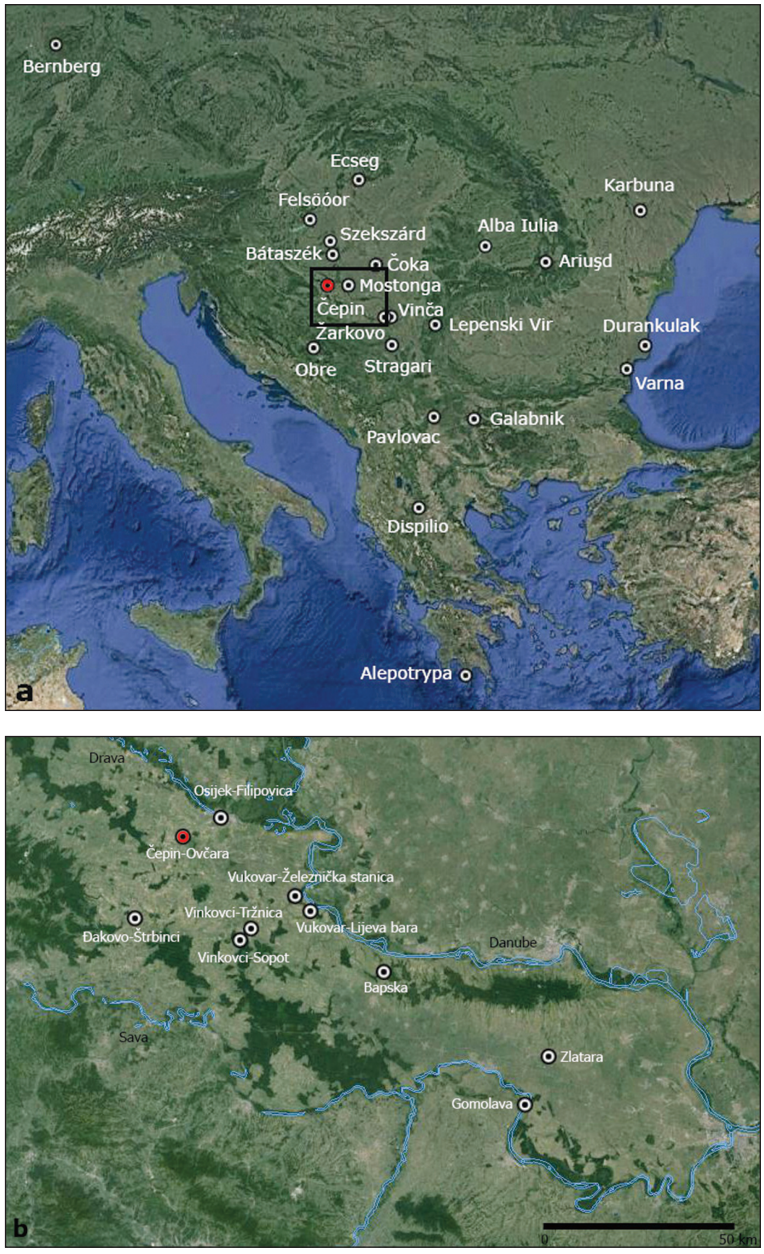


Fig. 14. Neolithic sites with finds of marine shell items mentioned in the text:* a *in the Carpathian Basin and South-East Europe,* b *in the area defined by the rivers Sava, Drava and Danube (area marked by a square in Fig 14.a). Adapted Google Earth picture.

It appears that the inhabitants of Late Neolithic settlements in the interfluves of the Sava, Drava, and Danube generally used smallish oval and rectangular pendants with two perforations, like the ones predominant in the Čepin hoard. Pendants of similar design and dimensions were documented at the nearby Late Neolithic sites of Sopot (*Dimitrijević 1968*), Hermanov vinograd (*Šimić 2006; 2008*) and Bapska (*Balen 2006; Burić 2011*), as well as at the Čepin-Ovčara settlement itself (unpublished, Museum of Slavonia, Osijek). The traces of use of these pendants have not been described, and the published photographs and drawings are usually insufficient to conclude how the objects were worn. In the photographs and drawings of the pendants from Bapska and Sopot that show only one side, usually the front, of the objects, imprints of string are visible between the two holes (Fig. 15).

6 The objects have not been published and are kept in the Museum of Slavonia in Osijek.

However, at least one of the pieces from the site at Hermanov vinograd (unpublished; inventory no. AP-1454, Museum of Slavonia in Osijek), and another from Sopot (*Burić 2011.112, Fig. 36*), also have horizontal incisions that extend from the perforations towards the edge of the objects, suggesting that they were attached and worn in the same manner as the pendants from the hoard described here. A detailed analysis of use wear on the other pendants from the Sopot culture sites and the wider region is necessary for any further assumptions about the ways in which they were worn. That they could have been strung in different ways is indicated by the example from Vinča, which has two pairs of perforations, one opposite the other, and without visible traces of string impressions (*Dimitrijević, Tripković 2006.Fig. 7*). If our reconstruction, based on the finds' context and use wear, is correct – that the pendants from the Čepin hoard are parts of a composite belt – the design of the belt can be compared with, and is, in fact, similar to, the depictions of belts on anthropomorphic figurines from the coeval Vinča culture. For instance, some of the figurines from Vinča, Žarkovo, Pavlovac (Fig. 16) and Stragari (*Stanković 1988.98*) bear representations of a belt in the form of one or more circular applications that reminiscent the ornaments made of spondylus shell. The belts depicted on the figurines from Vinča (not shown in Fig. 15, but see *Vasić 1932.Pl. 19.95; 1936.Pl. 32. 158*) and Pavlovac (Fig. 16.d) bear the closest resemblance to our reconstruction of the belt from Čepin-Ovčara.

The remaining objects from the hoard, such as the crescent-shaped pendant with perforations at both ends, and the discoid spondylus beads, do not display any specific cultural or regional characteristics. They could have been created from the previously unworked shells or, through reduction and re-working, from fragmented bracelets and other objects, which contributed to their wide distribution, diversity and abundance (see *Todorova, Vaisov 2001.Fig. 2*). Both types of ornament have been documented at different sites in the immediate vicinity of Čepin, although only the lunular pendant from the settlement at Bapska, with holes at both ends, securely dates to the period of Sopot culture (*Balen 2006*). For the two bead necklaces, one most probably from a grave at Željeznička stanica in Vukovar and the other from an unknown location near Vinkovci, the context of the finds and the period from which they derive have not been confirmed. The Vukovar necklace is broadly placed in the period from the Late Neolithic to the Bronze Age, although the general opinion is that it is Late Neolithic/Early Eneolithic

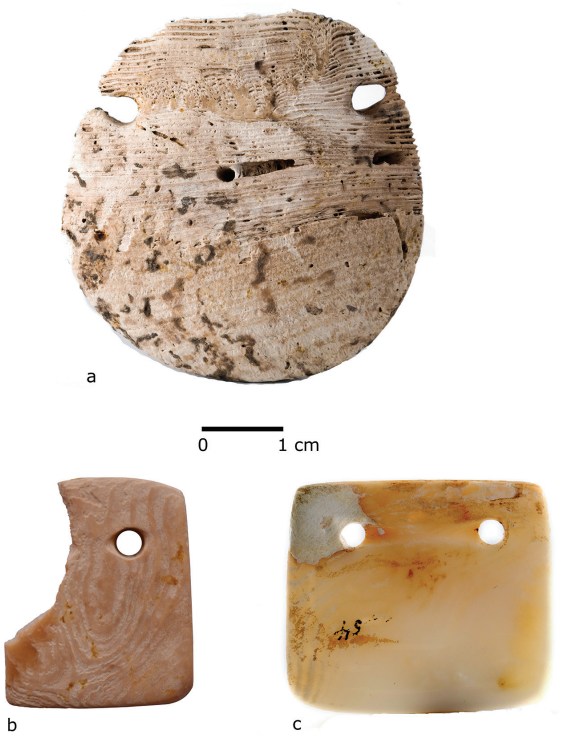


Fig. 15. Spondylus pendants:* a *Čepin-Ovčara (*Rajković 2014*);* b *Čepin-Ovčara (Museum of Slavonia in Osijek, inventory no. 166960);* c *Hermanov vinograd (Museum of Slavonia in Osijek, inventory no. AP–1454).

(*Chapman, Gaydarska and Balen 2012*). The necklace is composed of at least 81 discoid beads, 88% of which is up to 6mm thick, which makes them similar to most of the spondylus beads from the Čepin hoard. However, the beads from Vinkovci are different; the necklace consists of 11 large cylindrical beads that, based on the dimensions, probably originate from an earlier period.

There are no useful data from the Sopot sites in the Sava-Drava-Danube interfluves on the ways in which the necklaces were worn. In other regions, spondylus as well as dentalium beads are more abundant in graves characterised by rich offerings for the deceased, and in hoards (*Chapman 2000*). They were worn in diverse ways. They were usually attached to clothing or strung and worn around the wrist or neck, or as an ornamental headdress (diadem) or decorative belt, and this can be deduced from their various locations in the graves with inhumations (*Avramova 2002; Ivanov, Avramova 2000; Nieszery, Breinl 1993*). An illustrative example, and the one closest to the Čepin-Ovčara site, comes from the Alsónyék-Bátaszék site in south-eastern Transdanubia in Hungary, where 2359 Late Neolithic graves were detected, and some 100 contain rich offerings accompanying the deceased (*Osztas, Zalai-Gaal and*

Banffy 2012; Banffy et al. *2014*). In one of the graves characterised by a complex funeral ritual, a woman was buried with her body and clothes decorated with numerous ornament pieces. There were bracelets made of spondylus beads on her left and right arms, and spondylus, dentalium and copper/malachite beads on her chest, while particularly impressive is a belt made of spondylus beads wrapped 12 times around the body (*Banffy* et al. *2014.361, Figs. 14–15*).



Fig. 16. Representation of belts on the figurines of the Vinča culture:* a *Vinča (*Tasić 2008*);* b *Vinča (*Ignjatović 2008*);* c *Žarkovo (*Petrović, Katić and Spasić 2009*);* d *Pavlovac (*Vuković, Perić 2014*).

Given its frequent presence in the graves, seashell adornment must have had a significant role in the construction and reinforcing individual identities. The objects from the Čepin hoard, as elements of a personal set of accessories, had the same purpose, but we cannot determine whether they belonged to one or more persons. The belt clasp with two perforations for stringing was probably part of a woman's dress, as in the Carpathian Basin (*Siklósi 2013*); based on this, we can assume that at least some of the objects in the Čepin hoard was worn by a female. We cannot, however, be entirely sure about this. The cultural affinities involved in the collection and wearing of ornaments made of sea shells could have varied greatly, as evidenced in the settlement at Vinča near Belgrade (Serbia), which is only 150km from Čepin. A number of bracelets made of the Mediterranean clam *Glycymeris glycymeris* were discovered at this Late Neolithic site beside the Danube (*Dimitrijević, Tripković 2006*), as well as beads made of fossil dentalium shells (*Dimitrijević 2014; Dimitrijević, Tripković and Jovanović 2010*); both are entirely absent at Čepin and other sites in the interfluves of the Sava, Drava and Danube. Besides the previously described certain similarities, the inhabitants of the settlements in the two neighbouring regions were obviously guided by different value systems in the procurement and use of ornaments made of marine shells. Thus investigations of the regional and local specifics concerning the use of seashell adornment remain an important research task.

Spondylus and dentalium in ornament hoards

Only about 20 hoards containing spondylus and dentalium ornaments have been documented for the Neolithic and Copper Age of southeast Europe and the Carpathian Basin (*Chapman 2000; Siklósi 2013*). The instance of spondylus valve with two perforations functioning as a container for storing other pieces of jewellery is not known from other sites. A ceramic vessel was usually used as a container; objects were placed inside, and then everything was stored in the house or deposited within or even outside the settlement (*Chapman 2000*). The available data reveal that, apart from Čepin, dentalium beads have so far been found only in the Early Neolithic hoard from Galabnik (western Bulgaria) and in the Late Neolithic hoard from Felsöóors (Hungary). In both cases, the jewellery was placed in a ceramic vessel. There were more than 10000 beads made of dentalium, stone and bone in the Galabnik hoard, along with the rings manufactured from spondylus and nephrite (*Chapman 2000*). The Felsöóors hoard contained 280 objects made of mollusc shells and some stone beads; malacological analysis determined the presence of a fossil species, *Dentalium badense* (*Regenye* et al. *2009; cf. Sztancs, Beldiman 2010*).

On the other hand, miscellaneous spondylus objects commonly occur in hoards, and sometimes they are the only pieces of adornment in them. Besides Galabnik, the only other Early Neolithic hoard that included spondylus items is the one from Lepenski Vir. This hoard consisted of beads of spondylus and palygorskite, possibly parts of the same bead strand, and

deposited in a Starčevo culture vessel (*Srejović 1969*). Some other of the earliest examples of ornament hoards comprised exclusively of spondylus objects and deriving from the second half of the 6th millennium BC from the Carpathian Basin and central Europe include: the Bernburg hoard (Germany) consisting of two bracelets, 178 beads and two pendants/belt pieces deposited in a Linearbandkeramik vessel (*Willms 1985.333, Fig. 1*); Ecseg hoard (Hungary), probably deriving from the same period, contained a V-shaped belt clasp, bracelets and beads (*Siklósi 2013*); a chance find (hoard?) from Szekszárd–Palánki-hegy (Hungary) included a valve with two perforations, three massive bracelets and elongated cylindrical beads (*Siklósi 2004; 2013*); finally, the Alba Iulia hoard from the early Vinča culture should also be mentioned – it comprised two belt clasps and nine large beads (*Comşa 1973.71*). It is important to emphasise that these hoards include belt clasps, *i.e.* pendants that have the same purpose and/or shape as the central belt piece from the Čepin hoard.

From the end of the 6th millennium BC, in the wider Middle Danube area, a much greater number of items, made from various materials, were deposited in hoards; this was the beginning of a trend that characterised the following millennium. Two hoards were discovered in the early 20th century in the close proximity of Čepin-Ovčara at a settlement at Čoka-Kremenjak that combines elements of the early Vinča and the Tisza cultures. Some of the contents of these hoards have been lost over time (*Raczky 1994*). The Čoka 1 hoard contained items made from marine shells, marble, malachite and animal teeth, and also ochre lumps *etc.*, all placed in a sizeable ceramic pot with two horizontally attached handles. The spondylus objects included 3231 beads, one bracelet and fragments of bracelets, as well as several pendants (*Raczky 1994*). Čoka 2 comprised similar materials, with pendants manufactured from shell, bone and animal teeth, and stored in a spherical vessel (*Raczky 1994*). The contents of these hoards clearly demonstrate the practices of collecting, keeping and storing adornment made from various materials, many of which are white, directly signalling the raw material being emulated. This is particularly indicative in the case of two objects from the Čoka 1 hoard (*Raczky 1994.Pls. 1, 3.1–2*), which are made of marble and appear similar to the large belt buckles made of spondylus.

The trend of collecting and cache-depositing various objects can be considered a hallmark of the 5th millennium BC in the broader region, best exemplified by the hoards at Ariuşd (Romania) and Karbuna (Moldavia) in eastern Europe. In the hoard from Ariuşd (Ariuşd culture, Cucuteni-Tripolye cultural complex) more than 2233 objects were deposited in two pots with lids found within a possible residential structure (*Sztáncsuj 2005*). The majority of items were made of copper (1938 beads and six bracelets), while the rest of the hoard consisted of bone pendants and plaques, animal teeth pendants, stone beads, gold twisted wire and plaques made of freshwater shells, as well as over 40 objects made of spondylus (*Sztáncsuj 2005*). Among these, fragmented lunular pendants, often with preserved one or two perforations, predominated; some of them showed traces of repair (*Sztáncsuj 2005.95*). The shape of these objects renders them very similar to the crescent-shaped pendant from the Čepin hoard. The hoard from Karbuna (Tripolye A culture) contained 852 objects made of copper (beads, appliqués and axes), stone (axes), beads made of red deer teeth, and ornaments made of marine shells, all placed in a ceramic container. The spondylus assemblage includes 254 beads, plaques and bracelets.

The Ariuşd and Karbuna hoards consist of a large number of spondylus ornaments, but they are not the principal component. Instead, copper prevails, as it was a raw material whose importance significantly increased during the 5th millennium BC. The expansion of choice of raw materials took place in the Carpathian Basin and eastern Europe in parallel to the process of disintegration of Neolithic social and economic networks that had for centuries facilitated the exchange of spondylus objects. From the mid-5th millennium BC onwards, spondylus hoards were deposited only in the eastern Balkans (*Chapman 2000*). They mainly contain chipped stone tools, fragmented bracelets and beads. During this period, the circulation of items made of Mediterranean seashells ceased on the European mainland, and the traditional ornaments were replaced by ornaments manufactured from other materials (*Georghiou 2012*). The best evidence of continuity of use and the significance of ornaments over this period comes in the form of a representative hoard from Brad in east Romania dated to phase A3 of the Cucuteni culture, *i.e.* the late 5th millennium BC (*Anthony 2010*). In addition to the numerous pendants made of deer teeth and various copper objects, the hoard included five copper and gold discs which, judging by their shape, size and probably also function, mimic the traditional spondylus pendants and belt clasps from earlier periods.

Although they derive from different periods, all of the described hoards share a characteristic that can help us better understand cross-cultural patterns in the procurement and deposition of ornaments crafted from exotic seashells. It is worth noting that the locations at which the hoards were registered are distributed along the edge of the area of exchange across the continent of ornaments made from Mediterranean shells. During the first half of the 5th millennium, when the Čepin hoard was deposited, the amount of spondylus objects reaching western and central Europe had already decreased, and the Carpathian Basin was the last major centre in continental Europe where the exchange and use of Mediterranean items was intensive (see *Windler 2013*). Thus, if the hoards indeed reflect inter-communal relationships, as suggested by Chapman (*2000*), then the reasons for hoarding of ornaments should also be sought in the realm of the intensive social competition that characterised the Late Neolithic of the region. Just as the objects were acquired for social display, we expect that they were deposited in hoards in order to be secured and/or concealed.

Conclusions

The only hoard of marine shell ornaments to have been discovered in the interfluves of the Sava, Drava, and Danube was discovered in the Sopot culture settlement at Čepin-Ovčara. It was found next to a house belonging to the latest settlement horizon of the Sopot culture. The ornaments in the hoard included two strands of strung beads made of shells of *Spondylus gaederopus* and a scaphopod *Antalis vulgaris*, and 15 pendants made of *Spondylus gaederopus* that are, based on their use wear, here interpreted as segments of a belt. Pendants have distinct traces from being worn and re-worked, which led to the conclusion that they had been in use for a long time before being placed in the hoard.

Across the Danubian region, similar objects were widely used for decorating the body and clothing; only in hoards and graves furnished with rich offerings for the deceased have they been found in very large quantities. Unlike these, the beads made of *Antalis vulgaris* shell are unique examples in the region. They have been known only from the Aegean and eastern Balkans, which indicates that the dynamics and mechanism of their exchange in inland areas were different. Nonetheless, both types of ornaments document that, during the Late Neolithic, body adornment and clothing accessories were important aspects of social life in the Sava-Drava-Danube interfluves, and that ornaments made of Mediterranean marine shells played a particularly important part in it.

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The exploitation of animal resources in Şoimuş-La Avicola (*Ferma 2*) settlement (Romania)

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ABSTRACT – *The aim of this paper is to present an interesting archaeological assemblage discovered during archaeological research at the settlement of Şoimuş-La Avicola (*Ferma 2*) (Romania). So far, this is the only example of a Turdaş culture osseous assemblage published. It is numerically representative, with 901 pieces, of which 796 are bone, 94 antler, 8 tooth and 3 valve. Among the bone pieces, a high standardisation in the selection of blanks is noticeable, with* Bos taurus *ribs being prevalent. At the same time, the techniques and procedures vary only a little within the groups, which allows for the identification of typological series. The recovery of all the products and sub-products resulting from the operational sequences of raw material transformation and the analysis of the wear and technological traces led us to try to reconstruct a behavioural model of the ways raw material was acquired, processing techniques and activities developed with them, or in other words to outline the economic and cultural features of the Şoimuş-La Avicola (*Ferma 2*) community.*

IZVLEČEK – *Namen članka je predstaviti zanimiv arheološki zbir, ki smo ga odkrili pri arheološkem raziskovanju naselbine Şoimuş-La Avicola (Ferma 2) v Romuniji. To je edini primer objavljenega kostnega zbira kulture Turdaş. Zbir sestavlja 901 kosov, od tega 796 kosti, 94 ostankov rogovja, 8 zob in 3 lupine školjk. Pri izbiri kosti prepoznamo visoko stopnjo standardizacije, prevladujejo pa rebra vrsta* Bos taurus*. Poleg tega je le malo variacij znotraj skupin pri izbiri tehnike in postopkih izdelave orodij, kar omogoča prepoznavanje tipoloških serij. S pomočjo analize vseh izdelkov in pod-izdelkov iz analize operacijske sekvence spremembe naravnih surovin in analize uporabe ter tehnoloških sledov lahko poskušamo rekonstruirati načine, kako so v preteklosti pridobivali surovine, kakšne so bile tehnike izdelave in druge aktivnosti povezane z obdelavo kosti; z drugimi besedami, lažje zaobjamemo gospodarske in kulturne značilnosti skupnosti na najdišču Şoimuş-La Avicola (*Ferma 2*).*

KEY WORDS – *Turdaş culture; raw materials; operational schemes; wear traces*

Archaeological background

Turdaş culture evolved along the middle and lower stretches of the Mureş River, and included approx. 60 settlements (*Suciu 2009.Fig. 259*). Among the best researched are those at Turdaş-*Luncă*, Orăştie-*Dealul Pemilor* (punct x2), Deva-*Tăualaş*, Mintia, Zlaşti-*Gruiul lui Moş*, Peştera Cauce, and Nandru Vale (*Lazarovici, Lazarovici 2006*). Several radiocarbon dates place this important manifestation of the Transylvanian Neolithic in the first half of the 5th millennium BC (*Draşovean 2013a; 2013b*).

Settlements have extensive surfaces, generally between 7 and 10ha, but there are also cases when they reach 55ha (Nandru Vale) or even 75ha (Turdaş-*Luncă*). Surface dwellings and numerous pits are attested as inhabited structures, and enclosure ditches or defensive structures, like trenches and palisades are also mentioned (Turdaş, Orăştie, Şoimuş). Along with the settlements, several seasonally inhabited caves were also excavated, probably connected with sheep herding, like at Cauce Cave (*Lazarovici,*

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Lazarovici 2006; Luca 2012). As ceramic forms specific to Turdaş culture, we may mention goblets with high feet, rectangular vessels, cups, bitronconical pots, amphorae, and bowls. The main types of ornament are incised lines with arrays of dotted lines in the interior, or incisions cut in the vessel wall before firing, while parallel incised lines are rarely painted. Numerous anthropomorphic and zoomorphic figurines have also been found, as well as anthropomorphic representations on vessels, anthropomorphic vessels, and miniature altars (*Roska 1941; Luca 1997; 2001*). The connections of Turdaş culture with the great Vinča area are obvious through the forms and decoration of pottery, figurines, architectural or cult objects. Moreover, in most of the archaeological literature, Turdaş culture is considered a distinct group, with strong affinities in the Vinča area, which appeared as a consequence of a migration at the Vinča C level in south-western Transylvania (*e.g., Berciu 1966; Lazarovici 1981; Chapman 1981.Fig. 13*).

Because of the construction of the Deva-Orăştie segment of the A1 Motorway, the 'Vasile Pârvan' Institute of Archaeology, Bucharest, the Deva Museum of Dacian and Roman Civilization, and the National Museum of Romanian History undertook rescue excavations in the settlement of Şoimuş-La Avicola (*Ferma 2*) (Hunedoara County). This is within the area of Şoimuş village, between the eponymous settlement and Bălata village, on the first terrace of Mureş (Fig. 1).

Given the size and archaeological complexity of the work, the site was divided into two sections: area A, the Neolithic nucleus, and area B, the Bronze Age settlement. According to the preliminary field observations, a Neolithic settlement with two main habitation phases was located here. From the stratigraphic perspective, the first phase corresponds to a settlement comprised of houses, followed by a field levelling, with brown-grey sediment discovered in the filling's upper side of many stratigraphic features at the site. The second phase of habitation is indicated by surface dwellings, where a consistent level of destruction was identified in the form of pieces of house daub scattered throughout the surface, fireplaces, fragments of clay floors with a substructure of river gravel, post holes and a very rich archaeological assemblage (ceramics, bones, lithic material). Most of the Neolithic complexes consist of pits with different functions: for storage or for clay extraction, later on transformed into domestic waste pits.

A first conclusion we may draw after researching area A of the site at Şoimuş is that the site on this terrace of Mureş was intensively occupied during the Neolithic period by people of the Turdaş culture, a fact demonstrated by the impressive amount of archaeological material, which includes coarse and fine ceramics (166 complete pots and numerous other ceramic fragments), anthropomorphic and zoomorphic figurines (over 200 clay weights, complete or fragmentary), lithic items (flint and obsidian blades, grinders, 150 axes of polished stone), processed and unprocessed bones, miniature altars *etc*. (*Petcu* et al. *2012; Ştefan* et al. *2013; 2015; Ştefan 2014; Niţă* et al. *2015; Ştefan, Petcu 2015*).

Methodology

The methodology used in this study relied on both macroscopic and microscopic analysis of the technological and wear traces present on the finds, aided by published technological data from other archaeological assemblages from the same area and neighbouring regions. In the first stage of analysis, a chart was drawn for each artefact, with observations on raw material, the type of find (waste, blank, preform, finished piece) or morphology; then followed processing techniques (two main operations: debitage and shaping) and, finally, hypothetical function resulting from identified use wear was proposed. In the next stage, in order to correlate the data offered by each artefact, the analysis was largely dependent on specific raw materials (such as bone, antler, valve, tooth), because, as we will observe in this study, the different mechanical characteristics of raw materials required the use of different techniques adapted to their characteristics. Within the main large categories of raw materials, the finds were subdivided in terms of how finished they were, thus resulting in four categories; the presence of all the constitutive elements of an operational sequence offered clues regarding the *in situ* processing of the necessary toolkit for this community.

When the degree of preservation allowed, pieces were examined with a Keyence VHX-600 digital microscope at 30x to 150x magnification; images were focused with the aid of a camera incorporated into the microscope. Analytical criteria for the technological and functional interpretation of micro-stigmata were established based on comparisons with other publications on osseous industries in prehistory (*e.g., Maigrot 2003; Sidéra, Legrand 2006; van Gijn 2007; Legrand 2007; Legrand, Sidéra 2007; Gates St-Pierre 2010; Buc 2011*).

Raw materials exploitation

The osseous industry at Şoimuş took raw materials from both domestic and wild animal species, as well as from trade networks (Tab. 1; Fig. 2). We identified continuity in the selection of species and the skeleton elements, with few variations. Cattle (*Bos taurus*) predominates (accounting for approx. 72% of all processed bones) with a predisposition for ribs. They provided a matrix for various types of object: pointed tools, spatulas, spoon-spatulas and pendants. Moreover, there is a noticeable standardised processing of blanks and of preforms, processed finished objects which could be transformed, for instance, into both pointed tools, and into spatulas on a rib split lengthwise. The difference between them lies only in the extremity at which wear is present. Next in quantity, sheep/goat (*Ovis aries/Capra hircus*) bones (13% of osseous blanks) were made into pointed tools only. Other species were used sporadically, probably opportunistically, by recovering blanks morphologically adapted to different uses from culinary waste.

The deer (*Cervidae*) antler was not very intensively exploited (11.43% of the archaeological assemblage). It is difficult to establish how many of the items derive from shed antlers and how many from hunted animals, given the preeminence of the tines and the quasi-absence of the antler's basal area. Nevertheless, the basal area of a red deer (*Cervus elaphus*) antler was identified, considered debitage waste, and two finished items from roe deer (*Capreolus capreolus*) antlers, which demonstrate the obvious exploitation of a shed antler. The presence of a shed antler implies that expeditions with the aim of gathering the antlers were organised a short time after the red deer lost its antlers. Antlers grow from April until July (when they reach maximum calcification) and fall at the end of the winter (in March for adult specimens) (*Provenzano 2001*). They are attacked by rodents, carnivores, even red deer, then by invertebrates, shortly afterward (*Averbouh 2000; 2005; van Gijn 2007*); however, prehistoric communities needed them in good condition. This is why we assume the organisation of expeditions shortly after the red deer lost its antlers.

A third type of raw material is the boar (*Sus scrofa*) canine. Being a wild species, the acquisition of this raw material was exclusively the result of hunting.

Finally, the items made from *Spondylus* and *Glycymeris* valves derive from exchanges with other communities. A number of prehistoric communities are known to have used fossil species, but a series of studies, like those of Shakelton and Elderfield (*1990*), or, more recently, of Bernadett Bajnóczi *et alii* (*2013*), seem to confirm the use of fresh valves, at least of *Spondylus*. Exchanges could have entailed the direct import of raw material or of finished pieces via direct exchange or group to group (*kula*-like exchanges, such as those in Polynesia; *Malinowski 1989*). The socio-economic importance of these shells, probably along with difficulties in acquiring them, compelled the community at Şoimuş to manage items carefully, reflected by long usage (advanced wear) and by repairing or recycling fractured items (see the *Spondylus* valve bracelet).

Management of technology

The assemblage of hard animal material at the Şoimuş settlement totals 901 objects, which can be assigned to four product and sub-product categories as mentioned above (Fig. 3). Their distribution is uneven, favouring finished products, which total 769 (85.4% of all products), whereas 20 objects were being processed (2.2%) and blanks and wastes amount to 14 items (1.6%). We have also added the important category of 'undetermined', which includes 98 artefacts (10.8%).



Fig. 1. Location of the Şoimuş-La Avicola (*Farm 2*) settlement.

Bone

Pointed tools (458 items) comprise the most numerous typological category within the assemblage from Şoimuş. We observed a couple of typological sub-groups, which are defined first by the manner in which the blank was obtained. Most of the items (246 samples) were made of cattle rib by splitting the bone lengthwise. In samples in which the shaping stage was not clear, it is evident that semi-ribs were detached by direct diffuse percussion, with the procedure being finished by indirect percussion. The manner of treating the cancellous tissue is not quite the same: in some items, it was not removed, while in others it was removed completely. The inferior side was afterwards smoothed by abrasion (Fig. 4.1,2). A convex or rectilinear form was impressed at the proximal extremity by abrasion (Fig. 4.3). The debitage edges were generally also shaped by abrasion (Fig. 4.4), after which, at the distal end, bilateral scraping was applied (Fig. 4.5) in order to shape the point. The active surface morphology of the pieces with wear traces is generally rounded, with fine longitudinal scratches (Fig. 4.6). Twenty-two other items were included in this typological subgroup, also obtained by a method of splitting by percussion. Anatomically, the blanks are various. The technological data on the shaping operation are identical with those on the pointed tools made of ribs.

A second type of processing (92 items) used sheep/goat bones (metapodials, 55 items; metatarsus, 17 items; metacarpus, 12 items) and secondarily roe deer (metatarsus, 4 items, metapode, 4 items). The two points which seem to derive from the same bone and which illustrate perfectly the debitage method (Fig. 5.1) are very interesting. The method was to split the bone, generally preserving the epiphysis (Fig. 5.2). At the proximal end, both sides were flattened by abrasion (Fig. 5.3,7). On most pieces, abrasion does not seem to have been used exclusively until the two blanks were detached. It was applied until the medullary canal was reached, over a small surface, with the splitting of the two halves by indirect percussion. Nevertheless, in a couple of samples, it is obvious that bifacial abrasion was the only method used (Fig. 5.6). The blank was shaped by longitudinal scraping applied around the entire circumference at the mesial-distal end (Fig. 5.4). The points are rounded, with marked wear polish (Fig. 5.5,8).

The third subgroup comprises 94 items made on flat blanks obtained by dividing the bone into four by percussion (Fig. 6.1,2). In most cases, the shaping stage took the form of abrasion of the debitage edges (Fig. 6.3), superposed at the distal end with bilateral scraping (Fig. 6.4) in order to develop the point (Fig. 6.5). In items that were preserved, the proximal extremity was shaped by abrasion. Some samples were shaped only by abrasion or scraping applied to various areas.

Seven pieces were made on blanks in the assemblage. Atypical raw materials were used that do not appear in other categories, *e.g.*, boar ulna and fibula or two horse metatarsus (*Equus caballus*). In one sample, at the epiphysis end, bifacial abrasion was applied to make the surfaces regular. In others (Fig. 7.1), the only technological intervention was the procedure for finishing the point by scraping around

SKELETON ELEMENTS	*Bos taurus*	*Ovis aries/ Capra hircus*	*Equus caballus*	*Sus scrofa*	*Sus domesticus*	*Cervus elaphus*	*Capreolus capreolus*	*Aves* sp.	Indeterminate sp.	*Spondylus* sp.	*Glycymeris* sp.
Valve										2	1
Antler						88	6				
Incisor	1										
Canine				7							
Rib	549										
Coxae	2										
Humerus	1										
Scapula	5										
Radius	6										
Ulna		1									
Metacarpus	1	14					1				
Femur	1										
Tibia	1	3			1	1					
Metatarsus	4	19	2			1	5				
Metapodial	1	69				4	4		1		
Long bone diaphysis		1						2	96		
TOTAL	**572**	**107**	**2**	**7**	**1**	**94**	**16**	**2**	**97**	**2**	**1**

Tab. 1. Numerical distribution of the differents types of raw material and their selection by species and skeletal elements.

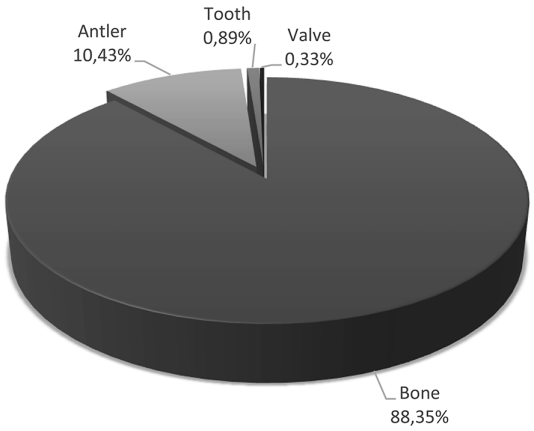


Fig. 2. Percentages of raw materials used for tools.

the entire circumference (Fig. 7.2). When preserved, points are very rounded, showing no signs of being worked on (Fig. 7.3). A second method (Fig. 7.4) of processing points on blanks consisted of eliminating the epiphysis by percussion, without regularising the debitage plan. In order to form the active front (*i.e.*, anatomically preserved surface), the object was struck obliquely. The point was developed by bilateral shaping (Fig. 7.5). Still, we are no longer able to identify any technological traces, because the piece is very worn, with a high surface macroscopic polish. The point is blunt and rounded. Moreover, 7mm of the point developed a depression around the entire circumference, which might have resulted from the use of the piece to make perforations by rotation, the depression being the piece's penetration limit (Fig. 7.6).

Spatulas (118 items). A first variant of processing consists of using the rib's natural blank (16 pieces) (Fig. 8.1,4). The development of the active front started with a segmentation procedure using percussion, according to all the data we have. Unifacial abrasion was then applied (Fig. 8.2,5) to the active front. The wear is characterised by a macroscopic polish, with longitudinal scratches (Fig. 8.3,6), demonstrating use in a lengthwise movement in contact with a soft material.

A second technological variant consists of applying a method of splitting ribs (99 pieces), seemingly accomplished by diffuse percussion (Fig. 8.7,9). The form was created by scraping the fracture sides (Fig. 8.10). The inferior side was not cleaned thoroughly in all the samples, with the complete elimination of the cancellous tissue. The proximal part was developed by abrasion. The active front was also made by bifacial abrasion, applied only at the extremity. The active surface presents macroscopic polish and oblique scratches (Fig. 8.8,11). On the superior side, a strong macroscopic polish developed at the medial side, probably because of handling.

In the spatula category we also included pieces deriving from the diaphysis wall, entirely shaped and having two spatula extremities, with macroscopic polish (3 pieces) (Fig. 8.12,13). We do not know the debitage procedures, due to the very smooth shaping by abrasion applied on the entire surface. The two extremities, also shaped by abrasion, developed functional longitudinal scratches.

Spoons (96 items). In this category, we integrated different pieces whose common element is the presence of a concavity which transforms them into receptor elements. Some pieces (72 pieces) were made on longitudinally split cattle rib split lengthwise (Fig. 9.1). The debitage edges and the convex distal extremity were made by abrasion. The technological data which led us to define the group as spoons rather than spatulas relate to both with the concavity created by profound deep longitudinal scraping (Fig. 9.5), and the finishing of a narrower proximal area by bilateral scraping (Fig. 9.4). In some samples, the handle presents an example made by alternative cutting (Fig. 9.3). The cutting was applied subsequently when the sides were shaped because specific traces are still visible (Figs. 9.6,7). Perforations were also made in the proximal extremity (Fig. 9.2).

Spoons with a different morphology were obtained from the diaphysis of some cattle and red deer long bones (24 pieces) (Fig. 10.1). The pieces consist of three distinct parts: receptor element, the rod and the specific proximal extremity. Generally, we identified fractured proximal parts and meso-distal parts that lack a specific proximal extremity. We believe that the pieces fractured quite often at the proximal end and were fixed by the abrasion of the frac-

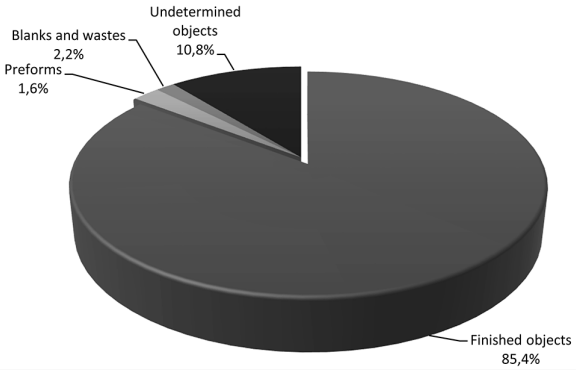


Fig. 3. Percentages of tools and semi-finished products of the operational sequence.

ture plan. Unfortunately, we have not identified pieces in intermediary processing stages, which raises the problem of reconstructing the operational transformation scheme, given the complexity of the procedures. The experimental study published by Isabelle Sidéra (*2011*) allowed us to reconstruct the succession of the technological process. Thus, in the first stage, a method of splitting the bone was applied, thus obtaining two similar blanks. The debitage edges were regularised by abrasion, including the distal extremity, with a convex morphology (Fig. 10.4). In order to make the concavity specific to spoons, the medullary canal was used, deepened either directly by longitudinal scraping (Fig. 10.7) or by a delineation procedure in the form of a perforation made by rotation (Fig. 10.3), starting from which longitudinal scraping was applied (Fig. 10.2).

In most pieces, the handle is cylindrical (Fig. 10.6), probably shaped by scraping (Fig. 10.10), over which an abrasion meant to create a specific morphology was superposed. At this end, the wear on the is great, with macroscopic polish and the disappearance of technological traces (Fig. 10.5,8). The proximal extremities (Fig. 10.9) are actually the extremities of the epiphysis, illustrating a procedure of bifacial abrasion applied until the two perfectly plain sides appeared (Fig. 10.11).

Bevelled objects (9 items). A first processing variant started from dividing the bone into four pieces by percussion (2 items) (Fig. 11.1). The active front was achieved by bifacial abrasion applied only at the distal end (Fig. 11.2). The wear consists of longitudinal scratches, with a very high polish, from which we concluded that the pieces were used in a linear movement (Fig. 11.3). The other six items were made by splitting the bone longitudinally; with one exception, percussion was used. The exception (Fig. 11.4) consists of splitting by grooving (Fig. 11.5) one of the edges, the detachment continuing by indirect percussion. The active front was developed by bifacial abrasion applied at the distal end. In most pieces, the active front exhibits important fractures (Fig. 11.4), illustrating their use as intermediary tools in indirect percussion actions. In one item (Fig. 11.6), the surface presents wear in the form of fine scratches that are slightly oblique, superposed by abrasion incisions, which demonstrate several stages of resharping the piece (Fig. 11.7,8). One last item is a fragment detached by percussion from a cattle scapula. Abrasion for regularisation on the debitage edges and at both extremities was applied on irregular surfaces. The wear of the active front is not great.

Fish hooks (5 items) (Fig. 12.1). The presence of the constitutive elements of the technological scheme (see preforms section) helped us to reconstruct the stages of blank extraction for future hooks. The surface was smoothed by longitudinal scraping (Fig. 12.2) applied on variable surfaces according to the piece. The specific point of the hook was sharpened by scraping (Fig. 11.5). Abrasion was the final processing stage for 3 items (Fig. 12. 3). The pieces have one (1 piece) or two perforations (4 pieces) at the distal end, accomplished by bifacial rotation (Fig. 12.4).

Adornments (14 items). A bracelet was made from a rib (Fig. 13.1). The item was fractured; the two fragments could not be fastened, but they seem to belong to a single unique piece. The blank is flat, obtained by longitudinal splitting; the procedure could not be reconstructed, due to subsequent interventions. The lower side was thoroughly shaped lengthwise (Fig. 13.3), eliminating the cancellous tissue. The same technique was applied to the debitage edges (Fig. 13.2). The extremities were made regular. It is worth noting that the blank underwent a treatment that allowed it to flex, so that it took the form of a bracelet. This was clasped by means of two perforations made by bifacial rotation (Fig. 13.5) at the extremities. They are noticeably worn; the rotation scratches can no longer be seen. Moreover, one of the extremities bears the remains of a fractured perforation (Fig. 13.4). The item was repaired with a new perforation. Another fragment also seems to derive from a bracelet. In this case also the bone was split, but we do not know the procedure, because the debitage edges were thoroughly abraded. Deep scraping, still visible, was applied to the inferior side. One extremity still retains part of a perforation made by unifacial rotation.

Twelve items, similar in raw material and technology, have raised framing issues. They could have been transformed either into points or into spatulas, but the extremities do not have traces of wear (Fig. 13.6). On the contrary, a perforation was made by bifacial rotation at the pointed extremity (Fig. 13.9). All the pieces are made on flat blanks obtained by splitting the rib lengthwise, with the edges achieved by lengthwise scraping (Fig. 13.8) in order to achieve the desired form of the piece. The cancellous tissue was removed from all the pieces. The lower side and both extremities were made regular by abrasion (Figs. 13.7,10) on variable surfaces, according to the item.

Needles (2 items). The first item (Fig. 14.1) is made on a flat blank obtained by splitting the bone into four pieces by percussion. The debitage edges were entirely shaped by lengthwise scraping. The active front was developed by scraping around the entire circumference at the distal end (Fig. 14.2). Proximally, a perforation was made by unifacial rotation from the lower side. The point is blunt, with marked polish and functional scratches in parallel with the item's axis (Fig. 14.3). The second needle is a mesoproximal fragment on a flat blank obtained by splitting the bone into four pieces. We do not know the debitage procedure, because the entire surface of the item was made regular by lengthwise scraping. Abrasion was used only at the proximal extremity. Its function as a needle is suggested by a bifacial rotation perforation.

Ring (1 item). The item was obtained through a segmentation procedure by sawing. The segmentation plan was shaped by abrasion. At the same time, the diaphysis' medullary canal was enlarged by scraping.

Knife (1 item). Although the item is fractured (Fig. 14.4), we may assert that the blank was obtained through lengthwise percussion. Only the edge used as the active front was processed. It was bilaterally shaped with lengthwise scraping (Fig. 14.5). A convex and very sharp bevel resulted. Presently, it is highly polished on both sides (Fig. 14.6) and the traces of scraping have begun to disappear. We do not know if it was used for cutting or scraping. Whatever the case, this type of active front is useful for both types of action.

Belt element (1 item). One item (Fig. 14.7), interesting because of its morphology and technological scheme, was placed in this typological category based on comparisons with similar items from the literature (*Ramseyer 2001*). It was made on a flat blank derived from a long bone. Due to subsequent work on the item, we were not able to identify the debitage procedures. The form was created by sawing, after which the debitage edges were shaped. The perforation was accomplished by bifacial rotation, with still visible grooves (Fig. 14.9). We also identified areas of wear, with the disappearance of technological traces. The lower side was regularised by abrasion (Fig. 14.8). The entire surface of the item presents a strong macroscopic polish, probably caused by prolonged use. Unfortunately, it is fractured and we do not know its intact morphology.

Handle (1 item). The item (Fig. 15.1) was made by eliminating the epiphysis by sawing (Fig. 15.2), after which the segmentation plan was thoroughly polished (Fig. 15.3). The natural medullar canal was used for gloving.

Indeterminates (87 items). This category mainly includes items made on ribs split lengthwise – most probably pointed tools, spatulas or spoons-spatulas; their high degree of fragmentation prevents identification of the exact morphology/function (70 items). Several items (17) made on other types of blanks, alas also fractured, proved interesting due to their technological traces. For the first item (Fig. 15.4), a flat blank was used, the debitage edges being regularised by abrasion (Fig. 15.5). Three bifacial rotation perforations were made centrally (Fig. 15.6) and a fourth was initiated from the inferior side, by rotation. Another item (Fig. 15.7) is a mesoproximal fragment. First, the model was cut (Fig. 15.9), after which the item's entire surface was regularised by lengthwise scraping (Fig. 15.8), which covered all the traces appearing during the debitage operation. The extremity was made regular by abrasion. One of four pieces is technologically worth noting: they seem to have been made on flat bones, preserving the matrix's anatomic volume. We do not know the procedure for obtaining the blank, because the form was achieved by scraping the side lengthwise (Fig. 15.11) and by surface abrasion (Fig. 15.13), which destroyed some of the previous traces. In one of the pieces (Fig. 15.10), the preserved extremity seems to have been segmented by sawing; it also exhibits two perforations made by alternative bifacial rotation (Fig. 15.14). A third perforation was initiated from the inferior side, which is very important because it demonstrates that the perforation was not performed with a perçoir-type lithic tool, but with a circular item, hollow on the inside (small central waste) (Fig. 15.12). Another piece presents a small perforation at its base accomplished by bifacial rotation, above which a perforation with a greater diameter was made. The fact that the latter has a morphological deformation, probably following the pressure of a thread, seems quite interesting. The wear covers the entire surface of the item.

Preforms (3 items). Two preforms identified in the Şoimuş settlement were destined to be transformed into fish hooks. These are flat blanks (Fig. 16.1) obtained by splitting the bone, seemingly by percussion, after which the debitage edges were completely abraded. The segmentation was done by

sawing. One of the samples was shaped by lengthwise scraping, while the upper side was regularised by abrasion in order to reduce the bone's convexity. The extremities were also regularised by abrasion. In order to make the future hook, perforations were made with bifacial (1 item) or unifacial (1 item) rotation (Fig. 16.2). Afterwards, grooving traced the form of the future hook (Fig. 16.3).

Another type of item which was still being processed (Fig. 16.4) consisted in obtaining a splinter by successive partitions. A proximal peduncle-shaped gloving system was set up by progressive cutting, followed by shaping applied meso-proximally by abrasion to the upper side. The item remained at this stage of processing.

Antler

Punches (17 items). The items were made on red deer antler tines (Fig. 16.5), except for a single piece, an antler branch of roe deer. Usually, the antler's natural form was used with minimal technological interventions. Segmentation was probably made by percussion applied to various surfaces, the procedure being finished by bending or, in rare cases, again by percussion (Fig. 16.6). The active front was fixed at the point of the tine by small chiseling, thus creating a flattened surface. Another manner of achieving a point consisted in thinning by scraping around the entire circumference. The pressed aspect of the active front, with fine irregular scratches (Fig. 16.7), might be due to its use for crushing different materials. For instance, one of the items shows spots of black pigment on the active front (Fig. 16.8).

Six of these pieces seem also to have been used as pressure flakers (Fig. 16.9). One piece presents a small area with oblique, sub-parallel scratches on the point (Fig. 16.10), perpendicular to the item's axis (Fig. 16.11). The point's anatomic form was modified by some degree of chiseling around the entire circumference, like the other pieces in this typological category.

The roe deer antler is a shed one, upon which the tines were eliminated by percussion on half of the diameter, followed by bending. A tine was preserved. Its surface is covered by macroscopic polish and transversal scratches, probably due to contact with a lithic tool.

Fish hooks (13 items). The blank was obtained from the compact tissue of the antler, by lengthwise percussion. Segmentation was made transversally by percussion. The form was achieved mesodistally by bilateral lengthwise scraping (Fig. 12.7). Abrasion was the final process for 11 items (Fig. 12.8). The distal extremity was shaped by abrasion, acquiring a rectilinear morphology. At the distal end, the items have one (4 pieces) or two perforations (8 pieces), accomplished by bifacial rotation. One item (Fig. 12.6) presents a different clasping system, namely a perforation made by rotation (Fig. 12.10), associated with a groove cut at 19mm from it, by sawing applied around the entire circumference (Fig. 12.9).

Bevelled objects (12 items). The common element of these pieces is that the blanks in the assemblage were made only from red deer antler tines (Fig. 17. 1,4). Segmentation was by percussion around the entire circumference (Fig. 17.5) in 4 items, while the procedure was undetermined in the others (8 items). The oblique distal end was finished by percussion (Fig. 17.2) or scraping (Fig. 17.6); in 3 of the items, the debitage plan of the active front was regularised by abrasion (Fig. 17.7) or scraping. The manner in which the fractures evolved both distally and proximally alongside the macroscopic polish with longitudinal scratches (Fig. 17.3,8) clearly illustrate these items' function as intermediary tools.

Composed tools (4 items). All the items were made from the superior area of a branch. At the segmentation level, the preserved volume was thinned by abrasion, thus creating an area with biconvex section and convex-concave sides (Fig. 18.6). The rest of the surface was regularised by lengthwise scraping (Fig. 18.2). Towards this end, a perforation was made by rotation (Fig. 18.4,7). Moreover, one item (Fig. 18.5) was fractured and repaired, as demonstrated by the presence of median technological traces which attest the existence of previous perforations. Another item (Fig. 18.1) presents two perforations performed by bifacial rotation. Two grooves developed towards the point, which seem to have resulted from tying a thread (Fig. 18.3). Finally, a third item (Fig. 18.8) has an ornament accomplished by rotation quite randomly distributed over the entire surface.

Handles (2 items). The pieces attributed to this category differ, so they will be described separately. The first (Fig. 19.1) is a segment on a tine detached by percussion at both extremities (Fig. 19.2). Technological traces of this segmentation procedure can hardly be identified because the pearling was elim-

inated by chiseling over the entire surface of the piece, on which a procedure of shaping by scraping was superimposed (Fig. 19.4). Both segmentation plans were regularised by abrasion (Fig. 19.5). At the narrower extremity, the cancellous tissue was excavated, thus developing a hole (Fig. 19.3) with a depth of 11 mm and a diameter of 9 mm. The item is highly worn, with lengthwise cracks as a consequence of the pressure exerted by the gloved piece, and presents strong macro-wear.

The second item is a percussion segmented beam. A procedure of surface modification by percussion was employed, eliminating the pearling. A median rectangular perforation by bifacial cutting was made, as well as a small perforation by rotation, probably for blocking the gloved piece.

Receptacle (1 item). An antler tine (Fig. 19.6) from the basal area was processed by segmentation and lengthwise splitting; the procedures could not be identified because the debitage edges were regularised by abrasion. The cancellous tissue was entirely removed, deep lengthwise scraping being visible on the inside. Lengthwise scraping was also applied to the upper side to eliminate the pearling and clean the surface. A concavity is visible on the lower side, which led us to identify the item as a receptacle.

Bracelet (1 item). The piece (Fig. 19.7) was made on flat blank, which was probably processed in order to be curved and achieve the bracelet form. The lower side was thoroughly abraded. Small cuts were applied by sawing (Fig. 19.8), at a distance of approx. 3mm, while the depth of the grooves is approx. 1.87mm. Three perforations were made by unifacial rotation (Fig. 19.9) from the upper side, and were intended to clasp the item.

Comb (1 item) (Fig. 20.1). In order to obtain the blank, an extraction method by sawing was used (specific technological traces may still be identified on the item's long side) (Fig. 20.2). Afterwards, the debitage edges were thoroughly shaped (Fig. 20.3). On the lower side, the blank was shaped by a lengthwise scraping. Two perforations were made at the extremities by unifacial rotation from the lower side (Fig. 20.4). The perforations were subsequent to the scraping made on the superior side, because they superpose it. They were probably intended for clasping. The ornament consists only of incisions (Fig. 20.7). Initially, there were 13 teeth, obtained by the intersection of two grooves (Fig. 20.5). The procedure was applied until the cutting of a small fragment, with triangular morphology. The teeth present macroscopic polish and are well rounded (Fig. 20.6).

Ring (1 item). The item (Fig. 20.8) was obtained through a segmentation procedure, probably by sawing. The traces are no longer visible, because the segmentation plan was regularised by abrasion (Fig. 20.9). Grooves were made on its surface (Fig. 20.10), traced around the entire circumference, probably to suggest an ornament. The ring's interior was enlarged by means of lengthwise scraping.

Undetermined (11 items). In this category, we included pieces whose function could not be determined, generally because of breakage. The first piece (Fig. 21.1) is a beam fragment for which the segmentation was made by percussion. The segmentation plan was subsequently shaped. The pearling was completely eliminated by percussion (Fig. 21.2). The item shows one broken perforation. Nevertheless, a new median perforation was made by bifacial cutting (Fig. 21.3). We may be dealing with the recycling of an item by transforming it into a handle. Another piece (Fig. 21.4), also made from a beam, is longitudinally fractured, so that we were not able to entirely reconstruct its morphology. The segmentation plan was thoroughly abraded proximally. At the opposed extremity, it seems that the segmentation was made by percussion. The item's entire surface was shaped by lengthwise scraping (Fig. 21.6). A perforation was made 75 mm from the proximal extremity by bifacial cutting. The item is decorated (Fig. 21.5): longitudinal proximal rows of 8–9 perforations and a long row of 13 meso-distal perforations (the row was probably longer).

The basal area (Fig. 21.7), with the first tine of a shed antler, was detached by percussion applied to half of the diameter, followed by bending. A portion of the outer burr was eliminated by percussion. Circular incisions appeared in this area (Fig. 21.8), surely resulting from the pressure of threads, either wool or plant fiber. The preserved tine shows no sign of wear.

Preforms (17 items). Seventeen items are in an intermediate processing stage. They were processed on red deer (15 pieces) and roe deer (2 pieces) antler tine. Blanks prevail in the assemblage, but flat ones are also present. Where identifiable, segmentation was made by percussion on variable surfaces, followed by bending (6 pieces) or by percussion around the entire circumference (6 pieces). Among

these preforms, we identified items which were about to be turned into punching tools by applying lengthwise scraping (5 pieces) or small chiseling (2 pieces) around the circumference. Visible traces appear on a roe deer tine (Fig. 22.2) detached by percussion applied on one third of the diameter and bending. A chiseling procedure was distally applied around the entire circumference to prepare a punch-type item. Another type of fixing consists in the initiation of a bevelled-type active front (2 items – Fig. 22.1) by percussion.

The first flat blank is from a roe deer tine. It is proximally fractured, so we do not know the segmentation procedure. The lengthwise splitting was done by percussion. On the upper side, a chiseling procedure was applied in *taille au canif*. The second flat blank derives from a red deer tine split by percussion. Shaping by chiseling was initiated on the debitage edges. Transversally, a bending technique seems to have been used. The making of three fish hooks was also initiated on flat blanks. They were detached from the raw material, but had not reached the final processing stage. After extraction, the shape was created by scraping. All the items have a perforation accomplished by bifacial rotation at the distal end.

Blanks (11 items). Nine tines and two beams were attributed to the blanks category. They lack any specific trace of shaping operations and, because of their size, they became finished items. All the blanks preserve the antler's anatomic volume. Segmentation was achieved by percussion, applied either on approx. half of the matrix diameter (6 items), followed by bending, or by percussion applied around the entire circumference (5 items).

Wastes (3 items). In this category, we included artefacts unfit to be transformed into finished items. We refer here to two roe deer antler tines, segmented by percussion and detached by bending, and to the basal area of a shed red deer antler, from which the basal tines were detached by bending and the beam by percussion around the entire circumference.

Teeth

Teeth objects form two typological categories: scrapers (6 items) and adornments (2 items). All the scrapers (Fig. 22.3,7) were made on flat blanks obtained by percussion (5 items) or grooving (Fig. 22.4), combined with indirect percussion (1 item). The proximal extremity preserved in two samples was regularised by abrasion (Fig. 22.8). The lower side was shaped by abrasion (4 pieces) (Fig. 22.5) or lengthwise scraping (1 piece). The active front was achieved by scraping applied on the debitage edges (Fig. 22.6,9). The items seem to have gone through successive stages of reshaping the active front by scraping applied only on the concave side. All the samples are of boar canines.

The first adornment is a cattle incisor (Fig. 23.1), simply perforated by bifacial rotation (Fig. 23.2). The wear is not too advanced, the rotation scratches still being visible. The second is more elaborately processed, starting from a boar canine (Fig. 23.3). The flat blank was obtained by percussion. The sharp form was achieved by lengthwise scraping (Fig. 23.4). The perforation was made by unifacial rotation (Fig. 23.5) from the lower side. Towards the end point, it presents a slight deformation of the wall, probably the clasping area.

Bivalve

Spondylus valves were turned into two types of adornment. The first, extremely interesting because of the traces of wear, is a perforated plaque (Fig. 23.6). An extraction method by sawing was used to process the blank. All traces of the debitage operation were removed by the shaping operation, which was accomplished by abrasion of the entire item (Fig. 23.7). Laterally, two perforations were made by bifacial rotation. The rotation scratches are quite blurred. Small fractures of the wall appeared at the extremity, superimposed by wear polish (Fig. 23.8). Moreover, on one of the item's superior side a small depression developed, the result of friction with a thread for a long period. We suppose that each perforation was intended for an individual clasp. The second item is a fragment from a bracelet (Fig. 23.9) which was previously fixed. A fragmented perforation has survived at one end, apparently made by bifacial rotation. The bracelet had probably fractured and a perforation was made for a clasp. The general wear on the item is very advanced.

A bracelet made from a *Glycymeris* valve (Fig. 23.10) was discovered in fragmented form. The finished item was obtained by bifacial abrasion (Fig. 23.11), acquiring a rectangular section. Towards the end point, a unifacial perforation was made (Fig. 23.12) by rotation, with still visible technological traces.

Discussion

The exploitation of animal resources to produce tools, weapons, or ornaments is subject to a succession of technological stages, beginning with the acquisition of raw material and continuing with transformation and consumption, which does not always end the operational chain, because recycling may sometimes also intervene. Through traces, these artefacts recorded all the actions which led to their production, so we may assert that they offer an insight into the life and occupations of prehistoric communtities. Moreover, anthropologists and archaeologists, following their observations on pre-industrial populations, underlined that objects and, implicitly, technology are subordinate to the social realm (*Malinowski 1939; Pétrequin, Pétrequin 2006; Choyke 2008 etc.*) or, as splendidly summarised by Pfaffenberger (*1988.249*): "*To construct a technology is not merely to deploy materials and techniques; it is also to construct social and economic alliances, to invent new legal principles for social relations, and to provide powerful new vehicles for culturally-provided myth.*"

The study of the above-mentioned categories (see Tab. 2) led to the identification of the following detachment procedures: transversal debitage, to which a transformation scheme by segmentation corresponds, and longitudinal debitage, to which transformation schemes by splitting into two, successive splitting and extraction are subordinate. As for the techniques used during the debitage stage, we produced some figures on raw material types, as we could clearly highlight different treatment for bones, antlers, and teeth. For bone, the debitage resulted in two blank types: with the original volume or flat. Considering the percentage, we may state that flattened blanks were preferred. Transversal debitage was performed by direct percussion and sawing (*e.g.*, ring, handle). To split items lengthwise, percussion and abrasion were mainly applied; a groove and splinter combination was used less (1 item), while for successive splitting, only percussion was used. For the extraction procedure, groove and splinter (*e.g.*, fish hooks) or sawing techniques (*e.g.*, comb) were used. Among the surface modification procedures, we identified a variety of combinations of techniques. Abrasion was used primarily for points, superposed by scraping; also, abrasion was used to create flat surfaces; to make spoons concave, abrasion was used either in a combination of perforation by rotation and scraping, or merely scraping. Grooving was used to make surface ornamentation (comb and ring). The techniques used for volume modification procedures were perforation, having only one variant, namely ro-

Raw materials	Species	Typological category	No. pieces
Bone	Mammals	Pointed tool	458
		Spatulas	118
		Spoon	96
		Fishing hook	5
		Bevelled object	9
		Adornment	12
		Bracelet	2
		Needle	2
		Ring	1
		Belt	1
		Handle	1
		Knife	1
		Indeterminate	87
		Preform	3
Antler	*Cervus elaphus*	Fishing hook	13
		Punching tool	11
		Punching and retouching tool	6
		Bevelled object	12
		Composite tool	4
		Handle	2
		Receptacle	1
		Bracelet	1
		Comb	1
		Ring	1
		Indeterminate	9
		Preform	15
		Blank	11
		Waste	1
	Capreolus capreolus	Punching tool	1
		Indeterminate	1
		Preform	2
		Waste	2
Tooth	*Sus scrofa*	Adornment	1
		Scraper	6
	Bos taurus	Adornment	1
Shell	*Spondylus*	Adornment	2
	Glycymeris	Adornment	1

Tab. 2. Types of tools and semi-finished products of the transforming technique.

tation. Sawing, used for decorated handles and grooving, was also used to detach the comb's teeth.

For antlers, the situation is completely different, given the predominance of volume blanks. For transversal debitage, percussion combined with bending, or only percussion, were used. The few flat blanks were obtained by splitting the antler lengthwise by percussion. Direct percussion, scraping, abrasion and perforation by rotation were used for surface modification. Anatomically preserved volume was modified particularly by perforation or cutting. Sawing was also used to modify, being used for the decoration of the bracelet.

Finally, in the case of teeth, we do not know how the blank's transversal segmentation was made. Lengthwise splitting was achieved by debitage, which involved percussion or, in one item, a groove and splinter combination. The procedures for surface modification were abrasion and scraping, while perforation by rotation was used for volume modification.

The general picture shows that techniques and procedures varied. Still, they are quite standardised within the groups, which allows the identification of typological series; some are numerically significant (see the case of the pointed tools). They are well adapted to different raw material types, illustrating a good knowledge of the field. This assertion is also sustained by the presence of a highly complex transformational technological scheme. We do not know if they were created by specialists, but the repeated elements of the operational sequence found within the assemblage are evidence of skill or knowledge that is transmitted from one generation to the next.

Among these items, the biggest typological category is that of pointed tools, including needles, probably having been related to domestic activities such as hide perforation or knitting of textile fibres (*Campana 1989; LeMoine 1991*). Projectile points, which could certainly be included here, are not present. We think that the varying hardness of the processed materials is also reflected in the different appearances of the active extremity wear. The fact that soft materials were processed is proved by the prevalence of rounded points (Figs. 4.6; 5.5,8; 7.3,6), highly worn, with lengthwise traces of wear.

By their extended and fine use polish (Fig. 8.6,8), spatulas seem to correspond to a functionality characterised by prolonged movement on soft materials, such as hides (*Averbouh, Buisson 2003; Raskova Zelinkova 2010*). However, other studies suggest the use of these objects in clay pot making (*Struckmeyer 2011*). Our own experiments on ceramics illustrated, especially for spatulas with convex extremities, that they are very useful for smoothing surfaces and removing excess clay (*Mărgărit 2015*).

The items categorised as spoons are very interesting. As far as wear is concerned, the area with the most significant polish is the handle. The receptor element presents intense wear in a few of the items. Selena Vitezović (*2014*) considers that they were used for preparing and applying pigments. Even if the hypothesis cannot be rejected, our microscopic analysis did not identify pigments on these items.

The bevelled objects may have been intermediate tools, according to the fracture type, such as wedges for splitting wood or removing tree bark. In most objects, made both of bone and antler, the active front has an intense macroscopic polish, with fine perpendicular marks on the extremity being increasingly more extended on one face. As a result, we may consider that they belong to the transformation tool category, used for processing soft materials (*Maigrot 2000*).

The fish hooks exhibit different degrees of finish, which suggests the importance of this activity to the community's economy. A stock was made, which allowed the quick replacement of broken or lost pieces. Moreover, whenever possible, fractured pieces were repaired. The presence of fish hooks and the total absence of classic harpoons suggest only one type of fishing was practised. The dimensions of the items (in the intact items, the length is generally standardised between 6–7cm) suggest that they were used to catch large fish. Still, the composed tools (Fig. 18) made of antler tine might also have a connection with fishing, resembling some toggle harpoons. The points are not sharpened to be stuck into prey, which urges caution about the proposed hypothesis.

The processed antler objects with a circular active extremity and the development of functional scratches seem to correspond to an action involving breaking and friction for an abrasive material. The wear area is quite well defined, being concave in some cases. At the same time, we have seen that some of these items were used for retouching lithic tools.

The tools made of boar teeth seem to have been used, according to the experimental data, in scraping, and for wood and bark processing (*Maigrot 1999*). Moreover, they were sharpened periodically, indicating prolonged use.

The assemblage demonstrates that these tools were used especially in activities of a domestic nature, like processing leather, vegetal fibre, wood or stone, along with fishing and, to a lesser extent, hunting. All types of artefacts were randomly disposed in the settlement's ensemble, as shown in the previous diagram (Fig. 24). There are no differences even between dwellings and the housekeeping area because, very curiously, finished tools also appear in the pits area, which, in our opinion, was still functional. This might be proof of a multitude of activities developed at domestic level, and the lack of specialisation inside the community in favour of tool management and, implicitly, of activities involving the entire group.

The studies published by Selena Vitezović on a series of Vinča settlements are very useful in this context. We may thus see how the Şoimuş assemblage fits into the larger phenomena of Vinča culture. One example is the site at Divostin; the raw materials that were used indicate a major difference between the two sites. At Divostin, antler (49%) was followed by long bones (36%) and, finally, ribs (9%) (*Vitezović 2013a.Graph 1*). Also, blanks deriving from bones of sheep/goats predominate at Divostin, while at Şoimuş the bones of cattle dominate selection. Typologically, the archaeological assemblages have common features: the most numerous are the pointed tools, followed by chisel-type forms, spatulas, and punching tools. Composite tools such as the toggle harpoon type are attested at Divostin, but also at Drenovac (*Vitezović 2011*). At other three Vinča sites – Vitkovo (*Vitezović, Bulatović 2013*), Drenovac (*Vitezović 2011*) and Grivac (*Vitezović 2013b*) – the selection of raw materials illustrates the prevalence of long bones and ribs of medium-sized ungulates, mainly sheep/goat, while large mammal bones were used to a lesser extent. Typologically, these are roughly the same types of item: pointed tools predominate, followed by chisels and spatulas, and scrapers made of wild boar tooth. At Opovo, fishing tools like those from Şoimuş are mentioned (*Vitezović 2012*). Bracelets made of *Spondylus* and *Glycymeris* valves also appear at other Vinča sites, at Vitkovo, Divostin, Drenovac (*Vitezović 2013c*) or Belo Brdo (*Dimitrijević, Tripković 2006*).

In conclusion, we observe that at the Şoimuş-La Avicola settlement the selection of raw materials is not identical to that of other Vinča sites, for, as Selena Vitezović and Jelena Bulatović (*2013*) stressed, irrespective of the faunal assemblage, sheep/goat bones predominate among tools made of hard animal materials, which demonstrates a deliberate choice. At Şoimuş, we have seen that cattle ribs predominate. Different ratios of antler exploitation have been registered at Vinča settlements. Typologically, at all the sites, pointed tools are the most numerous, but for the remaining typological categories, the proportions are different. The types identified at Şoimuş are also to be found at other Vinča sites, but the picture is never the same. This is why, at least at this stage of the research, the site seems to be exceptional compared to the Vinča sites. Another interesting fact is the preservation of some typological elements which are specific to the previous period – the Starčevo-Criş culture (pointed tools processed by splitting and abrasion, spoons, rings, belt elements) – and more or less absent from Vinča culture sites. Our paper, even if it is a case study, brings useful

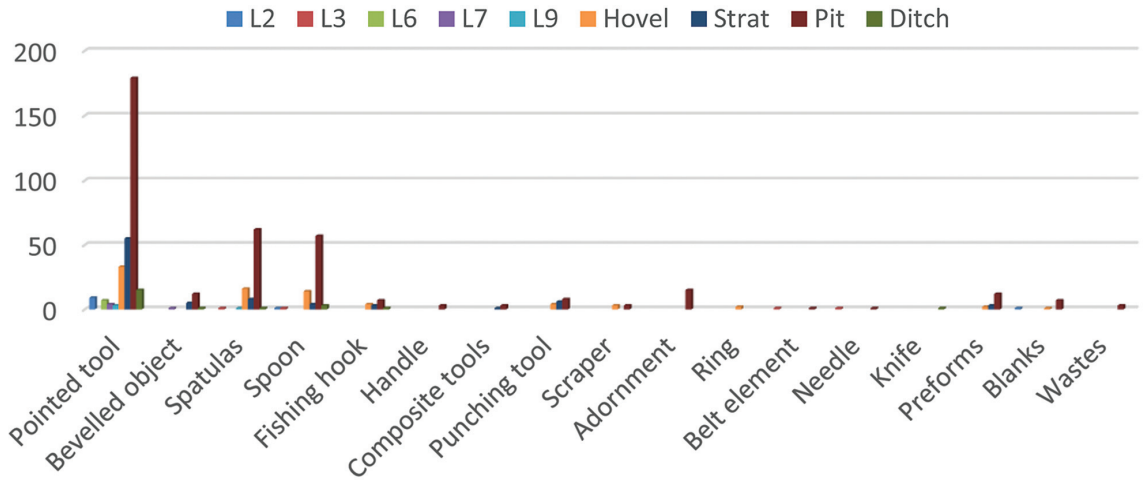


Fig. 24. Archaeological context for the artefacts at the Şoimuş settlement.

information about the hard animal material industry specific to the Turdaş culture. Comparative studies connecting these finds to other contemporary or successive sets found in Romania would be needed in order to identify the cultural innovation and continuity processes in time and space.

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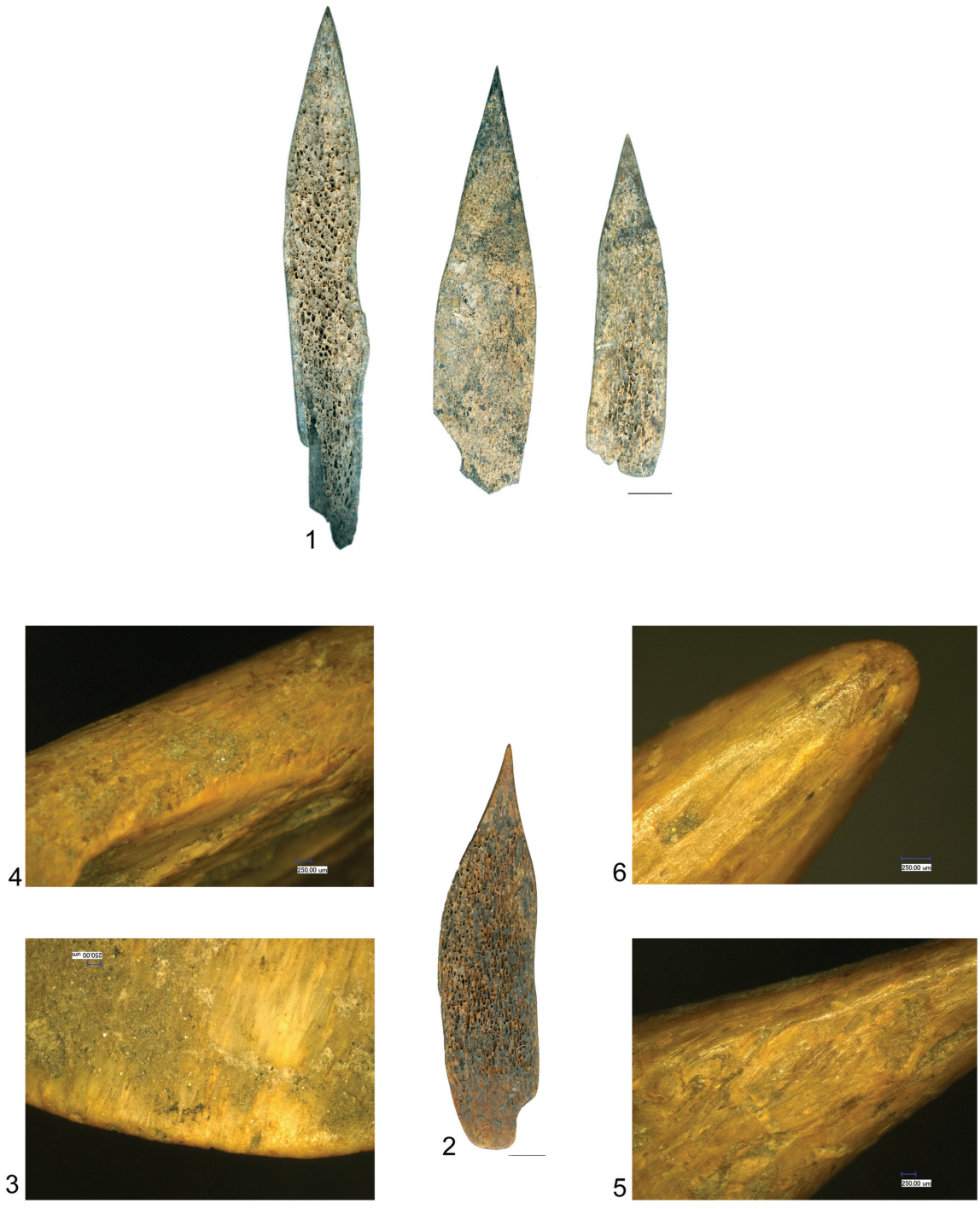


Fig. 4.* 1, 2 *pointed tools made on cattle (*Bos taurus*) rib; 3 proximal end developed by abrasion; 4 shaping of debitage edges by abrasion; 5 point developing by scraping; 6 point with extended wear.

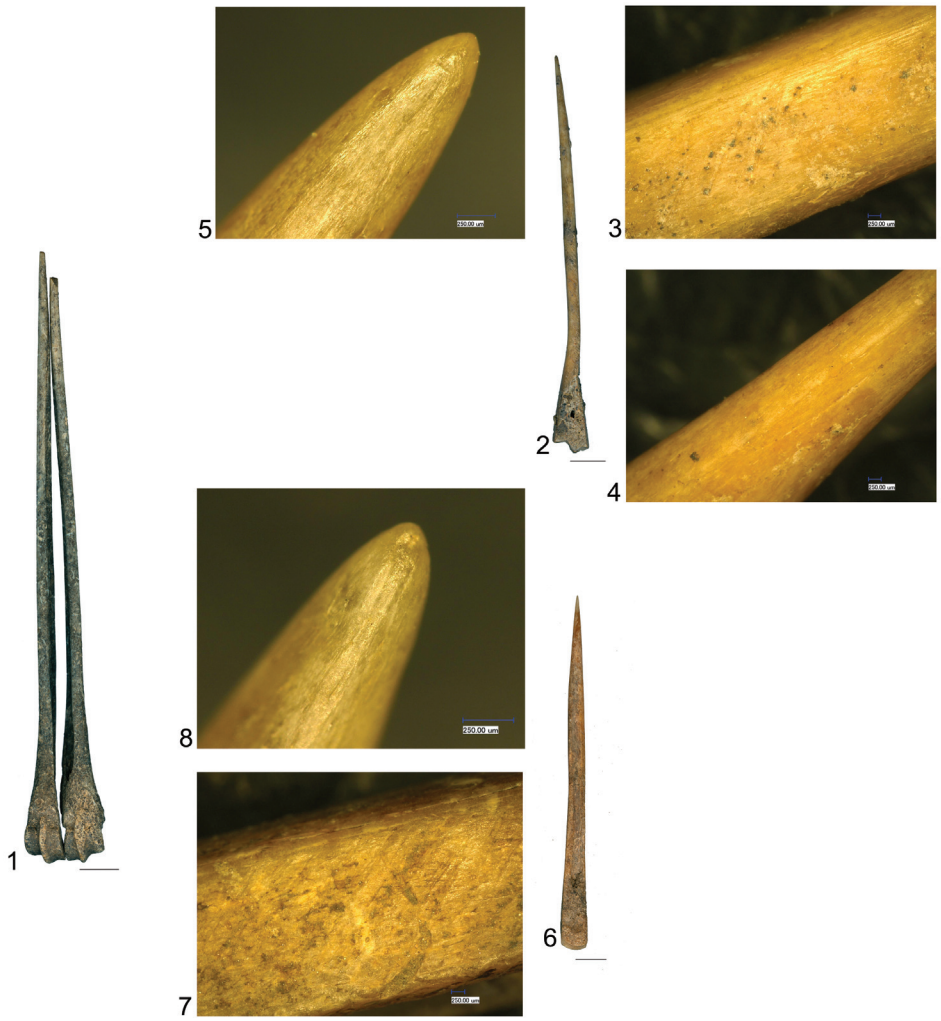


Fig. 5. **1, 2, 6** ***pointed tools obtained by a bipartition debitage method;*** **3, 7** ***debitage by bifacial abrasion;*** **4** ***point developed by scraping;*** **5, 8** ***points with functional wear.***

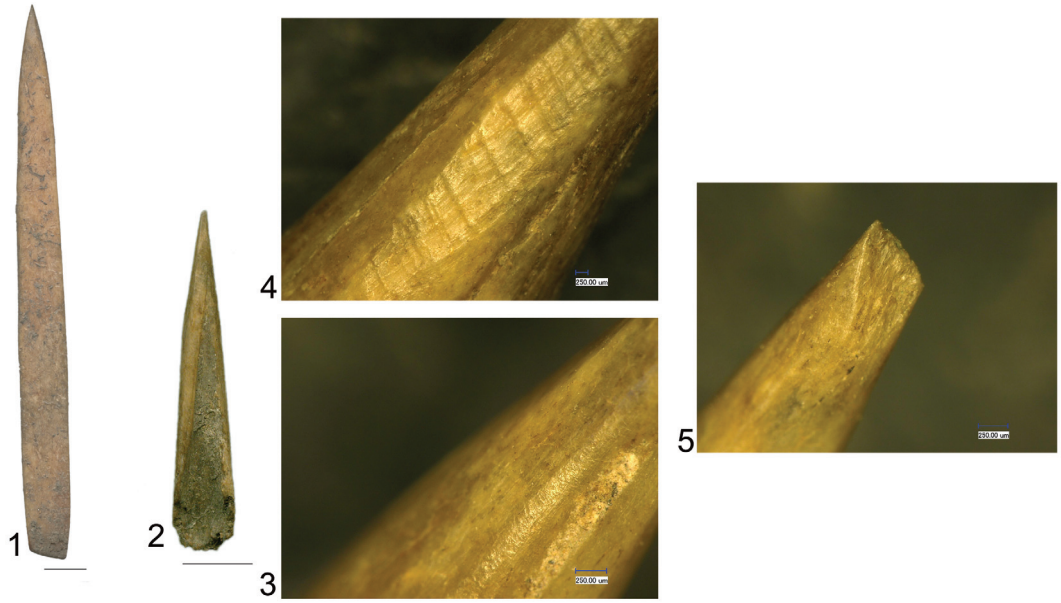


Fig. 6. **1, 2** ***pointed tools obtained through splitting the bone into four;*** **3** ***abrasion of debitage edges;*** **4** ***point developing by scraping;*** **5** ***fractured point.***

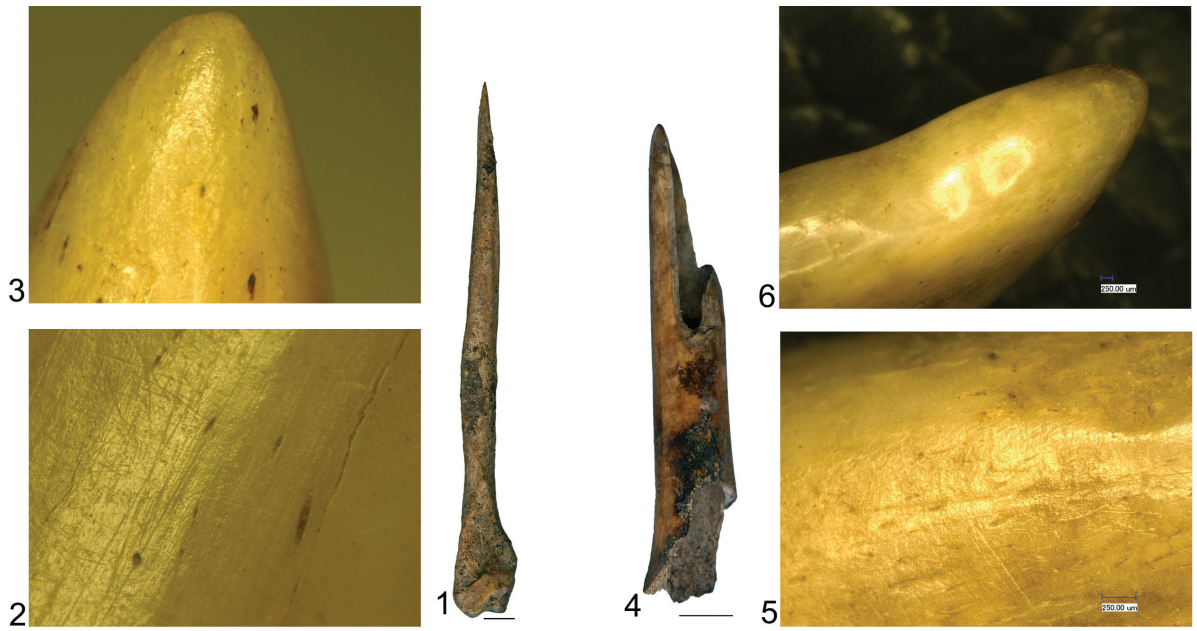


Fig. 7.* 1, 4 *pointed tools made on blanks on preserved volume;* 2 *point achieved by scraping;* 5 *wear on surface;* 3, 6 *active front highly worn.

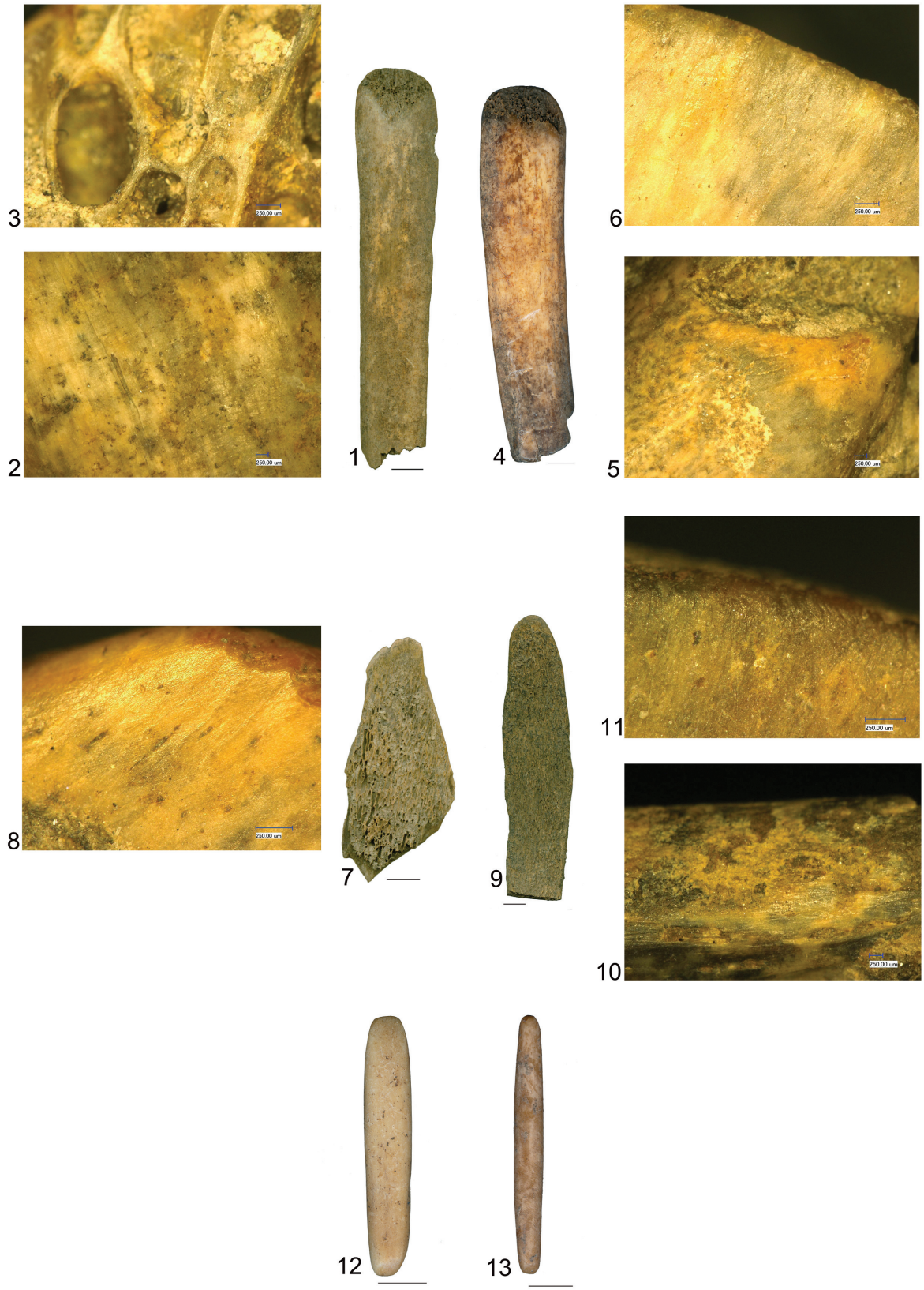


Fig. 8. **1, 4, 7, 9, 12, 13** ***different types of spatula;*** **2, 5** ***active front made by abrasion;*** **10** ***debitage edges shaped by scraping;*** **3, 6, 8, 11** ***active surface with wear traces.***

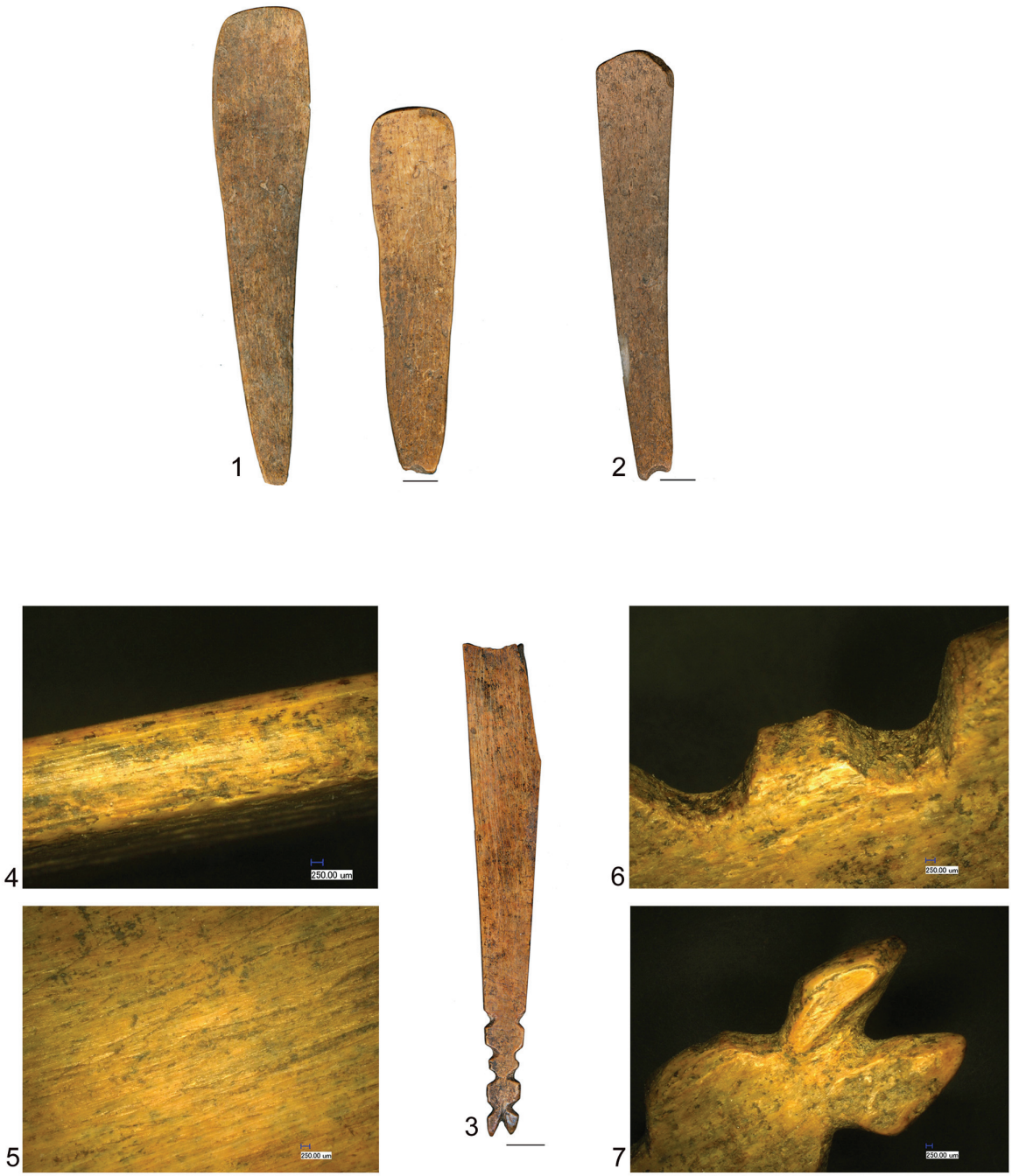


Fig. 9. **1, 2, 3** ***spoons made on rib split lengthwise;*** **4** ***debitage edges shaped by scraping;*** **5** ***concavity achieved by lengthwise scraping;*** **6, 7** ***proximal extremity cut by sawing.***

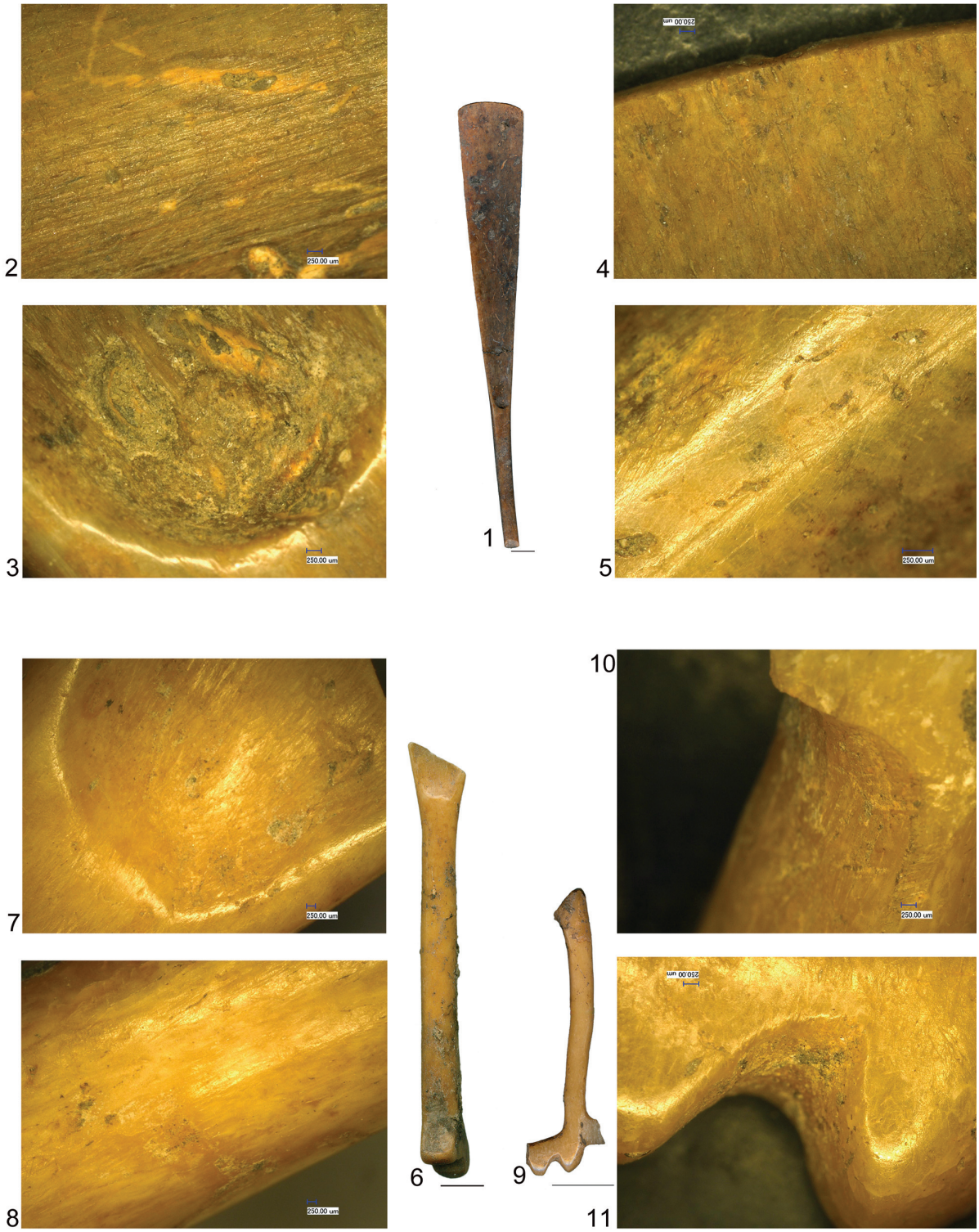


Fig. 10. **1** ***spoon made on long bone diaphysis;*** **2, 7** ***concavity developed by scraping;*** **3** ***procedure of delineation by perforation;*** **4** ***distal extremity shaped by abrasion;*** **5, 8** ***wearing present on the handle;*** **6, 9** ***meso-proximal fragments deriving from spoons;*** **10** ***handler developed by scraping;*** **11** ***detail of proximal extremity.***

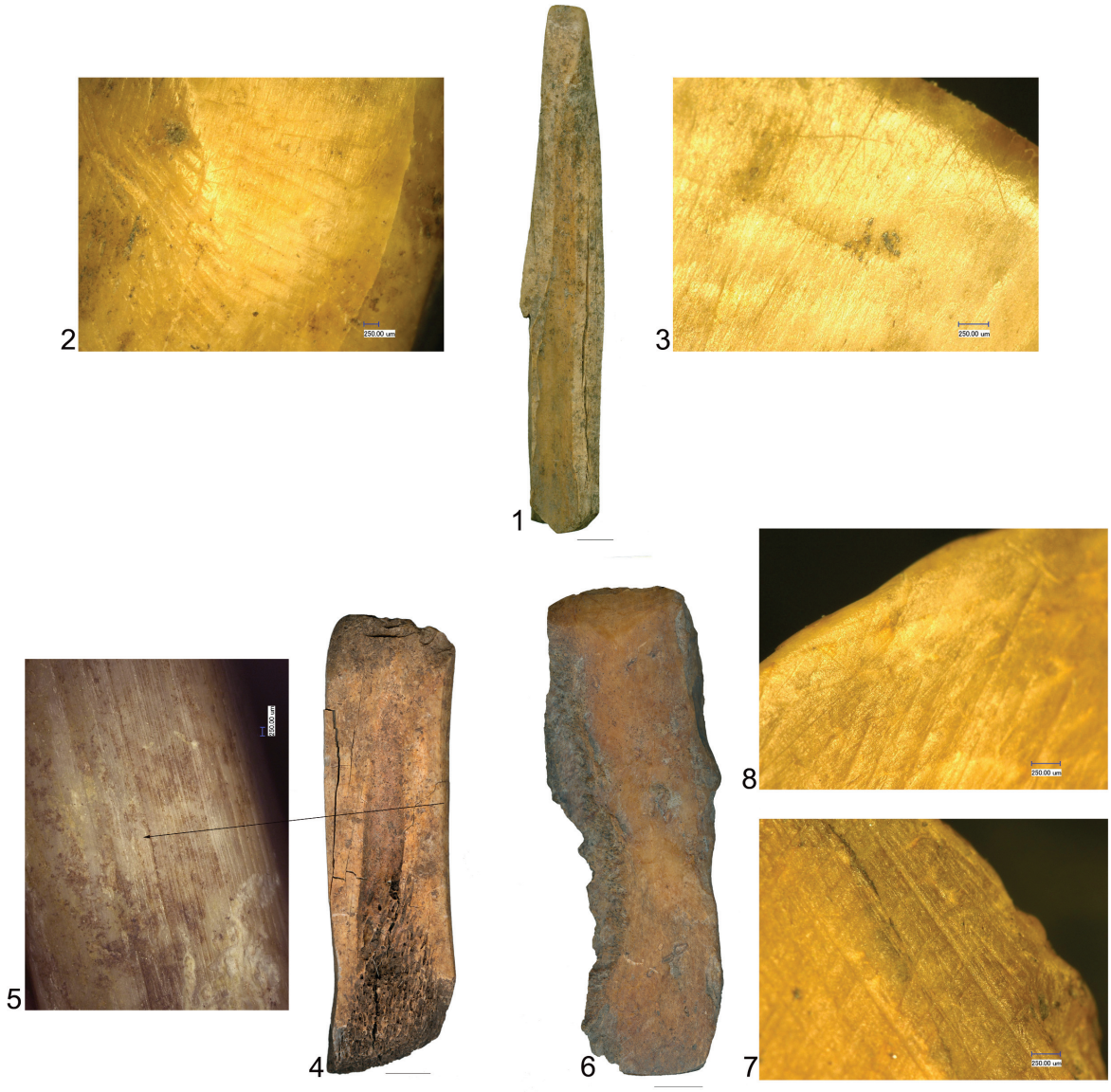


Fig. 11. **1, 4, 6** ***bevelled objects;*** **2** ***active surface processing by abrasion;*** **3** ***active surface wearing;*** **5** ***splitting method involving grooving;*** **7, 8** ***re-sharpening active surface.***

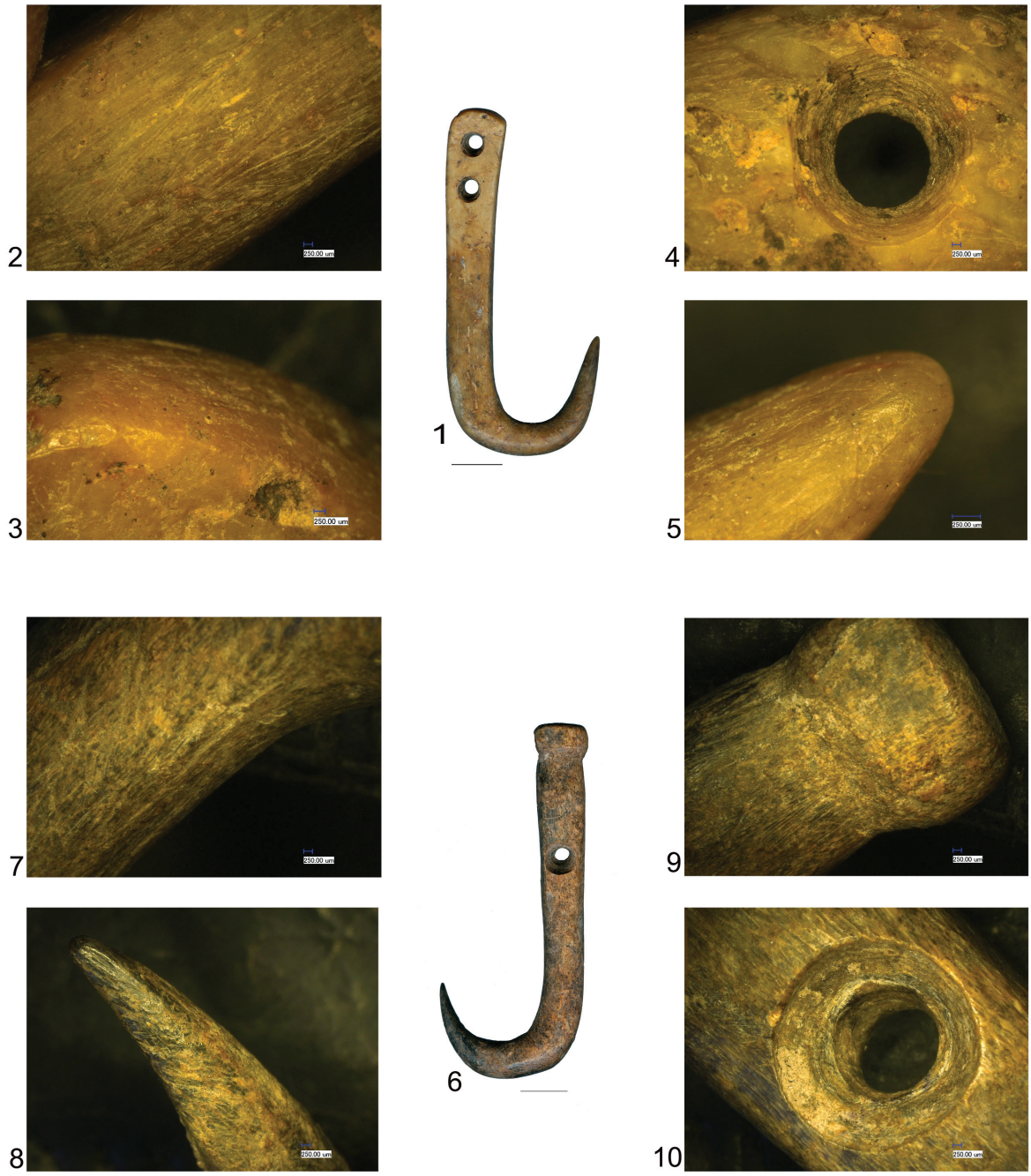


Fig. 12. Fish hooks made of bone* 1 *and antler* 6*;* 2, 7 *preform processing by scraping;* 5, 8 *point sharpened by scraping;* 3 *distal extremity achieved by abrasion;* 4, 10 *perforation made by rotation;* 9 *clasping system made by sawing.

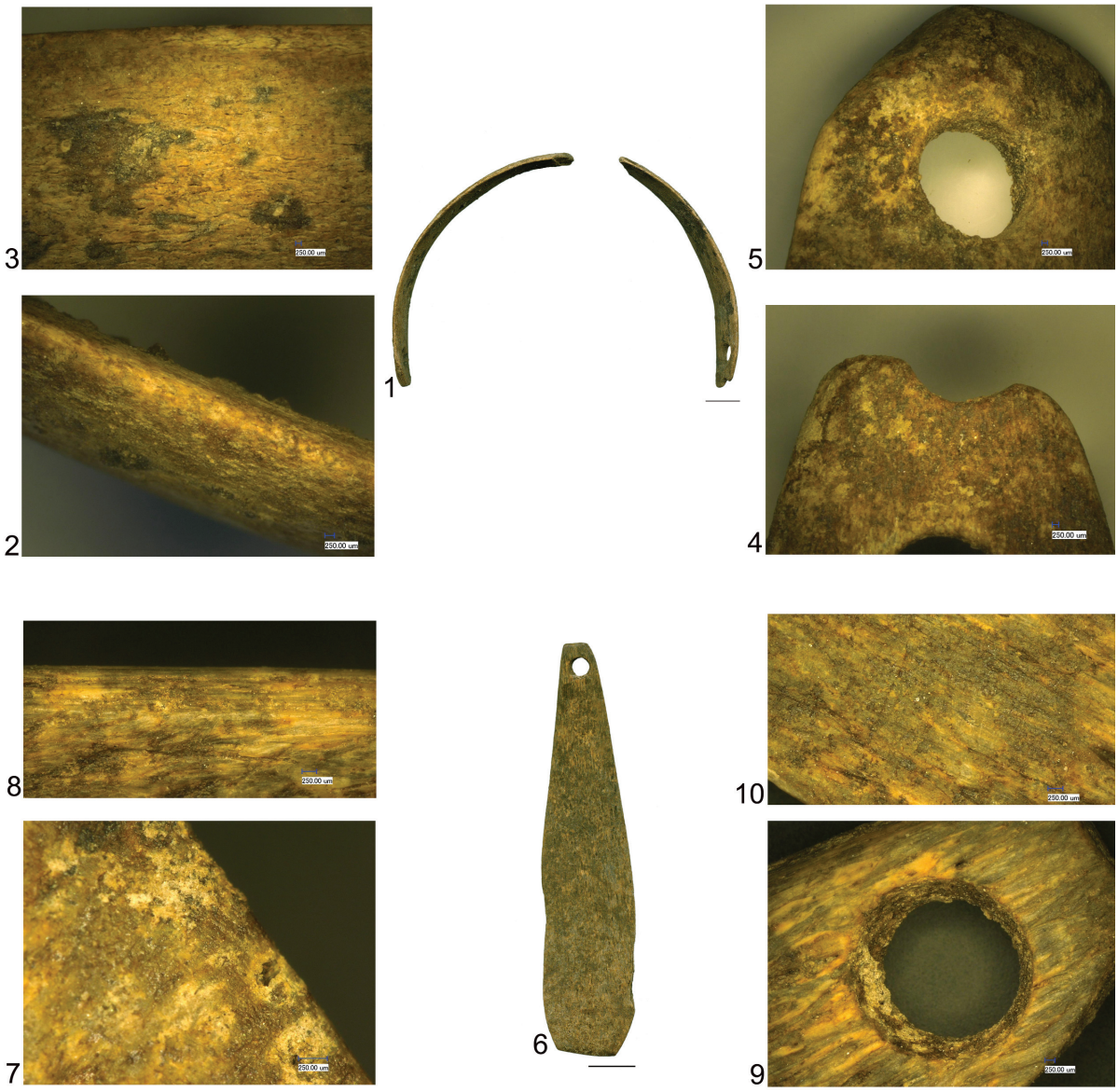


Fig. 13. **1** ***bracelet made on rib;*** **2, 3, 8** ***scraping of debitage edges and inferior side;*** **4** ***fracture at the perforation;*** **5, 9** ***perforation made by bifacial rotation;*** **6** ***pendant made on rib;*** **7, 10** ***inferior side and extremities abrasion.***

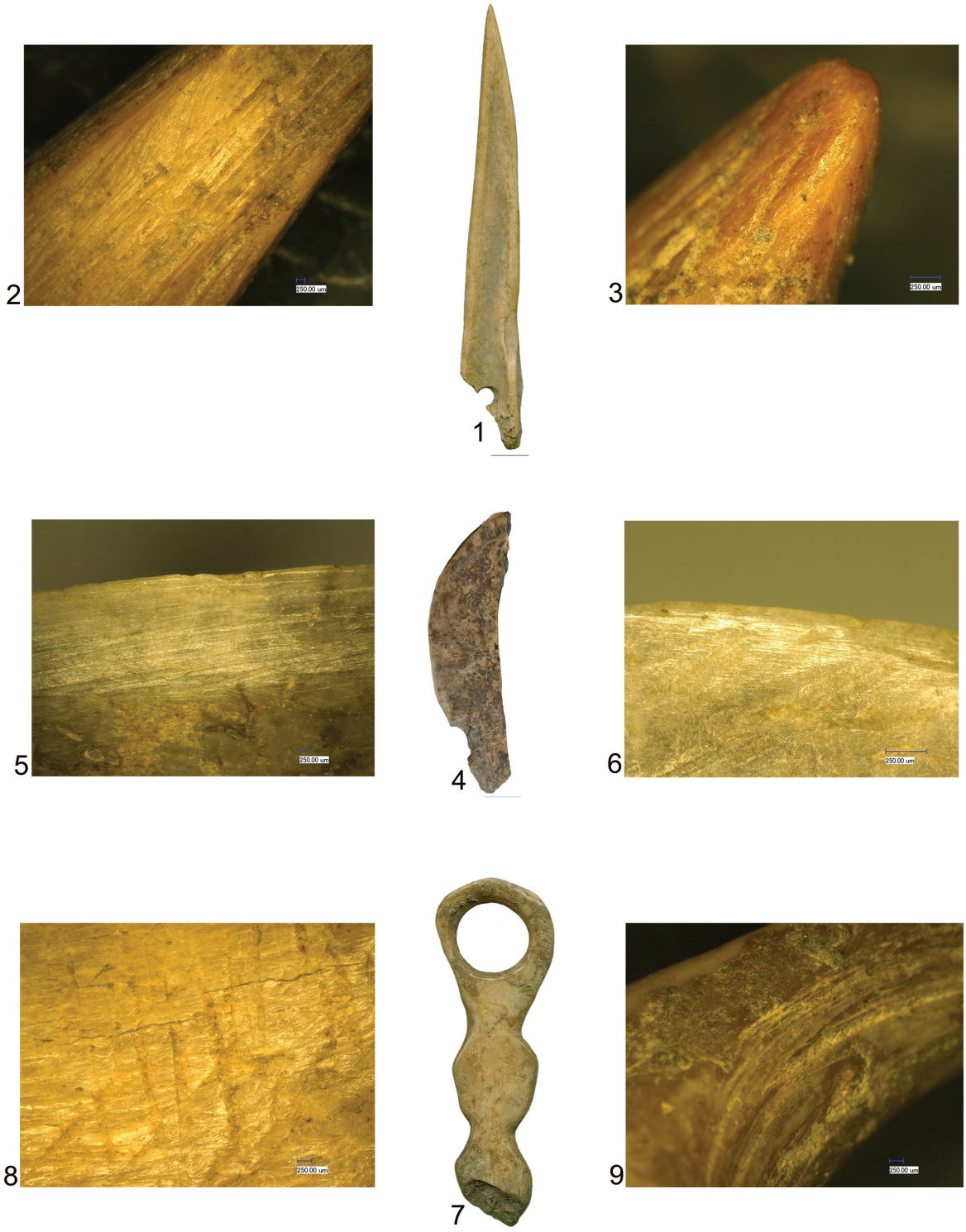


Fig. 14. **1** ***bone needle;*** **2** ***point developing by scraping;*** **3** ***point with functional wear;*** **4** ***knife;*** **5** ***active surface achieved by scraping;*** **6** ***active surface wear;*** **7** ***belt element;*** **8** ***surface shaping;*** **9** ***detail perforation.***

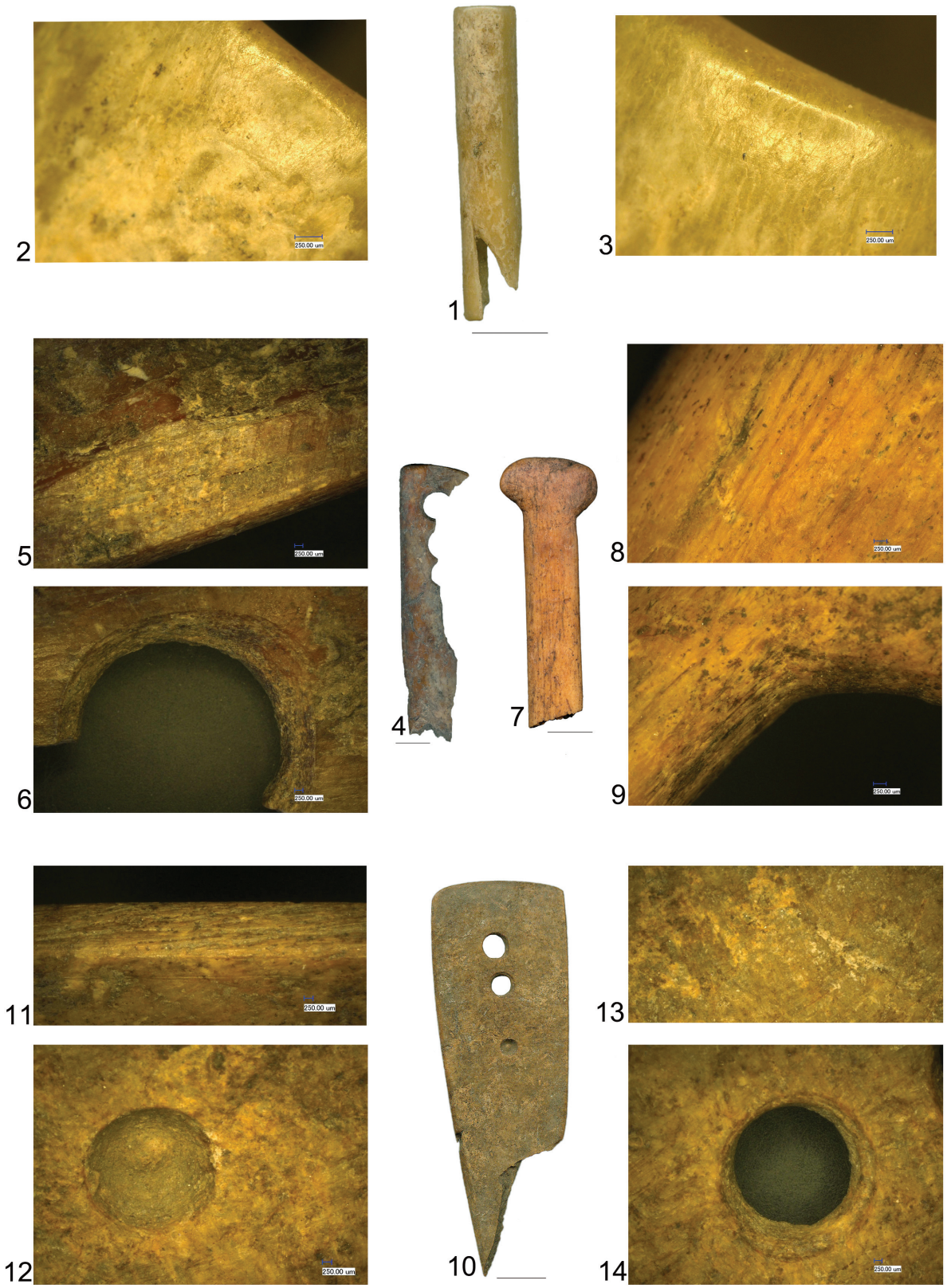


Fig. 15. **1** ***bone handle;*** **2** ***traces of segmentation;*** **3** ***abrasion of the segmentation plan;*** **4, 7, 10** ***items of undetermined function;*** **5** ***abrasion of the debitage plan;*** **6, 12, 14** ***perforations details;*** **8** ***surface scraping;*** **9** ***traces of sawing;*** **11** ***scraping of debitage edge;*** **13** ***abrasion area.***

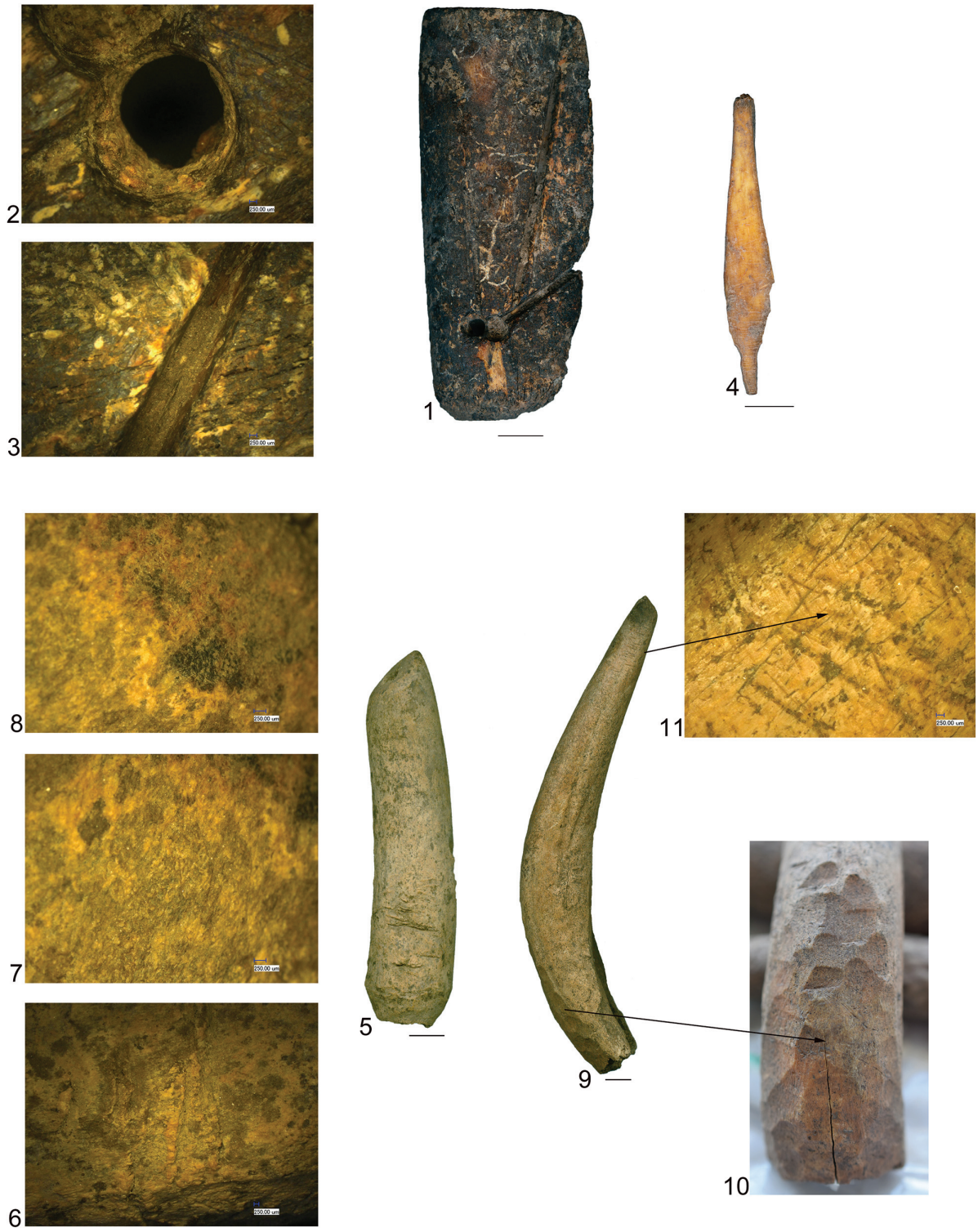


Fig. 16. **1** ***preform for a fish hook;*** **2** ***perforation detail;*** **3** ***traces of grooving;*** **4** ***preform;*** **5**, **9** ***punches;*** **6** ***segmentation by percussion;*** **7**, **8** ***active surface detail;*** **10** ***procedure of surface modification;*** **11** ***area with functional traces.***

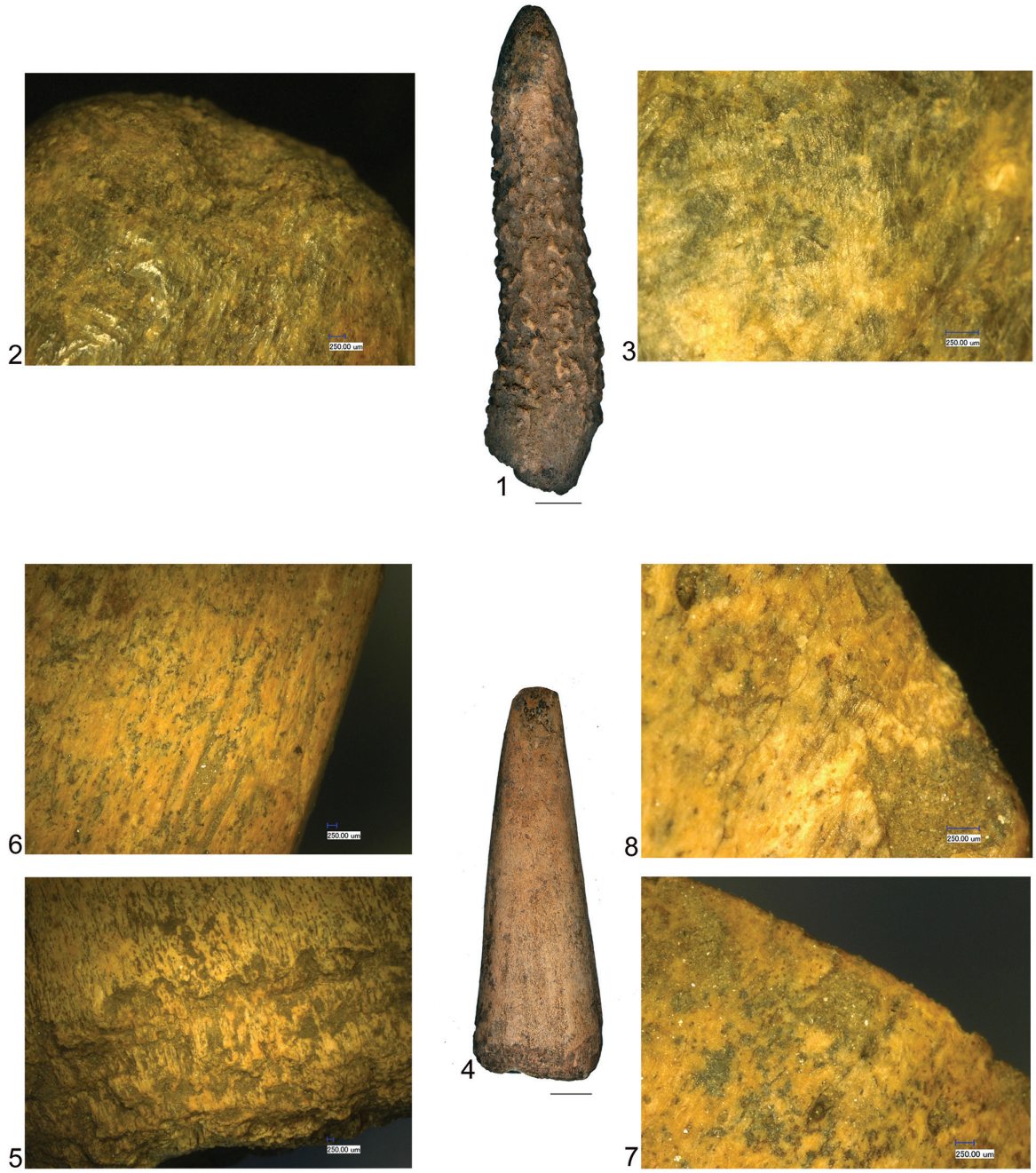


Fig. 17. **1, 4** ***bevelled objects;*** **2** ***active surface developed by percussion;*** **3, 8** ***active surface detail;*** **5** ***segmentation by percussion;*** **6** ***active surface processed by scraping;*** **7** ***shaping of active surface.***

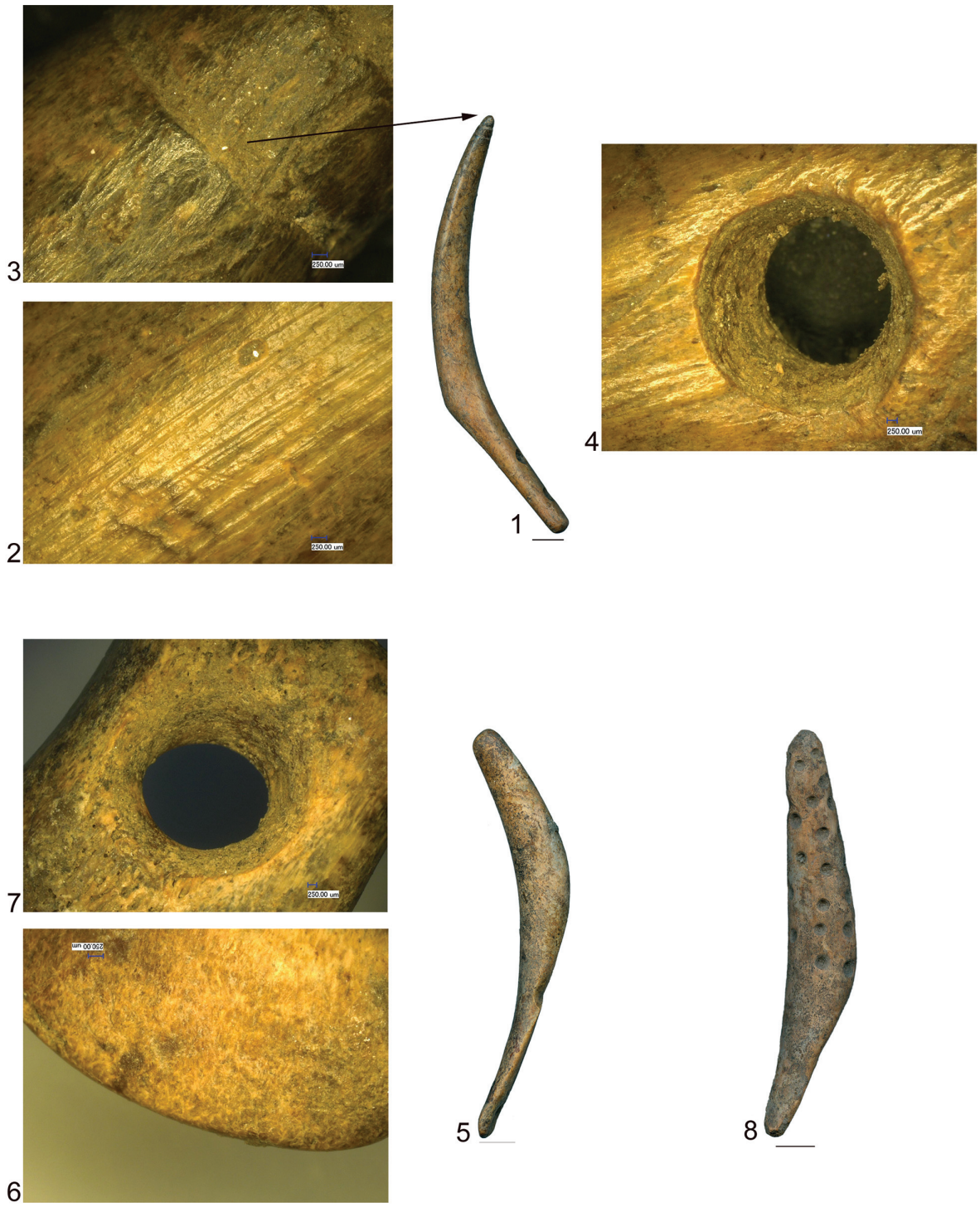


Fig. 18. **1, 5, 8** ***composite tools made of red deer (*****Cervus elaphus*****) antler;*** **2** ***scraping;*** **4, 7** ***perforation detail;*** **3** ***groove detail;*** **6** ***shaped proximal extremity.***

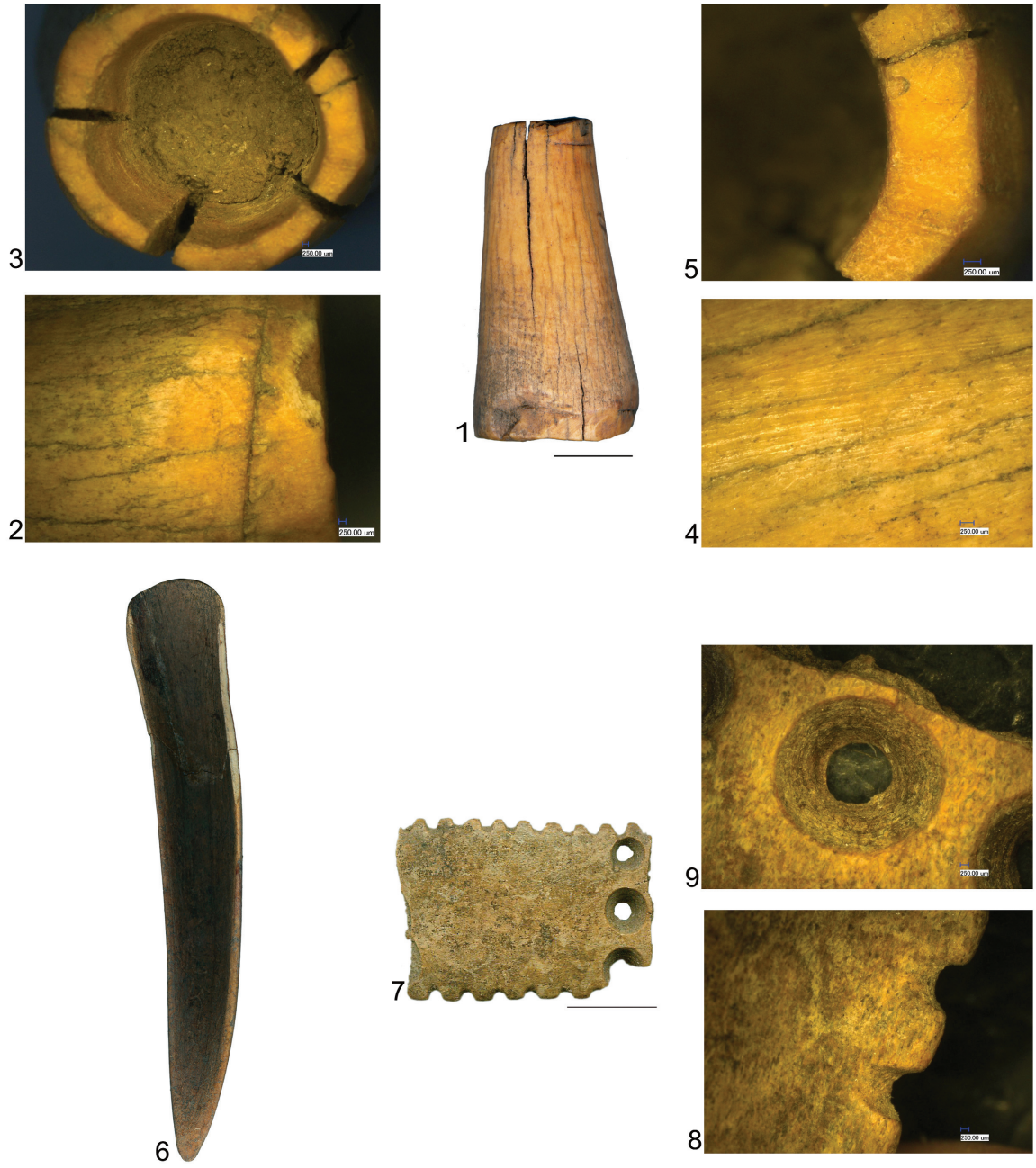


Fig. 19. **1** ***antler handle;*** **2** ***segmentation by percussion;*** **3** ***hole for gloving;*** **4** ***scraping;*** **5** ***abrasion of segmentation plan;*** **6** ***receptacle;*** **7** ***bracelet;*** **8** ***detail of ornament;*** **9** ***perforation detail.***

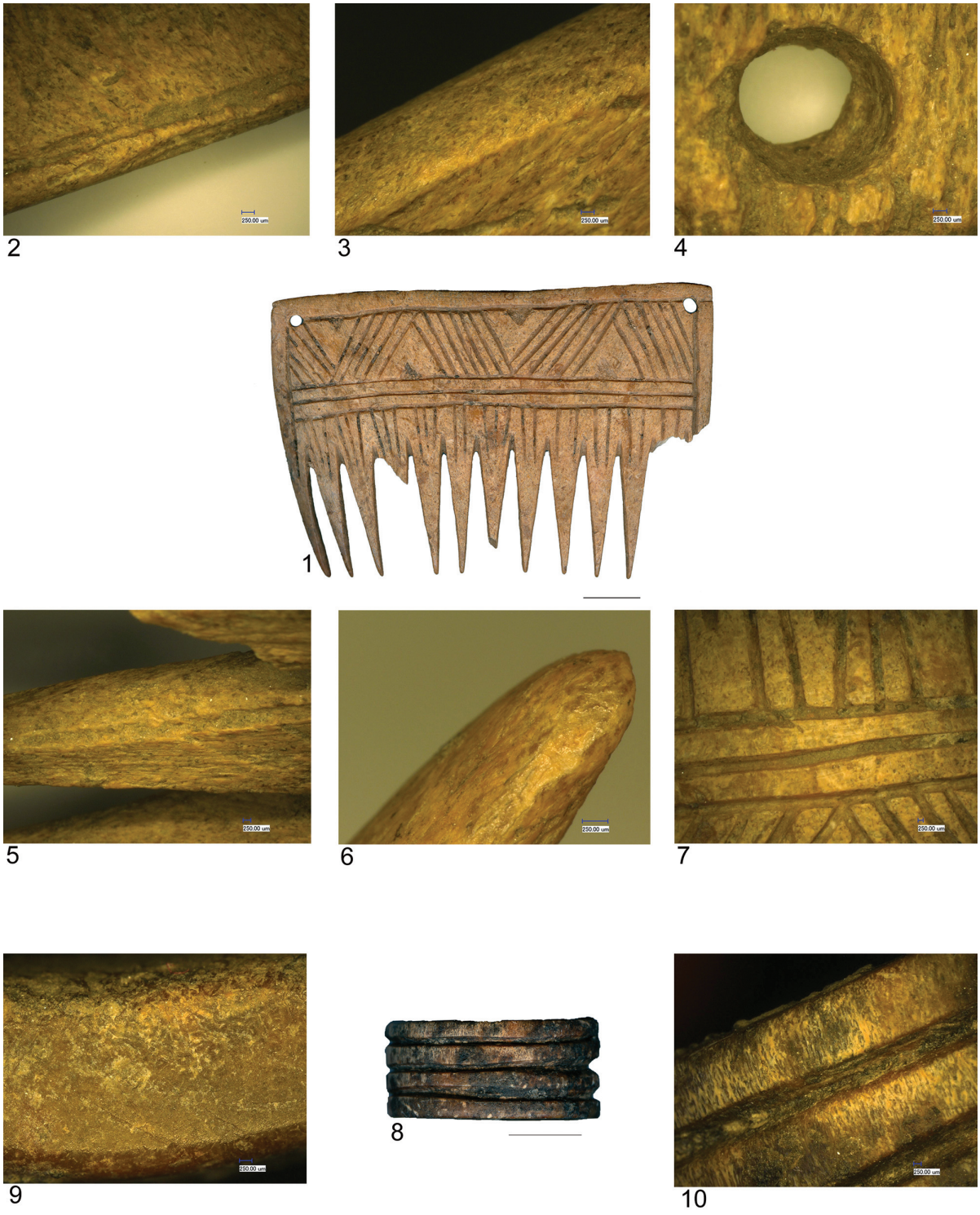


Fig. 20.* 1 *comb;* 2 *method of extraction by sawing;* 3 *abrasion of the debitage edges;* 4 *perforation detail;* 5 *teeth detached by grooving;* 6 *tooth with wearing;* 7 *ornament detail;* 8 *ring;* 9 *abrasion of segmentation plan;* 10 *ornament made by grooving.

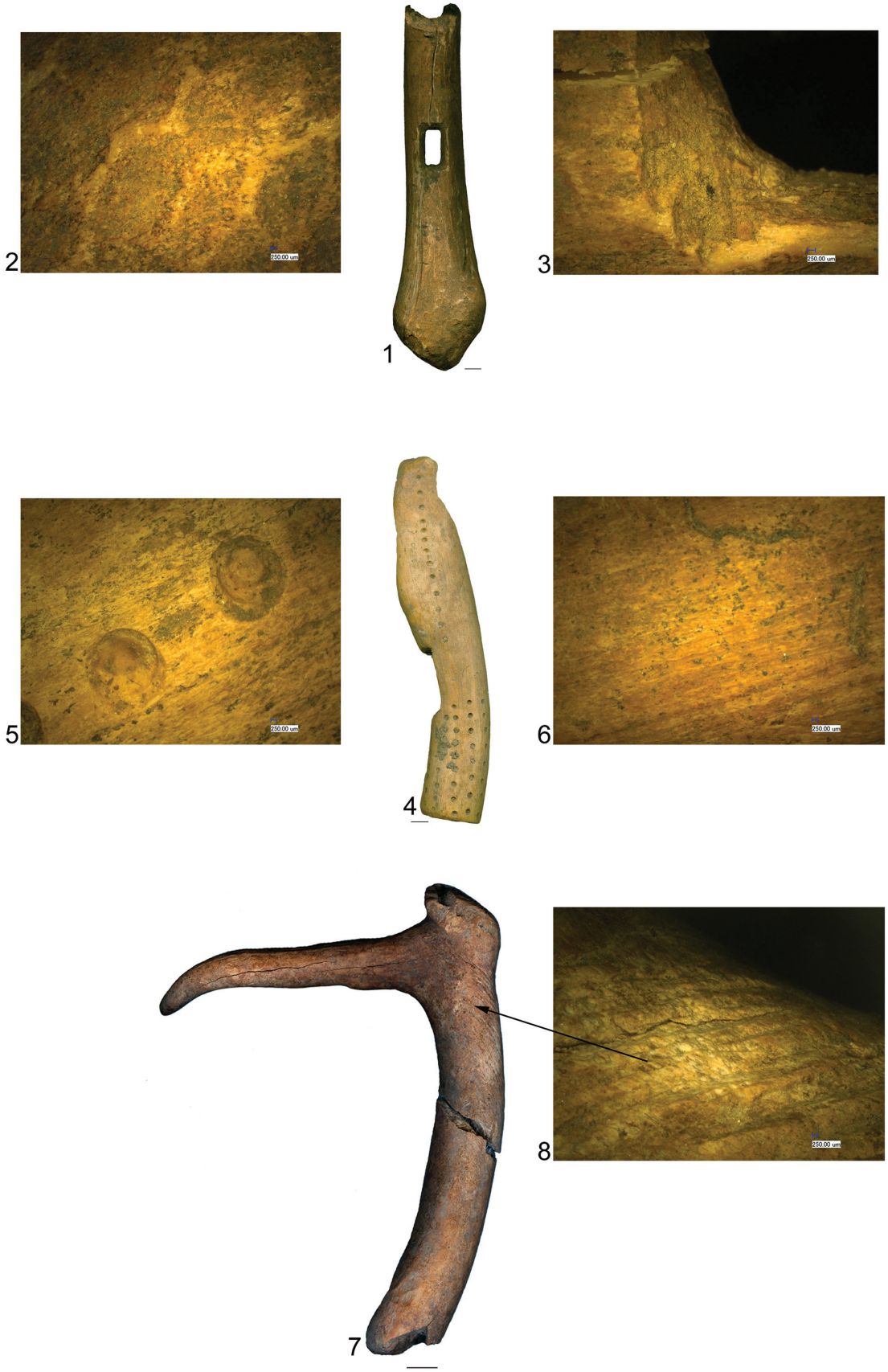


Fig. 21. **1, 4, 7** ***items of indeterminate function made of antler;*** **2** ***pearling elimination by percussion;*** **3** ***perforation made by cutting;*** **5** ***decoration made by rotation;*** **6** ***surface shaping by scraping;*** **8** ***incisions on the item's surface.***



Fig. 22. Preforms made of red deer (*Cervus elaphus*) 1 and roe deer (*Capreolus capreolus*) 2 antler; 3, 7 scrapers made of boar (*Sus scrofa*) tooth; 4 splitting by grooving; 5 abrasion of the inferior side; 6, 9 active surface achieved by scraping; 8 abrasion of proximal extremity.

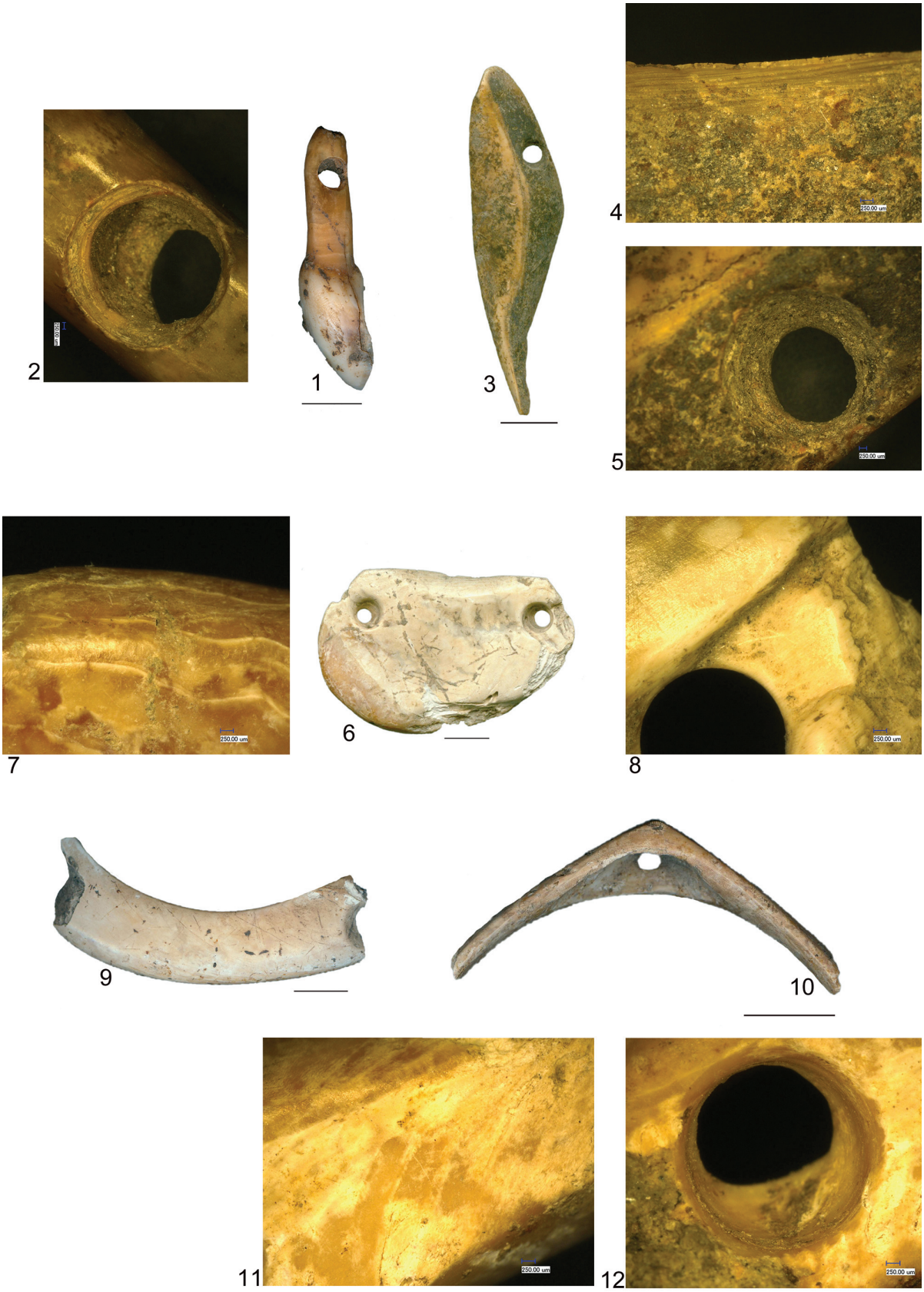


Fig. 23. **1** ***perforated cattle (*****Bos taurus*****) tooth;* 2** ***perforation detail;* 3** ***pendant made of boar (*****Sus scrofa*****) canine;* 4** ***scraping of debitage edges;* 5, 8, 12** ***perforation detail;* 6** ***perforated plaque of*** **Spondylus** ***valve;* 7** ***surface abrasion;* 8** ***deformation of the perforation;* 9** ***bracelet of*** **Spondylus** ***valve;* 10** ***bracelet of*** **Glycymeris** ***valve,* 11** ***surface modification by abrasion.***

Reconstructing late Neolithic plant economies at the Eastern Adriatic site of Veliš̌tak (5th millennium cal BC)

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ABSTRACT – *The archaeobotanical remains from Veliš̌tak are the first evidence of plant economies from an open-air settlement dating to the late Neolithic Hvar culture in Croatia (c. 4900–4000 cal BC). The results presented here are from the 2007–2013 field seasons. Based on an examination of carbonised macro-remains, it is suggested that emmer, einkorn, and barley were the main crops at Veliš̌tak, along with lentils, bitter vetch, and possibly peas and flax. Wild plants were also exploited, with evidence of wild fruits, such as cornelian cherry. Similarities with archaeobotanical finds from the early/middle Neolithic (c. 6000–4900 cal BC) also suggest that plant economies remained relatively unchanged during the Neolithic.*

IZVLEČEK – *Arheobotanični ostanki z najdišča Veliš̌tak predstavljajo prve dokaze o rastlinski ekonomiji iz naselbine na prostem, ki datira v pozni neolitik hvarske kulture na Hrvaškem (ok. 4900–4000 cal BC). Predstavljeni rezultati so iz podatkov, pridobljenih med izkopavanji med letoma 2007 in 2013. Na podlagi preiskave karboniziranih makroostankov ugotavljamo, da so dvozrnica, enozrnica in ječmen predstavljali glavna žita na Veliš̌taku, navzoči pa so tudi ostanki leče, lečnata grašica ter morda grah in lan. Nabirali so tudi divje rastline, saj so ohranjeni ostanki divjega sadja kot je rumeni dren. Podobnosti z arheobotaničnimi ostanki iz časa zgodnjega in srednjega neolitika (ok. 6000–4900 cal BC) kažejo, da je rastlinska ekonomija na tem območju ostala relativno nespremenjena v celotnem obdobju neolitika.*

KEY WORDS – *charred macro-remains; cereal cultivation; archaeobotany; Croatia*

Introduction

Archaeological research into the plant economies of the late Neolithic Hvar culture in the Eastern Adriatic is rare. So the discovery of the late Neolithic settlement of Veliš̌tak (formerly known as Čista Mala – Veliš̌tak) in 2007 presented a unique opportunity to examine the development of farming in the Eastern Adriatic, as well as providing the first archaeobotanical results from an open-air Hvar culture village in Croatia (Fig. 1). Hitherto, only two cave sites, Grapčeva (*Borojević* et al. *2008*) and Turska Peć (*Reed 2015*) in Croatia, and a few grain impressions from daub collected at Lisičići, Herzegovina (*Benac 1958.84; Hopf 1958*), had provided archaeobotanical evidence of the plant economies of the Hvar culture. However, the social role of caves and the range of activities conducted in them are probably very different from those of open-air settlements (*e.g., Bonsall, Tolan Smith 1997; Sampson 2008; Trantalidou* et al. *2010*). Therefore, this paper presents the archaeobotanical results from the 2007–2013 field seasons at Veliš̌tak in order to explore plant exploitation at the settlement more fully, which is important for understanding the development of farming communities in the Eastern Adriatic.

The Eastern Adriatic during the Late Neolithic

The division of the Neolithic is based on three major pottery stylistic traditions or cultures; Early (Impresso culture, *c.* 6000–5400 cal BC), Middle (Danilo culture, *c.* 5400–4900 cal BC) and Late Neolithic (Hvar culture, *c.* 4900–4000 cal BC). Hvar-style pot-

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tery is decorated with a rich variety of incised and painted designs and is best known from Grapčeva Cave on the island of Hvar (*Novak 1955; Forenbaher, Kaiser 2008; Forenbaher* et al. *2010*). Traces of paint, which would have been applied after firing, indicate that several pigments were used, including red ochre and cinnabar (*Forenbaher* et al. *2010*). So far some 30 Hvar culture sites have been identified, showing that this cultural tradition extended throughout Dalmatia (Croatia) and the hinterlands (Hercegovina). Most of these sites are caves, probably because they are easier to locate than flat open-air settlements.

Research on the Neolithic in the Eastern Adriatic has largely focused around these stylistic and technological changes (*e.g., Chapman 1988; Spataro 2002; McClure* et al. *2014*), while in comparison very little is known about possible underlying socio-economic and cultural shifts.

Evidence of farming in Neolithic Dalmatia

The first domestic crops and animals, originating from south-west Asia, spread by sea along the coast, reaching Dalmatia at *c*. 6000 cal BC (*Chapman, Müller 1990; Bogucki 1996; Forenbaher, Miracle 2005; Davison* et al. *2006; Forenbaher* et al. *2013*). Evidence of early farming is limited in Dalmatia, but once established, it would have been an intrinsic part of everyday life during the Neolithic. The earliest indications we have of early Neolithic (*c*. 6000–5400 cal BC) plant economies in coastal Croatia come from Crno vrilo (*Šoštarić 2009*), Kargadur (*Komšo 2005.212–14*), Krćina cave (*Müller 1994.64*), Pokrovnik (*Legge, Moore 2011*), and Tinj-Podlivade (*Huntley 1996*). Einkorn (*Triticum monococcum* ssp. *monococcum*), emmer (*Triticum turgidum* ssp. *dicoccum*), and barley (*Hordeum vulgare* ssp. *vulgare*) were the most common cereals identified, along with flax (*Linum usitatissimum*), grass pea (*Lathyrus sativus*), and a range of wild fruits and weed type species. Similar archaeobotanical evidence has also been recorded for the middle Neolithic (*c*. 5400–4900 cal BC) sites of Danilo-Bitinj (*Hopf 1964; Reed 2006; Legge, Moore 2011*), Pokrovnik (*Karg, Müller 1990*), and Gromače – Brijuni (*Gnirs 1925.24–25*). Although limited, these finds suggest that the plant economies did not change drastically in the Eastern Adriatic from the early to the middle Neolithic.

For the late Neolithic (*c*. 4900–4000 cal BC), plant remains are equally rare, having only been identified from two cave sites in coastal Croatia: Grapčeva (*Borojević* et al. *2008*) and Turska Peć (*Reed 2015*). At Grapčeva, the evidence consists of a few grains of emmer, einkorn, naked wheat (*Triticum cf. aestivum*), and lentil (*Lens culinaris*), as well as shell fragments of almond (*Amygdalus communis*), acorns (*Quercus* sp.), and juniper (*Juniperus* sp.). The naked wheat grain from Grapčeva was also securely radiocarbon dated to 4838–4712 cal BC, confirming its presence during the late Neolithic (*Borojević* et al. *2008*). From Turska Peć, emmer, einkorn, barley, naked wheat (*Triticum turgidum* ssp. *durum/Triticum aestivum* ssp. *aestivum*), possible spelt (*Triticum cf. aestivum ssp. spelta*), and broomcorn millet (*Panicum miliaceum*) were identified (*Reed 2015*). In addition, a large number of weed species were also recovered and are thought to have been associated with episodes of dung burning, possibly to clear the cave of excess waste during seasonal habitation of the cave by herders and livestock (*ibid.*).

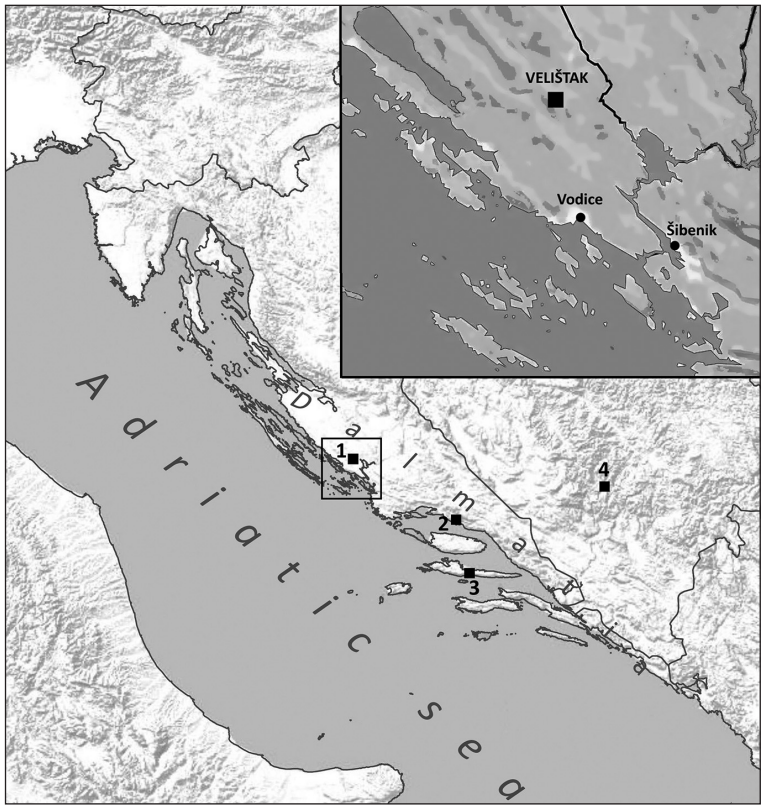


Fig. 1. Late Neolithic sites mentioned in the text:* 1 *Velištak,* 2 *Turska Peć,* 3 *Grapčeva,* 4 *Lisičići.

The only exclusively Hvar culture settlement excavated prior to Velištak was at Lisičići (Hercegovina) in the 1950s, where the only evidence of plant remains came from grain impressions found in daub fragments. These were only briefly listed as wheat, barley, and rye (*Benac 1958.84; Hopf 1958*), although it is likely that the rye was a weed, as evidence suggests that rye was not grown as a crop until at least the Iron Age (*Behre 1992*).



Fig. 2. Pottery of the 'Outlined' Hvar style from Velištak.

Zooarchaeological studies of Neolithic assemblages in the Eastern Adriatic have also demonstrated the predominance of domesticated species such as cattle, ovicaprids, and pig (*Miracle, Forenbaher 2005; Moore* et al. *2007a; 2007b; Legge, Moore 2011*). Sites such as Pokrovnik and Danilo-Bitinj suggest that hunting played a minor role in subsistence during the early and middle Neolithic (*Moore* et al. *2007a; 2007b; Legge, Moore 2011*), while stable isotope studies of early Neolithic human remains suggest that marine resources were also consumed by some individuals during this time (*Lightfoot* et al. *2011*). Stable isotope studies on animal remains have also provided information about animal management strategies, suggesting that pig management changed during the Neolithic, possibly through different foddering practices, while in contrast, cattle and ovicaprid management remained unchanged (*Zavodny* et al. *2014*).

The case study

The archaeological site of Velištak is situated in the Velim Valley to the north of Vodice in northern Dalmatia, Croatia (Fig. 1). The site was discovered in 2007 during agricultural work, and excavations subsequently were begun in the same year by Emil Podrug of Šibenik Municipal Museum (*Podrug 2010; 2014*). The excavations are continuing, but after nine excavation campaigns (2007–2015), an area of 335m² has been opened. A large quantity of classic Hvar culture pottery has been recovered (Fig. 2), along with tools made of animal bone, knapped and polished stone, as well as jewellery and polished shells (*Spondylus gaederopus*) (*Podrug 2010; 2013*). The Velištak pottery corresponds to the initial 'Outlined' decorative stage (*e.g.*, sub-phase 1.1 of Grapčeva –'bordered' classic Hvar) (*Forenbaher, Kaiser 2008.51–52*). This is supported by six radiocarbon dates that show the settlement was founded sometime after 5000 cal BC and lasted until 4700 cal BC (*McClure* et al. *2014.1027, T.1*), making Velištak the earliest known Hvar culture site.

At the subsoil level, numerous pits and other dug-out features have been revealed, often intersecting each other, suggesting that they were not all dug and used at the same time (Fig. 3). Most of the pits are round or oval in plan and cylindrical or spherical in shape, and it is suggested that some were probably used for grain storage (*Podrug 2013*). The pits were usually filled with pottery and animal bones, which, along with numerous layers of soot and ash,



Fig. 3. Plan of the excavated area at the subsoil level and the eastern profile at Velištak.

suggest that the pits were eventually used as disposal places for household refuse and other communal waste (*ibid.*). Several fragments of house floors, fireplaces and hearths are also present in undisturbed general cultural layers (in the northern part of the excavation area, these layers are preserved up to 60cm in thickness). Overall, the stratigraphy at Velištak shows continuous successive occupation at the settlement over several generations.

Material and methods

During 2007–2013, 52 samples were collected from 24 contexts relating to house floors, pits and fireplaces from trenches A to F (Tab. 1). A total of 52 samples were collected, totalling 571.5 litres of sediment, and processed through bucket flotation using 1mm and 250μm mesh sizes.

The plant taxa were established with a low resolution (7–40x) binocular microscope and comparisons made from the modern reference collections at the School of Archaeology and Ancient History at the University of Leicester. The nomenclature of scientific plant names for cultivars follows Daniel Zohary *et alii* (*2012*) and for wild plants Tom G. Tutin *et alii* (*1964–1980*). All floats were 100% sorted and the charcoal volumes recorded. A standardised counting method was used, whereby each grain counts as one and the whole grain equivalent (WGE) was estimated for fragments of grains. Glume base fragments were counted as one unless clearly representing part of another fragment, while whole spikelet forks were counted as two glume bases. The fruit and weed seeds were counted as one, even when only a fragment was found, except when large seeds were broken and the parts were clearly from the same seed (*e.g.*, Cornus mas).

Results

Carbonised plant remains were recovered from 45 of the 52 samples, as well as two mineralised seeds of Buglossoides from samples 34 and 62. A total of 3491 seeds were identified, with a further 973 indeterminate plant items. Seed density was particularly low, with 37 samples having a density of less than 1 seed per litre of sediment (Tab. 1, Fig. 4). The two samples with the highest density were 184 and 185, both from the same lower half of a pit fill, with a seed density of 16.7 and 93.5, respectively. Charcoal density was also low, with all the samples having less than 2.0cm^3 per litre.

Crops

Cereals were the most commonly recovered plant remains at the site, accounting for 94% of the identified assemblage, not including cereal fragments and indeterminate remains (Fig. 5). Of the cereal grains, 93% of the remains were of barley (*Hordeum vulgare* ssp. *vulgare*), totalling 879 grains, although 838 of these were recovered from samples 184 and 185 (Fig. 6).

In addition, 19 grains of emmer (*Triticum turgidum L.* ssp. *dicoccum*), 18 grains of 1-grained einkorn (*Triticum monococcum L.* ssp. *monococcum*), 1 grain of 2-grained einkorn (for identification criteria see *Kroll 1992; Kreuz, Boenke 2002*) and 1 grain of naked wheat (similar to *Triticum aestivum L.* ssp. *compactum*) (Tab. 2) were recovered. A large

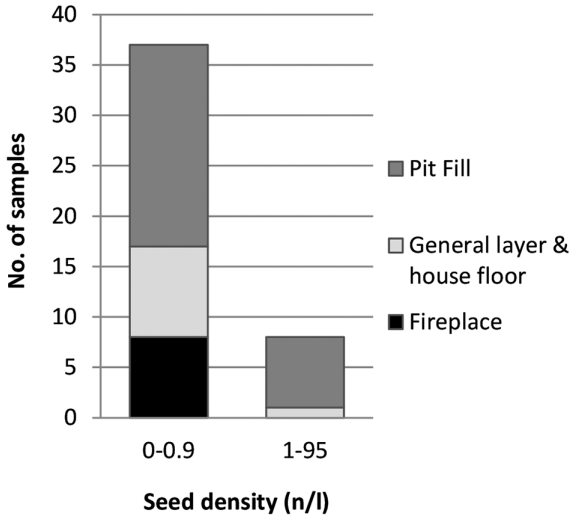


Fig. 4. Seed density (n/l) per sample per context type at Velištak.

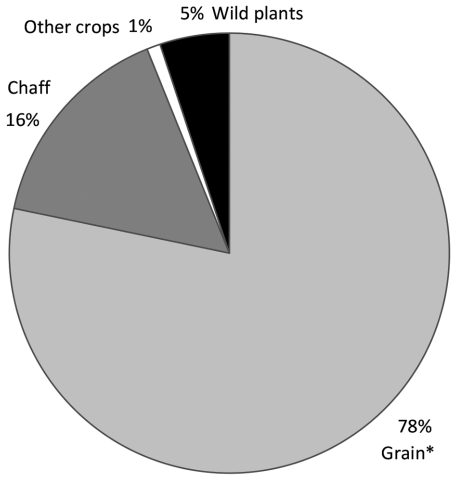


Fig. 5. Composition of the carbonised plant assemblage per plant category at Velištak. *Not including cerealia fragments.

number of fragmented cereal remains were also recovered from samples 179, 184 and 185, which are all from the same pit feature, totalling approx. 1 225 grain fragments (Tabs. 1–2).

Cereal chaff (cereal husk separated by winnowing and/or threshing), which accounts for 16% of the assemblage, is dominated by glume wheat glume bases. Preservation was particularly poor, but where possible, einkorn, emmer and the 'new-type' glume wheat were identified, although in low numbers (Tab. 2). The identification of the 'new type' of glume wheat glume base was based on observations made by Glynis Jones *et alii* (*2000*) and Marianne Kohler-Schneider (*2003*) and stood out, as they were more 'robust' than the emmer and einkorn glume bases.

A small number of other crops were also identified from pit samples, including four lentils (*Lens culinaris*), two possible peas (*Pisum* sp.), one bitter vetch (*Vicia ervilia*) and two possible flax seeds (*Linum* sp.) (Tab. 3).

Wild plants

Wild plants make up 5% of the assemblage, and consist of fruit remains, possible weed species and other wild plants (Fig. 4; Tab. 3). Of the fruits, only one cornelian cherry (*Cornus mas*), one rose hip (*Rosa canina*), and one bramble fruit seed (*Rubus* sp.), as well as two acorn fragments (*Quercus* sp.) were identified within four samples taken from pits (Tabs. 1, 3). Due to poor preservation, the vast majority of the wild plant remains are identified only to family or genus, with the highest number of remains being identified as either large-seeded legumes (Fabacaeae) or large- and small-seeded grasses (Poaceae) (Tab. 3).

Sample no.	Trench	Stratigraphic unit (SJ)	Feature type	Sample vol. (l)	Seed density (n/l)	Charcoal density (cm³/l)
16	A	3	General layer	9	0.6	1.1
19	A	3	General layer	6.5	0.5	1.5
22	A	3	General layer	7	–	0.4
25	A	19-1	Pit Fill	5	0.6	1.0
26	A	3 & 14	Fireplace	6	0.0	0.5
30	A	17-1	Pit Fill	7	0.7	0.3
34	A	18-1	Pit Fill	6.5	3.1	2.0
37	A	23-1	Pit Fill	5	0.2	0.8
41	A	3	General layer	5.5	0.2	1.1
44	A	14	Fireplace	8	0.2	0.4
48	A	20	Fireplace	5	0.1	0.2
49	A	23-1 & 23-2	Pit Fill	5	11.0	2.0
50	A	24-1	Fireplace	4	0.2	0.1
61	A	24-2	Pit Fill	7	0.3	0.9
62	A	24-3	Fireplace in a pit	5	0.1	0.2
63	B	3	General layer	7	0.4	0.7
70	A	24-4	Pit Fill	3.5	–	1.7
72	B	3	General layer	5	2.4	2.0
84	B	24-4	Pot fill in pit	2.5	0.0	0.2
90	C	46-1	Fireplace in pit	6	–	0.1
91	C	46-3	Fireplace in pit	7	0.2	0.1
92	C	46-3	Fireplace in pit	7	0.4	0.1
93	C	45-1	Pit fill	7	0.2	0.3
94	C	45-1	Pit fill	10	0.3	0.2
97	C	46-6	Pit fill	8	0.3	0.4
98	C	46-6	Pit fill	6	0.3	0.1
110	D	57-1	Pit fill	13	0.1	0.2
111	D	57-1	Pit fill	10	0.1	0.1
112	D	41-2 to 41-8	Fireplaces in pit	10	–	0.1
117	D	41-2 to 41-4	Fireplaces in pit	16	0.5	0.2
118	D	41-9	Pit fill	13	0.6	1.2
119	D	41-9	Pit fill	19	0.7	0.4
121	D	41-10	Pit fill	14	0.1	0.1
122	D	41-10	Pit fill	12	0.3	0.1
177	F	3-1	General layer	17	0.5	0.2
178	F	3-1	General layer	19	0.5	0.3
179	F	73-1	Pit (upper half of fill)	21	7.6	0.6
180	F	73-1	Pit (upper half of fill)	17	3.2	0.4
184	F	73-1	Pit (lower half of fill)	18	16.7	0.9
185	F	73-1	Pit (lower half of fill)	19	93.5	1.1
193	F	74-1	Pit fill	20	0.4	0.8
194	F	74-1	Pit fill	19	0.2	0.4
216	B-E	84-1	Pit fill	13	0.7	0.2
218	B-E	3-1	General layer	17	0.1	0.1
219	B-E	3-1	General layer	16	–	0.0
221	B-E	85-1	Pit fill	13	0.3	0.1
238	B-E	3-1	General layer	17	–	0.0
239	B-E	3-1	General layer	15	–	0.0
249	B-E	3-1 & 106	General layer + house floor	18	0.2	0.0
250	B-E	3-1 & 106	General layer + house floor	18	0.2	0.0
258	B-E	105-6	Pit fill	13	5.4	0.8
259	B-E	105-6	Pit fill	14	0.8	0.4

Tab. 1. Summary table of charcoal and seed densities/l for each sample at Velištak.

Sample no.	16	19	25	26	30	34	37	41	44	48	49	50	61	62	63	72	84	91	92	93	94	97	98	110	111	117	118
GRAIN																											
Hordeum vulgare ssp. *vulgare*	1	1	1							1																	
Hordeum sp.																											
Triticum turgidum L. ssp. *dicoccum*						1										2											(1)
Triticum monococcum L. ssp. *monococcum* (1-grain)	2		1		1										1	1								1		1	(1)
Triticum monococcum ssp. *monococcum* (2-grain)																											
Triticum monococcum/ turgidum L. ssp. *dicoccum*									1						1												
Naked wheat *																											
Triticum sp.																											
Cerealia indet. fragment			2		3	7	1				5		1			9					2	2				2	5
CHAFF																											
Hordeum vulgare ssp. *vulgare*																											
Triticum turgidum L. ssp. *dicoccum*																											
Triticum monococcum L. ssp. *monococcum*						1					6																
Triticum sp., "new-type" glume wheat											1																
Triticum monococcum/ turgidum ssp. *dicoccum* "new-type" glume wheat	1	1						1			41					5											
Triticum sp.						9													1								1

Sample no.	119	121	122	177	178	179	180	184	185	193	194	216	218	221	249	250	258	259	TOTAL
GRAIN																			
Hordeum vulgare ssp. *vulgare*	3	1			3	12	13	76 (10)	752	1		2	1				1		**869 (10)**
Hordeum sp.				1														1	**2**
Triticum turgidum L. ssp. *dicoccum*				(2)		1			9		1		1				1		**16 (3)**
Triticum monococcum L. ssp. *monococcum* (1-grain)			1		1				2	2							1 (2)		**15 (3)**
Triticum monococcum ssp. *monococcum* (2-grain)							1												**1**
Triticum monococcum/ turgidum L. ssp. *dicoccum*					1									2					**5**
Naked wheat *								1											**1**
Triticum sp.						3						1			1		1	5	**11**
Cerealia indet. fragment	3			1	3	69	17	156	1000		2	5		4	2	2	13	6	**1322**
CHAFF																			
Hordeum vulgare ssp. *vulgare*									1										**1**
Triticum turgidum L. ssp. *dicoccum*								3		1									**4**
Triticum monococcum L. ssp. *monococcum*						2		2											**11**
Triticum sp., "new-type" glume wheat											(1)								**1 (1)**
Triticum monococcum/ turgidum ssp. *dicoccum* "new-type" glume wheat																			**49**
Triticum sp.						5	1	27		4							72		**120**

***Tab. 2. The total number of cereal items (inc. whole grain equivalents, WGE) per sample at Veličtak. (n) = cf; * Naked wheat* = Triticum turgidum *ssp.* durum/Triticum aestivum.**

Discussion

Formation processes

In order to understand the archaeobotanical results, it is important to explore the formation processes at the site in order to identify any possible bias in the samples that may influence interpretations. The most common form of preservation at Veliš̌tak was carbonisation or charring, which results from organic material being exposed to heat either accidentally or deliberately, such as cooking, burning rubbish or fuel (*Hillman 1984; Miller, Smart 1984; Charles 1998; Valamoti, Charles 2005; Van der Veen 2007*). Thus, carbonised plant remains will be heavily biased towards items that come into contact with fire more frequently and survive the charring process (*Dennell 1972; Hillman 1981; Jones 1981; Boardman, Jones 1990; Van der Veen 2007*).

The deposition of these remains within the archaeological record also needs to be considered. For example, Richard N. L. B. Hubbard and Alan J. Clapham (*1992*) suggested that charred assemblages can be divided into three groups: Class A, where remains have been burnt within the context within which they are recovered; Class B, where an assemblage derives from one burning event that was subsequently moved to the context (secondary deposition); and Class C, where the assemblage derives from different charring events that were subsequently deposited within the same context. Seed density has also been used to reflect the rate of deposition, whereby a low density of plant remains indicates slow accumulation, while high densities suggest rapid deposition (*Jones 1991*).

At Veliš̌tak, seed density was particularly low, with 37 samples having a density of less than 1 seed per litre of sediment (Fig. 4). In addition, only ten samples were collected from a fireplace or area where burning occurred and only a few seeds were recovered. The remaining contexts and the overall low seed and charcoal densities of the samples suggests that the remains probably reflect Class C assemblages, which derive from different charring events that were subsequently deposited within a secondary or even tertiary context. The only exceptions to this are the two samples with particularly high densities, 184 and 185, which were both from the same lower half of a pit fill. Both are dominated by barley grains, although poor preservation led to a high number of grains being identified as 'cerealia' fragments. The samples also contain a small number of wheat grains and chaff, a few pulses and a handful



Fig. 6. Barley grains (*Hordeum vulgare *ssp.* vulgare*), sample no. 185.

of weeds. In contrast, samples 179 and 180 from the upper half of the same pit contain only a small number of barley grains (<13). These differences may suggest that the charred plant remains at the bottom of the pit were deposited more intensively, as part of one activity, or more rapidly, from a number of activities, than at the top of the pit.

But what activities might these plant remains represent at Veliš̌tak? Since the 1970s researchers have determined that carbonised remains are more likely to result from food production processing, *e.g.,* crop processing, rather than food consumption (*Knörzer 1971; Dennell 1972; 1974; 1976; Hillman 1984; Jones 1984*). Predictive models have since been created to identify which stage of the crop processing sequence an assemblage represents, based on the assumption that each stage produces a characteristically different ratio of cereal, chaff and weeds within the sample (*Hillman 1984; Jones 1984; Van der Veen 1992; Van der Veen, Jones 2006*).

The general uniform composition of the assemblage at Veliš̌tak of cereal grains, chaff and weeds would suggest that the remains represent harvested cereals. Overall, the low seed density makes it difficult to apply any of the predictive models, as over 50 seeds per sample are required for a meaningful result (*e.g., Bogaard 2004.63*). Only four samples (nos. 179, 184, 185, 258) have over 50 plant items, although sample no. 179 is dominated by cereal fragments. The dominance of barley grain within sample nos. 184 and 185 and their high density within the context may suggest that these samples represent a deposit of a barley crop. In contrast, sample no. 258, which is from a pit a few metres away, has a high proportion of glume wheat glume bases and

no weed remains. This sample may therefore represent the dehusking of cleaned glume wheats (*Reed 2015*). Some suggest that the daily processing of stored glume wheats occurred within the household, where the waste (cereal chaff) was then swept into fires and carbonised (*cf. Hillman 1984; Gregg 1989; Meurers-Balke, Lüning 1992; Bogaard 2004.68; Kreuz 2012*). The waste from these fires may have then been deposited outside the house, and so sample no. 258 may indicate the secondary or tertiary deposition of discarded wheat chaff. Archaeological finds of querns and flint sickle blades also attest to crop processing activities at Velištak. However, the recovery of only one barley rachis at the site may suggest that either barley was mainly processed away from the settlement or that the more fragile barley rachis did not survive the carbonisation process (*cf. Dennell 1976; Hillman 1981; Boardman, Jones 1990*).

The importance of barley

Barley is one of the principle crops that spread with farming and as such is found in varying quantities throughout the Neolithic in south-east Europe. In Albania (*e.g., Xhuveli, Schultze-Motel 1995; Gjipali, Allen 2013*), Bosnia and Herzegovina (*e.g., Hopf 1958; 1966/7; Renfrew 1979; Kučan 2009*), Serbia (*Filipović, Obradović 2013* for summary), Slovenia (*e.g., Tolar* et al. *2011*), and Italy (*e.g., Robb 2007. 129–131; Rottoli, Pessina 2007; Rottoli, Castiglioni 2009*) hulled and naked six-rowed varieties have been recovered along with emmer and einkorn. In Hungary, the late Neolithic settlement of Battonya-Parázstanya has the largest number of naked barley grains, totalling 2792 (*Gyulai 2010*).

There are advantages and disadvantages to growing both naked and hulled barley. In terms of crop processing, naked barley is easier to process, as the grain is looser in the spikelets and can be easily threshed, while hulled barley requires an extra crop processing stage to release the grain from the tighter chaff. On the other hand, it has been suggested that hulled barley has a greater tolerance to adverse environmental conditions (*e.g.*, soil salinity, parasites) (*Ceccarelli* et al. *2001; Lister, Jones 2013*), while it has been suggested that naked barley grains are

Sample no.	16	19	25	26	30	34	37	41	44	48	49	50	61	62	63	72	84	91	92	93	94	97	98	110	111	117	118
OTHER CROPS																											
Lens culinaris																							1		(1)		
Pisum sp.																											
Vicia ervilia																											
Linum sp.																											
WILD PLANTS																											
Asteraceae												1															
cf. *Avena* sp.											1																
Buglossoides (mineralised)						1								1													
Chenopodium album																											
Chenopodium sp.																											
Cornus mas																											
Fabaceae (large)																				1			1				
Fabaceae (small)																											
Galium sp.	1																										
Lolium sp.																											
Lolium temulentum																											
Phleum sp.																											
Poaceae (large)						2												1									
Poaceae (small)											1																
cf. *Polygonum* sp.																											
Quercus sp.																											
Rosa canina																											
Rubus sp.																											
Rumex sp.						1																					
Sambucus ebulus																											
Teucrium sp.																											
Verbascum sp.																											
Indeterminate fruit																											
Indeterminate	26	10	12	3	1	18	3	9		5	56		4		3	71	3										

Tab. 3. The total number of other crops and wild plants per sample at Velištak. (n) = cf.

Sample no.	119	121	122	177	178	179	180	184	185	193	194	216	218	221	249	250	258	259	TOTAL
OTHER CROPS																			
Lens culinaris								2	1										**4 (1)**
Pisum sp.									2										**2**
Vicia ervilia								1	(3)										**1 (3)**
Linum sp.	1								(1)										**1 (1)**
WILD PLANTS																			
Asteraceae																			**1**
cf. *Avena* sp.																			**1**
Buglossoides (mineralised)																			**2**
Chenopodium album				1															**1**
Chenopodium sp.							1												**1**
Cornus mas								1											**1**
Fabaceae (large)			3			2	2	3	2										**14**
Fabaceae (small)				1															**1**
Galium sp.																			**1**
Lolium sp.																1			**1**
Lolium temulentum															1				**1**
Phleum sp.									1										**1**
Poaceae (large)						5		2											**10**
Poaceae (small)				1		4			1			4							**11**
cf. *Polygonum* sp.							1												**1**
Quercus sp.							1	(1)											**1 (1)**
Rosa canina			1																**1**
Rubus sp.									1										**1**
Rumex sp.												1						1	**3**
Sambucus ebulus								1											**1**
Teucrium sp.					1														**1**
Verbascum sp.							1												**1**
Indeterminate fruit						3													**3**
Indeterminate				9	11	113	19	180	300	26	22	4	1	2	2		48	12	**973**

Tab. 3. continued

more susceptible to increased moisture in the atmosphere and to fungal attack (*Van der Veen 1992.74*).

In the archaeobotanical results at Veliš̌tak, barley dominates the crop remains, accounting for 94% of the cereals. As already discussed, sample no. 185 (lower half of a pit fill) contained 752 barley grains, but very few other plant remains, although over 1000 cereal grain fragments were also identified. Due to poor preservation, most of the grains could not be identified as either hulled or naked varieties, but many did have the more rounded shape of naked barley, while a couple were more angular, characteristic of hulled barley. A few grains also had the characteristic lateral twist of six-rowed barley (*Zohary* et al. *2012.56*). Thus, poor preservation prevents further discussion as to the preference for hulled or naked barley growing at Veliš̌tak from the current assemblage.

Apart from this pit feature (samples nos. 179, 180, 184, 185), the quantity of barley, emmer and einkorn grains is the same, suggesting that barley may not have been the main 'preferred' crop at the site. This is further supported by the relatively high number of glume wheat glume bases seen in samples nos. 49 and 258. The ratio of cereal species may therefore indicate differences in preservation rather than the predominance of barley at the site.

Plant economies of the Hvar culture

The entire area of the Eastern Adriatic, from the Trieste Karst in the north to the Gulf of Kotor in the south, is characterised by alternating dry barren karst landscapes, sunken karst fields and ridges, limestone plateaus and fertile valleys filled with springs, underground streams and gorges (*Magaš 1998.195*). Within this landscape, early Neolithic occupation seems to have clustered in three main areas: one cluster of cave and open-air settlements in coastal Istria and the Kvarner islands, a second cluster of open-air settlements in the Zadar and Šibenik area, and a third cluster of cave sites to the south in the Pelješac peninsula and within the hinterlands of Herzegovina (*Marijanović 2007*). The fertile valleys of the Zadar/Šibenik area, and the fact that most of the archaeobotanical evidence has been

recovered from this region, has led researchers to believe that this area provided the best conditions for Neolithic crop agriculture (*e.g., Brusić 2008.63–64*). In contrast, the cave sites are located in mountainous areas away from land suitable for agriculture, and are usually interpreted as seasonal herding camps, marked by low density pottery and animal bone finds (*e.g., Miracle, Forenbaher 2005; Mlekuž 2005*). This is probably the case at Turska Peć, where the archaeobotanical remains identified an area resulting from human activities (where cereal remains were recovered) and an area that was probably subject to the periodic burning of animal dung (where wild, weed species were recovered) (*Reed 2015*). An exception to this is Grapčeva, where the large number of animal remains, artefacts and scattered human remains suggests ritual activities, where feasts, offerings and secondary burials took place (*Forenbaher, Kaiser 2008; Forenbaher* et al. *2010*).

Therefore, the three late Neolithic sites present archaeobotanical remains from a ritual context, a possible herding camp and a valley settlement. Although they cannot be directly compared, as bias in the range of plant remains found in such locations will be present, we can begin, if only tentatively, to reconstruct the plant economies of the late Neolithic period in the Eastern Adriatic. For example, emmer, einkorn, and barley are the most common cereals identified from the three sites. This corresponds with archaeobotanical evidence from northern Italy (*Rottoli 2014.76*), Slovenia (*Tolar* et al. *2011*), and continental Croatia (*Reed 2015*) and would suggest that these were the main cereals grown at the time. Evidence of naked wheat, spelt, rye, and millet is sporadic, so it is unlikely that they were grown as part of the crop package during the late Neolithic in this region. Unfortunately, the general low density of plant remains at Velištak also means that the analysis of samples in relation to cultivation methods (*i.e.* whether crops were manured, weeded, *etc.*) is not possible at present. Other crops were also probably grown, including pulses, such as lentil, pea and flax. The recovery of cornelian cherry seeds (*Cornus mas*), brambles (*Rubus* sp.), oak (*Quercus* sp.), dog rose (*Rosa canina*), and dwarf elder (*Sambucus ebulus*) suggests that local woodland and woodland fringes were exploited by the inhabitants of Velištak to supplement the diet.

Compared to the earlier Neolithic, the plant spectra in coastal Croatia does not seem to change, with the main founder crops – emmer, einkorn, barley, lentil, pea, and flax – being found throughout the Neolithic (*Reed 2015*). Although naked wheat (*Triticum durum/turgidum/aestivum*) has also been discovered at the early Neolithic site of Tinj-Podlivade (*Huntley 1996*), the middle Neolithic site of Danilo-Bitinj (*Reed 2006*), and late Neolithic levels at Grapčeva cave (*Borojević* et al. *2008*), it is unlikely that the few grains recovered, as well as the single grain from Velištak, means it was cultivated during the Neolithic in the Eastern Adriatic.

Conclusion

The analysis of carbonised plant remains from Velištak presents the first archaeobotanical evidence from an open-air settlement dating to the late Neolithic Hvar culture in the Eastern Adriatic. The formation processes inferred from the plant remains suggest that they probably resulted from a number of charring events that were then discarded as secondary or tertiary deposits. The only possible exception to this was the recovery of a relatively large deposit of barley grains in the bottom of a pit feature. The remains are probably from a barley crop that were carbonised and, as there was very little sign of burning in the pit, dumped as waste. The remains of a relatively high number of glume wheat (*Triticum monococcum/turgidum* ssp. *dicoccum/'new-type' glume wheat*) glume bases within a pit a few metres away also suggests that crop processing of glume wheats occurred at the site, probably within the home where the by-products could be easily thrown into the hearth and then re-deposited within the pit as waste. Thus the results from the 2007 to 2013 field seasons suggest that emmer, einkorn and barley were grown as the main crops at Velištak, along with lentil, bitter vetch and possibly pea and flax. However, further work is clearly needed in recovering archaeobotanical remains from late Neolithic sites in order to understand more fully the development of subsistence economies in the Eastern Adriatic.

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Comparing different sampling methods in order to reconstruct plant economies at the Eneolithic lake dwelling site Stare gmajne, Slovenia

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ABSTRACT – *The results of plant macroremains studies of the Eneolithic (*c. *3160–3100 cal BC) lakeshore settlement at Stare gmajne on the Ljubljansko barje in Slovenia are presented. Archaeobotanical material was collected in two different ways: (1) systematic surface sampling from the cultural layer, and (2) judgement sampling from an incompletely burnt large loom-weight. The preservation state and the spectra of plant macroremains were different in both types of samples. The first study primarily deals with the waterlogged plant remains of various types and taxa, while the second deals with carbonised and half-carbonised cereal macroremains, mostly chaff. Both studies confirm the cultivation of main crops: emmer, einkorn and barley.*

IZVLEČEK – *Predstavljeni so rezultati analiz rastlinskih makroostankov z eneolitskega (ok. 3160–3100 cal BC) kolišča Stare gmajne z Ljubljanskega barja, Slovenija. Material za arheobotanične raziskave smo pridobili po dveh metodah: (1) sistematično površinsko vzorčenje iz kulturne plasti in (2) vzorčenje po presoji iz nepopolno žgane velike glinene uteži. Ohranjenost in spekter rastlinskih makroostankov iz obeh vzorcev se bistveno razlikujeta. Prva študija se ukvarja predvsem z ne-zoglenelimi in z vodo prepojenimi makroostanki različnih tipov in taksonov, medtem ko druga proučuje v glavnem zoglenele in pol-zoglenele ostanke žit, predvsem plev. Obe študiji potrjujeta gojenje glavnih kulturnih rastlin: dvozrnice, enozrnice in ječmena.*

KEY WORDS – *Eneolithic; pile dwelling; Slovenia; plant economy; taphonomy*

Introduction

The Stare gmajne site is an Eneolithic (Copper Age) pile dwelling site in Slovenia dated to the 4th millennium BC. According to dendrochronological and radiocarbon dating, it was settled many times (*Čufar* et al. *2015*). The earliest settlement ended before 3300 cal BC, and the latest around 3110 cal BC (*Čufar* et al. *2009; 2010; 2015*). The site became more widely known when a wooden wheel with an axle, the oldest found to date, was discovered in 2002. Taking into account its radiocarbon dating and the age of the settlement where it was found, it is *c*. 5150 years old (*Velušček* et al. *2009*). In 2006 and 2007, the site was excavated; two 15m^2 trenches (*Velušček 2009.54–55*) were opened and researched in detail (see *Velušček 2009*).

During the excavation in 2006, a large loom-weight was found in the latest settlement phase, which is dendrochronologically dated to between 3160 and 3100±14 cal BC. The bottom of the loom-weight was accidentally broken or fell off during the excavation. It was carefully stored as a judgement sample for analysis in the lab. Waterlogged clayey material was obtained from the interior of the broken loom-weight and analysed in detail (*Tolar* et al. *2016*).

In 2007, for the first time in Slovenia, excavations included appropriate sampling and treatment methods for archaeobotanical investigations of waterlogged material (*Tolar* et al. *2010*). Three 1m^2 qua-

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drants from the 15m² trench with an approx. 46cm thick cultural layer were systematically surface sampled and archaeobotanicaly analysed (Fig. 1). Both the latest (upper 21cm of the sediment in the cultural layer) and the earliest (lower 25cm of the sediment) settlement phases were investigated (*Tolar* et al. *2011*).

The present paper compares these two studies: surface sampled sediment samples from the latest cultural layer of the excavated trench in 2007 *vs*. judgement sampled material from the loom-weight. Both samples were waterlogged and therefore had great potential for archaeobotanical investigation. There are also important differences between the two. Although preserved in waterlogged conditions, the first study deals mainly with waterlogged plant macroremains that were deposited on the surface during the life of the settlement, while the second deals mainly with carbonised plant macroremains that were intentionally added by the dwellers to reinforce the large clayey object. Comparing plant remains that were preserved under various taphonomic conditions and collected by different sampling methods is important, because they can present different sources of evidence (*Jones 1991; Tolar 2016. 46, 56–59, 62–65, 142–148, 166*).

Material and methods

Two methodologically different archaeobotanical investigations from the same archaeological site (*i.e*. Stare gmajne) and period (the latest settlement phase) are presented and compared. The first includes an analysis of the surface sediment samples taken systematically from the trench excavated in 2007. The second includes an investigation of the material from the broken loom-weight, called judgement sampling. Therefore, two sampling methods, surface and judgement (see *e.g., Jacomet, Kreuz 1999; Tolar 2016.62–65*) were applied and compared.

Surface sampling from the trench

From the Stare gmajne trench in 2007 (Fig. 1) surface sediment samples of approx. 1 litre of sediment per 1 depth/cut (see Fig. 1b) from the cultural layer were collected. Horizontally, it was sampled from three randomly chosen square metres (*i.e*. quadrants 1, 9 and 13) (Fig. 1a).

The 46cm thick cultural layer was divided vertically into 8 depths/cuts of approx. 5cm (Fig. 1b). Depths/cuts 4 and 5 pertain to the latest (*i.e*. the youngest) settlement phase, while depths/cuts 7 and 8 pertain to the earliest (*i.e*. the oldest) phase.

Altogether, 15 samples with a total volume of some 9 litres were analysed. The samples were first washed and wet sieved, as proposed for waterlogged sediments (see *e.g., Hosch, Zibulski 2003; Tolar* et al. *2010*). Sieves with 2mm and 0.355mm mesh sizes were used. The collected waterlogged organic fractions were stored (and kept) in water and at low temperatures. Prior to the analysis, random sub-sampling was necessary, especially of the small (*i.e*. 0.355mm) fractions, because the samples were very rich in macroremains. In addition to whole seeds/fruits and grains, grain fragments with embryo ends, glume bases, rachis fragments, fragments of seeds/fruits with the base and flax (*Linum*) capsule fragments with a tip larger than 3mm were sorted out and counted. A Leica MZ75 stereomicroscope with 6.3 up to 50 magnification was used for the examination. For identification, the reference collections of IPAS, Basel and Institute of Archaeology ZRC SAZU, as well as special literature (*Berggren 1969; 1981; Anderberg 1994; Cappers* et al. *2006; Jacomet 2006*) were consulted.

Judgement sampling from the loom-weight

A special and very important find, a loom-weight 22.5cm high and 14.4cm wide, was discovered in 2006. During the excavations, the bottom of the

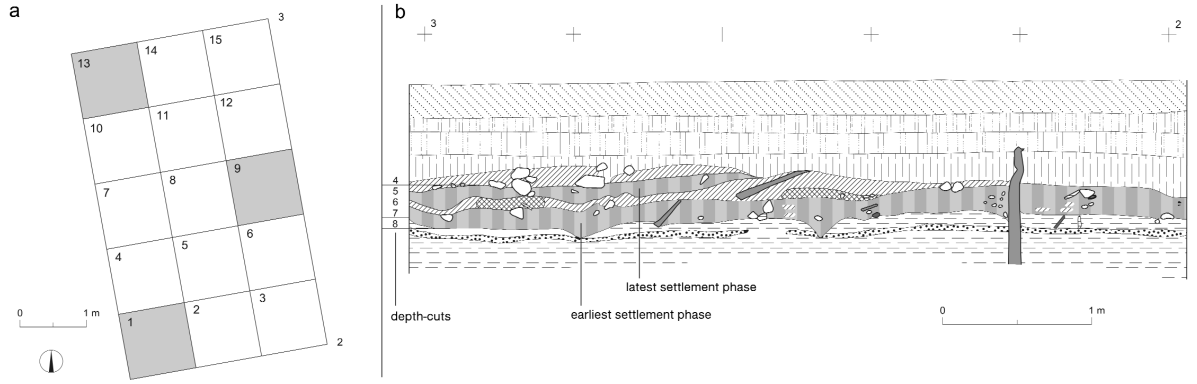


Fig. 1. The trench in 2007.* a *horizontally and* b *vertically (drawing T. Korošec).

weight broke off and its incompletely burnt, clayey and waterlogged interior became visible. Its outer parts were burnt, but the interior was full of waterlogged clayey material (Fig. 2) – original material for making larger clayey objects.

The inner, clayey and waterlogged parts were removed from the weight (Fig. 2b). In total, almost 1 litre of clayey sediment was obtained and analysed. It was very carefully wet sieved through two sieves with standard mesh sizes (2 and 0.355mm). Both organic fractions were wet stored and examined under a stereomicroscope at up to 50 magnification(s). Identifications, type of remains, state of preservation and counts were noted. A careful morphological study of different cereals remains (mainly chaff) was made and the proportions of different cereal types and crop species were calculated. Based on this, an estimate of the clay-straw ratio used for making the clayey objects was made (*Tolar* et al. *2016*).

The main aim of the present paper is to summarise and compare the archaeobotanical results from two contexts (surface sampling from the trench and judgement sampling from the loom-weight) from the same site and period (*i.e.* the latest phase of pile dwelling site Stare gmajne, dendro dated to *c.* 3160–3100±14 cal BC) in order to reconstruct the plant economy at the site, especially of cereals.

Results

Surface sampling from the latest cultural layer of the Stare gmajne site

The concentrations of the identified plant macroremains averaged 1572 remains per 1 litre of sediment; 95.4% of the identifiable plant macroremains were preserved in an uncarbonised state, *i.e.* waterlogged.

A total of 38 taxa were identified, 5 of which were cultivated: emmer (*Triticum dicoccum*), einkorn (*Triticum monococcum*), barley (*Hordeum vulgare*), poppy (*Papaver somniferum*), and flax (*Linum usitatissimum*) (Fig. 3). While the remains of poppy and flax were mainly represented by the remains of seeds/fruits (*e.g.*, Figs. 3d, e), the cereal macroremains were mainly represented by chaff remains (*e.g.*, Figs. 3a-c). Only 8 cereal grains (of all three taxa) were sorted out. The concentrations of cereal chaff remains (129 per 1 litre of sediment) are normal for waterlogged cultural layers (or even lower; *e.g.*, for the earliest settlement phase of Stare gmajne site, the average concentration of cereal macroremains is 652). They comprise general waste around the site and are therefore not concentrated in a particular feature.

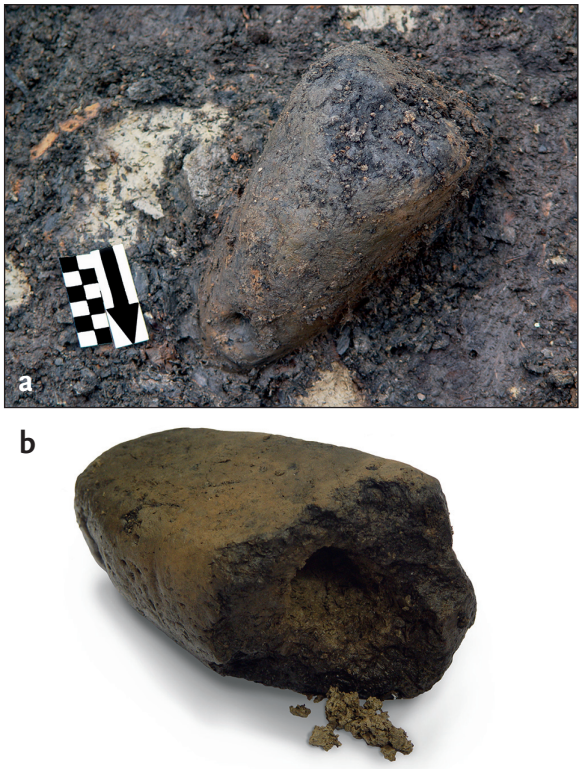


Fig. 2. Incompletely burnt pyramid-shaped 1.5kg heavy clayey loom-weight was 22.2cm high and up to 14.4cm wide. During excavations (a) and during cleaning in the lab (b) (photo a M. Turk and b T. Tolar).

Another 7 taxa were presumably collected for human consumption: turnip (*Brassica rapa*), acorn (*Quercus* sp.), hazelnut (*Corylus avellana*), water chestnut (*Trapa natans*), apple/pear (*Maloideae*), strawberry (*Fragaria vesca*), and blackberry (*Rubus fruticosus*).

Surface sediment samples also include the remains of the wild (*i.e.* not nutritive) plant taxa: 4 water plants, 9 lakeshore plants, 6 field weed and ruderal plants, 6 woodland plants, which give an insight into the ecological conditions at the site in the time of the pile dwellers. The settlement was located near the lake; the dwellers also exploited the surrounding woodland for pasturing, gathering and tree felling (for details from both the latest and the earliest settlement phases, see *Tolar* et al. *2011*).

Judgement sampling from the Stare gmajne loom-weight

The density of botanical macroremains was high: in the less than 1 litre of clayey material obtained

from the loom-weight, a total of 1950 identifiable plant macroremains were sorted and counted. They were all preserved in a carbonised or semi-carbonised state. Among them, more than 1800 very well preserved and easily identifiable cereal by-products, *i.e.* chaff (Fig. 4) and 22 cereal grains were identified. The clay-organic material (mainly chaff) ratio was easily determined. It is at least 93:7 (*i.e.* 93% of clayey material and at least 7% of cereal by-products) (for details, see *Tolar* et al. *2016*).



Fig. 3. The most important cultivar macroremains from the Stare gmajne site, surface sampling:* a *emmer spikelet fork carbonised and uncarbonised;* b *einkorn spikelet fork carbonised and uncarbonised glume base;* c *barley rachis fragments carbonised and uncarbonised;* d *uncarbonised poppy seed;* e *uncarbonised flax seed;* f *carbonised barley grains (photos* a-e *T. Tolar,* f *D. Valoh).

As well as 3 cereal taxa, emmer (*Triticum dicoccum*), einkorn (*Triticum monococcum*) and barley (*Hordeum vulgare*), another 9 taxa were identified: poppy (*Papaver somniferum*), oak (*Quercus* sp.), brome grass (*Bromus* sp.), grasses (*Poaceae*), *cf.* millet (*Panicum miliaceum*), sedges (*Cyperaceae*), goosefoot (*Chenopodium album*), moth mullein (*Verbascum blattaria*), and St John's wort (*Hypericum perforatum*). In total, the 64 seeds/fruits of these 'non-cereal' taxa are not representative enough to enable interpretation of the gathering economy or ecological conditions at the site.

An experiment was conducted to learn why different processes occurred when the plant remains were deposited in the loom-weight, *i.e.* mostly carbonised in waterlogged clayey material. Dry plant material (hay) was added to the clay from which two objects shaped similarly to the Stare gmajne loom-weight were made. As well as tempering, it became clear that the added plant material allowed very fine and easier moulding and forming of the raw clay. Two objects were made, each of them burnt (baked) on an open fire with hot coals for different times. The added plant remains in the object that was burnt for a longer time (*i.e.* 3 hours and 35 minutes) were completely charred and highly reduced, while the plant remains in the second (that was burnt for 2 hours less) were differently preserved, *i.e.* mostly in a carbonised and semi-carbonised state, and some not carbonised.

Discussion

Comparison between the surface and judgement sampled material

Although in both cases of sampling, the researched material was waterlogged and clayey, the state of



Fig. 4. Most frequent macroremains from the loom-weight cereal by-products.* a *emmer spikelet forks;* b *glume bases;* c *barley rachis fragments (photo D. Valoh).

preservation of the plant macroremains between the two compared contexts varies. Some 95.4% of macroremains from the surface cultural layer were preserved in an uncarbonised, *i.e.* waterlogged state (Fig. 3), while the plant remains from the loom-weight are all preserved in carbonised (71%) or at least in a semi-carbonised (29%) state (Fig. 4).

Table 1 presents some basic differences between the surface (S) and the judgement (J) sampled material. Lower concentration of plant macroremains in the sediment samples from the cultural layer (S in Tab. 1) in comparison to the judgement sampled material from the loom-weight (J in Tab. 1) is evidence of intentionally added (or used) plant macroremains (especially of cereals) in the judgement sample. Evidently, the greater diversity of plant taxa in the surface samples in comparison to the judgement sample additionally indicates the intentional use of carefully selected cereal by-products for tempering the large clayey object.

The plant spectra between the compared contexts differs considerably. Samples from the cultural layer contain remains of diverse plants (38 taxa altogether: cultivated, gathered and wild). Most of the remains are not carbonised, *i.e.* waterlogged. On the other hand, the sample from the loom-weight consists mainly (96%) of 3 cultivar species: emmer, einkorn and barley, preserved in a semi-carbonised or fully carbonised state; these macroremains (especially chaff) were intentionally added to the clay in order to obtain well-tempered material for making quite a large loom-weight.

As the judgement sampled material contains evidently carefully selected and charred cereal by-products, the only possible comparison between the two differently sampled and preserved materials is the importance of cereal species for the plant economy at the Stare gmajne site. Despite the different preservation conditions (waterlogged *vs*. charred) in both samples (surface and judgement) cereal by-products (*i.e.* chaff) prevail over cereal grains. Therefore, the grain units (*i.e.* 1 grain = 1 spikelet fork = 2 glume bases = 1 barley rachis frg.) in 1 litre of sediment sample of both investigated materials (surface-S and judgement-J) were compared (Tab. 2). The only difference between the two is the preservation state: surface – waterlogged chaff *vs*. judgement – charred chaff.

Cereal macroremains (especially by-products) are obviously concentrated in the material from the loom- weight (1412-J : 526-S). It seems that the proportions of glume wheat-GW (*i.e.* emmer and einkorn) remains in the loom-weight are higher than those of barley rachis fragments-B (949-GW : 463-B). In contrast, barley grain units in the wet soil surface samples from the cultural layer prevail over glume wheat grain units (387-B : 139-GW). Was barley more a popular crop species than glume wheats? Did the inhabitants deliberately choose glume wheat by-products (although they were in a minority) for tempering?

Data from a single loom-weight and the only and first appropriately investigated surface sediment samples from Slovenian pile-dwelling sites are not sufficient for definite conclusions. More archaeobotanical studies at Ljubljansko barje pile-dwelling sites should be made to answer the two questions posed above. At the moment, we can only assume that different taphonomical processes are the most likely principal reason for such a result. Carbonised plant material from the loom-weight could contain more glume wheat by-products (*i.e.* glume bases and spikelet forks of emmer and einkorn) merely because of the taphonomy. The inhabitants may have simply used the available chaff without selection, but differential carbonisation and destruction rates of different plant types (*e.g., Bowman 1966; Hillman 1981; Boardman, Jones 1990*; see also experimental work in this paper and *Tolar* et al. *2016*) that were added to the clay may have played the main role. This could be one of the reasons for the higher proportions of glume wheat over barley by-products preserved in the incompletely burnt loom-weight.

Tempering with plant macroremains

The clay which was used by the dwellers to make the weight was tempered with probably uncarbo-

	vol. of the sediment (ml)	vol. of organic fractions (ml)	no. of ident. plant remains	conc. per 1 litre of sediment	no. of cultivar taxa	no. of gathered taxa	conc. of cultivar remains
S	3200	420	1583	495	5	7	141
J	< 1000	65	1950	> 1950	4	1	> 1875

Tab. 1. Some of the basic archaeobotanical results for surface sediment samples* S *and judgement sample from the loom-weight-* J. *Both sediments were waterlogged preserved and represent the same site and period (latest settlement phase).

nised cereal chaff to reinforce it (the experimental work in this paper confirms this). It has already been proven that tempering was practised, not necessarily for loom-weights, at earlier settlements throughout Europe (*e.g., Hopf 1977; 1980; Borojević 2006; Henn* et al. *2015*). Ethnographic evidence from present-day societies as well as the archaeobotanical evidence of past societies indicate that by-products produced during cereal processing (*i.e.* chaff, straw and weed seeds, as well as some grains; *e.g., Hillman 1981; 1984a*) were used as fuel, fodder or temper (*Watson 1979; van der Veen 1999; Henn* et al. *2015*). Examples of the use of cereal by-products for tempering in the late Neolithic have been found in plant impressions at many European sites (*e.g., Hopf 1977; 1980; Bakels 1984; Borojevič 2006*). Imprints of wheat chaff and culm fragments of wild grasses on daub and ceramics (*e.g., Kohler-Schneider 2007; Borojević 2006*) are proof of this. It is very difficult both to precisely identify the plant material used and define its proportions, since there are no techniques to identify the actual quantity of straw and chaff used, because plant remains or even just their imprints are preserved in burnt and dried pottery or daub (*Henn* et al. *2015*). Many attempts have been made to calculate this ratio (*Ginder 1996; Borojević 2006; Henn* et al. *2015*), but the results have never been straightforward. The unburnt original material for making the clayey object from the Stare gmajne site gives us an opportunity to calculate this ratio. In less than 1 litre of waterlogged sediment from the loom-weight, 65ml of organic fractions, mainly cereal by-products, were caught in the sieves. Some 1950 plant macroremains were sorted, identified and counted. Cereal by-products of barley, emmer and einkorn predominate; in total, 1412 grain units were counted. The clay-organic material (mainly chaff) ratio is at least 93 : 7 (*i.e.* 93% of clayey material and at least 7% of cereal by-products).

	emmer (*Triticum dicoccum*)	einkorn (*Triticum monococcum*)	emmer/einkorn (*Triticum* di/*monococcum*)	barley (*Hordeum vulgare*)	Total
S	67	72		387	526
J	482	193	274	463	1412

Tab. 2. Numbers (concentrations) of grain units in 1 litre of sediment for 3 cereal taxa.* S *surface samples from the cultural layer in which uncarbonised cereal chaff predominate;* J *judgement sample from the loom-weight in which carbonised cereal chaff predominate.

Conclusions

The results of the plant macroremain studies of the Eneolithic lakeshore settlement Stare gmajne at Ljubljansko barje are presented. Archaeobotanical material was collected with two different sampling methods: 1) systematic surface sampling from the cultural layer, and 2) judgement sampling from the incompletely burnt large loom-weight. When comparing the results, the preservation (taphonomy) and the spectra of plant macroremains diverse greatly, so the results of both studies yield different, but favourable conclusions.

The surface sampled sediment from the cultural layer gives an insight into the plant economy and nutritional habits of the settlers, as well as an insight into the environment and ecological conditions on and around the site. Six crop taxa were recorded. Plants that had been gathered from the woodland, woodland edges and the lake were also important for nutrition. Other non-nutritive seeds/fruits remains of wild flora indicate that the settlement was located close to the lake or a slow-flowing river. Marshy or lakeshore plant species and the ruderals grew nearby or even within the settlement. The remains of woodland plants and plants from woodland edges suggest that the settlers exploited the nearby forest for gathering food, felling trees, pasturing animals and hunting.

The judgement sampled sediment from the loom-weight deals primarily with carbonised and semi-carbonised cereal macroremains (mostly chaff) that were preserved inside the loom-weight and were intentionally added to the clay to reinforce the large clayey object. This gives a detailed insight into the cereal cultivation and crop processing habits of the settlers. The deliberate use of cereal by-products was confirmed. The clay-cereal chaff ratio (93:7) was established.

It was possible to compare both studies with regard to the cereal economy. The cereal by-products, which were preserved in two different ways (not carbonised in surface samples *vs*. carbonised in the loom-weight), confirm the cultivation of the main crops: emmer, einkorn, and barley. The greater importance of barley is suggested by the surface samples, but the judgement sample does not confirm this. The differential carbonisation and destruction rates of different plant types when exposed to heat (*e.g., Boardman, Jones 1990*; see the experiment) prevent us from establishing which crop species predominated at the Stare gmajne site.

The investigation of the surface samples yields additional information about the plant economy. The

settlers' activities and plant gathering, pasturing and fodder collection had an impact on the vegetation in the vicinity of the settlement (also *e.g., Andrič* et. al. *2008; Andrič in prep.*).

The judgement sample provides supplementary information about crop husbandry practices, the development stage and the inventiveness of the Eneolithic settlers. According to Marijke van der Veen (*1999*), the use of chaff can be linked to various scales of production and organisation in the agricultural system. She suggests that different types of use (casual use, intentional local use, use as a commercial commodity) can be broadly correlated with three developmental stages of agricultural production. The intentional local use of cereal by-products as temper suggests that pile dwellers all around the Alps were highly organised and developed as a result of the expansion of crop production and processing.

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A small-scale cult centre in Southeast Turkey: Harbetsuvan Tepesi

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ABSTRACT – *The present paper aims to assess the finds from Harbetsuvan Tepesi, which we consider a small-scale satellite settlement located some 7km southwest of Karahan Tepe. The paper also endeavours to show analogous characteristics of Harbetsuvan Tepesi by comparing the site with PPN settlements in adjacent regions. The remains of a round-plan building, a recent discovery observed on the surface in Harbetsuvan Tepesi, which features T-shaped pillars, is particularly notable. The remains of this building, which has characteristics analogous to 'Enclosure F' at Göbekli Tepe, is extremely important, as it demonstrates that round-plan buildings were still in use during the early PPNB period.*

IZVLEČEK – *V članku vrednotimo najdbe iz najdišča Harbetsuvan Tepesi, t. j. manjše satelitsko naselje, ki leži ok. 7 km jugozahodno od najdišča Karahan Tepe. Prikazujemo tudi značilnosti, ki Harbetsuvan Tepesi vežejo na druga PPN naselja v sosednjih regijah. Opozorili bi predvsem na ostanke okrogle stavbe, ki je bila nedavno odkrita na površini najdišča Harbetsuvan Tepesi, za katerega so značilni predvsem stebri v obliki črke T. Ostanki te stavbe, ki ima podobnosti z 'ogrado F' na najdišču Göbekli Tepe, so pomembni, saj dokazujejo, da so bile okrogle stavbe navzoče tudi še v zgodnjem PPNB obdobju.*

KEY WORDS – *Pre-Pottery Neolithic; T-shaped pillar; Karahan Tepe; Göbekli Tepe; cult centre*

Introduction

Recently discovered during surface surveys conducted in 2014, Harbetsuvan Tepesi settlement is located within the provincial borders of Şanlıurfa (Urfa) province in southeast Turkey (*Çelik 2015a. 12–14; 2015b.81*). Harbetsuvan Tepesi is located approx. 53km[1] east of Şanlıurfa on a plateau known as the Tektek Mountains (Tektek Dağları) (Fig. 1). Similar to Göbekli Tepe, Karahan Tepe, Hamzan Tepe, and Şanlıurfa-Yeni Mahalle, PPN settlements positioned around the Harran plain in the Urfa Region, Harbetsuvan Tepesi settlement was also founded on a mesa at the eastern edge of the Harran Plain. The Harran Plain extends west of the settlement, which is on a hill that forms the western margin of the Tektek Mountains (Map 1).

The studies undertaken on the surface at the Harbetsuvan Tepesi settlement revealed depressions carved into the bedrock, and flint and obsidian tools. The finds recovered from the settlement point to the fact that it was used as a small-scale cult centre during the Pre-Pottery Neolithic period. Moreover, several T-shaped pillars, known from Nevali Çori, Sefer Tepe, Hamzan Tepe, and Göbekli Tepe, were also recorded on the surface. The study undertaken at the settlement further resulted in the discovery of reliefs that depict the fingers of a hand on a T-shaped pillar recovered from an area excavated by treasure hunters.

1 Several publications state this distance as 45km, as it is possible to access Harbetsuvan Tepesi from two different roads (see *Çelik 2015a.12*).

Location

Harbetsuvan Tepesi settlement is located approx. 714m a.s.l., between 39°15'8,76" East, 37°2'55,23" North[2]. The settlement was founded on mountainous highland terrain called the Tektek Mountains. This region forms the southernmost margin of the Urfa Plateau, which has high hills rather than mountains. In this region, which has no water sources, calcareous rocks are encountered frequently due to soil erosion. The sole source of water in the region is the creeks that spring to life and flow only after heavy rain. Therefore, even today cisterns in villages are used to collect rainwater for use during summer, when water is scarce.

The section of the Harbetsuvan Tepesi settlement that has survived covers an area of approx. 6000m^2. The settlement site is concentrated precisely on the peak of a rocky hill. Karahan Tepe settlement, considered to be a mega settlement dating to the Pre-Pottery Neolithic period, is located some 7km northeast of the settlement (Fig. 2). The Harran Plain, the most important plain in the region, is located some 5km west of Harbetsuvan settlement. Flint deposits are present in the vicinity of Karahan Tepe settlement, 8km northeast of Harbetsuvan Tepesi (*Çelik 2011.241*). Moreover, abundant flint deposit outcrops at an area known as Recmelsuvan, 10km south of the settlement, have also been noted (*Çelik 2015b. 82–83*). The flint finds are abundant over the entire area of Harbetsuvan Tepesi, with the number of flint artefacts per 1m^2 being around 30. On the other hand, the closest basalt quarry to the settlement is 15km northwest of the archaeological site.

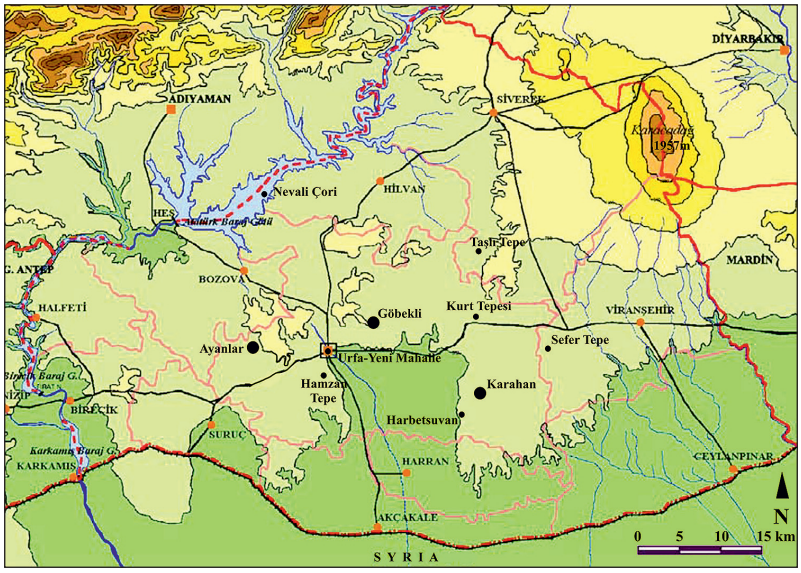
This small-scale settlement on the eastern margin of the Harran Plain, together with nearby Karahan Tepe, was probably a satellite settlement of Karahan Tepe. The position of Harbetsuvan Tepesi is the best location for overlooking the Harran Plain, a strategic advantage that Karahan Tepe does not have (Map 1). The location of Karahan Tepe allows monitoring only of the interior areas of the Tektek Mountains. Zakzuk Bastion (Zakzuk Kalesi) located some 4km north of Karahan Tepe lies at an elevation of approx. 750m. However, this hill provides only a distant view of the Harran Plain. The fact that both Harbetsuvan Tepesi and Karahan Tepe are within the Tektek Mountains arises from an extremely suitable environment for setting snares and traps for hunting at such localities. The studies conducted in the region revealed some evidences related to trapping areas[3].

Pre-Pottery Neolithic assemblage at Harbetsuvan Tepesi

Harbetsuvan Tepesi was inhabited only during the Pre-Pottery Neolithic period. The finds discovered at the settlement are in the form of architectural remains and small finds, such as flint and obsidian tools, comprising 76 small finds and 3 architectural remains. Two of the architectural remains were exposed by illegal excavations, and include T-shaped pillars. The other architectural find is part of a limestone block, which is in an interior space.

Architectural remains

The architectural remains at Harbetsuvan Tepesi are numerous and still well-preserved. The T-shaped pillars, some of which are still standing, are scattered



Map 1. Map illustrating settlements with pillars from the Pre-Pottery Neolithic Period (drawing M. S. Şahinalp).

2 Karahan Tepe settlement located northeast of Harbetsuvan Tepesi is positioned between 39°18'11,85" East and 37°5'29.16" North coordinates.

3 A further study is currently in progress concerning the trapping areas south of Harbetsuvan Tepesi.

all around the entire surface of the site; only their capital sections are partially broken, almost 20-30cm of which are visible from the surface. The pillars are arranged side by side at intervals of 1.5 to 2m; a total of 14 pillars were identified on the surface. The length of some of the pillars recovered at the settlement site due to illegal excavations varies from around 1 to 1.5m; they vary in thickness from 20 to 25cm, while widths range from 40 to 50cm. One of the pillars bears an imprint of the fingers of a hand and a girdle relief on one side (Fig. 3). However, no relief was observed on the other pillars. Another intact pillar was also discovered, again by illegal excavations (Fig. 4). This intact pillar lacks any relief, although the dimensions are identical to the dimensions of the pillars observed at Karahan Tepe (*Çelik 2000a.7; 2011.242*).

The upper parts of walls are still visible in some areas, seemingly from the Neolithic period. Pillars arranged at intervals of 1.5 to 2m adjacent to the wall were discovered in the interior section of such walls. Upon tracing the walls, it was observed that the structure suggests a round-plan building (Fig. 5). This building is similar to 'Enclosure F' discovered at Göbekli Tepe, three-quarters of which have been excavated and revealed (*Dietrich* et al. *2012.Fig. 12; Schmidt 2010.240, Fig. 15*). 'Enclosure F' at Göbekli Tepe appears as a building attributed to Layer II in some publications (*Schmidt 2007.276–277, Fig. 9*), between Layers II and III in other publications (*Schmidt 2010.240, Fig. 2*), or as an uncertain building in some others (*Dietrich* et al. *2014.Fig. 2; Becker* et al. *2012.16, 18, Abb. 3*). The most interesting aspect of this building is that it is a round-plan structure resembling the architecture of Layer III, while the pillars are similar in size to pillars from Layer II. The round-plan building found at Harbetsuvan Tepesi is almost twice the size of 'Enclosure F' at Göbekli Tepe (Fig. 6).

No excavations are being undertaken at Karahan Tepe, so it is extremely difficult to make any conclusions. However, the site is dated to the same period as Layer II of Göbekli Tepe on the basis of the dimensions of the T-shaped pillars (*Çelik 2011.242–246*). At Harbetsuvan Tepesi, on the other hand, the existence of a round-plan building, which is almost entirely exposed, may be testament to the existence of similar round-plan buildings with pillars at Karahan Tepe in the close vicinity of the site. The building discovered at Harbetsuvan Tepesi can be seen clearly from satellite images; the diameter is estimated to be approx. 20m.

One fractured limestone vessel fragment was discovered at Harbetsuvan (Fig. 7); most of these artefacts were found inside buildings. Similar vessel fragments with a diameter of approx. 50cm have also been encountered at Göbekli Tepe (*Dietrich* et al. *2012.Fig. 11; 2014.Fig. 5*), Karahan Tepe, and Ayanlar Höyük.

Three cavities were carved out of the bedrock to the north of the settlement. One of these is smaller, while the diameter of one larger cavity appears to be around 1.5m and the depth around 80cm (Fig. 8). This type of depression, also observed at Karahan Tepe (*Çelik 2011.242*), Göbekli Tepe (*Beile-Bohn* et al. *1998.50, Abb. 20*), Hamzan Tepe (*Çelik 2004.Fig. 3; 2006.Fig. 4; 2010.Figs. 5, 7–8*), Kurt Tepesi (*Çelik 2015*), and Domuzcurnu Tepesi (*Güler, Çelik 2015*), was probably built to collect rainwater.

Rectangular buildings approx. 4m wide and 7m long built side by side are present on the western slope of the settlement site (Fig. 9). The wall stones of such buildings are large, untrimmed and flat. The building appears to have no entrances. No ceramic fragments were discovered in the buildings, but flint blades and chips were recovered. At present, we do not know the purpose of the buildings. However, ruined buildings similar to these are also found on the side slopes south of Harbetsuvan Tepesi.

Another small-scale settlement covering an area of approx. 1000m² was discovered on a hill 350m southwest of Harbetsuvan Tepesi. This settlement contains pillar fragments and architectural remains, while flint and obsidian blades and chips were also recovered on the surface. The purpose of this settlement also remains unknown.

Finds with depictions

Reliefs were discovered on one pillar recovered from Harbetsuvan Tepesi by illegal excavations (Fig. 3). The reliefs on the side of the pillar depict the fingers of a hand and a girdle, which also occur at Göbekli Tepe (*Schmidt 1999.Taf. 9.2; 1997/98.163–164, Abb. 13*), Nevali Çori (*Schmidt 2010.Fig. 5*), and Kurt Tepesi (*Güler, Çelik 2015.78–79, Res. 2; Çelik 2015c.Fig. 2*). An interesting fact here is that, while the pillars bear reliefs depicting the fingers of a hand and a girdle, no reliefs depicting arms, as observed on the pillars at Nevali Çori and Göbekli Tepe, were found. Something similar is true of the single pillar discovered at Kurt Tepesi. This pillar lacks reliefs depicting either arms or fingers; only the girdle and chevron patterns were found (*Çelik 2015a.12, Fig.*

5). The fact that both examples lack arm patterns point to the possibility that these types of pillar were probably inserted into the walls. One pillar with a broken capital part inside the 'Lions Pillar Building' at Göbekli Tepe also has similar reliefs depicting the fingers of a hand and a girdle. This pillar too stands as if inserted into the wall (*Schmidt 1997/98.Abb. 13; 1999.Taf. 2, 9.2*).

Technology and typology

A total of 77 small finds were acquired from the Harbetsuvan Tepesi settlement site. Of these, the Neolithic find assemblage comprises flint (65 artefacts) and obsidian (12 artefacts). The flint tools consist of arrowheads, scrapers, perforators, burins, crested blades, cores, and sickle blades with silica shine. The obsidian tools are in the form of blade pieces and flakes (Fig. 10).

An abundant amount of flint and a small amount of obsidian finds were acquired from Harbetsuvan Tepesi. The blade industry contributed most to the flint and obsidian finds, with different types of blades accounting for the highest proportion in the flint tools.

The flint tools are represented by 60 finds in the entire flint assemblage. Other flint artefacts are 1 core (Fig. 10.26) and 4 crested blades (Fig. 10.32–35), which are core replenishment parts. The flint tools consist of 48 arrowheads and arrowhead fragments (Fig. 10.1–20), 5 perforators (Fig. 10.21–25), 2 end scrapers (Fig.10.36–37) and 5 silica sickle blades (Fig. 10.27–31). With respect to all the flint tools discovered at Harbetsuvan Tepesi, the ratio of arrowheads is 74%, while the ratio of arrowheads recovered from Göbekli Tepe is only 20% (*Schmidt 2001. 51–52, Fig. 9; Beile-Bohn* et al. *1998.59*), and 66.2% at Karahan Tepe (*Çelik 2011.Tab. 2*).

The raw material is high-quality flint. During the studies conducted in the area, flint deposits were encountered 8km northeast and 10km south of the archaeological site. The cores discovered at this site are only bipolar cores (Fig. 10.26). Regarding the colour distribution of all the flint finds discovered at the site, 32 finds are grey, 8 are dark grey, 22 are dark brown, and 3 are light brown. There are 12 obsidian finds, but no tools were discovered among these (Fig. 10.38–46); the finds comprise 10 blade fragments and 2 flakes.

When we examined the flint tools, we came across tool types that in terms of their typology date to the Pre-Pottery Neolithic period. Arrowheads comprised the majority of the finds, with the Byblos type being the most common. A detailed study of the arrowheads reveals their resemblance to arrowheads encountered in the region, where they are dated from the late PPN A to the middle of PPN B (*Cauvin 1994. 78–95*). Arrowheads similar to these were also found at settlements such as Karahan Tepe (*Çelik 2011. Fig. 18.4, 6, 8–9*), Göbekli Tepe (*Schmidt 2001.52, Figs. 10/3, 11/5*), and Mureybet (*Cauvin 1994.79*).

Unidentifiable arrowheads are represented with a total of 46 finds (Fig. 10.5–20). When we take into consideration the blade width and thickness of all arrowheads, the arrowhead piece should have an upper and a lower section. Currently, we have no information on the shape of such arrowheads. However, arrowheads similar with respect to the shaft section in particular are known from Karahan Tepe (*Çelik 2011.Fig. 18.4, 6*). Total of 4 intact arrowheads (Fig. 10.1–4) are discovered, where arrowheads similar to these are also known from Karahan Tepe (*Çelik 2011.Figs. 18.1, 19.1*).

Concluding remarks

The most striking characteristic of Harbetsuvan Tepesi is that it is a small-scale settlement like Sefer Tepe, Taşlı Tepe, and Kurt Tepesi. Moreover, the settlement contains only Pre-Pottery Neolithic finds. It is highly possible that Harbetsuvan Tepesi is a small-scale cult centre with T-shaped pillars, just like at Sefer Tepe, Kurt Tepesi, and Taşlı Tepe. The surface surveys conducted south of Harbetsuvan Tepesi revealed numerous domestic settlement sites dating to the Pre-Pottery Neolithic period (*Çelik 2015b.81–83, Map 1*). A similar occurrence was observed in the area surrounding Sefer Tepe settlement (*Güler* et al. *2013.294–297, Map 1*), which might be evidence that Neolithic settlements with pillars are cult centres, while other domestic settlements lay in the hinterland.

The closest settlements contemporaneous with Harbetsuvan Tepesi during the Pre-Pottery Neolithic period are Karahan Tepe (7km north-east), Kurt Tepesi (20km north), Taşlı Tepe (35km north), Sefer Tepe (26km north-east), Şanlıurfa-Yeni Mahalle (43km west), and Göbekli Tepe and Hamzan Tepe settlements, which are located approx. 40km to the northwest. The architectural remains and small finds discovered at Harbetsuvan Tepesi have identical characteristics with finds from the Karahan Tepe, Taşlı Tepe, Kurt Tepesi, Sefer Tepe, Hamzan Tepe, Şanlıur-

fa-Yeni Mahalle, and Göbekli Tepe settlements. The cavities located north of the settlement carved out of the bedrock, on the other hand, resemble the depressions discovered at the Karahan Tepe, Göbekli Tepe, Hamzan Tepe, Domuzcurnu, and Kurt Tepesi settlements.

The currently exposed section of Harbetsuvan Tepesi greatly resembles the pillars in Layer II of Göbekli Tepe. In particular, a building similar to 'Enclosure F' at Göbekli Tepe is visible on the surface of Harbetsuvan Tepesi. The walls of the building remains with a diameter of approx. 20m are clearly visible and exposed on the surface. The presence of pillars inserted into the walls points to the fact that this is a cult building. The ruins cover 1/6 of the entire Harbetsuvan Tepesi settlement. In the light of all these finds, Harbetsuvan Tepesi appears to be contemporaneous with the upper layers of Göbekli Tepe and Layer III of Nevali Çori.

The pillars discovered in situ on the surface of the Karahan Tepe site were also discovered at Harbetsuvan Tepesi. However, although the capital sections of the pillars at Karahan Tepe were recovered intact, the capital section of all the pillars at Harbetsuvan Tepesi were broken and fractured for unknown reasons (Fig. 11). The fact that the settlement contains no Palmyra points or Çayönü tools enables us to date this settlement to the Early Pre-Pottery Neolithic Period Phase B (EPPNB).

Future excavations to be conducted at the Harbetsuvan Tepesi settlement site will help reveal that small-scale cult centres could have existed alongside large-scale cult centres such as Karahan Tepe and Göbekli Tepe.

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Fig. 1. View of Harbetsuvan Tepesi from the north (photo B. Çelik).



Fig. 2. View of Karahan Tepe from the east (photo B. Çelik).



Fig. 3. The pillar with finger relief unearthed at Harbetsuvan Tepesi (photo B. Çelik).



Fig. 4. An intact pillar at Harbetsuvan Tepesi (photo B. Çelik).



Fig. 5. View of the ruin of the round-plan building from the east (photo B. Çelik).

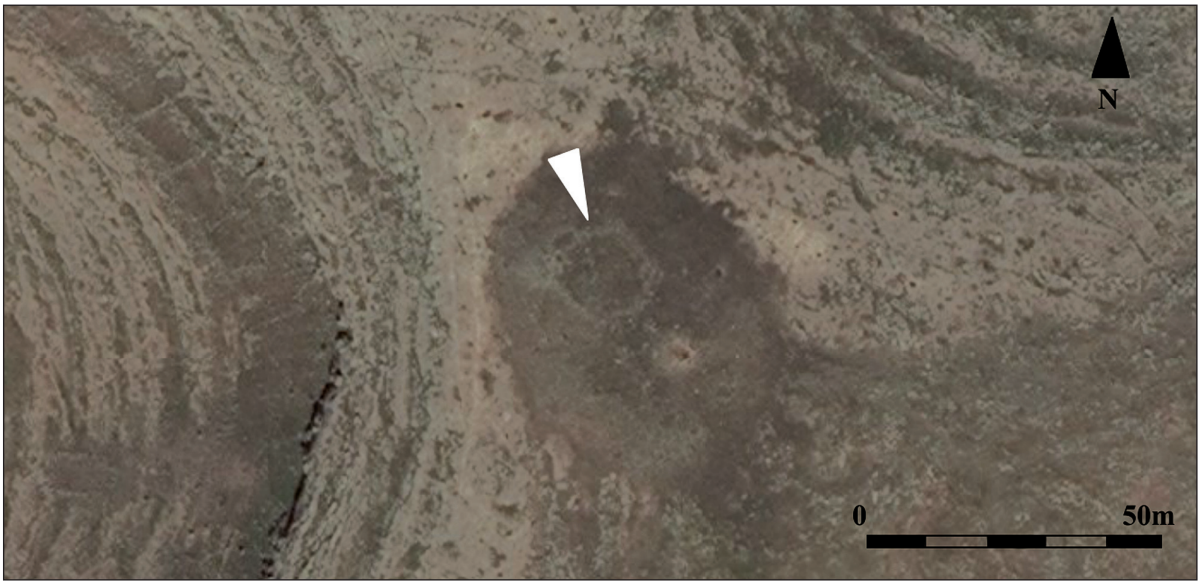


Fig. 6. Aerial view of the ruin of the round-plan building (photo B. Çelik).



Fig. 7. Limestone vessel fragment from Harbetsuvan Tepesi (photo B. Çelik).

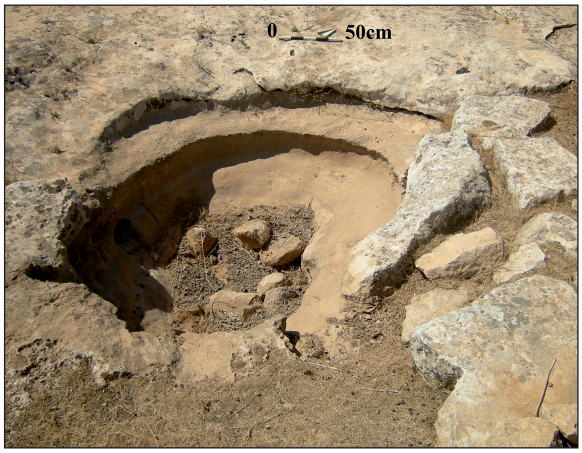


Fig. 8. Larger cavity carved out of the bedrock from Harbetsuvan Tepesi (photo B. Çelik).

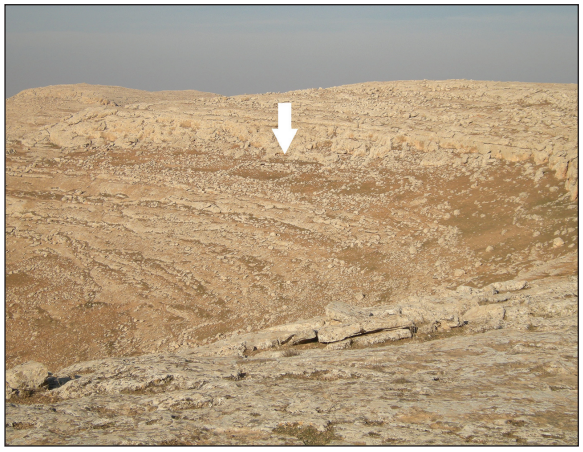


Fig. 9. View of the rectangular-plan buildings located on the western slope of Harbetsuvan Tepesi (photo B. Çelik).



Fig. 11. An example of a broken pillar from Harbetsuvan Tepesi (photo B. Çelik).

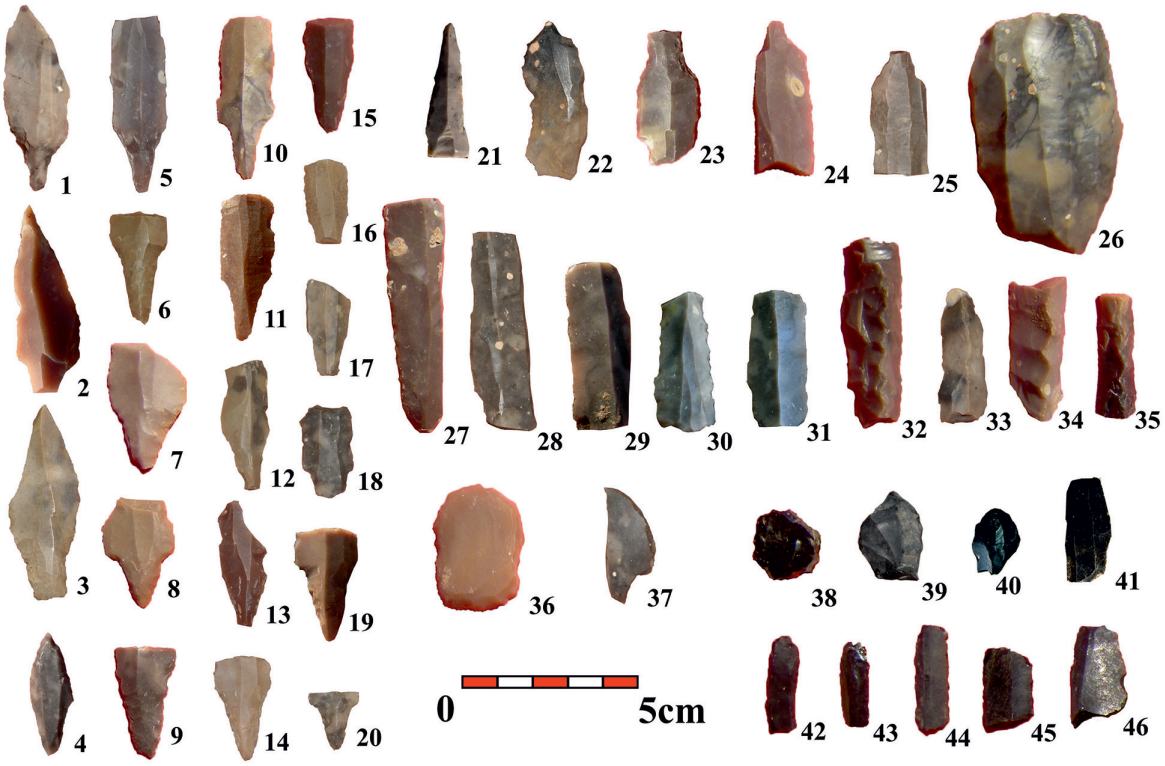


Fig. 10. Neolithic tools from Harbetsuvan Tepesi (photo B. Çelik).

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The power of the dead in Neolithic landscapes: an agricultural-celestial metaphor in the funerary tradition of the Funnel Beaker Culture in the Sandomierz Upland

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ABSTRACT – *FBC earthen long barrows were roughly oriented along the East-West axis, with deviations not exceeding the frame of the solar arc. Also, the Sandomierz Group monuments display this general pattern. The paper brings together archaeoastronomy, landscape archaeology and symbolic archaeology.*

IZVLEČEK – *Dolge zemljene gomile kulture lijakastih čaš so v glavnem orientirane v smeri vzhod-zahod in ne presegajo okvirja solarnega loka. Tudi spomeniki skupine Sandomierz kažejo na podobne vzorce. V članku združujemo spoznanja iz področja arheoastronomije, prostorske arheologije in simbolične arheologije.*

KEY WORDS – *Funnel Beaker Culture; long barrows; Sandomierz Upland; calendar dates; archaeoastronomy*

Introduction

One of the essential features of the Funnel Beaker Culture (FBC) was the development of long monumental barrows with timber structures. Having elongated, almost triangular or asymmetrical trapezoidal forms with wider 'entrances' or 'facades' and narrower ends, they were often located in abandoned agricultural fields or settlements near wet or boggy areas (*Midgley 2008.11–12; Woźny 1996.94–96; Adamczak 2013.184–186*). Their elongated shapes seem to evoke the concept of axiality, suggesting they were carefully positioned in the landscape. Archaeoastronomy may elicit the meaning of orienting long barrows in one direction or another. In this paper, I report on an ongoing study of orientations of long barrows in the Sandomierz Upland, in central-south-eastern Poland.

Traditionally, the Funnel Beaker Culture area is divided into five broad groups (*Midgley 1992.41, Fig. 10; 2008.2–3, Fig. 1.1*): western (Holland and adjacent Germany), northern (southern Scandinavia, Denmark, Holstein, Mecklenburg and Brandenburg), eastern (lower Oder, Silesia, Greater Poland, Kuyavia, Chełmno Land, and Pomerania), southern (middle and upper Elbe, upper Oder) and southern-eastern (Little Poland). The Little Poland group is further subdivided into four smaller regions: Cracow, Sandomierz, Lublin, and Volhynia (*Burchard* et al. *1991.96; Kruk, Milisauskas 1999.109–110, 312–313*), where most FBC settlements occupied loess uplands.

The Sandomierz Upland (region 342.36 in Kondracki's 1994 taxonomy) is a north-eastern extension of the Holy Cross Mountains. It is a well-defined and rather flat area, rarely exceeding 300m a.s.l., and bounded by river valleys: to the east by the upper Vistula, to the north by Kamienna, and to the west by Świślina. To the south, the upland is bound by the Wygiełzowskie Range and is drained by two Vistula tributaries, Opatówka and Koprzywianka (*Kondracki 1994*). The whole upland is covered with a

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thick layer of loess deposits accumulated during the Vistulian (Weichselian) glaciation. The eastern and northern borders of the upland have steep escarpment edges that abruptly descend to the bottoms of river valleys. The rest of the area is broken by numerous deep and narrow stream and river valleys. The major Vistula tributary, Opatówka, runs NW-SE through the region, but various small streams are oriented SW-NE, giving the local topography considerable variation (Fig. 1). To the south and southwest, clusters of the Holy Cross Mountains rise to around 600m a.s.l., generating prominent landscape features.

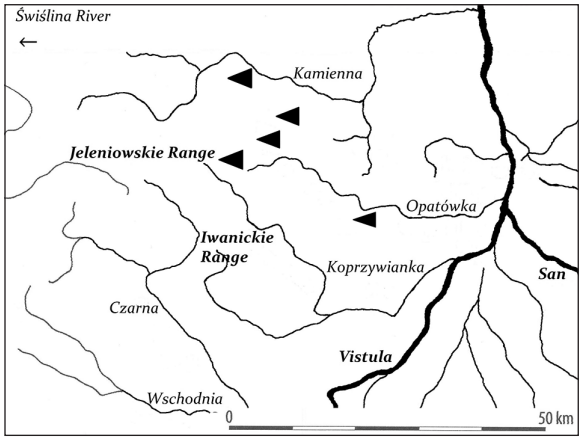


Fig. 1. Simplified map of the Sandomierz Upland.

Within the Stryczowice sub-region, FBC large settlements were located at the edge of river valleys, and some small and less permanent sites occupied loess uplands. In many cases, they were located where a Lengyel-Polgár settlement existed earlier (*Burchard* et al. *1991.100*). Large settlements were established along small tributaries of the Kamionka River, which is exposed to the Sun, clustering around Stryczowice and Broniszowice, where the densest network of meandering stream valleys and richest rolling landscape features occur in the region (*Bąbel 1975.536*). Apart from settlements, the outstanding characteristics of the FBC Eastern and South-Eastern Groups were the constructions of earthen long barrows. While in Pomerania, Greater Poland, Kuyavia and Lower Silesia, irregular boulders were used to enclose the mound, in the South-Eastern Group large blocks were replaced by smaller limestone stones or a timber palisade. Although lacking massive stones, the earthen long barrows erected in the Sandomierz Upland should also be interpreted as monumental tombs. Within the whole area, these earthen long barrows were usually situated near the highest elevations, include watershed splits (*Bąbel 1975.535–536*). The area is drained towards the north-east by the Kamionka River, which flows into the Kamienna, and then into the Vistula (see Fig. 1). Recently, Marek Florek (*2011*) aptly described all the mounds and barrows known in the region.

Long barrows and their spatial perception

To begin with, I will suggest that long barrows were often deliberately built in places so as to appear to create skylines viewed from neighbouring settlements. Viewed from settlements these barrows indeed were silhouetted, but no less important was the constitution of the visual network between barrows in the entire sub-region. I have discussed the visual appreciation of these monuments in detail elsewhere (*Iwaniszewski 2006*), but my aim here is to emphasise the reproduction of their privileged locations with respect to visual and astronomical involvements. My research indicates that the long barrows located in elevated positions have greater visual control of the overall environment than the settlements situated on the slopes descending to the riverine valleys. Furthermore, all long barrows investigated have visual predominance in almost all directions, while settlement areas tend to have more restricted visual relationships. This contrast in the visibility patterns suggests that the barrows' associated symbolism and meaning were probably extended over specific areas, linking monuments with exterior referents. The erection of long barrows at higher elevations may also be interpreted as the placement of the dead in closer proximity to the heavenly sphere. For these reasons, the location of the monuments and settlements in the landscape and their visual properties should be seen as reflecting patterns between two spatially separated, but also socially and ritually, parts of the same society. It seems evident that their visibility and intervisibility patterns and an overall spatial interplay were produced as a result of field clearing and deforestation.

The incorporation of these monuments into the landscape can be understood in the broader context of visual experiences. It seems evident they were unlikely to be visually perceived, unless we admit that the surrounding forest was cleared (see *Tilley 2010. 47–49*). Fortunately, there is much evidence for the burning of the natural vegetation from the Bronocice region in the south (*Kruk* et al. *1996.55–69; Kruk, Milisauskas 1999*). Although the oldest traces of deforestation in Bronocice may derive from pre-FBC periods, the intensification of the slash-and-burn technique resulted in a substantial thinning of the forest cover during the Bronocice II–III, between

3560 and 3100 BC (*Kruk, Milisauskas 1999.120; Kruk* et al. *1996.26, 68–69; Milisauskas* et al. *2012. 81*). The changes in the woodland cover in the Stryczowice sub-region have not been studied yet. The only, and indirect, evidence comes from Gawroniec Hill at Ćmielów (mid-4th millennium BC), located 15.5km east-northeast of the Stryczowice long barrows, where, in the FBC context, archaeologists found mollusc shells of particular snail species (*Krysiak 1952*). The presence of these snails, which is indicative of the ecological conditions of habitats where they were found, suggests that in the Kamionka and upper Kamienna areas some of the upland slopes and hilltops could also have already been partially deforested due to the expansion of croplands and pastures (*Barga-Więcławska, Jedynak 2014*).

To sum up, these anthropogenic changes in the natural environment could have improved visibility conditions across the entire region. I do not want to say that the whole area was already totally and permanently deforested; what I am suggesting is that the fact that the monuments were erected near elevated prominences suggests they would become visible from similarly high and already deforested locations. So it is possible that grasslands mixed with agricultural plots and pockets of woodland dominated the upland loess landscape (see also *Nowak 2009.449–450*). Observe the tree, water, wagon, and field motifs on a late Funnel Beaker vessel from the Bronocice phase II, dated to about 3637–3373 cal BC (*Milisauskas, Kruk 1982; Bakker* et al. *1999.785–786*), which seem to represent parcelled fields separated by trees (woodland?) (Fig. 2).

Diverse FBC groups inhabited the Stryczowice sub-region for a longer time, not only significantly transforming the local landscape (deforestation produced by slash-and-burn and scratch plow agriculture and intensive grazing), but also dramatically changing their experience of the surrounding world, permitting them to create a visual relationship into a wider landscape experience. Naturally, it is hard to evaluate the overall extension of forest clearance, but examples from Bronocice suggest that an important part of the region, especially in the valleys, should have remained forest. Be that as it may, there can be little doubt that the growing importance of long-distance panoramas of landscapes required changes in traditional ways of perceiving the cosmos, both in terms of everyday habits and shared worldviews (see more in *Tilley 2010.42–51*). I am aware that the analysis of the visibility of the long barrows shows a tendency to emphasise them as primarily visual constructs, and stress visual perceptions of the landscape at the expense of other forms of landscape perception. This position appears to privilege knowledge gained through sight, which might be due to our western mode of seeing the landscape, and not one shared by FBC peoples (see *Ingold 2000. 243–287; Cummings, Whittle 2004.8–9*). Therefore, to avoid easy over-interpretation, I add to sight the notion of the feeling of the weather-world (*Ingold 2010; 2011.126–135*) which introduces a more multi-sensory experience of the surrounding world.



Fig. 2. A late FBC vessel from Bronocice showing the tree, water, wagon, and field motifs (after* Kruk, Milisauskas 1999.Pl. 4*).

Having established that Middle Neolithic cereal agriculture and the maintenance of domesticated livestock could have caused more permanent deforestation of the region, I am now in a position to find out whether the monuments were oriented to the Sun's positions on the distant horizon. I am assuming that the elevated locations where the monuments were built allowed the horizon to be seen. As is known, archaeoastronomy maintains that orientations of structures have some meaning in relation to astronomical objects or events observed in the sky. This is not to say that different structures are set up in the landscape to represent patterns in the heavens for no other purpose. Rather it implies that their constructors laid them out to utilise the celestial realm as a way of a social discourse (*e.g.*, to reinforce the elite's right to rule, to legitimise rituals performed on specific dates).

Within this context, we must attend more closely to the orientation patterns of long barrows. In general, all FBC long barrows, regardless of geographical location, appear to follow a more or less regular pattern of placing monuments on an E-W axis, with deviations to NE-SW and SE-NW (*Iwaniszewski 2015*). In Kuyavia, the overall majority of axes are situated

within the angle of the annual movement of the Sun along the horizon, or the solar arc of the region (*Iwaniszewski 1995*). I assume that the axis of long barrows conveys a strong sense of a directed sightline determining movements toward and away from targeted landmarks and solar events. Therefore, astronomical sightlines may act as a means by which meanings and values projected onto distant landmarks are evoked at the monuments, with the monuments themselves associated with them (see below). In one a way or another, this pattern is indicative of a particular symbolic significance accorded to the E-W axis and to astronomical phenomena that occurred along the horizon. If this last argument is valid, then FBC groups sought for suitable places that afford a sufficiently wide, but not necessarily panoramic, view. The sites of earthen long barrows appeared to meet those conditions and enabled the potential observers to see a horizon position of the Sun. Now, if observations made from these spots not only served to record of recurrent positions of the Sun, but also to schedule particular activities (such as planting or harvesting), they had to return to these places at regular intervals. The monuments physical presence in the landscape could have been used to assess and reassess the importance of the location from which astronomical observation was possible. The evidence for ritual practices found in the wider area of long barrows is evidence that these places were visited regularly. The orientation patterns of monuments suggest they could have acted as kinds of calendrical indicators for recurrent astronomical events, as well as for specific activities shared by whole communities.

Archaeoastronomical arguments are essential for this interpretation. All sites in the Stryczowice sub-region have been visited and examined (see Fig. 3). Since there may be some ambiguity as to the direction in which a given alignment might have been used, declinations were obtained in both directions. On the eastern Stryczowice eastern, the spread of declinations is between –16° and –22°, corresponding to solar dates between February 3/November 7 and January 5/December 3. Westward orientations of both long barrows yield declinations between 15° and 21°, corresponding to solar dates between May 1/August 14 and May 26/July 22. At Broniszowice, the axis of the long barrow extended eastward points to a declination close to –14°, corresponding to solar dates of February 11/October 31. Its westward orientation corresponds to the days of April 29/August 14. The comparable solar dates collected at Kunów are February 19/October 23 for the barrow's eastern alignment and April 26/August 18 for the western one.

It is important to observe that orientation patterns of the FBC long barrows are not linked with turning points in the yearly solar cycle, namely, the solstices, and equinoxes. However, it is noteworthy that all orientations are located within the solar arc of particular sites, that is, within the angle of annual displacement of the Sun along the horizon, suggesting their constructors oriented them intentionally. It may imply that Funnel Beaker sky watchers were interested in specific dates marked by the rising and setting positions of the Sun rather than in astronomical events such as solstices or equinoxes. The meaning of the dates mentioned above will become evident when compared to the region's seasonal changes. So now I will attempt to find associations between the solar times determined by the axes of the long barrows and the annual distribution of climatic and ecological variables.

Monument	Western alignment (narrower end)	Eastern alignment (wider end)
Stryczowice long barrow 1	May 1–4/Aug 11–14	Jan 31–Feb 3/Nov 4–7
Stryczowice long barrow 2	May 14–26/Jul 22–Aug 2	Jan 5–19/Nov 19–Dec 3
Broniszowice long barrow 1	Apr 29/Aug 14	Feb 11/Oct 31
Kunów, long barrow 1	Apr 26/Aug 18	Feb 19/Oct 23
Malice Kościelne, long barrow 1	Feb 12/Oct 30	Apr 29/Aug 16
Malice Kościelne, long barrow 2	Feb 22/Oct 19	Apr 16/Aug 27
Malice Kościelne, southern side of long barrow 2	Mar 14/Sep 30	Mar 27/Sep 16

Fig. 3. Alignments of earthen long barrows at the Sandomierz Upland. Dates arbitrarily computed for 3500 BC. Due to the lack of* in situ *measurements, the dates from Malice Kościelne should be taken as approximate ones (even as ± 6 days).

Today, the region has a dominant warm summer continental (Dfb) climate bordering on temperate oceanic climate (Cfb). Notable precipitations occur in all seasons. The key months for seasonal climatic changes are February (the driest month), July (the warmest

and also the wettest month), and January (the coldest month). However, the local climate may further be affected by the climatic conditions of the adjacent Holy Cross Mountains. After winter, minimum rainfall steadily increases from March to July. Soil moisture depends on rain, and any lack of rain in March-April and July may substantially reduce yields. The turn of April and May coincides with the onset of a warmer part of a year. Delayed frosts can occur as late as mid-May (*Kowalski 1997.17*). The ripening of cereals occurs between May and July, a time when rain is also required; a lack of rain in summer also reduces yields. In total, the duration of the growing period is about 200–210 days (see Fig. 4). It should be remembered that present-day climatic phenomena differ from those in the past. During the Atlantic climatic period (7460–3830 BC) the temperature in central Europe was 2° higher than modern levels (*e.g., Harmata 1995.33*), so it is probable that delayed frosts were less frequent.

Overall, winds from the WSW and West bring most precipitations and increased cloud (*Kowalski 1997*). The wind rose from Sandomierz shows in the region the prevailing winds are from the West, WSW, and WNW (see Fig. 5).

To sum up, eastward and westward solar calendar dates roughly tend to cluster around the so-called mid-quarter days. As is known (*e.g., McCluskey 1989*), this term refers to dates falling midway between the dates of the solstices and equinoxes, *i.e.* at the beginning of February, on the turn of April and May, in mid-August and in November. Some scholars associate the quartering of the year with the traditional beginning of the four climatic seasons (*Nilsson 1920.76; McCluskey 1989*). However, in my opinion, it may well refer to the much earlier division of the year into cold and warm halves, with the starting dates around the beginning of November and of

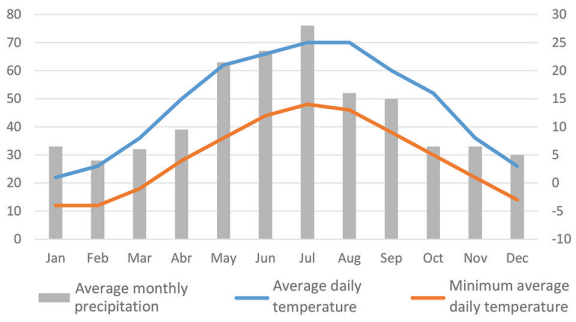


Fig. 4. Seasonal Cycles at Sandomierz. Source: me teoblue.com/pl/pogoda/prognoza/modelclimate/sandomierz_polska_759603, acceded August, 2, 2016.

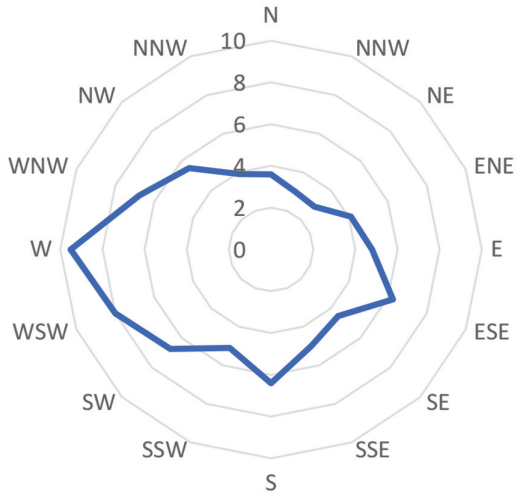


Fig. 5. Wind rose plot for Sandomierz. Source: me teoblue.com/pl/pogoda/prognoza/modelclimate/sandomierz_polska_759603, acceded August 2, 2016.

May, respectively (*Liugman 1938.445, 450–451*). This concept finds additional support in the history of Indo-European languages. The earliest division of the year seems to have been based on the separation of two distinct seasons (either as 'wet' and 'dry' or as 'cold' and 'hot' seasons, *Buck 1971.1011–1016*). Nilsson (*1920.45–85*), who discusses the history of ancient European time-reckoning, also observes that the names of the seasons are borrowed from the names of the climatic phases.

The turn of April and May, as well as the turn of October and November, fall approximately at midpoints between the equinoxes and solstices. Thus, the orientations of Stryczowice, Broniszowice, and Kunów long barrows seem to be linked with turning points in the annual seasonal cycle (Fig. 6). The third turning point (at the turn of January and February) may eventually be related to the period of maximum cold, so its significance for the farming calendar is nil, since it is a resting time in agricultural activities. The fourth turning point, mid-August, may denote the end of harvest-time. The clustering around these dates may suggest they were the intended targets. Of course, these associations are speculative, and the proposed link between the seasonal cycle and the third and fourth dates remains to be further explored.

I shall now recapitulate what archaeoastronomy adds to the overall image of long barrows' significance. The shape of earthen long barrows shows clear evidence of axiality. These monuments denote meaningful directions formulated in terms of alignments towards landscape and horizontal astronomi-

cal targets at seasonally significant times. The meaning of the dates revealed by long barrow orientations is inferred from their correlation with important seasonal changes (such as rainfall, temperature, and vegetative cycles) and agricultural activities (planting, harvesting). In my opinion, the changing positions of the Sun along the horizon provide the temporal and spatial frame for activities performed at the monuments. It informed the potential participants of rituals about the context within which they acted. It shows that solar positions along the horizon cannot be interpreted as being observed by a detached Sun watcher interested in fixing the Sun's positions at the turning points of the annual solar cycle. Rather, solar positions should be viewed as being associated with other natural cyclical phenomena. If this is true, then we are dealing with new types of interpretation. The Sun might be considered as capable of communicating with humans, *i.e.* as being able to signal the change in the seasons and the need to start/end specific agricultural tasks. To sum up, locations of long barrows in high places, together with their solar alignments associated with seasonal changes seem to show new ways in which FBC peoples approached (and understood) their environs.

This idea leads me to the following proposal. The constructors of long barrows who observed the turning points in the annual agricultural cycle also discovered the recurrent character of particular weather patterns. Now, although long barrows were constructed and erected by living inhabitants, they were built to house the dead, mythical or real ancestors of the nearby villagers. To predict and thereby to control recurrent solar and weather, or astrometeorological, phenomena occurring at specific dates would have been the symbol and prerogative of those ancestors rather than of their living descendants. It might be that it was the ancestors buried under long barrows were who utilised the Sun to signal a change in the weather to humans. It might also be that these distant horizon features where the Sun was observed at meaningful dates provide indications about those ancestors abode. In the following, I will explore these possibilities.



Fig. 6. Alignments of long barrow 2 at Stryczowice (photo by author).

Both proposals are in many ways speculative, but at least they fit the body of data we have at present.

The dead and the fertility of the soil: Neolithic beginnings of an agricultural metaphor in burial practices

As a particular kind of artefact, earthen long barrows have received numerous interpretations. However, these interpretations cannot be limited to socio-economic or ritual-mortuary issues. I suggest the spatial layout of long barrows not only permitted a new visual perception of the landscape, but also involved a different perception of the sky. Perceptions of the celestial vault within dense forest and cleared areas should have produced different experiences of the world, giving rise to new cosmological beliefs (*Tilley 2010.50–51*). Therefore, archaeoastronomy, together with walking around the landscape may add new evidence which allows the formation of new and more nuanced interpretations.

As has been suggested many times (*Childe 1949; Fleming 1973; Kośko 1976; Hodder 1984; 1992; Midgley 1985; Sherratt 1990*), the silhouette and outline of long barrows were regarded as imitations (in shape and arrangements) of monumental trapezoidal timber longhouses built by previous LBK (Linearbandkeramik) and Lengyel-Polgár groups. The arrangement of a series of long barrows at Stryczowice, Broniszowice, Garbacz-Skała, and Kunów suggests that a similar metaphor may have been used by Neolithic societies in this region. These 'villages for the dead' situated at the highest locations could have been easily seen from similar places in the upland, but remained invisible from the bottom of the river valleys or lower slopes descending into those valleys. It seems that long barrow locations were visually interconnected and involved in the same web of cosmological concepts. From this brief description,

it is clear that their intervisibility and spatial interplay must be regarded as reflecting a new understanding of the landscape. In my opinion, these elements provide us with a potential guide to interpretation: uplands were associated with funerary monuments and dead ancestors, while lower slopes, lower elevations, and lowland river valleys were associated with living communities.

Furthermore, I also observed (*Iwaniszewski 2006*) that Funnel Beakers situated the barrows in the context of 'outdoor' activities performed outside settlements rather than within the sphere of daily household activities. Regarding the spatial pattern, long barrows were located in fields, grasslands, and forests, *i.e.* within areas of the routine, daily economic activities of Middle Neolithic societies. It is possible that long barrow locations were considered as desirable within a landscape in which primary 'outdoor' economic activities took place. Still, the association of essential economic activities such as gathering, farming or pasturing with enduring funeral monuments appears to be systematic regarding both spatial location and conception. Not only were they linked with the dead, with an ancestral presence in the landscape, and the possible reassessment of the rights over particular plots of land, but also represented a formalised and repeated pattern of social activities that could have been symbolically controlled by those ancestors. This ongoing transformation of the landscape could have provided both identities for the nearby population and symbols of authority imbued with religious meaning. Barrett makes a closely related point, observing that "*as people move through their lands, not only do they learn about relationships between place and their ancestors but also learn about themselves and their particular rights and responsibilities in this land-based scheme of existence*" (*Barrett 1999. 193*). My argument is that clearing the farmland of trees not only permitted the view that land ownership was ancestrally determined, but also that it derived its potency (or fertility) from powerful ancestors. In other words, what I am proposing here is the starting point of a process of associating a fertility cult with a cult of the dead that still is observed in Central European folk culture (*e.g., Pisarzak 1978*).

Although long barrows from the Stryczowice sub-region differ in many aspects (construction materials, location near water sources), they nevertheless match the FBC earthen long barrow general system. Their orientation, shape, size, and internal structure evince a formalised practice within well-defined spaces and follow a definite conceptual system.

In light of the above, it seems significant that the constructors of long barrows intentionally linked their orientations with turning points in the annual seasonal and farming cycles (and not with turning points in the solar year, such as solstices or equinoxes). Consequently, to predict or control those turning points by a dedicated ancestral monument would have been a symbol of the ancestors' power over the farming practices of their descendants.

Malice Kościelne

To test the hypothesis mentioned above, I examined two earthen long barrows at Malice Kościelne. Since I have not visited the site, my study relies on data provided by Barbara Bargieł and Marek Florek (*2006a*). The site occupies the southern bank of the Opatówka River, on the upper part of a slope falling towards the N-NE, about 34–35m above the present valley bottom. The site consists of the remains of two long barrows, and a nearby FBC settlement (about 200m away). My calculations based on the maps and plans published by the authors and from Google Earth maps show that the barrows are roughly oriented towards the distant (over 18km) hills of the Iwanickie Range, which has summits above 300m a.s.l. Declinations corrected for mean refraction vary between –13°06' and – 9°28' (walls of Barrow 1 and the northern wall of Barrow 2), and correspond to sunset dates between Feb 12/Oct 30 and Feb 22/Oct 19) (Fig. 3). The Iwanickie Range may be used as a visual marker of the Koprzywianka River catchment area, which delimits the southern extension of the Sandomierz Upland. The Koprzywianka rises in the Jeleniowskie Range (below the Szczytniak summit, clearly visible from the Stryczowice Region) and flows into the Vistula in the city of Sandomierz.

Assuming that some alignments might be used in both directions, eastern declinations were also computed. On a nearby upland, there are a few small elevations, but they do not seem to be very impressive, so I cannot be sure of the intended direction. In general, these reverse alignments point to the distant and invisible valley of the Vistula, or to the place of the rising sun during the second half of April and August.

It is observed that the southern side of Barrow 2 is significantly skewed and displays alignments around the equinoxes. These are the only alignments that

could have astronomical (*i.e.* equinoctial) meaning. Local topography shows that the longitudinal axes of both tombs are skewed from the mean axis of the slope on which they were built. The site is unusual in that the direct view to the South is entirely blocked by the nearby elevations (azimuths between 216° and 183°), but does not affect vistas to the South-West and West. It seems therefore that through their alignments the tombs were deliberately placed to show visual links with a distant foresight where the Sun sets on specific days. Interestingly, this south-western horizon cannot be observed from the nearby settlement area.

It is immediately evident that the Malice barrows are not aligned in the same way as those from the Stryczowice region (see Fig. 3). At Malice Kościelne, both long barrows are oriented along the SW-NE axis, while the Stryczowice ones prefer the SE-NW axis. Following Christopher Tilley (*1984.122*), this may be interpreted as signifying "*the opposition or relations of non-identity*" between two areas. Therefore, regarding the spatial pattern, it can be suggested that the Stryczowice and Malice Kościelne sites represent different social or political entities. However, in both cases, the long barrow orientations have clear connections with similar local climatic-meteorological cycles. Accepting that alignments were used in both directions, we find they are connected with almost the same turning points of the agricultural year. Therefore, although distinctly oriented, the Malice Kościelne long barrows appear to show the same concern with the solar dates as the ones in the Stryczowice sub-region.

In other words, in all the measured and analysed long barrows, the dates indicated by sunrise/sunset positions are close to the turning points of a seasonal calendar and may easily be associated with some ceremonial activities related to a fertility cult. The watershed of a given cycle (starting in October/November or in April/May) may be interpreted as signaling a liminal situation when one cycle ends and the other begins. The dead were naturally sent to the afterworld at different times, but privileged communication with them might have been achieved during these particular periods of the year. In this context, the above dates may also refer to liminal moments when the 'opening' and 'closing' of the natural world is observed, enabling the transition from the cold to warm or warm to cold halves of a year. These dates also enable open, direct and more efficient communication with the dead to be opened. In this way, the permanent link of long barrows with solar dates could have emphasised an idealised space/time structure shared by the members of a community and a particular association between the ancestors and the potential of cultivated fields.

The realms of the land of the dead

The wider ends of the excavated long barrows at Broniszowice, Stryczowice and Malice Kościelne, and a long barrow at Kunów, which has not been excavated, are on the eastern side. They are all situated near the highest parts of mounds. Although I consider the direction from the broader base towards the narrower end of a barrow to be the proper one (*Iwaniszewski 1995.35*), in the present paper both directions were assessed. The eastern horizon as observed from Stryczowice and Garbacz-Skała is connected to the distant and separate valley of the Opatówka River, a tributary of the Vistula. At Kunów and Broniszowice, however, direct views towards more distant horizon features are obstructed by the nearby hills. However, in all four cases, the long barrow alignments relate to distant horizon features located in the northwestern quadrant. I observed that the narrower and lower ends of long barrows tend to point to higher parts of distant horizons, while their higher and wider 'façades' seem to point much lower and nearer skylines. As the heads of the deceased were also oriented westward, it is possible that they were visually connected through the orientation of a long barrow to the distant and higher northwestern skyline.

Furthermore, Neolithic settlements here tend to be concentrated in the lower parts of the lands separated by adjacent smaller rivers or streams. They are located to the east and southeast of the Garbacz, Stryczowice, and Broniszowice long barrows. It seems, therefore, that in the entire micro-region, long barrows were built with entrances oriented downhill towards the nearby river valleys.

At Malice Kościelne, the FBC settlement is located to the NW, also on a slope descending to a river. The barrows are roughly oriented towards a distant and natural fore sight associated with the catchment area of a remote Vistula tributary. The eastward alignments point to the nearby Opatówka valley. Like all earthen long barrows built by Funnel Beakers, these monuments also display formalised and standardised ritual and spatial behaviour. The space in front of the long barrows seems to have had special ritual significance (*Midgley 1985.64; Bąbel 2006*) where people could have occasionally gathered. The creation of a ritual space for a local community so as

to receive the rays of the rising Sun obviously contrasts with the position of the dead, who are oriented towards the direction where the Sun sets and from where winds, precipitation, storms, and thunder come. As stated above, the locations of long barrows invariably maintain a spatial separation from settlements. In this way, the dead gradually become more distanced from the living community to turn into ancestors or mythical figures relegated to an indefinite abode. In my opinion, the dead, ancestors or mythological subjects might finally be transformed into inhabitants of the world which they shared with the Sun and significant meteorological events. Although the dead were buried in long barrows, their 'real' abodes became the heavens containing the Sun and water. Thus the placement of those funerary monuments at elevated locations could have emphasised their proximity to the celestial sphere.

Having established that these long barrows were preferentially oriented towards higher features found on distant horizons, the reasons for such targets must be defined. In my opinion, the lack of easily observed waterways nearby on the eastern horizon is contrasted with the presence of a remote river valley on the northwestern horizon. The Stryczowice long barrows align with distant landmarks of the valley of the Świślina River. Not only is this a distant horizon, but it also relates to a distinct waterway. The same case is found at Malice, where the distant landmark (Iwanickie Range) is related to the Koprzywianka River. One reason for this pattern might be that long barrow orientations relate them to remote 'upper' cosmic waters, rather than with actual lower watercourses below. If this is true, then the monuments could have been metaphorically viewed as vehicles joining the Eastern and neighbouring world of living with the Northwestern, Western and Southwestern distant world of the dead. Since non-local horizon targets involve the presence of remote 'upper' waters, then it is probable that a symbolic association between the dead and agricultural lands is produced through the mediatory roles of solar events and water falling from the skies.

South-eastern Funnel Beaker Culture and Tripolye cultural affinities

The Tripolye (Trypilia) culture occupied the territory between the Dnieper and the Carpathians next to the eastern limits of the southern-eastern FBC group (namely, the Lublin and Volhyn regions). This very rich painted-ware culture developed during the 5th, 4th and 3rd millennia BC. Wider relationships that existed between communities evident in Trypolyean cultural traits and their western neighbours (*e.g., Balcer 1981; Kośko 1981; Jastrzębski 1985*) resulted in the reception and adaptation of a great variety of Trypolyean cultural patterns by FBC groups. They ranged from technological and stylistic traits in pottery manufacturing to cosmological ideas associated with concepts of the afterlife and ancestors (*Kośko 1981.123–162*).

Close contacts between the Sandomierz Upland and Trypolean Culture (TC) are both reflected in imported materials and artefacts and imitations of them. Objects made of Volhynian flint or items imported from the Tripolye area were found at Ćmielów (3500–3200 BC; *Balcer 2002.15, 90*), Stryczowice (*Matraszek 2001.287*), Malice (*Bargieł, Florek 2006a. 375, 380*), and Pawłow (flat grave 3, *Bargieł, Florek 2006b.386*). Archaeologists have also identified several imported or imitated painted pottery forms and pigments at FBC sites of the Sandomierz Group: Kamień Łukawski (*Kempisty 1968; Jastrzębski 1985*), Stryczowice and Opatowice (*Kadrow 2005.14–15; Kadrow 2009.140–142; Kośko* et al. *1999*) dated to 3640–2888 BC.

The growing number of Trypolyean finds within the Sandomierz area has led some researchers to propose (*e.g., Kośko* et al. *1999.288*) that these FBC communities were 'trypolyezed' ('eneolithised'). Others suggest that contacts were in both directions (*Videiko 1999.43–44*). Still others suggest (*Nowak 2014.193–194*) the growing awareness of borderland society, which led to a very "*peculiar, unique and autonomous space in relation to neighbouring areas*."

To sum up, cultural exchange between FBC and TC groups occurred between 3640–2880 BC or during the Late Middle Neolithic period, when intensive agricultural activity resulted in the clearing of forest from uplands and slopes (*Kruk, Milisauskas 1999. 312–316; Videiko 1999*). It was during this time that FBC mortuary rituals were affected or influenced by south-eastern neighbours (*Burchard* et al. *1991. 99*). Also, certain motifs found in the ornamentation of FBC pottery appear to be adapted from the Trypolean Culture (*Videiko 1999.66*).

The upper world levels and motifs on the painted pottery of Tripolye Culture

So far, I have pointed out that long barrow orientations suggest that the ancestors' abode was localised

in the upper regions of the universe. Within the Stryczowice sub-region, the northwestern part of the skyline was linked to the setting Sun and the moment the hot season arrived, especially the coming of spring storms, thunder and rain which typify the weather during the spring. The onset of the hot season may be identified through the alignments of long barrows, possibly conceptualised as 'houses of the dead'. I suggest that this relationship was reassessed through a series of ceremonies arranged to ensure good crops and the well-being of the ancestors who kept the fields fertile. The alignment came alive again shortly after the harvest. Ceremonies involving pouring grain from the recent harvest onto the monument to ensure a supply for the fields in the coming year could have been performed.

FBC groups evince a similar spatial-meteorological-astronomical symbolism in Malice Kościelne. In February, they could have celebrated the transition from the dry to wet season, and when the Sun set over distant horizon fore sight in early November, they could have observed the arrival of the cold season and a significant decline in precipitation. Both calendar dates are liminal, since they indicate the transition from one season to another. In contrast with the Stryczowice region, where the calendar dates relate to the wet and hot season, at Malice Kościelne the solar calendar dates made manifest through alignments are associated with the dry, cold season.

The influence of TC noticed in the materials from the large FBC settlements in the Sandomierz sub-region of the southeastern FBC group allows me to ask whether any ideological or worldview patterns were imported from Tripolye Culture into the Sandomierz Upland.

My argument in this section will be that the location of the long barrows at the Stryczowice sub-region reflects a worldview which can be explained by specific depictions on Tripolye pottery. As is known, Boris A. Rybakov interpreted the motifs painted on Trypolyean cooking pottery in terms of a fertility cult. Furthermore, he concluded that these motifs represented the tripartite structure of the world (*Rybakov 1965.37*). Thus the upper band of wavy lines represented the 'upper' heavenly waters. Just below it, another band filled with spirals, solar and lunar symbols, and vertical streamer-type lines recalling falling rains rendered the 'upper' atmospheric-meteorological waters. The bottom band filled with vegetal, animal or human figures represented the level inhabited by people (see Fig. 7). It seems that the sky with its rain resources, together with the alternation of seasons and the life cycle, constituted central themes in the worldview of the Tripolyeans. Curiously enough, there is no place for the dead in Rybakov's interpretation (compare *Kośko 1981.159*).

Today, many of these ascriptions of meanings may appear ambiguous. Scholars who examine these depictions usually focus on the ascription of meanings, and this idea is based on an interpretation of motifs as visual symbols or signs. For example, spiral ornaments are interpreted as visual images of serpents, celestial dragons, dragon-serpents and serpen-

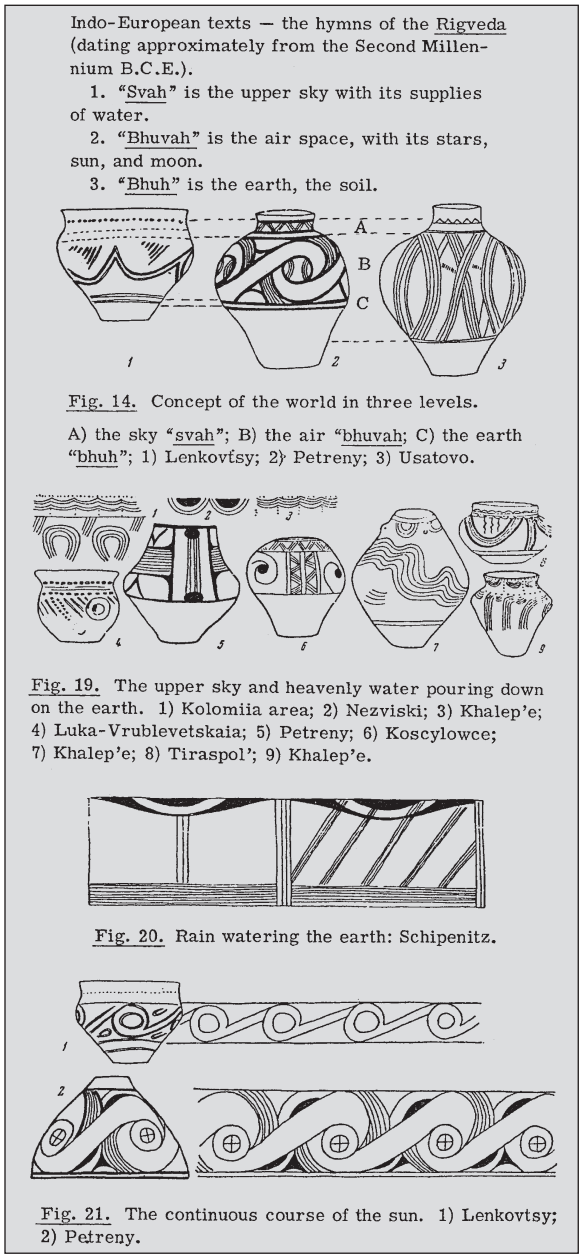


Fig. 14. Concept of the world in three levels.
A) the sky "svah"; B) the air "bhuvah; C) the earth "bhuh"; 1) Lenkovtsy; 2) Petreny; 3) Usatovo.

Fig. 19. The upper sky and heavenly water pouring down on the earth. 1) Kolomiia area; 2) Nezviski; 3) Khalep'e; 4) Luka-Vrublevetskaia; 5) Petreny; 6) Koscylowce; 7) Khalep'e; 8) Tiraspol'; 9) Khalep'e.

Fig. 20. Rain watering the earth: Schipenitz.

Fig. 21. The continuous course of the sun. 1) Lenkovtsy; 2) Petreny.

Fig. 7. Collage of Rybakov illustrations showing the vertical and tripartite structure of the Trypolyean cosmos (after* Rybakov 1965*).

tine-like goddesses, or as solar signs (*Palaguta 1999; 2009; Tsvek 1993.81–87*).

The importance of water symbolism in funeral practices cannot be ruled out, since fragments of similar motifs have been found on pottery excavated at Broniszowice, Stryczowice, and Malice Kościelne. This fact enables us to explore other research possibilities.

Various scholars (*e.g., Bradley 2000.60–63; Woźny 1996.50–55, Tab. 1, Map 1, 103–106; Adamczak 2013.183–186*) have already noticed a correlation between the locations of long barrows and ritual deposits placed in water (springs, lakes, bogs, rivers). Watery associations between FBC settlements and long barrows have long been reported in other FBC groups. For example, in Kuyavia, Eastern Funnel Beakers often located their settlements and long barrows near water sources, deposited ritual items in water and used damp soils with snails and mussels to cover the dead in earthen long barrows (*Woźny 1996.53–57, Tab. 1; Adamczak 2013.183–188*). Similar votive bog deposits of the FBC have recently been suggested for the area of the South-Eastern Group (*Libera, Zakościelna 2006*). In the Sandomierz Upland, long barrows were located on raised loess hills, which are relatively dry areas. Unfortunately, the distribution of long barrows in connection with the locations of streams or springs has not been studied yet.

Now, according to Jerzy Bąbel (*1979*), Jacek Woźny (*1996.55*), and Kamil Adamczak (*2013.184*), the vessels used as ritual deposits seem to have shared a specific type of decoration. The most typical decorative motifs include wavy horizontal lines, or zigzags placed just below the rim, presumably representing water symbolism. Below them, sometimes motifs consisted of a central stalk and short lines in pairs placed at intervals and directed downwards, possibly representing trees or plants, seem to suggest a kind of composition containing a water and vegetative components (*Woźny 1996. 103*). According to Bąbel (*1979*) and Aleksander Kośko (*1981.159–161*) Funnel Beaker communities depicted celestial waters (in the form of horizontal lines), clouds (garlands) and falling waters (vertical rows of cuts). Note that, when connected with agriculture, such motifs may refer to the warmer half of the year, between March and July, when most rainfall occurs (*Kowalski 1997. 17–18*).

Assuming that the sky as conceptualised by Funnel Beakers was permeated with water and depicted in its pottery, one may ask whether the realm of the land of the dead was also related to water symbolism. My interpretation links the dead with celestial waters. It associates both the long barrows and the dead with the time when the warmer part of the year begins. The Earth is 'opened', so vegetation sprouts and the dead or the ancestors approach human settlements for food. Does it mean that it is the dead who pour water on the fields?

According to Rybakov (*1965*), the lower level of the sky was where celestial bodies pass across the heavens and rain waters were stored. It follows that the decorated pottery describes the relationship between the upper sky, the lower sky, and the land. Thus it represents two celestial layers rather than one. My interpretation links the dead with the waters above. Both proposals are in many ways speculative, but at least fit the body of data we have at present.

There is little evidence showing the Sun was imagined as an animate being, with agentive power. The status of ancestors seems to be different. Examples from the Northern Funnel Beaker Group indicate they could use ships to reach the heavens (*Adamczak 2013.184*), but no such associations are known in the area. Therefore, I assume that the ancestors buried under long barrows were considered as animate beings who used the Sun to signal changes in weather to humans.

Conclusions

The landscape, archaeoastronomical and symbolic analysis of long barrow locations in the Stryczowice micro-region reveal interesting patterns related to the worldview of its Neolithic inhabitants. Combined with the designs displayed on some FBC vessels, those examples show patterns of the worldview of FBC societies. Although FBC vessels seem to imitate the ornamentation of Tripolye pottery, which depict a three-level structure of the world, some substantial differences in both images of the universe existed. According to the present interpretation, the fertility of the fields was interwoven with an ancestor cult. Different elements in the sky were merged: the Sun, spring rains, rain-bringing winds, cold, dry winds, remote mountain landmarks, and ancestors. While the first two elements were possibly of Tripolyean origin, the development of long barrows in the region resulted in the placement of the dead in the western quadrant of the sky, where they became associated with waters.

It can be argued that the dead were either incorporated into existing long barrows or were provided with monuments of their own to denote that the land – its productive-vegetative cycles – were owned or at least controlled by them. The dead were perhaps seen as having more permanence in the landscape than living communities and therefore had a longer-term claim to the land. On the other hand, the people were concerned with their own identity and defining themselves as separate from both the natural world and the physical location of the dead. The dead were approached and incorporated into systems of beliefs through the agricultural cycle itself. The structural organisational metaphor used to understand the world was based on the correlation made between astronomical and meteorological cycles.

This paper shows that archaeoastronomy can offer valuable insights into the study of the past. However, it also indicates that not all Neolithic monuments display align with turning points in the annual cycle. While such alignments may easily be dismissed by scholars whose research interest is limited to seeking astronomically meaningful orientations, researchers with a keen interest in cultural phenomena may find this evidence strongly indicative of the intentions of long barrow builders and users. This type of research shows more affinities with the practice of archaeology than with archaeoastronomy itself (*Bostwick 2006*).

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The swan chariot of a solar deity: Greek narratives and prehistoric iconography

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ABSTRACT – *Literary testimonies for the Greek concept of Apollo's swan chariot and the accompanying set of ideas were often discussed alongside some comparable Central and North European iconographic representations. This study approaches the problem by collating, with a help of structural analysis, a number of highly specific complex prehistoric iconographic arrangements (most notably the Dupljaja chariot), which suggest a similar concept was indeed current in the tradition of some European pre-literate societies. The principles employed here in the iconographic analysis of complex symbolic structures, offered a sound methodological basis for comparing literary with iconographic sources. It is concluded that their underlying* muthos *represents an account of the annual solar movement in terms of anthropomorphic causation.*

IZVLEČEK – *Pisni viri, ki se nanašajo na grški koncept Apolonovega voza z labodi in na idejne nastavke, ki spremljajo ta koncept, se pogosto uporabljajo ob primerljivih ikonografskih upodobitvah iz srednje in severne Evrope. V tej študiji se spoprimemo s tem konceptom s pomočjo strukturalne analize, tako da primerjamo nekaj zelo specifičnih in kompleksnih prazgodovinskih ikonografskih postavitev (najbolj znan je voz iz Dupljaja), ki kažejo na to, da je bil koncept sočasno navzoč tudi v tradicijah nekaterih evropskih pred-pismenih družbah. S principi ikonografske analize kompleksnih simbolnih struktur smo postavili dobro metodološko bazo za primerjavo pisnih in ikonografskih virov podatkov. Sklepamo, da osnovni* muthos *predstavlja razlago o letnem gibanju Sonca v antropomorfnem smislu.*

KEY WORDS – *water-birds; Apollo; iconographic analysis; Dupljaja; sun*

Introduction

Much has been written in the past on the question of the connections between Greek Apollo and a Central and/or Northern European prehistoric solar deity recognised in iconographic representations[1], frequently called, not without some justification – although only if this name is put inside quotation marks and understood as a provisional term referring to a specific concept – 'Hyperborean Apollo' (*Krappe 1942; 1943; 1947; Sprockhoff 1954; Gelling, Ellis Davidson 1972; Ahl 1982; Kaul 1998. 253; Kristiansen, Larsson 2005.44*)[2]. These connections cannot be treated – and they are in general not treated in such a way – discriminatively towards other influences on the formation of this

1 For the derivation of a (hypothetical) North European anthropomorphic solar deity from an (equally hypothetical) Central European one, see Kaul (*1998.56, 252*).

2 The earliest undoubted identifications of Apollo with the sun in Greece appear in Telesilla (fr. 2 *PMG*) and in Aeschylus' *Bassarai*, where it is attributed to the Orphics (TGrF III.138 Radt ap.[Eratosth.] Cat. 24, *cf.* Σ Germ. 273 p. 84.6–12 Breysig = *PEGr* 1148 T I Bernabé; *West 1990.38–39; Seaford 2005.602*); it is also implied in Aesch. *Sept.* 856–860. West (*1990.40–41*) associates the information in the *Bassarai* with the description of Orpheus' *katabasis* in Plutarch's *De sera num. vind.* 22.566BC (*Orph. fr.* 294 Kern = *PEGr* 412 F, 998 T I Bernabé) involving Apollo, and concludes that Aeschylus and Plutarch might have used the same source, the Orphic poem *Krater* attributed to the early Pythagorean Zophyrus or, alternatively, an early Orphic-Pythagorean *Katabasis* (*cf. Seaford 2005.602*). Thus the identification of Apollo with the sun was current at the latest in the 6th century BC.

Olympian deity, even though they occasionally tend to be over-emphasised. Although I will not discuss numerous further components involved in Apollo's formation, I must clearly state that this essay, although focused on a single aspect, is not irreconcilable with, and fully acknowledges the existence of, other approaches (see *Graf 2008; cf. Solomon 1994; Detienne 1998*). The prevalent opinion among modern scholars is indeed that Apollo is a complex figure that developed diachronically by a process of synthesis, and that his 'fully formed' character can be analysed into its component parts (*Burkert 1985. 144; Versnel 1985–1986.136; 1994.293; West 2007. 148*). The results of these modern studies show that any connection with either Central or Northern Europe is at best secondary, but not irrelevant.

Two types of evidence are normally adduced in the discussions on the 'Hyperborean Apollo' (here covering both Greek, where the name is attested in literary sources, and prehistoric concepts): literary sources, when analysing Greek tradition, and the archaeological record, when analysing the prehistoric. But a coherent methodological basis for certain far-reaching conclusions has rarely been offered. This paper will try to review the available evidence, both literary and iconographic (the *explananda*), and to propose, building from this evidence, what I believe is a sound methodological foundation for the comparative (*i.e.* paradigmatic) approach in analysing the objects of material culture alongside literary testimonies, based on a structural analysis of complex iconographic arrangements, as well as to offer an interpretation of both types of evidence based on the conclusions derived from these comparisons (for the indispensability of the comparative method in religious studies, see especially *Segal 2001*).

The main criterion employed in the process of collating iconographic testimonies for this particular concept will be a syntagmatic analysis of their design, but one which is intimately connected to the comparative approach outlined above. This procedure was selected in order to emphasise that it was the data themselves that instigated the discussion on methodology, rather than a preconceived notion subsequently applied to the two categories of testimonies. However, interplay between theory and data is necessary in all research, and I will often work my way downwards, interpreting data with the help of a theory, in its turn based on ancient literary and iconographic testimonies – thus employing a form of hermeneutic circle. The main hazard of this approach is the possible fall into circular reasoning, which I will try to avoid by different control mechanisms that will be elaborated at appropriate places.

Another difference from earlier studies using similar approaches is that I have chosen to study a more restricted range of iconographic motifs, effecting a significantly more focused analysis of a single, yet complex, iconographic design. I believe that this method offers additional stability on rather slippery ground, and I am confident that the decisive element in this particular design – namely, the presence of anthropomorphic agent – offers still more evidence for the basic similarity of approaches in the treatment of identical phenomena by different traditions.

As a final introductory remark it should be emphasised that the concept analysed here was either directly or indirectly connected with cultic activities, which is discernible from both the iconographic and later literary sources, and could thus be classified as 'religious'. But, as will become clear in my discussion, the subject of analysis of this essay are literary and iconographic manifestations of a myth understood as a narrative model representing a specific aspect of physical reality (annual solar movement)[3], which can only anachronistically be classified as a 'religious' phenomenon (see *Insoll 2004. 6–8*). Therefore, this study will support the notion that although myth undoubtedly has much in common with the category of 'belief systems', its independence from the concept of religion or cult, with which it is connected and intertwined, but from which it is certainly distinct, should be respected[4]. This also accounts for the relative stability of the narrative model, as opposed to its appropriation by various belief-systems, which undoubtedly in the process re-interpreted it in their idiosyncratic, now largely hard to reconstruct, manners.

3 This definition of myth is very close to Donald's (*1991.213–215, 259*). He understands myth as a use of language in constructing conceptual models of the human universe, *i.e.* of relevant features of the environment, which creates a coherent system of explanatory metaphors. Furthermore, myth is a modelling device primarily on a thematic level, rather than episodic, focused on deriving general principles, which corresponds to the nature of the concept treated in this paper. For myth and archaeology see Insoll (*2004.127–131*).

4 For an overview of theories on myth in general and Greek myth in particular, see, for example, Kirk (*1974*), Dundes (*1984*), Bremmer (*1988*), Edmunds (*1990*), Graf (*1993*) and Csapo (*2005*).

A concise review of literary sources

The 'Hyperborean Apollo' is mentioned for the first time by Alcaeus (born *c*. 620 BC), unfortunately only in a summary preserved by the 4th century AD rhetorician Himerius[5]. Here, Apollo's swan-chariot in which the god flew after his birth to the land of the Hyperboreans, whence he returned to Delphi in the middle of summer, is described (Alc. fr. 307c Lobel-Page *ap*. Him. *Or*. 48.10–11)[6]. Unfortunately, this testimony is more often than not the single statement adduced in the discussion of the Greek concept of Apollo's swan chariot and his voyage to the Hyperboreans.

However, there are many more. First, I shall briefly review the tradition of Apollo's visit to Hyperborea. Thus, the mythic 6th century BC sage Abaris allegedly wrote a poem on the arrival of Apollo to the Hyperboreans (Suid. α 18), Hecataeus of Abdera (late 4th–early 3rd century BC) described the island Helixoia in the far north inhabited by the Hyperboreans, visited every 19 years by Apollo (*FGrHist* 264F7; D. S. 2.47.1, 6; F11a; St. Byz. s.v. *Helixoia*, *cf.* Hdn. Gr. iii.1.281.13–14 Lentz), while Apollonius Rhodius (1st half of the 3rd century BC) reports how Apollo travelled to Hyperborea starting off from Lycia (A. R. 2.674–675), and he describes Apollo's sojourn in Hyperborea as a kind of exile, not as a regular occurrence (A. R. 4.611– 617). Simmias of Rhodes (late 4th–early 3rd century BC), on the other hand, implies he visited the Hyperboreans starting off from Babylon (fr. 2 Powell *ap.* Ant. Lib. *Met.* 20). Plutarch (2nd half of the 1st–early 2nd century AD) says Apollo is absent from Delphi during the three winter months, not explicitly mentioning where he actually departs to, while for the remaining three quarters of the year the god is in his sanctuary (*De E* 9.389BC), and Cicero (1st century BC) reported how, according to tradition, Apollo came to Delphi from the land of the Hyperboreans (*Nat.* D. 3.57). Claudian (late 4th century AD) described how Apollo leaves Delphi for Hyperborea only to return from the Riphaean on a chariot drawn by griffins (*Cons. Hon.* 26–27, 30–31). It seems that Claudian replaced Apollo's swans with griffins, because the latter became in time associated with Scythia and the farthest north – their fight over gold with the Arimaspians in the vicinity of Hyperborea was repeatedly described – and thus became a symbol of Apollo. Claudian certainly knew of Alcaeus' poem, as did his slightly older contemporary Himerius, or at least of a tradition that described Apollo's arrival (or return) from Hyperborea on a chariot drawn by some mythic animals. Moreover, he is the only author apart from Alcaeus who combined these two concepts, *i.e.* the chariot and the Hyperboreans.

The second concept, that of the swan chariot, was mentioned only occasionally by Greek authors. Thus Sappho (late 7th–early 6th century BC) and Pindar (late 6th–1st half of the 5th century BC) deck Apollo with golden hair and lyre and 'send him drawn by swans (*kuknois epochon*) to Mount Helikon' (Sapph. fr. 208 Lobel-Page and Pi. fr. 262b Bowra *ap.* Him. *Or.* 46.6, trans. *Campbell 1982*)[7]. This translation suggests that Apollo used a chariot drawn by swans (*cf. Page 1955.249*), but *epochon* means 'mounted upon something', whether a horse or a chariot (*LSJ s.v.*); on the other hand, it is not probable that the god was carried on more than a single swan, and his swan-chariot seems to explain the passage in a satisfactory manner. Finally, Nonnus (late 4th–early 5th century AD) reported that Apollo has a winged swan, not a running horse, presumably drawing his chariot, or he has it simply to ride on (*D*. 38.206).

In short, this whole concept as known from literary sources seems to echo a conflation of two different yet complementary ideas: a seasonal change associated with the sun's return from the south where it abided during winter months, and its cohabitation with the Hyperboreans in the farthest north at the time of the summer solstice (*Olmsted 1994.137; Bilić 2012.509–510, 515–519, 527; cf. Gernet 1981 [1933].116; Parker 2005.417–418*).

Hyacinthus – a convergence of literary and iconographic testimonies

Interestingly, there is only a single – and rather late – iconographic depiction of Apollo in a swan-drawn chariot: the deity (with a quiver) is thus represented together with Cyrene (?) on a Roman-period engraved gem (*M.-A. Zagdoun* in *LIMC VI.1 (1992).169 s.v. Kyrene, no. 18*). Moreover, this is the only non-Etruscan depiction of a swan-drawn chariot that can be associated with the god. The connection of this

5 Here the word Hyperborean is put inside quotation marks, because it refers to a Greek notion of Apollo associated with certain set of ideas (swans, Hyperboreans, northern voyage, *etc.*), not all of which were consistently attached to him in every specific manifestation of this model.

6 Aristophanes' description of swans on the Hebrus greeting Apollo (Ar. Av. 769–783) could be associated with his return from the north (*Sprockhoff 1954.70; Kothe 1970.205*), but this is only hypothetical.

7 Cf. fr. 52c Snell = Pa. 3 in POxy. 5.841 and Snell's discussion in his edition of Pindar (*Snell 1964.20*).

unusual chariot with Apollo in Etruscan tradition is plausibly established through the appearance of Hyacinthus in a chariot drawn by swans. Apollo is indeed sometimes explicitly syncretised with Hyacinthus (Plb. 8.28.2; Nonn. *D*. 11.220), perhaps also in iconography (*L. Villard, F. Villard* in *LIMC V.1 (1990).550, s.v. Hyakinthos, no. 55*), his Laconian appearance as Apollo *tetracheir* (Hsch. κ 3853, *cf*. κ 4558; Sosib. *FGrHist* 595F25; Lib. *Or*. 11.204; *IG* V.1.259) can be associated with the hero (*Farnell 1907.127, 371*), while Spartan Hyacinthia were devoted to both (*Pettersson 1992.9–41; Graf 2008.34*), also suggesting a sort of syncretism. With this in mind, Hyacinthus' appearance in a swan-drawn chariot closely associates him with Apollo.

However, as opposed to Apollo in a swan chariot, this concept is almost exclusively known through iconographic representations. Actually, Philostratus (3rd century AD) is the only literary source mentioning the hero riding in Apollo's swan-chariot (Im. 14), albeit while describing a painting, although not the depiction itself, whereas the theme was rather popular in Etruscan art from the 4th century BC onwards (*L. Villard, F. Villard* in *LIMC V.1 1990.548–549 s.v. Hyakinthos, nos. 35, 37–40*)[8]. Thus the Hyacinthus/swan-chariot association is almost exclusively known through iconographic representations of Etruscan origin. This is not so strange if we take into account that Etruscan iconography occasionally illustrates certain poorly documented versions of Greek myths (*Nielsen 2002. 183*).

On the other hand, it will be shown below that it is perhaps possible to associate this particular Etruscan iconographic motif with a strong local prehistoric tradition of producing structurally similar complex symbolic iconographic nexuses.

Archaeological evidence

Introduction

In this part of the paper, I offer an analysis of several prehistoric iconographic arrangements revealing a similar syntagmatic structure, allowing for certain paradigmatic shifts: an anthropomorphic deity (or mythic person) riding in a chariot drawn (or accompanied) by water birds, normally swans, decorated with postulated solar symbols[9]. With respect to these, it appears that often the scholars discussing many of the complex symbolic objects analysed here independently arrived at some rudimentary form of the interpretation that is argued for in this essay, but failed to precisely define the characteristics of the symbolic structure that was the object of their immediate study, to use comparative pieces of evidence and to contextualise particular manifestations of the concept underlying them in their proper intellectual setting. I will henceforth refer to this set of ideas as the 'Dupljaja concept', not because I believe it is the 'origin' of all other attestations of this matrix, but because it is its best known and, as it will be shown below, one of its most revealing, materialisation. This complex arrangement permits, I believe, the supposition of a similar underlying *muthos*, a story or concept shared by these complex schemes[10].

In any case, as will be shown below, it seems more profitable to compare systems composed of several elements that otherwise appear separately, since single motifs or symbols can cover a wide range of meanings, but their arrangement into a presumably coherent structure – *i.e.* one that carries some meaning (*cf. Renfrew 1994.53*) – significantly reduces the number of possible meanings. Because of this, I have selected a highly complex and specific system rather than such simpler matrices as *Vogelsonnenbarke* or *Vogelbarke* or water-bird symbolism in general, on which most of the earlier analyses focused. In this way, I hope to bypass some of the pitfalls of comparative method, especially circularity, *i.e.* arbitrarily adducing the meaning of a motif and applying this interpretation to other occurrences of this motif without further discussion.

I have applied two main criteria for selecting the complex sets discussed in this study. First, following Colin Renfrew, I employ a cross-cultural identifica-

8 No. 39 might show a trace of a quiver, which is highly conjectural, but it would associate the figure with Apollo, rather than Hyacinthus.

9 The postulated solar symbolism must naturally always remain tentative. As a rule, I have noted under this category only those iconographic elements that were accepted as having some solar connotations by previous authors that discussed the respective objects considered here. An element of circular argument is unavoidable at this point, but the structural analysis should eliminate the arbitrariness of the assumptions adduced here. For solar symbols in the European BA iconography, see Müller-Karpe (*1978–1979.23*).

10 I will use the transliterated Greek word when referring to this specific meaning of the concept 'myth' in order to avoid the negative connotations acquired by the latter, especially with respect to its truth-value. It also recollects the Aristotelian meaning of the term (*Poet.* 1450a4–5, *cf.* 32–33, 36–39), which is very close to this specific meaning.

tion of various representations of recurring mythic persons, defined by their specific attributes (*Renfrew 1994.53*)[11], although I have studied these 'clues' in the context of the structure of a complete iconographic scheme[12]. I have thus been able to recognise a recurring interrelation of a group of motifs and their syntagmatic arrangement (an anthropomorphic deity/mythic person riding in a chariot drawn/accompanied by water birds, normally swans, decorated with postulated solar symbols), and have provided a syntagmatic analysis (*cf. Hodder 1987.3*) of thus collated complex prehistoric iconographic arrangements (Tab. 1). This criterion could provisionally be called 'structural'.

Additionally, I have placed one of the accents on the precise (as much as possible) chronological relations in order to contextualise the discussed symbolic structures and thus to eliminate the inherent ahistorical nature of the structuralist approach[13]. It could be objected that the complex figures analysed in this paper cover vast chronological (more) and spatial (less) distances; this is indeed true, but I hope that the following discussion will explain why this is not an insurmountable problem[14]. The key concept with respect to this possible objection will be the definition of a large-scale context or shared cultural space in which these complex figures appear. In a similar fashion, Svend Hansen argued for a spatially and temporally broad perspective in studying the formal similarities of Neolithic and Chalcolitic anthropomorphic figurines of the Near East, Anatolia and South-Eastern and Central Europe (*Hansen 2001.38–42*). This criterion could provisionally be called 'contextual'.

These main criteria, together with their refinement, which allows a stronger focus and control, create a solid framework that eliminates up to a reasonable point the possibility of arbitrariness in the selection of the complex symbolic objects used in this study.

Dupljaja

Apollo's swan chariot and its connection with Hyperborea were long ago, and still regularly are, associated with the famous BA wagon model from Dupljaja (Fig. 1). It shows a male god[15] riding in what is best described as a swan-chariot, defined by three water birds emerging from the vehicle. The base of the hemispherical wagon-box is decorated with a four-spoked wheel, most probably a solar symbol (*Petrović 1928–1930; Kossack 1954.11–12; Sprockhoff 1954.67; Bošković 1959; Letica 1973.63–64; Coles, Harding 1979.408; Pare 1987.58–61, Fig. 25; 1989.84–85, Fig. 4; 2004.357–358, Fig. 2; Green 1991.45, 84, 114, Figs. 88a–b; Kaul 1998.254; Harding 2000.167, 322, 324; Vasić, Vasić 2003.158–160; 2003–2004.182–183; Holenweger 2011.223–*

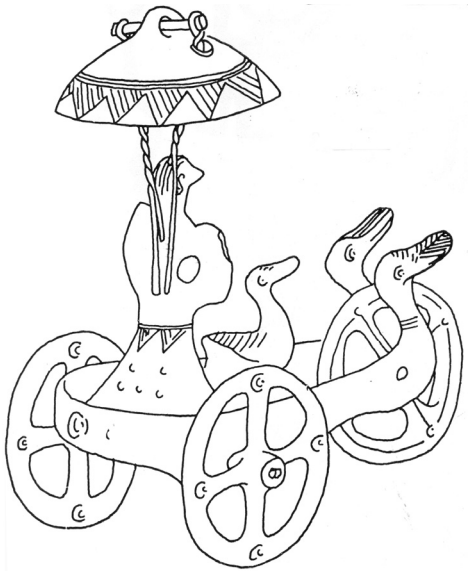


Fig. 1. Dupljaja model (after* Bošković 1959.Pl. 24. 13*).

11 The emphasis on the anthropomorphic character of the main agent in the structure of a complex figure will be explained later; it is not conditioned by Renfrew's discussion.

12 Occasionally, an individual religious or iconographic motif could be tentatively treated as an element in a complex religious phenomenon, and, moreover, as representing some feature of particular natural forces (*Kaul 1998.13*). I decided not to apply this hypothesis in my discussion, since I wanted to give additional stability to my argument by relying on structural analogies between complex symbolic structures.

13 For an analysis of the ahistorical nature of structuralism, see Vidal-Naquet (*1981.175–176, 185*) and Hodder, Hutson (*2003.62–63*). For structuralism and history, see also Harkin (*2009.39–40, 44, 46–48, 50, 52*). For the importance of chronological relations in approaching similar issues, see Kaul (*1998.10, 15*). For the structural analysis of material culture, see Hodder (*1987.3*) and Hodder, Hutson (*2003.45–74, 126, 214–215*).

14 Compare Müller-Karpe's study on BA objects with religious symbolism, which covers the area from Egypt to Atlantic and the North Sea during the Middle and Late BA (*Müller-Karpe 1978–1979*).

15 An anthropomorphic solar deity, according to Sprockhoff (*1954.67 (cf. Maraszek 1997.75)*), Gelling, Ellis Davidson (*1972.119*), Green (*1991.114, cf. 13, 84*), Kaul (*1998.254*) and Kristiansen, Larsson (*2005.150, 307*). Holenweger (*2011.223–224, 242–244*) also argues for the statuette's role in the solar cult manifested in the ceramic material of the Dubovac-Žuto Brdo-Gârla Mare cultural group. For this particular solar cult (*cf. Palincaş 2013.317*).

	Dupljaja	Knossos	Floth	Italy?	Veii
Date (BC)	1500–1200 (?)	950–900	900–700	1200–900	900–875
Agent (anthropomorphic)	male divinity	female divinity	male divinity/ divinities	divinity/divinities (male and female)	male divinity
Transport	chariot	chariot	boat(s)	boat(s)	boat
Water birds	water birds + ornitomorphic face	birds	water birds	water birds	water birds
Postulated solar associations	four-spoked wheel	seasonal character	circles, disks	disks, circles	disks

	Campania	Bisenzio	Cerveteri	Saône	*Kriegerwagenfibeln*
Date (BC)	850–750	725–675	625–600	500–400	late 6th–5th *c.*
Agent (anthropomorphic)	female (?) divinity	female (?) divinity	male divinity	male divinity	male figure
Transport	boat	boat	chariot	chariot	chariot
Water birds	water birds	water birds	ornithomorphic body	bird's head, bird	(water) bird
Postulated solar associations	spirals, radiating and concentric circles, disks, cross	disk	rosettes	none	none

Tab. 1. Structural analysis of iconographic complexes discussed in the text.

224, 242–244, 334–335). Alternatively, the model can be interpreted as a sun-ship with swan-stems (*Sandars 1968.174; Kaul 1998.254*). This paradigmatic shift does not change much in the model's syntagmatic arrangement (*cf. Kaul 1998.254*). In any case, the model could be interpreted as a fairly faithful illustration of the myth of Apollo riding in a swan-chariot (although I must emphasise that it most certainly is not such an illustration)[16].

Fortunately, it is possible to date the model with a precision that allows it to be contextualised with some certainty. It is thus regularly associated with MBA 'Danubian' anthropomorphic figurines[17], and is accordingly dated to this period[18]. However, the Dupljaja chariot shows some features that are quite unique in the complex of the 'Danubian' MBA anthropomorphic figurines, at the same time clearly foreshadowing the future Urnfield solar/water bird symbolism (*cf. Kristiansen, Larsson 2005.307–308*). This fact is reflected in the attempts to date it by a number of scholars, opting for a somewhat later period (the LBA) in comparison to the opinions adduced above[19]. From a semantic point of view, that is; with respect to the interpretation of its meaning, however, it is less relevant whether the chariot should be dated to the Middle or Late BA, as long as its large-scale context is clearly defined: the symbolism of either a nascent or already established Urnfield cultural complex. Relatively numerous finds of a type of *Kesselwagen* (cauldron-wagons) incorporating the water-bird symbolism in their design[20] and other

16 Compare Sprockhoff (*1954.70–71*) and, more cautiously, Kaul (*1998.254*); this is one of the reasons that led Vasić (*1954*) to pronounce it a forgery.

17 For a lengthy review of previous scholarship on the origin of these figurines, see Holenweger (*2011.123–148, 150–151*); for their Aegean origin, see Holenweger (*2011.45–46, 148–153, 188–191, 266–267, 270*), Chicideanu-Sandor, Chicideanu (*1990.69–73*), Kalogeropoulos (*2007.263–265*) and Palincaş (*2012.24*); for their Central European origin, see Letica (*1973.53* (*cf. Kossack 1954. 9*)), Sandars (*1968.176, 315*) and Kiss (*2007.125–128*).

18 Br C1–Br C2, contemporaneous with LH IIIA (late 15th–14th century) Mycenaean Phi idols (*Pare 1989.84; cf. Chicideanu-Sandor, Chicideanu 1990.57*); Bz B (1600–1500 BC; *Letica 1973.60*); the whole complex of these figurines is dated to Br C1–Br C2 (1500–1300 BC; *Majnarić-Pandžić 1982.53*); to Br B1–Ha A1 (1600/1500–1200/1100 BC; *Kiss 2007.127*), or to a somewhat broader chronological horizon (the entire MBA) (*Hänsel, Hänsel 1997b.59*).

19 Bz D (early Urnfield, 1300–1200 BC; *Sprockhoff 1954.67, 73; Bouzek 1985.53, 178, 234; Kaul 1998.254*); vague attribution to 'the Urnfield sphere', at the same time suggesting a date as late as 1050 BC or even later (*Coles, Harding 1979.408; cf. Green 1991.147*); late MBA/early Urnfield period (*Hänsel, Hänsel 1997b.67*).

20 Orăştie, Br D–Ha A, 13th–12th century (*Demakopolou* et al. *2000.260–261, 134*); Skallerup, earlier period III, Br D, 13th–12th century (*Pescheck 1972.50; Egg, Kaul 2001.474, Abb. 55*); Peckatel, earlier period III, Br D, 13th–12th century (*Demakopolou* et al. *2000.261*); Acholshausen, transition from Ha A2 to B1, *c.* 1050/1020 BC (*Pescheck 1972.49–52*); the 8th–7th century examples from Bujoru (*Moscalu, Beda 1991.217, Abb. 11*), Delphi (*Kilian-Dirlmeier 1974*), Marsiliana d'Albegna (*Egg 1991.192–207*), Veji, Grotta Gramiccia (*Müller-Karpe 1974.96–97, T. 22.1*), and Vetulonia, Circolo dei Lebeti (*Egg 1991.202 Abb. 10*).

objects decorated with motifs such as water birds, sun-symbols, and (occasionally) a barque (especially the *Vogelsonnenbarke*), dating from the Bronze-age Urnfield cultural complex and the later Hallstatt period[21], distributed throughout the Central Europe and beyond (Italy, Northern Europe, the Aegean), show that the Dupljaja wagon, although unique in its complexity, is not an isolated find, but part of an elaborate and widely distributed set of beliefs.

Thus the existence of an intricate concept can be recognised in the Middle Danube region in the second half of the 2nd millennium BC, manifesting itself in the Dupljaja figure. This complex structure then occasionally reappears in succeeding periods throughout Central, South-Eastern, South-Central and Northern Europe, as will become apparent in the following discussion.

Northern Europe

The only direct Northern European structural parallel to the 'Dupljaja concept' is an LBA belt buckle from Floth (Ha B2/3–Ha C1, 9th–8th century) (*Hänsel, Hänsel 1997a.133–134; Hänsel 1997.20–21, Fig. 2*) (Fig. 2). Two symmetrical *Vogelbarken* with stylised human adorants (the head of one of the figures is formed of two concentric circles, the head of the other of a single circle) are depicted on this buckle, with three solar disks around them – positioned at sunrise, zenith and sunset? (*Hänsel 1997.21*) – the two flanking ones pulled by water birds. Bernhard Hänsel recognises in the left corner of the plate another stylised human figure with the head in the form of a solar disk and argues that this depiction suggests the existence of the personification of the sun – an anthropomorphic solar deity – in the north of Europe (*Hänsel 1997.21*).

Italy

As already noted, the concept of Hyacinthus in a swan-chariot is exclusively known through Etruscan material. Several other examples from earlier periods similar to the 'Dupljaja concept' were found in Etruria. The earliest is a bronze Protovillanovan razor (12th–10th century), unfortunately of unknown provenance (*Bouzek 1985.216, Fig. 103. 11; Kaul 1998.284–285, Fig. 180*)[22]. The razor is in the abstract form of a female idol (a paradigmatic shift), with a double-axe depicted on the body, inside of which is a mirror-image figure with arms formed of *Vogelbarken*, with two flanking figures of a similar type, this time with *Vogelbarken* forming their lower extremities – or, better, showing a human figure inside a *Vogelbarke* (perhaps representing '*die Personifizierung der Sonne*'; *Jockenhövel 1974.87*) and four water birds in the corners (Fig. 3). Not unlike the Knossian pithos discussed below, this symbolism suggests an association with female cult (*Bouzek 1985.217; Wachsmann 1998.195–196*). In chronological terms, this object would represent a transition from the Middle or Late BA Dupljaja model to the somewhat later Italian specimens described below.

A similar representation is depicted on a vessel from Veii decorated in the *Buckeltechnik* and dated to the early Iron Age (early 9th century) (Fig. 4). The vessel type to which the Veii specimen belongs is attributed to the late phase of the Central European Urnfield culture (*Von Merhart 1952.12–13*). The decoration on this vessel depicts a frieze of water birds (swans?), but not the symmetrical *Vogelbarke*, although one could argue that the bodies of the birds indeed form a boat. Between the heads, concentric circles are depicted, most probably designating the sun, and, most interestingly, two human figures with outstretched arms and circular heads (*Sprockhoff 1954.81–82, Fig. 24; cf. von Merhart 1952.Pls. 3.8, 23.1; Iaia 2004.397, Fig. 2.10*). Since both the birds and the sun-rings form a continuous frieze, it is unlikely that two human figures repre-

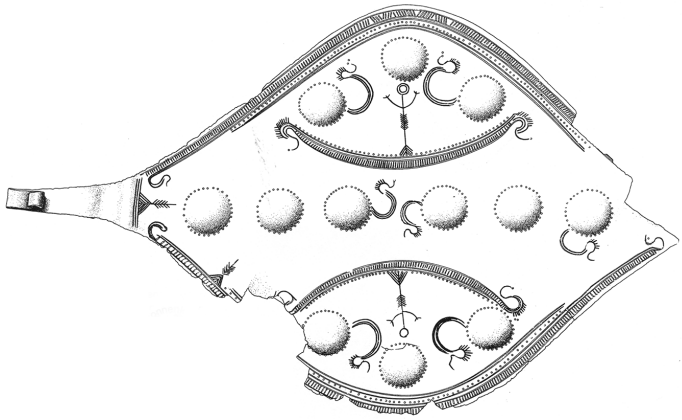


Fig. 2. Belt buckle from Floth (after* Hänsel 1997.20–21, Fig. 2*).

21 Bouzek (*1985.178*) dates the earliest Vogelbarke in early Br D (after 1250 BC), while Matthäus (*1980.319*) and Kaul (*1998.278, 280–281, 283*) date it to the much later Ha B1 (*c.* 1000 BC).

22 Jockenhövel opts for a somewhat later date (10th century) and recognises in it an eastern Mediterranean influence (*Jockenhövel 1974.84, 87–88; Pl. 19.1*).

sent twins of any kind (*pace Sprockhoff 1954.81*). Indeed, the decoration on the Veii vessel could represent a sun deity travelling in a solar swan-boat.

A slightly later group of Early IA fibulae (Ha B3, *c.* 850–750 BC) from Campania, with a person or a deity in a *Vogelbarke*, almost certainly belongs to the same cultural circle and represents the same matrix (see *Lo Schiavo 2010.880–881, Pls. 694– 698, 883, 885–886, Pls. 709, 719–725*), as does a bowl handle from Bisenzio in Etruria (late 8th/ early 7th century) depicting a person or a deity whose hands and feet extend into ornithomorphic forms standing in a circular *Vogelbarke* (*Kossack 1954.Pl. 13.1; Bietti Sestieri, Macnamara 2007; 2004*).

Another example of a similar concept is a *bucchero* vase from Tomba Calabresi (?) in Cerveteri, dated to the later part of the 7th century (*Guggisberg 1996. 185, Fig. 16*). It is modelled in the form of a double imaginary being with horses' heads and ornithomorphic body, with two rosettes on its sides, suggesting a solar association and at the same time symbolising a wagon. A man standing on the body of the animal and holding a yoke in his hand is at the same time the rider and wagon-driver, riding his *Vogelpferde* or being drawn by them in a chariot (*Guggisberg 1996.186*). The *bucchero* vase could represent a solar deity in his chariot drawn by mythic horse-birds.

Finally, Woytowitsch believes that a bronze 6th century lid in the form of a large stylised bird's head (with a small bird on the top) on whose back a human figure drives a *biga* (the wheels are not represented, but only the wagon-box) probably originated in Italy, yet it was found in the Saône River (*Woytowitsch 1978.64–65, Pl.29*). Thus, this depiction can be added to the Etrurian ones enumerated above.

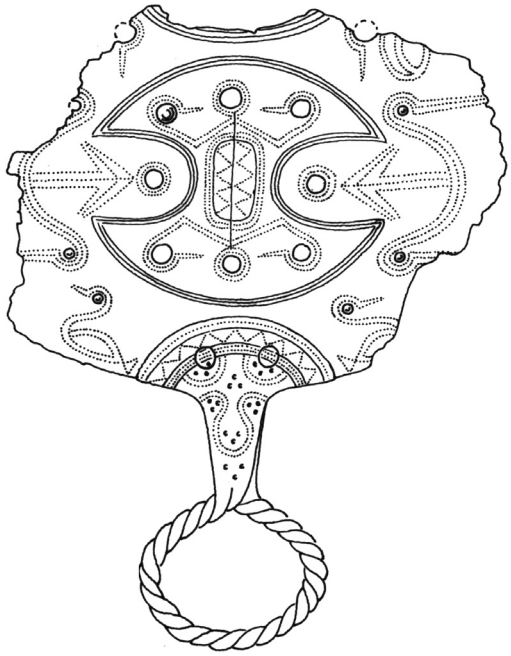


Fig. 3. Protovillanovan razor (after* Jockenhövel 1974.Pl. 19.1*).

Apparently, the 'Dupljaja concept' was current in Central Italy during both the prehistoric and historical (Etruscan) periods, with a clear continuity between the two, which supports (but does not prove) the proposed continuity with later literary testimonies argued for below.

Eastern Alpine region

The so-called *Kriegerwagenfibel*, a group of Iron Age fibulae with the depiction of a male figure on a

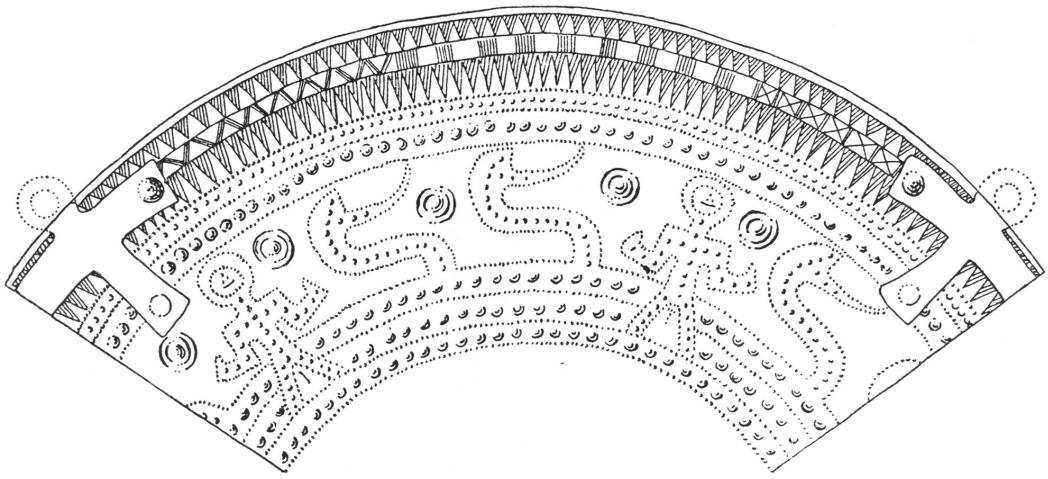


Fig. 4. Vessel from Veii (after* Sprockhoff 1954.82, Fig. 24*).

23 Perhaps even to the early MBA (Br B), if the specimen from Nagyhangos belongs to this type (*Müller-Karpe 1978–1979.23, Abb. 6.23; 1980.Pl. 318.E8*).

horse-drawn chariot on the bow and a bird at the end of the foot, found at several sites in the eastern Alpine region (*Starè 1954.188, Fig. 15; Guštin 1974.95–98; Lunz 1974.139–140, Pl. 40.9, 91B; Tecco Hvala* et al. *2004.Pl. 10.A2; Tecco Hvala 2012.228, 259, 260, Fig. 99.2, 262–263*), are composed of identical structural elements, and should be compared to the 'Dupljaja concept'. Regardless of the fact that there is no apparent solar symbolism in these fibulae, they were nevertheless associated with the Phaethon legend (*Tecco Hvala 2012.262, 340–341, 385*). Even though this seems somewhat far-fetched, their solar character could be tentatively recognised in other structural elements present in these artefacts. These fibulae are very similar and chronologically close to the bronze lid found in the Saône described above.

Possible Central European parallels

Several bronze *Vogelsonnenbarke* pendants found over a wide area (Hungary, Bosnia, Italy, France, Austria), and dated to a long time span stretching from the middle Urnfield[23] to the late Hallstatt period (Ha A2 to D) perhaps portray an anthropomorphic figure, with *Vogelbarke* representing its outstretched hands (*Kossack 1954.Pls. 11.2–4, 7, 9–11, 13, 12.4, 7, 9–18; Bouzek 1985.171, Fig. 86. 12, 174, Fig. 87.1*)[24]. At the same time, the *Vogelbarke*, together with the figure's circular head, could represent a transport vehicle of the solar disk. Thus this representation can at the same time be interpreted as an anthropomorphic figure with hands in the form of a *Vogelbarke*, or as a *Vogelbarke* transporting the solar disk. Due to their extreme stylisation, and, more specifically, to the uncertainty regarding the anthropomorphic interpretation of the composition, I am not completely convinced that these artefacts belong to the group of complex symbolic sets discussed above. Nevertheless, it is possible to recognise in them all the structural elements that were present in other manifestations of the 'Dupljaja concept': anthropomorphic figure, solar symbolism (the disk-shaped head of the figure), boat (explicitly present only in the specimens reproduced on Kossack's plates 11.7 and 10, otherwise suggested by the *Vogelbarke* representing the figure's outstretched hands), and water birds. Moreover, both geographically and chronologically, they belong to the same large-scale context (the Urnfield symbolism) with other examples discussed here. Thus I would leave the question of their affiliation open, which equally applies to two Ha D pendants from Vače and Vinji Vrh in Slovenia, where a highly stylised combination of an anthropomorphic figure and a *Vogelbarke* can be discerned (*Kossack 1954.44, Pl. 17.2, 4; Tecco Hvala 2012.298*).

The Aegean

A similar nexus appears in the decoration of a straight-sided pithos from Knossos. This depiction of a winged female divinity riding in a chariot[25] with birds in her hands suggests that the 'Dupljaja concept' was current on Crete in the Protogeometric period (later 9th century). This is the only Aegean example of a complex symbolic structure related to the 'Dupljaja concept', suggesting (but not in itself proving) continuity between the pre-literate and literary traditions in this particular region. Cretan adaptations, which can be understood as paradigmatic shifts that do not change the structure of meaning of the matrix, are revealed in the driver's gender and in the appearance of birds, which are depicted identically to earlier illustrations of that kind in Cretan tradition. The seasonal character of the depiction is evidenced in the fact that the pithos shows two contrasting scenes, probably representing summer and winter (Fig. 5)[26]. While it is not clear from the depiction whether the birds actually draw the chariot, the similarity with the 'Dupljaja concept' is more than obvious. Since this particular complex symbolic structure departs in the intensity of paradigmatic shifts from other examples studied in this paper, I am willing to accept that it might not belong to the group of manifestations of the 'Dupljaja concept'; however, this would not affect any of the main arguments expressed in this essay.

Methodological procedure for comparing the literary and iconographic record

Material evidence for past beliefs

Several important questions must be raised with respect to the categorical statements outlined in the introductory section of the part of the paper analysing material objects, which I will try to answer here, while simultaneously building an argument for the possibility of comparing literary with iconographic sources. One of the basic questions is whe-

24 Kossack (*1954. 42, 44, 53, 58–59*) only argues for the anthropomorphic nature of the amulets reproduced on his plate 12.1–10 (*cf.* for analogous interpretation of similar amulets *Müller-Karpe 1978–1979.26*).

25 Coldstream (*1984.97, 99*) argues that the wheeled platform is an abbreviation of a chariot (*cf. Marinatos 2000.126*).

26 Coldstream (*1984.99, Figs. 1–2*) recognises in this representation the spring arrival of the goddess, and her departure in winter (*cf. Marinatos 2000.126*).



Fig. 5. Straight-sided pithos from Knossos (after* Guggisberg 1996.183, Figs. 12–13*).

ther it is at all possible to gain any insight into a past belief system that is manifested only in material objects. Without acknowledging this possibility, it remains impossible either to assess the content of, or meaning inherent in a system, or to compare it with literary sources. The cognitive-processual approach indeed allows that iconographic analysis, that is, the analysis of symbolic systems, represents a coherent method for reconstructing particularities and meanings of a belief system attested in non-literary sources (*Renfrew 1994.49, 53–54*). Thus a cautious interpretation of past beliefs based only on iconography is indeed admissible, representing an important step in attempts to compare them profitably with each other or with written testimonies.

Reading the visual language

In general, iconography can be understood as a symbolic system employing a coherent non-verbal language used for codifying a culture's reflections on objective reality through a system of associations, with the knowledge of the significance of these symbols being shared by everybody that is 'initiated' into the system (*Morgan 1985.7; Renfrew 1994. 53; cf. Harding 2000.345–346*)[27]. A 'translation' of visual into spoken language, which is a basic act of any iconographic interpretation (*Morgan 1985.6*), is necessary in order to compare iconographic with literary testimonies. In this way, the former are treated as equals to the latter, differing idiomatically but not essentially.

Structural analysis of visual language

Acknowledging iconography as an interpretable system of communication is a first step in building a defensible method for comparing material and literary sources, but is also a crucial move towards allowing the introduction of a profitable structural study of complex iconographic systems, which was actually applied in the preceding discussion. Since language, as the form of its communication, is inextricably linked with meaning (*cf. Hodder, Hutson 2003.160*), a structural analysis of the language's visual form must necessarily be incorporated into the interpretation of meaning (*Morgan 1985.6*), for it is the structure of iconographic elements that reveals the meaning of a complex image, rather than individual elements taken outside their immediate context. This analysis is therefore focused on finding structural principles behind complex images – what Morgan appropriately calls an idiom (*Morgan 1985.9*) – but what could more specifically be understood as 'the content of ideas' that assemble signs into a syntagmatic or paradigmatic set (*Hodder 1987.3*), and which I previously termed a *muthos*. The Dupljaja model is precisely this kind of a complex figure which should be studied in terms of structural analysis and compared with other analogous nexuses in order to interpret 'the semantic implications of syntax' (*Morgan 1985. 16*). This is exactly what I am trying to do in this essay.

The transfer of meaning

With reference to the problem of context, it is now time to analyse another important question raised in my introduction to the part of the paper analysing material objects: whether the transfers of symbols between cultures could also be accompanied with the transfers of meaning (*Miličević Bradač 2005. 187*), *i.e.* whether it is possible to argue for any type

27 On some idiomatic differences between textual and pictorial mode of representation, see Ornan (*2005.11–12*).

of connections between the meaning(s) of these complex arrangements. That is, after I have recognised syntagmatic similarities in the structure of several complex prehistoric iconographic matrices, I must now raise the question of their mutual relations. Are meaningful relations between these complex figures even possible? A transfer of a symbol, however complex, bereft of its underlying meaning is not very revealing for attempting to reconstruct a past belief system, although it could be revealing in other respects. But the recognition of the existence of a shared *muthos*, 'story' or concept behind symbols could allow some insight into past beliefs, even without reconstructing the actual contents of the underlying tradition.

Once again, the cognitive-processual approach allows the recognition of references in iconographic representations to recurrent themes across cultures, and the existence of single coherent systems, both symbolic systems and systems of belief underlying them, where there are significant overlaps between the specific symbols that appear at various locations (*Renfrew 1994.49, 53–54*). In other words, the existence of shared cross-cultural belief systems is recognised in the appearance of similar iconographic solutions in different cultural systems. Consequently, under certain conditions, similar iconography could indicate similar beliefs. A concrete example of this interpretation is provided by Hansen's study of the formal uniformity of Neolithic and Chalcolitic anthropomorphic figurines, for which he argued that it indicates the existence of distinct ideas behind them, which he classified as elements of a religious belief-system (*Hansen 2001.42–45*).

A similar conclusion can be reached by a study of post-processualist or contextualist accounts of diffusion, which are implicitly discussed in the foregoing cognitive-processual account of recurrent cross-cultural iconography[28]. Ian Hodder and Scott Hutson thus argue that objects can be transferred from culture to culture or context to context with their meaning unchanged, or if changed, this new meaning is still based on the old (*Hodder, Hutson 2003.140*)[29]. Thus, once again, under certain conditions, similar objects could indicate similar beliefs. However, a 'larger-scale context in which similar meanings are assigned to similar objects' must be defined in order to be able to discuss the more localised contexts responsible for both spatial and temporal variability, if any exists, in various manifestations of both widespread and long-term symbolic structure I have recognised and discussed in this paper (*Hodder 1990. 21; cf. Miličević Bradač 2005.188*). I have indeed tried to summarily contextualise (*i.e.* to position them chronologically and culturally) individual manifestations of the symbolic structure discussed in this paper, which I provisionally called the 'Dupljaja concept', at appropriate points in the discussion, and also to provide a particular large-scale context in which this structure appeared and in which similar sets could have had related meanings (*cf. Hodder 1987.8*). I believe I have managed to avoid circularity in my reasoning – defining a large-scale context by the successive appearances of a similar structure and then interpreting the structure by its participation in that very context – by delineating this large-scale context (when discussing the Dupljaja model) by additional elements that it contains: the Urnfield symbolism. In any case, the existence of the particular symbolic complex (or cultural *koine*) to which the 'Dupljaja concept' belongs is non-controversial, and does not in any way depend on its delineation as outlined in this paper (see, *e.g., Bouzek 1985*). This large-scale context will be further discussed in the concluding section of this essay.

The transfer of beliefs

This archaeological large-scale context corresponds to what Graf refers to as an osmotic similarity of cultural space, in which a transfer of analogous ritual and mythic concepts between cultures is as likely an explanation for their formation as is independent origin (*Graf 2004a.5*). Here the emphasis is on the transfer of concepts or beliefs (*i.e. muthoi*), rather than objects, but it is equally plausible to assume that *muthoi* accompanying iconography with cultic significance are transmitted in a precisely identical fashion, especially in light of the discussion in the preceding section of this paper. Thus both narratives and symbolic representations – the latter together with accompanying beliefs – are equally transferrable between cultures, which allows attempt at reconstructing these very beliefs through a comparison with literary sources.

28 I find it a felicitous occurrence that two different approaches to archaeological theory agree on this particular point, although this does not automatically prove its validity. For their respective positions on religion, here used as a broad term encompassing symbolism and belief, see Insoll (*2004.79–87, 94–100*); for Hodder's position specifically, see Bredholt Christensen, Warburton (*2014*).

29 Here the authors do not refer to complex symbolic structures, but their observations certainly apply to these even more than on simpler objects.

Transferability is indeed one of the most conspicuous characteristic of traditional stories or myths (*Bremmer 1994.57; cf. 2011.540; Wyatt 2005[2001].170*), and both motifs and entire narratives can migrate between cultures, including their denotative applications (*Burkert 1988.12; Graf 2004b.52*). In any case, these borrowings between cultures are never random, but rather result from a structural similarity between myths in both the 'receiving' and 'giving' culture (*Doniger 2009.208*). Thus a transfer of beliefs – whether accompanied by or accompanying iconographic solution with cultic significance or not – is plausibly ascertained; moreover, it is myths or traditional stories that are particularly prone to diffusion. But other types of 'beliefs' are also culturally transcendent. Thus the transmission of scientific 'traditions' between cultures is an accepted fact in the history of science. Knowledge or methods (the contents of the 'tradition') are received, adapted and occasionally transformed when being translated between cultures, but they still remain within the culturally transcendent tradition (*Rochberg 1992.549–550*). This fact is tangentially relevant to the contents of the narrative model discussed in this essay, since the particular *muthos* reconstructed here attempts to give an account of a phenomenon that would later be treated by Greek cosmologists and astronomers, although in a radically different fashion.

With respect to the relation between material testimonies and narratives that treat identical concepts, the former are sometimes indeed of prime importance in studying the latter. The significance of iconography in recognising oral tradition behind it is emphasised by Walter Burkert, who argues that iconographic treatments of myths "*... play a fundamental role in the fixation, propagation and transmission of those myths ...*" (*Burkert 1988.25*). He further maintains that iconography can unmistakably indicate connections between different societies, although at the same time he believes it cannot positively indicate a particular myth's diffusion (*Burkert 1988.26*). He allows for some transfer of underlying meaning, but also recognises possible deviations (*Burkert 1988.27*). These well-balanced remarks, equally applicable to a pre-literate period (but without the control offered by literary sources), emphasise that one should always have in mind possible misunderstandings and reinterpretations in the transmission of meanings of symbolic representations; the method I have adopted in this paper, in the first place the focus on a quite specific single, yet complex, iconographic design, of a particular character (*i.e.* anthropomorphism), is meant to reduce these pitfalls as much as possible, although they can never be completely evaded.

It is possible to raise the objection here that religion is a structured system whose elements derive their meaning through their relations with other elements on various levels, from the arrangement of elements in a nexus to the complete world-view of a society. Change on any of these levels affects all the others, and the meanings of apparently identical elements also change in new circumstances (*Sourvinou-Inwood 1995.20–24, 29*)[30]. Indeed, even collective representations of the physical environment are argued to be culturally determined, and thus both these representations and their meanings are liable to alterations, which are induced by changes in other elements of the systems forming a society's world-view (*Sourvinou-Inwood 1995.22–23*). But I have demonstrated that meanings can be preserved within a common cultural space, and I will show immediately below that this is especially the case when complex symbolic structures are involved. This claim is less dogmatic and allows for both modification and preservation of meaning, without a priori rejecting, but insisting on arguing for or against either possibility. Moreover, a preservation of meaning does not mean that, for example, the 'Dupljaja concept' was not modified in a number of ways – which are particularly visible in paradigmatic shifts noted at appropriate points – but that both elements (less) and nexuses (more) can keep their meaning relatively unchanged; what is more, these meanings can be reconstructed by following a careful methodological procedure.

All the manifestations of the 'Dupljaja concept' analysed here are, naturally, culturally determined, but even so they have a stable referent in the physical environment. The precise roles of these manifestations in the world-views or belief-systems of their respective societies, however, are much harder to grasp, and I have not attempted to reconstruct them here (see *Kaul 1998; Kristiansen, Larsson 2005*). This is thus not a simple case of dynamism vs. apparent permanency, but rather of dogmatism vs. argued tolerance. My case should be judged by assessing the arguments for continuity of ideas and their expression in material form I have offered and

30 Paradoxically, in the same work, Sourvinou-Inwood (*1995.19–20, 25, 29*) does acknowledge continuity in certain elements of various religious nexuses, although not the nexuses themselves.

not by an a priori rejection due to some presupposed eternal flux in the content of ideas forming belief-systems. Two additional arguments could be adduced in further support of my position: the inherent conservatism in ancient religious works of art (*Ornan 2005.10*) and the more conservative nature of cultural forms in earlier periods (*Wyatt 2005[2003]. 220*). Both these factors speak in favour of preservation of meaning in the concrete transfer of complex symbolic structures argued for here.

Transfer of complex symbolic structures

It is important to emphasise that, on one hand, a simpler form of a symbol makes its interpretation to the 'uninitiated' more difficult (*Morgan 1985.7; Miličević Bradač 2005.188–189*) and thus more complicated to transmit unchanged and unscathed its intrinsic meaning between cultures, but on the other hand, "*... complex symbolic structures are more likely to maintain their internal meaning unchanged than simpler ones, as their transmission demands the adoption of a corresponding complex knowledge ... the parallel transmission of two or more symbolic structures makes it increasingly likely that they maintained their internal meaning unchanged, as it testifies to a more complex and direct transmission of knowledge ...*" (*Kristiansen, Larsson 2005.22*).

This statement is an important argument for the comparison between symbolic structures attempted here. It plausibly suggests that a complex structure – in this case a matrix consisting of a travelling solar deity or, if one prefers, an anthropomorphic agent providing causation of solar movement – might have been transmitted from one cultural complex to another without losing much of its intrinsic meaning. In this sense, it is not unreasonable to presume that certain ideas were transmitted both horizontally (in spatial terms) and vertically (in temporal). Since the meaning of complex symbolic structures is more likely to be transmitted unchanged between cultures, it can be argued that the ideas (*muthoi*) behind them were transmitted together with their manifestations in iconographic arrangements.

***The Dupljaja model as a complex symbolic structure accompanied by a* muthos**

It is possible to recognise in the Dupljaja model an iconographic depiction of a mythic concept that could have played – to paraphrase Burkert – an important role in the latter's fixation, propagation and transmission. Generally, this is hardly a novel conclusion, since a number of earlier authors recognised its importance, although not in such a specific sense as argued for in this paper. Thus the origin of the concept of a solar chariot or boat associated with swans was traced to Central Europe, from where it arrived in both Greece and Northern Europe (*Sprockhoff 1954.60, 71–73, 103; Gelling, Ellis Davidson 1972.119; Ahl 1982. 39; Kaul 1998.53, 55–56, 75, 93–94, 130–136, 143–148, 157–163, 173–178, 214–215, 242–244, 251–258, 260–261, 276–278, 282–284*). The Dupljaja model itself is described as a vital link in this process (*Sprockhoff 1954.73; Gelling, Ellis Davidson 1972.119; Hänsel, Hänsel 1997b.67; Kaul 1998.253, 256*). But what is novel in this essay is that, while the authors named above all discussed a more general concept (solar chariot/boat associated with water birds), I have taken into account and emphasised the anthropomorphic nature of the main agent in the iconography[31]. While theirs is a legitimate hypothesis, it nevertheless seems safer to draw conclusions from an even more complex and less ambiguous example such as the one chosen for this discussion. What is more, this symbolic structure was selected precisely for its complexity and specificity, which permitted a more secure 'control' over speculating on various possible semantic interpretations of 'mute' artefacts of material culture in order to, finally, allow the comparison of the content of ideas behind these material objects with literary sources.

Comparison of literary sources with iconography

This discussion finally raises the all-important question: can the *muthos* – in the meaning of an applied traditional tale, a narrative model representing a specific aspect of physical reality – behind prehistoric iconography be compared to the one attested in literary sources? The foregoing discussion demonstrate, I believe, that a positive answer can be plausibly defended, or at least that it is possible to (1) gain insight into a past belief system manifested only in material objects, (2) translate the visual language of iconography into a spoken idiom by (3) performing a structural analysis of complex iconographic symbolic sets in order to enable the interpretation of their meaning, and (4) recognise the transmission of both the meaning and beliefs accompanying symbolic structures between cultures shar-

31 Kaul (*1998.251–256*) does discuss the anthropomorphic solar deity in this context, but not in the specific way I am studying it in this paper.

ing a common cultural space, (5) especially when these symbolic structures are complex. With this in mind, it certainly seems possible to compare the written *muthoi* with those reconstructed in steps (1) to (5).

Several parallel case studies might further strengthen the argument. Thus Stuart Thorne postulated a similar hypothesis of iconographic and narrative continuity in the case of the concept of Cretan Zeus. He recognises that a story or myth of Zeus' birth was 'firmly associated' with a constant iconography – a youthful god – first attested in the Minoan period (*Thorne 2000.149–152*). The similarity between my thesis and Thorne's lies in the fact that the early attestations of the youthful god iconography are not accompanied by literary evidence, but the interpretation of iconography both in this early and later periods is associated with literary evidence accompanying the latter[32]. Nevertheless, both solely iconographic and iconographic and narrative continuities are emphasised in Thorne's paper, persistently re-appearing or being preserved in differing spatial, temporal and cultural frameworks. This is exactly parallel to my interpretation of the 'Dupljaja concept' and its relation to literary testimonies.

In a similar fashion, Preben Sørensen interprets iconographical sources from a largely illiterate period of Nordic history with the help of myths recorded in a later period, basing his comparative method mainly on the recognition of a common cultural affiliation of iconographical and literary material, even though the sources are both spatially and temporally dispersed (*Sørensen 2002 [1986].121–122, 130*). Goodison likewise freely discusses iconographic sources from an illiterate period of Aegean (pre) history (which she prioritizes) alongside later literary testimonies (focusing on the earliest written works), arguing that their correspondence actually strengthens her particular claims (*Goodison 1989. 119–123, 131, 23–168*).

Another comparable case is Kristian Kristiansen's study of Divine Twins in Bronze Age belief-systems, whose additional value lies in that it offers a methodological framework (*Kristiansen 2014; cf. Kristiansen, Larsson 2005.20–24, 256–257, 263–265, 316, 329, 368*), roughly analogous to the one employed in this essay. He argues for the complementarity of literary and archaeological sources from the Bronze Age onwards, and uses the former to formulate a hypothesis, by identifying gods and their characteristic features in textual evidence (both Bronze-Age and later), which he subsequently 'tests' in the archaeological record by identifying corresponding features in material testimonies. Kristiansen believes he has found a full correspondence between the two types of evidence in the case of Divine Twins and freely uses the archaeological record alongside literary evidence in his study of the phenomenon (*Kristiansen 2014.81–82*). His method is complementary to my own and, if applied to the concept discussed here, would similarly allow a comparison between the two types of evidence.

These parallel cases show that a profitable parallel study of iconography with literary sources is indeed possible, offering theories that explain a number of otherwise poorly understood phenomena.

Concluding remarks: large-scale context, anthropomorphism and the contents of the *muthos*

Before proceeding to emphasise and clarify several key suggestions that were proposed in various parts of this essay, I must point out that it was not my intention to extensively discuss the precise genetic relations between different manifestations of the 'Dupljaja concept', since the method I have employed in this paper cannot be used for this purpose. Similarly, I cannot discuss here the complicated problem of cultural interrelations during the LBA and EIA between Central and South-Eastern Europe, although this question is certainly raised by my discussion, since its solution is similarly outside the scope of the analytic procedure I have employed in the paper. These connections are discussed throughout this essay only in the broadest terms, but I must emphasise it is generally acknowledged that they indeed existed[33].

The analysis performed here can, on the other hand, help to recognise the proper large-scale context in which this complex symbolic figure appears. Furthermore, it can suggest its possible meaning, that is, the content of the *muthos* underlying its manifestations,

32 Thorne (*2000.150*) regards the myth/story accompanying iconography as a constant, and does not associate it with 'religious' or 'theological' interpretation, which he finds variable.

33 The literature on this subject is indeed vast, and I can only offer a selection here: Milojčić (*1948–1949*), Garašanin (*1953; 1962; 1982; 1983*), Kossack (*1954*), Gimbutas (*1965*), Gelling, Ellis Davidson (*1972*), Müller-Karpe (*1978–1979*), Coles, Harding (*1979*), Matthäus (*1980; 1981*), Bouzek (*1985; 1994*), Schauer (*1985*), Pare (*1987; 1989*) and Kaul (*1998*).

especially when compared with relevant literary sources, which is precisely what is attempted here. Finally, the conclusions reached in this way reveal something new – or support something only scarcely known from literary sources – with respect to the Greek notion of 'Hyperborean Apollo' and its underlying concept.

Thus, in the analysis of material evidence, a large-scale context of various appearances of the 'Dupljaja concept' in which the manifestations of this concept occur and in which structurally similar arrangements have related meanings was defined: it could provisionally be called the Urnfield symbolic complex, after its most distinctive manifestation. It is not easy to precisely delineate either its spatial or temporal span: it certainly encompassed the entire Balkan (with an outpost in the Aegean) and Carpathian regions, together with much of Central Europe, with an offshoot in the Nordic region, and also Italy; furthermore, it could be argued that it spans at least the full millennium from the mid-2nd to mid-1st millennium BC. Within this context the osmotic nature of cultural space provides an alternative model for previously dominant discourse of invasions and migrations[34], allowing for an inter-cultural transfer of symbols, especially complex symbolic systems, together with their accompanying meanings. In this particular case, perhaps the culturally transcendent term 'tradition' should specifically be applied to what I regularly called the 'Dupljaja concept', since this term emphasises its realised transferability, longevity and propensity to expand spatially.

The Dupljaja model could be understood as a particularly important object for understanding one important part of the symbolism of this large-scale context. I have already noted that it probably had an important role in the spread of the concept of a solar chariot or boat associated with swans from Central to both Northern and Southern Europe. But more generally it could be claimed that it also played a decisive role in the formation of the Urnfield symbolic complex (*Pare 1987.61; 1989.84; cf. Sandars 1968.175*), and thus its importance – on a much lesser scale – in the formation of what I have called the 'Dupljaja tradition' is immediately obvious.

Next, an attempt to reconstruct the contents of the *muthos* behind both material evidence and literary sources seems possible at this point. In this context, the anthropomorphic nature of the agent in the complex symbolic structure of the 'Dupljaja tradition' should not be treated simply as a development of earlier, pre-anthropomorphic ideas accounting for similar phenomena. In this respect, the present analysis bears an additional weight, since it recognises a supplementary feature that reveals more information on the concept behind a group of structurally similar material testimonies. Although the question of the occurrence of anthropomorphism in myth or science and human cognition in general is a complicated and widely discussed issue, I cannot enter into an extended treatment of this topic here, and will offer instead a summary review of a relatively recent plausible thesis. Building upon the work of numerous predecessors, Guthrie recognises anthropomorphism both in religion and in science as an almost universal explanatory method, a strategy of hypothesising about the surrounding world and attempting a plausible interpretation of it (*Guthrie 1993.3–4, 31–38, 62–64, 82–89, 102–103, 176, 197; Segal 2004.33*). The very act of perception, he continues, is already thoroughly theoretical and interpretative and, furthermore, identical to cognition, which is the origin of the prevalence of anthropomorphism in all forms of thought (*Guthrie 1993. 37, 90–98, 121, 140, 188, 201–204*). Thus, it seems that anthropomorphism has its place in interpretations of nature when understood as a model-building on the basis of metaphor and analogy. It is, moreover, 'uniquely intelligible' and accounts for a large number of phenomena, resulting in a truly scientific interpretation:

"*They [the gods] give much explanatory return for little investment. Hypothesizing a humanlike being at work behind appearances accounts for effects of unparalleled diversity. This principle, that efficiency in explanations is the ratio of effects predicted to hypotheses made, underlies Occam's razor: do not multiply hypotheses unnecessarily*" (*Guthrie 1993.189*).

Consequently, anthropomorphism is equally present (even if not to the same extent) in both myth and science, in this way effectively bridging a large gap that seemed to exist between these two assumed forms of thought. It thus cannot be treated as an 'improvement' on some earlier non-anthropo-

34 For the introduction of Apollo in Greece by various migration-theories, see Müller (*1839.48, 219–220, 266–267, 272*), Farnell (*1907.99*), Sprockhoff (*1954.68*), Kothe (*1970.219–221, 223–227*); for the survey of the problem of 'Dorian migration' and the Sea Peoples, see Hall (*1997.4, 6–15, 64–65, 114–121, 156, 158–161*) and Dickinson (*2006.2–4, 11, 44–54, 77, 102, 159, 243*).

morphic thesis accounting for the same phenomenon, and should be studied in its own right. Since it is undoubtedly present in the 'Dupljaja tradition', it must be studied with respect to this tradition in the context of its explanatory qualities noted above, and not merely as one iconographic solution among many employed by those working in the tradition of the Urnfield symbolic complex. My proposed reconstruction of the contents of the *muthos* behind this tradition takes into account this decisive circumstance, which is further strengthened by the use of Greek literary testimonies, allowed by the procedure outlined in steps (1) to (5) above.

All the elements that appear in the structure of manifestations of the 'Dupljaja tradition' point to a close parallelism with the 'solar' myth of the Delphian Apollo: an anthropomorphic figure transported in a vehicle and decorated with solar symbols, drawn by animals with an undeniable seasonal character[35]. The annual solar movement is a time-factored phenomenon, and the only means to either describe or account for it in prehistory was through a story or *muthos* (*Marshack 1972.133, 197, 279, 283, 316, 330; cf. Burkert 1979.23*). This resulted in the creation of a narrative model representing a specific aspect of physical reality in terms of anthropomorphic causality: the annual solar movement, with an emphasis on the solstices, as observed, recognised, described and interpreted by prehistoric European populations. An anthropomorphic explanatory model, accompanied by an array of relatively stable non-anthropomorphic symbols, suggests a shared tradition accounting for a specific phenomenon, while every piece of evidence gathered either from iconographic or literary sources points to the tradition's seasonal or, more precisely, solar character. While the validity of this particular character cannot be conclusively proven due to the inherent nature of the material being studied, it best explains all the available evidence, while none contradicts it (*cf. Sourvinou-Inwood 1995.133–134*).

Finally, Alcaeus' 'Hyperborean Apollo' – and the same could be claimed for the Greek notion of this concept in general, as attested in other authors – is thus one of the manifestations of this narrative model expressed in a hymn to a deity that was precisely in the period when Alcaeus was composing it in the process of attaining his illustrious Pan-Hellenic status. There is no basis, however, for calling the deity or mythic person attested in the archaeological record either 'Apollo' or 'Hyperborean Apollo' without the use of quotation marks. The 'Dupljaja tradition' (in the sense I outlined above), on the other hand, does indirectly suggest that Apollo could have occasionally been recognised as a sun god in Greece, with a special connection to the solstices, at least in the concepts associated with the Delphian myth discussed in the first part of the paper, although it should again be pointed out that this does not exclude numerous other functions he fulfilled in Greek society, nor does it emphasise this particular feature at the expense of others.

In conclusion, in this essay I have provided an analysis of a complex prehistoric iconographic structure which I christened the 'Dupljaja concept', consisting of an anthropomorphic solar deity riding in a chariot drawn (or accompanied) by water birds. This complex arrangement permitted the recognition of a similar underlying *muthos*; after reconstructing the large-scale context in which this structure appears, which is also reflected in literary testimonies, I concluded that its underlying *muthos* represents an account of the annual solar movement in terms of anthropomorphic causation.

35 For the birds' seasonal character specifically in the Bronze Age, see Teržan (*1999.123*). Cunliffe (*2002.121*) argued that the communities living in northern Scotland actually associated the seasonal migration of the whooper swan to the annual solar movement.

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What is a lunar standstill III[1]?

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ABSTRACT – *Prehistoric monument alignments on lunar standstills are currently understood for horizon range, perturbation event, crossover event, eclipse prediction, solstice full Moon and the solarisation of the dark Moon. The first five models are found to fail the criteria of archaeoastronomy field methods. The final model of lunar-solar conflation draws upon all the observed components of lunar standstills – solarised reverse phased sidereal Moons culminating in solstice dark Moons in a roughly nine-year alternating cycle between major and minor standstills. This lunar-solar conflation model is a syncretic overlay upon an antecedent Palaeolithic template for lunar scheduled rituals and amenable to transformation.*

IZVLEČEK – *Poravnava prazgodovinskih spomenikov na Lunine zastoje se trenutno sklepa za razpon horizonta, perturbacijo, prehod Lune, napovedovanje Luninih mrkov, polne lune na solsticij in solarizacije mlaja. Prvih pet modelov ne zadostuje kriterijem arheoastronomskih terenskih metod. Zadnji model lunarno-solarne zamenjave temelji na vseh opazovanih komponentah Luninega zastoja – solarizirane obrnjene Lune, ki kulminirajo v mlaju v solsticiju v devetletnem izmeničnem ciklu med največjim in najmanjšim zastojem. Ta lunarno-solarni model je postavljen na temeljih predhodne paleolitske predloge za načrtovanje lunarnih ritualov in je dojemljiv za preobrazbe.*

KEY WORDS – *Lunar standstill; synodic; sidereal; lunar-solar; syncretic*

Introduction

Thom's publications between 1954 and 1975 galvanised a generation – with horror among many archaeologists and inspiration for others, some of whom began reconstructing the discipline of archaeoastronomy (*Ruggles 1999.1–11, 275*). However, since the 1980s, an extended re-evaluation of his work within archaeoastronomy has questioned many of his claims that some monuments of prehistoric North-West Europe were aligned on the Sun's solstices and the Moon's standstills (*Ruggles 1999. 49–67*). Nevertheless, some leading archaeologists in Britain have begun to embrace the evidence for prehistoric monuments' 'astronomical' alignments (*Thomas 1999; Parker Pearson 2012*). To unravel what has been lost and gained after half a century of scholarly endeavour, we need to re-examine the properties of prehistoric monument 'astronomical' alignments to trace their variable engagement by different researchers.

Solar and lunar alignments

A prehistoric monument alignment on the Sun and Moon is an architectural arrangement of materials orientated on a horizon position locating where either luminary rises or sets. At summer solstice, the Sun rises in the north-east and sets in the north-west. Six months later at winter solstice, the Sun rises in the south-east and sets in the south-west. For any given time period, latitude and horizon altitude these horizon positions are fixed. At the latitude of Stonehenge, the azimuths of the solstice Sun are

1 The first version was my 2007 paper for the 2006 SEAC conference in Rhodes, and the second was an unpublished paper for the 2014 SEAC conference in Malta. This latest, third, paper is an elaborated version of the second paper. It should be read alongside the Forum debate 'What is the minor standstill of the Moon?' in *Skyscape Archaeology 2(1): 67–102*.

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about 40° above and below the west-east axis (Fig. 1). From three days before and after the solstice, the unaided human eye cannot detect the 2´ change from its solstice limit, and in seven days it remains within 11´ of its solstice extreme (*Ruggles 1999.24–25*). Each of the four solstice rise and set events therefore lasts for at least one week in prehistory. Outside of the two weeks of both solstices, for about 5 1/2 months, the Sun's horizon rise and set positions slowly begin to change towards its greatest rate of daily horizon change during the equinoxes of 24´ per day – three quarters of its 32´ diameter. A monument's single solstice alignment therefore abstracts out just 1 horizon event repeating for seven days out of a possible 178[2] solar alignments. While a severe selection of the Sun's movements, nevertheless these horizon positions do not contradict, and may act as proxies, for the seasonal changes marked by the full suite of the Sun's movements.

A monumental lunar alignment is a more complex matter and, in important respects, quite different from a solar alignment. For while the Moon also has horizon range limits just as the Sun does, instead of being fixed they vary over an 18.61 year cycle. Thom named this phenomenon the lunar standstills, which every 9.3 years alternate between major and minor standstills (*Thom 1971.19, 124, 173*). The range of the Moon's horizon rises and sets complete over the course of the 27.3 day sidereal month – the time it takes to complete its circulation of the earth. During a major standstill of the Moon at the latitude of Stonehenge, the Moon rise and sets about 10° of azimuth further north and south on the horizon than the Sun ever reaches during its solstices. After a period of over a year, the Moon's orbital plane about the earth begins to reduce from 5° above the earth's equatorial plane about the Sun to, 9.3 years later, 5° beneath the equatorial plane. This minor standstill's horizon range limits are now about 10° within the Sun's solstice positions at the latitude of Stonehenge, and for over a year the Moon returns to these 'same' positions (Fig. 1). The Moon therefore has eight horizon limits, unlike the Sun's four.

Throughout its 18.61 year cycle, the Moon rises and sets on intermediate horizon positions between these changing horizon extremes of the Moon. Only during the period of a lunar standstill, major or minor, does the Moon return to the same small region of the horizon, when it is at its standstill range limit. It is therefore a selection of just one horizon moment during one day or night out of about 27 days and nights during two periods of the 18.61 year cycle. While, like the Sun, a lunar alignment is therefore a selection from all possible horizon positions, unlike the Sun, it is not an observation repeated over the course of a week, but a one-moment time-lapsed observation separated by periods of about 27 days during either the major or the minor standstill about every nine years. When the Moon returns each sidereal month to its horizon alignment, it does not repeat its earlier lunar phase. While it takes the Moon 27.3 days to circle the earth, during that time the earth is also moving around the sun, and the three bodies re-align at the completion of the synodic month in 29.5 days. Therefore, a lunar alignment presents phase sequences which are about 2.2 days earlier phases than the previous lunar phase alignments. An alignment on a lunar standstill therefore selects lunar phases in reverse sequence to when, contrarily, we view the Moon's phases over the course of a synodic month. Lastly, as the Moon circulates the Earth, which itself circulates the Sun, the changing gravitational interaction of all three bodies are reflected in small differences in the position of the maximum range limits of either standstill. Modern heliocentric positional astronomy has shown that at different positions in its orbit of Earth, these perturbations exhibit a regular sinusoidal alternation of the order of about 10´ of arc (*Thom 1971.15–27; Sims 2006*).

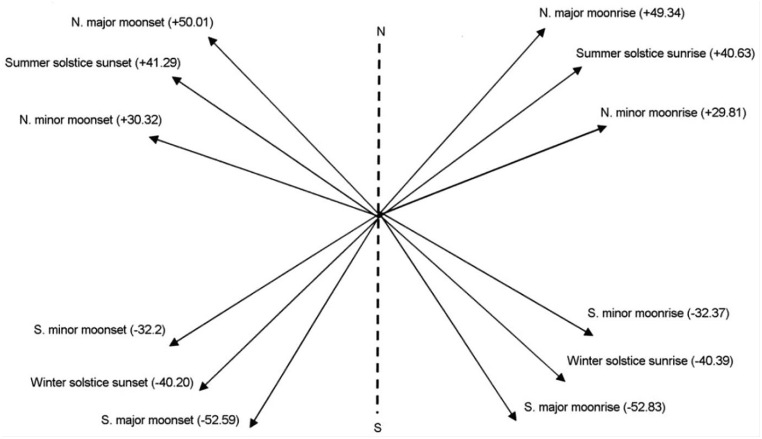


Fig. 1. Plan view of natural horizon alignments on Sun's solstices and Moon's standstills at Stonehenge 2500BC (bracketed numbers are degrees of azimuth above or below the west-east axis).

2 Subtracting the 14 days of the two solstice weeks from 365 days (=351), dividing by two for the outgoing and returning Sun overlapping on the same alignment (=175.5), and then adding 2 for the two solstice events, each of one week (=178).

In summary, just like a solstice alignment, a lunar standstill alignment is a selection of a few horizon positions from its total rise or set positions, but unlike the Sun, this alignment is not a simple proxy for other characteristics of the Moon. Instead of four solstice horizon positions, there are eight lunar standstill horizon range limits of the major and minor standstills; its sidereal properties are cryptic, not redundantly obvious as are the solstices; they reverse its lunar phases, and at its horizon limits exhibit small perturbations. It is in the variable interpretation of these similarities and differences between solstices and standstills that scholars in archaeoastronomy have marked out six different approaches to lunar standstills. There is therefore no consensus within archaeoastronomy on how to interpret lunar standstills, and these divisions require resolution (*Sims 2013a*).

To evaluate the strengths and weaknesses of each of these six positions, I will refer to the archaeological details at the Stonehenge monument complex, since this is, arguably, one of the culminating achievements of a wider cosmology extant throughout Neolithic Europe. This late Neolithic and Early Bronze Age site has attracted close scholarly attention, which has amassed enough fine detail to allow us to design discriminating tests between the available interpretive models.

Lunar standstills as horizon range

According to Fabio Silva and Fernando Pimenta (*2012. 206*), the majority view within archaeoastronomy is that lunar standstills were selected by prehistoric monument builders for the Moon's extended horizon range displayed only during the major standstill of the moon. Throughout this period of over a year, every thirteen or so days the Moon reaches its northern and southern limits at azimuths roughly 50° above and below the west-east axis at the latitude of Stonehenge, which is about 10° beyond the Sun at its solstice horizon positions (Fig. 1). Between these periods, the Moon's daily and nightly changes touch intermediate horizon positions and pass through the range limits of the minor standstill, which the Moon reaches 9.3 years later. When the Moon is at its minor standstill, its azimuth is about 30° above and below the west-east line, well within the Sun's azimuth at about 40°. Compared to the major standstill, this approach considers that since the Moon passes through this position for much of the 18.61 year cycle, the minor standstill is both difficult to observe and has little significance because of the narrower width of its horizon range. Gauging the lunar standstills against the Sun's horizon range is therefore a solarist attribution that the Moon at a major standstill is a 'superior sun' by virtue of wide horizon range alone. Authors who adopt this view emphasise the period of 18.61 years as the time span of lunar standstills.

However, César González-García (*2016*) has shown that it is not difficult to observe the minor standstill of the Moon. During this period, the Moon's horizon range is at its narrowest, while the number or rises and sets remain the same at just over 27 events each sidereal month. This produces a proportionally increased bunching of maximum horizon events which is greater than the maximum horizon range bunching for both the Moon's major standstill and the Sun's solstices. Further, if the solarist understanding of the prehistoric appropriation of lunar standstills is correct, then it would predict that no monuments in prehistory would have alignments on the minor standstill of the Moon beyond those of chance. This is incorrect. Clive Ruggles (*1999. 74–76, 95*) has shown that Scottish recumbent and West Scotland rows have statistically significant alignments on both the southern major and minor standstills, as has Aubrey Burl (*1981*) for the Clava Cairns. Furthermore, along the West Kennet Avenue at Avebury, Lionel Sims (*2015*) has shown that across paired stones 1–37, out of 362 possible alignments, 145 solar and lunar alignments can be found. Using Bernoulli's Law, so accounting for possible overstatement from straight sections along the avenue with a regular horizon, Sims shows that this is a possible chance occurrence for 3.3 in every million times. Within these 145 alignments, 21 are on solstices, 31 on major standstills and 48 are on minor standstills. The rejection of minor standstills as chance alignments therefore does not meet the requirements expected in archaeoastronomy field methods. Emphasising the Moon's extended horizon range during the major standstill is more an extemporary field method device to distinguish a monument's possible orientation on the Sun. But in its rejection of the minor standstill of the Moon, this approach has failed to lay the basis for investigating what properties it may share with the major standstill.

Major and minor standstills as separate phenomenon

The second type of archaeoastronomy theory considers the minor standstill of the Moon as requiring special explanation separate from that of the major

standstill, which is understood to be defined by its wide horizon range. There are currently two versions of this approach – North's (*1996*) alternating perturbations and Silva's and Pimenta's (*2012*) crossover model.

North showed that, while in plan view Stonehenge is gaps surrounding an empty space, in elevation view, paradoxically, it is an 'obscuration' device of a seemingly near-solid mass of stone when approaching it from the north-east uphill along the Avenue and past the Heel Stone. Viewed from the Heel Stone, two windows can be seen one above the other, framed by the Grand Trilithon and the outer-circle lintels (Fig. 2). From the right-hand side of the Heel Stone, the lower window frames the setting winter solstice sunsets, and from the left-hand side of the Heel Stone at an altitude of about 4–5°, the upper window captures the setting southern minor standstill moonsets. North considered these two alignments separately and suggested that the southern minor standstill moonset perturbations would have been seen in this upper window smoothly zigzagging left and right four or so times over the course of a minor standstill year. North suggested that since the Sun does not do this when at its solstice horizon range limit, then the people of Stonehenge would have considered this property of the southern minor standstill magical and worthy of a monument (*North 1996.441–474; Sims 2006*).

It is not clear that the Moon's perturbations will be observed at Stonehenge, as the architecture of the monument does not assist such high-fidelity observations. The distance from the Heel Stone to the Grand Trilithon is about 88m, which is not enough to provide the resolution to discern the movements of a few minutes of arc of any (obscured) edge of the lunar disc. From the Heel Stone, the height of the upper window would have subtended an angle of about 10´ and a width over one degree. Since the lunar disc is about 31´ in diameter, this upper window would have framed just a descending sliver of the Moon in its 1–2° of oscillating azimuths at its standstill horizon range limits (see below). That is assuming the perturbations could be seen distinct from other movements of the Moon. As the Moon is constantly changing its declination[3], and since the moment of the geocentric declination extreme is generally independent of the moment when the Moon meets the horizon, by the time the Moon is on any horizon, its declination is at a different value from its perturbation limit. Therefore, there will be no regular zigzag horizon movement of the Moon at its minor standstill limit, but irregular movements. This can be seen in Figure 3, which contrasts the smooth sinusoidal perturbations of the Moon when orbiting the Earth with how these become irregular oscillations by the time the Moon sets on the horizon (see also *Sims 2007*).

Finally, every standstill at its horizon limit, whether major or minor, north or south, rising or setting, exhibits similar (irregular) perturbations to that of the southern minor standstill moonsets, so either all of these are equally 'magical' or none of them are. North defines the southern minor standstill by the boundary oscillations of the lunar horizon range limits, and the major standstill by its greater horizon range than that of the Sun, without interrogating the shared properties of both. This model also therefore emphasises the period of 18.61 years between major standstills, and misinterprets minor standstills.

Silva's and Pimenta's winter solstice lunar crescent crossover model, the second within this group, offers an alternative explanation to that of alignments on

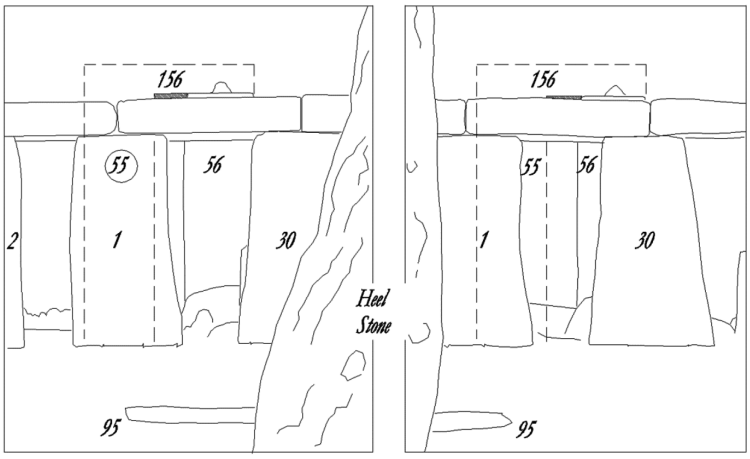


Fig. 2. The lower and upper gaps through the central axial stones at Stonehenge as seen from the left- and right-hand sides of the Heel Stone (*North 1996.446*). Numbering follows the accepted notation for each stone.

3 This is the measure used in modern heliocentric positional astronomy, and is the number of degrees above or below the celestial equator. In the geocentric flat earth cosmology of prehistory, a concept of declination would have carried no meaning. Instead, some concepts equivalent to our 'azimuth' and 'altitude' would have been used.

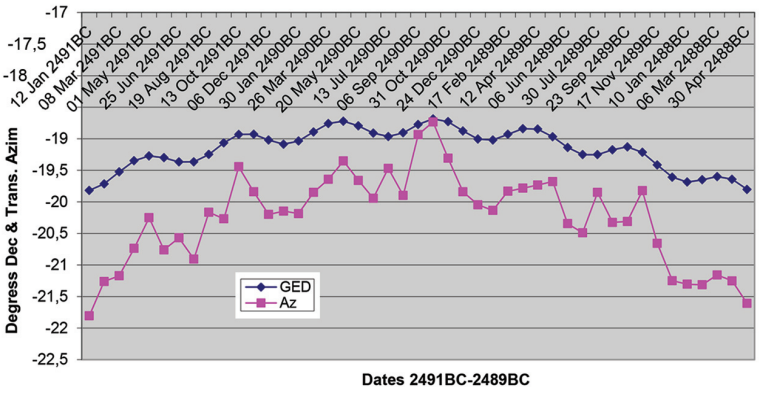


Fig. 3. Contrast between the Geocentric Extreme Declination of the Moon (GED) 2491–2488 BC and Azimuth (Az) of the southern minor standstill Moon setting in the Upper Window at Stonehenge. Note: Azimuth values have been transformed to fit the declination scale, and should be examined for shape, not values, alone.

the minor standstill of the Moon. They demonstrate that during summer and autumn, the first crescent Moon always sets to the left of the Sun's horizon setting, but within a period of 150 days over winter the Moon switches and sets to the right of the Sun's setting position. The pattern of alignments for this crossover event is a non-Guassian distribution with a marked modal frequency which coincides with that of the southern minor standstill of the moon. Any monument with an alignment on the minor standstill would, the authors suggest, be better explained by this annual event. According to the authors, the preferred function for the crossover event would have been to mark annual calendrical calculations, while the major standstill of the Moon is best explained by its wide horizon range (*Silva, Pimenta 2012. 202, 206*).

While the authors claim that the Sun crosses over the first crescent Moon at the winter solstice, during the 2014/2015 minor standstill of the Moon the actual date of the crossover was the 12th December, not the solstice of 21st December. Not just the time, but the horizon position of the crossover event is also highly variable. While the azimuth band for the range limit of the minor standstill is only about 1–2° (see below), that of the first crescent winter crossover horizon event is spread over an azimuth range of about 26°, a qualitatively higher order of magnitude than that of all lunar standstills. The Stonehenge axial upper window, which captures all the southern minor standstill moonsets, would not be able to capture about 89% of these crossovers.

It remains to be explained why the non-Gaussian distribution of the first lunar crescent crossover with the Sun has a peak which coincides with the southern minor standstill horizon moonsets. A crossover event is an amalgam of the properties of two variables – the movements of the Sun and those of the Moon. To disentangle conjoint influences, we need to elaborate their separate effects. Consider first when the Moon is at the southern minor standstill. For this year and adjacent years, the Moon's horizon range does not move much further south than when within 10° of azimuth or so of the Sun's horizon range. Only when the Sun starts to leave its winter solstice declination and begins to set further north on the horizon does it approach close enough to the Moon for a crossover to occur.

Therefore, while the event will coincide or be close to the southern minor standstill declination, it cannot take place at the winter solstice. Since Stonehenge has a lower window aligned on winter solstice sunset, the crossover model cannot explain the monument's conflation of the Moon and Sun. Now consider when the Moon is at the major standstill. The Moon then sets much further south on the horizon than the Sun ever reaches, but the Moon's horizon movements from south to north take 13/14 days, while those of the Sun take 6 months. The Moon's movements will now allow the crossover event to take place when the Sun is still at, or close to, its winter solstice horizon position, but not at the horizon position of the southern minor standstill. Therefore, this event will coincide with a winter solstice declination, but it cannot take place when the Moon is at the southern minor standstill declination.

We now turn to the Moon's movements when either expanding or contracting its horizon range and can cross over with the Sun. During this inter-standstill period, when the Sun has moved to the horizon position of the southern minor standstill about 6 weeks after the winter solstice, the Moon will cross over the Sun once it has left its southern horizon limit. In both cases, the Sun is not the winter solstice Sun, and neither is the Moon the southern minor moon. In aggregate, these separate effects create the non-Gaussian distribution, with a peak that coincides with the southern minor standstill, yet it will only rarely take place at winter solstice; most frequently, it will take place when the Moon is not at the southern minor standstill, and it will never take place during the southern minor standstill at winter solstice.

Therefore, a monument aligned on the minor standstill of the Moon and the winter solstice Sun cannot be explained by the crossover model.

The shared properties of Major and Minor lunar standstills

The third group of theories for lunar standstills identifies shared properties between the major and minor standstills; three different theories take this approach.

Alexander Thom (*1971.15*) suggested that monuments aligned on both types of standstill were devices to predict lunar eclipses. In both cases, eclipses occur when the Moon's perturbations coincide and add to the horizon range limits of lunar standstills every 9.3 years. Since the maximum perturbation only very rarely occurs when the Moon is on the horizon, Thom suggested that 'extrapolation devices' were necessary to extrapolate the precise moment of the maximum. There is, however, no evidence for such devices, and it would not be possible to track these tiny horizon movements with low-resolution alignments (*Ruggles 1999.63*). Nevertheless, as during a lunar standstill, these maximum perturbations always occur close to the equinoxes, and as NW European late Neolithic/EBA prehistoric monuments which conflate the Moon with the Sun choose the solstice Sun, and not its equinoxes (*Ruggles 1999.148–151*), the monument builders appear to be avoiding not predicting an eclipsed moon. Since an eclipsed Moon is an interrupted full Moon, it seems that the monument builders were selecting for some aspect of an uninterrupted cycle of lunar phases at their ritual centres.

The remaining two models of lunar standstills current within archaeoastronomy engage with the intrinsic properties of the Moon's phases rather than just their horizon location. Ruggles suggests that the monument builders entrained their monuments on lunar standstill full Moons. Ruggles' critique of Thom's work was based on a major field work exercise of five regional groups of monuments in the British Isles. A strong preference emerged from the data for lunar alignments on the southern lunar standstills, both major and minor, and particularly onto settings rather than risings. Ruggles concluded that they would have observed the full Moon setting along these alignments (*Ruggles 1999.75, 96–98, 107, 128, 130, 138–9, 149, 154*). But for the Moon to be full when it is at its southern extreme range, whether at the major or the minor standstill, the Sun has to be at its northern extreme, namely at summer solstice. Since all of these monument groups also included alignments on the winter solstice sunsets, not summer solstice, and since they paired the southern standstill moons with the winter solstice, this skyscape archaeology provides no justification for conflating the southern standstill Moon as full Moon with the summer solstice. Furthermore, the Sun would not be simultaneously setting in the lower window, but rising on the north-east horizon. Both the astronomy of a single point estimate for a lunar standstill and the skyscape archaeology of Stonehenge do not support selecting summer solstice full Moon as the way to interpret the southern minor standstill at Stonehenge (see also *Heggie 1981.98*).

The final sixth model of lunar standstills addresses the emergent properties from their combination with the Sun's solstices. Sarsen Stonehenge is a binary monument, with two circles and two horseshoes. With the half height, half width and half depth stone 11 it has 29 1/2 stones in the outer sarsen circle and 19 stones in the bluestone horseshoe, both lunar numbers. The building's design principle of obscuration by nested lintelled and ranked wide pillars allows bringing onto one alignment from the Heel Stone a lower window opening onto the setting winter solstice Sun and above it in another window upon the southern minor standstill moonsets (*North 1996; Sims 2006; 2016*). In short the precise archaeology of sarsen Stonehenge defines what 'astronomy' is being selected for through the cropping of the lunar and solar discs by these two windows.

Both Ruggles (*1999*) and John North (*1996*) define a lunar standstill by a single point for its geocentric extreme, and respectively use this value to justify their suggestions that the builders either selected full Moon at summer solstice or alternating perturbations during the minor standstill. To evaluate the details of these positions, consider in Figure 4 the southern minor standstill of the Moon at the latitude of Stonehenge for the thirty months from 9th November[4] 2510 to 30th April 2507 BC – the minor standstill immediately before the probable date for the building of sarsen Stonehenge around 2500 BC (*Parker-Pearson 2012*).

The extreme range is reached on 12th April 2508 BC at a declination of –19.25°, when the Moon is a

4 All dates are Julian dates.

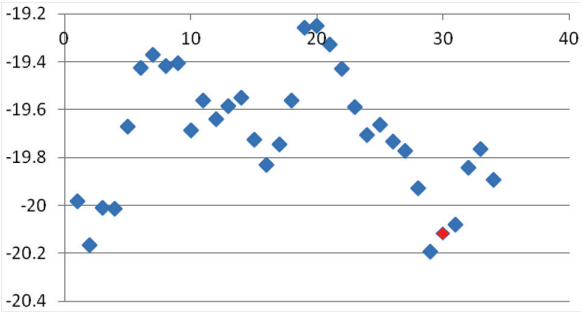


Fig. 4. Southern Minor Standstill 2510–2507 BC at latitude of Stonehenge. Note: 1 Vertical axis in degrees of topocentric declination. 2 Horizontal axis is the number of each southern lunar extreme between 2510 and 2507 BC. The topocentric extreme declination occurred on 12th April 2508 BC at declination –19.25°. 3 Dark Moon during week of winter solstice (in red) on 10th January 2507 BC at declination –20.115°. 4 Declination values for all moonsets at 4 p.m., the approximate time the winter solstice Sun sets in the Stonehenge lower window. 5 Source SkyMap Vers. 8.

waning quarter Moon. Full Moon is met three sidereal months later, during the summer solstice week of the 3rd July[5] 2508 BC at a declination of –19.59°. Since one degree of declination translates into about two degrees of azimuth at this latitude, ignoring any refraction effects, this summer solstice full Moon is about 41´ of azimuth less than the extreme point of the standstill. A descending sliver of this Moon would still be seen in the Stonehenge upper window with its declination limits as shown in Figure 4, but to the left by over one lunar diameter and not at the actual extreme value used to define the lunar standstill. This value cannot justify the choice of either full Moon or alternating perturbations as suggested by these two authors. Furthermore, during full Moon, the Sun would not be simultaneously setting in the lower window, but rising on the north-east horizon. Both the astronomy of a single point estimate for a lunar standstill and the skyscape archaeology of Stonehenge do not support selecting summer solstice full Moon as the way to interpret the southern minor standstill at Stonehenge (see also *Heggie 1981.98*).

Over a period of about 36 months, the southern extreme horizon moonsets of the minor standstill of the Moon irregularly alternate between a declination of about –19° and –20° (Fig. 4). Unlike the sun's solstice horizon position, a lunar standstill extreme limit is not a point, but a small region on the horizon which displays a vacillating reverse sequence of 36 or so lunar phases. These phases of the Moon include all phases that can be witnessed during the transiting synodic Moon, but in reverse. Selecting any one of these phases to define a lunar standstill cannot be justified by a single declination value. The archaeology at Stonehenge, and at the five regional sites reported by Ruggles, is clear – all of these 36 or so reversed lunar phases descend through the upper window at Stonehenge. This includes the dark Moon of –20.115° during the week of winter solstice on 10th January 2507 BC, ten sidereal months after the extreme declination of the Moon (Fig. 4). But the monument builders conflated this sequence in the upper window with the week of winter solstice sunsets in the lower window. By the binary architecture of the monument, this arrangement selects the entire reverse phased sequence of lunations which culminate with the binary astronomy of dark Moon at winter solstice. Since the subsequent Moons on this alignment are reversed waning crescent Moons, and as these are visible only when rising a few hours before sunrise and not at their setting, then for three or so months from the winter solstice no Moon will be seen setting in the Stonehenge upper window. It seems that the monument builders required their rituals to coincide with the start of the longest darkest night.

It may be thought that when a dark Moon coincides with the Sun's solstices outside the periods of lunar standstills, this invalidates selecting this conjunction for standstills alone. For example, dark Moons occurred during this millennium's winter solstice week in 2003, 2011 and will do so in 2017, none of which are standstill years. However, the issue is that none of these occurrences outside of the 2014–2016 period of the lunar standstill could be identified by a stable alignment spread of a few degrees over the course of 36 months. The moon's horizon range limits occupy two very small and stable parts of the horizon only at these periods of the major and minor standstills. This is not possible during inter-standstill years, where the range limits are changing substantially. In Figure 5, it can be seen that over the three years of the inter-standstill years of 2505–2503 BC the southern lunar extremes range from –22.4° to –27.5° declination. This difference of 5.1° declination equals 10.2° of horizon azimuth, and could not be accommodated within the Stonehenge architecture. Only during the period of a lunar standstill could an alignment with a range of two degrees

5 Summer and winter solstices were on 3rd July and 9th January, respectively, around 2600 BC, and 2nd July and 8th January, respectively, around 2500 BC.

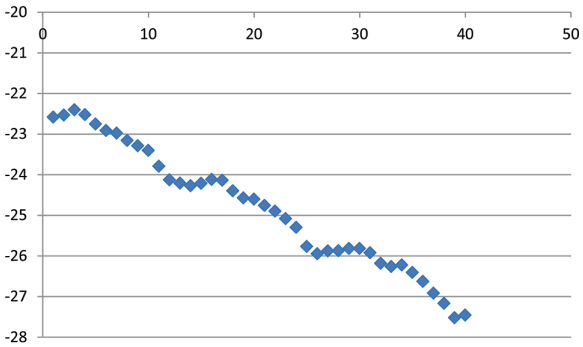


Fig. 5. Southern lunar extremes at the latitude of Stonehenge during the inter-standstill years 2505–2503 BC. (Source SkyMap vers. 8). Note: 1 Vertical axis in degrees of topocentric declination. 2 Horizontal axis is the number of each southern lunar extreme between 2505 and 2503 BC. 3 Declination values for all moonsets at 4 p.m., the approximate time the winter solstice Sun sets in the Stonehenge lower window. 4 Source SkyMap Vers. 8. 5 Another possible challenge concerns the claim for the meshing of lunar phases exactly conflating dark Moon with the solstices between each standstill. Since the standstill cycle recurs every 18.61 years, and as this is an irregular number, repeating standstill dark Moons will not always coincide with the solstices close to the central extreme declination value of the following or preceding standstill.

accommodate a horizon reversed suite of lunar phases culminating in dark Moon at winter solstice and so be enshrined into the axial centre of the monuments. Such was the case for the minor standstill period of 2014–2016, when dark Moons also occurred during winter solstice week on the 22nd December 2014, when the Sun was setting in the Stonehenge lower window.

The peaks and troughs in the Moon's horizon movements will therefore migrate serpent-like through each standstill, and this would seem to invalidate the model's claim that dark moons will always coincide with solstice weeks during lunar standstills. This misunderstanding of the model is a consequence of defining lunar standstills by the 18.61 year cycle of modern celestial mechanics, whereas prehistoric sky watchers understood it by horizon azimuth. However it should be remembered that the archaeology of Stonehenge, and the five regional groups studied by Ruggles, specify the combined selection of winter solstice sunsets and the southern (major and minor – see below) lunar standstill sunsets. The association of these two alignments migrates through a 36 month period of each standstill, sometimes occurring before the extreme declination and at other standstills after that extreme. Table 1 shows the six minor standstills that occurred during the century before the presently understood building date of Stonehenge. At the latitude of Stonehenge, in these cases over a maximum period of twenty months, the moment of the extreme declination of the Moon varies over the course of the one month of April, while dark Moon coinciding with winter solstice also varies over the course of the third millennium BC, but by either four months before the extreme or ten months after it. In short, within a small alignment horizon band of about $1\,1/2°$ (0.7196 x 2) over the course of one year in the three years of these minor standstills, 13 reversed phased sidereal Moons culminate in dark Moon at winter solstice for all six minor standstills.

Northern lunar standstills

Our critique through the details of sarsen Stonehenge of the first five archaeoastronomy models of lunar standstills has concentrated on the minor standstill of the Moon at its southern moonsets. An identical structure is revealed in the northern extreme moonsets of the minor standstill and in the southern and northern major lunar standstills. Figure 6 shows the northern and southern minor standstill for 1978 AD and similarly for the major

Year BC	Moon's topocentric extreme date	Moon's topocentric extreme declination°	Winter solstice dark Moon date	Winter solstice dark Moon declination°	Deviation in sidereal months of dark Moon from top. Extreme	Deviation of winter dark Moon from topocentric extreme in degrees declination°
2602	30 April	–19.633	10 January	–20.0101	–4	0.3768
2583	2 April	–19.517	10 January	–19.808	–3	0.3713
2564	28 April	–19.241	9 January	–19.727	–4	0.4853
2546	11 April	–19.367	10 Jan 2545	–19.819	+10	0.4519
2527	11 April	–19.233	10 Jan 2526	–19.953	+10	0.7196
2508	12 April	–19.583	10 Jan 2507	–20.116	+10	0.5325

Tab. 1. Relationship between dark Moon during week of winter solstice and the topocentric extreme of the southern minor standstills at latitude of Stonehenge for 2602–2508 BC. (Source SkyMap vers. 8)

standstill of 1969 AD. It should be remembered that these smooth sinusoidal plots represent the points of the geocentric extremes of the Moon during its orbit around the Earth, but that once reaching the horizon, the Moon's declination will have changed and a more erratic fluctuation will be observed (see Figs. 3 and 4). The remaining pattern and properties shown in Figure 6 are general for all lunar standstills (see *Thom 1971.20; 1978.11–16; North 1996.553–572*).

Just as we found that the extreme declination value for the southern minor standstills occurred at first or third quarter Moons around the time of the equinoxes, this remains the case for northern minor standstills and major standstills at both northern and southern extremes. For the twenty or so sidereal lunations shown here in each lunar standstill, they all occur within a very narrow band of about 30´ of declination and all present a reverse sequence of lunar phases every 27 or so days spread over the course of $1^1/_2$ years. The remaining structural feature of dark Moon synchrony with the Sun's solstice that we have found for the southern minor lunar standstills also belongs to the northern minor standstills and both the southern and northern major lunar standstills. Thus while during the southern major standstill dark Moon happens during the week of winter solstice just as it did for the southern minor standstill, now for the northern lunar standstills, whether minor or major, dark Moon occurs during the week of summer solstice.

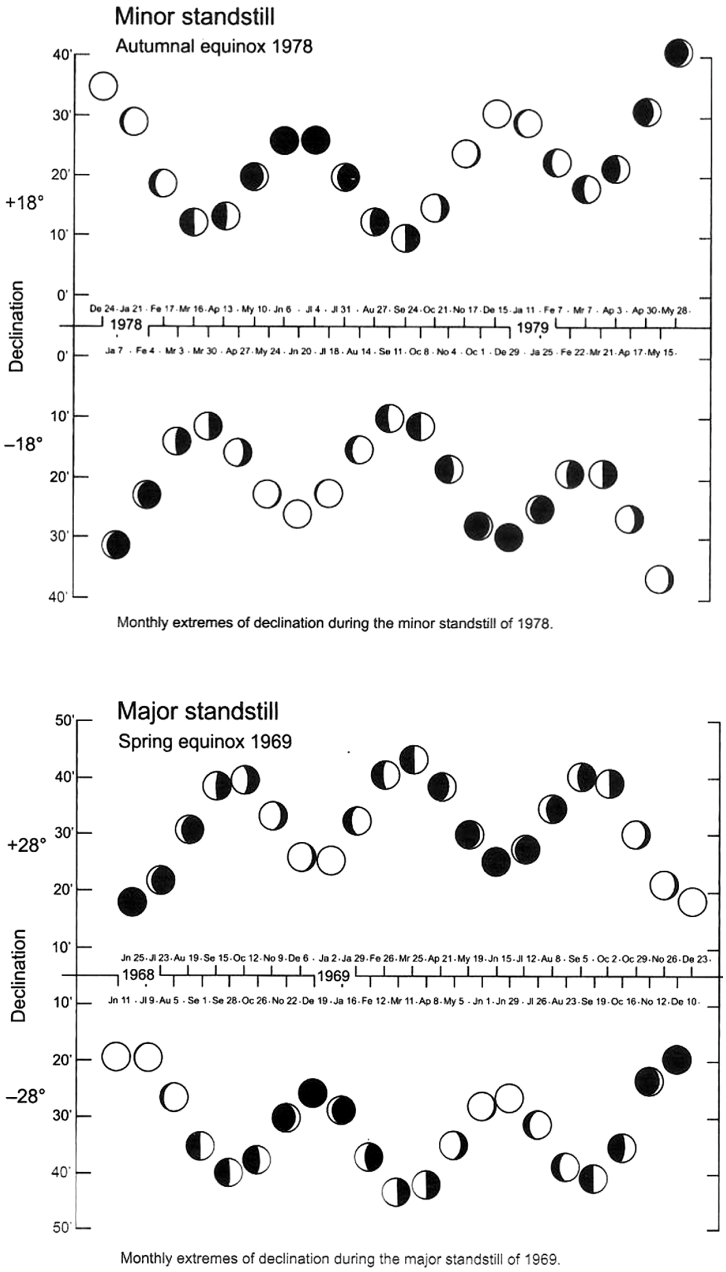


***Fig. 6. Monthly geocentric extreme declinations of the 1969 major standstill and the 1978 minor standstill, by date and lunar phase (*Morrison 1980*)*[6].**

For the minor standstill period of 2014–2016 dark Moons occurred not just during winter solstice week on the 22nd December 2014, but also for the summer solstice week of 17th June 2015. This synchronisation will always occur within a period of about 36 months around the extreme horizon moonsets of each lunar standstill of the Moon. Because of this

6 Four considerations need to be kept in mind when interpreting this computer- generated model of lunar standstills: (a) The vertical axis is cropped, so abutting the northern and southern horizon extremes when they are actually widely separated on the western and eastern horizons by about 60° for minor standstills and about 100° for major standstills at the latitude of Stonehenge. (b) The diameter of the lunar orb is not to scale and has been reduced to 5' from its actual 30' to better display its 20' perturbations. (c) The Moon's path is measured by its geocentric declination, which is a modern measure from heliocentric positional astronomy of the distance in degrees from the celestial equator to the centre of the lunar disc. Prehistoric horizon flat-earth 'astronomy' measures by azimuth and horizon altitude to the upper or lower limb of the Sun and the Moon. At the latitude of Stonehenge, 1° of declination translates as about 2° of azimuth for a given horizon. (d) The Moon's geocentric extreme declination occurs at any time in its transit around the earth and only very rarely when it is breaking the horizon. As the Moon is always changing its declination, the regular sinusoidal variation in perturbation displayed in this figure is not observable on the horizon.

fluctuating synchronisation of solstice and dark Moon during each minor and major standstill, the alternation between them is about nine years and the 18.61 year nodal cycle length is an understanding from modern heliocentric positional astronomy and not relevant to a prehistoric flat-earth geocentric cosmology.

Interpreting the model of dark Moon lunar-solar conflation

This understanding of lunar standstills as conflating the Sun's solstices with dark Moon seems counter-intuitive for observational astronomy – "*... this makes no sense...[when] the Moon is new, and hence invisible ...*"(*Ruggles 1999.247*). It was probably for this reason that Ruggles characterised his own field data, which largely conflate solstice and standstill alignments to the south west, as 'anomalous' (*Ruggles 1999.142, 158*). But as long as his findings are data, then it is only the interpretation of full Moon that can be anomalous. Instead of making an a priori assumption that the monument builders required a full Moon, we need to ask the question of what properties are revealed by solarising the Moon' alignment? Sims' model of lunar-solar conflation argues that a monument's combined alignment on the Moon and the solstice Sun selects sidereal properties that reverses lunar phases, attenuates a full suite of lunar phases in a time-lapsed observation exercise spread over the course of a year, and culminates at winter and summer solstices with dark Moon at southern and northern lunar standstills, respectively, every nine or so years. In short, this model embraces all of the observed characteristics of lunar standstills as a horizon alignment. We would expect these themes of solarisation, reversal, attenuation and alternating dark Moons over a nine-yearly cycle to inform an interpretive theory of lunar standstills.

The suite of properties which has survived our critique exponentially reduces the number of possible interpretations. Any theoretical model which prioritises full Moon, annual calendars or eclipse prediction is not supported by our findings. This complex portfolio of characteristics suggests symbolic aspects of ritual embedded within signalling the large labour investments required by monumental architecture. If this interpretation is correct, then we would expect similar themes of alternation, reversal and calibration or re-calibration of the lunar and solar cycles to be predicted by an appropriate theoretical model.

Three considerations suggest we should look at this suite of characteristics as the property of a syncretic ritual – an overlay on a previous system of ritual: the formal properties of lunar-solar alignments, the prehistoric archaeology and the anthropology of the prehistoric socio-political systems that built the monuments. Since reversal is built into the properties of a solarised lunar alignment, this is formally consistent with the way in which syncretic systems build reversed structures on those which preceded them, and which they are designed to displace, confiscate and annul. It is also consistent with the continuity paradigm that Neolithic cosmologies derived from their antecedent Mesolithic and Palaeolithic forager ancestors (*Silva, Franks 2013*). And it is anthropologically sensitive to the monument builder's culture. They were Neolithic cattle herders, who, while continuing to hunt and forage, had split with their Mesolithic/Palaeolithic solely hunter-gatherer origins (*Stevens, Fuller 2012*). Since hunters earn a wife through a life-time's bride-service, and cattle owners purchase a wife through bride-price payments, this transition is fraught with dislodging matrilineal rights in the interests of an emerging patrilineal culture which prioritises the accumulation of cattle wealth (*Sims 2013b*). If we pare away the surface overlay that constitutes this solarised lunar syncretism, this formal exercise requires us to reverse the reversed lunar phases of lunar standstills while preserving the themes of alternating dark Moons. The result is to radically simplify the root template out of which lunar-solar conflation can emerge. Instead of reversed-phased Moons, we would then have synodic lunar phases prioritising dark Moon rituals, and instead of lunar-solar attenuated timescales, we have monthly alternation every 29/30 days – in short the transiting Moon as seen in the sky by any observer without the intermediary of a monument alignment. We are left with a ritual system synchronised with lunar phases which culminate with dark Moon. As a formal operation, as Palaeolithic continuity and as gender reversal, we arrive at a lunar transformational template.

Lunar-phased ritual system considered as a transformational template

Our interpretation of solarised lunar standstills as syncretic cosmological systems derives from a prior condition of Palaeolithic gender equality with (synodic) lunar scheduled rituals. This predicts an initial situation, cultural origins model of lunar- scheduled ritual syntax, which entails, consequent upon later socio-economic changes, later Neolithic lunar-solar monument alignments. This lunar template suggests

that those who monopolise ritual power do so through a dark Moon performative achievement. While we have derived this model through the archaeoastronomy of solarised lunar monumental alignments, it converges with the predictions of sex strike theory (*Knight 1991*) that, in conditions of abundant mega-fauna, monthly dark Moon menstrual seclusion rituals of matrilineal siblings were used by Palaeolithic women to motivate prospective 'husbands' from other clans for hunting services.

Limiting ourselves in this paper to the archaeoastronomy implications alone, while the model predicts that the ritual syntax of dark Moon is invariant, it also predicts that changing relations of power and economic shifts provide the motivation to transform this lunar template. For example, matrilineal sibling coalitions relying on monthly big game hunt provision will become vulnerable during the mega-fauna extinctions that took place in Palaeolithic Europe between the Aurignacian and the Magdalenian (*Surovell 2008*). Once such resource stress sets in, then according to regional circumstance, the model predicts a number of alternative routes for the ritual appropriation of 'astronomy'. We have found monumental solarised sidereal lunar alignments at Stonehenge which reverse the synodic Moon while preserving a dark Moon culmination. Ruggles provides the same data for five other regional groups of monuments in the prehistoric British Isles, and North showed it for the Avebury monument complex 20 miles north of Stonehenge. Exactly the same 'astronomy' is found in the ancestral Hopi 'Sun Dagger' site at Fajuda Butte (*Sofaer 2012; Sims 2016*). It also allows a solar or stellar cosmology to overlay, or replace and annul an earlier lunar cosmology.

Evidence for an earlier version of this transformation can be seen amongst one group of Magdalenien hunter-gatherers in the Praileaitz I cave in the Basque country with a solarised and modularised synodic lunar transformation (*Sims, Otero in press*). For any solar cosmology, we would expect it to carry contrary evidence of an earlier lunar origin exhibiting formal attributes according to lunar laws of motion. For example, it suggests that later versions might include cosmologies appropriating heliacal risings and settings as lunar equivalents of waning and waxing crescent Moons spanning the period of dark Moon, or using the phases of Venus as lunar equivalents as do the Ona hunter gatherers of Tierra del Fuego (*Bridges 1988*). This critique of lunar standstills reveals the prospect of a lunar transformational template being the source of a 'periodic table' of 'astronomies' used by the world's cultures throughout history to buttress ritual systems experiencing varying degrees of stress and emerging social complexity. Rather than archaeoastronomy becoming a field discipline for 'alignment studies' eschewing interpretation (*Ruggles 2011*) or as a fringe discipline (*Hutton 2013*), it opens up an alternative robust and scholarly future as cultural astronomy allied to and embedded within archaeology and anthropology.

Conclusion

The 'Thom paradigm' (*Aveni 1988*) found solstice and standstill alignments in many prehistoric monuments of NW Europe, and claimed that this was in the service of eclipse prediction. After fifty years of research, eclipse prediction has not been accepted within archaeoastronomy, but the remaining evidence of solar and lunar alignments remain and still require interpretation. In this paper, we have rejected all except one model remaining within archaeoastronomy for this evidence. Horizon range, crossover, perturbation and full Moon fail the tests internal to the discipline to explain the properties of prehistoric monument alignments on the Moon. Our critique instead suggests that a model of lunar-solar conflation points to a ritual syntax centred on dark Moon rituals is amenable to multiple transformations consequent upon shifts in socio-political power. If this model of a lunar transformational template withstands refutation, then these examples open the prospect for archaeoastronomy to find a 'periodic table' of alignments that will map onto the world's cosmologies and religions. It predicts that archaeoastronomy has a central and essential role to play in future research into the cosmologies of the world's cultures.

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Landscape construction and time reckoning in Iron Age Celtic Iberia

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ABSTRACT – *In this paper, we report on three areas of the Iberian Peninsula that were occupied at least during the Iron Age and the early stages of Romanisation, where observations of astronomical phenomena in the landscape, rock carvings, and Latin inscriptions point to a particular method of time reckoning. All of these sites have previously been connected with the Celtic culture. The knowledge of the natural world that Classical sources assigned to these peoples need not have been reflected in a monolithic calendrical system used by all Celtic communities on the Continent. In fact, such a 'Celtic calendar' may have had different expressions in different areas, expressed in different ways, although sharing some common characteristics such as the particual use of the lunar and solar cycles.*

IZVLEČEK – *V članku poročamo o treh območjih na Iberskem polotoku, ki so bila poseljena vsaj od železne dobe in začetka romanizacije, kjer smo na podlagi opazovanj astronomskih fenomenov v pokrajini, na podlagi skalnih rezbarij in latinskih napisov prepoznali posebno metodo merjenja časa. Vsa predstavljena najdišča so bila doslej povezana s keltsko kulturo. Znanje o naravi in svetu, ki so ga klasični viri pripisali Keltom, se ni nujno odražalo v monolitskem koledarskem sistemu, ki so ga uporabljale vse keltske skupnosti na celini. Takšen 'keltski koledar' se je lahko v različnih območjih izražal na drugačne načine, vendar je pri tem ohranil nekatere skupne značilnosti, kot je npr. posebna uporaba Luninih in Sončevih ciklov.*

KEY WORDS – *archaeoastronomy; cultural astronomy; calendars; Celtic Spain*

Introduction

A calendar reflects a particular conception of time constructed to meet the needs of a given society. How this time reckoning may have been first observed and recognised and later reflected in a calendrical system is a matter of debate (see *e.g., Marshack 1985* and references thereafter), also taking into account its symbolic implications, as they are well known from the classical work by Martin P. Nilsson (*1920*).

In this paper, we report on three areas in the Iberian Peninsula that were used at least during the Iron Age and the early stages of Romanisation, where observations of astronomical phenomena in the landscape, rock carvings and Latin inscriptions point to a particular method of time reckoning which may be seen as attempts at establishing a calendrical system. These sites are the rock art area of Campo Lameiro in the province of Pontevedra (Spain), the Panoias Sanctuary, near Vila Real in the North of Portugal, and the Celtiberian site of Peñalba de Villastar, next to the town of Teruel (Spain; Fig. 1). All of them are sites which have been well known for decades, although a number of profound revisions have been carried out in recent years, and we had the opportunity to

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carry out field work at all three of them. All of these sites have been previously connected with the Celtic culture.

A critical view of the European second Iron Age has led to what has been referred to as 'Celt-scepticism' (*Merriman 1987; Hill 1993; Sims-Williams 1998; James 1999*). This view was inspired mainly by an in-depth re-examination of the archaeological evidence presented by scholars of the 19th and early 20th centuries (*Collis 2003; Brunaux 2006*). Nevertheless, the samples of data, analyses and studies accumulated over the last century in areas of knowledge other than archaeology, highlight the presence of shared cultural forms by Celtic language speakers, who also present diverse forms of social organisation, and who lacked a common political structure (like, for example, the Ancient Greeks; *Megaw, Megaw 1996*). Thus, we face the apparent paradox of the presence and absence of the Celts. Possibly, following Simon James (*1999*), the traditional understanding of the term 'Celtic' might be misleading, and those societies were more varied than usually assumed. Not all 'Celts' may have shared a common 'cultural package'; however, some common features could have been shared in some instances. Arguably, how time was managed in a broad sense could be one of these and deserves investigation.

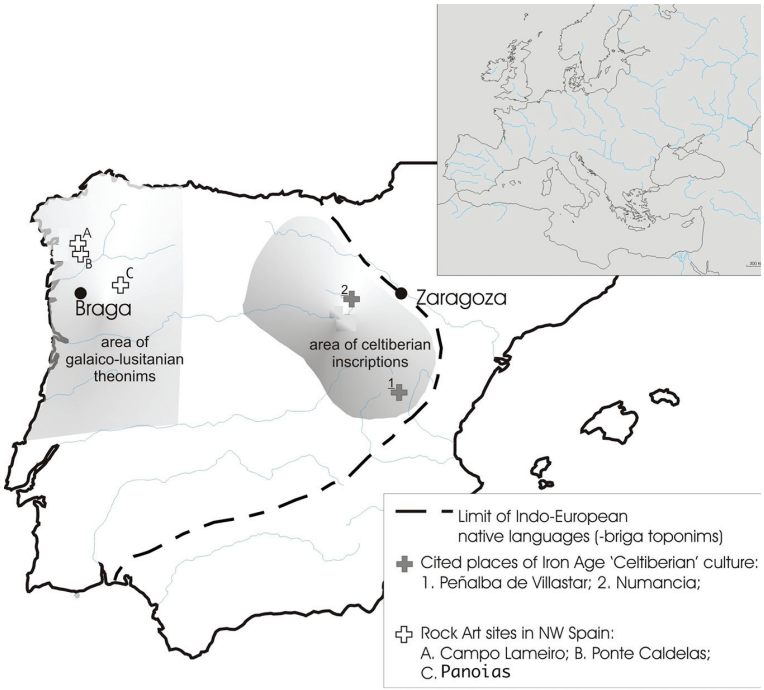


Fig. 1. Iberian Peninsula sites and cities mentioned in the text.

According to the traditional view, the Celts were reluctant to adopt writing, a common cultural fact in the Indo-European tradition (*Sergent 2005*). The only written records about them come after inspiring ethnographers from antiquity (*Tierney 1960; Nash 1976*), by adopting writing from other cultures (*Jordán 2007; Lejeune 1985; 1988*) or after the introduction of a new cultural/religious manifestation, such as Christianity (as happened in early medieval Ireland).

Celtic calendar

As mentioned above, one of the supposedly common cultural aspects could be the Celtic calendar. However, this requires a renewed study in order to reveal its religious, cultural and intellectual frameworks, and the likely differences among varying Celtic areas. In fact, a large part of our knowledge of the Celtic calendar relies only on the Coligny calendar.

The Coligny calendar was discovered in 1897 at Coligny, 100km North of Lyon in France. It is comprised of several dozen broken fragments containing Gallic language inscriptions in Latin script dated on a palaeographical basis to the end of the second century AD. The inscriptions are arranged in sets of twelve groups repeated five times, which seems to point to a series of 5 lunar years of 12 months, with each month having either 30 or 29 days. There also seems to be the possibility of introducing intercalary months at appropriate times (*Duval, Pinault 1986*; see also *McCluskey 1990*).

In a paper published in 1904, J. Loth pointed out the parallelism between the temporal notations in the Coligny calendar and the temporal formulae present in modern Celtic languages and folklore (*Loth 1904*; in a similar line, see *Duval, Pinault 1986; Laurent 1995*). The foundation for such a calendar would have been the knowledge of astronomical phenomena that Graeco-Latin ethnography attributed to the Druids (see, *e.g.*, Caesar, *De bello gallico* VI, 18; Pliny, *Naturalis historia* XVI, 95; Diodorus of Sicily V, 31; Strabo IV, 4,4) and, to the Celtiberians of ancient Iberia (Strabo III, 4, 16).

However, it is one thing to identify and admit this type of knowledge, and quite another to state what

this knowledge was about. What celestial phenomena did they identify? For example, it is interesting to note that Julius Caesar (*De bello gallico* VI, 14, 3) mentions that Gallic druids were trained over a 20-year period. Could this period be related to a knowledge of the Metonic lunar cycle of 19 years within the framework of the general astronomical science attributed to the druids? Also, it is necessary to establish the temporal and geographic dimensions of this knowledge (*Gaspani, Cernuti 1997; Gaspani 1999; Kruta* et al. *2008*). Did the traditionally claimed Celtic tribes throughout Europe share this knowledge, or were there differences among them?

In this case, it is important not to rush to conclusions. Instead, we must design a methodology to study the relationship between landscape and time in places and periods where the consideration of the Celtic cultural background is firmly based. In the present paper, we present the results of a preliminary attempt to investigate the differences and similarities in time reckoning systems from three sites in Iberia traditionally linked with that Celtic milieu.

When dealing with calendrical issues, it is important to note the problem of incommensurability. This problem arises due to the inequality of the solar and lunar cycles. The simplest way to accommodate both is the three-year cycle with 37 months; 37 synodic lunar months amount to 1092.61 days, while 3 tropic solar years are 1095.73 days, or just three days' difference[1].

Iron Age 'Celtic' Iberia

The Iberian Peninsula has commonly been neglected by traditional continental Celtic studies, basically due to the absence of the La Tène style art. However, it must be stressed that, other than Gaul, Classical writers use the term 'Celtic' to describe several tribes in Iberia (*James 1993*). Alberto Lorrio and Gonzalo Ruíz Zapatero (*2005*) offer a general characterisation of the period between the end of the Bronze Age and the Iron Age in the Iberian Peninsula, and discuss the problems posed by the Celtic question in Iberia.

From the Roman conquest of the Iberian northwest in 19 BC, there are theonyms and anthroponyms together with toponyms in Celtic language that coexisted with another language, to an extent that is still debated, conventionally known as 'Lusitanian' (*Prósper 2002.311–312, 357–382; De Bernardo, García Quintela 2008*). The Celtiberian area, in central Iberia, is where most texts in a Celtic language have been recorded from antiquity. These were first written in paleo-Hispanic characters and later in the Latin alphabet (*Jordán 2007; 2008*). We must bear in mind that in both cases, we face situations of cultural intersection.

There are some precedents to our study linking the landscape and the sky in several archaeological sites in the Celtic-speaking area of the Iberian Peninsula. Juan Antonio Belmonte and Michael Hoskin (*2002*) indicate that the 'verracos', sculptures created by the Vettons in central Spain (Toros de Guisando, Ávila, Spain) face the sunrise at the equinox. However, this could be a unique case, as no systematic study on these sculptures has followed this first attempt. The sanctuary of Ulaca belongs to the same culture, and was recently reported as having some astral connections (*Pérez Gutiérrez 2008*). Isabel Baquedano and Carlos M. Escorza (*1998; 2008*) report that the stelae in the necropolis of La Osera are also oriented with respect to the skies, notably with some stars, to some extent. Among the Celtiberians, Manuel Pérez and Francisco Burillo (*2009*) claim that a peculiar, possibly ritual, building found on the outskirts of Segeda is aligned with summer solstice sunset (*Pérez, Burillo 2009*). Necropolises such as Tiermes (*Argente, Díaz and Bescós 2001*) and Herrería (*Rodríguez* et al. *2007*) have been claimed to include astronomical orientations, although these are highly debatable. Finally, Luis Valdés (*2005*) links the orientations at the Iron Age sanctuary of Gastiburu in the Basque Country with control of a seasonal calendar. Also, the rock art site of A Ferradura (Ourense) in Galicia has several engraved panels that have been linked with astronomical alignments (*García Quintela, Santos Estévez 2008*).

All these works point towards a possible interest in devising and perhaps using some kind of time-reckoning system. Most are linked to the sun and perhaps the moon, although for some of them stellar alignments are also investigated. However, it is difficult to draw a common picture from these analyses. All of these studies lack the general treatment and methodology we are seeking, including a truly interdisciplinary approach. While each individual study offers a sound and scientific treatment of the

1 This simple system has been proposed before for different cultures both in the Mediterranean (*e.g.*, Ancient Greek calendars may have incorporated cycles of this kind; see *Hannah 2005*) and in the Canary Islands (*Belmonte, Hoskin 2002.235–42*).

data, we believe the way to advance further is by exploring the data simultaneously from several points of view.

Therefore, we begin by discussing the methodology of our approach. Secondly, we develop study cases. We then situate the results within the framework of the religious and historic context and the symbolic structure of the landscape in order to finally reach a series of conclusions and propose further work for the future.

Disciplines and methods

Calendar studies find their place necessarily at a crossroads of disciplines. The first issue is the relationship between calendar and landscape. A number of authors argued that the normal perception of reality in different societies begins with space (*Bender 2002; Criado 1989; 1999; Ingold 1993*), and with other interests (*Levinson 2003; Burenhult, Levinson 2008*). Filling in the landscape with content helps to apprehend a territory. This can be achieved by associating tales that give meaning to the natural landscape, or by building monuments.

Using this general idea as our starting point, we based our research on the tenets of landscape archaeology. This perspective considers that societies always leave a 'footprint' in space at several levels of intensity. These footprints may overlap in several ways with older ones, leaving a more or less firm imprint, leading us to read the landscape as a palimpsest. However, each human group in a given territory assumes the landscape completely or in part according to its own intellectual code. In other words, a landscape, *i.e.* the natural and/or artificial elements placed in a given space, forms part of the present in each historical moment, regardless of when they were built or created (*Parcero* et al. *1998*).

Secondly, from an archaeoastronomical point of view, we are faced with the duality of the possible methodologies. On the one hand, there is 'ethnographic' archaeoastronomy, which considers architectural alignments with heavenly bodies detected in historic contexts according to knowledge derived from written and/or oral sources[2]. On the other hand, 'statistical' archaeoastronomy mainly operates by studying possible statistical regularities in prehistoric remains. The two perspectives are not contradictory, as they merely refer to the way of adapting the investigation to the available information resources, and most archaeoastronomical studies include both approaches to a certain degree (see *Iwaniszewski 2009* and *Ruggles 2011* for recent papers on these issues).

Thirdly, the temporal and cultural framework (see below) allows us to introduce the comparative method of the history of religions. The Indo-European horizon presents a well-known framework of reference on the symbolic plane identified by landscape archaeology (*García Quintela, Santos Estévez 2008*). With respect to archaeoastronomy, the same Celtic cultural horizon allows to contrast the astronomical observations with ethno-historic evidences. This said, the places studied are not outside the historical process and, as we will see, including Latin inscriptions, and also the Christian saints who were/are worshiped in these landscapes, provide additional strata of information and meaning that are worthy of inclusion within the general interpretative framework.

Of course, other disciplines could have been applied, but given the nature of the investigation presented below, we considered that these methodologies were the most fitted for the problem that concerns us: how these peoples may have imprinted their sense of time, their calendar and perhaps their rituals on the landscape, and whether we can learn something about their notion of time by studying their archaeological remains. It will finally be interesting to see how this picture contrasts with traditional views on the Celtic calendar.

In order to address these questions, we endeavoured to make a series of archaeoastronomical measurements at the several sites of interest. After determining the direction from which to set the orientation, we take the azimuth for this direction by using two tandems including a precision compass and an inclinometer; one is a Suunto 360PC/360R and the other a Silva Surveymaster. The error of an individual reading judged by the scale of the instrument is $\pm\ 1/4°$ for the azimuth and $\pm\ 1/2°$ for the height of the horizon. Note that the individual azimuth determined will have a larger possible error due to, above all, the condition of some of the remains measured.

2 This type of investigation also relies on iconography and other types of contextual evidence. It should not be confused with another methodology also called 'ethnoastronomy', which is the study of astronomical concepts in ethnographically documented societies.

Since the instruments used are magnetic, we correct magnetic declination readings. This value was estimated for the fieldwork dates from the models available in http://www.ngdc.noaa.gov.

The data can be compared with estimates for celestial objects visible in that section of the horizon. To perform this comparison, our measurements were translated to declination, resulting in an error estimate around 1°.

Calendars and landscape

Campo Lameiro: carved deer and time reckoning

The prehistoric rock carvings found in the northwest of the Iberian Peninsula are among the most important of this type of artistic manifestation. Discovered between the 1920s and 1930s (*Sobrino 2000*), they have been studied fundamentally from a formal, chronological and inventory-based perspective. These carvings are concentrated in the southwest of Galicia, coinciding with the present-day Spanish province of Pontevedra, although more and more carvings are appearing in other zones, not always in the same style. Also, the carvings do not appear at random, but are situated at specific points and on specific rocks, and arranged in patterns that are discovered little by little, as they are not always easy to determine. The largest concentration of these carvings appears in the area known as Campo Lameiro. This area includes carvings of great variety, including circular motifs (spirals and labyrinths), swords, and many others, with only two written inscriptions in Latin. Among the different motifs that they include, deer are the most important (*Santos Estévez 2008b*).

Carved deer appear forming herds and, on some occasions in hunting scenes (*Peña-Santos, Vázquez-Varela 1996.41–58; Peña-Santos, Rey-García 2001*). The common size of these deer is between 40 to 50cm (*Santos Estévez*, per. comm.), and here we consider four in which an oversized deer (mean of 100cm) is represented. These are in Laxe dos Carballos and Rotea de Mendo (both in Campo Lameiro), Laxe das Cruces and Campo de Cuñas (both in Ponte Caldelas, an area some 20km from Campo Lameiro). They are the largest of the carved deer known in Galicia (Fig. 2). In three out of four cases, a 'great deer' dominates an unusually complex carved panel and has an unnatural number of tines per antler. Only the one at Campo de Cuñas (our fourth great deer) appears alone.

Previous studies have linked the petroglyphs in Galicia with calendric issues. Alonso Romero (*1983*) found some numerical relations on the carved panels from Muros (Pontevedra) that he interpreted as calendric. A dual time-reckoning system (solstices and mid-season Celtic feasts) was identified in the engraved rocks of the Ferradura area (Ourense) (*García Quintela, Santos Estévez 2008.231–295*). But both proposals are limited to isolated cases. The case we will now present possibly overcomes this handicap.

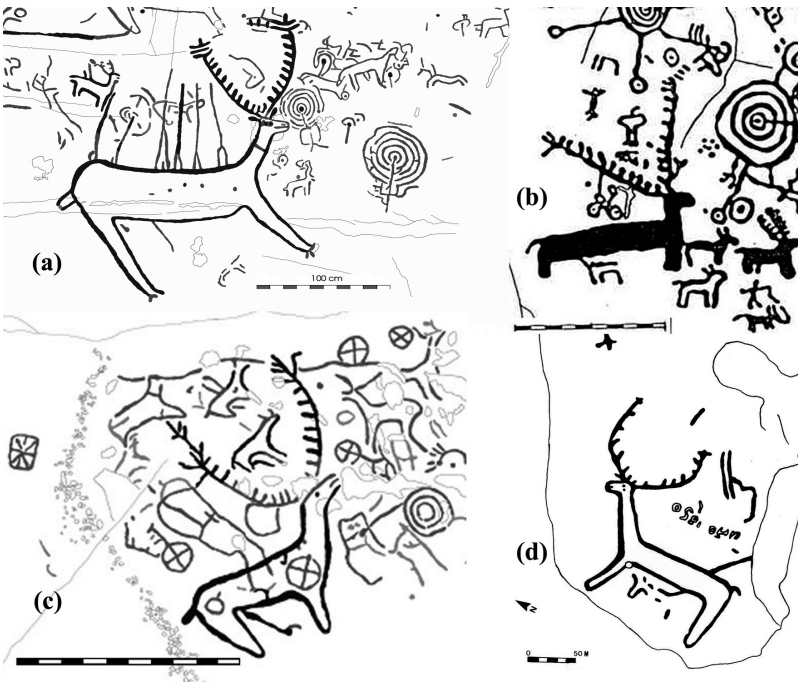


Fig. 2. The four great deer:* a *Laxe dos Carballos and* c *Rotea de Mendo are located in Campo Lameiro, while* b *Laxe das Cruces and* d *Campo de Cuñas are located in Ponte Caldelas.

The carvings considered in this study are located at a series of places with common characteristics at which we find huge deer at sites where astronomical events might be witnessed in particular areas of the horizon. Moreover, these deer present an 'abnormal' number of tines in their antlers. Their representation is not 'naturalistic'. Arguably, apart from the landscape orientations, a possible way of counting the tines may link them with a calendrical meaning. This is the case with three of our four great deer.

Laxe dos Carballos (Fig. 2a) is the only carved panel with a relevant adjacent and datable stratigraphy out of the fifteen or so excavated in Galicia over the last ten years. Radiocarbon dating gives 800 BC as a date post quem relevant to these carvings (*Santos Estévez 2008a*).

The iconographic and topographic characteristics of the great deer and panel of Laxe dos Carballos are:

❶ The deer is much larger than the average size of those in the region.
❷ The deer faces right.
❸ The horizon is open to the southeast.
❹ This horizon has significant astronomical events (solstices and/or lunastices).
❺ The deer is in front of a large, circular motif, surrounded by other smaller similar motifs[3].
❻ A carving is located within the antlers.
❼ The antlers have an excessive number of tines (*i.e.* ≥ 11, as opposed to the standard of 7 in smaller deer).
❽ There are three isolated 'strokes' beside the right antler.
❾ The way of counting the number of tines could evoke an 'astronomical' number (12, 13, 15, 30).

The distant horizon from Laxe dos Carballos opens to the southeast (see Tab. 1), and it is in this direction that we find the only two written inscriptions in all Campo Lameiro: two rocks with the Latin text DIVI. They are located at the top of two low hills on a ridge in front of that far horizon, which is itself dominated by a distant mountain. Around 800 BC, sunrise at the winter solstice and moonrise at the southern major lunastice (SML) occurred close to the locations of the rocks inscribed later with the two DIVI inscriptions (Fig. 3; Tab. 1)[4], *i.e.* the most southerly rising position of both celestial bodies.

Arguably, the number of tines in the antlers and the way they are distributed may evoke some interesting astronomical numbers (see Fig. 4): 12 is the number of lunar months in a single solar year, while (12 + 3) x 2 = 30 is the whole number of days in a lunar month. We might also count the tines in a sequence suggested by the three isolated strokes next to the

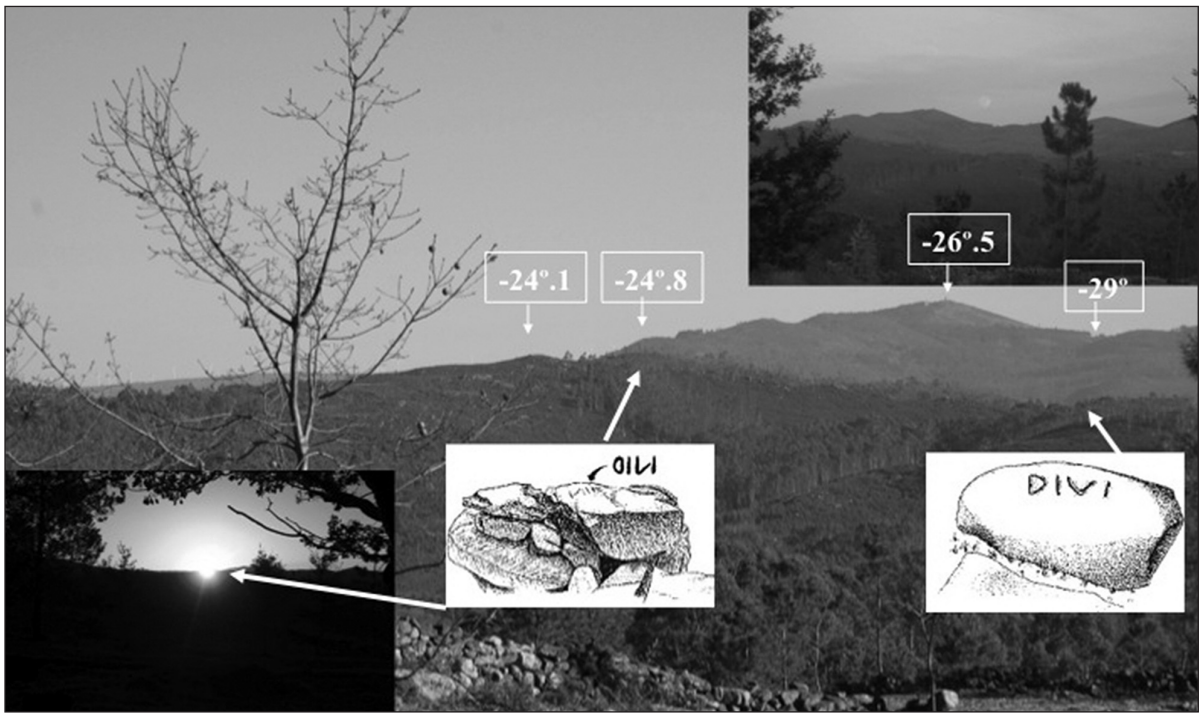


Fig. 3. SE horizon from Laxe dos Carballos. The two small inset pictures indicate sunrise at the WS (lower left), and full moonrise at the SML of July 2006 (upper right). The drawings indicate the shape and location of the two DIVI inscriptions. The numbers indicate the astronomical declination for different points in the horizon.

3 This is not surprising, given the frequent connection between deer and concentric circles in Galician rock art. However, this particular setting appears only in 25% of the cases, as noted by Åsa Fredell (*2006.129–130*), while in our sample it appears in three out of four cases.

4 Normally called the lunar standstill, we prefer the nomenclature of lunastice, as opposed to the also common name lunistice. First, the term lunastice is a parallel to the solar solstice, meaning solar standstill. Second, the Latin word Luna declines to luna-stitium, or lunastice.

right antler. Starting at the farthest to the right and counting three times (right-left-right), we obtain 12 + (12 + 1) + 12 = 37, which is the number of lunar months in three solar years, as explained above (Fig. 4). The isolated stroke in the upper part of the left antler may represent the intercalary month.

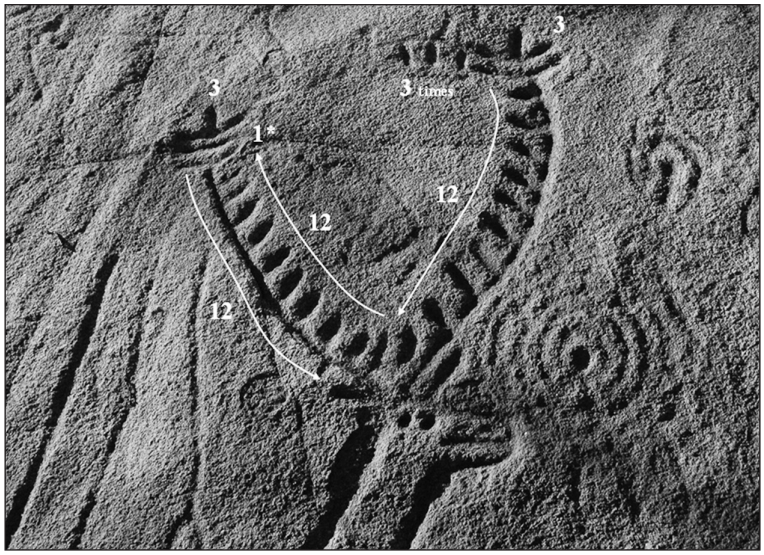


Fig. 4. The calendrical marks of the deer of Laxe dos Carballos. Each antler has 12 tines, with an extra stroke marked in the left one. The two antlers end in a three-tine mark. Finally, there are three additional strokes next to the right antler. For more on the calendrical details, see text.

The carved panel at Laxe das Cruces (Ponte Caldelas; Fig. 2b) is 20km to the south of Campo Lameiro. The large deer in this panel complies with all of the characteristics found in the deer of Laxe dos Carballos, so this is not a 'unicum'. There is a distant horizon to the southeast, as in Laxe dos Carballos where the moonrise at the SML occurs at a notch in the intersection of this distant horizon with a closer mountain (Fig. 5; Tab. 1). Moreover, this deer also presents three strokes next to the right antler, again perhaps indicating a counting procedure. The tines of the antlers could be counted in the following way: (11 + 2) + 12 + 12 = 37, again giving the number of lunar months in three solar years. Admittedly, this way of counting is subjective, but the similarities with the deer in Laxe dos Carballos, especially the horizon observations, are remarkable and seem to back up each other.

Our third panel in Rotea de Mendo is situated to the east of the Campo Lameiro area (Fig. 2c). Large eucalyptus trees surround this panel at present, which prevented us from observing the horizon. We were able to reconstruct the visibility with a 3D GIS model of the area (Fig. 6), although the horizon reconstruction is approximate, as we lack the fine detail, the most distant horizon opens to the southeast, with interesting possible landmarks towards SML and WS happening at the intersection of distant and closer lines of horizon.

Other smaller deer and circular motifs, including a large circle to its right, surround this great deer. It faces right and fulfils eight of the characteristics indicated. The only exception is the absence of the three strokes beside the right antler. The deer has two large symmetrical antlers, each with 13 tines, although the left antler seems to have an extra feature with another 4 tines. The sum of 13 + 13 + 4 = 30 once again yields a lunar number.

Our fourth great deer in this region is located at Campo de Cuñas (Ponte Caldelas; Fig. 2.d). However, apart from its size, none of the characteristics so far analysed apply to this deer, not even the horizon, as it is located in a place with a rather close horizon in all directions. As a result, we would consider this as merely a large representation of a deer. While this deer and most of the normal size deer in the Galician carvings have a mean of seven tines, the previous large deer are not 'naturalistic' representations: deer in nature usually have an average of seven tines on each antler. In nature, eleven or ten-tine deer are found in exceptional cases.

These carvings present a particular example of how time reckoning and landscape may be intimately related: the choice of carving site was intentional, favouring places with a clear view of the south-eastern horizon, where it is possible to observe important moments in the movements of the sun and moon at particularly interesting points. Also, the carvings might present, in an intuitive way, how the people who carved them may have tried to combine in the simplest possible way the cycles of the sun and moon (in a lunisolar cycle of three years).

In summary, the carved great deer with 'abnormal' antlers are animals that are 'good for thinking' (*Sperber 1975*), in this case in relation to the apprehension of astral events with the panel's topographic location, and with a symbolism related to the same order of facts: the possible knowledge of simple luni-

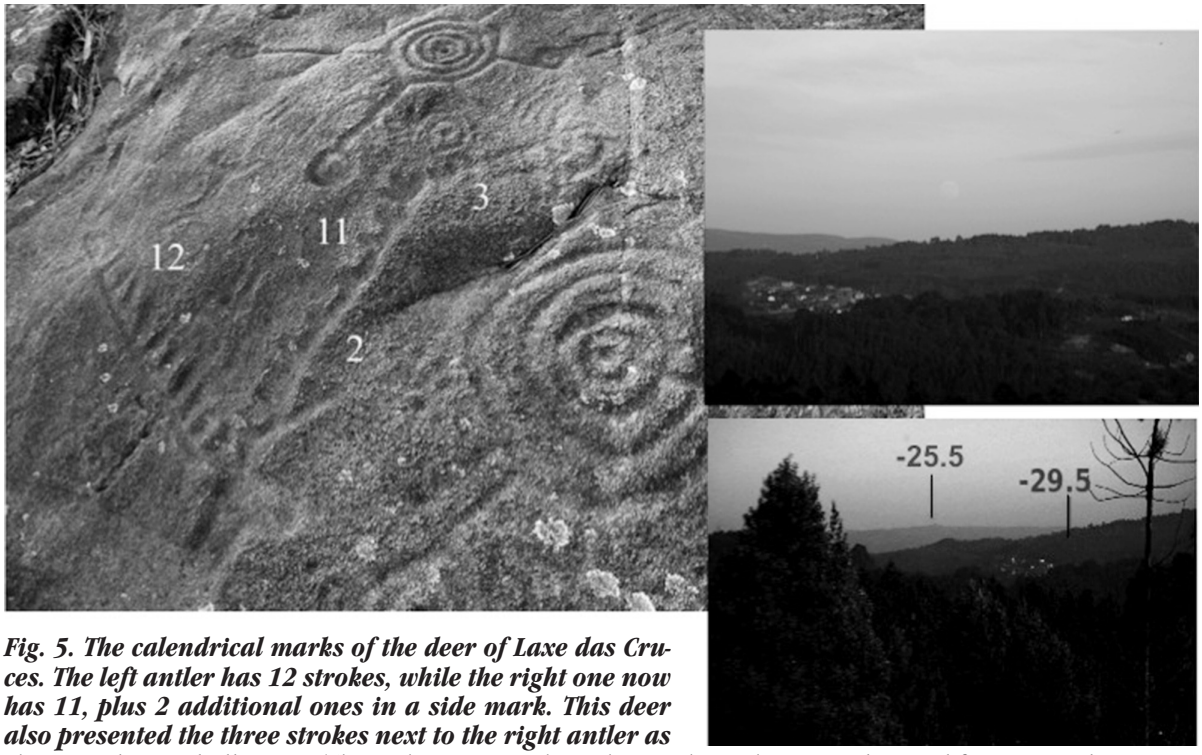


Fig. 5. The calendrical marks of the deer of Laxe das Cruces. The left antler has 12 strokes, while the right one now has 11, plus 2 additional ones in a side mark. This deer also presented the three strokes next to the right antler as the Laxe dos Carballos one. The right pictures show the southeast horizon observed from Laxe das Cruces (bottom) and the SML moonrise for July 2006. The numbers indicate the astronomical declination for different points in the horizon. For further details, see text.

solar cycles. In particular, the panels at Laxe dos Carballos and Laxe das Cruces with the three isolated strokes may indicate a three-year cycle, when nature's clock could be gauged in a simple but still particular and important way through the observation of particular astronomical events.

Panoias: Latin texts and indigenous timekeeping

The rock sanctuary of Panoias (Vila Real, northern Portugal) has been known since the eighteenth century; it consists of a series of excavated rocks with different structures and up to five inscriptions (see *Alföldy 1997*, for all of the archaeological and epigraphic issues), one of which is now destroyed, and another in bilingual Greek-Latin, concentrated next to rock no. 1. In formal terms, it has well-known parallels in North Portugal (*González-Ruibal 2006–2007.562–567; Santos 2010*) and Galicia (*García Quintela, Santos Estévez 2008.97–142*), as they are based on large rocky surfaces subjected to an intentional harmonically distributed work in the form of holes, reliefs, decorations, *etc*. The inscriptions clearly reveal the culturally mixed nature of the Panoias sanctuary, as they make equal mention of local divinities, the standard Latin divine expressions diis deabusque (two occasions), and a mystic cult dating to the second or third century AD, with careful observations of superimposed carvings revealing different stages of production (*Santos 2010*).

We were able to take a number of measurements of the rocks conventionally numbered as 2 and 3, as other rock inscriptions and carvings in the settlement did not offer measurable patterns. The excavated area around rock number 2 is interpreted as

Site		A(°)	h(°)	φ	δ(°)±1°	Astronomical Event
Laxe dos Carballos	DIVI N	126 1/2	2.5	42°32'	−24.1	WSS (−24°)
	DIVI S	134 1/2	3.0	42°32'	−29.0	SML(−29°)
Rotea de Mendo*	North	125	1.5	42°32'	−23.9	WSS(−24°)
	South	132	1.5	42°32'	−28.4	SML(−29°)
Laxe das Cruces		133	1.0	42°24'	−29.5	SML(−29°)

*The alignments to horizon landmarks for Rotea de Mendo were obtained from a Digital Terrain Model.

Tab. 1. Archaeoastronomical observations in Galicia. Columns* 1 *show the observation point,* 2 *the azimuth A,* 3 *the height of the horizon h,* 4 *the latitude of the site,* 5 *the given declination and* 6 *the corresponding astronomical event (WSS = winter solstice sunrise; SML = southern major lunastice).

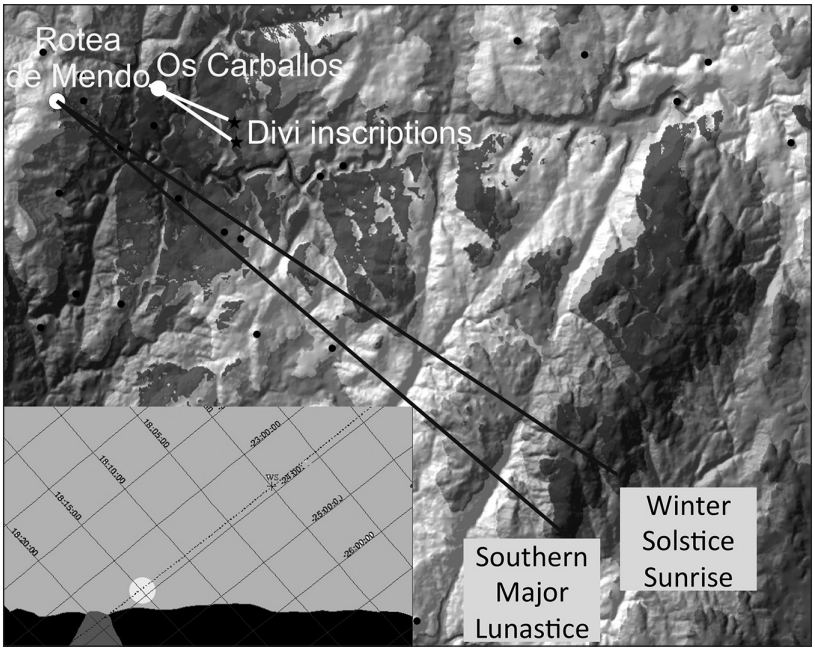


Fig. 6. Visibility of the eastern part of the landscape seen from the deer of Rotea de Mendo with an indication of the lines for WS and SML. Inset: reconstruction of the SE horizon seen from the engraved panel; the grey shaded area corresponds to a closer feature seen in the background of more distant hills.

a platform for the foundations of a building, such as those mentioned in the inscriptions (aedes, inscription no. 2), whose gate, also excavated on the rock, was facing moonrise at SML and may suggest a lunar association for the corresponding shrine[5]. Rock 3 is a complicated structure that includes a number of deeply carved basins. There is no gate in this cluster of ritual elements; however, most of the carved and excavated structures cluster in the eastern part of the rock, so we considered this as the most probable for our measurements. Thus, an overall orientation of the main elements of the platform can be established at 124.25°, a suggestive figure, as it is close to the minimum declination of the sun at the winter solstice (Fig. 7; Tab. 2).

It is relevant to note that both measurements can be easily related to the three occasions (one reconstructed) when the word templum appears in the local inscriptions (no. 1: *diis [deabusque templi] huius* ...; no. 2: *Diis Seve[r]is in hoc templo lo[ca]t[i]s* ...; no. 3: *omnibusque numinibus et Lapitearum cum hoc templo sacravit* ...). We must recall that the function of the Roman augur was to establish a templum in caelo (*Ciprianno 1983; Magdelain 1990*) and thus we can infer the conscious use of orientations looking towards the horizon. Far away from Rome, the word can easily be used to integrate or to understand more romano, the orientations mentioned above, or others we cannot recognise.

These observations suggest a different materialisation, the result of a different local history, from the case studied in Campo Lameiro: a relationship between the 'monument' (the great deer of Laxe dos Carballos or the platform/basins in Panoias) and the inscriptions connected with the sunrise at the winter solstice and moonrise at the southern major lunastice. The horizon at this site does not offer a particular feature in those directions, but these are signified by the orientations of the different elements.

Celtiberia: Numantia and Peñalba de Villastar, a cultural crossroads and the organisation of space/time

The Peñalba de Villastar sanctuary is located some 10km south of Teruel (Spain), and occupies a cliff at the top of a plateau flanked to the east by the River Turia. It has been studied since the early twentieth century due to the accumulation of rock inscriptions in Celtiberian and Latin languages and, to a lesser extent, due to the carvings etched in the soft limestone. Francisco Beltrán *et alii* (*2005.938–939; Marco, Alfayé 2008*) describe a set of newly discovered Latin inscriptions called the 'Great Panel'.

Site	A(°)	h(°)	φ	δ(°)±1°	Astronomical Event
Rock #2	132 1/4	1	41°17'	−29.8	SML(−29°)
Rock #3	124 1/4	1	41°17'	−24.5	WSS(−24°)

Tab. 2. Archaeoastronomical observations at Panoias. For legend see Table 1.

5 The second Christian Council of Braga, a city near Panoias, held in 572, strictly forbade Christians to observe some pagan traditions such as *observare et colere elementa at lunam aut stellarum cursum*. Braga Council II, 72, (*Vives 1963.103*; similarly, at the XII Council of Toledo in 681, *Vives 1963.398*). While it is impossible to strictly connect the observations from Panoias (and elsewhere in northwest Iberia) with these Christian prohibitions, they do reveal the interest in and opportunity to use archaeoastronomical observations in order to try and understand what really lay behind the previously mentioned pagan astral observations.

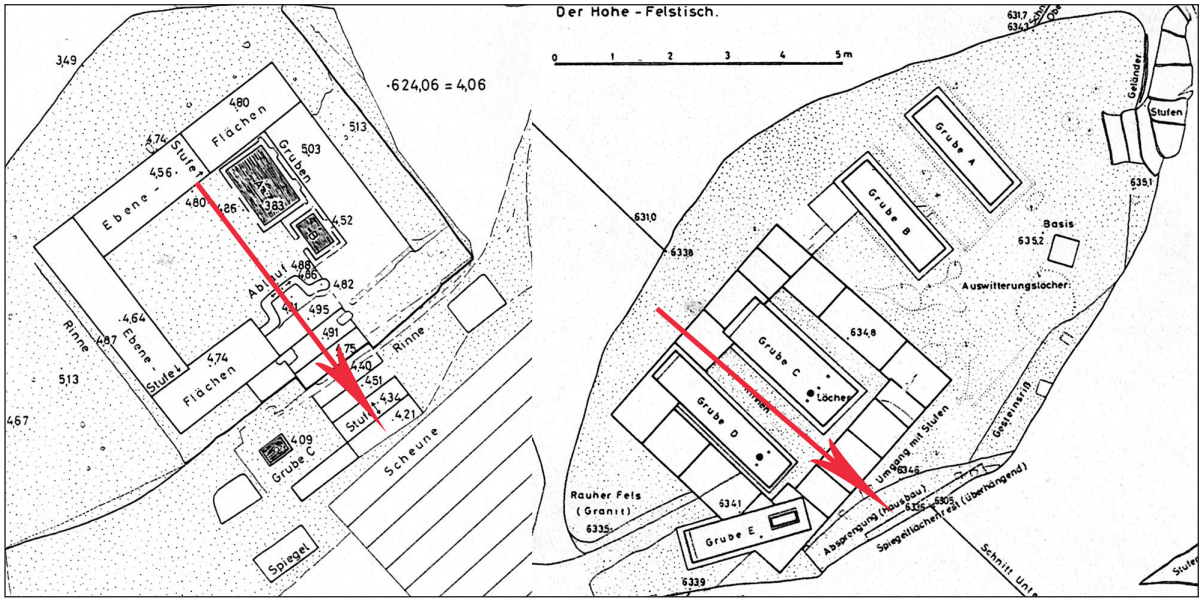


Fig. 7. Archaeoastronomical orientations of the carved rocks of Panoias. Left rock 2, right rock 3. The arrows indicate the measured directions considered in the text (adapted from* Alföldy 1997*).

There, a local god, Cordonus, is identified by the Latin epithet Cornutus, which is strongly suggestive of the god Cernunnos, well known in ancient Gaul. Another Latin text from the same Great Panel mentions actions related to the winter solstice and a feast during the last days of April (*García Quintela, González García 2010*).

The motifs carved in the limestone cliff that could be dated to the Iron Age (Fig. 8), are grouped in the areas of the rocky wall where the inscriptions are also located, leaving empty areas between. As shown in figure 8, these parts of the cliff systematically face southeast in the broad sense. Of course, we do not claim that the perpendicular to the surface they were carved on points precisely to the winter solstice sunrise or the southern major lunastice. The panels face in the general southeasterly direction. This is the general orientation of the cliff, but particular areas of the cliff with different orientations lack 'ancient' inscriptions and carvings. The inscriptions appear only in areas that are roughly face southeast. It must be stressed that nature is not intentionally oriented, but the Turia valley in this area has several other plateaus with cliffs which could have been used.

Inspecting the eastern horizon from these sites, we verified that the carvings face the point where the sun rises at the winter solstice through a notch on the distant horizon. Moonrise at the SML is also relevant, as it would occur on top of one of the farthest observable mountains in that part of the horizon. Finally, the so-called 'Great Panel' is located in an area with difficult access, where the cliff twists, making it possible to observe only an important landmark on the horizon, a peak where sunrise could occur close to October 29th (see Fig. 8, the peak marked with –12.6° of declination).

It is interesting to stress that the reference to the winter solstice on the 'Great Panel' inscription apparently coincides with the archaeoastronomical observations on the horizon. Also, the date at the end of April forms a pair with the eastern point, where sunrise occurs on October 29th: It shows that the sanctuary was facing sunrise in the dark part of the traditional Celtic year (conventionally between November 1st and May 1st, a period that would include the SML during the years of the lunar cycle when this actually happens)[6].

These observations share some similarities with those mentioned for Campo Lameiro (in *García Quintela, González-García 2010* we stressed the differences between the two places, as it is not our intention for the similarities to be so general) and A Ferradura (*García Quintela, Santos Estévez 2008.231–295*), because we may see the 'natural' observation of par-

6 Here it is interesting to note one of the precepts of the first Christian Council of Zaragoza, held 380: between 17th December and 6th January it was strictly forbidden not to attend church (*nulli liceat de ecclesia absentare*), for anyone to carry out private activities, or to fall victim to pagan practices such as travelling to the mountains or walking barefoot (*nec montes petere, nec nudis pedibus incedere*) Zaragoza Council I, 4, (*Vives 1963.17*).

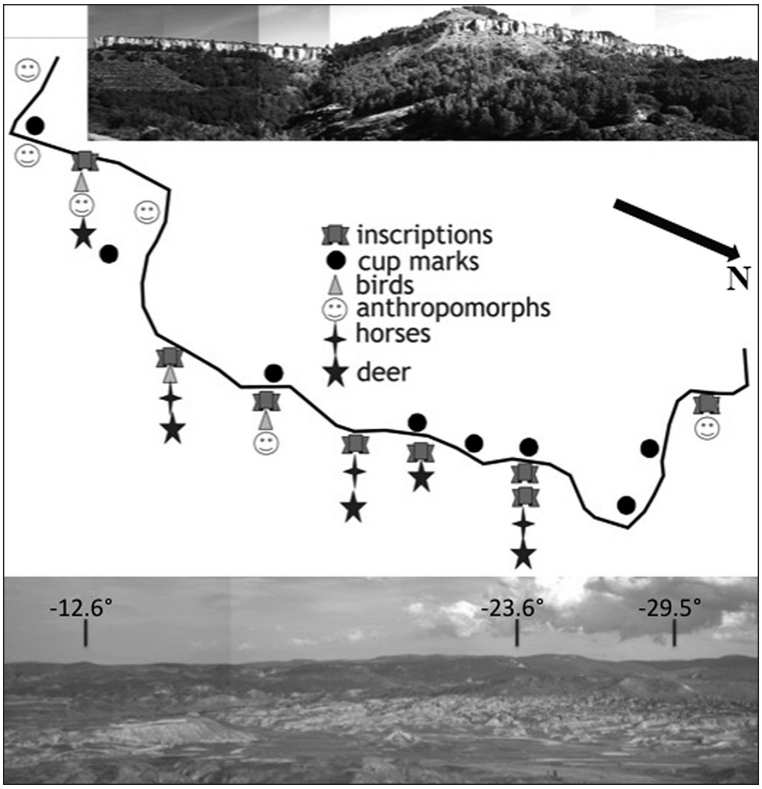


Fig. 8. The rock art sanctuary of Peñalba de Villastar. Above, a general view of the rock wall as seen from the valley from the southeast; in the centre, the location of the 'old' carvings, sharing their position with the inscriptions. The Great Panel is located in the far right inscription symbol; below, the southeastern horizon from Peñalba with the relevant points in relation to astronomical events.

ticular moments of the solar and lunar cycles (solstices and lunastices). However, it might include other variables not observed at Campo Lameiro such as mid-season festivals. Also, they convey what we have already referred to: the relation between the 'monument' (the whole sanctuary in this case), the inscriptions (with explicit references to particular dates in this case) and the observations on the horizon.

To complete the case, it should be noted that numerous deer are depicted among the carved motifs in Peñalba, although none has the characteristics of the great deer in Galicia. Nevertheless, the deer is commonly found in Celtiberian art on metallic or ceramic supports, mainly associated with solar or lunar symbolism. We could also mention a decorated plaque (usually interpreted as a 'breastplate') that may be an iconographic complement to the observations in Peñalba de Villastar.

The plaque (Fig. 9) was found during the excavation of the Numantia necropolis (*Jimeno* et al. *2004*). Similar pieces have been found in other Celtiberian necropolises, especially in the Arcobriga collection (*Lorrio, Sánchez de Prado 2007; Lorrio* et al. *2005*). The plaque was part of tomb no. 68, which due to the number of objects (17) is one of the richest at this site. It is important to stress the mutual exclusion of arms and decorated plaques and that these appear in the tombs of both women and men (*Jimeno* et al. *2004.208, 341, 382*). The piece is described thus: "*The plaque in tomb 68 is composed of three rectangular sheets (6.7 x 5.1cm), joined at their smaller edges by two rings; two trapezoidal plaques ending in astral or lunar discs hang from the third or bottom plaque. A staircase-like frieze frames all the articulated elements. The three plaques bear the same motif: a schematic horse with a flat muzzle and standing, with four flat legs and horsehairs simulated with thin lines like a crest. A small sheet in the upper part decorated with a concentric circle and drilled with a needle allowed it to be hung*." (*Jimeno* et al. *2004.210*).

As a result, the plaque reproduces a count similar to that found in the deer of Laxe dos Carballos and Laxe das Cruces, this time replacing the deer with a horse, a fact well known in Celtiberia (*Lorrio, Sánchez de Prado 2007.151*): counting the number of horsehairs of the three horses there are 37 with 12 on the top and bottom horses, respectively, and 13 on the central horse. It is true that the calendric significance of this number is speculative, but the astral meaning of this series of representations is commonly accepted (*Jimeno* et al. *2004. 205–216*).

PEÑALBA DE VILLASTAR					
Site	A(°)	h(°)	φ	δ(°)±1°	Astronomical Event
Horizon notch	122 3/4	0.75	40°15'	–23.6	WSS(–24°)
Distant Mountain	132	1	40°15'	–29.5	SML(–29°)
Great Panel	107 1/4	0.25	40°15'	–13.2	Sunrise Feb 13/ Oct 29 (~200BC)

Tab. 3. Archaeoastronomical observations at Peñalba de Villastar. For legend see Table 1.

Once again, we are aware of the differences: here we are dealing with metal, not stone, and the animal is a horse, not a deer, although the connection between both species and solar symbolism was a constant feature of the Bronze Age (*Briard 1987; Kristiansen, Larsson 2006.355–407; Bradley 2006; Garrido, Muñoz 2000*), and an apparent substitution of the deer by the horse in artistic remains through time has been postulated (*Lorrio, Sánchez de Prado 2007.151–153*). In any case, a more detailed study would be necessary, considering the same series found in this plaque in the context of other similar plaques.

In summary, in the three cases explored we have a 'monument' (rock carvings, rocky sanctuaries, or both) with observations on the horizon and possible calendric information (either explicit in Peñalba, or suggested by horizon features and perhaps 'abnormal' antlers).

Diachrony, landscape and structure

We will now incorporate a diachronic process. The astronomical events we have referred to, the southernmost rise of the sun or moon, were not affected by secular changes, and would have changed by less than 1° due to the variation in the obliquity of the ecliptic, (less than the precision claimed by our measurements) throughout the period of the first and second Iron Ages for the area (from nearly 900 BC to the change of era). Unfortunately, a diachronic analysis is possible only if we apply the knowledge derived from an intensive archaeological, geomorphologic and palaeo-environmental study in Campo Lameiro, but we lack such information for the other areas studied here. Furthermore, in Campo Lameiro, we depend largely on the results of the Laxe dos Carballos excavation (*Santos Estévez 2008a*).

We will use the relative stratigraphic study carried out on the great deer of Laxe dos Carballos by Åsa Fredell (*2006*) (Fig. 10), noting that it is a working hypothesis in which we have combined Fredell's proposal with the archaeoastronomical observations in that area. Such a proposal indicates the existence of several phases in the evolution of the carvings in Laxe dos Carballos where we might see the introduction of the astronomical elements investigated above.

❶ There is a clear difference in depth between the great deer and the surrounding carved motifs (Fig. 10 – top left panel). There are two explanations:

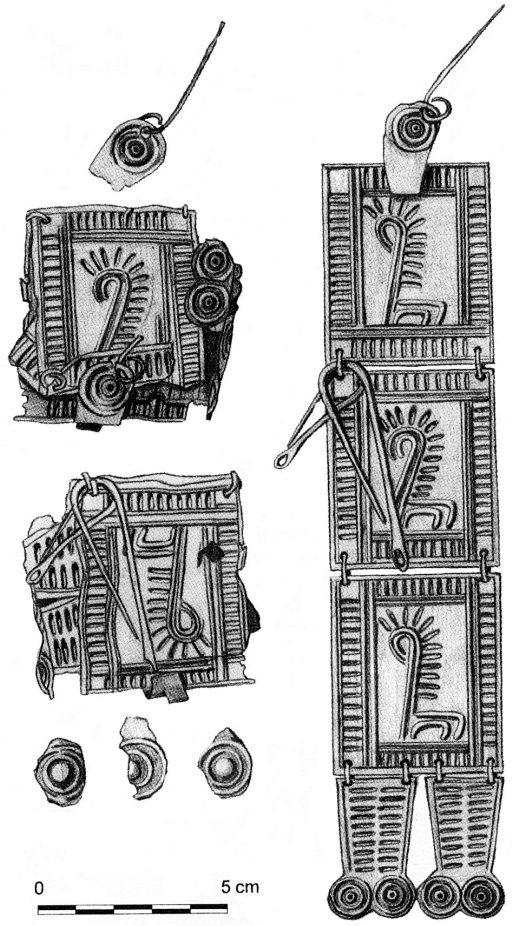


Fig. 9. Decorated bronze plaque from Numantia (after* Jimeno 2004*).

either the more superficial carvings were subject to more prolonged erosion, or they were carved with 'softer' tools. Either reason, or a combination of both, would mean that the great deer is more recent than the others, according to Fredell, who dates the deer to the end of the Bronze Age (*c*. 800 BC; Fig. 10 – bottom left panel), although we do not know if this date is relevant for the astronomical observations.

❷ We take Fredell's phases two and three together (Fig. 10 – top right panel). These phases have been dated through the adjacent stratigraphy to the first Iron Age, and continue until the change of era with the working calendrical count. This count relates the cycles of the sun and moon, and so it is probable that the two astronomical events on the horizon were recognised at this stage.

❸ According to Fredell, the last part to have been carved is the groove through the deer's neck (Fig. 10 – top right panel). This could be a necklace or, we suggest, a torque, considering the omnipresence of this attribute in Cernunnos iconography (*Bober*

1951). The DIVI inscriptions on the first line of the horizon are also dated to the beginning of the era, highlighting the relationship between Laxe dos Carballos and the southeastern horizon.

❹ Finally, it is possible to identify the chronologic-cultural moment of the introduction of Christianity, according to an already identified model (*Ayán 2005; García Quintela 2006*): the patron saints of the hamlets of Praderrei (Saint Blaise, February 3rd) and Paredes (Saint Anthony, January 17th) next to Laxe dos Carballos are celebrated close to the Celtic mid-season feast of winter. Also, the Fentáns slope (the one close to the DIVI inscriptions) is Christianised by the saints Justus and Pastor, whose feast day is on August 6th, close to the Celtic mid-summer feast. These saints are all palaeo-Christian, and therefore it could be justified to date their introduction in late Antiquity.

Thus we see that the elements associated with a calendric system in this carved panel could be connected with a cultural horizon from the first Iron Age, which, as mentioned above, is certainly indo-European and perhaps Celtic in this region of Galicia.

Turning away from Galicia, the cases in Panoias and Peñalba de Villastar appear to be more firmly embedded due to the local inscriptions which explicitly mention events, dates or gods that lend substantial support to our interpretation, but which also present chronological problems. Firstly, there are no excavations or substantial geomorphologic studies to make a geological and palaeoenvironmental history of both sites possible. Under these conditions, the chronology depends on the correct interpretation of the given data.

In Panoias, fortunately, the inscriptions explicitly refer to a previously existing religious cult of native gods and the implementation of a new religious strata and meaning by the hand of notable and cultivated Roman from the Imperial Age. Also, the detailed examination of the carved pits made by Maria J. Santos reveals traces of overlapping and, therefore, long-lasting, but still imprecise, use (*Santos 2010*).

Peñalba is a more difficult case, as people from all periods left signs of their presence on the soft limestone of the cliff. The problem is to establish when the religious aspects make it possible to define the site as a 'sanctuary'. The dominant epigraphic research limits the temporal gap to the history of writing in this specific place – starting in Celtiberian times – the question being whether some carvings are earlier and have a religious meaning. In any case, it is interesting that, according to the inscriptions in the Great Panel, the site was already recognised by Roman times as a sacred area where ritual had to be performed on specific dates. Finally, the plaque from Numantia is clearly from Celtiberian times, a few centuries BC.

This possible Celtic milieu points to the active cultural role of priests, known as druids in other Celtic areas; known from Classical sources as physiologoi, they were knowledgeable on heavenly bodies (supra, and see *García Quintela 1999* and *Marco Simón 1994*, for the druids in Spain). Apparently, Celtic ideology was dominated by a dual conception expressed in particular in their organisation of time reckoning, beginning with the "*dark side*", meaning night before day or winter before summer (*Caesar De Bello Gallico VI, 18, 2; Duval, Pinault 1986.404–405*). Finally, a number of investigations have indicated the persistence of Celtic elements in Christian traditions (*Guibert de la Vaissière 2003; Laurent 1995; McCluskey 1989; MacNeill 1962*).

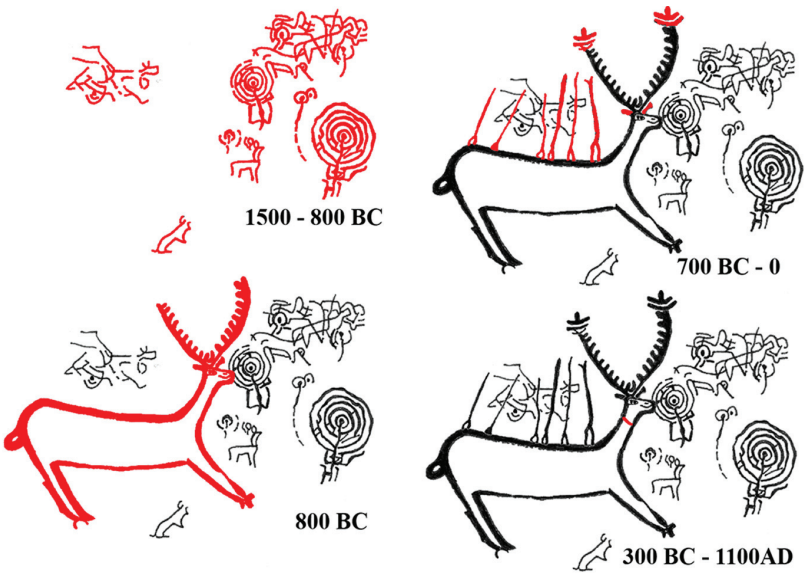


Fig. 10. Fredell's stratigraphic-chronological proposal for the Laxe dos Carballos deer.

However, a chronological interpretation of the different ele-

ments carved in each panel or site is not the same as interpreting the panel itself or, even less so, a number of panels in a certain area, or the sites as a whole. In any case, one of the peculiarities of our analysis is that it uses archaeoastronomical observation as the common factor that connects different parts of the landscape. This structural understanding allows us to elaborate some ideas on the methodology and relations between space and time.

Space/time continuum and sacred landscape

We have used the archaeological data to propose an iconographic analysis which considers the different sites as the result of an on-going process during a prolonged period of time. This proposal makes it possible to incorporate cultural elements from the Iron Age into the process of interpreting the motif.

As an astronomical matter, we have proposed a possible case for one or several lunisolar calendars, whose best-known example in the Celtic cultural tradition would be the Coligny calendar, but which need not be the only materialisation of knowledge of the skies among peoples of Celtic cultural traditions.

Finally, the combination of landscape archaeology and the history of religion allows us to propose an interpretation. This proposal consists of achieving a global comprehension of the carved panels in a given area by examining their possible connections. Archaeoastronomical observations make it necessary to carry out this type of analysis, as they give added value to a number of other elements (the nature of the rock, configuration of the landscape, habitat distribution, panel placement, motifs used, *etc*.).

It is interesting to note that the cases studied so far (the carved deer from southern Galicia, Panoias, Peñalba and the plaque from Numantia) could be considered as structural variables materialised in different ways in each area according to specific historical constraints. According to these facts, shared elements such as time reckoning through lunar phases and festivals, particularly solar dates, may have led people to try and find ways to coordinate both cycles, first through practical observations, such as those which could have been performed in the Galician 'Great Deer' and finally through a 'model' calendar, such as the three-year cycle calendar, the 18.6 or 19 year cycle, or the five-year Coligny calendar. It is necessary to emphasise that it is not our intention for the observations made at these different sites to be considered as the direct precedents of the Coligny calendar, but rather that this framework could have been in place in different Celtic areas with different results. Table 4 may help to elucidate this line of thought.

We use the term 'observation point' or 'back sight' to refer to the spot from where the viewer may look towards the horizon. It may be in itself a naturally oriented site (towards the southeast in most cases), or artificial (Panoias). Next, we consider the 'horizon' where the 'landmarks' or 'foresights' make it possible to situate the astronomical events, which were essentially two: the winter solstice sunrise (WSS) or the southern major lunastice (SML); although in Panoias, the fact that the 'back sight' is artificially oriented makes it possible to dispense with landmarks on the horizon[7].

The 'texts' share the space with the rock carvings, and together, they either construct the 'monument', or make it possible to select the 'observation point', or indicate relevant points on the horizon. Also, in all the recorded cases, the 'texts' contain mentions or allusions of a religious kind.

It is clear that we are dealing with areas that were culturally constructed and 'thought', which are the properties of a 'landscape'. The accumulated materials are footprints through which it is possible to identify the key cultural elements in this 'landscape'. These footprints are always a combination of natural elements, natural/artificial elements (when a natural element contains an anthropic action) and purely artificial elements (such as the inscriptions).

On a global scale, the sites studied provide a consistent way of understanding the relationship between space and time. This is due to a very fundamental aspect: the reversibility of space and time for an observer at a given spot. The rising and setting of the main celestial bodies will coincide year after year

7 This is a complex issue. The Latin rule to establish a *templum* implies that the augur sets some references on the horizon, which may be a perishable element, such as a tree (Varro, *Lingua Latina* 7, 8–9). The Celtic term *nemeton* (found in other sites in Hispania) would also fit this consideration and its meaning, 'sacred place' (*Lambert 2008.140*), perfectly fits our requirements. In pre-Columbian Mexico the so-called 'Teotihuacan markers' are identified as key elements in the astronomical relations of certain monuments (*Iwaniszewski 2006.151–153*). We could never know which perishable elements were used in each case, and it is extremely difficult to discern a mark with an astronomical meaning without a relevant study in its context.

Observation point	Horizon	Archaeoastronomical observations	Archaeological indications	Religious indications	Carved deer	3 /18.6 Year Cycle
GALICIA						
Os Carballos. Looking SE	Landmarks	WSS / SML	Monumentalization of landmarks	*DIVI / DIVI*	Yes	Yes/Yes
Laxe das Cruces. Looking SE	Landmarks	WSS / SML			Yes	Yes/Yes
Rotea de Mendo. Looking SE	Landmark	WSS / SML			Yes	?/Yes
PANOIAS						
Rock 2. *Aedes* SE		WSS	Rock 1 "observatory": indicate *templum*	DIIS DEABUSQUE/ DII SEVERI/ NUMINA LAPATIARUM	NO	?/Yes
Rock 3. Basins SE		SML				
PEÑALBA DE VILLASTAR						
General: Looking SE	Landmarks	WSS / SML	In observatory	Local gods	Yes	?/Yes
Great Panel. Looking SE	Landmark	29th October	In observatory, indicate WSS and end of April	God labelled *Cornutus*		
NUMANTIA						
Plaque					Horse	Yes/?

Tab. 4. Summary of relevant information.

with certain areas in space. This simple observation may be conferred a special meaning in certain places for a number of reasons, and it is possible that the aggregation of natural features and observations, such as the ones mentioned here, led to more prolonged use in time and their progressive monumentalisation: in our case, this basically means carving motifs and texts in different ways.

The texts examined here underline this equivalence between space and time. The DIVI inscriptions in Campo Lameiro are in positions which, when viewed from Laxe dos Carballos, coincide with the WSS and SML; in Panoias the inscriptions mention an oriented celestial space, templum, whose existence is verified by the astronomical orientation; in Peñalba, the inscriptions offer time indications related in different ways to important landmarks on the horizon. The religious nature of all of these inscriptions puts beyond reasonable doubt the sacred nature of all these spaces, and of the space/time combinations fixed in the landscape.

It is true that the differences between all the sites and artefacts examined here are important. They appear as a result of their inherent morphological and geographical characteristics, and from the different ways in which humans modified the site.

We have also referred to the difficulty of correctly analysing ethnographic texts in order to discover how much was known about astronomical phenomena. So the question remains open, although we can state that, at least, the observations and analyses performed point to the need for further research along these lines.

Conclusions

A calendrical system is a way of comprehending time and its cycles. The religious and practical issues related to developing a calendar have been highlighted throughout the paper. According to our results, and those stated in the introduction, the different Celtic tribes in the Iberian Peninsula might have comprehended space and time by observations of the solar and lunar cycles, notably the winter solstice sunrise and the moonrise at the southern major lunastice, from certain interesting viewpoints in the landscape. These observation points were therefore 'monumentalised' in different ways (by carving animals in an initial stage and later by engraving inscriptions), including symbolic representations of the events they were interested in, or an inscription with a dedication to a given god or a festival to be carried out at a particular time of the year.

Therefore, we would like to highlight a series of conclusions:

● Evidence is seen of the use of spatial relations with astronomic events at sites connected in some way with Celtic traditions in the Iberian Peninsula. We highlight the prominence of the winter solstice sunrise and the southern major lunastice moonrise.

● This evidence, which reveals an interest in the sun and moon and their observations at important points of their cycles, is also supported by ethnographic and epigraphic information from these sites, and at a later date, in the interdicts of these observations established by Christianity.

● We may speculate about efforts to create a calendar, although this calendar is not known.

● There is some evidence of a possible calendric cycle of 37 months which was used, in the simplest possible way, to adjust the lunisolar cycles at Iron Age sites in Galicia, and in the plaque from Numantia.

● This calendar was not necessarily the same at all of the sites inhabited by speakers of Celtic languages. In other areas with Celtic traditions, similar observations may have led to other proposals, such as the calendar of Coligny.

It will also be necessary to extend the range of our observations, as other rock art sites are known in Galicia, and other cliffs with archaeological remains are known both in Iberian culture and Celtiberian areas (Peñalba is located on the frontier of both areas). Also, Francisco Marco and Simón Alfayé (*2008*) introduce other sites in the Iberian Peninsula in their study. As a result, it would be interesting to carry out further research in these areas.

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Function and behaviour: use-wear evidence from Upper Paleolithic tools in southern Shanxi Province, North China

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ABSTRACT – *Lithic use-wear analysis has become a principal approach for interpreting the function of stone tools and inferring human behaviour. This study presents the results of use-wear analysis on lithic tools excavated from the Upper Paleolithic sites of Xiachuan and Chaisi in the southern part of Shanxi Province, North China. In this study, microblades and so-called core-like tools from these two sites were selected for examination by low-power techniques to identify their use patterns. The results suggest that approx. 30% of microblades might have been used mainly to process animal substances, and a lower percentage for vegetal substances. Based on the use-wear evidence, items classified as core-like tools should be regarded as microblade-cores, since they exhibit few traces of utilisation.*

IZVLEČEK – *Analiza sledov uporabe kamnitih orodij je postala osnoven pristop pri razlagi funkcije kamnitih izdelkov in pri razlagi človekovih vedenjskih vzorcev. V študiji predstavljamo rezultate analize uporabe na kamnitih orodij, ki so bili izkopani na mlajše paleolitskih najdiščih Xiachuan in Chaisi v južnem delu province Shanxi na severu Kitajske. Za prepoznavanje sledov uporabe s pomočjo stereomikroskopa smo izbrali vzorce majhnih rezil in orodij, ki so podobna jedrom. Rezultati kažejo, da je bilo okoli 30% mikro-rezil uporabljenih pri predelavi živali; orodja, ki so podobna jedrom, pa predstavljajo verjetno jedra, iz katerih so lomili in izdelovali rezila, saj kažejo le zelo redke sledove uporabe.*

KEY WORDS – *Upper Paleolithic; Xiachuan and Chaisi sites; tool function; use-wear analysis*

Introduction

Stone tools are widely regarded as good indicators of the development of intelligence, technique, cognition and adaptability of prehistoric people, because hunter-gatherers would have developed different strategies to cope with climate fluctuations, environmental changes and constraints on available resources in different areas. In accordance with the *châine opératoire* concept (*Schiffer 1972; Sellet 1993*), stone material, its production, use, repair, and waste, and every step of its utilisation are closely related to its function. Research into the function of stone tools is thus an important way to understand prehistoric human behaviour and subsistence strategies, and can also provide a new perspective for interpreting the development of human adaptations and social organisation.

Use-wear analysis is a method developed by archaeologists to infer the function of a tool on the basis of microscopic traces of wear left on its edges or surfaces. Since the introduction of Sergei Semenov's translated English monograph *Prehistoric Technology* (*1964*), use-wear analysis has become a principal approach for interpreting the function of stone

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tools in Europe and North America. There are two major techniques for lithic use-wear analysis. One is the high-power technique proposed by Larry Keeley (*1980*), which concentrates on the formation and distribution of use polish at relatively high magnifications (100-400x) under either incident light microscopes or scanning electron microscopes (SEM). The other is the low-power technique, advocated by Ruth Tringham *et alii* (*1974*) and George Odell (*1979*) that focuses on traces of edge-damage, microscopic fracturing and abrasion visible at relatively low magnifications (5–200x) under reflective-light stereoscopic microscopes. After decades of experiment and practice, it has been shown that each use-wear technique has its own particular advantages and weakness (*Shea 1987*), and analysts often use both high- and low-power techniques in one analysis (*Unger-Hamilton 1989; Grace 1996*).

The Xiachuan and Chaisi sites are important Upper Paleolithic sites in northern China (Fig. 1) with a microblade-dominated industry. The Xiachuan site was discovered in 1970 in southern Shanxi Province. Two cultural layers separated by a sterile layer were identified. It is reported that more than 1800 stone artefacts were excavated from the upper cultural layer in the 1973–1975 excavations (*Wang* et al. *1978*). In addition, 4415 stone artefacts were collected from other localities at Xiachuan between 1990 and 1992 (*Chen 1996*). Abundant microliths were found in the upper layer, including end-scrapers, backed-knives, burins, points, microblades and microblade-cores. According to radiocarbon dating, the age of the upper layer of Xiachuan site is estimated between 23 000 BP (*Tang 2000; Kuzmin 2007*) and 13 900 BP (CASS 1991). The Chaisi Site, also known as Locality 77:01 at Dingcun, was found in 1977 on the second terrace of the Fenhe River near Chaisi in Xiangfen County, Shanxi Province. The excavation in 1978 yielded numerous microblade remains and a few large chipping stone tools (*Wang 1986; Wang* et al. *1994*). There are two radiocarbon dates for the site: 26 495±590 BP and 40 000 BP (*Li 1993*). The excavator of this site argued that the former date is reasonable, particularly for the microblade remains (*Wang 1986*). It has been suggested that the lithic assemblage of Chaisi might have been the predecessor of that at Xiachuan (*Wang* et al. *1994; Zhang 2003*).

The function of stone tools has been a popular topic for prehistoric archaeologists. However, archaeological research on the stone artefacts from Xiachuan and Chaisi have so far focused only on their morphological features or manufacturing techniques. In this study, some artefacts from the two sites were selected for use-wear analysis to explore how the tools might have been employed and what materials might have been exploited.

Methods and materials

Use-wear analysis has emerged as one of the principal methods for interpreting the functions of stone tools. The low-power technique has been employed in several studies and in the past two decades has been proven to be a reliable method for interpreting uses of stone tools (*Shen 2001; Zhang* et al. *2010; Gao, Shen 2008; Chen* et al. *2010*). The low-power technique has a number of advantages. First, it is a reliable means of assessing the use-task of stone tools by identifying edge damage, as well as detecting polish and striations. Second, since observation of implements takes less time, this technique is suitable for examining a large number of artefacts in a limited time. Third, it has great potential for studying other material, such as bones and jade (*Potts, Shipman 1981; Bromage, Boyde 1984; Zhang* et al. *2002*). Fourth, for most analysts, the equipment needed for this technique is not expensive.

We thus employed the low-power technique in this study, using an Olympus SZX12-3131 stereoscopic



Fig. 1. Location of the Xiachuan and Chaisi sites.



Fig. 2. A piece of the observed specimens from the Xiachuan and Chaisi sites.

microscope with a magnification between 3.5x– 144x, to focus on evidence of micro-fractural scarring and edge rounding through use-wear. Polish and striation wear patterns were also observed if possible. After a preliminary examination, some artefacts from Xiachuan and Chaisi were selected for further analysis because they showed indications of use-wear. A total of 93 specimens were observed and analysed (Fig. 2), including 19 from Xiachuan (11 microblades and 8 core-like tools) and 74 from Chaisi (63 microblades and 11 core-like tools). The main raw materials of these specimens are black or yellow chert.

Results

The term 'functional unit' (FU) was used to describe the segment of the working edge, including both use-wear and hafting or prehensile wear. The analytic results suggest that 27.96% of specimens show use-wear (N = 26). Most tools display more than one FU. Therefore, 32 FUs were found in different locations on 26 used specimens.

For the Xiachuan specimens, five microblades and one core-like tool show positive use-wear. Eight FU's were identified. Four types of tool motion were inferred: cutting or sawing (up to 62.5%), slicing, scraping, and gripping (Tab. 1). Contact materials commonly range from soft to hard animal substances such as flesh, fresh hide, dried hide, and fresh bone (Tab. 2). From a cross-tabulation of tool motion and contact material, the use-tasks comprised cutting or sawing flesh (N = 2), cutting or sawing hide (N = 3), slicing flesh (N = 1), and scraping hide (N = 1).

On the Chaisi specimens, 24 FUs were identified on 20 specimens, including 15 certain and 9 uncertain types of use-wear. Three pieces retain a prehensile area associated with a working surface on edges. Use-wear was also identified on a number of microblades, accounting for 31.7%, while no use-wear was found on the core-like tools. Use-wear on blades or microblades indicated that these artefacts were used for cutting/sawing, slicing, scraping, and hafting (Tab. 1). Most of the use-wear was related to animal substances of varying hardness, while 8.3% were associated with vegetal substances (Tab. 2). Animal butchering, flesh processing and hide processing might have been the main tasks for the occupants of Chaisi; for instance, two use-wear FU's show the feature as a result of simultaneous contact with both flesh and bone. Three segments of micro-scars in a discontinuous distribution on the edges of microblades appear different from the scars caused by processing hard substances. It is inferred that these microblades were inset in a medium-hard material such as bone or fresh wood, and used as a composite tool with a hafted shaft, because the identifying features are similar to those simulated in previous experiments (*Zhao* et al. *2008*).

	XIACHUAN		CHAISI	
Tool Motion	N	%	N	%
cut/saw	5	62.5	15	62.5
slice	1	12.5	2	8.3
scrape	1	12.5	4	16.7
prehensive	1	12.5	0	0
hafting	0	0	3	12.5
total FU	8	100	24	100

Tab. 1. Tool motion at the Xiachuan and Chaisi assemblages.

	XIACHUAN		CHAISI	
Contact Material	N	%	N	%
flesh	2	25	4	16.7
fresh hide	3	37.5	2	8.3
dried hide	1	12.5	3	12.5
bone	1	12.5	7	29.2
vegetal	0	0	2	8.3
uncertain	1	12.5	6	25
total FU	8	100	24	100

Tab. 2. Contact materials of the Xiachuan and Chaisi assemblages.

Discussion and summary

In this study, we applied use-wear analysis to microscopically examine edge-damages and surface-rounding of specimens from the Upper Palaeolithic Xiachuan and Chaisi sites in order to assess how they were used. The analytic results reveal direct evidence of stone tool manufacturing and function. Those blades or microblades with straight and sharp edges might have been manufactured to be intentionally used as composite tools by being inset in a shaft. According to the evidence of functional analysis, the core-like tools should be re-classified as microblade cores rather than tools.

Function of microblades

The analytic results suggest that 5 pieces of microblades from Xiachuan and 20 pieces from Chaisi retain indications of use-wear, including 27 used wear FUs and 4 hafting wear FUs. Cutting and scraping are the main motions. Most of the corresponding contact materials were soft animal substances such as flesh and hide, and a few are hard animal substances such as bone. Only 27.8% of the microblades from Xiachuan had been used, which is lower than our previous expectations. Tracey Lu (*1999*) mentioned that by using high-power techniques she had found some use-wear on a few blades at Xiachuan that was similar to 'sickle gloss', a kind of use-wear often found on microliths in Southwest Asia. However, it is difficult to understand the features and details of this 'sickle gloss' on Xiachuan tools since no photographs have been published. Several microwear studies using the high-power technique have confirmed that the 'sickle gloss' might have been caused by processing cereals or seeds (*Unger-Hamilton 1985; Goodale* et al. *2010*). As suggested by Jian-Zhong Sun *et alii* (*2000*), the climate of the Xiachuan site was slightly colder than today, which was suitable for abundant temperate plants and animals. The use-wear evidence also suggests that the occupants of Xiachuan might have exploited and processed animals as their principal food resources (Fig. 3). It is consistent with some scholars' speculation that the microblades were probably tools for exploiting animal substances in the particular conditions of the terminal Pleistocene, and were used by hunter-gatherers to respond to changes in the availability of resources during the Last Glacial Period (*Chen 1994*).

The percentage of use-wear on microblades from Chaisi is higher than that from Xiachuan. Since the upper layer at the Chaisi site was deposited before the Last Glacial period in MIS 3, the climate was warm and humid, and plants and animals were relatively abundant. On the basis of the use-wear analysis, animal-processing (Fig. 4, lower part) would also have been one of major tasks for people living at Chaisi. Moreover, a few results indicate vegetable processing (Fig. 4, right upper part) and might provide a picture of a dualistic structure of resource exploitation.

According to archaeological and ethnological research, microblades might be parts of composite tools which were inset in wooden or bone handles (*Chard 1974; Sun 2003; Cui* et al. *2010*). At the Xiachuan and Chaisi sites, those microblades with a regular shape, appropriate size and suitable sharp edges might have been selected for use, while pieces that were too thick or small, and lacking sharp or straight edges would be discarded. The identification of the three hafting-wear FUs on the microblades (Fig. 4, left upper part) provides us with more reliable evidence for understanding how they were hafted or inset. The discovery of prehensile wear on

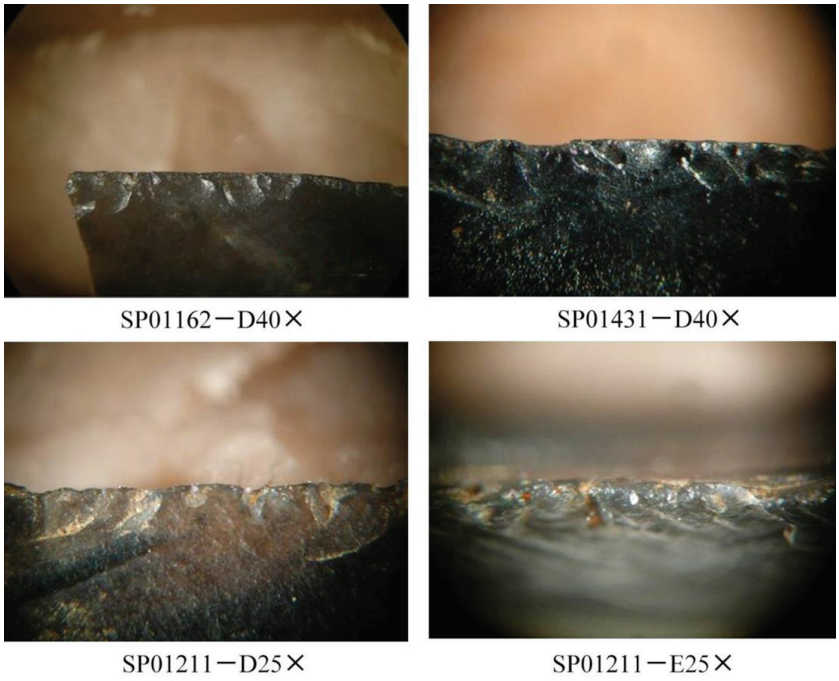


Fig. 3. Use-wear observed on microblades from the Xiachuan site.

blades is not accidental. In Xiao Zhang's dissertation (*2009*), she noted this phenomenon on one piece of blade from the Hutouliang site in the Nihewan Basin of North China. This tells us that there may have been an alternative mode in which some complete and large blades were directly used by hand rather than hafted.

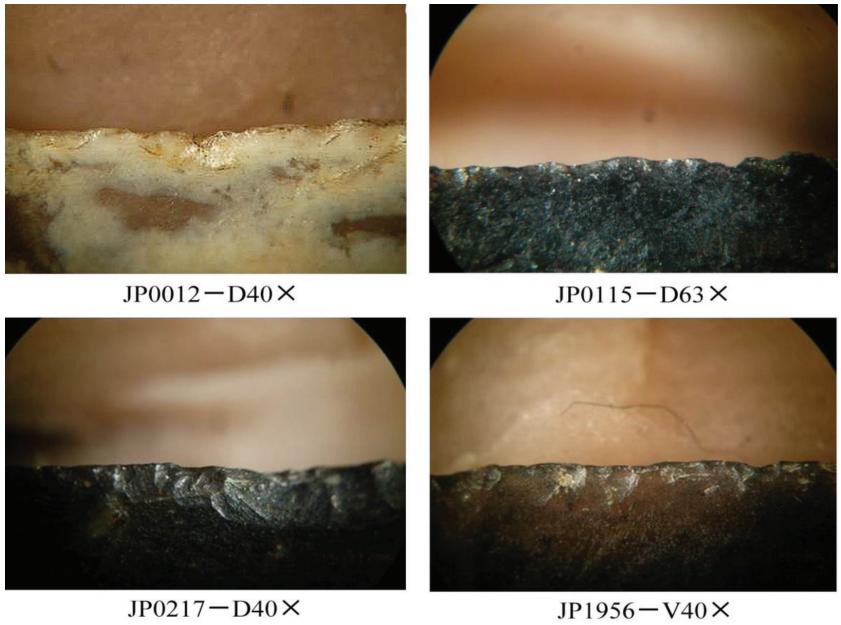


Fig. 4. Use-wear observed on microblades from the Chaisi site.

After an overview of the use-wear analysis on blades, we realised that the functions or worked materials in association with these kinds of artefact are various and diverse. Microblades might have been used for processing not only soft plants, but also the medium-hard parts of animals, hard woods or bone. Furthermore, the functions of microblades varied between different sites. More complex functions and tasks than we have hitherto understood might have involved microblades, which depends both on internal functional demands and external environmental conditions (*Chen, Lian 2013*).

Function of core-like tools

The group of core-like tools uncovered at both Xiachuan and Chaisi was classified as comprising a particular kind of stone artefacts. These specimens are made on thick flakes or tabulate cherts, and display continuously long and narrow scars similar to the working face of microblade cores. In terms of the shape of their edges, the excavators classified them into several subtypes, including oblique-edge shaped, flat-edge shaped, round-edge shaped, pointed, and so on (*Wang* et al. *1994*). In the excavation report, the excavators classified these artefacts as core-like knives, which means they were considered as knives (*Wang* et al. *1978; 1994*). However, our results demonstrate that only one specimen from the Xiachuan site was used as a tool, while the other seven specimens show no use-wear. Eleven specimens from the Chaisi site bear no use-wear in association with usage or hafting.

Specimen SP00971 is a good example to indicate how this kind of artefact was used. Small scars with mostly feathered terminations mainly in continuous distribution appear on the convex edge (pc8-1), reduced from the ventral side to the back with heavy rounding. Both the sheet-shaped gloss and striation can be clearly seen; moreover, these striations are vertical to the edge (Fig. 5). This is clearly indicative of the object being employed for hide scraping. As a result, we recognised that this specimen was used as a scraper rather than as a so called core-like knife.

The original researchers classified these artefacts as tools rather than microblade-cores due to the micro-flaking scars on their edges, which were obviously

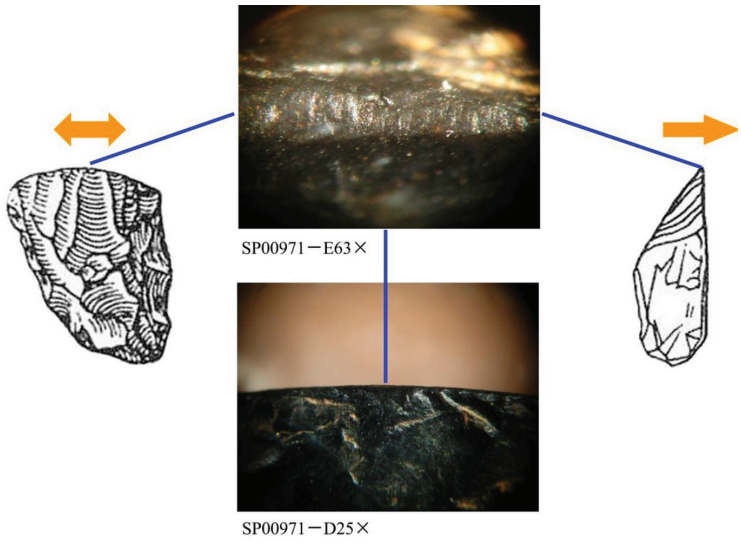


Fig. 5. Use-wear observed on a core-like tool.

produced by the impact with, or friction between, hard materials. The probable cause seems to trim the overhangs around the platform for the purpose of continued flaking. Therefore, we would like to classify these so called core-like knives as microblade-cores, rather than as a specific type of tool.

Some scholars have suggested that some wedge-shaped microblade-cores (Type I) at Hutouliang might have served the double functions of both tool and core (*Zhu 2006*). Zhang selected 52 microcores from the Hutouliang assemblage for use-wear analysis. As a result, it was demonstrated that only 12 specimens retain use-wear (23.1%). On the one hand, the use-wear patterns found on two specimens within them might be caused by adhering to somewhere for flaking rather than being used for processing other materials. On the other hand, four FUs were determined to be caused by scraping or cutting, which is similar to specimen SP0097. Above all, the microblade cores (Type I) could not be classified as a kind of tool with an intentional design. These traces often appear on both edges of the back or bottom of the specimens, which were considered as probable locations on the microblade cores for fixing tightly and then for removing microblades later.

Indications of human behaviour

The Upper Paleolithic is identified as blade-dominated (*Bar-Yosef 1999*), including the technologies based on microblades in Northeast Asia, Siberia and North America, as well as geometric microliths in Europe and West Asia (*Taylor 1962; An 2000*). The emergence of microblades might indicate a technology or strategy adopted to explore animal resources by people living in extremely diverse and harsh environments (*Chen 1984*), which were closely connected with human migrations during the global climate changes in the Late Pleistocene (*Chen 1984*). Based on the use-wear analysis of the lithic artefacts from the Xiachuan and Chaisi sites, we can gain some insights into human behaviour. On the one hand, the microblades with a regular shape, appropriate size and sharp edges might have been selected for use. Most of the use-wear could be related to animal substances, while a few might be associated with vegetal substances, which reveals a dualistic-structured strategy for exploiting resources. We suggest that most of the microblades might have been inserted into handles for use, while some complete and larger pieces might have been used freehand. On the other hand, the majority of core-like tools should be classified as microblade cores, while very few of them might have been used as tools with sharp edges from a functional perspective.

In summary, use-wear analysis can be used to connect the static archaeological record with the dynamic cultural context in which people operated in the past, and therefore it can play an essential role in linking human behaviour and natural processes to physical remains in the archaeological record. Use-wear patterns can provide direct evidence of tool functions and material exploitation. This method in archaeological analysis might provide a new way to understand human activities in prehistory.

ACKNOWLEDGEMENTS

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An experimental case of wood-working use-wear on quartzite artefacts

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ABSTRACT – *Use-wear analysis has become an essential method for the functional study of lithic artefacts from prehistoric archaeological assemblages. On the basis of earlier research, this article discusses experiments and analyses of use-wear on quartzite artefacts caused by wood-working. The raw materials of the artefacts were collected from the Wulanmulun Site, Inner Mongolia. The woodworking techniques include scraping, drilling, and chopping. Scarring sizes are mostly medium and small. Scarring terminations are mainly feathered; stepped terminations are caused by scraping and chopping wood. Scarring mainly appears as run-together distributions. Medium and heavy rounding is found on the edges of the artefacts.*

IZVLEČEK – *Analiza sledov uporabe je postala ključna metoda za prepoznavanje funkcij kamnitih orodij iz prazgodovinskih artefaktnih zbirov. Na osnovi starejših raziskav v članki razpravljamo o eksperimentih in analizah uporabe artefaktov iz kvarcita, ki so bili uporabljeni pri obdelavi lesa. Surovino za takšna orodja so v prazgodovini nabirali na najdišču Wulanmulun na območju Notranje Mongolije. Tehnike obdelave lesa vključujejo strganje, vrtanje in sekanje. Poškodbe na orodjih so večinoma srednje do majhne. Brazgotinaste poškodbe so v obliki peresa; stopničaste poškodbe je povzročilo strganje in sekanje lesa. Brazgotinaste poškodbe se pojavljajo v glavnem porazdeljene v skupine. Na orodjih smo prepoznali tudi srednje do močno zarobljenje roba delovne površine.*

KEY WORDS – *quartzite artefacts; wood-working; replicative experiment; use-wear analysis*

Introduction

Based on experimental observations, use-wear analysis refers to the study of wear traces on the edge or surface of artefacts caused by use (*e.g., Fullagar, Matherson 2013; Odell 2004*). It has been widely accepted that use-wear analysis is an important way to identify, classify and compare wear traces, which allow functional interpretations and reconstructions of human behaviour (*e.g., Redman 1973; Marreiros* et al. *2015*).

Low- and high-power magnifications are two methods that contribute to recognising use wear and functional interpretation (*e.g., Odell 1977; Keeley 1980*). Low-power magnification primarily follows Semenov's (*1964*) methodology of using a stereoscopic microscopy. This low-power approach, focusing mainly on microfractures and abrasion, such as edge damage, rounding, and diagnostic fractures, has an advantage over the observation and analysis of a large number of artefacts.

Quartzite is a non-foliated metamorphic rock containing more than 75% quartz. It can form sharp edges, and is suitable for tools due to its hardness, rigidity, and medium-grained texture. Use-wear analysis on quartzite artefacts began in the late 1970s (*e.g., Toll 1978; Christian 1978*), but developed slowly, since quartzite is difficult to observe and analyse under the microscope. In recent years, with methodological and technological developments, quartzite has become one of the most popular materials to study among use-wear researchers. Some replicative expe-

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riments have been conducted by Chinese researchers, but these are still far from enough to support the archaeological interpretation.

In many Paleolithic sites in China, quartzite was an important raw material widely used by early humans. The Wulanmulun site, located in Inner Mongolia, is a typical Paleolithic site where quartzite was the main raw material among the archaeological objects. Since its first excavation in 2010, large quantities of quartzite artefacts have been unearthed (*e.g., Hou* et al. *2012; Wang* et al. *2012*). According to the evidence of use wear and hafting wear features observed on some quartzite tools from former functional studies (*e.g., Chen* et al. *2014*), some tools from this site were used for woodworking.

However, previous studies of use-wear often focused on flints and obsidian (*e.g., Wang 1992; Li 1992; Hou 1992; Shen, Chen 2001; Chen 2008; Fang 2009*). We hope this experimental study may contribute a partial set of reference standards for constructing use-wear patterns on quartzite tools and aid interpretations of archaeological assemblages on the basis of the low-power technique.

Experimental programme

The aim of this experimental study is to summarise the identifiable use-wear features and patterns under various working techniques and use intensity, and subsequently to enrich the comparative reference collection that can be used in functional interpretations of archaeological assemblages.

Experimental design

Five flakes and one core, both unretouched and with usable edges, were selected for the replicative experiment; some of them have sharp working edges. All of the experimental specimens, produced by hard-hammer percussion technique, were made from quartzite nodules collected from Locality 10 at the Wulanmulun site. The nodules are in three colours: tawny, henna, and black; tawny and henna quartzite consists of much larger grains than black pieces. In order to make the results of the experiment more precise, we collected the supposed contact materials from the Wulanmulun site and local areas. Considering the probable tasks carried out on both fresh and dry wood by prehistoric humans, three working techniques were determined: scraping, drilling, and chopping.

All of the specimens were observed with the low-power technique with an Olympus SZX16 stereoscopic microscope at magnifications ranging from 8.75× to 143.75×. Typical use-wear patterns were photographed using a Nikon EOS 600D digital camera, and the photos were processed by image processing software.

Analytical items

The use of a stone tool usually results in two major types of microscopic wear: microfractures and abrasion. Microfracture mainly refers to scarring, including: (1) scarring size; scars can be defined as large (visible at less than 10×), medium (10–20×), small (20–40×), and tiny (above 40×); (2) scarring termination (Fig. 1), classified as feather, hinge, step and snap; and (3) scarring distribution (Fig. 2), which is divided into continuous, uneven, scattered and overlapped. Abrasion includes rounding, polish and striation, while polish can be observed only at high magnification. The three degrees of rounding are heavy, medium and light. Striations, the orientation of which is closely associated with the working technique, can usually be observed under low magnifications.

Experimental process

During the preparation stage, all of the basic information of each specimen was recorded accurately before use, including raw material colours, morphological characteristics and edge shapes. In order to record areas with use-wear, every specimen was

Working motion	Contact material	Specimen	Type	Employed edge shape	Employed edge length /mm	Max length /mm	Max width /mm	Max thickness /mm
Scrape	Fresh poplar	12EKAC6:81.1	Flake	Convex edge	13.9	27.4	21.2	3.5
Scrape	Fresh poplar	C15:1.2	Flake	Straight edge	24	25.4	21.9	4.8
Drill	Fresh poplar	AC5:19.1	Flake	Tip	–	25.8	16.7	8
Drill	Fresh poplar	BC7:5.2	Flake	Tip	–	41.5	30.3	9.9
Chop	Dry willow	12EKBC7-1	Core	Convex edge	15.1	63.7	54.6	37.5
Chop	Dry willow	BC7:9.1	Flake	Straight edge	19	54.8	66.3	19.5

Tab. 1. Basic information on the experimental specimens.

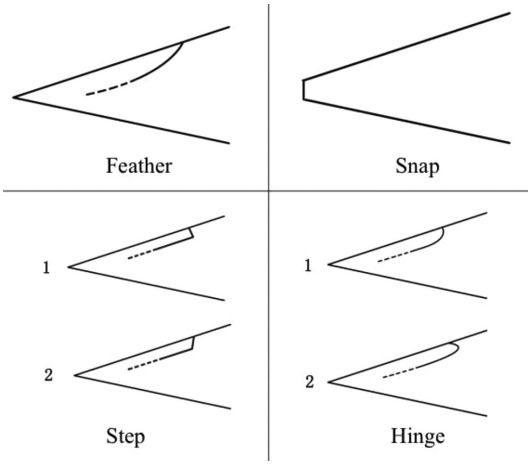


Fig. 1. Scarring termination (after* Ho Ho Committee 1979*).

sketched and photographed, using the 8-polar coordinate grid defined by George H. Odell (*1977*). To make it easier to detect change in working edges after use, we painted some white pigment on the working edges of the specimens before use, and then observed and photographed them under a microscope.

As a controlled experiment, each specimen must be used by one particular experimenter in the same working location, with the same working technique, applying the same amount of force. On the basis of some previous experiments we carried out (*e.g., Chen 2008; Chen* et al. *2015*), the total operating time of each specimen was limited to about 15 minutes. Furthermore, to ensure that the experimenters could apply speed and force to relatively the same degree, they had to stop every 3 minutes and record the required information. The experiment was stopped when the specimen became badly damaged.

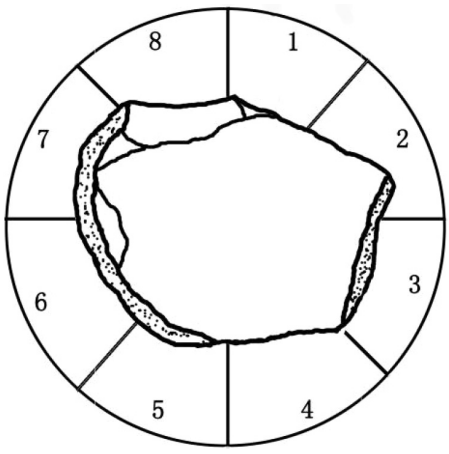


Fig. 3. 8-polar coordinate grid (modified from* Odell 1977*).

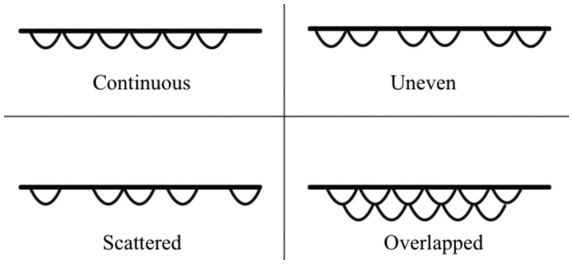


Fig. 2. Scarring distribution.

During the experiment, the working technique of the experimenters on every specimen was recorded in detail, including length, frequency, and time consumed and number of movements of each action (*Fang 2009*). Action length refers to the distance we worked on the contact material each time. Action frequency is equal to the number of movements in a given time (generally counted in minutes), which reflects the continuity and intensity of each technique. Time consumption means the total time of each experiment. Movement number refers to the total number of times each working action was taken during the experiment.

Experimental results

Three working techniques were involved in this experimental programme: scraping, drilling and chopping; two specimens were used to perform each technique. The result of the experiments is described below.

Wood-scraping experiment and its use-wear features

Specimen 12EKAC6:81.1 was used to scrape fresh poplar branch for 15 minutes; action frequency was limited to 511 times per minute. Medium rounding was observed along its edge ridge. Some half-moon-shaped notches and several stepped scars appeared along both sides of the working edge. Also, small feather scars were scattered continuously on its dorsal side, and medium feather scars with small feather scars nested inside clustered on its ventral side (Fig. 4).

Specimen C15:1.2 was used for the same task; action frequency was 351 times per minute. Medium rounding can also be observed on its edge ridge. The scars distributed along both sides of the working edge are mainly small feather and step scars. Feather scars appeared more on the ventral than on the dorsal side. It can be seen that scars cross irregularly from the dorsal to the ventral side, appearing in a half-moon shape seen from the dorsal side.

No visible modification was found on the two specimens during the experimental process. Use-wear resulting from scraping the fresh poplar branch consisted mainly of small and medium feather scars, with a few stepped scars. The feather scars were mainly distributed continuously on both sides of the working edge. Scars crossing the edge ridge are apparent, appearing in a half-moon shape from the top of the edge. Medium rounding appeared on both specimens after use.

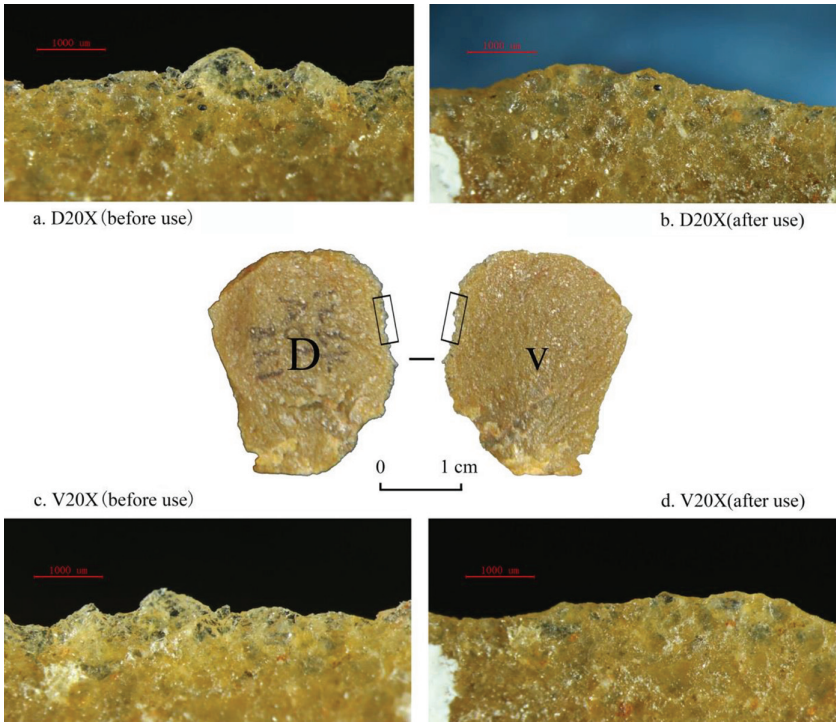


Fig. 4. Use-wear on specimen 12EKAC6:81.1 for scraping wood. **a, c** ***No traces.*** **b** ***Half-moon- shaped notches continuously distributed on the dorsal side, with a few small feather scars.*** **d** ***Heavy rounding and a notch appeared on the ventral side of the working edge.***

Wood-drilling experiment and its use-wear features

Specimen AC5:19.1 was used to drill a fresh poplar branch in a clockwise rotation for 15 minutes; action frequency was 52 times per minute. The tip and the right working edge became dull, and heavy rounding appeared after use. Small feather scars were observed on the tip, while medium feather scars in continuous distribution were observed on both sides of the right edge. The right edge became denticulate, and small feather scars were distributed on the other working edge.

Specimen BC7:5.2 was used to drill a fresh poplar branch with bidirectional rotation. The experiment lasted only 3 minutes due to the severe damage caused to the specimens. Action frequency was 59 times per minute. Small feather scars and a large crack where several small feather scars were distributed were observed along the edge ridge. Small feather scars were scattered irregularly on the left side of the tip.

The two specimens were used efficiently to drill the wood. The use-wear on the working edge consists mainly of continuously distributed small-medium feather scars. Heavy rounding was observed on the tip, being more marked on the wood drilled with bidirectional rotation.

Wood-chopping experiment and its use-wear features

Specimen BC7:9.1 was used to chop dry willow for 13 minutes; action frequency was approx. 96 per minute. Medium rounding appeared on both the working edge's dorsal side and its ridge. Small and medium scars on the dorsal side mainly appeared as feather termination, with a few stepped termina-

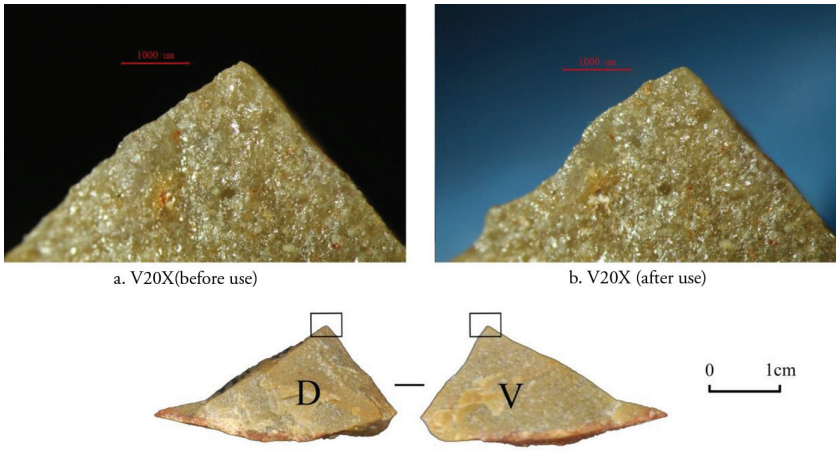


Fig. 5. Use-wear on specimen AC5:19.1 for drilling wood. **a** ***No traces.*** **b** ***Heavy rounding appeared on the tip, and medium feather scars were distributed on the working edge.***

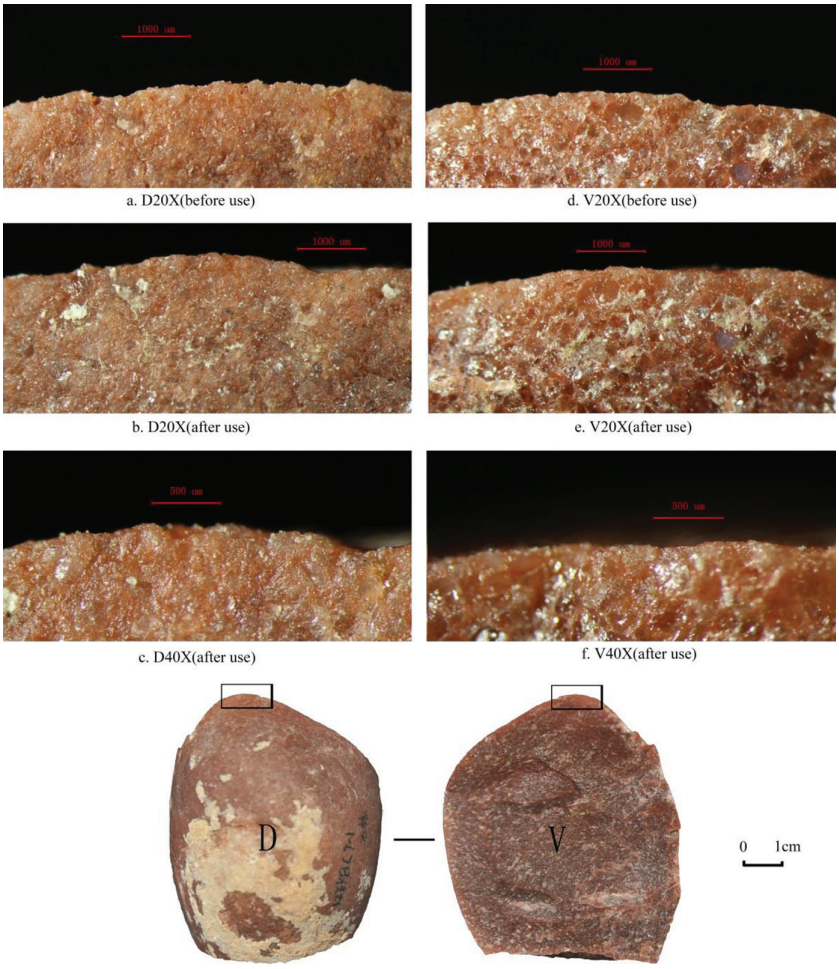


Fig. 6. Use-wear on specimen 12EKBC7-1 for chopping wood. **a, d** ***No traces.*** **b** ***Small scars unevenly distributed on the dorsal side, with mainly feather and step terminations.*** **c** ***Small feather scars continuously distributed on the working edge, with a few step scars.*** **e** ***Medium scars, most with step and feather terminations.*** **f** ***Feather scars crossing the edge ridge scattered irregularly on the ventral side.***

tions. Several small scars were nested in medium scars. Small feather scars and the starting point of crossed scars were distributed irregularly on the ventral edge.

Specimen 12EKBC7-1 was used for the same task for over 15 minutes. Action frequency was 73 times per minute. Individual small scars crossing from the dorsal to ventral side were observed on the edge ridge. Small scars were scattered continuously along the dorsal edge, most having feather terminations and a few stepped terminations. Medium scars were distributed continuously on the ventral side (Fig. 6).

The chopping efficiency of these two specimens is relatively high. Use-wear caused by chopping is visible to the naked eye, and is most evident in heavy rounding and medium-to-small scars in a continuous distribution. Most scars appear to be feather and stepped terminations, with a few scars crossing the two sides.

Discussion and summary

Theoretically and experimentally, the mechanical damage to the raw materials of lithic artefacts differed, because the composition and grains are different. Flint, obsidian and quartzite are common raw materials at prehistoric sites, so it is necessary to compare the similarities and differences between use-wear features and patterns from wood-working on raw materials based on experimental studies.

Use-wear features caused by wood-working on quartzite artefacts

The experimental results show that micro-wear was caused by wood-working activities. Some preliminary conclusions about use-wear features and patterns caused by wood-working can be indicated.

The distribution of micro-fracture damage on the working locations may somehow be affected by various working techniques. With the same technique, different specimens display similar sizes, terminations and distribution of scars. However, use-wear features may vary due to occasional factors during experiments. It is a distinct feature that working edges became dull after scraping wood. Most of the scars are distributed continuously; most have feather terminations, with a few step and rolled-over terminations. On the other hand, the specimens' edges became smoother after chopping wood; continuously scattered medium and small scars can be observed. Compared with wood scraping, step and rolled-over shaped terminations were observed much more on the working edge. After drilling wood, the tips of the specimens cracked, and only feather scars appeared.

The rounding which appeared on the quartzite artefacts after wood-working is obvious, and is main-

Comparing items		Quartzite	Flint	Obsidian
Microfracture	Size	Medium and small	Large, medium and small	Small
	Distribution	Continuous	More continuous, less few uneven and scattered	Continuous and overlapped
	Termination	Feather and step	Feather, snap, hinge, and few step	Snap and feather
	Other	Crossing the ridge	Crossing the ridge	/
Abrasion	Rounding	Medium and heavy	Heavy to light	Medium and heavy
	Striation	/	Few	Rare
	Polish	/	Little	/

Tab. 2. Comparison of use-wear results from wood-working on three main raw materials.

ly medium or heavy. It was also shown that the location and degree of rounding depend on the various working techniques. Rounding caused by wood-scraping appeared only on the edge ridge, while rounding results from chopping wood appeared mainly on the bulging part of the working edge. Rounding caused by drilling is heavier, especially with bidirectional rotation.

Comparison of wood-working wear traces on various raw materials

In recent years, experimental studies of wood-working use-wear on flint and obsidian have been explored by archaeologists. Thus, based on those first-hand data, we can summarise the identifiable use-wear features and patterns result from wood-working on various materials.

Using flint burins for carving, scraping and drilling wood, You-Ping Wang's research (*1992*) showed that polish, striations, and scars appeared on the tool edge margin. The polish is bright and smooth; the burins have a banding distribution along the flat edge, but these are distributed intermittently along the uneven edge. Striations are wide and shallow; scars are relatively deep, mostly with step terminations.

Wei-Dong Li (*1992*) suggests that the use-wear features on flint points after carving and drilling wooden materials are: (1) Apparent and bright polish; (2) Striations, thin striations parallel to the edge caused by wood-carving, and rather small striations caused by wood-drilling; (3) A few scars and small cracks after carving, while wear traces caused by drilling consist mainly of small step scars and some large shallow scarring.

By means of low magnification, Chen Shen and Chun Chen (*2001*) suggest that micro-fractures on the flint tools after working on materials of medium hardness (such as dry and fresh wood) consist mainly of large and medium rolled-over shaped scars. Using 20 flint artefacts to scrape, shave, chop, saw, cut, carve, and drill dry and fresh wood, Fu-You Chen *et alii* (*2008*) demonstrate that wood-working mainly results in light rounding, while striations are caused only by chopping wood. The edge damage consists mainly of large and small scars with snap and feather terminations. Apparent rolled-over shaped scars appeared along the working edge of several specimens. Qi Fang (*2009*) conducted wood-working experiments with obsidian artefacts, which showed that use-wear on the working edge consists mainly of step and feather scars, mainly with continuous or overlapped distribution, while striation is rare.

To sum up, apparent use-wear appeared on all of the three materials after wood-working; the similarities and differences are (Tab. 2):

❶ Rounding on quartzite and obsidian is heavier;
❷ A few striations are observed on flint and obsidian, but not on quartzite;
❸ Most scars have feather terminations; in a few step scars, the termination, distribution and size of scars observed on the flint specimens are more complex;
❹ Scars crossing the edge ridge are observed both on quartzite and flint specimens.

On the basis of the experiments, it can be observed that the use-wear appearing on the artefacts might be due to various factors. This replicative experiment on quartzite artefacts provide us reference data for identifying use-wear features caused by wood-working. The results of this experiment are important for understanding and identifying wear traces on various materials. However, due to the limited knowledge of the physical composition and relevant analysis of our experimental specimens, we cannot reach a precise conclusion. The use-wear of archaeological artefacts is more complex, and more experiments and further studies are necessary.

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Archery by the Apaches – implications of using the bow and arrow in hunter-gatherer communities

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ABSTRACT – *This review focuses on the technical and social details of production, training, and use of archery equipment by a Native American tribe, the Apaches. The study aims to understand the use of the bow in the Mesolithic and Early and Middle Neolithic societies of the Old World. The paper further describes arrow ballistics. An arrow and bow with similar dimensions and materials to those used by the Apaches was reconstructed and used in ballistic experiments. Shooting and the subsequent model calculation showed that the effective range of arrows made of reed and projected by a bow of medium strength (16–18kg) was not more than approx. 20m. Due to the initial flat part of the ballistic trajectory, such arrows were quite efficient in close-range contests. Within the model calculation, a regression procedure was introduced to determine the arrow air-drag parameters from an ensemble of shots.*

IZVLEČEK – *Članek podaja pregled o tehničnih in sociooloških podrobnostih pri izdelavi, treningu in rabi lokostrelske opreme pri ameriškem domorodnem plemenu Apačev. Študija je namenjena razumevanju rabe loka in puščic v mezolitskih ter zgodnje in srednje neolitskih kulturah Starega sveta. Drugi del študije se ukvarja z balistiko puščice. Predmet balističnih preizkusov sta bila puščica in lok podobnih dimenzij in materialov, kot so jih uporabljali Apači. Streljanje in modelsko računanje sta pokazala, da uporabni doseg puščice, izdelane iz trstike in izstreljene z loka srednje moči (16–18 kg), ni večji od približno 20 metrov. Ker je balistična krivulja take puščice v prvem delu leta zelo položna, so bile puščice izredno učinkovite na kratko razdaljo. V modelskem računu smo uvedli nov postopek za določanje parametrov zračnega upora iz skupine strelov.*

KEY WORDS – *Apache; bow and arrow; reed arrow*

Introduction

The invention of the bow and arrow provided the early hunter with a remarkable hunting tool. However, in complex human relations, it also turned into an efficient weapon to be used against others. In the prehistoric Old World, various testimonies to human violence exist, most of them manifested in changes in human skeletons, although some explicitly point to injury caused by an arrow. The earliest evidence of armed conflict from the Late Paleolithic (12000–10000 BC) is from Jebel Sahaba in Sudan, where half of 107 burials suggest violent death (*Christensen 2004.134*). Projectile injuries in the Middle and Upper Paleolithic are rare, but in the Mesolithic they amount to 17 out of total of 77 registered examples, or 22% (*Estabrook 2014.65*). A review by the same author (*Estabrook 2014.53–58*) lists the following Mesolithic sites with projectile bone injuries: Bøgebakken in Denmark (two perimortem projectiles), Vlasac (one perimortem bone projectile) and Schela Cladovei in the Danube region (6 perimortem flint or bone projectiles), and Vasilyevka in Ukraine (8 perimortem projectiles). Regarding the Vlasac example, the author also admits the possibility that the wound was inflicted by a dart (*Roksandić 2006b. 342*). Further examples of Mesolithic death caused by projectile injuries (*Christensen 2004.134–135*) include Téviec in France (two arrowheads in the spinal column) and Henricksholm/ Bøgebakken in

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Denmark (bone point in the throat). From the Mesolithic and Neolithic, we have further evidence in graphic depictions showing armed contests between archers. In Les Dogue, Ares del Maestra, eleven archers are attacked by seventeen running archers, and in Cueva del Roure, Morella, four archers are in the pincers of three others (*Christensen 2004.135*). In a mass grave at Talheim in Heilbronn, dated to the Early Neolithic, two individuals among 34 burials show injuries caused by arrow points. From the Middle and Late Neolithic, finds of human bones with embedded flint or bone tipped arrows are numerous: Castellet, Villevénard and Roaix in France, Porsmosen in Denmark, the Stapleton enclosure near Dorset and Stonehenge in the UK (*Christensen 2004.136–137*), Aktopraktic in Anatolia (*Erdal 2012. 80*). Two projectile injuries out of a total of ten traumatic injuries are also documented for Paleoamericans in North America (*Chatters 2014.75*).

The intensity of conflict may be estimated from the percentage of individuals showing signs of violent death in a certain grave assemblage. In Schela Cladovei, in the area of the Iron Gates, 15% of individuals died violently from shots of arrows tipped with bone points (*Bonsall 2008.263*). On the other hand, Mirjana Roksandić (*2006a*) estimates that conflicts were occasional, as among the 418 individuals she studied, only a few showed the consequences of violence. An opposite view is given by Jonas Christensen (*2004.130*): armed conflict in primitive societies caused 10–40% loss of population. For Linear Pottery culture, the skeletal material is well documented and shows that 20% of the population died violently (*Christensen 2004.152*).

As material remnants provide only limited sources of complex human relations, behaviour patterns are also studied by ethnographic research on contemporary, but archaic, societies which are still attached to their traditional way of life and have survived in a few remote parts of the world. The cultural groups most studied today or in recent decades are hunter-gatherer communities in Alaska or Australasia (*Kramer 1979.3; LeBlanc 2014*). However, with modern communication technologies, their life-style is rapidly disappearing, and many interesting data can be found only in the literature published since the second half of the 19th century. The present work aims to study the use of the bow by the Apaches, an indigenous tribe in the south-west of North America, about whom significant data exist in their memorial literature from the end of the 19th century and in ethnographic studies published between 1930 and 1960. In a review, we would like to give a comprehensive view of the technology of making archery equipment and the use of bows in hunting and combat. In the second part, we try to reproduce some specific item of archery equipment, notably reed arrows, and test their ballistic properties.

The Apaches, the Athabaskan-speaking native population, settled in the area of present-day Arizona, New Mexico and the northern borders of Chihuahua and Sonora between the early 15th and 16th centuries. Among this large group, we limit our study to the Chiricahuas and Western Apaches. The main memorial literature on the Chiricahua is the account of Geronimo as recorded by Stephen M. Barrett in 1906 (*1996*), and the autobiography of Jason Betsinez (*1959*). Many observations can also be found in the works of Eve Ball (*1988; 2003*). For the Western Apaches, ethnographic material and memories of war parties from the second half of the 19th century were recorded by Grenville Godwin and are available in Keith H. Basso's book (*Basso 1971*).

By the first half of the 19th century, the Apaches were living quite an independent way of life, during the period that started with Mexican independence in 1810–1821 and ended with the Mexican-American war in 1846. This period is characterised by an absence of organised Mexican military control, while the influence of white Americans was almost negligible. Relations with Mexicans were complex, involving peaceful co-existence and fierce military conflicts (*Utley 2012.16–28*). The Chiricahua economy was based on four main activities: hunting, gathering, modest farming, and casual looting of their Mexican neighbours. During looting expeditions or raids against the Mexicans, they usually used cold weapons, as described in the memories of Geronimo. The Western Apache economy was more advanced, being primarily agricultural; they also built dams and dug irrigation ditches (*Basso 1971.79*). However, it is interesting that they quit the irrigated cornfields as soon as the corn ears developed, and temporarily left to collect acorns (*Basso 1971. 95–96*). The Western Apaches generally made the transition to reservation life much more easily than the Chiricahuas. In the earlier period, the Chiricahuas also organised two kinds of military expedition: smaller parties of up to fifteen warriors generally aimed at looting, while a large number of warriors led by respected chieftains and a shaman (*Basso 1971.16–18*) normally avenged the deaths of casualties.

During this period, the bow was used as an effective long-range weapon, supported by the fact that contemporary guns were muzzle-loaders superior to their predecessors of previous centuries in having a more efficient firing system of percussion caps only. Mexican military doctrine had remained essentially unchanged since the Napoleonic wars and was based on the organised concentrated fire of multiple weapons, rather than on precise individual musketry. In such circumstances, the bow could compete with the gun in range and precision, and bettered it in the rate of fire.

Use of the bow

Hunting

Hunting was the main activity of men and boys as soon as they passed the age of eight or ten (*Barrett 1996.65*). The bow and arrow was not the only hunting weapon; larger animals were also hunted with the spear and smaller ones with a short stick or a hunting club. Horses were also used in hunting, notably for catching up with smaller animals such as turkeys and rabbits. The bow and arrow (but also spear) from horseback were used to hunt buffalo (*Barrett 1996.64*), though for Apaches, the buffalo was probably an occasional pray. Geronimo carefully describes efforts during deer hunting, which was based on concealed approach to a grazing herd. A skillful hunter could get several animals before the rest of the herd noticed him and ran away. Although not described explicitly, this type of hunting was possible only with bow and arrow. A good shot could kill a deer instantly at a distance of a hundred yards (90m).

Another animal that Geronimo explicitly says was hunted with the bow is mountain lion, although he also says he killed one with a spear (*Barrett 1996. 68*). The bow and arrow can also be used for some unusual practices, such as shooting down parts of a beehive of wild bees (*Ball 2003.122*).

The bow was used for hunting during the Turkey Creek settlement period (*Davies 1929.102–120*) as late as 1884, possibly due to the scarcity of ammunition (*Ball 2003.159*). Jason Betsinez remembers that the men used the bow to kill domestic animals allotted to them for food (*Betsinez 1959.6*). He was also impressed by the penetrative ability of the arrow, as he writes, "*Many men can drive an arrow clear through a large animal*." At a distance of 14m, an arrow could be sent through a deer (*Opler 1996.388*).

Combat

The Chiricahuas used the bow as the main ballistic weapon until about 1860. It was at the battle of Apache Pass in 1862 that they first used a considerable number of firearms – although most of them still carried bows and arrows (*Ball 1988.20*) – but they probably lacked sufficient ammunition (*Sweeney 1991.437*). During the 1870s, bows were used in small-scale conflicts on the Tularosa Reservation (*Thrapp 1974.156*). In an ambush set for Mexican soldiers in 1875 near Fronteras, the Mexican commander was reportedly killed by an arrow (*Sweeney 2010.37*). Bows were often used in internal conflicts and scuffles, which regularly followed excess consumption of alcohol (*Sweeney 2010.26*). Geronimo describes treating wounds after such fighting (*Barrett 1996.96*). Betsinez remarks that bows were seldom used after 1882 (*Betsinez 1959.85*). In spite of this, Bourke noticed in 1883 during the Mexican campaign of General Crook that the Apache still carried bows and arrows as a side arm, as well as the latest repeating rifles and revolvers (*Bourke 1958. 102*). The Western Apaches conducted raiding parties in Mexico armed with bows until the 1850s or 1860s (*Basso 1971.84, 195*).

Most Apache raiding parties started on foot, and each warrior carried equipment and rations for three days (*Barrett 1996.84*). From a description of fighting scenes in Geronimo, we learn that personal arms consisted of a spear, bow, arrows, and a knife (*Barrett 1996.93*), and eventually also a war club (*Opler 1996.340*). The number of arrows carried in important encounters was between thirty and forty (*Opler 1996.388*). In three places in his memoirs, Geronimo says that he ran short of arrows during a fight. The first two were in fights with Mexicans. In a supposed revenge battle (probably the battle at Pozo Hediondo in 1851), Geronimo used all his arrows in about two hours of fighting (*Barrett 1996. 62*). In some other attempt to raid an unnamed village, an Apache party was ambushed and pursued (*Barrett 1996.85*). The soldiers subsequently chased the Apaches, who were fleeing and hiding. From his hiding place, Geronimo used his bow to defend himself against soldiers who had spotted him. According to his account, he had enough time to take deliberate aim from a concealed place until he had spent all his arrows. These circumstances do not allow us to determine the range at which Geronimo used his bow, but the distances were supposedly from some tens of metres up to a hundred metres. When he left the hiding place, mounted Mexicans threatened to cut him off. In this case, the bow would have been

used at very close range. The third description refers to a conflict with United States soldiers in 1863, 1864 (*Barrett 1996.120*). The Apaches were only modestly armed, so Geronimo soon spent all his arrows. In a fight ten days later, he had spent all his arrows before ten o'clock in the morning, although the fighting lasted the whole day.

The bow's short range made it ineffective against firearms. On a raiding party near Arispe around 1867, the Apaches were pursued by Mexican horsemen (*Barrett 1996.99*). When they opened fire, they were too far away for the Apaches to respond with their bows. However, bows had sufficient range to shoot after the fleeing enemy (*Barrett 1996.93*). The bow was effective in short-range combat. This was seen when Mexican troops attacked Geronimo's settlement (*Barrett 1996.89*). In the thick of the fighting, Geronimo was able to shoot an officer and escape. The rate of fire of the bow was an advantage even in contests with modern repeating guns. As claimed by an unnamed warrior, it was possible to shoot three arrows before the opponent could load the magazine of the gun (*Opler 1996.388*). Long-range shooting is recorded for the Mescalero Apaches. In 1868, they besieged Mexican soldiers who had taken their horses into an enclosure. The Apaches shot their arrows high in the air so they fell into the enclosure and killed all the animals (*Sonnichsen 1958.144*).

Production of archery equipment and training

Archery equipment was manufactured by experienced old men who passed on their knowledge to the young (*Basso 1971.226*). Young boys had to observe men making bows (*Opler, 1996.28*). If the older man was a relative, he made the bow for free, but should then receive a portion of prey or booty without asking (*Basso 1971.226*). If the bow maker and owner were not related, the payment would be a shirt or buckskin (*Opler 1996.226*). Men were supposed to make arrows themselves. Making a full quiver of arrows took a month (*Opler 1996.388*).

Apaches trained to fire the bow from early childhood (*Oper 1996.50–51*). In a Massai legend (*Betsinez 1959.143; Ball 1988.248–261*), we learn that a child had to shoot through metal ring approx. 90m away (*Ball 1988.248*). In 1869, Mexican troops caught a man in the Guadalupe Canyon who had taught a boy how to make arrows (*Sweeney 1991. 267*). Children practiced bow shooting until the 1880s, when the bow was no longer used as a weapon (*Ball 2003.113*). Young Chiricahuas trained by shooting fish in streams, although animals like frogs and snakes were never eaten (*Barrett 1996.68*). Mastering the bow was also developed through numerous archery games; the contests involved shooting into the distance or touching the arrow shot by the first contestant. If the arrows touched, the second archer could keep both arrows. If he missed, his arrow served as a new target. A roll of twisted grass was thrown into the air and had to be hit before it touched ground (*Opler 1996.50–52*).

Even in adulthood, knowledge of the bow was maintained by frequent competitions. These events also involved fast shooting. The aim was to shoot three arrows before the first touched ground (*Opler 1996. 391*). A ball made of cedar bark was used for target shooting (*Basso 1971.226*).

The string was held by the middle three fingers of the right hand, with the first finger above the arrow nock. The bow was held with the left hand, and the arrow rested on left side of the bow on the archer's thumb (*Basso 1971.225*). The three fingers could also be used so the string was held between the thumb and first finger, with the second finger assisting (*Opler 1996.388*). For close shots, the bow was held vertically, but for long shots the bow was held crossways (*Basso 1971.226*). Aiming was taken along the arrow. A wrist guard made of rawhide (*Opler 1996.391*) or leather (*Basso 1971.224*) was often worn on the left wrist to protect the wrist when it hit the string (*Basso 1971.225*).

Making the bow

Apache bows were made from mulberry wood. The Chiricahuas cut second-growth trees found at foot of the hills (*Betsinez 1959.5*). After being cut, the wood was dried for a long time and then worked to the proper size, which was a man's wrist in the middle and tapering at the ends (*Betsinez 1959.6*). The Western Apaches also used mulberry wood, but fashioned the bow when the wood was still green, and then they hung it to dry for about five to seven days. The shape of the bow was a simple arc, with a straight middle section and flexible limbs. The Western Apaches also used bows in the shape of double arc, but learned that single arc bows are better. The double arch could be formed only when the wood was still fresh (*Basso 1971.223–224*). Oak, locust and New Mexico maple also furnished acceptable wood (*Opler 1996.386*).



Fig. 1. Photographs of Apache warriors with bows and arrows: two youths at San Carlos Agency in 1888 (*Utley 1977*), a warrior around 1860 (artificial scenery in the studio), Chatto, chief and later army scout, with reed arrows and boy with a child's bow (Fort Sill after 1894).

The shape of single-arc bows can be seen from a few photographs showing warriors with full equipment (Fig. 1). Comparing the bow size with the dimensions of the human body, the length of the bow with stretched string was between 1–1.2m. Opler states "*three to four feet*" or the "*length of two arrows*", adding "*the short or hardwood shafted arrows*" in the note (*Opler 1996.386*). The bow could also be smaller for hunting small animals and for training boys (*Opler 1996.388*). A size of 1.3–1.4m can be deduced from the photograph taken in the studio (Fig. 1); however, the bow here may also be an improvised item. Nevertheless, we learn from these photos that Apache warriors transported and shot the bow with several arrows in the hand that held the bow, being thus ready for a rapid exchange of shots. There are also several photographs of Geronimo making bows (Fig. 2). Some reveal the bow profile, with a width of about 4cm at the grip and a length of 1m. Supposedly, these dimensions were traditional, although one should not overlook that the bows in Geronimo's photographs were made for sale to tourists, and that Geronimo was wise enough to adjust his production to demand. It is known, for instance, that the Western Apaches made bows for tourists of lower quality wood (*Basso 1971.223*).

In the crafting procedure, the branch is cut, split, shaped and smoothed, and then left to season (*Opler 1996.386*). The wood was then greased and made slick and shiny. To bend into its final form, it was heated in hot ashes, shaped and then tied and left to dry for about ten days. To shape a double-arc bow, bending was easily achieved between two young trees growing close together (*Opler 1996. 386*).

The outer surface of the bow was painted in a solid color, while the inner surface was decorated with stars, crosses, serrated or parallel lines, or naturalistic figures (*Opler 1996.386*). The inner part of the bow is seen in a few photographs of Geronimo. In one of them, we can recognise a zigzag line and on another a series of triangles (Fig. 2).

The bowstring of the Western Apaches was made of sinew from the back of the deer or from the mus-

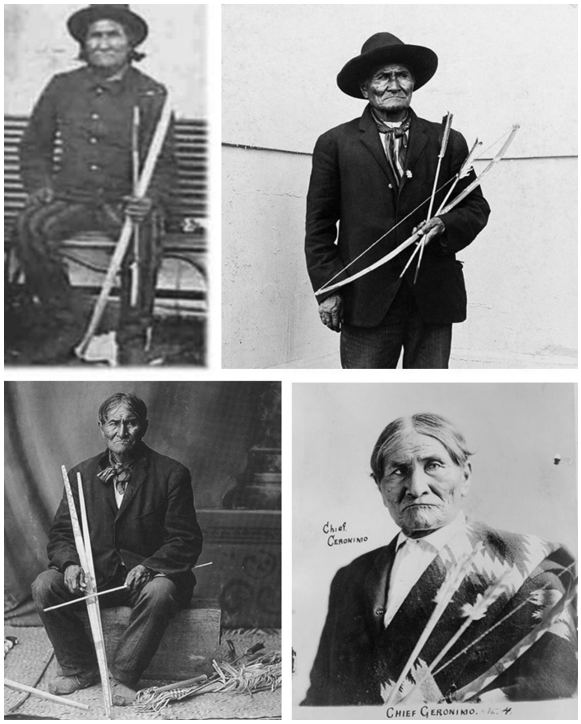


Fig. 2 Selected photographs of Geronimo posing with a self-made bow. Top row, left: in Mont Vernon, between 1888–1894; Bottom row, left: in St. Louis, 1904.

cle of the hind legs. The sinew was soaked and split into strips that were spliced together. The long string was then doubled and twisted together. The string was gradually made tighter after it was first put on the bow (*Basso 1971.224*). Twisted sinew was also used for bowstrings made by the Chiricahuas (*Betsinez 1959.6*). The warrior usually carried an extra string in case one should snap. If necessary, a good string could also be woven from the fibres of the mescal leaf. When not in use, bows were carried unstrung (*Opler 1996.387–388*).

Although the Apaches never produced composite bows with a sinew layer on the outer part of the limbs, they could use sinew or horse hair to bind a bow that was weakened by use. The sinew was fixed with glue made from boiled hooves and horns or occasionally piñon pitch (*Opler 1996. 387*). Sometimes pitch was rubbed into the inner side of the bow to strengthen it (*Basso 1971.230*). For comparison, the existence of composite bows in the European Neolithic is inferred from a rock carving in a Corded Ware tomb in Gölitzsch near Merseburg (*Christensen 2004.139*).

Arrows

The Apaches used two types of arrow, made either from reed for close range or full hard wood for long range (*Opler 1996.388*). The Apache had learned about using full-wood arrows from the Navajo (*Basso 1971.230*). Betsinez could not remember the name of the bush that produced straight stalks (*Betsinez 1959.6*), but the Western Apaches used desert broom (*Baccharis sarothroides*) (*Basso 1971.229*). The Chiricahuas could also use Apache plume, mulberry, mountain mahogany or Fendlera rupicola (*Opler 1996.388*). The shorter full wood arrows were heavier than the longer reed ones. The wood was cut into appropriate lengths, peeled of bark and scraped and dried for three to five days. The sticks were straightened by pressing between the teeth or against a heated rock (*Opler 1996.388*).

Reed arrows were actually composite. The front part with the point and the end part for the flight feathers and nock were made of hardwood, while the middle section was reed cane. The best reed was collected along the San Carlos River, but also deeper inside Mexico (*Basso 1971.227*). Reeds were collected green and fresh. They were straightened between the teeth and then allowed approximately two weeks to dry. Straightening could also be achieved by heating, and then rubbing the reed with a piece of heated discarded pottery (*Opler 1996.390*). The arrow shafts were smoothed by a stone arrow-smoother (*Basso 1971.229*), which was made of a porous, whitish soft stone collected in Bear Canyon. A notch was made in the stone and the arrow was run through the groove when the stone was heated.

Reed arrows were typically about 75cm long, while those made entirely of hard wood were about 5–10cm shorter (*Opler 1996.390*). The size of the arrows and bow was further adapted to the needs of the particular user.

The flight feathers could be from different birds, although turkey feathers proved the most durable (*Opler 1996.388*). The feathers of eagles and smaller birds of prey such as the red-tailed hawk (*Basso 1971.227*) were also highly prized, but were hard to collect (*Barrett 1996.68; Betsinez 1959.6*). Tail or wing feathers were split in half and fixed to the shaft with sinew; sometimes an adhesive made of pitch was also applied. Usually, one feather was fixed first and the other two were added one by one. The parts of the flight had to be of different feathers, and had to have the same direction of rotation (*Basso 1971.230; Opler 1996.389*). The length of particular feathers was 12–15cm (*Basso 1971. 388*). For a child's arrow or an arrow intended for hunting birds and small animals, a single long feather could have been wound spirally around the shaft for a length of about 20cm (*Opler 1996.390*).

The Western Apaches painted the last part of the arrow in red-black using hematite and charcoal as pigments; the dye was fixed with piñon pitch (*Basso 1971.230*). The painted shafts were polished with yucca leaves. The Chiricahuas decorated their arrows with black, blue or red stripes. A narrow band of green or red was traced on the upper part of the shaft that was to hold the feathers. Arrows were sometimes fluted with a sharp stone, or a spiral was made in them (*Opler 1996.388–389*). The fluted arrow might have resembled a crawling snake (*Opler 1996.286*). The style of the arrow generally indicated which tribe had made it (*Basso 1971.229*).

The front shaft of the reed arrow was about 10cm long, approximately half of which was in the reed and half protruding outside (*Opler 1996.390*). The shaft was set into the cane with pitch. The shaft held the arrow point, which could be of four types: stone, steel, sharpened wooden tip and wooden shaft with a four crosspiece rig (*Basso 1971.230–231*). The points filed from iron or steel were used in the 19th

century when flint points were already a thing of the distant past (*Betsinez 1959.5*). Hardwood tips were additionally hardened by fire (*Opler 1996. 389–390*). The Western Apaches used hardwood points equipped with a crosspiece for hunting birds (*Basso 1971.231*). The tip of the arrow was split with two notches, the crosspiece was inserted and the tip was bound firmly together with a sinew.

Flint points are interesting, of course, as they may resemble Stone Age examples from Europe. Unfortunately, the Apaches were not highly skilled at stone knapping. They usually sought flint from around ancient ruins (*Basso 1971.231*) and often used ready-made points (*Opler 1996.389*). They knew the artefacts belonged to an older people, and thought that some of the elaborate tools they found belonged to the mythical 'Thunder People' (*Opler 1996.389*) or that animals and birds had made them and used them to fight each other (see *Barrett 1996.49; Opler 1994.23–27*). There is a record of Chiricahuas splitting slate and using the most likely pieces for arrowheads (*Opler 1996.389*). It seems the Western Apaches were more advanced at working flint. They are documented as having held the flint with a piece of buckskin in the palm and using deer horn about 13cm long to flake and shape the stone into its desired form (*Basso 1971.231*). An interesting record of splitting flint by heating it in fire and cooling it in water can be found in the memoirs of Herman Lehman (*1993.93*). However, this description has to be taken with reservations, because in the opinion of certain Comanches and Kiowas, the story is false (*Robinson 2000.63*).

To mount the arrowhead, the shaft was split or a notch cut; the point was inserted and the shaft was firmly tied on with moistened sinew (*Opler 1996. 389, Basso 1971.231*).

Quivers and bow covers

Quivers were made of various skins and usually contained thirty to forty arrows (*Basso 1971.234*). Mountain lion skin was the most popular (*Barrett 1996.68; Basso 1971.234; Opler 1996.391*), while deer, wolf, wildcat, antelope and otter were used, as well as domestic animal skins in later periods. The tail and legs were left to hang, and red flannel and brass studs could be added as additional decoration. The quiver was worn on the back, with the strap passing over the right shoulder and under the left arm, making it easy to draw an arrow with the right hand (*Basso 1971.234*). The Chiricahuas reversed the quiver in combat, so that the feathers came under the left armpit. Sometimes the quiver was held over the chest (*Opler 1996.341*).

The Western Apaches used plain quivers, while the Chiricahuas preferred quivers combined with bow cases. To make the quiver and bow cover, women usually prepared the skin, men cut out the desired pieces, while sewing was again a woman's task (*Opfer 1996.380, 391*).

Poisoned arrows

The use of poison is seldom mentioned with respect to Apache warfare or hunting. The use of arrows soaked in a mixture of rattlesnake blood, prickly pear pulp and charcoal from a tree struck by lighting is known for the Navajo (*Hampton Sides 2007. 3*), but these have a more ritual or symbolic meaning. Lehman also mentions that the quiver contained a few arrows poisoned with rattlesnake venom to be used in battle (*Lehman 1993.94*).

The Chiricahuas occasionally used poisened arrows (*Opler 1996.340*). The poison was prepared from deer blood and plants believed to be poisonous. The mixture was left to rot and then put on the arrow points; variations of recipes including animal parts and different plants also existed. If somebody was hit with a poisoned arrow, he was expected to turn black.

The Western Apaches seemed to have been more inclined to use poison in combat and hunting (*Basso 1971.232–234*). The poison was made of deer spleen. First it was dried, then mixed with the ground roots or stalk of nettles and some other plants with a burning taste. The ingredients were put in a sack of deer intestine and hung on a tree for about three to five days. The liquid was then painted on the arrow tips. The dried poison was also efficient if ground and mixed with spit. A deer pierced or merely scratched with a poisoned arrow could run about seven hundred meters before falling, but the poison spoiled only the meat near the wound.

The experiment

Archaeological examples

Remnants of reed arrows have been discovered in several caves, such as the Fort Stanton Cave. The reconstruction of reed arrows can be seen in the museums in San Carlos, Mescalero and Fort Stanton. On territory once settled by the Apaches, the author

noted several traces of the flint industry at the northern entrance to the Ojo Caliente canyon (Winston, New Mexico) and at Turkey Creek (Fort Apache, Arizona). Several pieces were triangular in form, but it is impossible to guess if they were indeed used as arrow heads. The only fragment where the identification of an arrow head is not problematic is shown in Fig. 3. It is the lower part of a triangular head made of white flint without a stem, but with a clear notch for mounting into the split shaft. It is 11.6mm long and weighs 0.36g, so we may extrapolate its full length to about 25mm and weight to about 0.6g.

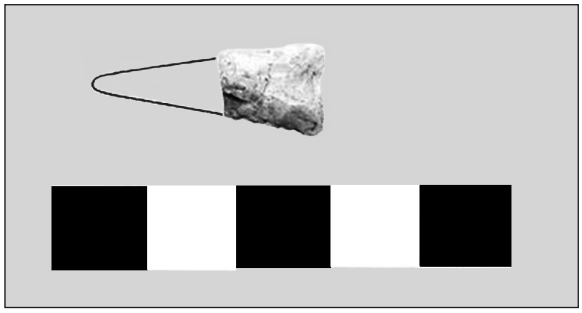


Fig. 3. Fragment of a flint arrow head (Turkey Creek) with supposed reconstruction.

Making an arrow

The reed arrow was manufactured from material collected in Slovenia, so in certain aspects it departs from historical examples. We also used modern thread and modern synthetic rubber or cellulose acetate glue for fixing; however, we do not believe these additions greatly affect its ballistic properties. The wooden parts were made from straight shoots of dogwood, which has compact wood. For the point, a triangular flake of flint weighing 0.4g was inserted into the split in the fore shaft, fixed with cotton thread and glued with synthetic rubber. The wood was split by a saw so as to prevent the shaft from cracking below the point. The shaft was made from a dry reed. After removing the dry leaves, we noticed the importance of properly smoothing the leaf nodes on the stem. We suppose historical arrow-smoothers were mainly used for this type of work. We made a proper notch and fixed three feathers at the end of the shaft, firstly with thread around the front and end parts; finally, we also applied a small amount of glue below the feather's pulp. The feathers were taken from small birds the size of a pigeon or magpie, which are softer than turkey feathers. Fixing the feathers was the most delicate and time-consuming part of the work (see also *Odar 2011.453*). The end parts of the reed stem were reinforced with cotton fibre and glue. For the final assembly of the three main parts, the sockets were gently wetted with cellulose acetate glue. The linear dimensions and weights of particular parts are shown in Table 1; details can be seen in Fig.4. Our final result was an arrow 70.7cm long, but with a remarkably low weight of 9.7g.

The bow

We made the bow by following the Apache tradition approximately, as we wanted to produce only a wooden bow with similar properties to suit our ballistic experiments. Most of the mulberry trees in Slovenia are old trees with massive trunks and young branches too thin for bow making. We were able to cut a branch from a yew with the appropriate length and thickness for shaping into a bow. One part was rasped in a limb, applying distinctive tapering, while the other part had to be tapered on the inner side only. The shaped bow was dried for three years before being used. A disadvantage of using such a branch was found to be in the curvature of the bow: it remained significantly curved even when unstrung.

The string was made of hemp cord 1mm thick, which was doubled by twisting and then treated with bee wax. When strung, the bow was 105.5cm long (Fig. 5). The weight of a full pull for a 70cm arrowhead was about 18kg, but we usually pulled the bow at a weight of 16kg. We also measured the pull force as a function of the arrow draw distance and estimated that one third of the bow's potential energy is released as kinetic energy in the arrow.

Shooting experiments

As a first attempt, we tried to determine arrow velocity with an apparatus used to measure the velocity of bullets, but the arrow's velocity was evidently too low to be detected, or the length of the arrow did not produce a short cut-off signal. Therefore, we tried to deduce the take-off velocity from the arrow range when the bow was fired at different angles, simultaneously measuring the flight time. The parameters of the ballistic trajectory can then be determined by means of a model calculation, assuming that

	Length/with socket (cm)	Mass (g)
Front shaft with flint tip	11.7/17.6	3.54
Reed middle shaft	46.3	3.51
Feathered end shaft	12.7/15.5	2.65
Total	70.7	9.70

Tab. 1. Dimensions and weights of reed arrow parts.

the air drag force varies with the square of the projectile's velocity (*Laharnar 2011.77–80*).

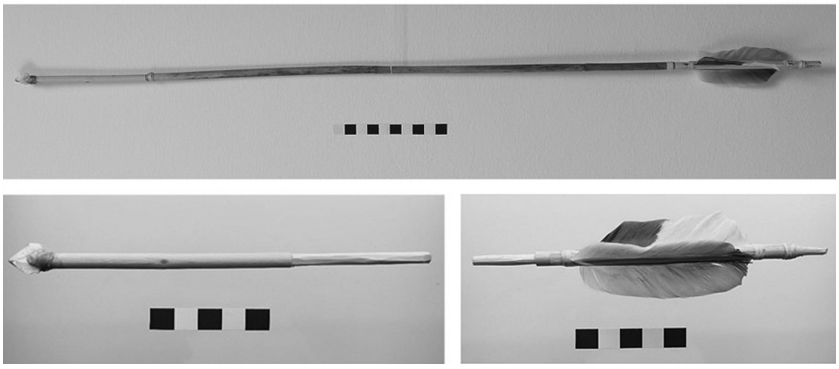


Fig. 4. The reed arrow used for the ballistic experiments.

Flight time was measured with a stop watch held by the archer in the left hand together with the bow and started at the same time as the arrow was released. The watch was stopped as soon as the archer saw the arrow touch the ground. Manipulating the stop watch prevented the archer from achieving maximum draw, so we may estimate that the draw weight of the bow was approx. 16kg. The angle of the arrow with respect to ground was also observed and compared with the calculated angle. Range was measured with a steel measuring tape with accuracy better than 0.2m. The experiments were performed at 300m above sea level at temperatures around 20°C. The reduced air pressure on the day of the experiment was 1015mbar. Subjectively, the feeling of shooting the reed arrow was good. It was possible to perceive that the arrow left the bow at a significant speed, but drag slowed it down noticeably after about 20m. The flight was stable and did not wobble, in spite of the shaft not being completely straight.

The results of the experiment are presented in the first three columns of Table 2.

By trial and error, we then looked for the ballistic parameters that matched our measured ranges and flight times. The variable parameters were take-off velocity, take-off angle and effective arrow cross section (the physical cross section multiplied by the drag coefficient). Three independent parameters are too many to determine a unique ballistic trajectory, so another principle was selected to discover the effective arrow cross section, which should be the same for all trajectories. As a starting guess, we used data from Jürgen Junkmanns (*2001.57, 58*). A yew bow with 28kg pull yielded a take-off velocity of about 50m/s for a flint-tipped arrow with a weight of 30g, which resulted in a range of 120m. The simulation gave the effective cross section as 3.5cm^2. We then calculated five sets of take-off velocities for an effective cross section varying between 3.25 and 4.25cm^2 and determined their mean and standard deviations. The realistic cross section corresponded to the values where the spread of take-off velocities was minimal. This principle is based on the supposition that all arrows were shot at approximately the same velocities at different angles. The first two shots in Table 2 were omitted from the calculation, as the archer was still learning to use the bow whilst holding the stopwatch. By plotting the chi-squared rather than standard deviation for the calculated take-off velocities (Fig. 6), we found the effective cross section of our arrow was 3.61±0.5cm^2. This value was then used to determine the ballistic parameters in the second three columns of Table 2.

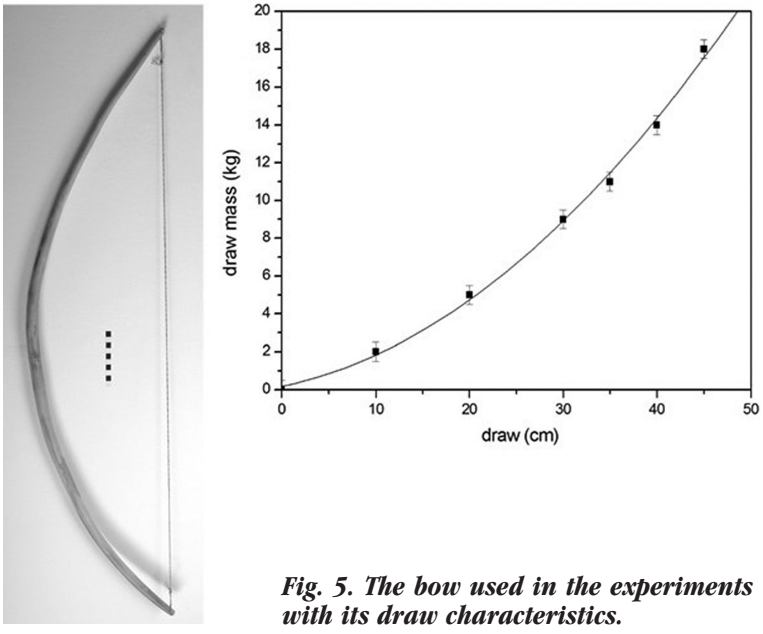


Fig. 5. The bow used in the experiments with its draw characteristics.

Discussion of shooting experiments

The ranges in Table 2 appear rather low, but one should remember that they were produced for an extremely light arrow. The ranges and times of flight imply take-off velocities of about 40m/s, which is also not high.

range (m)	time (s)	estim. angle to ground (deg.)	calculated take-off velocity (m/s)	calc. take-off angle (deg.)	calc. angle to ground (deg.)
44.5	2.8	–	33.5	32	50.6
48.5	3.4	60	36.1	39	59.9
47.5	4.0	60	37.6	49	69.1
35.5	4.9	75	39.2	66	79.2
49.5	3.8	60	38.0	45	66.2
51.5	3.5	60	38.7	39	61.2

Tab. 2. Results of shooting experiments (first three columns from left) and deduced take-off velocity, take-off angle and angle at which the arrow hit the ground for an effective arrow cross section of 3.61cm². Air density was taken as 1.16mg/cm³.

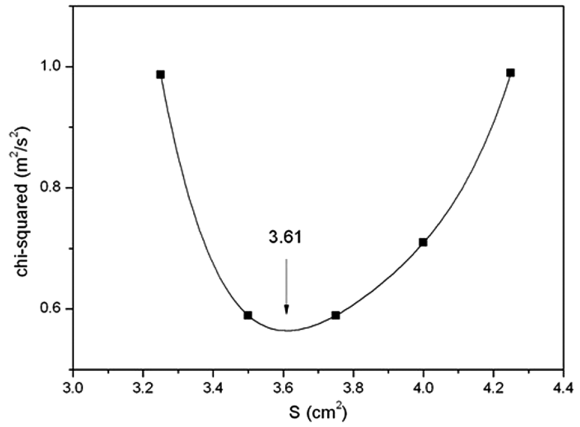


Fig. 6. Determination of effective arrow cross section as a value where the calculated take-off velocities have minimal spread. The fitted curve is fourth order polynomial.

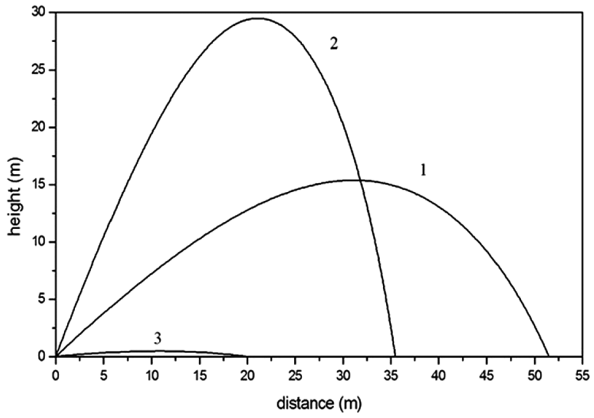


Fig. 7. Numerical simulation of the ballistic trajectories for the longest (1) and highest shot (2) in the experiment and almost flat trajectory for close-range shooting to a distance of 20m (3).

However, even if the take-off velocities were 60m/s and arrows were fired at 2000m a. s. l., the maximum range would not exceed 83m. For a take-off velocity of 45m/s, the arrow's kinetic energy is 10J, which is one fifth of the energy of 22LR bullets, and only ten times more than the energy of an air-soft pellet. At a distance of 10m, this energy is reduced to about 6.2J, and at a distance of 15m it drops to 5J, half of its initial value.

For comparison, a 30g arrow with a take-off velocity of 50m/s (having thus initial kinetic energy of 37.5J) would strike a target 100m away with an energy of 11J. We can conclude that the effective range of reed arrows was well below 20m. The main advantages of such arrows were that they could reach a reasonable velocity from a bow that was not very strong (as in our experimental case). Using a light bow further enabled the archer to fire more arrows in a short time, which might be essential in a dense fighting melee, and eased aiming, as the trajectory of the light arrow for the first 20m is almost straight (Fig. 7).

Conclusion

The use of reed arrows by the Apaches provided an efficient weapon for close-range hunting and combat. This selection of reed as arrow material is not unique and may not have developed strictly for functional reasons, but because material which is found in the woodland and deserts of the American southwest is less generous with long straight sprouts than bushes in Europe. Nevertheless, historical Apaches used the bow as their principal long-range weapon until the middle of the 19th century and developed a mastery that can serve as an example for current prehistoric models. As the use of light arrows in combat favoured close-range shooting, the rock painting in Cueva del Roure showing Neolithic archers in a short-range fight may indeed represent a realistic case.

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Book review

Raiko Krauß

Ovčarovo-Gorata. Eine frühneolitische Siedlung in Nordostbulgarien. Mit Beiträgen von Gerwulf Schneider, Malgorzata Daszkiewicz, Ewa Bobryk, Nguyen Van Binh, Petar Zidarov, Florian Klimscha, Norbert Benecke und Elena Marinova (Archäologie in Eurasien 29). Bonn >Habelt-Verlag< 2014, xiii+350 pages, 209 figures, 74 plates. ISBN 978-3-7749-3914-1

In the first half of the 1980s, lithic materials from the prehistoric settlement of Ovčarovo-Gorata in northern Bulgaria were studied by Vietnamese archaeologist Nguyen Van Binh. At that time, he was a doctoral student in the Department of Prehistory of the National Archaeological Institute and Museum Bulgarian Academy of Sciences. In 1985, Nguyen Van Binh completed his doctoral thesis "*Prehistoric flint artifact assemblages from the Late Pleistocene and Early Holocene on the basis of materials from North East Bulgaria*", which presents the results of lithic assemblages processed from the site.

Three decades later, thanks to Raiko Krauss, the work of Nguyen Van Binh on the flint assemblages of this prehistoric settlement was published with his consent in Krauss' monograph *Ovčarovo-Gorata. Eine frühneolitische Siedlung in Nordostbulgarien*. Archäologie in Eurasien, Herausgegeben von Svend Hansen, Band 29, DAI, Eurasien-Abteilung, Habelt-Verlag Bonn, 2014.

The study of flint assemblages from Ovčarovo-Gorata by Nguyen Van Binh is one of the first comprehensive and professional studies in Bulgaria of chipped stone artefacts from the Neolithic period. Naturally enough, this analysis of flint assemblages bears the imprint of its time.

Work on the thesis was carried out in the early 80s and is consistent with the then prevailing methodological trends in lithic studies. These were associated with traditional technological and typological analyses, which still focused heavily on typology and the more formal treatment of technological aspects.

With regard to the work of Nguyen Van Binh, the valuable results of such a study of flint raw materials used in the preparation of flint tools should be particularly noted. The Neolithic flint industry at the prehistoric settlement of Ovčarovo-Gorata has largely been associated with the use of local varieties of raw materials, which were processed mainly in the area of the settlement.

The analysis conducted by Nguyen Van Binh allows us to trace *chaînes opératoires* stages within a prehistoric settlement as well as see that the core preparation stage was not done at the site under discussion. The evidence for this is the absence of cortical flakes and the lower frequency of crest specimens compared to sites where core preparation occurred on site. Flint production focused mainly on the acquisition of flakes; moreover, the presence of splintered pieces was also noted. With regard to the core knapping process, the initial exploitation was linked to single platform specimens which were later transformed into two platform cores. The last stage of core knapping usually occurred on cores with an altered orientation – *e.g.*, all surfaces were used. Nguyen Van Binh's work revealed the relationship between technological characteristics and the type of raw material and nodule dimensions.

The lithic assemblage's typological structure includes flakes, end scrapers, and retouched flakes; perforators and drills are relatively poorly represented, straight and oblique truncations, and denticuled tools and fragments. Microliths occur in single items in the form of micro end scrapers and bladelets. According to Nguyen Van Binh, this was due to the lack of sieving rather than other factors. It should be noted that some of the conclusions drawn by Wang Bin Ngun have not lost their relevance today, such as the similarity of Ovčarovo-Gorata lithic assemblages and those of Ussoe I and Podgorica in northeastern Bulgaria.

On the other hand it is regrettable that the lithic assemblage was not available along with other groups of finds from the site in the monograph on Ovčarovo-Gorata, so that the analysis could be updated and the possibilities for interpretation increased.

Van Binh assumed that they were at least two *chaînes opératoires*, one of which is relatively poorly represented – for lamellar production (see bladelet cores – Abb.130: 1–3 and bladelet/microbladelet débitage products – Abb. 152: 9; Abb. 164: 6; Abb. 171:

DOI: 10.4312/dp.43.29

1, 3; Abb. 173: 3–5, 7, 8, 19; Abb. 174: 4; Abb. 184: 1, 4, 5, 11). While there are no data on the processing of these bladelets in geometric microliths (which may be due to the lack of sieving and washing), there is still a series of retouched microlithic forms, sufficiently distinctive semi-circular and circular micro end scrapers (Abb. 155: 3, 10–12; Abb. 159: 9–12). Although these elements are less represented in the Ovčarovo-Gorata lithic collection, they deserve more attention than they were given years ago in Nguyen Van Binh's dissertation.

The quality of illustrations is very high and allows one to get a good idea of the core types and retouched tools, all of which are accompanied by technical and typological characteristics.

It should be pointed out that it was Krauss's ambition to present as fully as possible the results of different studies from this settlement in order to create a general background for studies of the Neolithic in the Central and Eastern Balkans. Although these studies were done more than 30 years ago, most of Nguyen Van Binh's conclusions are relevant today and have their place and weight in the study of the Neolithic in the Lower Danube basin.

The professional level of the study of chipped-stone assemblages as presented by Nguyen Van Binh in the monograph Ovčarovo-Gorata is undoubtedly to the great merit of Krauß, to whom we owe the invaluable opportunity to add these almost unknown data to our general scientific knowledge and to advance the debate on Neolithisation in Southeast Europe.

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