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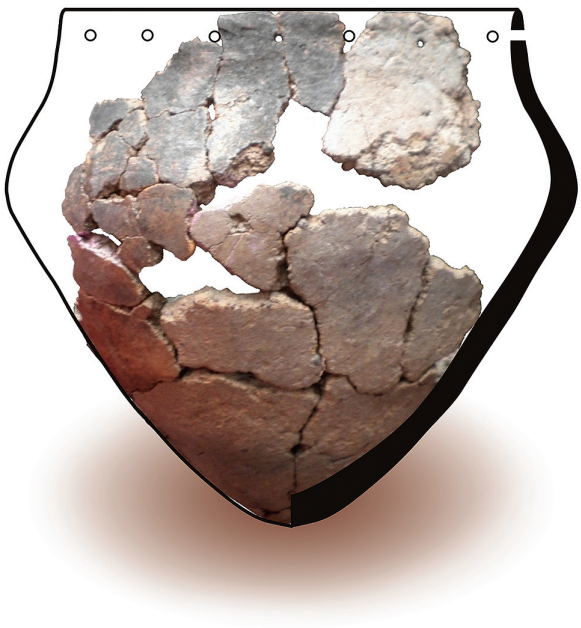
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# Contents

*Bernhard Weninger*
6 Niche construction and theory of agricultural origins. Case studies in punctuated equilibrium

*Tamara Blagojević, Marko Porčić, Kristina Penezić and Sofija Stefanović*
18 Early Neolithic population dynamics in the Eastern Balkans and the Great Hungarian Plain

*Agathe Reingruber, Giorgos Toufexis, Nina Kyparissi-Apostolika, Michalis Anetakis, Yannis Maniatis and Yorgos Facorellis*
34 Neolithic Thessaly: radiocarbon dated periods and phases

*Didier Binder, Philippe Lanos, Lucia Angeli, Louise Gomart, Jean Guilaine, Claire Manen, Roberto Maggi, Italo M. Muntoni, Chiara Panelli, Giovanna Radi, Carlo Tozzi, Daniele Arobba, Janet Battentier, Mario Brandaglia, Laurent Bouby, François Briois, Alain Carré, Claire Delhon, Lionel Gourichon, Philippe Marinval, Renato Nisbet, Stefano Rossi, Peter Rowley-Conwy and Stéphanie Thiébault*
54 Modelling the earliest north-western dispersal of Mediterranean Impressed Wares: new dates and Bayesian chronological model

*Kerkko Nordqvist, Teemu Mökkönen*
78 Periodisation of the Neolithic and radiocarbon chronology of the Early Neolithic and the beginning of the Middle Neolithic in Finland

*Andrey Mazurkevich*
88 Introduction to the absolute chronology of Neolithic cultures in Eastern Europe

*Aleksey Tarasov, Kerkko Nordqvist, Teemu Mökkönen and Tatyana Khoroshun*
98 Radiocarbon chronology of the Neolithic-Eneolithic period in the Karelian Republic (Russia)

*Henny Piezonka, Nadezhda Nedomolkina, Marina Ivanishcheva, Natalya Kosorukova, Marianna Kulkova and John Meadows*
122 The Early and Middle Neolithic in NW Russia: radiocarbon chronologies from the Sukhona and Onega regions

*Evgeniia L. Lychagina, Aleksandr A. Vybornov*
152 Chronology of Kama Neolithic culture

*Andrey N. Mazurkevich, Ekaterina V. Dolbunova, Ganna I. Zaitseva and Marianna A. Kulkova*
162 Chronological timeframes of cultural changes in the Dnepr-Dvina region (7th to 3rd millennium BC)

*Ekaterina V. Dolbunova, Elena L. Kostyleva, Marianna A. Kulkova, John Meadows, Andrey N. Mazurkevich and Olga Lozovskaya*
176 Chronology of early Neolithic materials from Sakhtysh IIa (Central Russia)

*Roman Smolyaninov, Andrey Skorobogatov and Aleksey Surkov*
192 Chronology of Neolithic sites in the forest-steppe area of the Don River

*Andrey Tsybrij, Viktor Tsybrij, Ekaterina Dolbunova, Andrey Mazurkevich, Marianna Kulkova and Ganna Zaitseva*
204 Radiocarbon chronology of Neolithic in the Lower Don and North-eastern Azov Sea

*Alexander Vybornov, Marianna Kulkova, Konstantin Andreev and Eugeny Nesterov*
224 Radiocarbon chronology of the Neolithic in the Povolzhye (Russian Eastern Europe)

*Marek Nowak*
240 Do $^{14}$C dates always turn into an absolute chronology? The case of the Middle Neolithic in western Lesser Poland

*Hans-Christoph Strien*
272 Discrepancies between archaeological and $^{14}$C-based chronologies: problems and possible solutions

*Raiko Krauß, Clemens Schmid, David Kirschenheuter, Jonas Abele, Vladimir Slavchev and Bernhard Weninger*
282 Chronology and development of the Chalcolithic necropolis of Varna I

*Malcolm C. Lillie, Chelsea E. Budd, Inna Potekhina, T. Douglas Price, Mykhailo P. Sokhatsky and Alexey G. Nikitin*
306 First isotope analysis and new radiocarbon dating of Trypillia (Tripolye) farmers from Verteba Cave, Bilche Zolote, Ukraine

*Kelly Reed, Maja Krznarić Škrivanko and Marija Mihaljević*
326 Diet and subsistence at the late Neolithic tell sites of Sopot, Slavča and Ravnjaš, eastern Croatia

*Lars Larsson*
338 The past in the past in the mortuary practice of hunter-gatherers: an example from a settlement and cemetery site in northern Latvia

*Alenka Tomaž*
346 Depiction of hairstyle, reflection of identity? Some considerations concerning Neolithic depictions of hairstyles in the Anzabegovo – Vršnik and Velušina – Porodin cultural milieu

*Bahattin Çelik*
360 A new Pre-Pottery Neolithic site in Southeastern Turkey: Ayanlar Höyük (Gre Hut)

*Jarrad W. Paul, Burçin Erdoğu*
368 An examination of the worked bone and antler assemblage at Uğurlu (Gökçeada, Turkey)

*Antonio Blanco-González, Cristina Alario García and Carlos Macarro Alcalde*
386 The earliest villages in Iron Age Iberia (800–400 BC): a view from Cerro de San Vicente (Salamanca, Spain)

*Simona Petru*
402 I remember. Differences between the Neanderthal and modern human mind

416 Book review

# Niche construction and theory of agricultural origins. Case studies in punctuated equilibrium

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ABSTRACT – *In contemporary archaeological and anthropological research, the domestication of plants and animals in the Near East during the Early Holocene is alternatively interpreted as an overall slow and gradual, or as a rapid process. The present reanalysis of published archaeobotanical and archaeozoological data shows that the wild-domesticate-transition (WDT) was indeed initially slow (millennial scale), but terminated at 10.2 ± 0.2 ka cal BP with an abrupt switch to herding and agriculture. The abruptness of WDT can be understood as due to amplification under positive feedback conditions (resonance) of some few biological and social factors, primarily the short and long-distance transport of domesticates, in conjunction with a synchronous, abrupt climatic switch to higher precipitation.*

KEY WORDS – *punctuated equilibrium; Neolithisation; cereal domestication; animal domestication; darwinism; complex system theory; palaeoclimatology*

## *Konstrukcija niše in teorija o izvorih poljedelstva. Študijski primer v modelu prekinitve ravnovesja*

IZVLEČEK – *Sodobne arheološke in antropološke raziskave razlagajo pojav kultiviranih rastlin in udomačenih živali na Bližnjem vzhodu v času zgodnjega holocena bodisi kot počasen in postopen bodisi kot hiter proces. Pričujoča ponovna analiza objavljenih arheobotaničnih in arheozooloških podatkov kaže, da je bil prehod med divjimi in domačimi vrstami (ang. kr. WDT) sprva počasen (na nivoju tisočletij), ki pa se je končal v času ok. 10.2 ± 0.2 ka cal BP z nenadnim preklopom na živinorejo in poljedelstvo. Nenadnost tega prehoda lahko razumemo kot posledico ojačenja pri nekaterih bioloških in družbenih dejavnikih, predvsem pri transportu udomačenih vrst na kratkih in dolgih razdaljah, do katerih je prišlo zaradi pozitivnih povratnih razmer (resonanca) skupaj z nenadno klimatsko spremembo, povezano z intenzivnimi padavinskimi obdobji.*

KLJUČNE BESEDE – *model prekinjenega ravnovesja; neolitizacija; kultiviranje žit; udomačitev živali; darvinizem; teorija kompleksnih sistemov; paleoklimatologija*

## Introduction

A central challenge to the theory of agricultural origins (TAO) concerns the integration and joint interpretation of the increasingly large amounts of numeric empirical data made available by participating scientific disciplines, for example, cultural studies, archaeobotany, archaeozoology, plant and animal genetics, radiometric dating, palaeogeography, palaeoclimatology, and others. In a recently published study, Kristen Gremillion *et al.* (*2014*) have argued that it may be possible to unify the scientific results pertaining to TAO under the umbrella of neo-Darwinian evolutionary theory. To the same topic, Kim

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Sterelny and Trevor Watkins (*2015.673*) propose that it would be advantageous to extend the application of niche construction theory (NCT) in archaeological research if it were extended to accommodate the more complex social worlds of human societies in the form of a cognitive-cultural (or informational) niche. Moving in the same direction, in the present paper it is suggested that a particular extension of NCT, namely Punctuated Equilibrium (*Gould, Eldredge 1993*), can be observed in the archaeological record for Early Neolithic plant cultivation and animal domestication, despite its high degree of $^{14}$C-related chronological noise.

Parallel to the rapid expansion of empirical data and knowledge pertaining to the archaeological, palaeogenetic, and socioecological context of Early Neolithic plant cultivation and animal domestication in the Near East, what we observe in the archaeological theory of agricultural origins (TAO) – according to Gremillion *et al.* (*2014*) – is an increase in particularism and a major retreat from generalising anthropological theory. The authors propose that this change in research traditions may be due to the wealth of archaeological records, the very richness of which appears to "*dampen the appeal of general explanations for the transition to agriculture*" (*Gremillion* et al. *2014.6171*), and which has the effect of producing an "*increasingly critical attitude of archaeologists towards hypothetico-deductive science*". According to the authors, this scientific disposition would lead to a proliferation of research in favour of "*historical narratives that highlight local events and processes and downplay general principles*" (*ibid.*). They propose unifying the different approaches to human agricultural origins under the umbrella of neo-Darwinian evolutionary theory (*Gremillion* et al. *2014.6176*).

Interestingly, a similar repositioning of agricultural theory is envisioned by Sterelny and Watkins (*2015*), who contend that concepts underlying now widely applied biological niche construction theory (NCT) would also fit the description of the Neolithisation process, if only NCT were extended to encompass the more complex social worlds of human societies in the form of a cognitive-cultural (or informational) niche (*Sterelny, Watkins 2015.673*). We may abbreviate discussion of these issues by confirming directly that NCT has increasing importance in a variety of disciplines, ranging from anthropology, biology, evolutionary theory, genetics, palaeontology and biological physics, all the way through the alphabet to zoology, and thereby, naturally, for different species of plants and animals, both microscopic and macroscopic, including humans (*Gould, Eldredge 1977; 1993; Gould 1989; Jones* et al. *1994; Laland* et al. *2016; Saltz* et al. *2016; Zeder 2016*). NCT is equally promising for applications in archaeology, for which purpose even the elementary (unpretentious) renaming of the Neolithic Package as a mobile eco-system that is capable of environmental or climatic habitat-tracking may help students and researchers alike to achieve a qualitatively better understanding of the complex processes underlying Neolithisation. In the long run, however, quantitative modelling of archaeological NCT appears to be necessary.

**Punctuated Equilibrium (PE)**

In the following, let us explore what might happen in archaeological NCT discourse if concepts derived from the neo-darwinian theory of punctuated equilibrium (*Gould, Eldredge 1977; 1993; Gould 2007*) are taken into consideration. In contrast to classical Darwinian forecasting, the geological record shows not a slow and continuous fossil development (*graduation*), but instead long periods of stasis with no observable change. Then follows an abrupt switch from one species to the next (*punctuation*), with no apparent transition. According to Darwin's (and others'), explanation, the geological observation of a seemingly abrupt and quasi-instantaneous origination of new palaeontological species is caused by the notoriously imperfect character of the fossil record due to stratigraphic disturbance, incomplete preservation, and fragmentary research (*Gould, Eldredge 1993.223*). For PE theory, in contrast, the abrupt origination of species is the result neither of noisy or missing data, nor of an unobserved geographic switch in habitat, but the expected and meaningful consequence of a rapid genetic switch from one species to the next, following the law of natural selection. In a nutshell, most species originate in such brief moments of time, that expected 'transitions' have no apparent manifestation in the geological stratigraphy (*Gould 2007*).

But how does PE work? As indicated above, many PE related processes are (today) subsumed under what is more commonly called the Theory of Complex Systems (or similar), but I propose we continue to use the term PE. An example from physics would be coulomb excitation, whereby a subatomic particle passes so close to an atomic nucleus that the local disturbance of the electromagnetic field triggers the production of a new particle (*Alder, Winther 1958*). The key word in this example is disturbance, al-

though other scientific disciplines might replace it by words such as amplification, bifurcation, psychological or mechanical stress, break in symmetry, genetic bottleneck, or genetic isolation. Hence, in TAO, disturbed equilibrium would be a useful alternative to punctuated equilibrium. In general terms, when a long-stable running system is disturbed, interesting things may happen, and if the change does happen, it will typically happen *suddenly* (*e.g.*, particle production, formation of ice crystals, Neolithic founder crops (*Heun* et al. *1997; 2012*), Rapid Climate Change, the French Revolution, particle freeze out in cosmology, Neolithisation (this paper), switch in pottery style, North Atlantic thermohaline circulation (*Rahmstorf 2002*), division-by-zero, and genetic bottleneck (*Lucas* et al. *2012*). If all disturbances were put together in a box (modelled) and compared (quantified) it is quite likely that the strongest disturbance will turn out to be: human agency. This is our first accomplished PE forecasting.

**Archaeological examples of punctuated equilibrium**

To continue the (now initialised) archaeological PE thought experiment we must next be unscrupulous enough to replace geological with historical timescales, whereby millions of palaeontological years – as in the original case studies by Stephen J. Gould and Niles Eldredge (*1993*) – are reduced to the few generations (or less) required for prehistoric societal change, even down to the few nanoseconds needed for the molecular reactions of DNA-molecules. But as a reward, the following case studies render some first indication that punctuated equilibrium may also be identifiable in the Neolithisation process, even if initially the concept is seemingly contradictory. But there are many other archaeological studies with PE application (*e.g., Kolodny* et al. *2015;* with references).

In contemporary Neolithisation research, the spread of farming/herding lifestyles from the Near East to Europe is most often described as a slow and continuous process, steered mainly by demographic considerations, which need focus on limitations on otherwise explosive exponential population growth, and whereby many thousands of years are considered necessary for the long-distance transfer of the new lifestyle from the Fertile Crescent through Anatolia to Central Europe. Average speeds are estimated to be in the order of 1 km/yr, with small variations, max ± 30% (*e.g., Ammerman, Cavalli-Sforza 1971; Pinhasi* et al. *2005*). Observed deviations from such slow and gradual Neolithisation are understood to be noteworthy exceptions, which therefore require exceptional explanation. This is evident in the formulation of research questions such as "*why did the expansion of the Körös-Starčevo culture stop in the centre of the Carpathian Basin?*" (*Kertész, Sümegi 2001*).

A further whispering of the possible existence of a very different, namely rapid, PE-type of Neolithisation is manifest in the names chosen for a number of farming dispersion models, such as leapfrog Neolithisation (*Arnaud 1982*), late escape (*Schoop 2005*), floodplain hopping (*van Andel, Runnels 1995*), and – most clearly – in arrhythmic dispersal (*Guilaine 2001; 2013*). Admittedly, *nomen est omen* is not an entirely convincing argument. Perchance a better example would be the Neolithisation of the British Isles, which was established around 4000 cal BC, within less than 200 years (*Bayliss* et al. *2007; Whittle* et al. *2008; Collard* et al. *2010*). In this case, it is the transition from the Mesolithic to the Neolithic that would appear punctuated (P), and the punctuation P is both preceded and followed by extended periods of cultural equilibrium (E); first, a long Mesolithic-E, then a long Neolithic-E, but with only a little time in between for changes in culture and economy, perhaps a few human generations. The occurrence of rapid cultural PE on the British Isles around 4000 cal BC is well-supported by vast numbers of $^{14}$C-dates. Although rapid Neolithic demographic expansion does not only follow from the size of the $^{14}$C-database, both are in perfect agreement with PE extension of NCT. We note with interest that the long-term success of Neolithic stasis on the British Isles has been called into question by Chris J. Stevens and Dorian Q. Fuller (*2012*), who postulate a failure of plant cultivation and temporary switch to pastoralism, if only based on missing data in the radiocarbon record. There is critical response by Rosie R. Bishop (*2015*).

Neither would the postulated overlap of European Neolithic 'cultures' based on arguments to replace the old pottery-style definitions with new $^{14}$C-derived concepts (*Manning* et al. *2014*), provide convincing anti-PE arguments. According to Katie Manning *et al.* (*2014.1065*), the "*...resulting [$^{14}$C-statistical] analysis gives a new and more accurate description of the duration and intensity of European Neolithic cultures*". In my view, the opposite is the case; namely, the traditional sequence of European Neolithic cultures, with its (true) abrupt and geographically widespread, indeed often block-wise switch from one

pottery style to the next (*e.g.*, LBK –> Stichbandkeramik –> Rössen –> Michelsberg), complies entirely with PE-forecasting. Furthermore, the $^{14}$C-overlap used by Manning *et al.* (*2014*) to motivate the introduction of a new, statistical definition of culture has little relation, if any, to any previous discourse on how to define archaeological culture (*e.g., Lüning 1972*). It is due to the inherent noisiness of underlying archaeological $^{14}$C-data (*e.g., Breunig 1987*). This readily explains the observed, largely Gaussian-shape (white noise) of calibrated summed $^{14}$C-distributions. Indeed, the noisiness of archaeological data is so overwhelming that the calibrated distributions (*Manning* et al. *2014.Figs. 4–6*) show little of the otherwise regularly observable distortion due to the non-linear shape of the $^{14}$C-age calibration curve. In comparison, the punctuated peak production (basically a division-by-zero problem) that is induced by theoretically motivated but experimentally invalidated Bayesian normalisation (*Weninger* et al. *2011; 2015*) remains all the more visible in the calibrated age distributions. Together with their wide Gaussian shape, these two observations imply that the graphs show (largely) noise. What does deserve further attention is the question why the abrupt changes in Neolithic pottery style observed so often in finds are so clearly compatible with PE rules.

A much larger scale PE-NCT application is demonstrated for the spread of farming from the Near East into the Aegean along established Epipalaeothic coastal networks in the eastern Mediterranean (*cf. Çilingiroğlu 2010; Reingruber 2011; Brami, Heyd 2011; Horejs* et al. *2015*). The radiocarbon dates indicate a simultaneous (decadel-scale) Neolithisation of the Turkish west coast and of the Peloponnese, which my colleague Lee Clare and I have attributed to climatic habitat-tracking due to widespread cold winter Rapid Climate Change (RCC) conditions, with a similar incentive presumably underlying the long-distance movement from the Near East along the Turkish south coast into the Aegean (*Weninger* et al. *2014; Clare, Weninger 2014; 2016; Clare 2016*). Recently, bio-climatically optimised choice of landscapes by Neolithic farming communities is also reported for the Balkans, both for the start and end of the RCC-synchronous Neolithisation of the circum-Aegean landscapes (8.6–8.0 ka cal BP), and this we may consider evidence of Neolithic climatic engineering, in any case of careful (simultaneous) ecological and cultural niche selection (*Krauß* et al. *2014; 2017*). High dispersion speeds are also reported for the land-based spread of farming out of the Aegean into the Pannonian Basin (*Weninger* et al. *2014*), as well as for coastal movements in the Western Mediterranean (*Isern* et al. *2017*) as far as Morocco (*Linstädter* et al. *2012; 2016*). Again, it is primarily the timing of these transitions that indicate PE-type Neolithisation. Conversely, beyond confirming PE-type Neolithisation, these findings immediately challenge the conclusion of Neus Isern *et al.* (*2017.897*), that speeds of ~2500km in 300yrs can be achieved only by sea travel, and not overland. This perception clearly relies on the validity of slow and continuous wave-of-advance-type dispersion, such that (slow) overland routes would be the predictable norm and (fast) sea travel the specific exception. Neolithic wave-of-advance dispersion is clearly at odds with PE-type modelling, for which both routes are equally fast. Hence, although yet further confirmation of the quite astonishing speeds of Neolithic dispersion would be welcome, these examples demonstrate the potential of PE-forecasting. In general terms, from the viewpoint of NCT, we may expect only a few exceptions from the otherwise general rule that, to be successful (in a Darwinian sense), major changes in both economic and cultural resources should be as rapid as possible.

Now turning to the theory of agricultural origins (TAO), it would follow from PE that the time required for the Near-Eastern transition from wild to domesticated (plants and animals) is likely to be short (*i.e.* punctuated), and unlikely to be extended (*i.e.* protracted). What complicates matters is the large number of participating units (cereals, legumes, sheep, goat, cattle, humans *etc*.), as they are intricately interconnected within a complex eco-system (*e.g., Gopher* et al. *2001; Jones* et al. *1994; Laland* et al. *2016*). Nevertheless, based on observed complexity alone, we should not automatically concede that the WDT was necessarily protracted (*e.g., Purugganan, Fuller 2011; Fuller* et al. *2012; Maeda* et al. *2016*; *cf.* significant critique by *Heun* et al. *2012*). An open question is, do we really observe the postulated protracted adaptation of domesticated plants and animals? Namely, given that corresponding timescales are essentially all based on $^{14}$C-data, and knowing of the extreme noisiness of such data, we might instead become immediately (very) suspicious as to the quality of the observations. Some large (but difficult to isolate) part of the observed slowness in the archaeological record is surely to be caused by the artificial spread of $^{14}$C-data, *e.g.*, due to stratigraphic disturbance, sample contamination, chance statistical reasons, age-distortion due to the non-commutative character of the calibration curve *etc*. Strictly speaking, with much of the $^{14}$C-data under study now half

a century old, we would like to disregard the data altogether. At first glance, the best procedure to separate the signal from the noise would indeed be to apply some strong taphonomic and statistical filter to the $^{14}$C-data. This was the analytical method applied to the $^{14}$C-data by Pascal Flohr *et al.* (*2015*) in search of the potential impact of the 8.2 and 9.2 ka cal BP cold winter climatic events on the Near Eastern Neolithic. Unfortunately, and as Flohr *et al.* (*2015*) correctly observe, even the strongest filtering of available $^{14}$C-data does not itself provide a straightforward 'yes/no' answer to the research question in hand, concerning potential social climate impact. It is also unfortunate that the postulated social resilience to climate change does not even theoretically follow from its non-identification (*Flohr* et al. *2015*). A more promising approach lies in dedicated climate-archaeological fieldwork (*e.g., Zielhofer* et al. *2012*).

In the following, we continue our previous WDT-studies with subordinate further consideration of the available $^{14}$C-data, which have already undergone sufficient analysis (*e.g., Weninger* et al. *2009; Asouti, Fuller 2013; Borrell* et al. *2015*). Instead, let us have a fresh look at the remarkable coincidence of the WDT with the previously identified major increase in precipitation levels in large parts of the Near East at around 10.2 ka cal BP. This is now possible in the context of newly available climate records, particularly, the Lake Neor Titanium (dust) record (*Sharafi* et al. *2015*). As previously noted (*Weninger* et al. *2009*), within dating errors of approx. ±100yrs (68%), the earliest use of genetically changed cereals coincides perfectly with both an abrupt 50-metre rise in Dead Sea levels, as well as the onset of Sapropel S1. On the archaeobotanical side, the synchronism is based on cereal data from a reasonable number of archaeological sites (N = 44), with cereal inventories classified as 'wild' (N = 8), 'domesticated' (N = 31) and 'unclear' (N = 5) by Mark Nesbitt (*2002*). In the meantime, and based on significantly extended archaeobotanical and $^{14}$C-radiometric datasets, Eleni Asouti and Dorian Q. Fuller (*2013*) have come to an entirely different conclusion, which is that the transition from the use of wild to domesticated plants was an extended (protracted) process, with a time-span in the order of thousands of years. This is curious, since statistical theory would normally predict a shortening of any time-span based on a refined set of $^{14}$C-data, and not a lengthening (and least not by a factor ~10 according to *Asouti, Fuller 2013* in comparison to *Nesbitt 2002* and *Weninger* et al. *2009*).

## Methods and data

We will return below to the arguments supporting rapid (decadel-scale) WDT versus slow and gradual (millenial scale) development. To run this comparison required the expansion of available CalPal-software, and in particular the development of a new CalPal-dialog (called Multiclimate Composer), as described in detail in the Appendix, available online at http://dx.doi.org/10.4312/dp44.1.

### *Results*

Utilising for the first time the new CalPal Multiclimate Composer, Figure 1 and Figure 2 provide a graphic representation of published archaeobotanical (here: barley), archaeozoological (here: cattle) and climatic data (selected regions). In my view, although non-expert in the analysis of archaeobiological data, the records would support the statements listed below (Points 1–8). Note that these results are based on (further) critical interpretation of the large amounts of archaeological $^{14}$C-data that were already critically assembled and statistically analysed by the authors of the respective botanical and zoological data (*Asouti, Fuller 2013; Arbuckle* et al. *2016*). Additionally, I am applying here an extended mode of record interpretation, whereby it is deemed necessary to read the given (68% confidence) chronological time-spans of the archaeological settlements in a specific manner:

(A) The time-spans provided for sites that contain domesticated cereals (here exemplified for domesticated barley) are interpreted as *termini post quem* for the earliest use of cereals. Hence, in Figure 1C, the true dates for the introduction of domesticated barley must range on the left (older) side of the (blue) set of site intervals.

(B) The time-spans provided for sites that contain wild cereals (here exemplified for wild barley) are interpreted as *termini ante quem* for the earliest (possible) use of domesticated cereals. Hence, in Figure 1E, the true dates for the introduction of domesticated barley must range on the right (younger) side of the (green) set of site intervals.

(C) The time-spans provided for sites that contain 'partially domesticated' cereals (here exemplified for barley) are indecisive in terms of further refining the already given age and length of the WDT (*Weninger* et al. *2009* – using data of *Nesbitt 2002*). The archaeobotanical refinement by Asouti and Fuller (*2013*) of introducing 'partially domesticated' cereals is

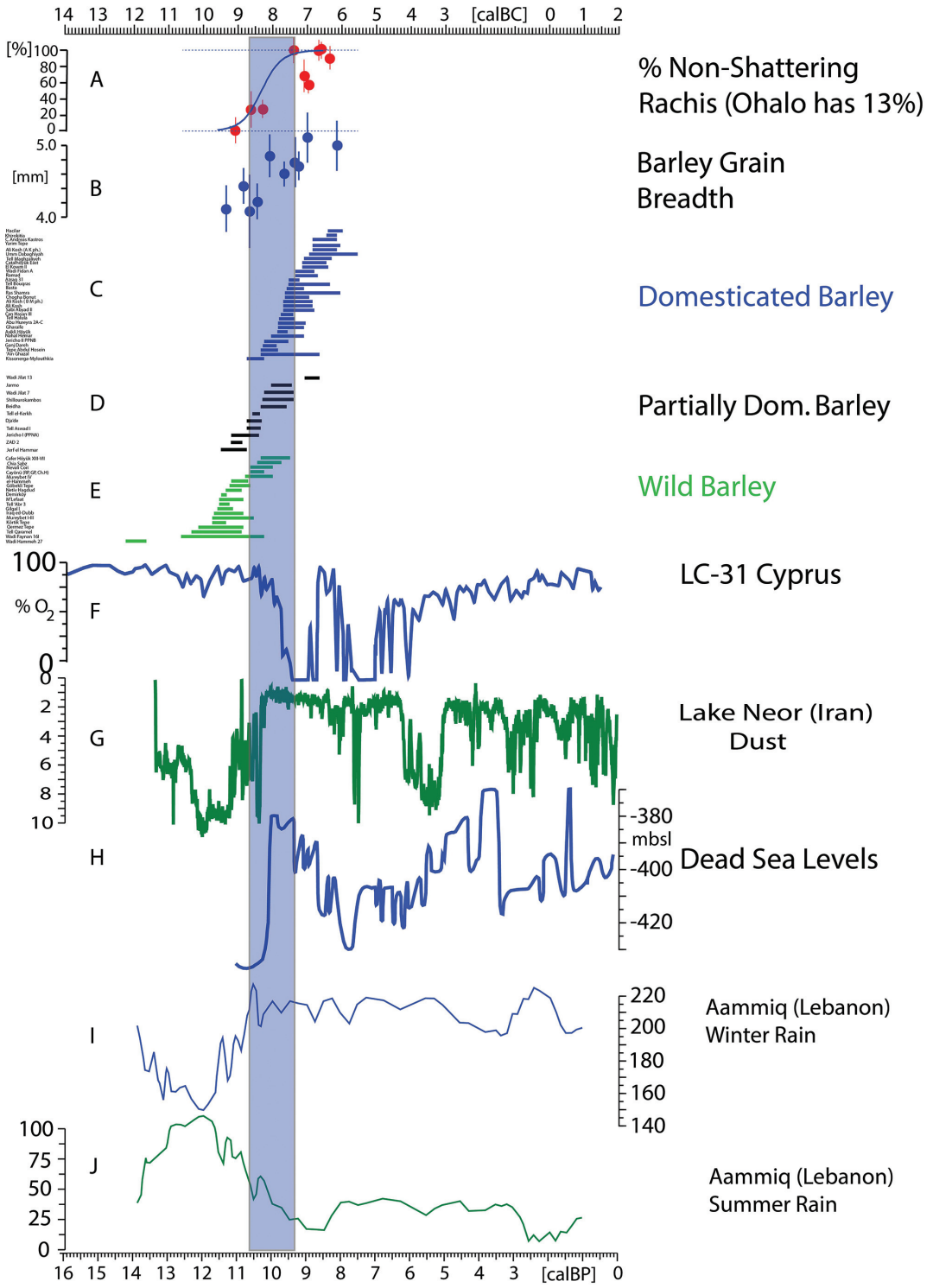



***Fig. 1. Selection of climatic and archaeobotanical records, drawn with the CalPal Multiclimate Dialog (Fig. 4), edited with Adobe Illustrator©.***
**Sources:** ***A*** **Asouti, Fuller 2013** ***(ebda. Fig. 4: A Barley); B*** **Asouti, Fuller 2013** ***(ebda. Fig. 5: grain breadth); C*** **Asouti, Fuller 2013** ***(ebda. Tab. 3: sites with barley and D-prefix); D*** **Asouti, Fuller 2013** ***(ebda. Tab. 3: sites with barley and d-prefix); E*** **Asouti, Fuller 2013** ***(ebda. Tab. 3: sites with wild barley); F Marine Core LC31 (Cyprus) (*** **Schmiedl** ***et al.*** **2010***), Benthic Foraminifera Oxygen Index; G Lake Neor (Iran) Dust Record (*** **Sharifi** ***et al.*** **2015***); H Dead Sea Levels (*** **Migowski** ***et al.*** **2006***); I Aammiq (Lebanon) (*** **Cheddadi, Khater 2016***); J Aammiq (Lebanon), Summer Rain (*** **Cheddadi, Khater 2016***).*
**Note:** ***$^{14}$C-based site-spans (68%) are taken unchanged from Asouti and Fuller (*** **2013***). The shaded area 10.2 ± 0.2 ka cal BP (68%) indicates the beginning of Sapropel S1 according to Schmiedl* **et al.** ***(*** **2010***), which is likely also to cover the WDT (visual analysis).*

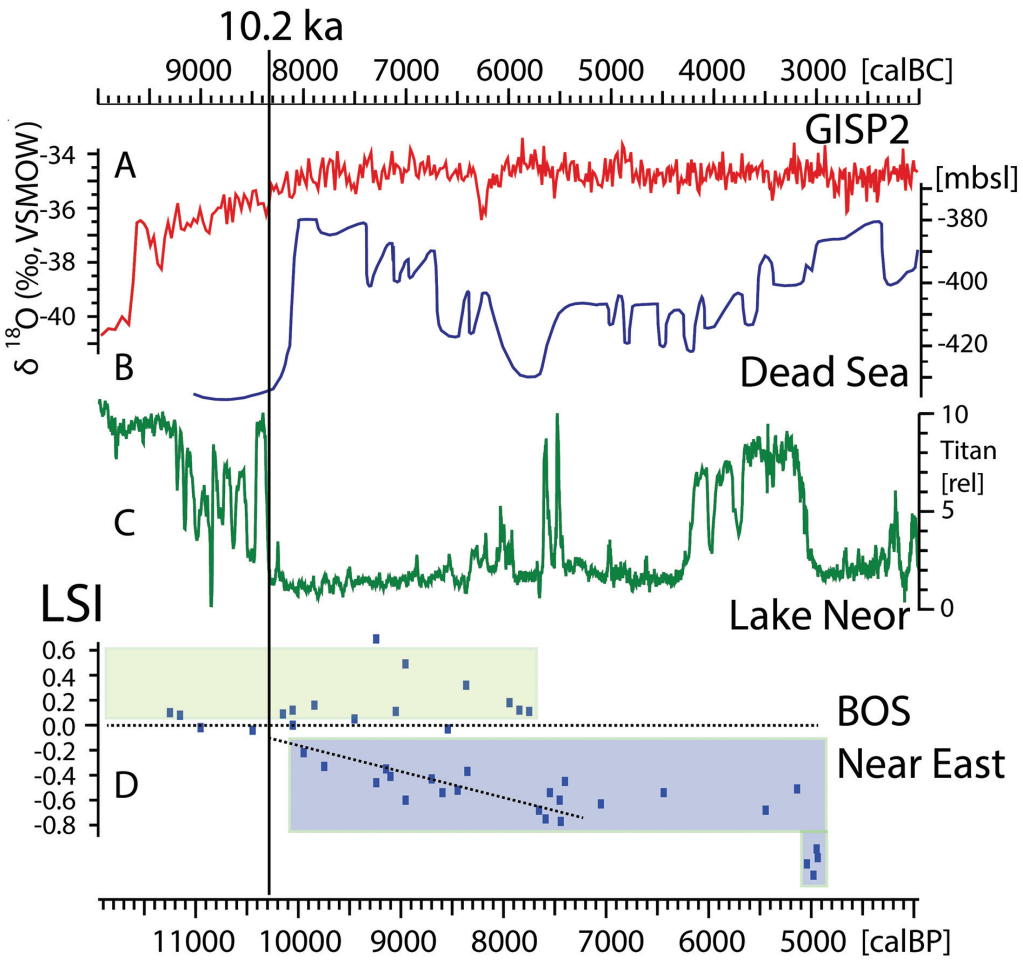



***Fig. 2. Selection of climatic records and comparison with LSI (Logarithmic size indices) for cattle bone from Early Holocene archaeological sites; graph drawn with CalPal Multiclimate Dialog (Fig. 5) and edited with Adobe Illustrator©. A Greenland GISP2 ice-core stable oxygen isotopes $\delta^{18}O$ (*Grootes *et al.* 1993*) shown to illustrate the long timespan (*i.e. *stasis) between Younger Dryas (end ~11.6 ka cal BP) and WD-transition at 10.2 ± 0.2 ka cal BP (vertical line); B Dead Sea Lake Level (*Migowski *et al.* 2006*); C Lake Neor (Iran) Dust Record (*Sharifi *et al.* 2015*); D LSI: Logarithmic Size Index for Bos. LSI-values > 0 (wild); LSI-values < 0 (domesticated). Data digitised from Arbuckle* et al. *(*2016.Fig. 3*) with minor age-corrections. Dashed line: Visual extrapolation of LSI-data (values < 0) back in time to identify (approx.) time-point of earliest cattle-domestication (near to 10.2 ± 0.2 ka cal BP).***

nonetheless helpful in identifying promising archaeological sites for further studies.

Accepting that available $^{14}C$-data are mostly too imprecise to support further modelling, in reward, we gain freedom in our ability to make generalising statements about the theory of agricultural origins, as advised by Gremillion *et al.* (*2014*). In the present paper, these generalising statements are as follows:

❶ The introduction of domesticated cereals in the Near East was a rapid and abrupt process for which a maximum time-span of ~1000yrs (p = 95%) is presently recognisable in the $^{14}C$-data. Due to the well-known highly distributive properties of historical $^{14}C$-data, the process itself is likely to be significantly shorter, in the order of 20–30 years (max. 200 years) as experimentally demonstrated for wild wheat and barley (*Hillman, Davies 1990*). Since the precise date and time-span of the WDT remain unknown, and also to emphasise their derivation from punctuated equilbrium (*i.e.* utiliding a specific theory of evolution), in the following we use the term 'punctuated' to denote a value of 0–200 years.

❷ The punctuated transition from wild to domesticated cereals occurred at 10.2 ± 0.2 ka cal BP (barley: Fig. 1; other species *cf.* data in *Asouti, Fuller 2013*).

❸ The punctuated transition from wild to domesticated animals occurred at 10.2 ± 0.2 ka cal BP (cattle: Fig. 2; other species *cf.* data in *Arbuckle* et al. *2016*).

❹ Following an extended period of cultural and biological stasis during and following the Younger Dryas (*Bar-Yosef 1989; 1998; Haldorsen 2011*), the WDT is coincident with a major climatic switch to higher levels of precipitation (winter rain). This quite remarkable climatic background to the WDT is observable as a sharp transition to higher levels of precipitation around 10.2 ± 0.2 ka cal BP in a large number of terrestrial records, including Lake Neor (Iran), Aammiq (Lebanon), at high resolution (U/Th) in Jeita Cave (Lebanon), as well as in many Eastern Mediterranean marine records (*Schmiedl* et al. *2010*).

❺ The age-value of 10.2 ± 0.2 ka cal BP common to these archaeobiological and climatic events and processes is itself synchonous (within given dating limits) with earliest farming communities in Central Anatolia, such as at Aşikli Hüyük (*Stiner* et al. *2014*), as well as in Iran, in particular at Ganj Dareh (*Zeder, Hesse 2000*). Additional evidence of a punctuated beginning of farming/herding at around 10.2 ± 0.2 ka in Iran can be seen in the remarkable increase in the number of radiocarbon dates that are classified as 'Neolithic' in the CalPal-database (*cf.* Appendix, available online at http://dx.doi.org/10.4312/dp44.1). The temporal development of Iranian Neolithic $^{14}$C-data runs closely parallel with Sapropel S1 as well as with the dust record from Lake Neor (Fig. 5, lowest record), for reasons yet to be deciphered. The Iran/Neolithic $^{14}$C-data (N = 362) is imported here with no filter applied from the CalPal $^{14}$C-database. The $^{14}$C-data in the database of Flohr *et al.* (*2015*) shows essentially the same structure, with or without filtering (*e.g.*, long/short-lived samples, high/low measuring precision, modern/old excavations *etc.*). This motivates further hydroclimatic-archaeological studies of the Iranian Neolithic, but is not our immediate topic.

In conclusion, the system disturbance necessary to understand PE-type Neolithisation is presumably to be found in (A) the self-pollinating properties of the Near Eastern founder cereals. This property makes the movement of domesticated plants beyond ~50m dependent on human agency (*Honne, Heun 2011; Heun* et al. *2012*), and/or (B) in genetic isolation of mixed W/D-cereals due to the colonisation of Cyprus and (amplifying) back-transport of domesticated cereals to the mainland (*Lucas* et al. *2012*), and/or (C) abrupt changes in precipitation that occurred around 10.2 ± 0.2 ka cal BP (Fig. 1); and/or (D) the occurrence of a brief (decadel-scale) cold-winter RCC-extreme event at around 10.2 ± 0.2 ka calBP (*Bar-Yosef 1986; Weninger* et al. *2009; Borrell* et al. *2015*), but with presumably a different impact in the northern and southern Levant (*Cheng* et al. *2015*), and/or (E) the major geographic dispersal of the Neolithic at around 10.2 ± 0.2 ka calBP into Central Anatolia and Iran that would itself have presumably caused the (further) genetic isolation of WD-transitional plants and animals (*cf. Brandolini* et al. *2016*); as well as, most importantly, (F) short- and long-distance exchange/trade in domesticates, as proposed by *Heun* et al. *2012*), and finally, (G) an amplifying combination of factors (A-F).

## Outlook for quantitative modelling

My personal preference for modelling the WDT is (G): the PE auto-amplification description. This is because, if confirmed, any attempted larger-scale mathematical study would presumably have a good start already by application of the well-known and widely applicable harmonic resonance equations (for different frequencies and dampening). In agreement with proposals by Sterelny and Watkins (*2015*), surely the most important causal parameter in the rapid WDT is human agency, which could be modelled as a central driving factor acting under resonance conditions within a wider network of natural (bioclimatic) processes. The factors leading to WD-resonance might have to be attenuated (dampened) to some extent, *e.g.,* to allow for continued human selection of wild cereals during and followed the WDT. This would introduce an additional temporal spread of the rapid transition, yet to be quantified (presumably multi-decadel scale), on top of the (conservative) 200-year estimate by Gordon C. Hillman and M. Stuart Davies (*1990*), but even then the width of transition would be well-covered by the statistical interval of ± 0.2 ka (68%), *i.e.* length 1000 years (>95%) as shown (graphically) in Fig. 1 for the WDT. Presumably, there exist other cultural and biological niche-related phenomena yet to be discovered that show resonance amplification. I could also imagine that the application of resonance equations would be an interesting alternative to the use of stepwise truncated exponential or logistic growth functions in archaeological (or other) applications of punctuated equilibrium, but this surely depends very much on application (*e.g., Kolodny* et al. *2015*).

## Conclusions

In this paper the suggestion is made that Punctuated Equilibrium (*Gould, Eldredge 1993*) can be observed in the archaeological and archaeobiological record for the Early Holocene WDT in the Near East,

despite its high degree of chronological noise. This idea is derived from a combined graphic visualisation of large quantities of palaeobiological, climatological, and archaeological data. From the viewpoint of Nonlinear System Theory, it appears possible to describe (as well as understand) the extreme rapidity of the WDT as due to amplification with positive feedback for a small number of reasonably explicit causal factors. With such an approach, it might be possible to decide whether the WDT-transition follows deterministic (strictly forecastable) or chaotic (non-predictable) laws. A more general application of PE-type Neolithisation in the Theory of Agricultural Origins is indicated by case studies relating to later phases of Neolithic Dispersion.

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back to contents

# Early Neolithic population dynamics in the Eastern Balkans and the Great Hungarian Plain

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ABSTRACT – *In this study, we reconstruct population dynamics in the Early Neolithic of the Eastern Balkans and the Great Hungarian Plain using frequency of radiocarbon dates as a population proxy. The method of summed calibrated radiocarbon probability distributions is applied to a set of dates recently published in Bulgaria and Hungary. The aim is to test the hypothesis of the Neolithic demographic transition (NDT) in these regions and to compare the patterns between these two and neighbouring regions. The results show that episodes of population growth occurred in both regions, which is in partial agreement with the predictions of the NDT theory. Population growth is detected, but it is followed by a bust, rather than stabilisation as predicted for the second phase of the NDT.*

KEY WORDS – *Early Neolithic; Neolithic demographic transition; palaeodemography; radiocarbon; Southeast Europe*

## *Zgodnje neolitske dinamike poselitve na Vzhodnem Balkanu in v Veliki madžarski nižini*

IZVLEČEK – *V članku poskušamo rekonstruirati populacijske dinamike v času zgodnjega neolitika na območju vzhodnega Balkana in Velike madžarske nižine, in sicer z uporabo pogostnosti radiokarbonskih datumov kot kazalcev poselitve. Metodo vsote verjetnostne razporeditve kalibriranih radiokarbonskih datumov smo uporabili pri analizi datumov, ki so bili nedavno objavljeni v Bolgariji in na Madžarskem. Na teh območjih smo preverjali hipotezo t.i. neolitske demografske tranzicije (NDT) in primerjali dobljene vzorce s tistimi v sosednjih regijah. Rezultati kažejo, da so se epizode rasti poselitve zgodile v obeh regijah, kar je delno v skladu z napovedmi teorije NDT. Zaznali smo sicer rast poselitve, ki pa ji sledi nenaden padec, kar ni v skladu z napovedmi za drugo fazo NDT, ki predvideva stabilizacijo.*

KLJUČNE BESEDE – *zgodnji neolitik; neolitska demografska tranzicija; paleodemografija; radiokarbonsko datiranje; jugovzhodna Evropa*

## Introduction

It is commonly accepted that the Neolithic was introduced to Europe from the Near East, and new genetic and bioarchaeological evidence undoubtedly show that these processes included movements of people (*Davison* et al. *2007; Haak* et al. *2010; Brami, Heyd 2011; Fort 2012; Pinhasi* et al. *2012; Borić, Price 2013; Gurova, Bonsall 2014; Özdoğan 2014; Mathieson* et al. *2015; Szécsényi-Nagy* et al. *2015; Hofmanová* et al. *2016*). The directions and rates of spread of the Neolithic in different regions of Europe have been important issues in numerous studies, many of which offered possible models of pop-



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ulation expansion. Different models have been suggested for the process, the most frequently considered being: the wave-of-advance model, leap-frog colonisation, and diffusion of cultural novelties (cultural transmission) (*Ammerman, Cavalli-Sforza 1971, 1973; Tringham 2000; Whittle* et al. *2002; Bar-Yosef 2004; Pinhasi* et al. *2005; Davison* et al. *2007; Bocquet-Appel* et al. *2009; Borić, Price 2013*). In recent years, the process of neolithisation has been studied as a more complex combination of demic and cultural diffusion (*Wirtz, Lemmen 2003; Fort 2012; 2015*).

The Neolithic way of life brought changes in subsistence and mobility patterns, and a major shift in population structure and dynamics known as the Neolithic Demographic Transition (NDT). According to Jean-Pierre Bocquet-Appel (*2002; 2008; 2011a; 2011b; 2013; Bocquet-Appel, Bar-Yosef 2008a*), the NDT was a two-stage process – the first stage being characterised by exponential population growth caused by increased fertility, followed by a second stage marked by increased mortality and decelerating growth. It is assumed that the increase in fertility was caused by changes in lifestyle which accompanied the Neolithic – dietary (introduction of new, more nutritious food), and changes in residential mobility (sedentary lifestyle). The increase in mortality that followed, especially among infants, was a result of numerous factors – introduction of new pathogens, lack of drinking water, contamination by feces, reduced breastfeeding and higher workload (*Bocquet-Appel 2008.49; 2013.2*). When the mortality rate equaled the birth rate, population growth stopped.

The pattern of Neolithic population dynamics, based on the frequency of radiocarbon dates from Western, Northern and Central Europe, consists of a population boom that occurred at the beginning of the period, followed by a population bust after a few centuries (*Shennan* et al. *2013; Timpson* et al. *2014*). This pattern is in agreement with predictions of the NDT theory regarding its first phase, when population growth should occur. A recent study has shown that a similar pattern is observed in the Early Neolithic of the Central Balkans (*Porčić* et al. *2016*).

In this paper, we extend the paleodemographic research to the area of Eastern Balkans and the Great Hungarian Plain. The aim is to reconstruct population dynamics and to test the NDT hypothesis on two datasets from Southeast Europe, where such studies have been lacking.

Two routes of expansion of the Neolithic way of life into Europe have been proposed. The continental route led from Thessaly, where Neolithic was introduced around the middle of the 7th millennium cal BC (*Perlès* et al. *2013*) through the Balkans, and to Central, Western and Eastern Europe (*Bocquet-Appel* et al. *2009; Brami, Heyd 2011; Özdoğan 2014*). The maritime (Mediterranean) route led from the coast of the Ionian Sea, along the eastern and western Adriatic coast, and further to the western Mediterranean and Iberia. Recent studies (*Wirtz, Lemmen 2003; Bocquet-Appel* et al. *2009; Lemmen* et al. *2011; Silva, Steele 2014; Weninger* et al. *2014; Brami, Zanotti 2015*) emphasised the complexity of these processes, and different rates and timings for different European regions. These differences depended on various factors, such as geography, climate and sociocultural trends.

The present state of research suggests that the Neolithic spread to the territory of Eastern Balkans (mostly modern-day Bulgaria), along the valleys of the Vardar, Struma and Marica rivers (*Boyadzhiev 2009*). After settling in Southwestern Bulgaria and Thrace, Early Neolithic populations spread further north. The Neolithisation of this territory was gradual, in a south to north direction, and absolute dates from sites such as Poljanica-Platoto and Džuljunica-Smărdeš date the beginning of these processes to around 6200/6100 cal BC (*Boyadzhiev 2009.11; Krauß* et al. *2014.63, Tab. 1*). The Early Neolithic lasted until around 5400/5350 cal BC, with the transition to the Late Neolithic occurring between 5500/5450 and 5400/5350 cal BC, which is thought to have been a gradual and smooth process (*Gatsov, Boyadzhiev 2009.26*).

The Early Neolithic on the Great Hungarian Plain (modern-day Hungary) is represented by the Starčevo and Körös cultures. The settling of these early farming populations was concentrated in the valleys of several rivers: Tisza, Körös, Maros and Beretyó. The highest density of sites has been found on the southern part of the Great Hungarian Plain, which is explained as a result of its rich and diverse landscape (*Paluch 2012.49*). The earliest $^{14}$C dates from the southernmost sites, such as Deszk-1, Pitvaros, Maroslele-Pana and Olajkút, indicate that the beginning of Körös culture can be dated to around 6000/5910 cal BC. A south-to-north expansion is also suggested, with the earliest dates for the northernmost (Upper Tisza) region covering the time span between 5630 and 5470 cal BC (*Domboróczki 2010; Domboróczki, Raczky 2010; Oross, Siklósi 2012*).

## Data and method

In this study, published data from Hungary (*Anders, Siklósi 2012*) and Bulgaria (*Gatsov, Boyadzhiev 2009; Krauß* et al. *2014*) were used. A total of 179 published radiocarbon dates from 16 Bulgarian sites and 117 dates from 24 sites from the territory of Hungary were analysed (Fig. 1; Appendix 1). Dates with large standard errors (170 radiocarbon years and greater) and dates that were out of the currently accepted chronological range for the Early Neolithic in Southeast Europe (~6200–5300 cal BC) were excluded from the analysis.[1]

The population dynamics were reconstructed by applying the summed calibrated radiocarbon probability distributions (SCPD) method. The main assumption of this method is that the quantity of material culture is directly proportional to population size in a certain time interval in a given region (*Rick 1987; Shennan* et al. *2013; Williams 2012*). If the number of radiocarbon dates is large enough, then the frequency of dates from a specific time period will be directly proportional to the quantity of archaeological remains from that period, and hence to the size of the population that produced them. The method that was applied in this study was developed by Stephen Shennan *et al.* (*2013*) and Adrian Timpson *et al.* (*2014*), and it accounts for biases that can greatly affect the final result: the effects of the calibration curve, research bias and effects of taphonomy. The analysis was performed in R programming language (*R Core Team 2014*), using the Bchron package for calibrating dates (*Parnell 2014*), and the INTCAL 13 calibration curve (*Reimer* et al. *2013*).

The research bias is the result of different sampling strategies, depending on particular research questions. In other words, samples are usually not collected randomly, but in order to provide chronological information for specific archaeological contexts. In order to reduce the research bias, a binning procedure was performed at the beginning of the analysis. Radiocarbon dates were binned into site-phases, and sorted in decreasing order within each site-phase. Subdivision into bins within site-phases was performed if the difference between two adjacent dates was greater than 200 radiocarbon years. After the calibration, dates were summed within and between bins, and normalised to produce the final SCPD curve. This procedure controls for research bias due to the different number of dates from different sites and site phases, but it cannot control for the bias resulting from the selection of sites and site phases themselves. The binning procedure performed on the 179 Early Neolithic dates from Bulgaria produced 22 bins, while the same procedure performed on 117 Early Neolithic dates from Hungary produced 26.

Taphonomic bias refers to the loss of archaeological material over time due to various taphonomic factors. In order to address this source of bias, the taphonomic exponential curve equation developed by Todd A. Surovell *et al.* (*2009*) was used as a null model. The null model assumes that the population was stationary and that, apart from the shape of the calibration curve, the taphonomy is the only factor which affects the shape of the empirical SCPD curve. According to the probabilities given by the null model, calendar dates from the specified time interval were randomly sampled, which produced a large number of simulated radiocarbon datasets. The number of dates for each simulated dataset is equal to the number of bins in the empirical data set. This procedure was repeated many times; for the Early Neolithic dates from Hungary and Bulgaria, we simulated 10 000 null model SCPDs. Sampled calendar dates were then 'back calibrated' and recalibrated afterwards, and summed to produce the simulated SCPD pattern. Finally, the empirical SCPD curve was compared to the 95% confidence intervals calculated from the simulated SCPD values. When the empirical SCPD is above or below the 95% confidence intervals, there is a statistically significant growth or decline of population relative to the null model. This whole procedure was undertaken in order to assess the statistical significance of the empirical SCPD pattern.

## Results

The results of the SCPD method for the territory of Bulgaria are shown in Figure 2. After ~6000 cal BC, the curve begins to increase, reaching a peak around 5700 cal BC, after which it decreases. However, none of the changes in the curve reach the threshold of statistical significance, as the curve is always within the 95% CI limits, meaning that it is consistent with the null model, which assumes uniform population (with effects of taphonomy).

1 The omitted dates are from the following Bulgarian sites: Ovčarovo-gorata (Bln-2031), Galabnik (GrN-19786), Poljanica-platoto (Bln-1571) and Džuljunica-Smărdeš (OxA–24937). From Hungarian sites, the dates that were excluded are: Ecsegfalva 23 (OxA-12857), Endrőd 6 (Deb-408, Deb-450), Maroslele-Pana (OxA-9403, Deb-2733), Szajol-Felsőföld (Deb-473, Deb-474), Szakmár-Kisülés (Deb-413), Szarvas 23 (BM-1865R) and Szarvas 56 (Deb-396).

The results of the SCPD method for the territory of Hungary are shown in Figure 3. The empirical curve increases after ~6200 cal BC and goes beyond the upper 95% CI limit between ~5750 and ~5500 cal BC, meaning that in this interval, there was a significant increase relative to the null model, which assumes uniform population (with effects of taphonomy). After this interval, the curve abruptly drops, but stays within the 95% CI limits. Around 5200 cal BC, a minor, but statistically significant drop can be observed.

## Discussion

In the Eastern Balkans, the curve started to increase with the beginning of the Neolithic. The peak around 5700 cal BC occurred afterwards, and may be considered as indicative of the NDT. The lack of statistical

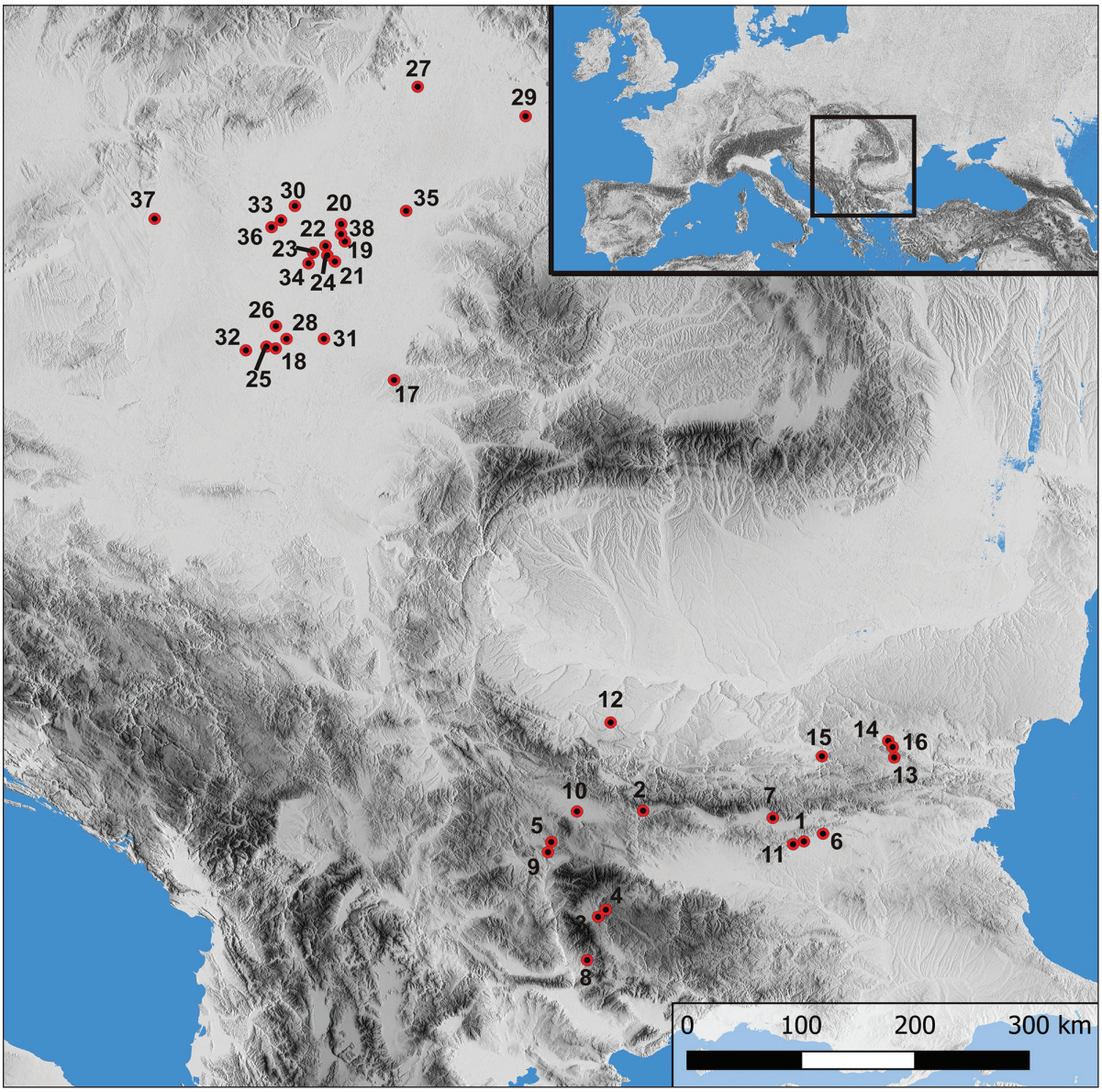



***Fig. 1. Early Neolithic sites from Bulgaria (1–16) and Hungary (17–38) with radiocarbon dates included in this study: 1 Azmak, 2 Čavdar, 3 Dobrinište, 4 Elešnica, 5 Galabnik, 6 Karanovo, 7 Kazanlak, 8 Kovačevo, 9 Kremenik (Sapareva Banja), 10 Slatina, 11 Stara Zagora (Okražna bolnica), 12 Ohoden, 13 Ovčarovo-gorata, 14 Poljanica-platoto, 15 Džuljunica-Smărdeš; 16 Ovcharovo-platoto 2; 17 Battonya-Basarága, 18 Deszk-Olajkút, 19 Dévaványa-Katalszeg, 20 Ecsegfalva 23, 21 Endrőd 35, 22 Endrőd 39, 23 Endrőd 119, 24 Endrőd-Varnyai-tanya, 25 Gyálarét-Szilágyi major, 26 Hódmezővásárhely-Kotacpart-Vata-tanya, 27 Ibrány-Nagyerdő, 28 Maroslele-Pana, 29 Méhtelek-Nádas, 30 Nagykörű-TszGyümölcsös, 31 Pitvaros-Viztározó, 32 Röszke-Lúdvár, 33 Szajol-Felsőföld, 34 Szarvas 23; 35 Szentpéterszeg-Körtvélyes, 36 Szolnok-Szanda, 37 Tiszaszőlős-Domaháza-puszta; 38 Dévaványa-Réhelyi gát (map produced by Jugoslav Pendić and Kristina Penezić).***

significance (at the 0.05 level) of the deviation from the null model is most probably due to the low effective sample size (the number of bins is only 22), which implies low statistical power.

The results for the Hungarian Plain dates show a significant peak around ~5750 cal BC, which can be interpreted as population growth at the beginning of the Neolithic, and the signal of the NDT. It is followed by a sharp decrease in the curve at ~5500 cal BC, suggesting a population bust in this period.

The observed pattern – a population increase at the beginning of the Neolithic, followed by a population decrease after about 150 years for Bulgaria, and about 250 years for Hungary – correspond to the boom and bust pattern observed in other regions in Europe and the Balkans (*Shennan, Edinborough 2007; Shennan* et al. *2013; Timpson* et al. *2014; Porčić* et al. *2016; Pilaar Birch, Vander Linden 2017*).

When compared to the results obtained for the territory of Serbia (*Porčić* et al. *2016*), it can be seen that they are quite similar in general, but some regional differences should be further discussed (Fig. 4). In Porčić *et al.* (*2016*) it was shown that the SCPD curve for data from Serbia had two statistically significant peaks (~6000 cal BC and ~5650 cal BC) and a major drop between. Two explanations have been proposed. The first perceives these changes as real demographic patterns that reflect major population growth followed by increased mortality or migration, with a rebound occurring after 350 years. The other explanation would be that this result is a consequence of a research bias that led to oversampling the earliest Early Neolithic contexts and that the peak around ~5650 cal BC is most probably the signal of the NDT (*Porčić* et al. *2016.6–7*). In a recent study by Suzanne Pilaar Birch and Marc Vander Linden (*2017*), which primarily deals with the correlation between environmental changes and population dynamics dur-

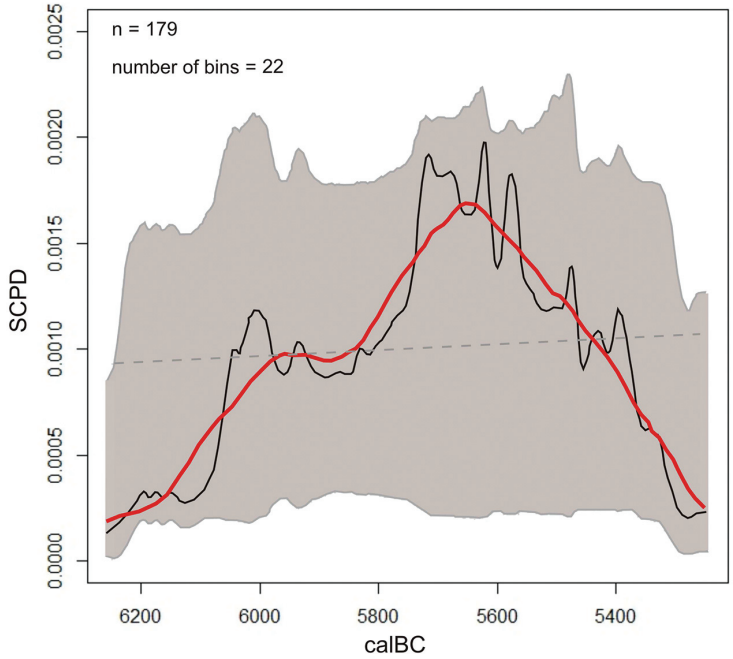



***Fig. 2. Results of the SCPD analysis based on the Early Neolithic radiocarbon dates from Bulgaria. SCPD empirical curve (black line) for Early Neolithic dates, with 95% confidence intervals (shaded) based on 10 000 simulations from the null model (grey dashed line) and 200 year rolling mean (red line); number of dates = 179; number of bins = 22; global p value = 0.5516.***

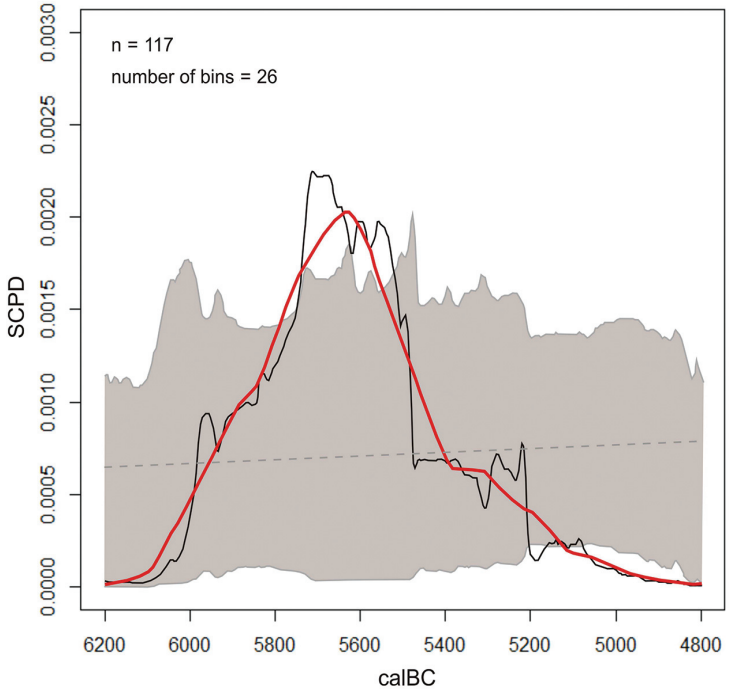



***Fig. 3. Results of the SCPD analysis based on the Early Neolithic radiocarbon dates from Hungary. SCPD empirical curve (black line) for Early Neolithic dates, with 95% confidence intervals (shaded) based on 10 000 simulations from the null model (grey dashed line) and 200 year rolling mean (red line); number of dates = 117; number of bins = 26; global p value = 0.0037.***

ing the Late Pleistocene and Early Holocene in the eastern Adriatic and western Balkans, the SCPD method was used in order to reconstruct population dynamics. The results have confirmed the boom and bust pattern in the Balkan region, and have also shown that these processes happened within the same time frame in the eastern Adriatic (*Pilaar Birch, Vander Linden 2017.Figs. 5 and 6*).

Additional data are available for the territory of Croatia. Botić presents the results of summed distributions of the Starčevo (Early Neolithic) and Sopot (Late Neolithic) dates from the territory of Croatia (*Botić 2016.17, Fig. 4*). A sign of possible population growth similar to the one observed in data from neighbouring regions is present. However, it should be noted that the number of dates from this study is very low (23 dates).

It is interesting to note that the peaks from the three curves (Bulgaria, Hungary, Serbia) coincide (Fig. 4), given the usual assumption that the Neolithic gradually spread from south to north. The earliest Neolithic in Serbia and Bulgaria is dated to ~6200 and ~6100–6050 cal BC, respectively (*Whittle* et al. *2002; Krauß* et al. *2014*). The earliest Körös sites in Hungary are not older than 6000 cal BC (*Anders, Siklósi 2012.153*). Therefore, it should be expected that population boom in Central and Eastern Balkans should have happened earlier than in the Great Hungarian Plain if the demographic process was the same. Given the small samples in all regions of Southeast Europe and the fact that the SCPD method is a very rough tool, these contradictions should not be given too much weight at this moment, as the precision to discriminate between the shifts of one or two centuries may be lacking in this case.

Given the increasing importance of the research focusing on the relationship between climate changes and cultural dynamics (*e.g., Wirtz, Lemmen 2003; Budja 2007; 2015; Gronenborn 2009; Weninger* et al. *2009; 2014; Clare, Weninger 2010; Shennan* et al. *2013; Lemmen, Wirtz 2012; Botić 2016; Pilaar Birch, Vander Linden 2017*), we compared the SCPD curves to a global climate proxy. In order to explore the relationship between climate and population dynamics in the three regions of Southeast Europe, the SCPD curves for Serbia, Hungary and Bulgaria are plotted against the GISP2 core curve (*Grootes, Stuiver 1997*) (Fig. 4). There is some indication that the troughs after ~5500 cal BC on SCPD curves based on dates from Serbia and Hungary may be related to the reduction in temperature which started somewhat earlier, but no strong sign of covariation is present. Unfortunately, at this point, no high-resolution climate proxies are available for the study region, and a more precise climate reconstruction is not possible. Relying on global proxies such as GISP cores when investigating populations dynamics in the central Balkan area can only be regarded as a general framework for further research.

In order to create a more accurate and precise reconstruction of population dynamics in Southeastern Europe, it is necessary to generate a new sample of radiocarbon dates according to a probabilistic sampling design, which would minimise the re-

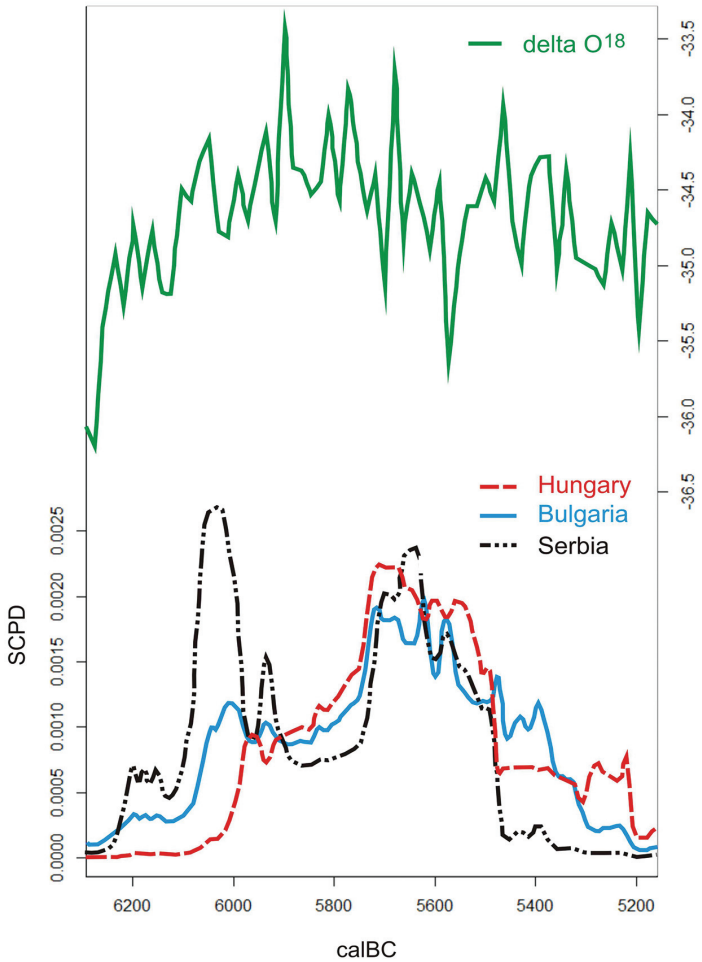



***Fig. 4. Climate proxy (raw $\delta O^{18}$ curve data from GISP2 core – green solid line) plotted over SCPD curves for Serbia (black dash-dotted line), Bulgaria (blue solid line) and Hungary (red dashed line)***

search bias and increase statistical power. For the region of Central Balkans, the collection of new radiocarbon samples is currently under way by the authors of this paper. This sample is specifically designed for the purposes of population dynamics reconstruction with the SCPD method; an effort is made to approximate a random sample. Therefore, the results presented in this paper should be considered as preliminary and will be further refined when the new data arrive.

## Conclusions

It can be concluded that in the Eastern Balkans and Great Hungarian plain, the shape of the SCPD curve is consistent with the population boom predicted by the NDT theory and empirical results from other parts of Europe and Balkans. No clear influence of climate on population dynamics patterns during the 6th millennium cal BC was detected.

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## Appendix 1

## List of sites from the territory of Hungary and Bulgaria, with radiocarbon dates used in this study

| HUNGARY | | | | | | |
|---|---|---|---|---|---|---|
| **Site (No. on the Fig. 1)** | **Coordinates** | **Lab. No** | **Uncal. BP** | **St. error** | **Cal BC** | **Reference** |
| Battonya-Basarága (**17**) | 45°59'37.84"N 21°28'10.12"E | BM-1862R | 6710 | 110 | 5840 (95.4%) 5473 | *Bowman* et al. *1990.73; Horváth, Hertelendi 1994.123* |
| Deszk-Olajkút (**18**) | 46°13'43.75"N 20°14'34.04"E | OxA-9396 | 7030 | 50 | 6010 (95.4%) 5796 | *Whittle* et al. *2002.111, 115* |
| Deszk-Olajkút | | Bln-581 | 6605 | 100 | 5709 (95.4%) 5374 | *Quitta, Kohl 1969.240* |
| Deszk-Olajkút | | Bln-584 | 6540 | 100 | 5643 (95.4%) 5317 | *Quitta, Kohl 1969.240* |
| Deszk-Olajkút | | Bln-583 | 6410 | 100 | 5613 (95.4%) 5083 | *Quitta, Kohl 1969.240* |
| Deszk-Olajkút | | Bln-582a | 6390 | 100 | 5551 (95.5%) 5078 | *Quitta, Kohl 1969.240* |
| Deszk-Olajkút | | Bln-582 | 6260 | 100 | 5469 (95.4%) 4994 | *Quitta, Kohl 1969.240* |
| Deszk-Olajkút | | OxA-9376 | 6225 | 55 | 5315 (95.4%) 5040 | *Whittle* et al. *2002.111, 115* |
| Dévaványa-Katalszeg (**19**) | 47° 0'56.39"N 20°57'35.72"E | Bln-86 | 6370 | 100 | 5524 (95.4%) 5070 | *Kohl, Quitta 1963.300* |
| Dévaványa-Réhelyi gát (**38**) | 47°4'9.37"N 20°55'8.78"E | Bln-1379 | 6640 | 60 | 5657 (95.4%) 5482 | *Oross, Siklosi 2012.Tab. 1* |
| Ecsegfalva 23 (**20**) | 47° 8'34.42"N 20°55'17.19"E | OxA-9329 | 6950 | 45 | 5974 (95.4%) 5733 | *Whittle* et al. *2002.110, 115* |
| Ecsegfalva 23 | | OxA-11871 | 6930 | 40 | 5899 (95.4%) 5726 | *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-9335 | 6920 | 50 | 5969 (95.4%) 5716 | *Whittle* et al. *2002.110, 115* |
| Ecsegfalva 23 | | OxA-9526 | 6915 | 50 | 5970 (95.4%) 5712 | *Whittle* et al. *2002.110, 115* |
| Ecsegfalva 23 | | OxA-11983 | 6915 | 36 | 5881 (95.4%) 5726 | *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-10500 | 6900 | 60 | 5968 (95.4%) 5667<br>5876 (95.4%) 5713 | *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-11984 | 6893 | 36 | 5876 (95.4%) 5713 | *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-12654 | 6889 | 36 | 5874 (95.4%) 5710 | *Bronk Ramsey* et al. *2007.176* |
| Ecsegfalva 23 | | OxA-10501 | 6885 | 50 | 5881 (95.4%) 5671 | *Bronk Ramsey* et al. *2007.176* |
| Ecsegfalva 23 | | OxA-9327 | 6870 | 50 | 5877 (95.4%) 5661 | *Whittle* et al. *2002.110, 115* |
| Ecsegfalva 23 | | OxA-11845 | 6865 | 40 | 5840 (95.4%) 5667 | *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-9333 | 6860 | 45 | 5844 (95.4%) 5658 | *Whittle* et al. *2002.110, 115*; *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-9334 | 6855 | 50 | 5844 (95.4%) 5644 | *ibid.* |
| Ecsegfalva 23 | | OxA-10505 | 6845 | 50 | 5838 (95.4%) 5643 | *Bronk Ramsey* et al. *2007.176* |
| Ecsegfalva 23 | | OxA-12655 | 6830 | 35 | 5777 (95.4%) 5642 | *Bronk Ramsey* et al. *2007.176* |
| Ecsegfalva 23 | | OxA-12860 | 6826 | 41 | 5787 (95.4%) 5637 | *Bronk Ramsey* et al. *2007.176* |
| Ecsegfalva 23 | | OxA-11863 | 6825 | 45 | 5796 (95.4%) 5633 | *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-12859 | 6818 | 44 | 5783 (95.4%) 5632 | *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-9328 | 6815 | 50 | 5797 (95.4%) 5627 | *Whittle* et al. *2002.110, 115*; *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-9331 | 6815 | 45 | 5778 (95.4%) 5631 | *ibid.* |

| Site (No. on the Fig. 1) | Coordinates | Lab. No | Uncal. BP | St. error | Cal BC | Reference |
|---|---|---|---|---|---|---|
| Ecsegfalva 23 | | OxA-9332 | 6810 | 45 | 5771 (95.4%) 5629 | *Whittle* et al. *2002.110, 115*; *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-11982 | 6806 | 39 | 5746 (95.4%) 5632 | *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-9330 | 6795 | 50 | 5771 (95.4%) 5621 | *Whittle* et al. *2002.110, 115*; *Bronk Ramsey* et al. *2007.176* |
| Ecsegfalva 23 | | OxA-X-2040-07 | 6787 | 37 | 5731 (95.4%) 5631 | *Bronk Ramsey* et al. *2007.176* |
| Ecsegfalva 23 | | OxA-13511 | 6785 | 45 | 5739 (95.4%) 5624 | *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-12858 | 6782 | 42 | 5733 (95.4%) 5627 | *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-11850 | 6780 | 50 | 5752 (95.4%) 5617 | *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-X-2040-09 | 6780 | 39 | 5728 (95.4%) 5630 | *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-X-2040-08 | 6775 | 37 | 5726 (95.4%) 5629 | *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-12854 | 6774 | 45 | 5736 (95.4%) 5621 | *Bronk Ramsey* et al. *2007.175* |
| Ecsegfalva 23 | | OxA-11868 | 6750 | 45 | 5728 (95.4%) 5571 | *Bronk Ramsey* et al. *2007.176* |
| Ecsegfalva 23 | | OxA-13510 | 6731 | 43 | 5720 (95.4%) 5563 | *Bronk Ramsey* et al. *2007.176* |
| Ecsegfalva 23 | | OxA-12140 | 6729 | 32 | 5711 (95.4%) 5571 | *Bronk Ramsey* et al. *2007.176* |
| Ecsegfalva 23 | | OxA-9325 | 6690 | 50 | 5707 (95.4%) 5526 | *Whittle* et al. *2002.110, 115*; *Bronk Ramsey* et al. *2007.176* |
| Ecsegfalva 23 | | OxA-10148 | 6665 | 50 | 5664 (95.4%) 5491 | *ibid.* |
| Ecsegfalva 23 | | OxA-11849 | 6660 | 40 | 5646 (95.4%) 5512 | *Bronk Ramsey* et al. *2007.176* |
| Ecsegfalva 23 | | OxA-12855 | 6596 | 42 | 5617 (95.4%) 5483 | *Bronk Ramsey* et al. *2007.175* |
| Endrőd 35 (**21**) | 46°52'8.86"N 20°51'23.05"E | Bln-1940 | 6615 | 60 | 5635 (95.4%) 5478 | *Oross, Siklosi 2012.Tab. 1* |
| Endrőd 35 | | Bln-1960 | 6415 | 60 | 5488 (95.4%) 5235 | *Oross, Siklosi 2012.Tab. 1* |
| Endrőd 35 | | BM-1864R | 6180 | 110 | 5369 (95.4%) 4840 | *Bowman* et al. *1990.73* |
| Endrőd 39 (**22**) | 46°58'59.01"N 20°45'33.37"E | BM-1868R | 6970 | 110 | 6047 (95.4%) 5662 | *Bowman* et al. *1990.73*; *Horváth, Hertelendi 1994.122* (with Lab no. BM-1668R) |
| Endrőd 39 | | BM-1863R | 6950 | 140 | 6083 (95.4%) 5571 | *Bowman* et al. *1990.73*; *Horváth, Hertelendi 1994.122* |
| Endrőd 39 | | BM-1870R | 6950 | 120 | 6034 (95.4%) 5635 | *Bowman* et al. *1990.73*; *Horváth, Hertelendi 1994.122* (with Lab no. BM-1971R) |
| Endrőd 39 | | BM-1871R | 6830 | 120 | 5982 (95.4%) 5540 | *Bowman* et al. *1990.73*; *Horváth, Hertelendi 1994.122* |
| Endrőd 39 | | Bln-1941 | 6785 | 55 | 5777 (95.4%) 5573 | *Oross, Siklosi 2012.Tab. 1* |
| Endrőd 119 (**23**) | 46°56'2.43"N 20°37'53.42"E | OxA-9587 | 6915 | 45 | 5899 (95.4%) 5716 | *Whittle* et al. *2002.110, 115* |
| Endrőd 119 | | OxA-9583 | 6895 | 45 | 5890 (95.4%) 5676 | *Whittle* et al. *2002.110, 115* |
| Endrőd 119 | | OxA-9588 | 6855 | 45 | 5842 (95.4%) 5657 | *Whittle* et al. *2002.110, 115* |
| Endrőd 119 | | OxA-9586 | 6850 | 45 | 5839 (95.4%) 5650 | *Whittle* et al. *2002.110, 115* |
| Endrőd 119 | | OxA-9582 | 6825 | 45 | 5796 (95.4%) 5633 | *Whittle* et al. *2002.110, 115* |
| Endrőd 119 | | OxA-9584 | 6825 | 45 | 5796 (95.4%) 5633 | *Whittle* et al. *2002.110, 115* |
| Endrőd 119 | | OxA-9590 | 6815 | 50 | 5797 (95.4%) 5627 | *Whittle* et al. *2002.110, 115* |
| Endrőd 119 | | OxA-9585 | 6795 | 50 | 5771 (95.4%) 5621 | *Whittle* et al. *2002.110, 115* |
| Endrőd 119 | | OxA-9589 | 6720 | 45 | 5717 (95.4%) 5559 | *Whittle* et al. *2002.110, 115* |
| Endrőd-Varnyai-tanya (**24**) | 46°54'54.34"N 20°46'37.73"E | OxA-9395 | 6595 | 50 | 5619 (95.4%) 5481 | *Whittle* et al. *2002.111, 116* |
| Gyálarét-Szilágyi major (**25**) | 46°14'32.24"N 20° 8'50.49"E | Bln-75 | 7090 | 100 | 6206 (95.4%) 5746 | *Kohl, Quitta 1963.299-300*; *1964.315*; *Horváth, Hertelendi 1994.122* |
| Hódmezővásárhely-Kotacpart-Vata-tanya (**26**) | 46°23'37.19"N 20°14'41.87"E | Bln-115 | 6450 | 100 | 5613 (95.4%) 5224 | *Kohl, Quitta 1963.299-300*; *1964.315-316* |

| Site (No. on the Fig. 1) | Coordinates | Lab. No | Uncal. BP | St. error | Cal BC | Reference |
|---|---|---|---|---|---|---|
| Ibrány-Nagyerdő (**27**) | 48° 8'3.32"N 21°42'51.46"E | Poz-28216 | 6630 | 40 | 5626 (95.4%) 5491 | *Domboróczki, Raczky 2010. 214* |
| Ibrány-Nagyerdő | | Poz-28214 | 6570 | 40 | 5615 (95.4%) 5475 | *Domboróczki, Raczky 2010.214* |
| Maroslele-Pana (**28**) | 46°17'58.53"N 20°21'17.99"E | OxA-9399 | 6965 | 50 | 5981 (95.4%) 5736 | *Whittle* et al. *2002.111, 115* |
| Maroslele-Pana | | OxA-10149 | 6845 | 50 | 5838 (95.4%) 5643 | *Whittle* et al. *2002.111, 115* |
| Maroslele-Pana | | OxA-9401 | 6780 | 50 | 5752 (95.4%) 5617 | *Whittle* et al. *2002.111, 115* |
| Maroslele-Pana | | OxA-9400 | 6740 | 50 | 5730 (95.4%) 5561 | *Whittle* et al. *2002.111, 115* |
| Méhtelek-Nádas (**29**) | 47°55'22.39"N 22°49'57.54"E | Bln-1331 | 6835 | 60 | 5843 (95.4%) 5629 | *Kalicz, Makkay 1977.23*; *Horváth, Hertelendi 1994.122*; *Raczky* et al. *2010.164* |
| Méhtelek-Nádas | | Bln-1332 | 6655 | 60 | 5665 (95.4%) 5484 | *ibid.* |
| Méhtelek-Nádas | | GrN-6897 | 6625 | 50 | 5628 (95.4%) 5486 | *ibid.* |
| Nagykörű-Tsz Gyümölcsös (**30**) | 47°16'28.34"N 20°26'30.85"E | VERA-3476 | 7065 | 35 | 6016 (95.4%) 5883 | *Raczky* et al. *2010.164* |
| *-ll-* | | Poz-23460 | 7040 | 40 | 6006 (95.4%) 5842 | *Gulyás* et al. *2010.1462* |
| *-ll-* | | Poz-26328 | 6970 | 40 | 5978 (95.4%) 5747 | *Raczky* et al. *2010.164* |
| *-ll-* | | Poz-26327 | 6940 | 40 | 5966 (95.4%) 5730 | *Raczky* et al. *2010.164* |
| *-ll-* | | Poz-23317 | 6890 | 40 | 5882 (95.4%) 5707 | *Gulyás* et al. *2010.1462* |
| *-ll-* | | VERA-3474 | 6890 | 35 | 5873 (95.4%) 5712 | *Raczky* et al. *2010.164* |
| *-ll-* | | Poz-26325 | 6860 | 40 | 5838 (95.4%) 5666 | *Raczky* et al. *2010.164* |
| *-ll-* | | VERA-3540 | 6850 | 35 | 5833 (95.4%) 5661 | *Raczky* et al. *2010.164* |
| *-ll-* | | VERA-3052 | 6755 | 40 | 5726 (95.4%) 5618 | *Raczky* et al. *2010.164* |
| Pitvaros-Viztározó (**31**) | 46°18'1.09"N 20°44'32.98"E | OxA-9336 | 7060 | 45 | 6018 (95.4%) 5845 | *Whittle* et al. *2002.110, 115* |
| Pitvaros-Viztározó | | OxA-9393 | 6940 | 50 | 5974 (95.4%) 5726 | *Whittle* et al. *2002.110, 115* |
| Pitvaros-Viztározó | | OxA-9392 | 6885 | 50 | 5881 (95.4%) 5671 | *Whittle* et al. *2002.110, 115* |
| Röszke-Lúdvár (**32**) | 46°12'52.36"N 19°56'1.82"E | Deb-2730 | 6972 | 59 | 5983 (95.4%) 5738 | *Horváth, Hertelendi 1994.122* |
| Szajol-Felsőföld (**33**) | 47°10'12.34"N 20°17'51.28"E | VERA-3531 | 6805 | 35 | 5738 (95.4%) 5638 | *Raczky 2006.383* |
| Szajol-Felsőföld | | VERA-3051 | 6725 | 35 | 5713 (95.4%) 5566 | *Raczky 2006.383* |
| Szajol-Felsőföld | | VERA-3534 | 6620 | 35 | 5621 (95.4%) 5491 | *Raczky 2006.383* |
| Szarvas 23 (**34**) | 46°51'19.61"N 20°35'1.11"E | OxA-9375 | 6855 | 55 | 5871 (95.4%) 5639 | *Whittle* et al. *2002.111–115* |
| Szarvas 23 | | BM-1866R | 6780 | 110 | 5894 (95.4%) 5491 | *Bowman* et al. *1990.73* |
| Szentpéterszeg-Körtvélyes (**35**) | 47°14'20.46"N 21°35'42.10"E | Bln-2578 | 6800 | 60 | 5835 (95.4%) 5617 | *Oross, Siklosi 2012.Tab. 1* |
| Szolnok-Szanda (**36**) | 47° 7'12.70"N 20°11'57.79"E | Bln-1938 | 7005 | 80 | 6018 (95.4%) 5732 | *Oross, Siklosi 2012.Tab. 1* |
| Szolnok-Szanda | | Bln-1946 | 7005 | 80 | 6018 (95.4%) 5732 | *Oross, Siklosi 2012.Tab. 1* |
| Szolnok-Szanda | | Bln-2576 | 6940 | 60 | 5981 (95.4%) 5718 | *Oross, Siklosi 2012.Tab. 1* |
| Szolnok-Szanda | | Poz-37861 | 6910 | 40 | 5886 (95.4%) 5721 | *Oross, Siklosi 2012.Tab. 1* |
| Szolnok-Szanda | | OxA-23754 | 6859 | 34 | 5836 (95.4%) 5667 | *Oross, Siklosi 2012.Tab. 1* |
| Szolnok-Szanda | | Bln-2577 | 6790 | 70 | 5837 (95.4%) 5564 | *Oross, Siklosi 2012.Tab. 1* |
| Szolnok-Szanda | | Poz-37860 | 6770 | 40 | 5726 (95.4%) 5626 | *Oross, Siklosi 2012.Tab. 1* |
| Szolnok-Szanda | | OxA-23756 | 6713 | 33 | 5707 (95.4%) 5562 | *Oross, Siklosi 2012.Tab. 1* |
| Szolnok-Szanda | | OxA-23755 | 6713 | 32 | 5707 (95.4%) 5562 | *Oross, Siklosi 2012.Tab. 1* |
| Szolnok-Szanda | | OxA-23753 | 6688 | 35 | 5665 (95.4%) 5541 | *Oross, Siklosi 2012.Tab. 1* |
| Szolnok-Szanda | | OxA-23752 | 6554 | 32 | 5606 (95.4%) 5474 | *Oross, Siklosi 2012.Tab. 1* |
| Tiszaszőlős-Doma-háza-puszta (**37**) | 47°10'53.07"N 18°59'18.34"E | Deb-11890 | 6920 | 50 | 5969 (95.4%) 5716 | *Domboróczki, Raczky 2010b. 152, Tab. 1* |
| *-ll-* | | OxA-20238 | 6789 | 37 | 5731 (95.4%) 5632 | *ibid.* |
| *-ll-* | | Deb-11902 | 6780 | 65 | 5807 (95.4%) 5561 | *ibid.* |
| *-ll-* | | OxA-20237 | 6776 | 34 | 5724 (95.4%) 5631 | *ibid.* |

| Site (No. on the Fig. 1) | Coordinates | Lab. No | Uncal. BP | St. error | Cal BC | Reference |
|---|---|---|---|---|---|---|
| Tiszaszőlős-Doma-háza-puszta | | OxA-20239 | 6775 | 40 | 5729 (95.4%) 5627 | *Domboróczki, Raczky 2010b. 152, Tab. 1* |
| *-II-* | | Deb-11804 | 6740 | 60 | 5736 (95.4%) 5547 | *ibid.* |
| *-II-* | | OxA-20236 | 6673 | 35 | 5657 (95.4%) 5531 | *ibid.* |
| *-II-* | | Deb-12962 | 6657 | 65 | 5701 (95.4%) 5481 | *ibid.* |
| *-II-* | | Deb-11898 | 6550 | 95 | 5639 (95.4%) 5326 | *ibid.* |
| *-II-* | | Deb-13045 | 6462 | 48 | 5492 (95.4%) 5324 | *László Domboróczki 2012.108* |
| *-II-* | | VERA-4243 | 6245 | 30 | 5309 (95.4%) 5076 | *ibid.* |
| | | | **BULGARIA** | | | |
| Azmak (**1**) | 42°27'6.06"N 25°43'0.61"E | Bln-293 | 7303 | 150 | 6452 (95.4%) 5901 | *Görsdorf, Bojadžiev 1996. 133–136* |
| Azmak | | Bln-291 | 7158 | 150 | 6361 (95.4%) 5739 | *ibid.* |
| Azmak | | Bln-292 | 6878 | 100 | 5982 (95.4%) 5625 | *ibid.* |
| Azmak | | Bln-294 | 6768 | 100 | 5877 (95.4%) 5494 | *ibid.* |
| Azmak | | Bln-296 | 6779 | 100 | 5886 (95.4%) 5516 | *ibid.* |
| Azmak | | Bln-295 | 6720 | 100 | 5808 (95.4%) 5479 | *ibid.* |
| Azmak | | Bln-203 | 6870 | 100 | 5983 (95.4%) 5621 | *ibid.* |
| Azmak | | Bln-299 | 6812 | 100 | 5968 (95.4%) 5542 | *ibid.* |
| Azmak | | Bln-267 | 6758 | 100 | 5846 (95.4%) 5487 | *ibid.* |
| Azmak | | Bln-224 | 6650 | 150 | 5872 (95.4%) 5317 | *ibid.* |
| Azmak | | Bln-297 | 6675 | 100 | 5776 (95.4%) 5390 | *ibid.* |
| Azmak | | Bln-298 | 6540 | 100 | 5643 (95.4%) 5317 | *ibid.* |
| Azmak | | Bln-300 | 6426 | 150 | 5641 (95.4%) 5043 | *ibid.* |
| Azmak | | Bln-301 | 6483 | 100 (1,3) | 5625 (95.4%) 5231 | *ibid.* |
| Azmak | | Bln-430 | 6279 | 120 | 5479 (95.4%) 4953 | *ibid.* |
| Azmak | | Bln-140A | 6476 | 100 | 5622 (95.4%) 5230 | *ibid.* |
| Chavdar (Čavdar) (**2**) | 42°41'38.57"N 24° 3'1.33"E | Bln-1583 | 6994 | 55 | 5988 (95.4%) 5753 | *Görsdorf, Bojadžiev 1996. 124–126* |
| Chavdar (Čavdar) | | Bln-1580 | 7003 | 45 | 5990 (95.4%) 5775 | *ibid.* |
| Chavdar (Čavdar) | | Bln-2108 | 7195 | 65 | 6221 (95.4%) 5929 | *ibid.* |
| Chavdar (Čavdar) | | Bln-1663 | 7070 | 50 | 6034 (95.4%) 5843 | *ibid.* |
| Chavdar (Čavdar) | | Bln-1582 | 7020 | 45 | 6001 (95.4%) 5796 | *ibid.* |
| Chavdar (Čavdar) | | Bln-1581 | 7000 | 60 | 5995 (95.4%) 5749 | *ibid.* |
| Chavdar (Čavdar) | | Bln-1578 | 6994 | 55 | 5988 (95.4%) 5753 | *ibid.* |
| Chavdar (Čavdar) | | Bln-2662 | 6400 | 100 | 5606 (95.4%) 5080 | *ibid.* |
| Chavdar (Čavdar) | | Bln-2107 | 6550 | 50 | 5619 (95.4%) 5385 | *ibid.* |
| Chavdar (Čavdar) | | Bln-4261 | 7120 | 80 | 6211 (95.4%) 5837 | *ibid.* |
| Chavdar (Čavdar) | | Bln-4106 | 6840 | 50 | 5837 (95.4%) 5639 | *ibid.* |
| Chavdar (Čavdar) | | Bln-1241 | 6852 | 100 | 5981 (95.4%) 5570 | *ibid.* |
| Chavdar (Čavdar) | | Bln-1241 A | 6830 | 100 | 5976 (95.4%) 5560 | *ibid.* |
| Chavdar (Čavdar) | | Bln-1162 | 6400 | 100 | 5606 (95.4%) 5080 | *ibid.* |
| Chavdar (Čavdar) | | Bln-1162 A | 6985 | 100 | 6047 (95.4%) 5676 | *ibid.* |
| Chavdar (Čavdar) | | Bln-1251 | 6997 | 100 | 6059 (95.4%) 5708 | *ibid.* |
| Chavdar (Čavdar) | | Bln-1160 | 6680 | 100 | 5782 (95.4%) 5469 | *ibid.* |
| Chavdar (Čavdar) | | Bln-1160 A | 7040 | 100 | 6085 (95.4%) 5720 | *ibid.* |
| Chavdar (Čavdar) | | Bln-908 | 6990 | 150 | 6207 (95.4%) 5626 | *ibid.* |
| Chavdar (Čavdar) | | Bln-911 | 6870 | 120 | 5998 (95.4%) 5564 | *ibid.* |
| Chavdar (Čavdar) | | Bln-909 | 6815 | 100 | 5970 (95.4%) 5546 | *ibid.* |
| Chavdar (Čavdar) | | Bln-910 | 6665 | 100 | 5753 (95.4%) 5385 | *ibid.* |
| Chavdar (Čavdar) | | Bln-910 A | 6555 | 100 | 5657 (95.4%) 5323 | *ibid.* |
| Chavdar (Čavdar) | | Bln-907 | 6320 | 100 | 5481 (95.4%) 5046 | *ibid.* |
| Chavdar (Čavdar) | | Bln-1030 | 6760 | 100 | 5868 (95.4%) 5488 | *ibid.* |
| Chavdar (Čavdar) | | Bln-906 | 6720 | 100 | 5808 (95.4%) 5479 | *ibid.* |
| Dobrinishte (Dobrinište) (**3**) | 41°51'6.48"N 23°35'4.94"E | Bln-3785 | 6650 | 60 | 5661 (95.4%) 5484 | *Görsdorf, Bojadžiev 1996.127* |

| Site (No. on the Fig. 1) | Coordinates | Lab. No | Uncal. BP | St. error | Cal BC | Reference |
|---|---|---|---|---|---|---|
| Dobrinishte (Dobrinište) | | Bln-3786 | 6610 | 50 | 5623 (95.4%) 5483 | *Görsdorf, Bojadžiev 1996.127* |
| Džuljunica-Smărdeš (**15**) | 43° 7'17.50"N 25°54'17.44"E | OxA–25045 | 6686 | 39 | 5669 (95.4%) 5531 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–25047 | 7140 | 40 | 6075 (95.4%) 5920 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–25046 | 6950 | 40 | 5971 (95.4%) 5736 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–24981 | 7185 | 40 | 6205 (95.4%) 5987 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–25043 | 7055 | 40 | 6013 (95.4%) 5846 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–24977 | 7136 | 40 | 6073 (95.4%) 5919 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–24978 | 7054 | 39 | 6012 (95.4%) 5847 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–24939 | 7171 | 36 | 6094 (95.4%) 5985 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–24935 | 7026 | 35 | 5995 (95.4%) 5840 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–24931 | 7066 | 38 | 6020 (95.4%) 5878 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–24932 | 7053 | 35 | 6010 (95.4%) 5849 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–25040 | 7049 | 39 | 6008 (95.4%) 5846 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–24938 | 7134 | 35 | 6067 (95.4%) 5923 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–25044 | 7095 | 40 | 6048 (95.4%) 5896 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–24979 | 7145 | 38 | 6075 (95.4%) 5925 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–25033 | 7084 | 36 | 6026 (95.4%) 5891 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–24980 | 7011 | 38 | 5990 (95.4%) 5802 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–24937 | 7588 | 37 | 6491 (95.4%) 6396 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–25042 | 7095 | 40 | 6048 (95.4%) 5896 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–24934 | 7195 | 37 | 6205 (95.4%) 5995 | *Krauß* et al. *2014.51–77* |
| *-II-* | | OxA–24936 | 7083 | 36 | 6025 (95.4%) 5892 | *Krauß* et al. *2014.51–77* |
| Eleshnitsa (Elešnitsa, Elešnica) (**4**) | 41°54'33.91"N 23°39'54.10"E | Bln-3238 | 7010 | 60 | 6002 (95.4%) 5758 | *Görsdorf, Bojadžiev 1996.126–127* |
| Eleshnitsa | | Bln-3241 | 6960 | 60 | 5982 (95.4%) 5730 | *Görsdorf, Bojadžiev 1996.126–127* |
| Eleshnitsa | | Bln-3242 | 6940 | 50 | 5974 (95.4%) 5726 | *Görsdorf, Bojadžiev 1996.126–127* |
| Eleshnitsa | | Bln-3239 | 6920 | 60 | 5978 (95.4%) 5677 | *Görsdorf, Bojadžiev 1996.126–127* |
| Eleshnitsa | | Bln-3940 | 6850 | 50 | 5841 (95.4%) 5643 | *Görsdorf, Bojadžiev 1996.126–127* |
| Eleshnitsa | | Bln-3245 | 6730 | 90 | 5786 (95.4%) 5485 | *Görsdorf, Bojadžiev 1996.126–127* |
| Eleshnitsa | | Bln-3237 | 6790 | 50 | 5762 (95.4%) 5620 | *Görsdorf, Bojadžiev 1996.126–127* |
| Eleshnitsa | | Bln-3244 | 6720 | 70 | 5736 (95.4%) 5514 | *Görsdorf, Bojadžiev 1996.126–127* |
| Galabnik (**5**) | 42°26'49.35"N 23° 5'54.29"E | Bln-3580 | 7120 | 70 | 6205 (95.4%) 5842 | *Görsdorf, Bojadžiev 1996.122–123* |
| Galabnik | | Bln-3579 | 7030 | 70 | 6022 (95.4%) 5752 | *Görsdorf, Bojadžiev 1996.122–123* |
| Galabnik | | Bln-3579 H | 7220 | 80 | 6245 (95.4%) 5920 | *Görsdorf, Bojadžiev 1996.122–123* |
| Galabnik | | Bln-3582 | 6950 | 70 | 5986 (95.4%) 5719 | *Görsdorf, Bojadžiev 1996.122–123* |
| Galabnik | | Bln-3581 | 6790 | 80 | 5870 (95.4%) 5551 | *Görsdorf, Bojadžiev 1996.122–123* |
| Galabnik | | GrN-19786 | 7070 | 180 | 6352 (95.4%) 5632 | *Görsdorf, Bojadžiev 1996.122–123* |
| Galabnik | | GrN-19785 | 7020 | 60 | 6010 (95.4%) 5763 | *Görsdorf, Bojadžiev 1996.122–123* |
| Galabnik | | GrN-19784 | 7070 | 60 | 6060 (95.4%) 5812 | *Görsdorf, Bojadžiev 1996.122–123* |
| Galabnik | | Bln-4095 | 7020 | 150 | 6211 (95.4%) 5643 | *Görsdorf, Bojadžiev 1996.122–123* |
| Galabnik | | Bln-4096 | 7140 | 80 | 6213 (95.4%) 5849 | *Görsdorf, Bojadžiev 1996.122–123* |
| Galabnik | | Bln-4094 | 6760 | 80 | 5834 (95.4%) 5527 | *Görsdorf, Bojadžiev 1996.122–123* |
| Galabnik | | Bln-4093 | 7100 | 80 | 6203 (95.4%) 5783 | *Görsdorf, Bojadžiev 1996.122–123* |
| Galabnik | | GrN-19783 | 6970 | 50 | 5981 (95.4%) 5740 | *Görsdorf, Bojadžiev 1996.122–123* |
| Galabnik | | Bln-4091 | 6760 | 60 | 5751 (95.4%) 5558 | *Görsdorf, Bojadžiev 1996.122–123* |
| Galabnik | | Bln-4092 | 6710 | 60 | 5723 (95.4%) 5529 | *Görsdorf, Bojadžiev 1996.122–123* |
| Galabnik | | Bln-3576 | 6670 | 70 | 5706 (95.4%) 5486 | *Görsdorf, Bojadžiev 1996.122–123* |
| Karanovo (**6**) | 42°30'45.67"N 25°54'55.43"E | Bln-4339 | 7090 | 90 | 6203 (95.4%) 5750 | *Görsdorf, Weninger 1993; Gorsdorf, Bojadziev 1996.133–136; Kohl, Quitta 1966; Quitta, Kohl 1969.37* |

| Site (No. on the Fig. 1) | Coordinates | Lab. No | Uncal. BP | St. error | Cal BC | Reference |
|---|---|---|---|---|---|---|
| Karanovo | | Bln-4336 | 7110 | 50 | 6067 (95.4%) 5892 | *ibid.* |
| Karanovo | | Bln-4338 | 6955 | 45 | 5975 (95.4%) 5736 | *ibid.* |
| Karanovo | | Bln-4337 | 6810 | 65 | 5842 (95.4%) 5618 | *ibid.* |
| Karanovo | | Bln-4335 | 6710 | 55 | 5719 (95.4%) 5535 | *ibid.* |
| Karanovo | | Bln-3942 | 6820 | 50 | 5803 (95.4%) 5629 | *ibid.* |
| Karanovo | | Bln-4177 | 7110 | 50 | 6067 (95.4%) 5892 | *ibid.* |
| Karanovo | | Bln-4179 | 7130 | 70 | 6206 (95.4%) 5846 | *ibid.* |
| Karanovo | | Bln-4178 | 6730 | 80 | 5756 (95.4%) 5490 | *ibid.* |
| Karanovo | | Bln-3943 | 6760 | 50 | 5736 (95.4%) 5569 | *ibid.* |
| Karanovo | | Bln-3941 | 6750 | 50 | 5732 (95.4%) 5565 | *ibid.* |
| Karanovo | | Bln-3944 | 6785 | 60 | 5794 (95.4%) 5566 | *ibid.* |
| Karanovo | | Bln-3716 | 6910 | 60 | 5972 (95.4%) 5674 | *Görsdorf, Weninger 1993; Gorsdorf, Bojadziev 1996.133–136; Kohl, Quitta 1966; Quitta, Kohl 1969.37* |
| Karanovo | | Bln-3716 H | 6850 | 60 | 5873 (95.4%) 5635 | *ibid.* |
| Karanovo | | Bln-3586 | 6780 | 60 | 5788 (95.4%) 5565 | *ibid.* |
| Karanovo | | Bln-152 | 6807 | 100 | 5966 (95.4%) 5536 | *ibid.* |
| Karanovo | | Bln-201 | 6540 | 100 | 5643 (95.4%) 5317 | *ibid.* |
| Karanovo | | Bln-234 | 6490 | 150 | 5716 (95.4%) 5079 | *ibid.* |
| Karanovo | | Bln-3904 | 6375 | 70 | 5476 (95.4%) 5224 | *ibid.* |
| Karanovo | | Bln-3458 | 6440 | 60 | 5509 (95.4%) 5309 | *ibid.* |
| Karanovo | | Bln-3459 | 6420 | 60 | 5491 (95.4%) 5236 | *ibid.* |
| Karanovo | | Bln-3460 | 6440 | 60 | 5509 (95.4%) 5309 | *ibid.* |
| Karanovo | | Bln-3461 | 6480 | 60 | 5545 (95.4%) 5321 | *ibid.* |
| Karanovo | | Bln-3464 | 6500 | 50 | 5602 (95.4%) 5358 | *ibid.* |
| Karanovo | | Bln-3463 | 6350 | 60 | 5469 (95.4%) 5221 | *ibid.* |
| Karanovo | | Bln-3465 | 6410 | 60 | 5486 (95.4%) 5232 | *ibid.* |
| Karanovo | | Bln-3587 | 6380 | 60 | 5476 (95.4%) 5227 | *ibid.* |
| Karanovo | | Bln-3717 | 6450 | 60 | 5513 (95.4%) 5315 | *ibid.* |
| Karanovo | | Bln-3717 H | 6510 | 60 | 5613 (95.4%) 5345 | *ibid.* |
| Karanovo | | Bln-158 | 6395 | 100 | 5558 (95.4%) 5079 | *ibid.* |
| Kazanlak (**7**) | 42°38'14.05"N 25°23'39.76"E | Bln-730 | 6335 | 160 | 5616 (95.4%) 4935 | *Georgiev 1974; Nikolov, Karastoyanova 2003* |
| Kazanlak | | Bln-729 | 6330 | 100 | 5482 (95.4%) 5053 | *ibid.* |
| Kovachevo (Kovačevo) (**8**) | 41°30'20.16"N 23°28'11.55"E | Ly-1437 (OxA) | 7180 | 45 | 6207 (95.4%) 5983 | *Grebska-Kulova 2008; Lichardus-Itten* et al. *2000; 2002; 2006; Kovacheva 1995; Pemitcheva 1990* |
| Kovachevo | | Ly-1654 (OxA) | 7090 | 70 | 6081 (95.4%) 5796 | *ibid.* |
| Kovachevo | | Ly-1439 (OxA) | 6975 | 50 | 5982 (95.4%) 5743 | *ibid.* |
| Kovachevo | | Ly-1438 (OxA) | 6990 | 45 | 5984 (95.4%) 5764 | *ibid.* |
| Kovachevo | | Ly-1620 (OxA) | 6980 | 65 | 5988 (95.4%) 5737 | *ibid.* |
| Kovachevo | | Ly-6553 | 6760 | 160 | 5992 (95.4%) 5385 | *ibid.* |
| Kovachevo | | Ly-6554 | 6830 | 85 | 5963 (95.4%) 5566 | *ibid.* |
| Kremenik (Sapareva Bania) (Sapareva Banja) (**9**) | 42°22'0.09"N 23° 3'53.50"E | Bln-2554 | 6620 | 100 | 5720 (95.4%) 5377 | *Görsdorf, Bojadžiev 1996.127–128* |
| Kremenik | | Bln-2552 | 6460 | 60 | 5524 (95.4%) 5317 | *Görsdorf, Bojadžiev 1996.127–128* |
| Kremenik | | Bln-2554A | 6840 | 60 | 5868 (95.4%) 5629 | *Görsdorf, Bojadžiev 1996.127–128* |
| Kremenik | | Bln-2553 | 6660 | 60 | 5671 (95.4%) 5483 | *Görsdorf, Bojadžiev 1996.127–128* |
| Kremenik | | Bln-2105 | 6530 | 50 | 5612 (95.4%) 5376 | *Görsdorf, Bojadžiev 1996.127–128* |
| Kremenik | | Bln-2556 | 6480 | 60 | 5545 (95.4%) 5321 | *Görsdorf, Bojadžiev 1996.127–128* |
| Kremenik | | Bln-2106 | 6475 | 40 | 5516 (95.4%) 5357 | *Görsdorf, Bojadžiev 1996.127–128* |
| Kremenik | | Bln-2550 | 6550 | 60 | 5621 (95.4%) 5379 | *Görsdorf, Bojadžiev 1996.127–128* |
| Kremenik | | Bln-2551 | 6450 | 100 | 5613 (95.4%) 5224 | *Görsdorf, Bojadžiev 1996.127–128* |

| Site (No. on the Fig. 1) | Coordinates | Lab. No | Uncal. BP | St. error | Cal BC | Reference |
|---|---|---|---|---|---|---|
| Kremenik | | Bln-2549 | 6350 | 60 | 5469 (95.4%) 5221 | *Görsdorf, Bojadžiev 1996.127–128* |
| Ohoden (**12**) | 43°23'7.84"N 23°42'49.36"E | KN-5655 | 6830 | 45 | 5803 (95.4%) 5636 | *Ganetovski, G. 2007* |
| Ovčarovo-gorata (**13**) | 43° 6'43.05"N 26°39'13.20"E | Bln-1544 | 6688 | 60 | 5715 (95.4%) 5511 | *Görsdorf, Bojadžiev 1996.128–129* |
| Ovčarovo-gorata | | Bln-1620 | 6463 | 50 | 5509 (95.4%) 5324 | *Görsdorf, Bojadžiev 1996.128–129* |
| Ovčarovo-gorata | | Bln-2032 | 6555 | 70 | 5625 (95.4%) 5376 | *Görsdorf, Bojadžiev 1996.128–129* |
| Ovčarovo-gorata | | Poz–16984 | 6890 | 40 | 5882 (95.4%) 5707 | *Krauß 2014.174–200* |
| Ovčarovo-gorata | | Poz–16985 | 6890 | 40 | 5882 (95.4%) 5707 | *Krauß 2014.174–200* |
| Ovčarovo-gorata | | Poz–16986 | 6500 | 40 | 5535 (95.4%) 5371 | *Krauß 2014.174–200* |
| Ovčarovo-gorata | | Poz–18480 | 6900 | 40 | 5881 (95.4%) 5716 | *Krauß 2014.174–200* |
| Ovčarovo-gorata | | Poz–18483 | 6750 | 40 | 5726 (95.4%) 5575 | *Krauß 2014.174–200* |
| Ovčarovo-gorata | | Poz–18484 | 6640 | 40 | 5632 (95.4%) 5494 | *Krauß 2014.174–200* |
| Ovčarovo-gorata | | Poz–18486 | 6800 | 40 | 5741 (95.4%) 5631 | *Krauß 2014.174–200* |
| Ovčarovo-gorata | | Poz–18487 | 6660 | 40 | 5646 (95.4%) 5512 | *Krauß 2014.174–200* |
| Ovčarovo-gorata | | Poz–18489 | 6750 | 40 | 5726 (95.4%) 5575 | *Krauß 2014.174–200* |
| Ovčarovo-gorata | | Poz–18490 | 6780 | 40 | 5730 (95.4%) 5628 | *Krauß 2014.174–200* |
| Ovčarovo-gorata | | Poz–18491 | 6810 | 40 | 5754 (95.4%) 5631 | *Krauß 2014.174–200* |
| Ovčarovo-gorata | | Poz–18493 | 6670 | 40 | 5659 (95.4%) 5522 | *Krauß 2014.174–200* |
| Ovčarovo-gorata | | Poz–18494 | 6690 | 40 | 5674 (95.4%) 5529 | *Krauß 2014.174–200* |
| Ovcharovo-platoto 2 (Ovčarovo-platoto 2) (**16**) | 43°11'39"N 26°38'12"E | Bln-1356 | 6480 | 60 | 5545 (95.4%) 5321 | *Görsdorf, Bojadžiev 1996.129* |
| Polyanitsa-platoto (Poljanica-platoto) (**14**) | 43°14'30.22"N 26°35'29.18"E | Bln-1571 | 7535 | 80 | 6563 (95.4%) 6230 | *Görsdorf, Bojadžiev 1996.121–122* |
| Polyanitsa-platoto | | Bln-1512 | 7140 | 80 | 6213 (95.4%) 5849 | *Görsdorf, Bojadžiev 1996.121–122* |
| Polyanitsa-platoto | | Bln-1613 | 7380 | 60 | 6392 (95.4%) 6094 | *Görsdorf, Bojadžiev 1996.121–122* |
| Polyanitsa-platoto | | Bln-1613 A | 7275 | 60 | 6242 (95.4%) 6020 | *Görsdorf, Bojadžiev 1996.121–122* |
| Slatina (**10**) | 42°41'18.06"N 23°21'56.18"E | Bln-3434 | 6890 | 60 | 5963 (95.4%) 5661 | *Görsdorf, Bojadžiev 1996* |
| Slatina | | Bln-3435 | 6860 | 50 | 5869 (95.4%) 5644 | *Görsdorf, Bojadžiev 1996* |
| Slatina | | Bln-3436 | 6840 | 60 | 5868 (95.4%) 5629 | *Görsdorf, Bojadžiev 1996* |
| Slatina | | Bln-3437 | 6810 | 50 | 5789 (95.4%) 5626 | *Görsdorf, Bojadžiev 1996* |
| Slatina | | Bln-3438 | 6960 | 60 | 5982 (95.4%) 5730 | *Görsdorf, Bojadžiev 1996* |
| Slatina | | Bln-3439 | 6940 | 60 | 5981 (95.4%) 5718 | *Görsdorf, Bojadžiev 1996* |
| Slatina | | Bln-3440 | 6840 | 60 | 5868 (95.4%) 5629 | *Görsdorf, Bojadžiev 1996* |
| Slatina | | Bln-3441 | 6960 | 60 | 5982 (95.4%) 5730 | *Görsdorf, Bojadžiev 1996* |
| Slatina | | Bln-3442 | 6780 | 60 | 5788 (95.4%) 5565 | *Görsdorf, Bojadžiev 1996* |
| Slatina | | Bln-3443 | 6840 | 60 | 5868 (95.4%) 5629 | *Görsdorf, Bojadžiev 1996* |
| Slatina | | Bln-3504 | 6970 | 60 | 5983 (95.4%) 5736 | *Görsdorf, Bojadžiev 1996* |
| Slatina | | Bln-3555 | 6930 | 60 | 5980 (95.4%) 5712 | *Görsdorf, Bojadžiev 1996* |
| Stara Zagora-Okrazhna bolnitsa (Okražna Bolnica) (**11**) | 42°25'45.00"N 25°36'17.97"E | Bln-1587 | 7139 | 65 | 6207 (95.4%) 5886 | *Görsdorf, Bojadžiev 1996* |
| *-ll-* | | Bln-1586 | 6814 | 65 | 5843 (95.4%) 5619 | *Görsdorf, Bojadžiev 1996* |
| *-ll-* | | Bln-1589 | 6918 | 45 | 5902 (95.4%) 5717 | *Görsdorf, Bojadžiev 1996* |
| *-ll-* | | Bln-1252 | 6844 | 100 | 5979 (95.4%) 5565 | *Görsdorf, Bojadžiev 1996* |
| *-ll-* | | Bln-1250 | 6820 | 100 | 5972 (95.4%) 5556 | *Görsdorf, Bojadžiev 1996* |
| *-ll-* | | Bln-1163 | 6688 | 150 | 5896 (95.4%) 5345 | *Görsdorf, Bojadžiev 1996* |
| *-ll-* | | Bln-1588 | 6750 | 60 | 5743 (95.4%) 5555 | *Görsdorf, Bojadžiev 1996* |
| *-ll-* | | Bln-1164 | 6723 | 100 | 5809 (95.4%) 5480 | *Görsdorf, Bojadžiev 1996* |
| *-ll-* | | Bln-1164 | 6744 | 100 | 5837 (95.4%) 5487 | *Görsdorf, Bojadžiev 1996* |

Note: the full code for the data analysis is available from M. Porčić on request.

# Neolithic Thessaly: radiocarbon dated periods and phases

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ABSTRACT – *Thessaly in Central Greece is famous for settlement mounds (magoules) that were already partly formed in the Early Neolithic period. Some of these long-lived sites grew to many metres in height during the subsequent Middle, Late and Final Neolithic periods, and were also inhabited in the Bronze Age. Such magoules served as the backbone for defining relative chronological schemes. However, their absolute dating is still a topic of debate: due to a lack of well-defined sequences, different chronological schemes have been proposed. New radiocarbon dates obtained in the last few years allow a better understanding of the duration not only of the main Neolithic periods, but also of the different phases and sub-phases.*

KEY WORDS – *Thessaly; Neolithic; radiocarbon dates; absolute and relative chronology*

## *Neolitska Tesalija: Radiokarbonsko datirana obdobja in faze*

IZVLEČEK – *Pokrajina Tesalija v osrednji Grčiji ima ohranjene številne naselbinske gomile (magoules), ki so nastale že v obdobju zgodnjega neolitika. Nekatera od teh dolgoživih najdišč so merila tudi več metrov v višino v kasnejših neolitskih obdobjih (v srednjem, poznem in finalnem neolitiku), poseljena pa so bila še tudi v času bronaste dobe. Te naselbine so predstavljale osnovo pri definiranju relativnih kronoloških shem. Zaradi pomanjkanja dobro definiranih stratigrafskih sekvenc pa ostajajo njihove absolutne datacije predmet številnih razprav in različnih kronoloških shem. V preteklih letih smo pridobili številne nove radiokarbonske datume, ki nam nudijo boljši vpogled v trajanje tako neolitskega obdobja v celoti kot tudi vpogled v časovno razdelitev posameznih neolitskih faz in podfaz v Tesaliji.*

KLJUČNE BESEDE – *Tesalija; neolitik; radiokarbonski datumi; absolutna in relativna kronologija*


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## Introduction: early investigations and the first radiocarbon dates

The first scientific investigations of Neolithic sites in Thessaly were conducted in its south-eastern areas, close to the Pagasitic Gulf (the Regional Unit of Magnesia – compare Figure 1). Situated in the hilly areas west of the modern city of Volos and close to the village of Sesklo, the prehistoric eponymous *magoula* was investigated more than a century ago by Christos Tsountas, in 1901–1902 (*Tsountas 1908*). The excavations revealed a lengthy stratigraphic succession covering all periods of the Neolithic, although in today's perception the earlier periods at the site are more prominent. Simultaneously, the nearby site of Dimini became famous for the later and final periods of the Neolithic. These findings gave rise to international as well as Greek interest in Thessalian *magoules* (*e.g., Arvanitopoulos 1910*); British archaeologists (*Wace, Thompson 1912*) recorded and occasionally investigated some Thessalian *magoules*.

With comprehensive publications by French (*Béquignon 1932.89–191*) and German (*Grundmann 1932. 102–123*) researchers in the 1930s, international interest in Neolithic Thessaly intensified. In 1941, excavations based on a extorted permit were carried out in Visviki Magoula by Hans Reinerth and his team from the universities of Berlin and Tübingen (*Alram-Stern, Dousougli-Zachos 2015*). Thanks in part to the intervention of the German Archaeological Institute in Athens, the work permit was not renewed in 1942 (*Hauptmann 2015.2*). More than a decade later, the prolific German-Greek collaboration between Vladimir Milojčić and Dimitrios R. Theocharis led to the systematic investigation of *magoules* situated mainly in eastern and southern Thessaly. The excavation methods applied by Milojčić met the highest standards of their time. The interpretation of the finds and their contexts relied largely on his highly erudite chronological scheme, which was based on a relative chronological approach supported by, and developed from, the method of comparative stratigraphy. According to this method, all relevant stratigraphic sequences from north-eastern Africa, the Near East and Southeast Europe were compared and tied together in a supraregional, not to say intercontinental perspective. The expectations of the Neolithic in Greece were thus not unbiased, since Milojčić's interpretations of both the beginning and end of the period were largely influenced by his view from the North (the Balkans with the Starčevo and Vinča cultures – (*Milojčić 1950/51.54–63*) and from the East (the Near East with the PPN – *Milojčić 1956*).

Milojčić's relative chronological appraisals were challenged in the late 1950s by the new and indeed revolutionary radiocarbon dates. Due to his premature death in 1978, Milojčić did not have the chance to re-appraise his views. In his last critical article on this topic (*Milojčić 1973.3–11*), he points to the contradictions not only between relative and absolute chro-

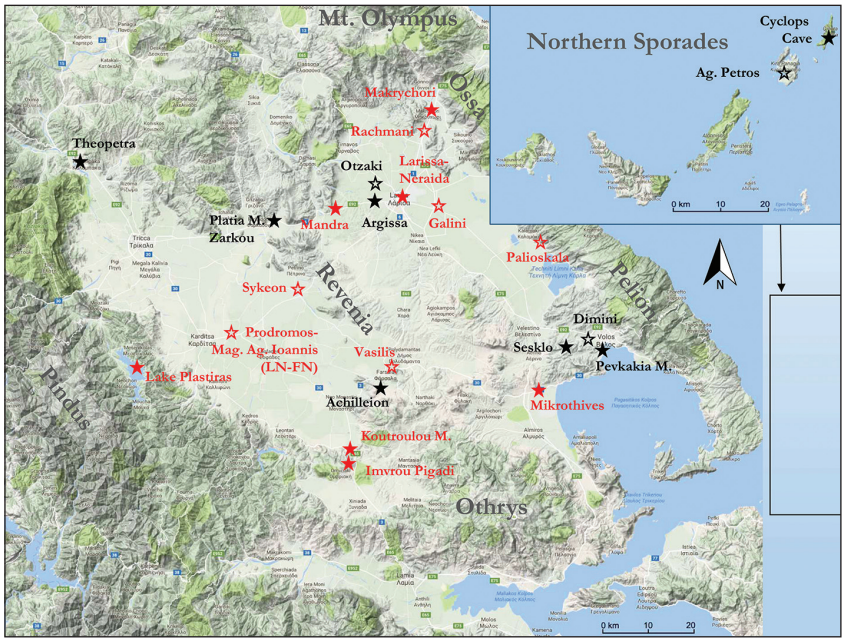



***Fig. 1. Thessaly: the vast plain (approx. 14 000km²) surrounded by steep mountains is divided by the Mid-Thessalian Hills (Revenia) into eastern and western parts; Magnesia with the islands of the Northern Sporades and the zone around the Pagasitic Gulf is also part of Thessaly (included in the study area is the municipality of Domokos in the northern Phthiotis). Only radiocarbon dated sites from the Neolithic are plotted (c. 6500–3300 cal BC): rendered in black are the 10 sites that were radiocarbon dated between the 1960s and 1990s; recently dated 13 sites are in red. Filled-in stars: sequences with four or more dates per site and phase; empty stars: 1–3 dates per site and phase (background for the map from URL: https://www.google.de/maps).***

nology, but also to the discrepancy between astronomical and radiocarbon years. And indeed, the first internationally accepted calibration curve was achieved only in late 1985 (*Stuiver, Becker 1986*). His repeated cautioning of an unduly uncritical acceptance of the radiocarbon method might have derived even from the dates obtained on animal bones he himself had excavated in Argissa Magoula in 1958: Reiner Protsch and Rainer Berger (*1973.235–239*) published three highly doubtful dates on bones that led to the assumption that the Early Neolithic (henceforth, EN) started in Thessaly around 7000 BC (for a critique of these dates, compare *Reingruber 2015; Reingruber, Thissen 2016. www.14sea.org/3_IIc.html#*).

Milojčić's critique of the radiocarbon method had a lasting impact on investigations carried out by German-speaking archaeologists in Southeast Europe. Quite to the contrary, investigations by English-speaking archaeologists (*e.g.*, Marija Gimbutas in Achilleion and Colin Renfrew in Sitagroi: *Gimbutas 1974. 283, Tab. 2; Renfrew 1970.280–311*) used the method in their research, with well-known results. Also, Theocharis recognised the radiocarbon method as a

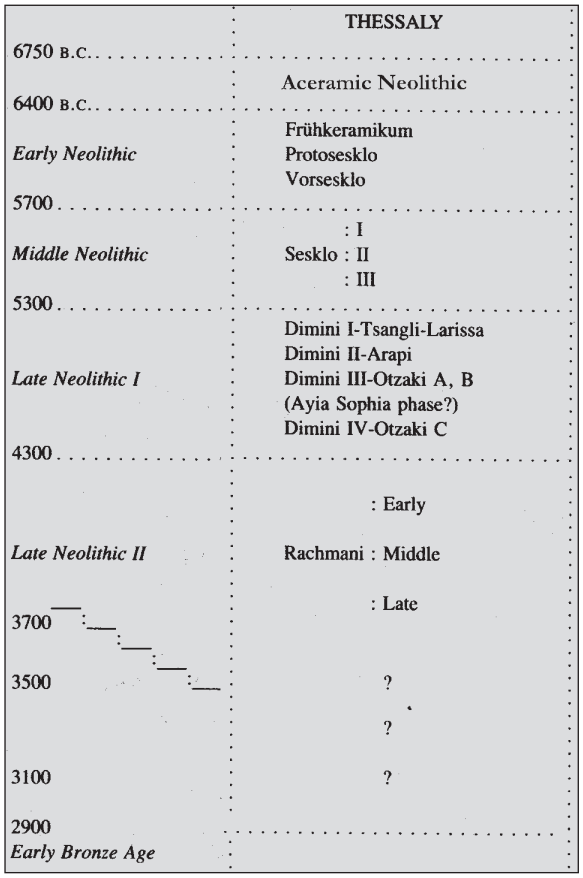



***Fig. 2. Duration of Neolithic periods and their phases as proposed by John Coleman in 1992.***

powerful tool early on, and compiled the available radiocarbon dates not only from Thessaly, but from all over Greece (*Theocharis 1973.119*). He was followed in this approach by younger scholars, *e.g.*, an updated version of his list inclusive of dates from Anatolia was published by Mies H. J. M. N. Wijnen (*1981.130–133*). However, it was not until the end of the 20th century that these dates were analysed in a broader context.

### *First radiocarbon-based appraisals of the duration of Neolithic periods and phases*

The first thorough synthesis based on absolute chronology was developed by John Coleman (*Coleman 1992.206, Fig. 4*). Not only did he bring together both published and hitherto unpublished dates from Greece, he also made them easily comparable by systematically using the calibrated dates, not uncalibrated values. He presented the dates separately for each region and compared the periods and phases obtained by relative chronological assessments accordingly. In this way, the duration of each period and phase became more evident (Fig. 2).

According to the knowledge of that time, the Neolithic period started in Thessaly with a Preceramic (Aceramic) phase comparable to the Pre-Pottery Neolithic in the Near East. Its beginning was almost undisputedly accepted as 7000 BC, being thus coeval with the PPNB in Anatolia. Together with the EN, it should have lasted until 5700 BC. In contrast, the subsequent period of the Middle Neolithic (henceforth, MN) encompassed only a few centuries, from 5700 to 5300 BC. It was followed by the, again, millennium-long phases of the Late Neolithic (henceforth, LN), the LN I ('Dimini': 5300–4300 BC) and LN II ('Rachmani': 4300–3000 BC).

As hardly any dates from Thessaly were available, not even from sites with long stratigraphic sequences, Coleman interpolated the duration of the Thessalian phases by using the results from neighbouring regions, both northern (from Macedonia) and southern (from the Argolid). For example, the dates available for the MN in Serbia started only after 5800 BC (*Coleman 1992.209–210*). The dates from the cave of Franchthi in the Argolid also point to such a late EN–MN transition. Nonetheless, for the earlier periods (EN and MN) the sequence of dates from Achilleion (*Gimbutas 1989.Fig. 3.4* and Fig. 3) could have served as a reliable background. However, Coleman decided in favour of a supra-regional balance between stratigraphic sequences, still very much in the tradition of relative chronological appraisals.

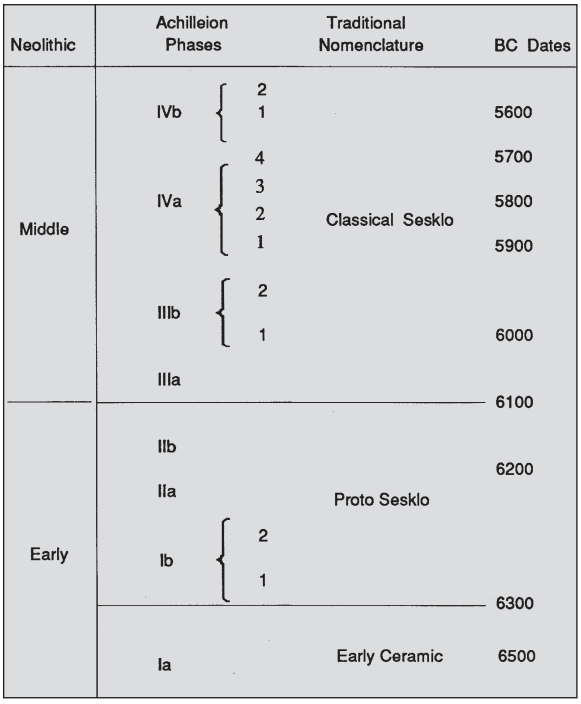



***Fig. 3 Duration of the Early and Middle Neolithic periods and their phases as proposed by Maria Gimbutas in 1989.***

Moreover, he did not verify the quality of these dates (especially not the dates obtained on bones from Argissa Magoula). At that time, it was impossible to determine which dates were more reliable and which were outliers. This is especially the case with the later Neolithic periods, which provided almost no direct evidence, the duration of these phases being more or less guesswork.

Nevertheless, Coleman's scheme became very influential and was often quoted in subsequent studies, in catalogues, handbooks and overviews (*e.g., Papathanasopoulos 1996.28–29, Fig. 3; Alram-Stern 1996.100, Fig. 4; Andreou* et al. *1996.538, Tab. 1*). The duration of the EN and MN periods as well as the transition between the periods around 5800/5700 BC became largely accepted. For the Late Neolithic a competing terminology also came into use: Coleman's LN I there is divided into an LN I and an LN II; Coleman's LN II is labelled as Final Neolithic or Chalcolithic (*Tsirtsoni 2016.19, Tab. 1* and Fig. 4). In order to avoid confusion resulting from the use of the terms 'Late Neolithic II', 'Final Neolithic' or 'Chalcolithic', we follow here the terminology proposed by Hans-Joachim Weißhaar (*1989*) and Zoï Tsirtsoni (*2016*), where 'Final Neolithic' (henceforth, FN) is synonymous with 'Chalcolithic' (henceforth, FN/Ch) and is dated to the second half of the 5th and to the 4th millennium BC. The labels LN I and LN II

| *Date BC* | *Periodization (dominant Aegean terminology)* | *Periodization (alternative Aegean terminology)* | *Thessaly* |
|---|---|---|---|
| **5400** | **Late Neolithic I** | LN Ia | Tsangli-Larissa |
| **5200** | | | Arapi |
| **4800** | **Late Neolithic II** | LN Ib | Otzaki<br>Dimini |
| **4500** | **(Final Neolithic or Chalcolithic)** | LN IIa | Rachmani |
| **4000** | | | |
| **3700** | | LN IIb | Petromagoula<br>Mikrothives |
| **3300** | **Early Bronze Age I** | EBA I | Pefkakia 1-2 |
| **2800** | **Early Bronze Age II** | EBA II | Pefkakia 3 |

***Fig. 4. Duration of the Late and Final Neolithic (Chalcolithic) periods and their phases as proposed by Zoi Tsirtsoni in 2016.***

are used exclusively for the millennium between 5500 and 4500 cal BC.

At the beginning of our century, it became even more evident that the scarcity of dates left serious doubts as to how exactly to define the length of a certain period. Catherine Perlès questioned the long duration of the EN, but in her general appraisal she reverted to the scheme as proposed by Coleman (*Perlès 2001. 92, 99*). Especially in a circum-Aegean perspective, a re-evaluation of the old dates has led to other possible interpretations (*Reingruber, Thissen 2005; 2009; Reingruber 2008*). New dates support these adjustments and substantiate new appraisals.

### *New evidence and new appraisals*

With every decade, more dates become available, and especially in the last few years, sound sets of dates allow for some rectifications. Certainly, these

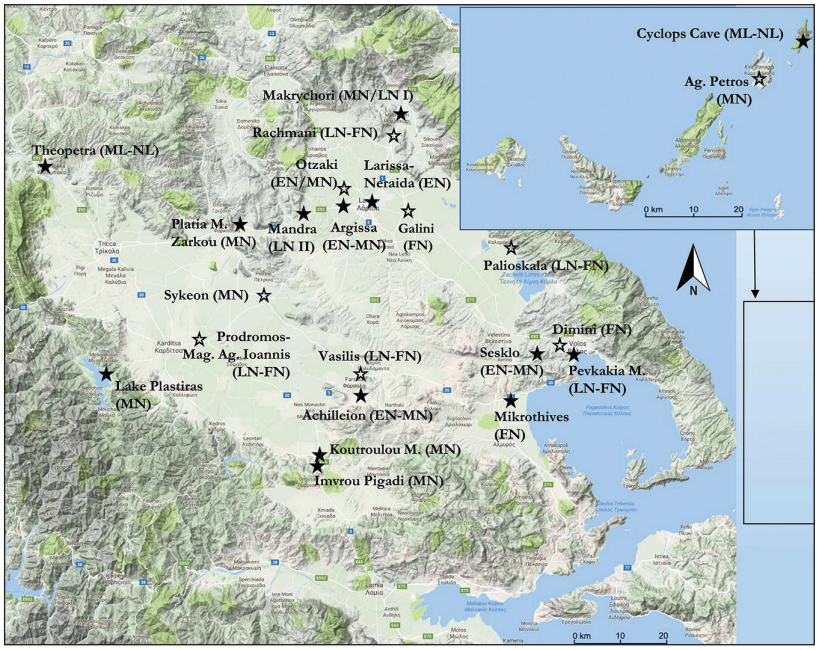



***Fig. 5. Sites with radiocarbon dates for the different periods and phases of the Neolithic Age (c. 6500–3300 cal BC). Filled-in stars: sequences with four or more dates per site and phase; empty stars: 1–3 dates per site and phase (background for the map from URL: https://www.google.de/maps).***

new appraisals must also be considered as provisional: each new sequence will provide new insights. However, future adjustments will probably not be necessary so much in terms of centuries, but rather in terms of decades.

This evaluation relies on the dates from two caves with sequences from both the Mesolithic (henceforth, ML) and the Neolithic (Theopetra Cave and Cyclops Cave) and from 21 open-air Neolithic settlements. Of these, 13 sites have only recently been dated (since 2014 – compare Fig. 1). Many of the new dates derive from early MN sites, especially from sites located in western Thessaly, as well as from sites of the LN and FN/Ch located in particular in eastern Thessaly (Fig. 5).

## The end of the Mesolithic and beginning of the Neolithic in Thessaly (*c.* 6600/6500 cal BC)

The Mesolithic is underrepresented in Thessaly. As is the case in other regions as well, it is very difficult to trace the ephemeral remains of highly mobile groups of people, except in caves where they have been protected from both erosion and alluvial or colluvial coverage. That Mesolithic populations indeed used the terrestrial and marine resources in the region of Thessaly is demonstrated by the two caves situated in its far west (Theopetra: compare *Kyparissi-Apostolika 2000a; 2000b; Facorellis* et al. *2001*) and far east (Cyclops Cave on the island of Youra: compare *Sampson* et al. *2003; Facorellis* et al. *1998*).

In the cave near the modern village of Theopetra, a body of 20 radiocarbon dates shows that the Mesolithic ended there around 6680 cal BC (Tab. 1). Two further dates on charcoal fit into the sequence of the EN, although the first phase is probably not represented. The final publication of the site will certainly allow more detailed interpretations (*Kyparissi-Apostolika* et al. *forthcoming*).

The complicated stratigraphy of the Cyclops Cave is also reflected in the radiocarbon dates, with either many outliers or with samples taken from mixed contexts. The many dates run on shells that needed MRE-corrections (compare Table 2) present another impediment.

Judging by the dates from the two caves, the ML–EN transition must have occurred anywhere between 6680 and 6400 cal BC. In the late 1950s, the transition between the Mesolithic (Epipalaeolithic in Near Eastern terminology) and the Pottery Neolithic was

| Theopetra Cave | | |
|---|---|---|
| **Periods and Phases** | **cal BC 1σ** | **Material** |
| Lower Mesolithic | 8780–7530 | charcoal |
| Upper Mesolithic | 7450–6680 | charcoal and human bones |
| Early Neolithic | 6400–6230 | charcoal |
| Middle Neolithic | 5990–5470 | charcoal |
| Late Neolithic I | 5490–5070 | charcoal |
| Late Neolithic II | 4970–4850 | charcoal |
| Final Neolithic/ Chalcolithic | 4460–4230 | charcoal |

***Tab. 1. Theopetra Cave: three dates with huge standard deviations (>125 years BP) are not included in this table (compare* Reingruber, Thissen 2016*). All dates have been calibrated along the IntCal13 calibration curve (*Reimer *et al.* 2013*), using the OxCal v4.2.4 program throughout this contribution (*Bronk Ramsey 2009*).***

| Cyclops Cave | | |
|---|---|---|
| **Periods and Phases** | **cal BC 1σ** | **Material** |
| Lower Mesolithic | 8600–8350 | charcoal |
| Upper Mesolithic | 8300–6420 | shells (MRE-corrected) and charcoal |
| Early Neolithic | 6450–6030 | shells (MRE-corrected) and charcoal |
| Middle Neolithic | 6070–5670 | bone and charcoal |
| Late Neolithic I | 5300–5000 | shells (MRE-corrected) |
| Neolithic? | 4230–4050 | charcoal |
| Final Neolithic/ Chalcolithic | 3650–3530 | charcoal |

***Tab. 2. Cyclops Cave: the dates on shells are corrected by the Marine Reservoir Effect (MRE), using the ΔR = 167 ± 116 $^{14}$C yr in conjunction with the Marine13 calibration curve (compare* Facorellis, Vardala-Theodorou 2015*; Facorellis et al.* 1998*).***

described as a distinguishable period in human prehistory and labelled the 'Pre-Pottery Neolithic' (PPN) or 'Preceramic Period' (*Milojčić 1956; Theocharis 1973*). Radiocarbon dates from the 1960s seemingly confirmed this interpretation, since *c*. 7000 BC for the 'Preceramic Period' in the Aegean overlaps with the final phase of the PPNB in Anatolia. As has been shown elsewhere (*Reingruber, Thissen 2009*), these early dates are highly dubious. For example, the dates obtained on bones from Argissa Magoula have to be excluded from all future evaluations: they were run on bones before the introduction of the AMS-method; they were published in such a way that the date and the bone sample from which it derived cannot be matched (*Protsch, Berger 1973*) and, in the worst case, they might have been faked (*Reingruber, Thissen 2016: www.14sea.org/3_IIc.html#*). Chronological appraisals relying on the bone samples from Argissa Magoula must therefore be rejected. Moreover, the levels presented as 'Preceramic' contained considerable amounts of sherds that were interpreted by their excavators as intrusions from above (*Reingruber 2008*).

The radiocarbon dates for the EN I levels at the *magoules* of Argissa and Sesklo fit well with the gaps

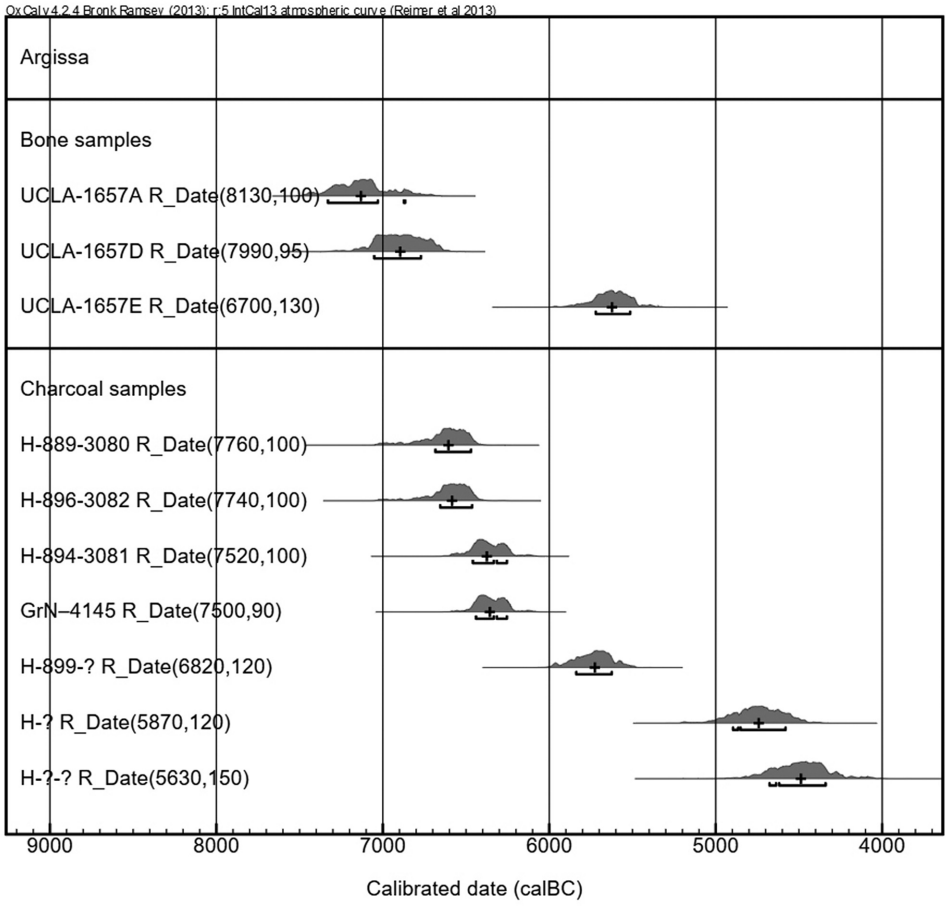



***Fig. 6. Argissa Magoula: note that the bone samples published in 1973 are erroneous and that the reliable sequence starts with the charcoal samples, for which 6600 cal BC serves as a terminus post quem (*Reingruber 2008.157*).***

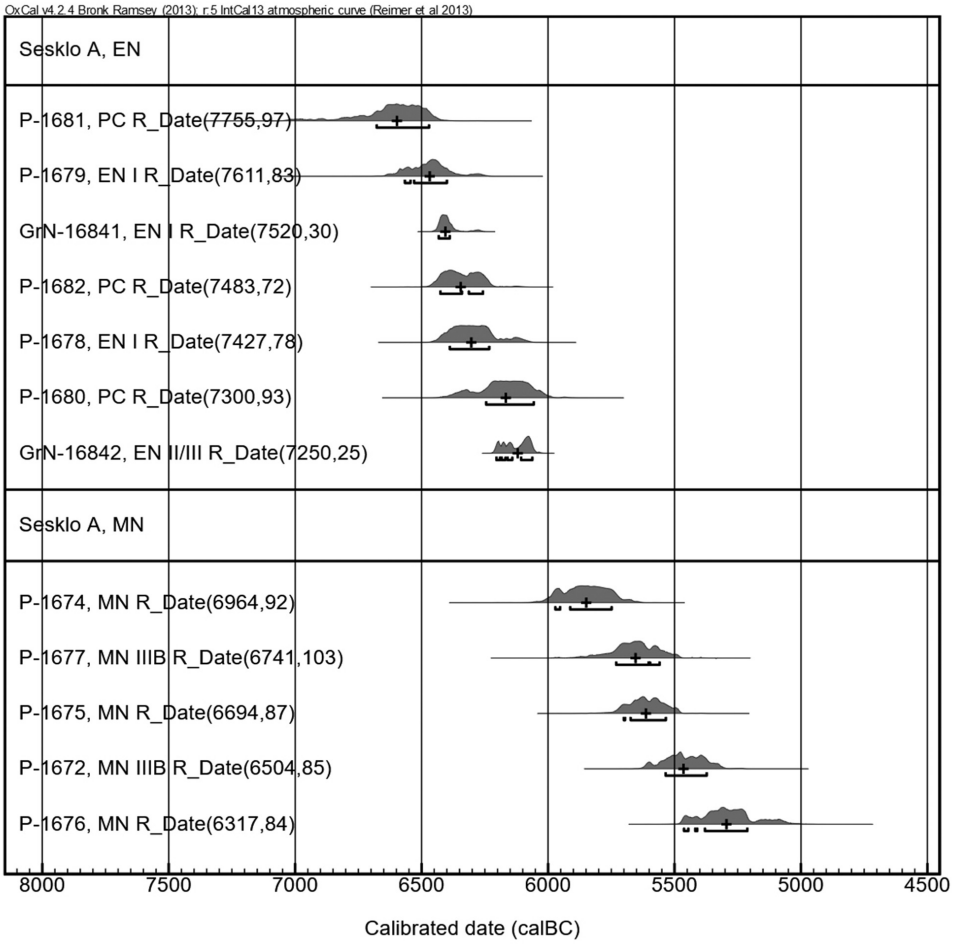



***Fig. 7. Sesklo Magoula (or Sesklo A): all dates are on charcoal (*Lawn 1975*).***

in the sequences of the caves mentioned above (Figs. 6 and 7). In a circum-Aegean perspective, this interpretation coincides well with the newly obtained dates from Ulucak, Çukuriçi Höyük, Franchthi and Paliambela-Kolindros (dates and references are compiled in *Reingruber, Thissen 2016*). Some of the earliest sites dated to around 6650 cal BC may have at their base a thin 'Aceramic' level, but they are exceptions rather than the rule. It could be further argued that the Thessalian dates are some decades younger: If it is accepted that the four oldest charcoal samples from Argissa Magoula (three from so-called pits and one from level 28b above them) do indeed belong to the same phase of the EN I (compare *Reingruber 2008.Tab. 3.1*), then their combined result post-dates 6500 cal BC (Fig. 8). Even this result must be regarded as a *terminus post quem* (TPQ), since the charcoal derived from unknown wood species: the old-wood effect can thus not be excluded (compare *Reingruber, Thissen 2009; 2016*). Therefore, a re-evaluation of the old dates from Argissa and Sesklo shows that the beginning of the EN in Thessaly can be dated

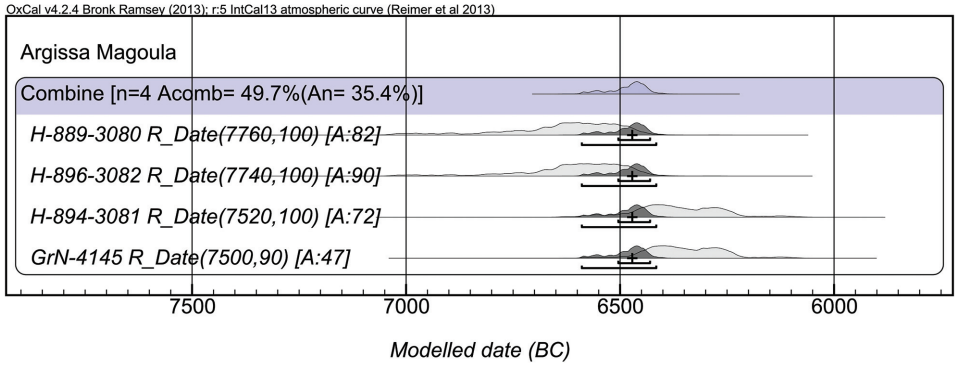



***Fig. 8. Argissa Magoula and the beginning of the Neolithic as resulting from combining the charcoal dates.***

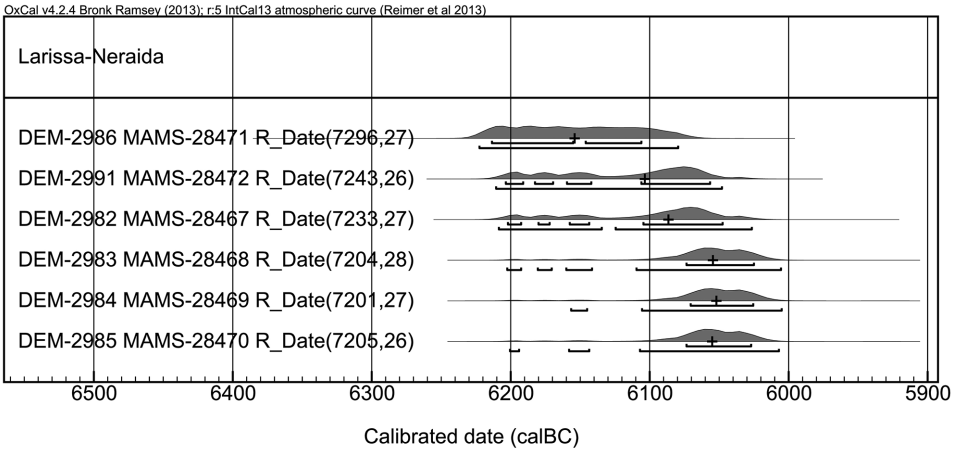



***Fig. 9. Dates for the Early Neolithic II from Larissa-Neraida.***

to only after 6500 cal BC. In addition, new dates from Sesklo run on old samples support this view: the oldest of them (DEM-2440) resulted in 6450 cal BC (*Maniatis, Kotsakis 2016*).

Although Thessaly is especially famous for the EN period, unexpectedly, despite the many efforts of the last decades, evidence for the beginning of the Neolithic Age is difficult to obtain. However, pottery of the 'Protoseskl o'-type was discovered (*Anetakis 2012*) during rescue excavations in the low *magoula* of Neraida in the city of Larissa. Six $^{14}$C dates date this phase of the EN (EN II or 'Protoseskl o') between *c.* 6200 and 6000 cal BC (Fig. 9) – but note the long interval covered by three of the dates. Such intervals are the result of flat portions (plateaus) in the calibration curve (see below). The median values, even of date DEM-2986 with 6150 cal BC, especially of all other dates at 6100/6080 cal BC, are compatible with the end of the EN II.

The most comprehensive sequence is still the one from Achilleion, including 40 dates from well-defined excavation units. Two more dates with huge standard deviations derive from a test-pit and have not been included in the statistical model proposed in Fig. 10. The model confirms the beginning of Phase I in Achilleion shortly after 6300 cal BC, and the transition from the EN to the MN during Phase IIIb around 6000 cal BC (note that no dates are available for Phase IIIa). The stratigraphic sequence ends in Phase IVa, with layers 2–10 dating to the 60th century cal BC. Additional samples assigned to Phase IVa derive from pits and ditches dug into layers 10–21. They suggest that the occupation lasted until 5800 cal BC. The single, much later, date for Phase IVb also derives from a pit that attests a brief re-occupation around 5540 cal BC. This youngest date corresponds well with the end of the MN at 5500 cal BC.

Achilleion Phase Ia starts according to this model at 6280 cal BC and thus does not date to the beginning of the EN in Thessaly, but is coeval with the EN II phase. This view is also supported by the pottery with painted motifs of the 'Protoseskl o' variant appearing from Phase I onwards. Furthermore, 6280 cal BC can be considered a useful *terminus ante quem* (TAQ) for the EN I ending around 6300 cal BC. Finally, if Coleman had given more weight to this sequence of dates, an alternative view regarding the transition EN/MN could have been considered: there is no direct evidence from Thessaly that the EN lasted there until 5800 cal BC (compare Tab. 3).

| Abs. dates cal BC 1σ | Archaeological phases | Sites |
|---|---|---|
| *c.* 6600 | EN I ('Initial Neolithic') | Beginning of the EN in predominantly coastal and/or hilly areas of the circum-Aegean |
| *c.* 6500–6300 | EN I ('Early Ceramic') | Argissa, Sesklo |
| 6280–6070 | EN II ('Protoseskl o') | Achilleion I–II, Sesklo, Larissa-Neraida |
| 6070–5980 | EN III/MN I ('Preseskl o') | Achilleion IIIb, Otzaki |
| 5980–5800 | MN I ('Sesklo I') | Achilleion IVa, Cyclops Cave, Theopetra |
| *c.* 5750–5600 | MN II ('Sesklo II') | Argissa, Sesklo, Agios Petros, Theopetra |
| *c.* 5540 | MN III ('Sesklo III') | Achilleion IVb, Sesklo |

***Tab. 3. The Early and Middle Neolithic sequences in Thessaly with the two terminological proposals at the transition EN-MN (in red). In brackets, the terms used and/or established by Milojčić and Theocharis.***

## The EN-MN transition (6000/5900 cal BC)

In the terminology of Milojčić, the final phase of the EN received the label 'Vorsesklo' ('Presesklo') and is relative-chronologically situated between 'Protosesklo' (EN II) and 'Sesklo' (MN). Expanding on this phase, Johanna Milojčić-von Zumbusch labelled it 'Magulitsa culture' and on the basis of pottery styles from Otzaki Magoula advocated two sub-phases (*Milojčić–v.Zumbusch 1971.146–148*): the older phase of the middle strata with so-called 'Barbotine' pottery with finger pinches and nail impressions, and the

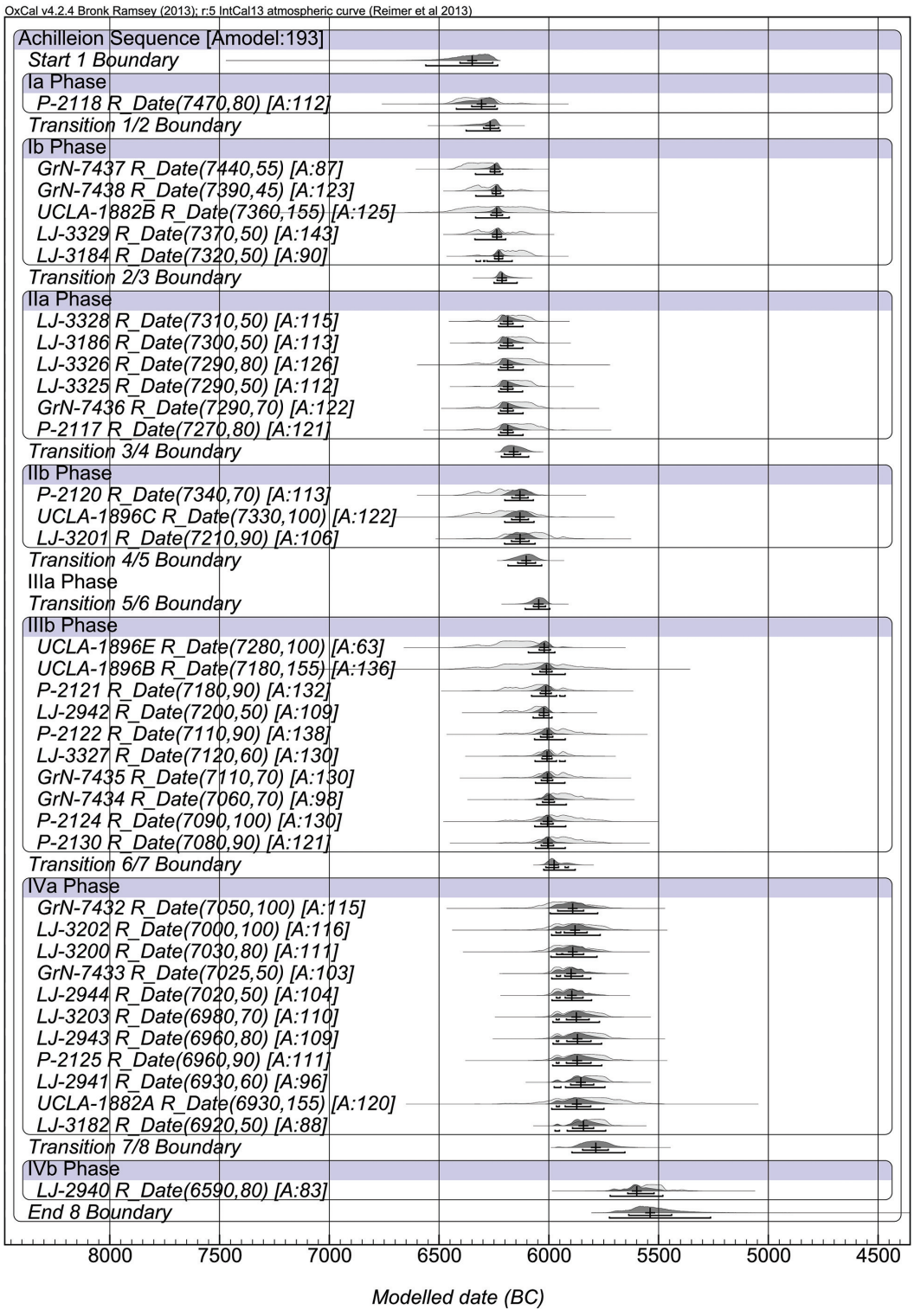



***Fig. 10. Achilleion: dates modelled statistically according to the seven phases Achilleion Ia to IVb (excluding two dates with huge standard deviations from a test pit) (all dates from* Gimbutas 1989*).***

somewhat younger phase of the upper strata, with so-called 'Cardium' pottery, with impressions made with an instrument. These interpretations are not grounded on sufficient stratigraphic observations (note that, precisely at the transition from the EN to the MN, 60–70cm are missing from the stratigraphic sequence in Otzaki: *Milojčić 1971.13,15; Pl. V*). Moreover, the division into two sub-phases relies on only few inventories, mainly on material deriving from sites in north-eastern and western Thessaly. It is especially in these parts of Thessaly that the defining pottery style for the EN III, Impresso pottery, occurs. Farther south (in Achilleion and Sesklo) this kind of pottery appears infrequently, and fades out completely south of the Spercheios valley. This may be the reason why Gimbutas proposed an alternative separation: she not only rejected the division of the EN into three stages and suggested an early start to the MN at 6100 cal BC instead (*Gimbutas 1989. Fig. 3.4* and Fig. 3). She even arrived at completely different conclusions concerning impressed pottery styles: based on less than 20 sherds, she suggested that first the punctuated/stabbed Impresso pottery appeared in phase Achilleion IIIb and stopped with Phase IVa, when fingernail impressions were applied to pots (*Gimbutas* et al. *1989.92* and Tab. 5.5).

Irrespective of styles, the radiocarbon dates for the levels with Impresso pottery both in Achilleion (phase IIIb) and in Otzaki (Area III, upper level) are of the same period, between 6060/6030 and 5880/5830 cal BC (Figs. 10 and 11).

Therefore, the transition between the two periods of the EN and the MN can be dated in Thessaly to around 6000 cal BC, but the correspondence between relative and absolute chronology is currently not satisfactorily solved. Only new and sound stratigraphic evaluations will contribute to a better definition of this transition. For the time being, a division into three EN-phases can be advocated.

That the MN started at the latest in 5900 cal BC is corroborated by dates known since the 1990s from the Cyclops Cave, Theopetra and Platia Magoula Zarkou; this view is further supported by dates obtained from Sykeon (Figs. 12 and 13). Also, new dates from the western fringes of the Pindus Mountains

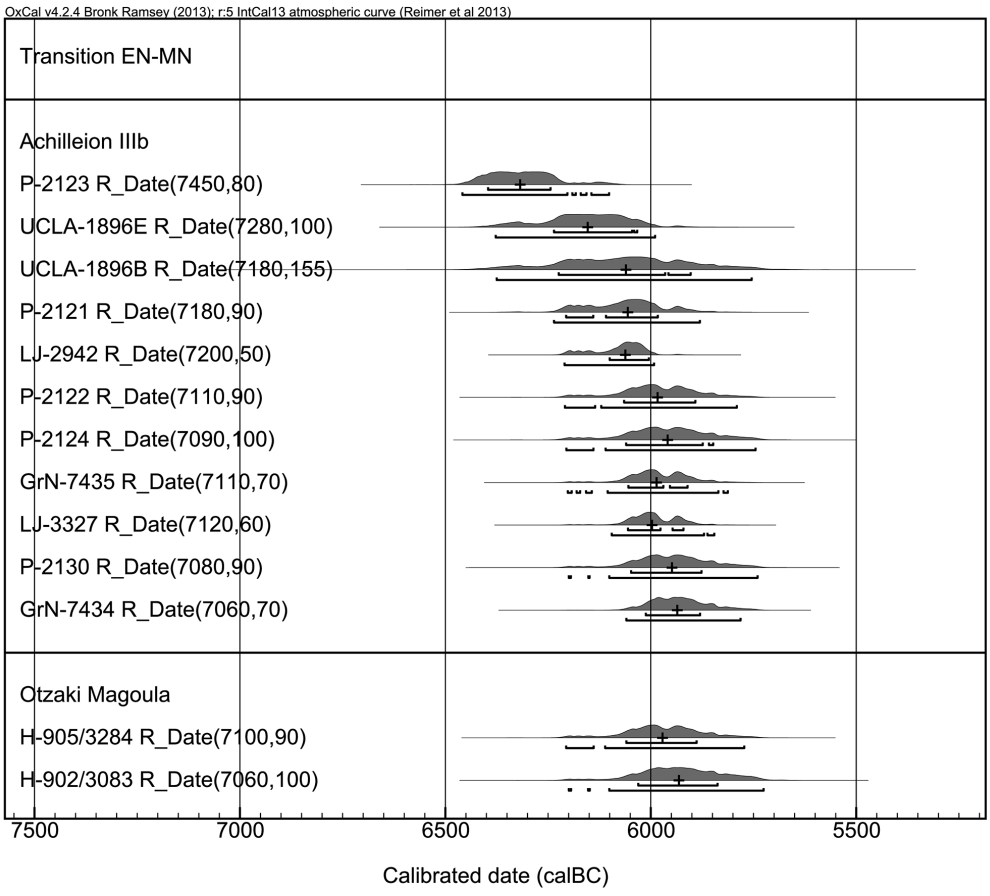



***Fig. 11. Dates for the transition EN–MN (the modelled dates of phase Achilleion IIIb in Fig. 10 resulted between 6070–5980 cal BC, corresponding well with the two dates from Otzaki Magoula; see* Reingruber 2008.270*).***

and from the southernmost tip of the Thessalian Plain in northern Phthiotis (now included in the municipality of Domokos) confirm this view: four dates from Lake Plastiras fall into the first quarter of the 6th millennium BC, as is the case also with two charcoal dates obtained from Imvrou Pigadi (Fig. 14). From the latter site, another four dates obtained by thermoluminescence dating do not contradict this view (*Kyparissi-Apostolika* et al. *2016.38*), despite the huge error margins of 500 years inherent to the method (Tab. 4). The reliable sequence consisting of six dates from Koutroulou Magoula confirms that the beginning of the MN occurred early in the 6th millennium BC (*Hamilakis* et al. *in print*).

Therefore, a first phase of the MN can be securely dated to between 6000/5900–5750 cal BC. For the ensuing centuries, fewer dates are available, but those from Achilleion and Theopetra can be followed up until 5500 cal BC. The 500-year duration of this pe-

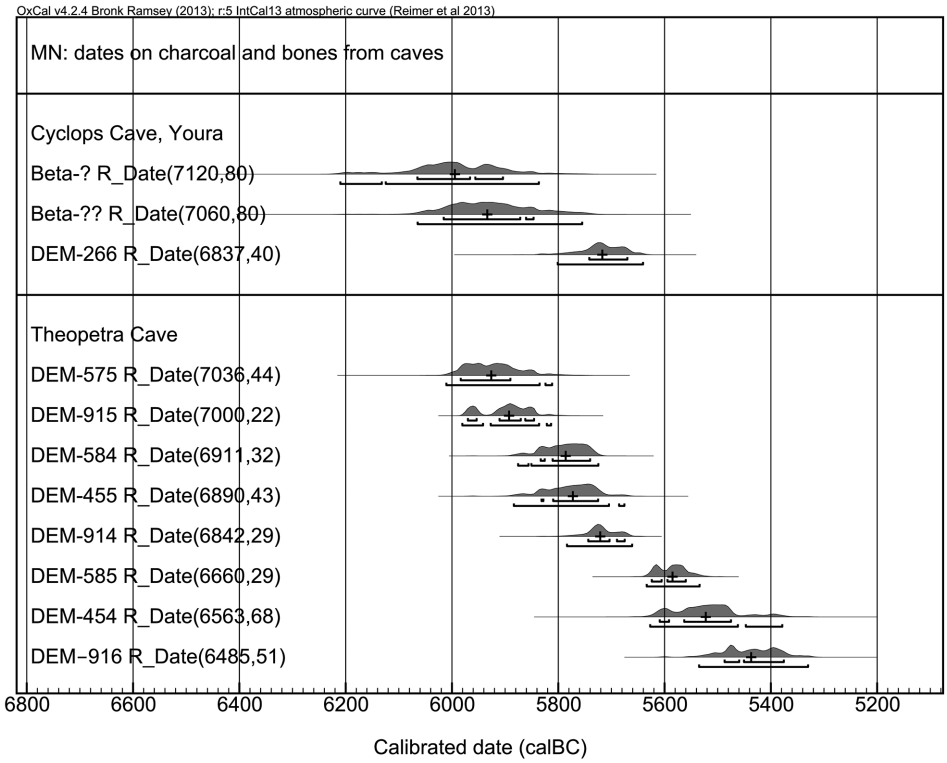



***Fig. 12. Charcoal and bone samples from the MN levels in the Cyclops Cave on Youra (compare* Facorellis *et al.* 1998.Tab. 1; Trantalidou 2003.157*) and from Theopetra Cave (*Facorellis *et al.* 2001*).***

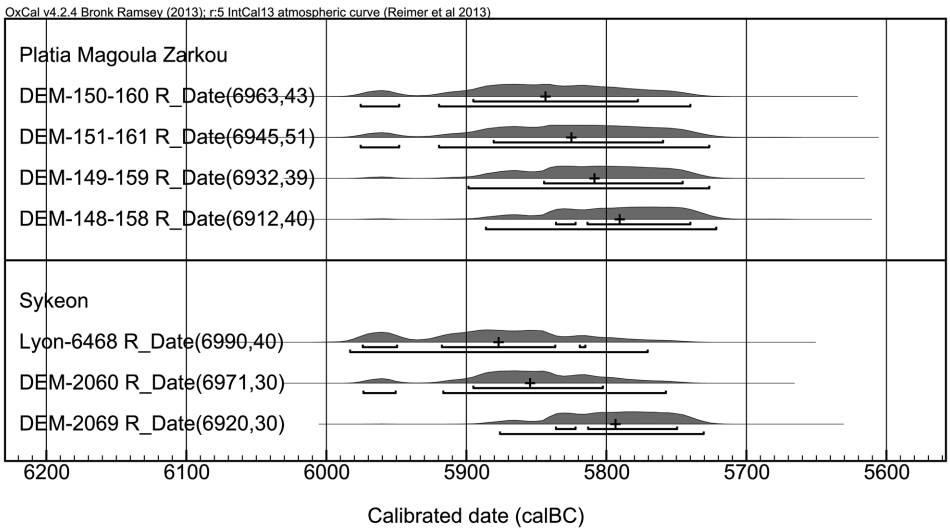



***Fig. 13. Platia Magoula Zarkou and Sykeon: dates from the MN levels (*Gallis 1990.214, Tab. 1; Maniatis *et al.* 2016.63–64, Tab. 1*).***

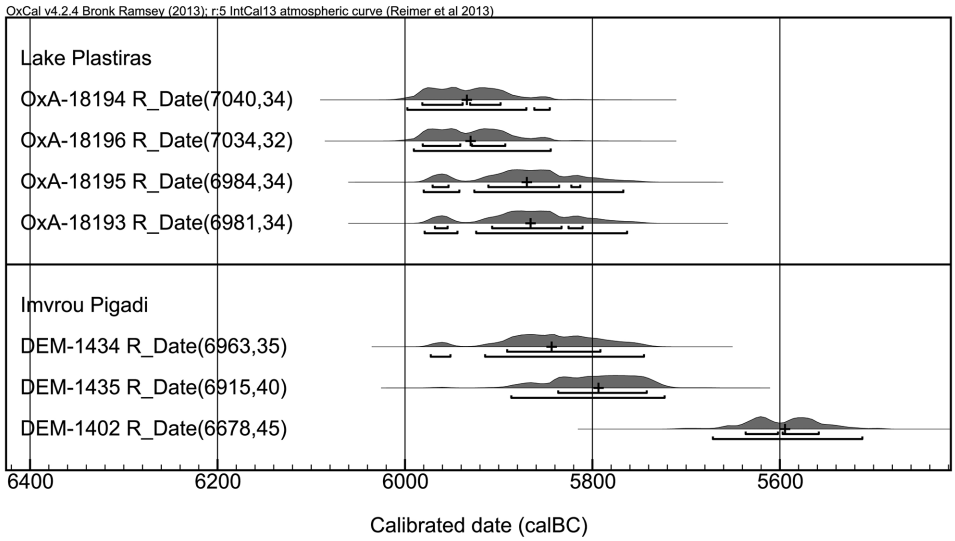



***Fig. 14. New dates for the MN from western Thessaly and the northern Phthiotis (*Kyparissi-Apostolika *et al.* 2009; Kyparissi-Apostolika 2012.436*).***

riod must therefore be shifted by 200 years from 5800–5300 cal BC to 6000/5900–5500 cal BC. Additionally, the single and free-floating dates from Argissa Magoula and Agios Petros (*Efstratiou 1985.167*) do corroborate a dating of the MN to the first half of the 6th millennium BC.

## The MN–LN transition and the LN I (5500–5000 cal BC)

The hitherto known sequences from MN sites suggest that this period ended around or even shortly before 5500 cal BC. There is only one date from Sesklo Magoula (P-1676: 6317±84 BP – compare Fig. 7) that, due to its big standard deviation and due to a plateau in the calibration curve, covers almost 300 years at 1σ (5470–5210 cal BC) and at 2σ more than 400 years (5480–5060 cal BC). It is certainly not suitable for defining the end of the MN at 5300 cal BC.

On the other hand, the oldest dates for the LN I obtained in Theopetra, Prodromos-Magoula Agios Ioannis, and Makrychori (Fig. 15) fit exactly into the centuries 5500–5300 cal BC, supporting the conclusion that the LN had already started at 5500 cal BC. Nevertheless, in the whole of Southeastern Europe, dates for the centuries between 5500 and 5300 cal BC are generally only few in number. In relative chronological terms, this is the time of the Tsangli-Larissa culture (*Gallis 1987*), with major transformations in many parts of the Balkans and Central Europe (beginning of Karanovo III, Vinča A and LBK). In addition, in terms of radiocarbon dates, the final two centuries of the 6th millennium in Thessaly are only poorly represented. No conclusive absolute dates are available yet for the (pottery) culture of Arapi.

| Lab. no. | Date BP | Age BC | ± years | ED (Gy) | U (ppm) | Th (ppm) | K (%) | DR (Gy/ka) |
|---|---|---|---|---|---|---|---|---|
| MI5 | 7177 | 5164 | 515 | 28.86 (2.09) | 5.43 (0.14) | 6.18 (0.18) | 1.81 (0.02) | 4.021 |
| MI6 | 7284 | 5271 | 533 | 30.51 (2.26) | 6.62 (0.15) | 7.46 (0.15) | 1.29 (0.02) | 4.188 |
| MI7 | 7269 | 5256 | 521 | 31.27 (2.32) | 6.02 (0.15) | 7.58 (0.18) | 1.71 (0.02) | 4.301 |
| MI12 | 6808 | 4795 | 499 | 31.69 (2.51) | 7.43 (0.11) | 7.68 (0.14) | 1.47 (0.02) | 4.655 |

***Tab. 4. Thermoluminiscence (TL) dates from Imvrou Pigadi (*Kyparissi-Apostolika *et al.* 2016.38*).***

## The LN I–LN II transition and the LN II (5000–4500 cal BC)

The beginning of the LN II in the first century of the 5th millennium is poorly attested by radiocarbon dates. From Otzaki Magoula, after which all the phases of the LN II have been labelled (*Hauptmann 1981; Hauptmann, Milojčić 1969*), no organic material has been sampled from these levels. Therefore, little can be said about the transition from the LN I to LN II. Moreover, the pottery sequences Otzaki A, B and C cannot be verified with the help of radiocarbon sequences. Most importantly, a first glimpse into the absolute dating of these phases has been made possible thanks to a sequence of eight dates from the sites of Mandra (Fig. 16). Judg-

ing by the median values, the site may have been inhabited between 4900 and 4700 cal BC, during the earlier part of the LN II (*Toufexis* et al. *2009.113; Karagiannopoulos 2016.388; Maniatis* et al. *2016.Tab. 1*). From the later part of the LN II, new $^{14}$C dates were obtained recently from rescue excavations at the famous site of Rachmani, confirming its date to the LN II and the FN/Ch (Fig. 17). Also, the new dates from Prodromos-Magoula Agios Ioannis and from Vasilis fall according to their medians between *c.* 4700 and 4600 cal BC. The pottery from the latter site is mainly of the 'Otzaki' and 'local Dimini' styles.

That the LN II indeed ended around or shortly after 4600 or rather around 4500 cal BC is corroborated by the sequence from Pevkakia Magoula in Magnesia

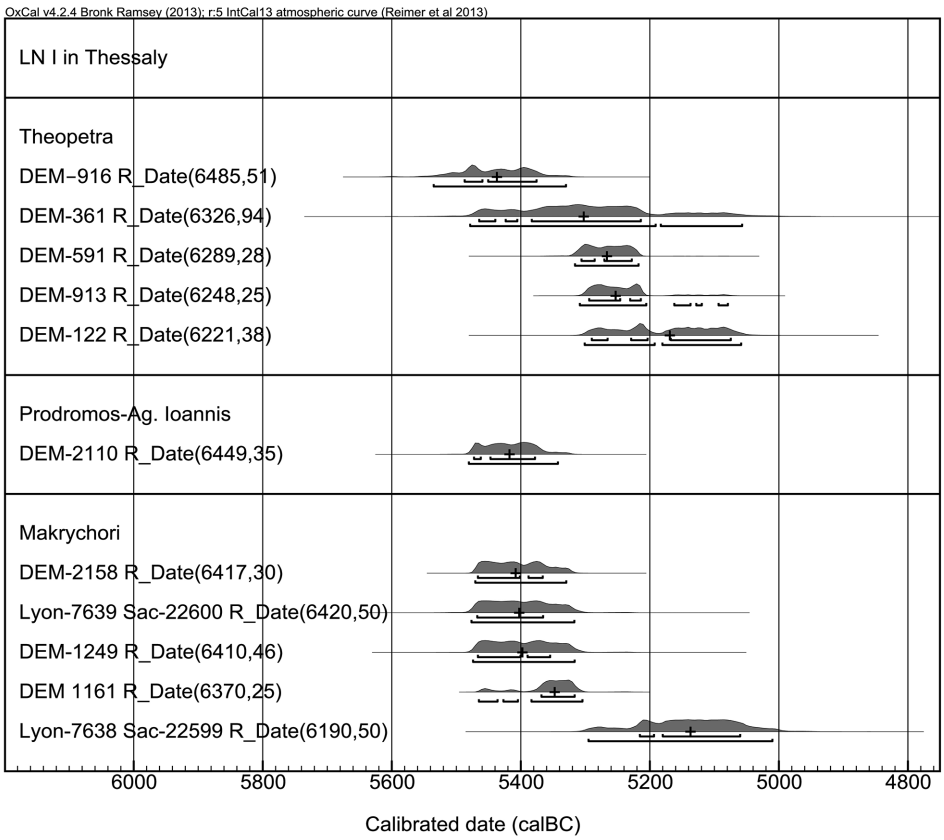



***Fig. 15. Thessalian sites with dates from the LN I (*Maniatis *et al.* 2016.Tab. 1; Reingruber, Thissen 2016*).***

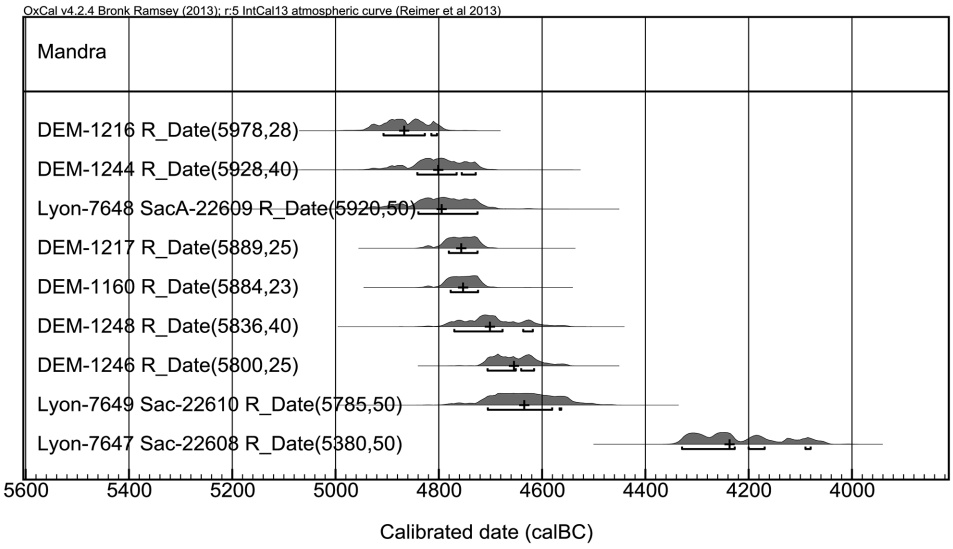



***Fig. 16. Mandra: radiocarbon dates from levels I–III of the LN II and from level V of the FN/Ch (*Toufexis 2000; forthcoming*).***

(*Weißhaar 1989.139*) for which ten dates were published as 'uncalibrated BC'. Therefore, the value 1950 must be added to the given dates to obtain the initial BP-value. When modelled, the six dates for the end of the phase fall within the range 4600 and 4500 cal BC (Fig. 18).

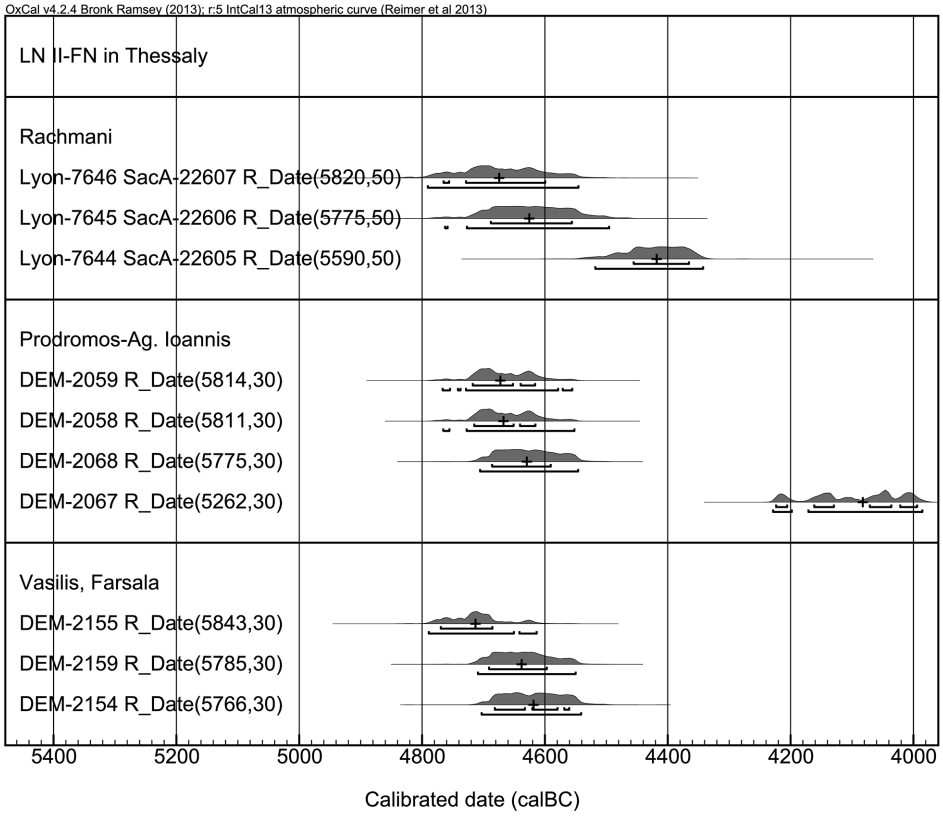



***Fig. 17. Thessalian sites with eight dates from the LN II before 4500 cal BC and two dates from the FN/Ch after 4500 cal BC (*Maniatis *et al.* 2016.Tab. 1*).***

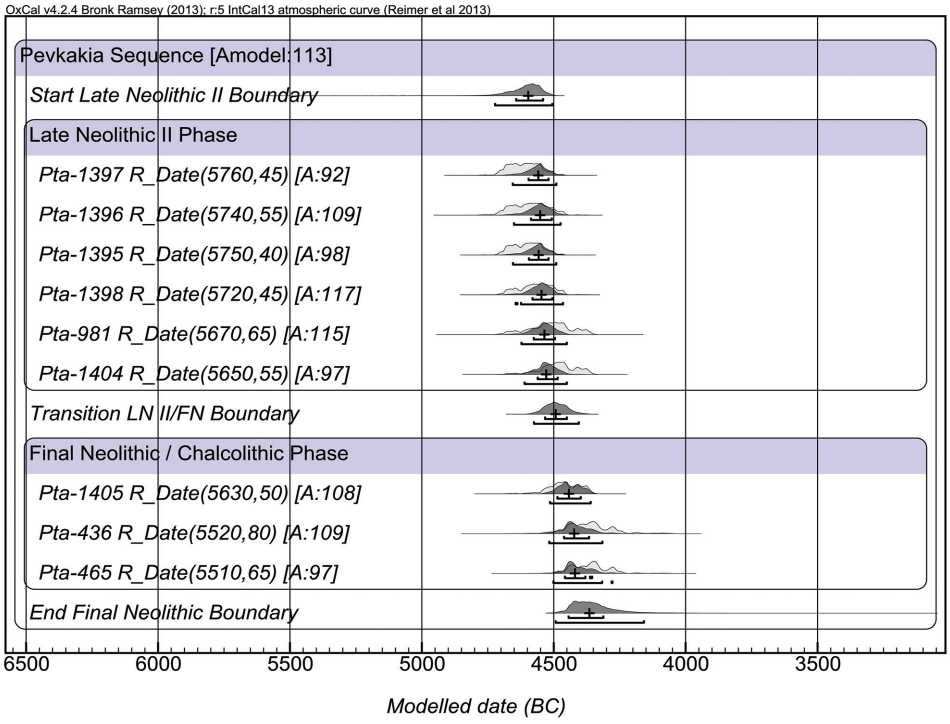



***Fig. 18. Pevkakia Magoula: modelled dates from the end of the LN II and the early FN/Ch, excluding the outlier Pta-435 (*Weißhaar 1989; Reingruber, Thissen 2016*).***

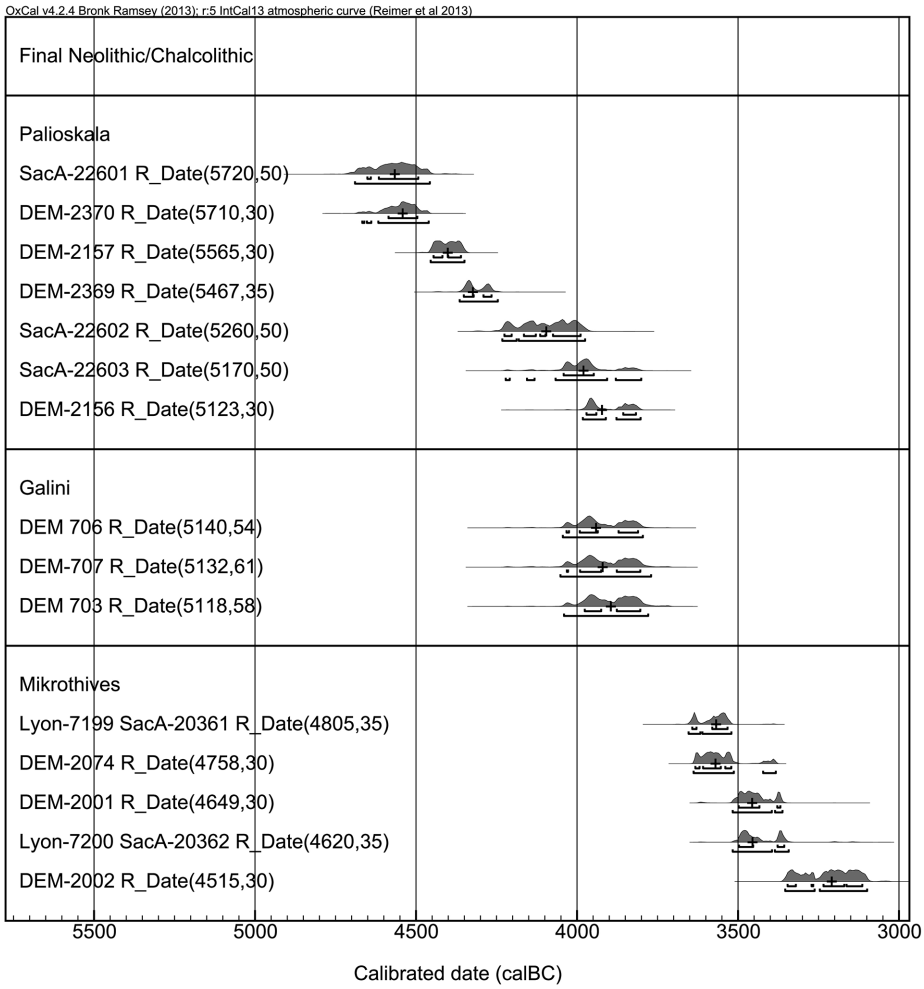



***Fig. 19. Radiocarbon dates for the FN/Ch between 4550 and 3300 cal BC (*Toufexis 2016; Maniatis *et al.* 2016*).***

The transition from the LN to the FN/Ch around 4500 cal BC is also supported by the new dates from Palioskala (*Toufexis 2016.371, Tab. 1; Maniatis* et al. *2016.Tab. 1*): the two oldest dates shortly before 4500 cal BC belong to the LN II (Fig. 19).

Although the terminology for the 'Dimini culture' evokes consistency and continuity among the different phases and sub-phases, only the final stage of the 'Dimini culture' is represented in the excavated levels of the eponymous site. One single date with a huge standard deviation 5630±150 BP (Lab. No. not given) covers the time between 4680 and 4340 cal BC and is therefore not suitable for evaluation (*Reingruber, Thissen 2016*).

## The Final Neolithic/Chalcolithic (4500–3300 cal BC)

In a pan-regional, Southeastern European perspective, the terminology for the 5th and 4th millennia is rather contradictory. Between 4600/4500 and 4200/4000 cal BC, the heyday of the Copper Age or Eneolithic in the Balkans (with the cultures Gumelniţa, Karanovo VI and Varna) had been reached (*Todorova 1995*). Beside the appearance of innovative techniques mostly related to the exploitation of metals (copper, gold and – only in the Aegean – silver), social transformations also allow a separation of this period from the proper Neolithic Age (*Souvatzi 2008*). Therefore, in this article the term Chalcolithic is used synonymously for Final Neolithic.

In Thessaly, the final dates for the LN 'Dimini culture' around 4500 cal BC also define the start of the ensuing 'Rachmani culture'. This is confirmed by the modelled sequence from Pevkakia Magoula, where three samples date the FN/Ch to 4500–4300 cal BC (Fig. 18). Also, single dates from the sites of Rachmani and Prodromos-Magoula Agios Ioannis fall into the second half or even the end of the 5th millennium (Fig. 17). The sample for the youngest date from Mandra (Fig. 16) was derived from a pit dug into the fill of a LN ditch. However, this youngest phase is re-

presented mainly by surface material.

In the Balkans, shortly before 4000 cal BC, the long-lived tell-sites were abandoned. Information for the following centuries of the Transitional Period (*Todorova 1995.89*) is meagre (but compare *Tsirtsoni 2016*). Also, in the Northern Aegean (*Maniatis 2014; Maniatis* et al. *2014*) and in Thessaly the time around and after *c.* 4200/4000 cal BC is extremely difficult to grasp. The scarcity of dates until *c.* 3750 cal BC coincides partly with a huge plateau in the calibration curve that impedes a precise determination of single dates. In this plateau fall the three youngest dates from Palioskala (*Toufexis 2016*; Fig. 19). Judging by these dates and the dates from Galini, this phase of the FN/Ch probably lasted until 3750 cal BC (yet the stratigraphical sequence in Galini is complicated by post-depositional disturbances: *Toufexis 1999*). 4200/4000 cal BC can provisionally be regarded as a turning point also for Thessaly, but the final evaluation of the Palioskala site will certainly shed more light on this still dark chapter in Thessalian prehistory (a period that may have been coeval with the Transitional Period in Bulgaria). With the dates from Mikrothives, a final stage of the FN/Ch period can be contoured between 3750 and 3300 cal BC. Therefore, for the moment it is impossible to go further than to state that three groups of dates from Palioskala, Galini and Mikrothives might reflect three stages of the FN/Ch: at 4500–4200/4000 cal BC, at 4200/4000–3750 cal BC and at 3750–3300 cal BC. More reliable dates are definitely needed to fill in the huge gaps and to understand the transition to the Early Bronze Age (and here again, Palioskala will offer valuable insights).

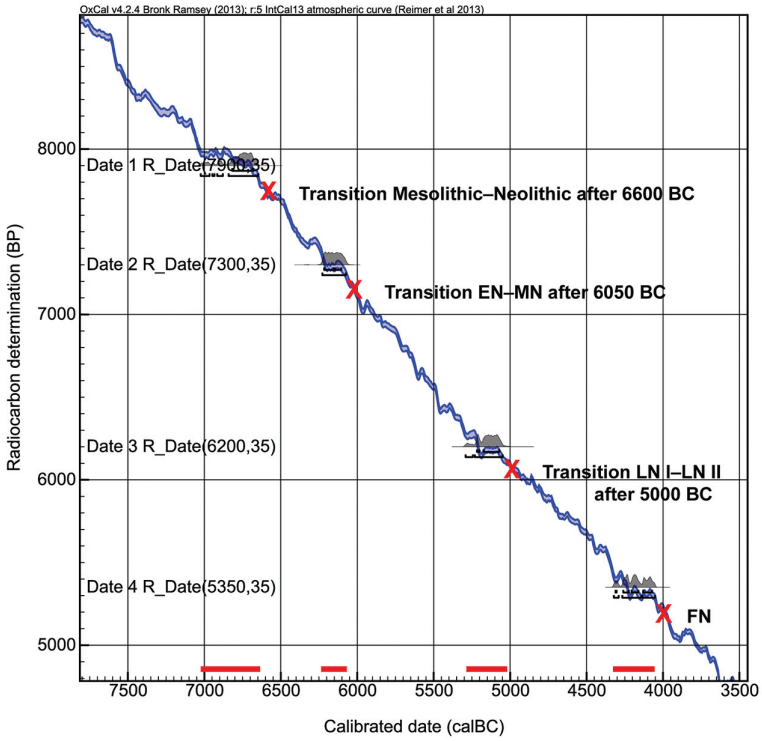



***Fig. 20. Calibration curve with wiggles (accentuated by fictional 'Dates 1–4') resulting in different plateaus that cover several centuries (red bars on the cal BC-line); transitions between Neolithic phases are marked with red crosses.***

## Discussion

From Thessaly, only two sites provided radiocarbon sequences suitable for statistical analysis (Achilleion and Pevkakia Magoula). Certainly, Bayesian modelling cannot be self-sufficient: it is an instrument, a method for obtaining more refined information on the duration of phases, especially on their boundaries. It is self-evident that the more data available for future analysis, the more reliable the results will be. Therefore, all conclusions based on this method are provisional and subject to continuous adjustments.

The two modelled sequences from Thessaly cover vital parts of the Neolithic Age: the sequence from Achilleion spans major parts of the EN and the MN, whereas the sequence from Pevkakia Magoula gave reliable results for the LN–FN/Ch transition. In addition to giving a good orientation for the probable duration of specific phases, these two sequences serve as TAQ and TPQ for the phases preceding and following them. Apart from this, they are especially helpful also regarding the appraisal of single, free-floating dates (both old and new dates available from different Thessalian sites). Together they contribute to a better understanding not only of the duration of periods and phases, but also of the transitions between them. Nevertheless, as has been shown for the early achievements of radiocarbon based chronological schemes, generalisations can always lead to imprecise results. This holds also true for this paper, especially regarding the LN and FN/Ch. To sum up, some provisional results are presented in Table 5.

The few and often ambiguous dates hamper a better interpretation of boundaries. Therefore, a more re-

| Abs. dates cal BC (rounded) | Archaeological periods and phases | Sites |
|---|---|---|
| 7000–6600 | Final Mesolithic | Theopetra Cave, Cyclops Cave |
| 6600–6500 | 'Initial Neolithic' | - (Identified mainly in circum-Aegean coastal and/or hilly areas) |
| 6500–6300 | EN I | Argissa M., Sesklo M. |
| 6280–6070 | EN II | Achilleion I–II, Sesklo, Larissa-Neraida |
| 6070–5980 | EN III / MN I | Achilleion IIIb, Otzaki |
| 5980–5750 | MN I | Achilleion IVa, Theopetra, Cyclops Cave, Koutroulou M., Platia M. Zarkou, Sykeon, Imvrou Pigadi, Lake Plastiras |
| 5750–5600 | MN II | Sesklo, Theopetra, Ag. Petros |
| 5600–5500 | MN III | Achilleion IVb, Sesklo, Theopetra |
| 5500–5300 | LN I (early) | Theopetra, Makrychori, Prodromos-M. Ag. Ioannis |
| 5300–5000 | LN I (late) | Theopetra, Makrychori |
| 4900–4700 | LN II (early) | Mandra |
| 4700–4500 | LN II (late) | Rachmani, Prodromos-M. Ag. Ioannis, Vasilis, Pevkakia M., |
| 4500–4250 | FN (Chalcolithic) | Rachmani, Pevkakia M., Palioskala, Mandra |
| 4250–3750 | FN (Chalcolithic) | Palioskala, Galini |
| 3750–3300 | FN (Chalcolithic) | Mikrothives |

***Tab. 5. General appraisal of periods and phases in Thessaly.***

fined delimitation of phases in terms of decades, not in terms of centuries, is impossible. In some cases, especially at the beginning and the end of the Neolithic, the calibration curve itself impedes the acquisition of more detailed results. Successive wiggles often form flat portions (so-called plateaus) that cover many centuries. They greatly influence the appraisal of certain dates, especially those in the Mesolithic–Neolithic transition between 7000 and 6600 cal BC (Fig. 20). At first sight, these dates seem to support the chronology with the Neolithic starting at 7000 cal BC (compare 'Date 1'). However, when such dates are modelled in line with methodologically well-founded procedures, their duration can be better evaluated. As has been shown by Bernhard Weninger *et al.* (*2014.Figs. 12–13*), the Neolithic starts at the Ulucak and Çukuriçi Höyük sites around 6650 cal BC, not at 7000 cal BC. Dates from Knossos X, Sarakenos and Franchthi, especially those obtained on short-lived grains, confirm this appraisal (*Reingruber 2015; Reingruber, Thissen 2016*). For Thessaly all dates available at the moment suggest that the Neolithic way of life started there only well after this plateau ended, around 6500 cal BC.

Other plateaus also occur again during the centuries preceding major transitions: this is the case before the transition from the EN to the MN ('Date 2') and before the LN I to LN II transition ('Date 3'). The interpretation of dates is greatly influenced by the plateau at the end of the 5th millennium ('Date 4'): these plateaus certainly distort to a certain degree the interpretation of the calibrated dates, especially when only single dates are available. Many more dates are needed to control for these shortcomings better, comparable to the dates obtained in Çatalhöyük (*Bayliss* et al. *2015.Tab. 1*) or Uivar (*Schier et al. 2016*).

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back to contents

# Modelling the earliest north-western dispersal of Mediterranean Impressed Wares: new dates and Bayesian chronological model

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ABSTRACT – *The authors attempt to specify the diffusion pattern of the Impressed-Ware Neolithic (Impresso-cardial complex, ICC), from south-eastern Italy onto the French Mediterranean coasts. Using ChronoModel® software, a Bayesian model was built with sets of dates obtained on well-contextualised, short-lived samples. The results highlight a clear tightening of the chronology in the so-called nuclear area (Apulia, Basilicata, Calabria) and a pioneer dispersal at record speed in the Tyrrhenian Basin. Moreover, they question the origins and initial developments of the Impressed-Wares techno-complex.*

KEY WORDS – *Italy; France; Neolithic; Impressed wares; Bayesian modelling*

## *Modeliranje najzgodnejše severno-zahodne širitve posod tipa Impresso v Sredozemlju: novi datumi in Bayesov kronološki model*

IZVLEČEK – *Avtorji poskušajo definirati vzorec difuzije neolitskih posod tipa Impresso (kompleks Impresso-cardium, ang. kr. ICC) iz jugovzhodne Italije do sredozemske obale Francije. Bayesovo modeliranje je bilo postavljeno s pomočjo programske opreme ChronoModel® na podlagi serije datumov kratkoživih vzorcev iz dobro definiranih kontekstov. Rezultati kažejo jasno oženje kronologije na t. i. jedrnih območjih (Apulija, Bazilikata, Kalabrija) in pionirsko širitev z rekordno hitrostjo v Tirenskem morju. Avtorji prav tako opozorijo na težave pri interpretaciji začetkov in prvotnega razvoja tehno-kompleksa posod tipa Impresso.*

KLJUČNE BESEDE – *Italija; Francija; neolitik; posode tipa Impresso; Bayesovo modeliranje*

## Issues

### *The western dispersal*

Western Mediterranean Neolithisation processes are thought to have been supported by a polythetic complex defined as Impressed Wares or the Impresso-cardial complex (ICC). Its precise sources are still controversial, despite genetic evidence concerning animals, cereals as well as humans that now clearly inscribe it in the framework of a peopling movement, originating from the Eastern Mediterranean (*Hofmanová 2016*). Indeed, in terms of intensity, rhythms, routes and recombination, the scenario of this dispersal is still poorly known (*Binder, Guilaine 1999; Manen 2014*). ICC provides huge internal diversity within, for instance, pottery styles, which makes the visibility of interaction and evolution processes rather fuzzy (*Guilaine 2003*). Moreover, towards the West, the Eastern-Mediterranean Neolithic package lost many of its attributes, especially in the symbolic range, and the farther West we go, the greater is this loss (*Binder* et al. *2014*). This addresses the problem of a cultural or social drift and admixture that could be at the origin of such a declension of the Neolithic paradigm in the Western Mediterranean.

What could be at the origin of such apparent variability? On the one hand, as shown by its typical coastal impact, the north-western Mediterranean colonisation by Neolithic people was certainly based on maritime seafaring (*Bernabò Brea 1950*) or voyaging (*Ammerman 2013*), which is evidenced by the diffusion of the whole set of western Mediterranean obsidian sources, a diffusion that did not exist at all in the same area before the farmers' dispersal (*Ammerman, Polgase 1997; Binder* et al. *2012; Muntoni 2012; Pessina, Radi 2006; Tykot* et al. *2013*), and whose speed has been several times discussed (*Isern* et al. *2017; Zilhão 2001*). In addition, such movements could have been more or less erratic, and even from diverse origins. On the other hand, the evidence of the Late Mesolithic setting in a large part of the Franco-Italian area during the 7th millennium as well as a few Mesolithic radiocarbon dates from the first half of the 6th millennium (*e.g.*, in the Middle Rhône valley and in the Tosco-Emilian Apennine) could support the coexistence of groups of early farmers and late hunter-gatherers, which could be at the origin of several scenarios of admixture, with consequences in terms of cultural mosaic and biological diversity (*Binder 2013; Binder* et al. *2017; Franco 2011; Perrin, Binder 2014; Marchand, Perrin 2017*).

### *Building reliable datasets and chronicles*

Comprehensive data are required to make this story clearer, including reliable radiocarbon chronicles from clear contexts, which is the topic of this paper.

Building reliable and accurate chronicles depends on the rules governing proof, the capacity to run a *quality approach*, which means outlining some basic and generally well-known premises for dating, *i.e.* to use only short-lived samples (abridged SLS) and to guarantee their association with well-defined events.

The earliest ICC settlements dated within such conditions are localised in Corfu (n = 1), in southern (n = 8) and central Italy (n = 3), in the Tuscan archipelago (n = 1), in Liguria and eastern Provence (n = 4), and Mediterranean Languedoc (n = 2). As a comparison, Dalmatia also provided nine ICC sites with reliable SLS-dates (*Forenbaher* et al. *2013; McClure* et al. *2014; Produg* et al. *2014*).

The south-eastern and central Italian settlements considered here are significant because of the stylistic variations of Impressa pottery, following Santo Tiné's periodisation (*Cipolloni Sampò* et al. *1999; Grifoni Cremonesi, Radi 1999; Tiné 1987*): *archaic*, with rather disorganised impressed decoration; *evolved* or Guadone, with structured impressed decoration; *recent*, with '*graffita dentellata*' and painted Lagano-da-Piede wares; a *final* phase, with Matera engraved and Masseria La Quercia painted styles.

For this study, we did not take into consideration the late dispersal towards the North along the Adriatic coast, and we omitted late SLS-dates from Molise (Monte Maulo) and Abruzzo (Fonti Rossi) (*Skeates 1994*). Likewise, among the southern Italian set of sites, late dates from Masseria Santa-Tecchia and Masseria Candelaro which pertain to the development of Red Painted *Figulina* Wares, mainly in the second half of the 6th millennium BCE (*Skeates 1994*), are not to be taken into account in our topic, which focuses on the Impressa aspects predating the mid-6th millennium BCE.

In Provence and Mediterranean Languedoc, ICC settlements display diverse pottery styles, marked by the importance of stab-and-drag, instrumental and pinched decoration, compared to the occurrence of shell impression, especially Cardium, which is very variable depending on the sites (approx. 50% at Pont de Roque-Haute as opposed to almost zero at Pendimoun). These Impressa aspects definitely predate the Franco-Iberian Cardial, a phase which develops during the second half of the 6th millennium, and even mainly the last third of it (*Binder* et al. *2017*).

Data from the major western Mediterranean islands is lacking. A significant number of Pre-Stentinello and Early Stentinello settlements, including Kronio style, is attested in Sicily, but with no SLS-dates published. No evidence of Impressa pottery sets is as yet provided in Sardinia, despite very early evidence of obsidian trade, such as at Peiro Signado (*Briois* et al. *2009*) and Arene Candide (*Ammerman, Polgase 1997*). Only one early date made on charcoal is known from Su Carroppu (*Lugliè 2014*), with uncertainties concerning the cultural attribution of the few sherds discovered. On the basis of pottery typology, a few Impressa indices, probably predating the Tyrrhenian Cardial, are now known in Corsica at Campu Stefanu (*Cesari* et al. *2014*) and at the Albertini rock-shelter (*Binder, Nonza-Micaelli 2016* and *forthcoming*) but not dated yet.

Data are critically lacking in Tuscany, Lazio and Campania. It has been thought that Late Mesolithic groups in the Tosco-Emilian and Ligurian Apennine were still settled during a part of the ICC dispersal and its early development; this is based on a few radiocarbon dates obtained from Castelnovian deposits, *e.g.*, at Lama Lite 2, US6, *c.* 5770–5640 cal BCE (6620±80 BP, Rome-394, charcoal) (*Castelletti* et al. *1994; Dini, Fioravanti 2011*) and Monte Frignone 2, US2, *c.* 5630–5480 cal BCE (6624±45 BP, LTL-2656A, charcoal) (*Dini, Fioravanti 2011*). In southern and central Tuscany, with the exception of new dates from Giglio Island discussed below, the available dates concern Cardial aspects from the Tuscan Archipelago (*Tozzi, Weiss 2001*) which are rather late in the perspective of this paper; in addition, no SLS-date are available for these contexts. In Lazio, the lacustrine settlement of La Marmotta displayed different early pottery assemblages, including Impressa, whose clustering is debatable, and which did not provide SLS-dates (*Fugazzola Delpino, Pessina 1999*).

The situation in Campania is very challenging, with very early dates associated with diverse Impressa aspects probably connected to Apulia via the Ofanto valley, *e.g.*, at Baselice (*Langella* et al. *2003*) and at La Starza d'Ariano Irpino (*Albore Livadie 2002*); unfortunately, the associated dates are suspected of suffering from the old-wood effect.

In total, a set of 17 sites offering 94 AMS dates (Fig. 1, Tab. 1) is considered here for a first appraisal of the earliest Neolithic dispersal from southern Italy and Corfu towards the North-West, using Bayesian modelling. Among these sites, when available, SLS-

dates from the period immediately following (*i.e.* Red Painted Wares and Cardial) were used to provide constraints on the probabilities of the earlier dates. Controversial SLS-dates from Mesolithic Terragne (*Gorgoglione* et al. *1995*) are also discussed infra.

To build this database, all material potentially affected by the marine or fresh-water reservoir effect, *i.e.* shells, was rejected. We kept the few (n = 5) directly dated human remains available from Pendimoun (early Cardial levels; *Le Bras-Goude* et al. *2006*) and from Arma dell'Aquila (Impressa levels; *Biagi, Starnini 2016*), since stable isotopes indicate that none of them were questionable. Collagen samples from animal bones (n = 14), including mostly domestic remnants, are also considered with a small risk, as the feeding of livestock with marine products (*Balasse* et al. *2005*) was never evidenced in the region (*Le Bras-Goude* et al. *2006*).

Considering charcoal, we have selected 10 dates, after rejecting long-lived tree samples (*e.g.*, oak or juniper) whose anatomical characterisation (*e.g.*, twigs or last rings samples) was not explicit. However, we kept, with question marks, a series of six unspecified charcoal samples from Trasanello due to the close connection of this site with Trasano. In addition, one date from Monochrome Sidari obtained on oak charcoal was used to constrain successive impressa deposits at this site. We also considered 58 dates from charred fruits and seeds, and primarily cereals, including husk.

We used Bayesian statistics through ChronoModel® software, version 1.5 (*Lanos, Philippe 2015a; 2015b; Lanos* et al. *2015*) and IntCal13 $^{14}$C curve (*Reimer* et al. *2013*) to model each site separately.

Similar methods have been classically applied using OxCal, for example, for the whole of Northern Italy (*Pearce 2013*) with consistent results at the general level, albeit with limited relevance due to the random intrinsic quality and stratigraphic accuracy of the samples.

ChronoModel software is based on the Bayesian event date model, which is aimed at estimating the date of a target event (*Dean 1978*) from the combination of individual dates derived from relevant dated events. This model has a hierarchical structure, which makes it possible to distinguish between a target event date (any date of interest for the archaeologist) and dates of events (artefacts) dated by chronometric methods, typo-chronology or historical documents. One assumes that these artefacts are all contemporaneous, which is relevant to the date of the target event. On the other hand, the dates can be affected by irreducible errors, hence the possible presence of outliers. To take into account these errors, the discrepancy between the chronometric dates and the target date is modelled by an individual variance, which allows the model to be robust to outliers, in the sense that individual variances act as outlier penalisation (*Lanos, Philippe 2015a; 2015b*). Thanks to this modelling, it is not necessary to discard outliers because the posterior (in the Ba-

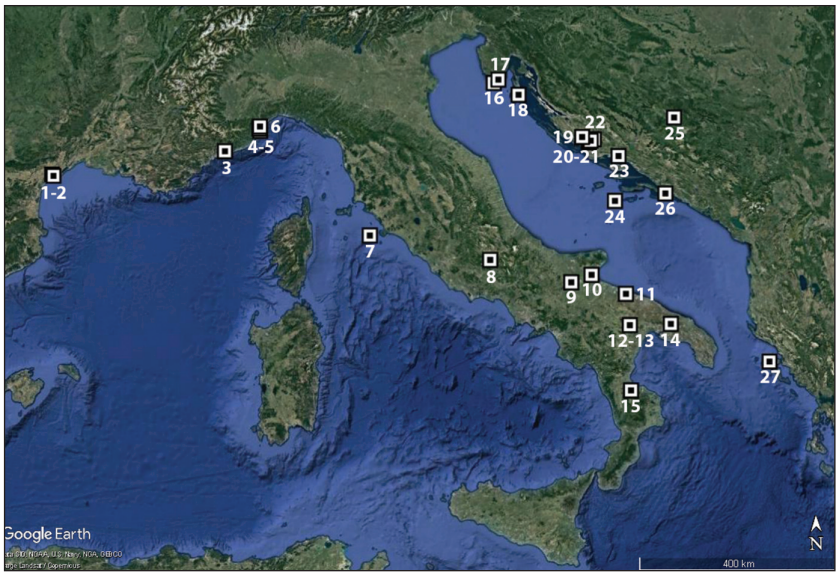



***Fig. 1. Earliest Central and Western Mediterranean Impressed Wares sites dated with short-lived samples: 1 Portiragnes – Peiro Signado; 2 Portiragnes – Pont de Roque-Haute; 3 Castellar – Pendimoun; 4 Finale-Ligure – Arene Candide; 5 Finale Ligure – San Sebastiano di Perti; 6 Orco Feglino – Arma dell'Aquila; 7 Giglio Island – Le Secche; 8 Ortucchio – Colle Santo Stefano; 9 Lucera – Ripatetta; 10 Manfredonia – Coppa Nevigata; 11 Molfetta – Pulo; 12 Matera – Trasano; 13 Matera – Trasanello; 14 Ostuni – Sant'Angelo; 15 Corigliano Calabro – Favella della Corte; 16 Vižula – Medulin; 17 Ližnjan – Kargadur; 18 Lošinj Island – Vela Špilja; 19 Rašinovac; 20 Drniš – Pokrovnik; 21 Šibenik – Konjevrate; 22 Mirlović – Škarin Samograd; 23 Zemunica; 24 Orebić – Nakovana; 25 Kakanj – Obre; 26 Sušac Island; 27 Corfu – Sidari.***

yesian sense) high values of the individual variances will automatically penalise their contributions to the estimate of event date.

Stratigraphic constraints, when available, are applied between event dates. Note that there is often only one chronometric date per target event date. Consequently, modelling makes sense only if there are order constraints between the event dates.

In ChronoModel, a phase is defined as a group of target event dates, with no statistical model. The group of events may belong either to a 'stratigraphic' phase defined as a group of ordered contexts, or to a 'chronological' phase defined as a set of contexts built on the basis of, inter alia, archaeological, architectural, geological, environmental criteria. In practice, a 'context' is defined by the nature of the stratification at a site, and the excavation approach used by the archaeologist. Together, these two phases determine the smallest units of space and time (*i.e.* the context) that can be identified in the stratigraphic record at an archaeological site. Some target events are then dated in these contexts.

We estimate the beginning, end and duration of a phase directly from the group of target dates, without adding any supplementary parametrisation.

Within 'multi-phase' sites, each chronological or cultural phase can include distinct clusters of stratigraphic units (Fig. 2) that could have been defined by spatial criteria, or in some cases, by the subdivision of a single phase deposits in distinct features directly (*i.e.* successive) or indirectly connected (*e.g.*, covered by deposits from the following phase); in addition a single feature (*e.g.*, stratigraphic unit) can provide one or several dates.

Within 'mono-phase' sites which display several features, constraints can be applied based on their relative chronology (*e.g.*, overlapping) or their internal stratigraphic subdivisions; each one of the so-called events can provide one or several dates.

A few 'mono-phase' sites provide several available dates which are not connected as yet to defined features with an explicit relative chronology. In such cases, the different dates are considered as potentially different events included in a single phase.

For this paper, each site was modelled separately. As a result, the dates *a posteriori* for a multi-phase or mono-phase site are totally independent of those obtained from the others sites.

Each phase modelling is based on three runs of Markov's chains of 10 000 iterations each. In order to compare the modelled phases, we calculated the probabilities of anteriority for each phase's beginnings compared to the others. For each couple of phase beginnings [ΦA≤ΦB], the distance is expressed as a percentage of the number of agreements (If Ai ≤ Bi then agreement = 1, otherwise agreement = 0 for each iteration i). The phase classifications using these anteriority probabilities and using the modes *a posteriori* (MAP) are similar, since the boundary distributions are mono-modal. This indicates that the MAP are very good *representations* of the relative position of the modelled boundaries of the different sites and phases (BMAP for the beginning and EMAP for the end of the considered phase). In this perspective, we assume that such representations are concepts, not values.

## Southern sites and samples

The south-eastern dataset taken into consideration for this paper is composed of nine sites from the Ionian Islands, Apulia, Basilicata, Calabria and Abruzzo. It includes three multiphase sites (Pulo di Molfetta, Trasano and Trasanello), two mono-phase sites with several events (Coppa Nevigata and Favella della

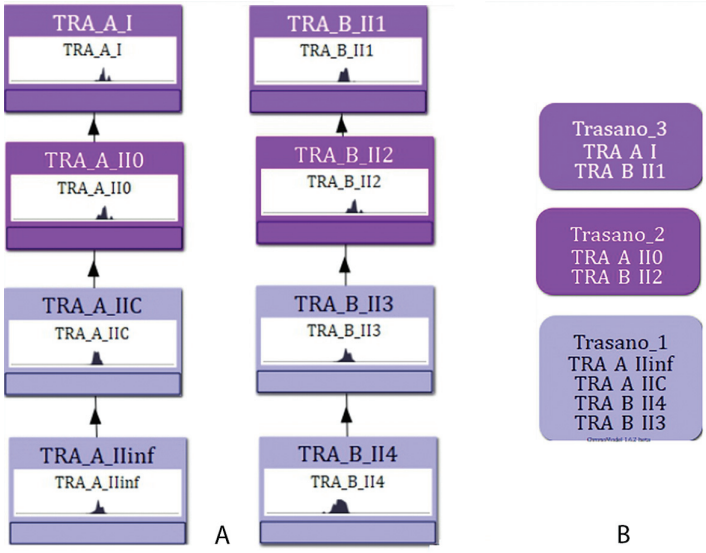



***Fig. 2. Example of events (A) and phases (B) diagrams at Trasano (ChronoModel 1.5). Arrows indicate the stratigraphic constraints applied to the successive events; no constraints are applied between phases which are defined on stylistic criteria.***

Corte), two sites where single Impressa events within multiphase sites were SLS-dated (Ripatetta and Colle Santo Stefano) and two settlements with single SLS-dates from multiphase contexts (Sidari and Sant'Angelo di Ostuni). For the final discussion we also took into account the Pokrovnik series in Dalmatia, which offers a set of 12 SLS-dates for the stratified Impressa and Danilo deposits (*McClure* et al. *2014; Produg* et al. *on line*).

At *Sidari* (Corfu), rescue excavations organised in 2004 provided a new stratigraphic record of the Holocene sequence (*Berger* et al. *2014; Sordinas 1967*).

Above Mesolithic deposits which were partly reworked during the first half of the 7th millennium, the Neolithic 'Monochrome', Phase 1 (US4a-b and pits F1 and F2), can be placed during the second half of the 7th millennium at the earliest, thanks to seven AMS dates on oak charcoal. Neolithic Impressa, Phase 2 (US5b-c), provided a single SLS-date (one event). The more recent date from Phase 1 can be usefully considered as a *terminus post quem* for constraining the beginning of Phase 2.

At the village of Pulo di Molfetta (Apulia), the excavation of Trench 3 in 1997–1999 allowed the recognition of three successive phases within the Neolithic deposits (*Fiorentino* et al. *2013; Muntoni 2003; 2009, Radina 2005*). Phases I (US10 with two SLS-dates available, US14 and 19) and II (US2 and 4) both belong to archaic Impressa, while Phase III (US9 and 17) belongs to the Serra d'Alto Culture (5th millennium). The further extension of Trench 3 in 2001, 2004 and 2007–2008 allowed the connection of US46 to Phase I and, directly above it, of US49 to Phase II, each with one SLS-date available.

The Sant'Angelo cave (Ostuni, Apulia), known since the 1930s for the tremendous richness of its pottery deposits, was re-excavated in 1984 (*Coppola 2001*). Two SLS-dates are available from Level 9 (evolved Impressa, *i.e.* Guadone) and Levels 6–7 (late Impressa, *i.e.* Masseria La Quercia).

The enclosed village of Ripatetta (Apulia) was excavated between 1982 and 1992. Inside the ditch enclosure, a rectangular wattle-and-daub building was identified in sector A, while a wide rectangular cobble-paved area was identified within sector B. The latter are related to the evolved Impressa, *i.e.* Guadone, with unusual painted and red-slipped pots; they predate deposits from recent Impressa linked to the Lagnano-da-Piede style, which are not SLS-dated as yet (*Costantini, Stancanelli 1994; Tozzi 2002; Tozzi, Verola 1991*). From two distinct parts of area B, three SLS-dates are available, clustered as two distinct events within the same phase.

Coppa Nevigata (Apulia) was considered an archetype of the archaic Impressa style, with closely paralleling pottery assemblages from Tremiti Islands and Pulo di Molfetta (*Cassano, Manfredini 1987*). Samples from Phase II-III provided a couple of SLS-dates, both belonging to the archaic Impressa phase and considered as distinct events within a single phase.

The site at Terragne (Apulia), excavated by M. Gorgoglione in 1985–1991, yielded a Neolithic deposit attributed to the evolved and final Impressa (US3) above a layer devoid of pottery and whose lithic series suggested a Late Mesolithic occupation (US4-5). The latter could be currently the sole Late Mesolithic settlement from southern Italy providing SLS-dates (*Gorgoglione* et al. *1995*); those two samples from wild fauna collagen are included as distinct events in a single phase, although their attribution to the Mesolithic is controversial.

Trasano (Basilicata), excavated by Jean Guilaine and Giuliano Cremonesi between 1984 and 1991, is a key enclosed village providing a clear succession of the three Impressa aspects: archaic, evolved and recent (*Angeli 2012; Guilaine, Cremonesi 1987; Radi* et al. *2000*).

Following a first set of dates with large standard errors, and the implementation of alternative methods to radiocarbon (*e.g., Vartanian* et al. *2000*), new AMS dates were obtained from sectors A and B. Within each one, four SLS-dates were obtained, as yet unpublished: Sector A: archaic (C2inf beneath C2c), evolved (C2.0) and recent (C1); Sector B: archaic (C2.4 beneath C2.3), evolved (C2.2) and recent (C2.1).

At Trasanello Cementificio (Basilicata), at approx. 1200m from Trasano, detailed stratigraphy has been recorded within Trench 11 in 2011 (*Angeli 2012*). A final Impressa occupation (US5 with four dates corresponding to different contemporary contexts) predates the Red Painted Wares (US3 with two superposed dated samples). Although unspecified charcoal was used, these dates, as yet unpublished, were taken into account in this paper regarding their connection with recent Impressa at Trasano.

Favella della Corte (Calabria) is a remarkable village, excavated from 1990 to 2002. The settlement, dated to the archaic phase, has a large set of pits considered as mono-phase, with partly staggered multi-events. Pottery analysis suggests a slight evolution of the archaic assemblages from structures A and D towards structures E and G (*Tiné 2009*). From this site, six SLS-dates are available from Structure A (middle part of Pit Z, US4), Structure D (bottom and top of Pit Y, US4), Structure E (Pit 30, US4, predating Pit T, US3) and Structure G (Pit 10, US3).

The village of Colle Santo Stefano (Abruzzo) offers multiphase stratigraphy covering the evolved Impressa aspects. This designates the site as the first pioneer settlement to be identified so far in Central Italy that was connected with the evolved Guadone aspects from the South-East. The earliest occupation is characterised by a cobble-paved area (US17) and the successive episodes (US8 and US3) provide diverse dated features (*Fabbri* et al. *2011; Radi* et al. *2001*). A set of eight overlapping dates on charcoal suggested less than four centuries for the whole occupation. A couple of new SLS-dates were run on samples from the same event within the earliest deposits.

**North-western sites and samples**

The north-western dataset is composed of two multiphase sites (Arene Candide and Pendimoun), one multi-event within the deposits of a mono-phase site (Pont de Roque-Haute) and one mono-phase site for which no distinct events have been recorded (Peiro Signado).

In addition, three sites are useful for the final discussion, although they provided SLS-dates which are not strictly connected to stratigraphic series and/or to stylistic phases (Le Secche, San Sebastiano di Perti and Arma dell'Aquila).

At Le Secche (Giglio Island, Tuscan archipelago), a thick deposit with abundant pottery and lithic series filled a narrow joint in a context of typical eroded granite 'marbles'. The Impressa pottery assemblage consists mainly of sherds offering parallels with the south-eastern archaic style, and a smaller set of later remains (*e.g.*, probably later Cardial, Linear pottery and Diana sherds) (*Brandaglia 1991; 2002*).

In 2016, new sampling of in situ deposits allowed AMS dating. Unfortunately, the samples were not found in a stratigraphic context and the three SLS-dates have to be included within a single generic cluster.

The vast cave of Arene Candide (western Liguria) is well known for its extended stratigraphic record of Upper Palaeolithic and Neolithic settlement (*Branch* et al. *2014; Maggi 1997a*). For various reasons – mainly the excavation of extended stratigraphic units lying over wide areas – the ICC periodisation from Bernabò Brea's and Tiné's operations has been debated since vertical movements of pottery were observed in different sectors of the site (*Biagi, Starnini 2016; Del Lucchese, Starnini 2010; Maggi 1997b*). The Neolithic chronology has improved thanks to new fieldwork adjacent to Tiné's operation carried out in 1997 (*Binder, Maggi 2001*), 2002 and more intensively in 2012 (*Arobba* et al. *2017*); both operations provided accurate stratigraphic control and recording.

Within Maggi's 1997–2002 sector, Impressa was found in two successive units (US10 and 10A with four SLS-dates under US.9Bbase with one SLS-date) and predating the Cardial deposits (US9B with one SLS-date). Within the 2012 area, R. Maggi, C. Panelli and S. Rossi clustered the ICC deposits into nine sets; among them, Impressa was associated with Phase AC1 at the bottom (from sets 2 to 4 including, US360 at the bottom, US347, US351A and US330 at the top, with four SLS-dates); early Cardial aspects define Phase AC2 (from sets 5 to 7, including US312, with two SLS-dates). In addition, a date has been obtained for the charred remains included in a typical Cardial pot from Phase AC2, with refitted sherds from set 6 and from Layer 26 of Bernabò Brea's excavations (*Arobba* et al. *2017*).

At San Sebastiano di Perti (western Liguria) in 1992, a deposit preserved on a small terrace produced a sherd set that included diverse types of Impressed wares and charred seeds (*Biagi, Starnini 2016; Capelli* et al. *2006; Starnini, Vicino 1993*). From this unique layer, three SLS-dates are to be considered as distinct events clustered in a single generic set.

Arma dell'Aquila (western Liguria), excavated in 1938–1942 by C. Richard, revealed a set of burials and human remains in a context where diverse Neolithic aspects were identified, which included Impressed wares (*Biagi, Starnini 2016*). Two skull fragments, from a child burial and from Layer 7, respectively, provided SLS-dates, here considered as distinct events included in a single generic phase.

Pendimoun (eastern Provence) is a large rock-shelter whose stratigraphy recorded a large part of the Neolithic period. Taking advantage of the preliminary results obtained in 1985–1992 (*Binder* et al. *1993*), more extended excavations were organised in 1998–2006 in both the northern and southern sectors, separated by the trench dug in the 1950s (*Battentier* et al. *2015; Binder, Sénépart 2010*).

Within the northern sector, the Impressa set encompasses several stratigraphic units and features of small size (including nine SLS-dates from five events: US2067, 41678, 47800 and 47801) which predate early Cardial units (including 10 SLS-dates from seven events: burials F1 and H2, US18364, 19 000, 19 001 and 42 370); US47799 is a technical unit situated at the interface between Impressa (#47 889) and Cardial (#48 256) phases. Within the southern sector, the Impressa set also contains several units (including four SLS-dates from four events: US5711, 28 889, 29 203 and base of US28 781#28 905) which also predate the early Cardial units (including two SLS-dates from two events: burial F1 and the top of US28 781#28 898). Current research is focused on the correlation of both sectors, since Impressa pottery assemblages differ slightly from one to another.

Pont de Roque-Haute (Mediterranean Languedoc) is a small open-air settlement with ten pits of different shapes. The consistent pottery assemblage is considered as mono-phase and, on the basis of its parallels with Le Secche, linked to the south-eastern Italian tradition (*Guilaine* et al. *2007*). A set of five SLS-dates from pit F1, which is the richest, is here clustered into two successive events (two from F1 base and three from F1) belonging to a single phase.

Peiro Signado (Mediterranean Languedoc), excavated in 1978 and 1996–1997, yielded the remains of an oval building and a set of adjacent pits (*Briois, Manen 2009; Briois* et al. *2009; Roudil, Soulier 1981*). As yet, the extremely abundant pottery assemblage associated with the archaeological features is considered as belonging to a unique phase. Then the two available SLS-samples are here clustered as distinct events within a single phase.

## Modelling results and interpretations

### *The early southern and central Italian chronology (Tabs. 2, 3 and 4, Fig. 3)*

The probability of Favella's beginning to predate Pulo's is very weak (53%). The modelled dates from both sites indicate that the Archaic Impressa stage could have begun during the second half of the 60th century (BMAP: 5918 and 5953 BCE respectively) and slightly post-date the earliest southern Dalmatian Impressa, *e.g.*, from Pokrovnik (BMAP: 5978 BCE).

The two SLS-dates obtained for Terragne-US4-5 (BMAP: 6138 BCE; EMAP: 5804 BCE) are not accurate enough to support a secure Late Mesolithic attribution.

The single Impressa date from Sidari-5cd (event_HPD: 6191–5885 BCE) could be placed over these boundaries, as the previous Monochrome phase Sidari-4 seems so far to have developed until the end of the 7th millennium (event_HPD: 6557–6019 BCE).

Trasano 1 and Coppa Nevigata settlements seem to have begun a century later (BMAP: 5823 and 5810 BCE, respectively). The whole dataset indicates that the archaic phase could have lasted three centuries, until the very beginning of the 57th century (EMAP: from 5704 to 5682). These results give us an idea of an internal periodisation of the archaic stage. Furthermore, the marked differences observed between Trasano 1, where tool impressions predominate (*c.* 65%), and Favella, where finger and nail impressions predominate (42%), support the idea of different stylistic traditions within the archaic stage. Nevertheless, as already suggested by Elena Natali and Vincenzo Tiné (*Tiné 2009*), our modelling does not support the idea of an internal evolution from one sector of the site to the other.

New modelled dates of Ripatetta confirm that the evolved Impressa, *i.e.* the Guadone style, clearly overlap the second part of the archaic phase (BMAP: 5841 BCE). The precocity of the Guadone aspect at Ripatteta illustrates the huge variability of pottery production during the 59th and 58th centuries in a rather small area; this raises new issues on the social origin of such discrepancies and, moreover, the increasing role of crafts and workshops. The single event dated at Sant'Angelo and its debated pottery assemblage providing both archaic and evolved aspects could have taken place in such a context.

The modelled dates highlight the very good seriation of archaic, evolved and recent stages of the Impressa in the Basilicata, at Trasano, during three centuries, until the end of the 56th (EMAP: 5588 BCE). Here the evolved and recent phases seem brief, approximately one century. Nevertheless, the earliest

| Event (n-dates) | e_HPD (95%) | e_MAP |
|---|---|---|
| Terragne_US4-5#2 (1) | [–6132; –5510] | –5803 |
| Terragne_US4-5#1 (1) | [–6398; –5857] | –6137 |
| Sidari_Fo4 (1) | [–6557; –6019] | –6250 |
| Sidari_Hearth5b-5c (1) | [–6191; –5885] | –6033 |
| Pulo_II_US49 (1) | [–5695; –5424] | –5579 |
| Pulo_Isup_US46 (1) | [–5824; –5554] | –5682 |
| Pulo_Iinf_US10 (2) | [–6078; –5790] | –5953 |
| S. Angelo_T6-7 (1) | [–5729; –5242] | –5502 |
| S. Angelo_T9 (1) | [–6151; –5599] | –5861 |
| Ripatetta_Acciottolato_C9 (1) | [–6049; –5521] | –5769 |
| Ripatetta_Acciottolato_IM30 (2) | [–5949; –5715] | –5812 |
| Coppa Nevigata_II-III_#A (1) | [–6083; –5458] | –5740 |
| Coppa Nevigata_II-III_#B (1) | [–6124; –5425] | –5767 |
| Trasano_B_II1 (1) | [–5718; –5489] | –5638 |
| Trasano_A_I (1) | [–5683; –5464] | –5620 |
| Trasano_B_II2 (1) | [–5743; –5591] | –5663 |
| Trasano_A_II0 (1) | [–5713; –5575] | –5646 |
| Trasano_B_II3 (1) | [–5823; –5649] | –5721 |
| Trasano_A_IIC (1) | [–5756; –5633] | –5691 |
| Trasano_B_II4 (1) | [–6006; –5705] | –5821 |
| Trasano_A_IIinf (1) | [–5884; –5665] | –5733 |
| Trasanello_US3sup (1) | [–5431; –5083] | –5269 |
| Trasanello_US3inf (1) | [–5585; –5368] | –5510 |
| Trasanello_US5_Foss (1) | [–5711; –5461] | –5578 |
| Trasanello_US5_C4 (1) | [–5716; –5473] | –5587 |
| Trasanello_US5_B3 (1) | [–5757; –5495] | –5607 |
| Trasanello_US5_cv (1) | [–5722; –5477] | –5585 |
| Favella_StrE_FoT-US3 (1) | [–5963; –5435] | –5755 |
| Favella_StrG-Fo10-US3-VI (1) | [–6150; –5625] | –5889 |
| Favella_StrD-FoY-US4-II (1) | [–5790; –5568] | –5680 |
| Favella_StrA-FoZ-US4-VI (1) | [–6070; –5549] | –5793 |
| Favella_StrE-Fo30-US4-II (1) | [–6080; –5652] | –5823 |
| Favella_StdD-FoY-US4-XIII (1) | [–6004; –5682] | –5820 |
| Colle-S.Stefano_17 (2) | [–5750; –5616] | –5683 |

***Tab. 2. Modelled events (from Table 1) of southern and central Italian ICC. The number of associated dates for each event is indicated in brackets: e_HPD (95%),* i.e. *the event's highest posterior density interval at 95% confidence; e_MAP, event's posterior mode.***

deposits from Trasanello 1 (BMAP: 5629 BCE; EMAP: 5542 BCE), attributed to the final phase and predating the development of Red Painted Wares, slightly overlap Trasano 3, which raises questions about possible old-wood effect.

The place occupied by the Stentinello aspects is still challenging due to the lack of SLS-dates and stratigraphic seriations, in Sicily and Calabria as well. The single date from Piana di Curinga was obtained from an excellent context on a pole from the wattle-and-daub house H, but with a possible old-wood effect (*Ammerman* et al. *1988*).

Thanks to a single event dated at Colle Santo Stefano (e_HPD: 5750–5616 BCE), the modelling confirms that Neolithic diffusion towards Central Italy is rather late, between the mid-58th and the very end of the 57th century, contemporary with the end of Ripatetta's evolved Impressa and the beginning of evolved Impressa aspects at Trasano 2. However, additional SLS-dates from the successive phases recorded at Colle Santo Stefano are necessary for a better understanding of the regional trend and the transition to the latest aspects of Medio-Adriatic Impressa during the second part of the 6th millennium.

| Phase (n–events, n–dates) | D_HPD (95%) | D_MAP | B_HPD (95%) | B_MAP | E_HPD (95%) | E_MAP |
|---|---|---|---|---|---|---|
| Terragne_Late Mesolithic ? (2, 2) | [1; 626] | 327 | [–6398; –5875] | –6138 | [–6108; –5530] | –5804 |
| Pulo–1_Archaic–Imp (2, 3) | [50; 441] | 257 | [–6078; –5790] | –5953 | [–5824; –5554] | –5682 |
| Favella_Archaic–Imp (6, 6) | [87; 705] | 248 | [–6205; –5792] | –5918 | [–5776; –5383] | –5669 |
| *Favella_2_Archaic–Imp (2, 2)* | [0; 505] | 107 | [–6123; –5685] | –5890 | [–5930; –5428] | –5753 |
| *Favella_1_Archaic–Imp (4, 4)* | [33; 570] | 201 | [–6189; –5737] | –5872 | [–5788; –5523] | –5679 |
| Trasano–1_Archaic–Imp (4, 2) | [18; 348] | 138 | [–6024; –5722] | –5823 | [–5740; –5633] | –5686 |
| Coppa–Nevigata_Archaic–Imp (2, 2) | [0; 511] | 56 | [–6141; –5607] | –5810 | [–5935; –5399] | –5704 |
| Ripatetta_Evolved–Imp (2, 3) | [0; 312] | 40 | [–6005; –5726] | –5841 | [–5901; –5566] | –5771 |
| Trasano–2_Evolved–Imp (2, 2) | [1; 115] | 15 | [–5738; –5622] | –5671 | [–5695; –5567] | –5641 |
| Trasano–3_Recent–Imp (2, 2) | [0; 207] | 23 | [–5701; –5561] | –5637 | [–5664; –5413] | –5588 |
| Trasanello–1_Late–Imp (4, 4) | [1; 304] | 87 | [–5850; –5552] | –5629 | [–5611; –5470] | –5542 |
| Trasanello–2_Bande Rosse (2, 2) | [16; 396] | 221 | [–5585; –5368] | –5510 | [–5431; –5083] | –5269 |

***Tab. 3. Modelled phases of southern and central Italian ICC. The number of associated events and dates for each phase is indicated in brackets: D_HPD (95%), highest posterior density interval at 95% confidence of phase duration; D_MAP, posterior mode of phase duration; B_HPD (95%), highest posterior density interval at 95% confidence of phase beginning; B_MAP, posterior mode of phase beginning; E_HPD (95%), highest posterior density interval at 95% confidence of phase's end; E_MAP, posterior mode of phase's end.***

***The Impressa spread towards the North-West and its evolutionary trends (Tabs. 5–7, Fig. 4)***

Compared to Abruzzo, which offers the earliest available dates for Central Italy, the first evidence of Neolithic settlement is very early, at least one century earlier, in the North-West and at the latest during the transition between the 59th and 58th centuries, at least two centuries before the Iberian Peninsula (*Isern* et al. *2017; Zilhão 2001*).

For the North-Western Mediterranean, the modelled dates indicate a rather good seriation of the sites and

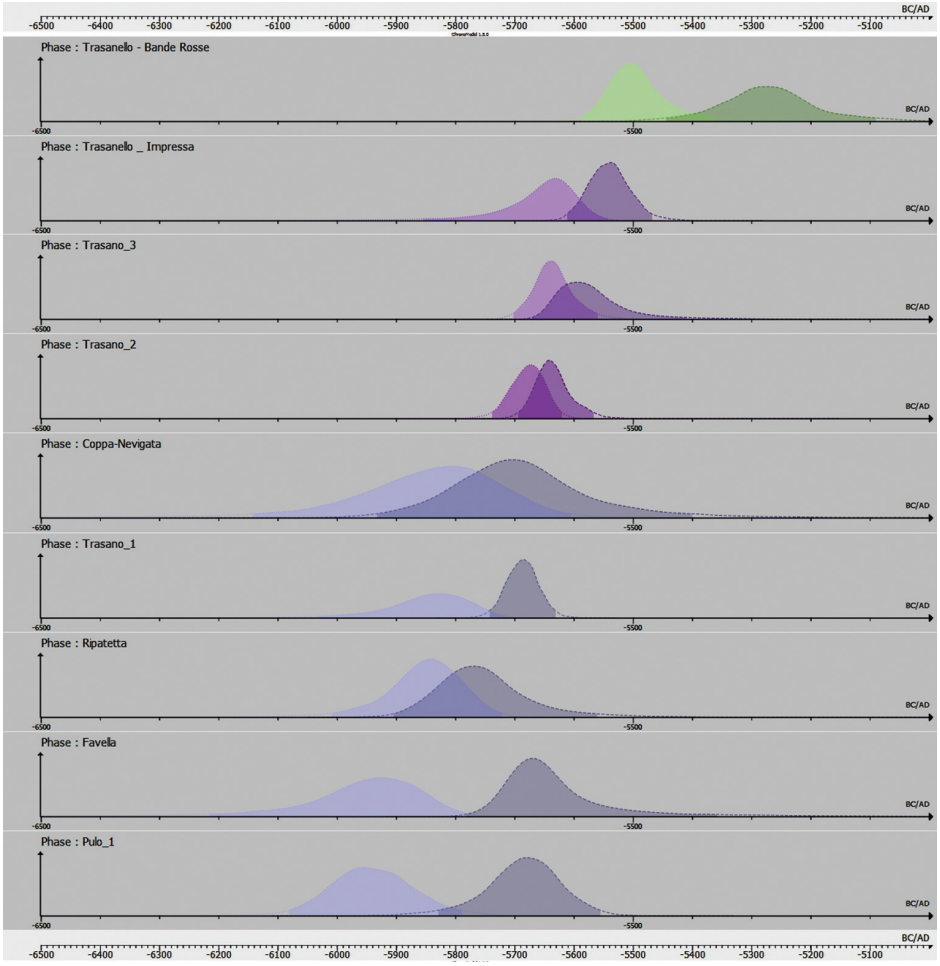



***Fig. 3. Posterior density distribution of all south-eastern Italian Impressa phases. The density region of the beginnings are the oldest. The areas below the curves represent the 95% highest posterior densities.***

| | FAVELLA | PULO_1 | RIPATETTA | TRASANO_1 | COPPA-NEVIGATA | TRASANO_2 | TRASANELLO_1 | TRASANO_3 | TRASANELLO_2 |
|---|---|---|---|---|---|---|---|---|---|
| FAVELLA | | 52,7 | 82,3 | 82,5 | 77,7 | 100,0 | 97,5 | 100,0 | 100,0 |
| PULO_1 | 47,3 | | 81,1 | 81,2 | 76,4 | 99,9 | 97,2 | 100,0 | 100,0 |
| RIPATETTA | 17,7 | 18,9 | | 52,9 | 55,4 | 99,7 | 94,9 | 100,0 | 100,0 |
| TRASANO_1 | 17,5 | 18,8 | 47,1 | | 53,6 | 100,0 | 94,6 | 100,0 | 100,0 |
| COPPA-NEVIGATA | 22,3 | 23,6 | 44,6 | 46,4 | | 92,8 | 90,2 | 97,0 | 99,8 |
| TRASANO_2 | 0,0 | 0,1 | 0,3 | 0,0 | 7,2 | | 66,5 | 100,0 | 100,0 |
| TRASANELLO_1 | 2,5 | 2,8 | 5,1 | 5,4 | 9,8 | 33,5 | | 59,4 | 100,0 |
| TRASANO_3 | 0,0 | 0,0 | 0,0 | 0,0 | 3,0 | 0,0 | 40,6 | | 99,2 |
| TRASANELLO_2 | 0,0 | 0,0 | 0,0 | 0,0 | 0,2 | 0,0 | 0,0 | 0,8 | |

***Tab. 4. Anteriority probabilities of phase beginnings for the southern and central Italian ICC (expressed in percentages). The higher the probability, the greater the distance.***

of the main pottery styles, although many questions remain unsolved.

Obviously, the pottery style of Peiro Signado (BMAP: 5826 BCE) and Arene Candide (BMAP: 5786 BCE), characterised by the predominance of stab-and-drag decoration, is currently the marker of the first Neolithic impact in the North-West, although its links with the South-East are weak, since almost no direct stylistic comparison can be established with either the archaic or the Guadone style, both contemporary. Some comparisons are still to be sought in Sicily and Calabria, within Stentinello *sensu lato* (*Bernabò Brea 1950; Scarcella 2011*).

The beginnings of the Pont de Roque-Haute aspects (BMAP: 5767 BCE) cannot be distinguished from Peiro Signado and Arene Candide, although they could be more clearly linked to the archaic style of the South-East, for instance Trasano 1, via Giglio in the Tuscan archipelago. Unfortunately, the dates from Giglio are not a great help: they appear to be rather late (BMAP: 5674 BCE) compared to the earliest dispersal, and their reliability to one or another style present within the pottery assemblage is weak. The shared use of obsidian from Palmarola and Sardinia adds to the general consistency of these earliest northern styles, which at the moment have to be kept in the same set.

The deposits and pottery production of Pendimoun cover a wide range, more than two centuries, starting at the very end of the 58th century in the southern sector (BMAP: 5715 BCE). It has virtually no stylistic connections with Arene Candide 1A, which is definitely earlier, and more consistent with Arene Candide 1B (event_HPD: 5704–5489). Surprisingly strong comparisons can be made with the archaic aspect of Favella that could have ended in the middle of the 57th century, with a similar proportion of finger and nail impressions. Later assemblages from the northern sector of Pendimoun (BMAP: 5608 BCE) can be connected with several sites in Liguria, including Arma dell'Aquila (BMAP: 5619 BCE), which offers some stylistic parallels, *e.g.*, small curvilinear impressions. All these aspects predate with a high probability the Cardial phases at Pendimoun (BMAP: 5503 and 5445 BCE) and Arene Candide 2 (BMAP: 5467 BCE).

### *Dispersal routes and speed, and the endless question of origins*

Regarding the distance, approx. 1500km of coastline, the spread from the South to the North-West occurred at a record speed, as the difference of BMAP between the earliest southern sites (Pulo di Molfetta or Favella) and the earliest northern one (Peiro Signado) is in the order of one century (Figs. 5–6). This confirms and specifies previous considerations that were based on a smaller set of less accurate radio-

| Event (n-dates) | e_HPD (95%) | e_MAP |
|---|---|---|
| Giglio-Secche_#3 (1) | [–5706; –5186] | –5450 |
| Giglio-Secche_#1 (1) | [–5742; –5409] | –5579 |
| Giglio-Secche_#2 (1) | [–5820; –5534] | –5669 |
| Arene-Candide_US9B (1) | [–5544; –5155] | –5351 |
| Arene-Candide_Cardial pot (1) | [–5590; –5234] | –5417 |
| Arene-Candide_US312 (2) | [–5620; –5196] | –5291 |
| Arene-Candide_US9Bbase (1) | [–5704; –5489] | –5625 |
| Arene-Candide_US330 (1) | [–5747; –5467] | –5657 |
| Arene-Candide_US10 (1) | [–5776; –5616] | –5704 |
| Arene-Candide_US347 (1) | [–5772; –5592] | –5685 |
| Arene-Candide_US351A (1) | [–5809; –5628] | –5712 |
| Arene-Candide_US10A (2) | [–5842; –5686] | –5748 |
| Arene-Candide_US360 (1) | [–5972; –5676] | –5771 |
| S. Sebastiano Perti_#1 (1) | [–5730; –5472] | –5586 |
| S. Sebastiano Perti_#2 (1) | [–5813; –5517] | –5664 |
| S. Sebastiano Perti_#3 (1) | [–5800; –5537] | –5672 |
| Aquila_#1 (1) | [–5731; –5471] | –5587 |
| Aquila_#2 (1) | [–5730; –5464] | –5584 |
| Pendimoun_N_US.18364 (2) | [–5400; –5146] | –5326 |
| Pendimoun_N_US.19000 (1) | [–5415; –5224] | –5342 |
| Pendimoun_N_US.42370 (2) | [–5427; –5262] | –5359 |
| Pendimoun_N_SEP.H2 (1) | [–5455; –5305] | –5383 |
| Pendimoun_N_SEP.F2 (1) | [–5506; –5336] | –5431 |
| Pendimoun_N_US.19001 (2) | [–5478; –5326] | –5413 |
| Pendimoun_S_SEP.F1 (1) | [–5549; –5265] | –5413 |
| Pendimoun_S_US28781A_sup (1) | [–5572; –5201] | –5377 |
| Pendimoun_N_US.47799A_sup (1) | [–5609; –5411] | –5502 |
| Pendimoun_N_US.47799B_inf (1) | [–5742; –5492] | –5601 |
| Pendimoun_N_US.47800 (2) | [–5544; –5383] | –5471 |
| Pendimoun_N_US.47801 (2) | [–5618; –5454] | –5519 |
| Pendimoun_N_US.41678 (2) | [–5641; –5484] | –5559 |
| Pendimoun_N_US.2067 (2) | [–5609; –5434] | –5505 |
| Pendimoun_S_US29203 (1) | [–5792; –5507] | –5654 |
| Pendimoun_S_US.28889 (2) | [–5695; –5521] | –5618 |
| Pendimoun_S_US.28781B_inf (1) | [–5834; –5546] | –5690 |
| Pendimoun_S_US.5711 (2) | [–5835; –5539] | –5682 |
| Peiro Signado_#1 (1) | [–5983; –5597] | –5780 |
| Peiro Signado_#2 (1) | [–6034; –5591] | –5798 |
| Pont de Roque-Haute_F1 (3) | [–5805; –5677] | –5739 |
| Pont de Roque-Haute_F1base (2) | [–5857; –5711] | –5767 |

***Tab. 5. Modelled events (from Table 1) of the north-western Mediterranean ICC. The number of associated dates is for each event indicated in brackets: e_HPD (95%),* i.e. *event's highest posterior density interval at 95% confidence; e_MAP, event's posterior mode.***

| Phase (n-events, n-dates) | D_HPD (95%) | D_MAP | B_HPD (95%) | B_MAP | E_HPD (95%) | E_MAP |
|---|---|---|---|---|---|---|
| PeiroSignado (2, 2) | [1; 329] | 38 | [–6034; –5703] | –5826 | [–5895; –5562] | –5763 |
| Arene-Candide-1A_Impressa (6, 7) | [40; 410] | 154 | [–5963; –5707] | –5786 | [–5726; –5473] | –5653 |
| Pont-de-Roque-Haute (2, 5) | [0; 109] | 12 | [–5857; –5711] | –5767 | [–5805; –5677] | –5739 |
| Pendimoun-S_Impressa (4, 6) | [18; 315] | 121 | [–5881; –5633] | –5715 | [–5671; –5499] | –5611 |
| S. Sebastiano Perti_Impressa/Cardial (3, 3) | [2; 293] | 103 | [–5841; –5609] | –5697 | [–5682; –5458] | –5581 |
| Giglio_Impressa/Cardial (3, 3) | [34; 498] | 210 | [–5837; –5544] | –5674 | [–5627; –5237] | –5456 |
| Aquila_Impressa (2, 2) | [1; 204] | 23 | [–5739; –5528] | –5619 | [–5654; –5447] | –5571 |
| Pendimoun-N_Impressa (5, 9) | [50; 299] | 147 | [–5737; –5532] | –5608 | [–5516; –5387] | –5470 |
| Pendimoun-N_Cardial (7, 10) | [77; 385] | 189 | [–5609; –5424] | –5503 | [–5400; –5146] | –5326 |
| Arene-Candide-2_Cardial (3, 4) | [13; 376] | 149 | [–5625; –5332] | –5467 | [–5458; –5131] | –5298 |
| Pendimoun-S_Cardial (2, 2) | [1; 237] | 26 | [–5599; –5323] | –5445 | [–5487; –5196] | –5364 |

***Tab. 6. Modelled phases of the north-western Mediterranean ICC. The number of associated events and dates for each event is indicated in brackets: D_HPD (95%), highest posterior density interval at 95% confidence of phase duration; D_MAP, posterior mode of phase duration; B_HPD (95%), highest posterior density interval at 95% confidence of phase beginning; B_MAP, posterior mode of phase beginning; E_HPD (95%), highest posterior density interval at 95% confidence of phase's end; E_MAP, posterior mode of phase's end.***

carbon dates (*Binder, Guilaine 1999; Zilhão 2001*). Our results contribute to moderating, and even to changing, the idea of a strong contrast between a fast continental farming dispersal following rivers (*i.e.* trans-Balkans routes) and a slow one following maritime itineraries (*i.e.* Adriatic routes) (*Biagi* et al. *2005*). Indeed, the dispersal from southern Italy towards Liguria and France appears seven or eight times faster than for reaching Abruzzo.

Within this Ulyssean world, voyagers faced many hazards, depending on their own sailing skills. Surface currents could have been a compelling factor limiting voyaging capacities, and this could partly explain the apparent discontinuity of the north-western spread and the lack of early sites in several regions (*e.g.*, Lazio, Tuscany or Sardinia on the western slope of the Apennine, or Molise, Umbria, Abruzzo, Emilia *etc*. on the eastern slope).

In the Alps, the Tosco-Emilian Apennine and the Po plain, a significant network of Late Mesolithic settlements is observed (*Ferrari 2010; Franco 2011; Marchand, Perrin 2017*) which is not the case everywhere in the North-Western Mediterranean and especially in places where the farmers first settled (Western Liguria, Eastern Provence, Mediterranean Languedoc). Although the Castelnovian chronology is still poorly known in general terms, late Mesolithic sites, contemporary with the first evidence of farmer settlement, are documented in the Rhône Valley and in the Tosco-Emilian Apennine (*Binder* et al. *2017; Dini, Fioravanti 2011; Marchand, Perrin 2017*). This has sometimes been considered to be

| | PEIRO SIGNADO | ARENE CANDIDE 1A Impressa | PONT-DE-ROQUE-HAUTE | PENDIMOUN-SOUTH Impressa | ARMA DEL-L'AQUILA | PENDIMOUN-NORTH Impressa | PENDIMOUN-NORTH Cardial | ARENE CANDIDE 2 Cardial | PENDIMOUN-SOUTH Cardial |
|---|---|---|---|---|---|---|---|---|---|
| PEIRO SIGNADO | | 63,9 | 79,7 | 88,4 | 98,1 | 98,1 | 100,0 | 99,5 | 100,0 |
| ARENE CANDIDE 1A Impressa | 36,1 | | 68,0 | 84,3 | 97,8 | 97,8 | 100,0 | 99,4 | 100,0 |
| PONT-DE-ROQUE-HAUTE | 20,3 | 32,1 | | 77,5 | 97,0 | 97,1 | 100,0 | 99,3 | 100,0 |
| PENDIMOUN-SOUTH Impressa | 11,6 | 15,7 | 22,5 | | 93,5 | 93,6 | 99,9 | 99,0 | 100,0 |
| ARMA DELL'AQUILA | 1,9 | 2,2 | 3,0 | 6,5 | | 52,9 | 96,3 | 94,3 | 98,4 |
| PENDIMOUN-NORTH Impressa | 1,9 | 2,2 | 2,9 | 6,4 | 47,1 | | 100,0 | 94,1 | 98,4 |
| PENDIMOUN-NORTH Cardial | 0,0 | 0,0 | 0,0 | 0,1 | 3,7 | 0,0 | | 64,3 | 83,5 |
| ARENE CANDIDE 2 Cardial | 0,5 | 0,6 | 0,7 | 1,0 | 5,7 | 5,9 | 35,7 | | 65,2 |
| PENDIMOUN-SOUTH Cardial | 0,0 | 0,0 | 0,0 | 0,0 | 1,6 | 1,6 | 16,6 | 34,8 | |

***Tab. 7. Anteriority probabilities of phase beginnings for the north-western Mediterranean ICC (expressed in percentages). The higher the probability, the greater the distance.***

at the origin of a lock for the ICC dispersion (*Binder 2000; 2013*).

As yet, the absence of Mesolithic data prevents a discussion of such a hypothesis for the eastern slopes of the central Apennine. Thus the question of a blocking situation of the Neolithic spread on the western side of the Adriatic remains wide open, unlike what is observed on the eastern shore (*Biagi* et al. *2005*).

The diversity observed in the earliest ICC from the northern Mediterranean reflects parts of the diversity observed in the South-East. This could have resulted from the diffusion of small culturally diverse

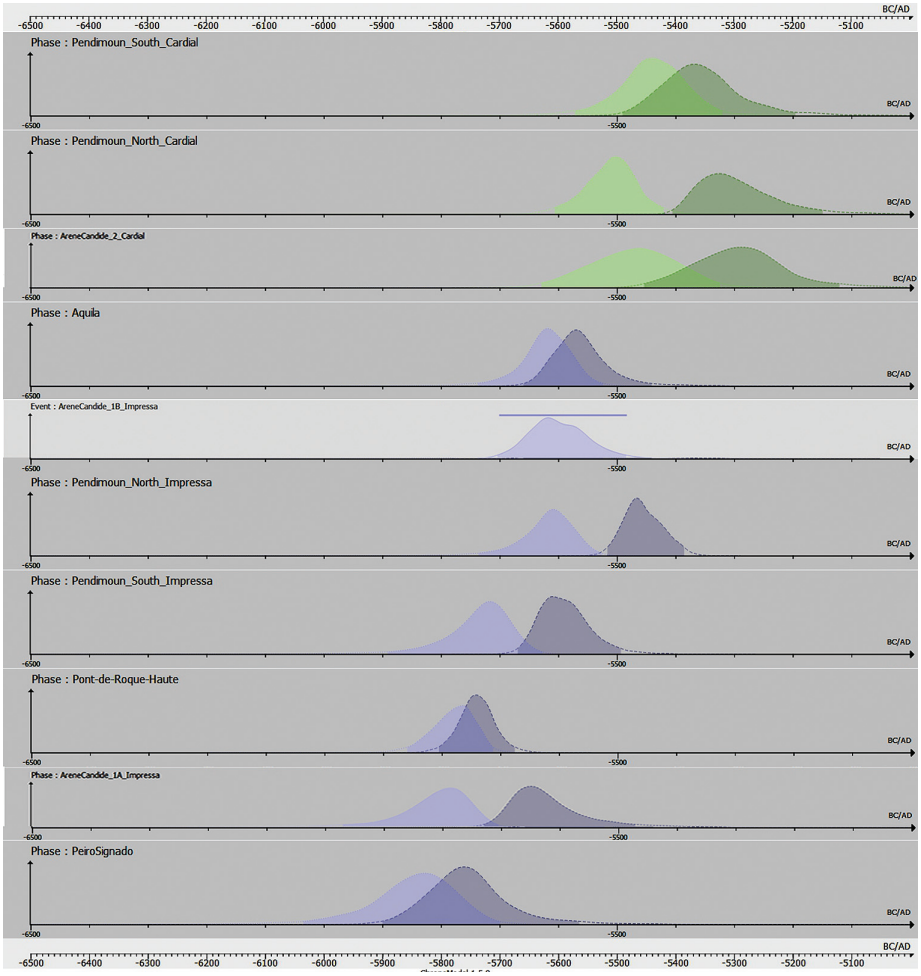



***Fig. 4. Posterior density distribution of all north-western Impressa phases. The density region of the beginnings are the oldest. The areas below the curves represent the 95% highest posterior densities.***

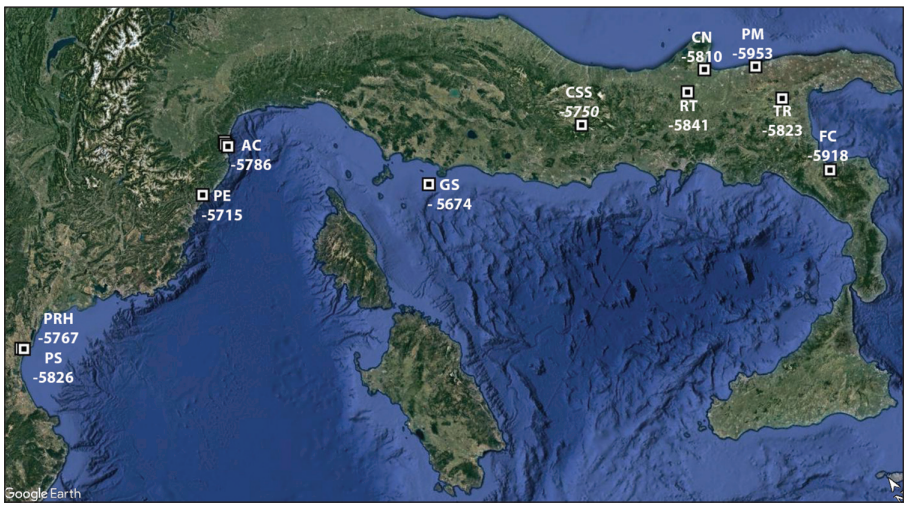



***Fig. 5. Representation of the earliest Italian and northwestern Mediterranean ICC settlements using the Mode a posteriori of Phases beginning (BMAP): AC Arene Candide; CN Coppa Nevigata; CSS Colle Santo Stefano; FC Favella della Corte; GS Giglio Le Secche; PE Pendimoun; PM Pulo di Molfetta; PRH Pont de Roque-Haute; PS Peiro Signado; RT Ripatetta; TR Trasano.***

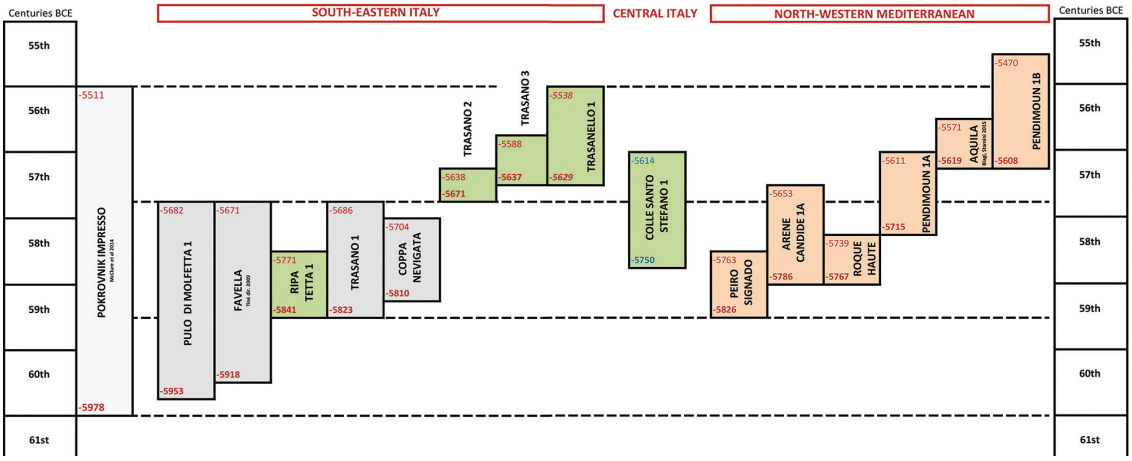



***Fig. 6. Periodisation diagram of the Impressa aspects from the Central and Western Mediterranean.***

groups. Indeed, some of the north-western pottery assemblages share more characteristics with the distant Apulian and Calabrian settlements than with their closest neighbours.

To date, the early north-western dispersal has been shown to have occurred from about the 59th century, a period during which diversification is observed within the material cultures in south-eastern Italy, *i.e.* the early emergence of Guadone. Nevertheless, north-western material cultures do not provide evidence of the evolved Guadone patterns, and they globally remain closer to the archaic patterns. Likewise, the origins of the Arene Candide – Peiro Signado style remains unsolved, even if some connections were highlighted on Corfu (Sidari) and Sicily (Kronio) (*Guilaine* et al. *2016*). New work on pottery technology now demonstrates a disconnection between north-western ICC, with a singular Spiral Patchwork technology, and the evolved assemblages from Ripatetta and Colle Santo Stefano, with a standard pan-European coiling technology (*Gomart* et al. *2017 in press*). This reinforces the hypothesis of cultural drift and questions the origin of both communities of practices. In this framework, Sicily still constitutes a priority target.

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*D. Binder ran the Bayesian modelling and wrote the paper with the collaboration of P. Lanos, who specified the ChronoModel rules and ran an anteriority probability calculus. All the authors discussed the results and interpretations before submission.*

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# Appendix

## Tab. 1. Conventional radiocarbon dates and samples of Central and Western Mediterranean ICC considered in this article.

| Region (district) | | Site | 14C_lab_label | Mean | StE | Sample |
|---|---|---|---|---|---|---|
| Ionian islands (Corfu) | Corfu | Sidari | Ly-5633 (SacA-13393) | 7170 | 40 | Cerealia charred seeds |
| Ionian islands (Corfu) | Corfu | Sidari | Ly-3172 (SacA-4513) | 7370 | 80 | *Quercus* sp. charcoal |
| Apulia (Bari) | Molfetta | Pulo di Molfetta | LTL-141A | 6651 | 50 | *Ovis* vel *Capra*, bone collagen |
| Apulia (Bari) | Molfetta | Pulo di Molfetta | LTL-3810A | 6764 | 60 | *Ovis* vel *Capra*, bone collagen |
| Apulia (Bari) | Molfetta | Pulo di Molfetta | LTL-4536A | 6983 | 50 | *Ovis* vel *Capra*, bone collagen |
| Apulia (Bari) | Molfetta | Pulo di Molfetta | LTL-142A | 7134 | 60 | *Ovis* vel *Capra*, bone collagen |
| Apulia (Brindisi) | Ostuni | Sant'Angelo | Gif-6722 | 6530 | 70 | Cerealia charred seeds |
| Apulia (Brindisi) | Ostuni | Sant'Angelo | Gif-6724 | 6980 | 70 | *Triticum* sp. charred seeds |
| Apulia (Foggia) | Lucera | Rippa Tetta | Beta-47808 | 6890 | 60 | Cerealia charred seeds |
| Apulia (Foggia) | Lucera | Rippa Tetta | LTL-16676A | 6910 | 40 | Cerealia charred seeds fragments |
| Apulia (Foggia) | Lucera | Rippa Tetta | LTL-16677A | 6988 | 45 | Cerealia charred seeds fragments |
| Apulia (Foggia) | Manfredonia | Coppa Nevigata | OxA-1474 | 6850 | 80 | Cerealia charred seeds |
| Apulia (Foggia) | Manfredonia | Coppa Nevigata | OxA-1475 | 6880 | 90 | *Hordeum* sp. charred seeds |
| Apulia (Tarente) | Manduria | Terragne | Beta-59934 | 6930 | 70 | *Cervus* sp, bone collagen |
| Apulia (Tarente) | Manduria | Terragne | Beta-67093 | 7260 | 60 | *Bos primigenius* bone collagen |
| Basilicate (Matera) | Matera | Trasano | Ly -3951 (OxA) | 6840 | 35 | Cerealia charred seeds |
| Basilicate (Matera) | Matera | Trasano | Ly -3949 (OxA) | 6730 | 40 | Cerealia charred seeds |
| Basilicate (Matera) | Matera | Trasano | Ly -3950 (OxA) | 6810 | 35 | Cerealia charred seeds |
| Basilicate (Matera) | Matera | Trasano | Ly -3948 (OxA) | 6710 | 35 | Cerealia charred seeds |
| Basilicate (Matera) | Matera | Trasano | Ly -3952 (OxA) | 6760 | 40 | Cerealia charred seeds |
| Basilicate (Matera) | Matera | Trasano | Ly -3953 (OxA) | 6730 | 40 | Cerealia charred seeds |
| Basilicate (Matera) | Matera | Trasano | Ly -3954(OxA) | 6835 | 40 | Cerealia charred seeds |
| Basilicate (Matera) | Matera | Trasano | Ly -3955(OxA) | 6935 | 40 | Cerealia charred seeds |
| Basilicate (Matera) | Matera | Trasanello | LTL-12139A | 6301 | 45 | Unspecified charcoal |
| Basilicate (Matera) | Matera | Trasanello | LTL-12146A | 6614 | 45 | Unspecified charcoal |
| Basilicate (Matera) | Matera | Trasanello | LTL-12142A | 6644 | 45 | Unspecified charcoal |
| Basilicate (Matera) | Matera | Trasanello | LTL-12143A | 6683 | 45 | Unspecified charcoal |
| Basilicate (Matera) | Matera | Trasanello | LTL-12144A | 6632 | 45 | Unspecified charcoal |
| Basilicate (Matera) | Matera | Trasanello | LTL-12145A | 6612 | 45 | Unspecified charcoal |
| Calabria (Cosenza) | Corigliano Calabro | Favella della Corte | Beta-165482 | 6940 | 40 | Cerealia charred seeds |
| Calabria (Cosenza) | Corigliano Calabro | Favella della Corte | Beta-71633 | 6910 | 60 | Cerealia charred seeds |
| Calabria (Cosenza) | Corigliano Calabro | Favella della Corte | LTL-202A | 6956 | 75 | Cerealia charred seeds |
| Calabria (Cosenza) | Corigliano Calabro | Favella della Corte | LTL-203A | 6890 | 50 | Cerealia charred seeds |
| Calabria (Cosenza) | Corigliano Calabro | Favella della Corte | LTL-204A | 6793 | 40 | Bone collagen |
| Calabria (Cosenza) | Corigliano Calabro | Favella della Corte | LTL-778A | 7003 | 55 | Bone collagen |
| Abruzzi (L'Aquila) | Ortucchio | Colle Santo Stefano | LTL-15952A | 6809 | 45 | Triticum dicoccum charred seed |
| Abruzzi (L'Aquila) | Ortucchio | Colle Santo Stefano | LTL-15953A | 6770 | 45 | Triticum cf. dicoccum charred seed |
| Tuscany (Grossetto) | Isola del Giglio | Le Secche | LTL-16671A | 6637 | 45 | *Erica* sp. charcoal |
| Tuscany (Grossetto) | Isola del Giglio | Le Secche | LTL-16672A | 6769 | 45 | *Erica* sp. charcoal |
| Tuscany (Grossetto) | Isola del Giglio | Le Secche | LTL-16673A | 6492 | 65 | Erica sp. charcoal |

| Identification | Field_label | Cultural attibution | Referneces |
|---|---|---|---|
| _ | Hearth 5b-5c | Archaic Impressa | *Berger* et al. *2014* |
| S. Thiébault | Pit 4 | End of the Monochrome phase | *Berger* et al. *2014* |
| S. Massala | Phase II, US49 | Archaic Impressa | Unpublished, I. Muntoni |
| S. Massala | Phase Isup, US46 | Archaic Impressa | Unpublished, I. Muntoni |
| S. Massala | Phase I, US10 | Archaic Impressa | Unpublished, I. Muntoni |
| S. Massala | Phase I, US10 | Archaic Impressa | *Fiorentino* et al. *2013* |
| L. Costantini | Level 6-7 | Red painted wares | *Coppola 2001* |
| L. Costantini | Level 9 | Evolved Impressa (Guadone) | *Coppola 2001* |
| L. Costantini | Cobble paved area (C9) | Evolved Impressa (Guadone) | *Costantini, Stancanelli 1994* |
| L. Bouby | Cobble paved area, TG1B (I-M30), #B | Evolved Impressa (Guadone) | Unpublished, CIMO project |
| L. Bouby | Cobble paved area, TG1B (I-M30), #A | Evolved Impressa (Guadone) | Unpublished, CIMO project |
| L. Costantini | Phase II-III | Archaic Impressa | *Skeates 1994* |
| L. Costantini | Phase II-III | Archaic Impressa | *Skeates 1994* |
| C. Corridi | US4-5 | Late Mesolithic ? | *Gorgoglione* et al. *1995* |
| C. Corridi | US4-5 | Late Mesolithic ? | *Gorgoglione* et al. *1995* |
| P. Marinval | Sector A (T44), C2inf | Archaic Impressa | Unpublished, J. Guilaine |
| P. Marinval | Sector A (U48), C2.0 | Evolved Impressa | Unpublished, J. Guilaine |
| P. Marinval | Sector A (U48), C2c | Archaic Impressa | Unpublished, J. Guilaine |
| P. Marinval | Sector A (U48-49), C1 | Recent Impressa | Unpublished, J. Guilaine |
| P. Marinval | Sector B (AB46), C2.1 | Recent Impressa | Unpublished, J. Guilaine |
| P. Marinval | Sector B (AB42), C2.2 | Evolved Impressa | Unpublished, J. Guilaine |
| P. Marinval | Sector B (AA44), C2.3 | Archaic Impressa | Unpublished, J. Guilaine |
| P. Marinval | Sector B (AA-AB south), C2.4 | Archaic Impressa | Unpublished, J. Guilaine |
| _ | Trench 11, US3sup, internal ditch edge | Red painted wares | Unpublished, L. Angeli |
| _ | Trench 11, US3inf, internal ditch edge (F4) | Red painted wares | Unpublished, L. Angeli |
| _ | Trench 11, US5, sherd concentration | Late Impressa | Unpublished, L. Angeli |
| _ | Trench 11, US5 (B3) | Late Impressa | Unpublished, L. Angeli |
| _ | Trench 11, US5 (C4) | Late Impressa | Unpublished, L. Angeli |
| _ | Trench 11, US5, ditch filing | Late Impressa | Unpublished, L. Angeli |
| S. Coubray | Structure D, Pit Y, US4_XIII | Archaic Impressa | *Tiné 2009* |
| S. Coubray | Structure A, Pit Z, US4_VI | Archaic Impressa | *Tiné 2009* |
| S. Coubray | Structure E, Pit T, US3 | Archaic Impressa | *Tiné 2009* |
| S. Coubray | Structure E, Pit 30, US4_II | Archaic Impressa | *Tiné 2009* |
| S. Coubray | Structure D, Pit Y, US4_II | Archaic Impressa | *Tiné 2009* |
| S. Coubray | Structure G, Pit 10, US3_VI | Archaic Impressa | *Tiné 2009* |
| L. Bouby | Cobble paved area (H20), US17, #A | Evolved Impressa (Guadone) | Unpublished, CIMO project |
| L. Bouby | Cobble paved area (H20), US17, #B | Evolved Impressa (Guadone) | Unpublished, CIMO project |
| C. Delhon | Grey sediment #1 | Impressa / Cardial | Unpublished, CIMO project |
| C. Delhon | Brown sediment #2 | Impressa / Cardial | Unpublished, CIMO project |
| C. Delhon | Brown sediment #3 | Impressa / Cardial | Unpublished, CIMO project |

| Region (district) | | Site | $^{14}$C_lab_label | Mean | StE | Sample |
|---|---|---|---|---|---|---|
| Liguria (Savona) | Finale-Ligure | Arene Candide | LTL-15943A | 6834 | 45 | *Ovis aries* bone collagen |
| Liguria (Savona) | Finale-Ligure | Arene Candide | LTL-15944A | 6864 | 45 | *Ovis aries* bone collagen |
| Liguria (Savona) | Finale-Ligure | Arene Candide | LTL-15946A | 6750 | 45 | *Vitis vinifera* ssp. *sylvestris* charred seed |
| Liguria (Savona) | Finale-Ligure | Arene Candide | LTL-15947A | 6861 | 45 | *Ovis aries* bone collagen |
| Liguria (Savona) | Finale-Ligure | Arene Candide | LTL-16680A | 6271 | 40 | *Capra hircus* bone collagen |
| Liguria (Savona) | Finale-Ligure | Arene Candide | LTL-16681A | 6623 | 45 | *Bos taurus* bone collagen |
| Liguria (Savona) | Finale-Ligure | Arene Candide | LTL-16678A | 6751 | 45 | *Capra hircus* bone collagen |
| Liguria (Savona) | Finale-Ligure | Arene Candide | LTL-6004A | 6446 | 45 | *Triticum monococcum* charred spikelet and fork |
| Liguria (Savona) | Finale-Ligure | Arene Candide | Beta-66552 | 6150 | 70 | *Phillyrea* sp. charcoal |
| Liguria (Savona) | Finale-Ligure | Arene Candide | Beta-66553 | 6880 | 60 | *Pistachia terebinthus* charcoal |
| Liguria (Savona) | Finale-Ligure | Arene Candide | Beta-170557 | 6870 | 40 | *Triticum monococcum* charred seeds |
| Liguria (Savona) | Finale-Ligure | Arene Candide | Beta-170558 | 6860 | 40 | *Cornus* sp. charred seed |
| Liguria (Savona) | Finale-Ligure | Arene Candide | OxA-23072 | 6778 | 39 | *Triticum dicoccum* charred seeds |
| Liguria (Savona) | Finale-Ligure | Arene Candide | Beta-110542 | 6830 | 40 | *Hordeum* sp. charred seeds |
| Liguria (Savona) | Finale-Ligure | Arene Candide | Beta-170555 | 6700 | 40 | *Euphorbia* sp. charcoal |
| Liguria (Savona) | Finale-Ligure | Arene Candide | Beta-109619 | 6370 | 50 | *Rhamnus alaternus* charcoal |
| Liguria (Savona) | Finale-Ligure | San Sebastiano di Perti | GrA-25715 | 6760 | 45 | *Hordeum* sp. charred seeds |
| Liguria (Savona) | Finale-Ligure | San Sebastiano di Perti | OxA-21359 | 6767 | 39 | *Triticum dicoccum* charred seeds |
| Liguria (Savona) | Finale-Ligure | San Sebastiano di Perti | OxA-19734 | 6675 | 33 | *Triticum vulgare* |
| Liguria (Savona) | Orco Feglino | Arma dell'Aquila | OxA-V-2365-31 | 6678 | 33 | Human bone collagen |
| Liguria (Savona) | Orco Feglino | Arma dell'Aquila | OxA-V-2365-50 | 6669 | 34 | Human bone collagen |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | GrA-26893 | 6445 | 40 | Human bone collagen |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-15940A | 6399 | 45 | Cerealia charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-15941A | 6803 | 45 | *Arbutus unedo* charcoal |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | GrA-29528 | 6650 | 45 | Cerealia charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | GrA-29403 | 6725 | 45 | Cerealia charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-15942A | 6745 | 45 | Maloideae charcoal |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | Lyon-1713 (GrA-20195) | 6790 | 50 | Pomoideae charcoal |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-8012A | 6499 | 45 | *Quercus* sp. charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-8011A | 6507 | 45 | *Quercus* sp. charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-14104A | 6466 | 40 | *Corylus avellana* charcoal |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-8007A | 6170 | 45 | *Quercus* sp. charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-8008A | 6337 | 45 | *Quercus* sp. charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-8009A | 6241 | 45 | *Corylus avellana* charred fruit |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-8010A | 6328 | 45 | *Quercus* sp. charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | GrA-32061 | 6450 | 40 | Human bone collagen |

| Identification | Field_label | Cultural attibution | Referneces |
|---|---|---|---|
| P. Rowley-Conwy | Phase AC1, US347 | Impressa | Unpublished, CIMO project |
| P. Rowley-Conwy | Phase AC1, US360 | Impressa | Unpublished, CIMO project |
| R. Nisbet | Phase AC1, US351A | Impressa | Unpublished, CIMO project |
| P. Rowley-Conwy | Phase AC2, US330 (anatomical connection) | Impressa | Unpublished, CIMO project |
| P. Rowley-Conwy | Phase AC3, US312, #A | Cardial | Unpublished, CIMO project |
| P. Rowley-Conwy | Phase AC3, US312, #B | Cardial | Unpublished, CIMO project |
| P. Rowley-Conwy | Phase AC3, US306, #B | Cardial | Unpublished, CIMO project |
| D. Arobba | Cf. Phase AC3, US26, #Cardial pot | Cardial | *Arobba* et al. *2017* |
| R. Nisbet | Cf. Phase AC4/, US27C | Impressa / Cardial | *Maggi 1997b* |
| R. Nisbet | Cf. Phase AC1/, US27G | Impressa / Cardial | *Maggi 1997b* |
| R. Nisbet | Phase AC1, US10A | Impressa | Unpublished, R. Maggi |
| R. Nisbet | Phase AC1, US10A | Impressa | Unpublished, R. Maggi |
| R. Nisbet | Phase AC1, US10 | Impressa | *Biagi, Starnini 2016* |
| R. Nisbet | Phase AC1, US10 | Impressa | Unpublished, R. Maggi |
| R. Nisbet | Phase AC2, US9Bbase | Impressa | Unpublished, R. Maggi |
| R. Nisbet | Phase AC3, US9B | Cardial | Unpublished, R. Maggi |
| D. Arobba | Unique layer | Impressa | *Biagi, Starnini 2016* |
| D. Arobba | Unique layer | Impressa | *Biagi, Starnini 2016* |
| D. Arobba | Unique layer | Impressa | *Biagi, Starnini 2016* |
| _ | Child burial | Impressa | *Biagi, Starnini 2016* |
| _ | Layer 7 | Impressa | *Biagi, Starnini 2016* |
| H. Duday, G. Goude | Sector South, Burial F1, #N16_606 | Cardial | *Binder, Sénépart 2010* |
| L. Bouby, A. Carré | Sector South, US28781-sup, #28898 | Cardial | Unpublished, CIMO project |
| J. Battentier | Sector South, Pit, US28781-inf, #28905 | Impressa | Unpublished, CIMO project |
| L. Bouby, A. Carré | Sector South, Pit, US28889, #28941 | Impressa | *Binder, Sénépart 2010* |
| L. Bouby, A. Carré | Sector South, US28889, #28938 | Impressa | *Binder, Sénépart 2010* |
| J. Battentier | Sector South, Pit, US29203, #29223 | Impressa | Unpublished, CIMO project |
| S. Thiébault | Sector South, US5711, #5720 | Impressa | Unpublished, D. Binder |
| L. Bouby, A. Carré | Sector North, US18364, #18512 | Cardial | Unpublished, D. Binder |
| L. Bouby, A. Carré | Sector North, US18364, #18365 | Cardial | Unpublished, D. Binder |
| J. Battentier | Sector North, US19000, #41859 | Cardial | Unpublished, D. Binder |
| L. Bouby, A. Carré | Sector North, US19001, #44387 | Cardial | Unpublished, D. Binder |
| L. Bouby, A. Carré | Sector North, US19001, #44473 | Cardial | Unpublished, D. Binder |
| L. Bouby, A. Carré | Sector North, US42370, #42861 | Cardial | Unpublished, D. Binder |
| L. Bouby, A. Carré | Sector North, US42370, #44077 | Cardial | Unpublished, D. Binder |
| H. Duday, G. Goude | Sector North, Burial H2, US43000, #43220 | Cardial | *Binder, Sénépart 2010* |

| Region (district) | | Site | 14C_lab_label | Mean | StE | Sample |
|---|---|---|---|---|---|---|
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | GrA-26894 | 6440 | 40 | Human bone collagen |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-13788A | 6547 | 45 | *Bryonia* sp. charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-13787A | 6666 | 45 | *Bryonia* sp. charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-8005A | 6599 | 45 | *Triticum dicoccum* charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-8006A | 6649 | 45 | *Triticum dicoccum* charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-8003A | 6452 | 45 | *Quercus* sp. charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-8004A | 6507 | 45 | *Quercus* sp. charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-8002A | 6539 | 45 | *Quercus* sp. charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | LTL-8001A | 6600 | 45 | *Triticum* sp. charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | GrA-26897 | 6500 | 40 | *Quercus* sp. charred seeds |
| Provence (Alpes-Maritimes) | Castellar | Pendimoun | GrA-26895 | 6605 | 40 | *Quercus* sp. charred seeds |
| Occitanie (Hérault) | Portiragnes | Peiro-Signado | Ly-5688 | 6910 | 40 | Cerealia charred seeds |
| Occitanie (Hérault) | Portiragnes | Peiro-Signado | Ly-5689 | 6925 | 45 | Cerealia charred seeds |
| Occitanie (Hérault) | Portiragnes | Pont de Roque-Haute | Beta-398950 | 6920 | 30 | *Triticum dicoccum* charred seeds |
| Occitanie (Hérault) | Portiragnes | Pont de Roque-Haute | Beta-398951 | 6870 | 30 | *Triticum dicoccum* charred seeds |
| Occitanie (Hérault) | Portiragnes | Pont de Roque-Haute | Ly-9879 (SacA-32046) | 7010 | 60 | *Triticum dicoccum* charred seeds |
| Occitanie (Hérault) | Portiragnes | Pont de Roque-Haute | Beta-398952 | 6910 | 30 | *Triticum dicoccum* charred seeds |
| Occitanie (Hérault) | Portiragnes | Pont de Roque-Haute | Ly-9878 (SaA-32045) | 6820 | 35 | *Triticum dicoccum* charred seeds |

| Identification | Field_label | Cultural attibution | Referneces |
|---|---|---|---|
| H. Duday, G. Goude | Sector North, Burial F2, #K16_603 | Cardial | *Binder, Sénépart 2010* |
| L. Bouby, A. Carré | Sector North, US47799-sup, #48256 | Cardial | Unpublished, D. Binder |
| L. Bouby, A. Carré | Sector North, US47799-inf, #47889 | Impressa | Unpublished, D. Binder |
| L. Bouby, A. Carré | Sector North, US41678, #47328 | Impressa | *Binder* et al. *2014* |
| L. Bouby, A. Carré | Sector North, US41678, #47292 | Impressa | *Binder* et al. *2014* |
| L. Bouby, A. Carré | Sector North, US47800, #47783 | Impressa | Unpublished, D. Binder |
| L. Bouby, A. Carré | Sector North, US47800, #47915 | Impressa | Unpublished, D. Binder |
| L. Bouby, A. Carré | Sector North, US47801, #48150 | Impressa | Unpublished, D. Binder |
| L. Bouby, A. Carré | Sector North, US47801, #48041 | Impressa | Unpublished, D. Binder |
| L. Bouby, A. Carré | Sector North, US2067, #2070 | Impressa | *Binder, Sénépart 2010* |
| L. Bouby, A. Carré | Sector North, US2067, #2066 | Impressa | *Binder, Sénépart 2010* |
| P. Marinval | Unique layer | Impressa | Unpublished, F. Briois |
| P. Marinval | Unique layer | Impressa | Unpublished, F. Briois |
| L. Bouby | Pit F1_base | Impressa | Unpublished, PROCOME project |
| L. Bouby | Pit F1_base | Impressa | Unpublished, PROCOME project |
| L. Bouby | Pit F1 | Impressa | Unpublished, L. Bouby |
| L. Bouby | Pit F1 | Impressa | Unpublished, L. Bouby |
| L. Bouby | Pit F1 | Impressa | *Guilaine* et al. *2007* |

back to contents

# Periodisation of the Neolithic and radiocarbon chronology of the Early Neolithic and the beginning of the Middle Neolithic in Finland

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ABSTRACT – *This paper discusses the basis of Neolithic periodisation used in mainland Finland. It is suggested that the periodisation should be revised: the boundary between the Middle and Late Neolithic periods should be moved to correspond with the appearance of Corded Ware (*c. *2800 cal BC), and the term 'Final Neolithic' introduced to cover the final centuries of the Neolithic. This kind of division would reflect changes in the cultural development better than that currently in use. In addition, the chronological frames for the pottery types dated between the late 6th and mid-4th millennium cal BC,* i.e. *the Early Neolithic and the beginning of Middle Neolithic, are presented.*

KEY WORDS – *Early Neolithic; Middle Neolithic; periodisation; radiocarbon chronology; Finland*

## *Periodizacija neolitika in radiokarbonska kronologija zgodnjega neolitika in začetka srednjega neolitika na Finskem*

IZVLEČEK – *V članku razpravljamo o osnovah periodizacije neolitika na območju celinske Finske. Predlagamo ponoven razmislek o periodizaciji: mejo med srednjim in poznim neolitikom bi morali premakniti tako, da bi ustrezala začetku kulture vrvičaste keramike (ok. 2800 pr. n. št.), in dodati fazo 'finalnega' neolitika, ki bi vključeval poslednja stoletja v obdobju neolitika. Te spremembe bi bolje odsevale spremembe v kulturnem razvoju kot trenutna periodizacija neolitika. Dodatno predstavljamo tudi kronološke okvirje za tipe posod, ki jih datiramo med pozno 6. in srednje 4. tisočletje pr. n. št., torej čas zgodnjega in začetka srednjega neolitika.*

KLJUČNE BESEDE – *zgodnji neolitik; srednji neolitik; periodizacija; radiokarbonska kronologija; Finska*

## Introduction

The chronological framework of the Neolithic applied in Finland differs from those currently used in neighbouring areas. The deviation does not concern the beginning of Neolithic, but internal division of the period. This paper deals with the basis of the periodisation and presents the chronological frames for pottery types dated between the late 6th and mid-4th millennium cal BC, *i.e.* the Early Neolithic (EN; 5200–3900 cal BC) and the beginning of the Middle Neolithic (MN; 3900–2300 cal BC) in mainland Finland.[1] No comprehensive list of Finnish radiocarbon dates is included in this article, since most of the EN–MN radiocarbon data originates in the Dating Laboratory of the Finnish Museum of Natural History (Luomus) with lab-codes Hel (conventional) and Hela (AMS); some of these $^{14}$C data have been published in the series *Radiocarbon Dates* (for the latest volume, see *Jungner, Sonninen 2004*; also *e.g.,*

1 All datings in this paper is calibrated with OxCal 4.2 (*Bronk Ramsey 2009*) and the calibration curve IntCal13 (*Reimer* et al. *2013*).


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*Carpelan 2004; Pesonen 2004; Pesonen* et al. *2012*), and the whole dataset should be available in an open-access database in the near future (*$^{14}$CARHU*, see www.oasisnorth.org). Thus, Appendix 1 includes only the published (AMS) dates made in other laboratories than Helsinki.

## Chronology and periodisation

The beginning of the Neolithic is defined by the appearance of ceramics, and pottery is also the main element for further internal division of the period. The periodisation currently in use is based on Christian Carpelan's (*Carpelan 1979*) compilation of earlier pottery typology studies and shoreline displacement-based chronologies (see *Siiriäinen 1974*). Even if the EN-MN division finds support in the general archaeological material, the subsequent periodisation is rather nondescript and does not reflect changes in cultural development. The MN is seen to continue some 1700 years and contain a variety of different pottery types and cultures, including Typical and Late Comb Ware, asbestos- and organic-tempered wares (Kierikki and Pöljä Wares), and Corded Ware. The Late Neolithic (LN) is often dated to 2300–1800 cal BC and is exemplified in the archaeological record by the coastal Kiukainen Ware in particular.

In north-eastern Europe, the appearance of pottery and the beginning of the Neolithic is generally accepted as taking place *c.* 5500–5200 cal BC (*Kriiska, Lang 2001; German 2011; Pesonen* et al. *2012; Piezonka 2015*). Research on this earliest phase of the Neolithic has been sometimes inter-regional (*e.g., Torvinen 2000; 2004; Hallgren 2008; Piezonka 2015*), but after the EN, attempts to overcome national and linguistic borders in east-west direction have been surprisingly few (see *Carpelan 1979; Mökkönen 2011; Nordqvist 2013*). Interestingly, for example, Typical Comb Ware is recognised as a phenomenon existing in Finland, parts of north-west Russia, Estonia, and Latvia (*e.g., Europaeus-Äyräpää 1930; Jaanits* et al. *1982; Vitenkova 2002*), but still lacks any truly inter-regional studies. While it is true that regional differences in the material culture do exist, the regional periodisations reflect more local research traditions and their emphases than real prehistoric differences between these areas (Fig. 1).

The current periodisation of the EN and the first part of the MN in Finland and Estonia is roughly equal, whereas the practice of placing the line between the MN and the LN is a different story. The deviation between Finnish and Russian periodisations is also notable: the Finnish MN is temporally equivalent to the Russian LN and Eneolithic/the beginning of the Early Metal Period. This is due to the fact that Finnish archaeology operates within a much more limited area than its Russian counterpart, and therefore it is not directly influenced by the research and periodisation of more southern areas (see also *Nordqvist 2013*).

In the context of north-east European archaeology, the long MN, from *c.* 3900 to 2300 cal BC, is a peculiarity of Finnish periodisation. As we pointed out

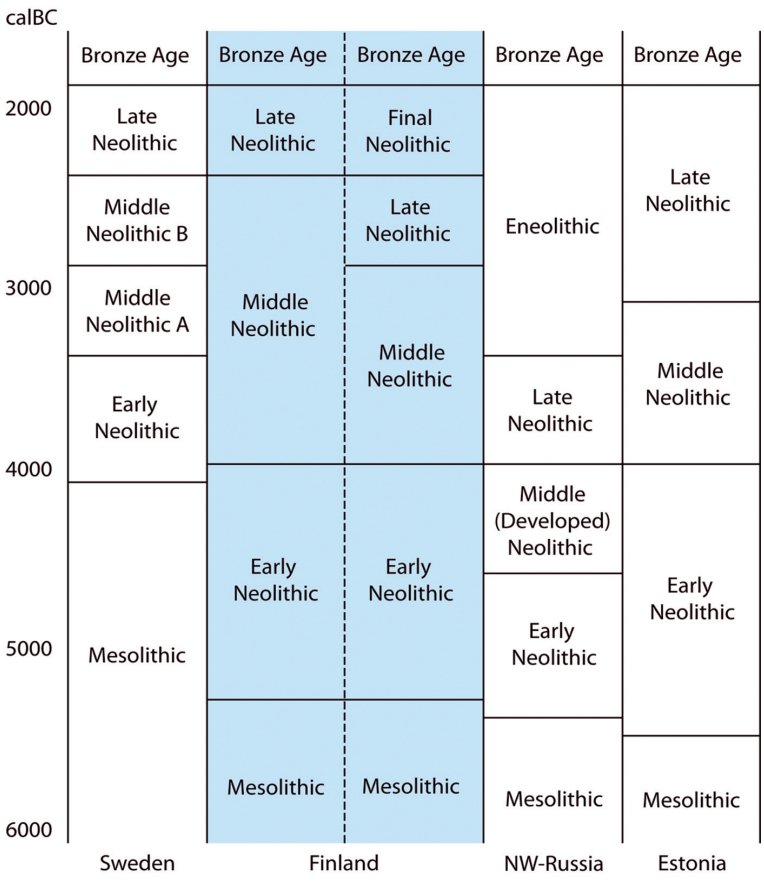



***Fig. 1. General periodisations in Finland and neighbouring areas of Sweden (after* Hallgren 2008; Larsson 2009*), north-west Russia (after* Kosmenko, Kochkurkina 1996; Zhul'nikov 1999*), and Estonia (after* Kriiska, Lang 2001*). The figure presents the traditional periodisation used in Finland (see* Carpelan 1979; 1999*), and the new periodisation suggested here.***

above, this is the product of 20th-century pottery typo-chronologies constructed prior to the application of accurate $^{14}C$ datings. Since then, the AMS dating technique has changed the temporal coverage of the typologically defined ceramic types (*e.g., Pesonen 2004; Pesonen, Leskinen 2011*) and, consequently, altered their chronological positions and mutual relations. Due to new datings, Typical Comb Ware is now completely subsumed within the MN (seen even as the boundary for its beginning), whereas it was previously placed partly within the EN and partly the MN (see *Carpelan 1979.11, Fig. 2*). Apart from this change, the main frame of periodisation has not been revised. The invalid synchronisation between the absolute datings of pottery types and the general periodisation is seen well in a comparison between the chronological charts presented in the 1970s and the 2010s (*Carpelan 1979.11, Fig. 2; cf. Mökkönen 2011.17, Fig. 5*), modified and reproduced here as Figure 2.

The appearance of the Corded Ware phenomenon in Finland at *c.* 2800 cal BC (*Mökkönen 2011; Nordqvist 2016*) is not visible in the currently used periodisation, even if it is a chronological boundary in neighbouring areas. In order to jettison the unduly long MN, we suggest a similar chronological division in Finland, and a separation of the current MN into two, into *Middle* and *Late Neolithic*.[2] The term *Final Neolithic* could be applied to the last centuries of the Neolithic after the decline of Corded Ware at *c.* 2300–1800 cal BC (*i.e.* the phase currently called LN).

The revised periodisation for Finland suggested here does not neither correspond neatly with all the phenomena observed in the current archaeological material. Nevertheless, even if Corded Ware is present in southern Finland only, it influences and is coeval with changes taking place in more northern areas, too, and therefore its use as a boundary is justified. Likewise, the separation of the Final Neolithic is based mainly on southern coastal materials, but supporting evidence can be found elsewhere, too. Therefore, the revised periodisation would be more suitable when dealing with wider typo-chronological entities within and beyond the borders of Finland than the chronological frame currently in use, which has become incompatible with present archaeological data.

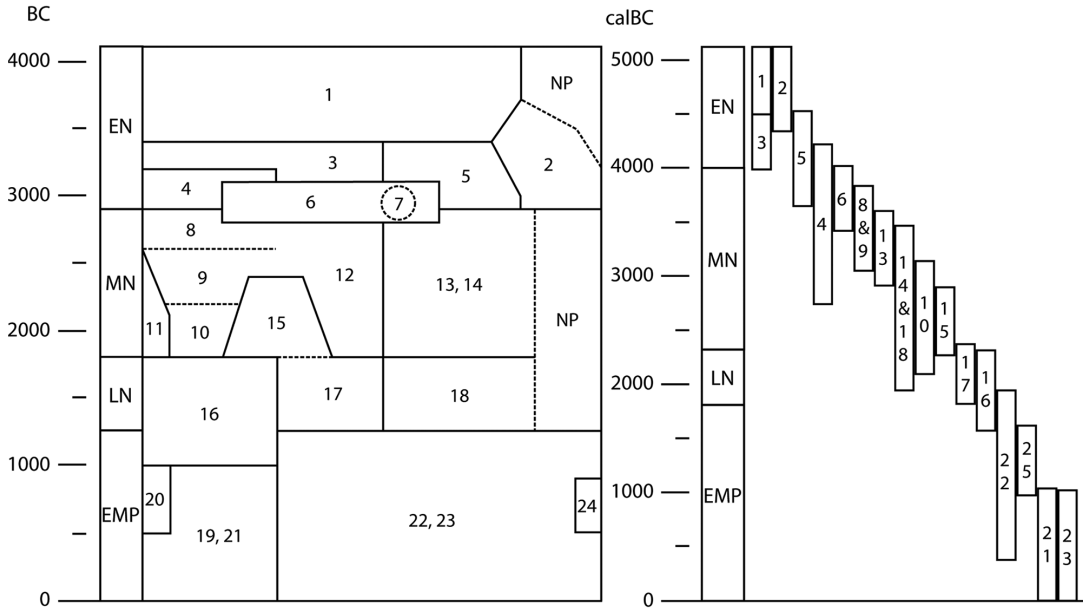



***Fig. 2. Chronological charts presented for Finland in the 1970s (left) and the 2010s (right) (modified from* Carpelan 1979.11, Fig. 2; Mökkönen 2011.17, Fig. 5*). Periods: EN – Early (Sub)Neolithic; MN – Middle (Sub)Neolithic; LN – Late (Sub)Neolithic; EMP – Early Metal Period; Pottery types: 1 Sperrings 1 (Ka I:1); 2 Säräisniemi 1; 3 Sperrings 2 (Ka I:2); 4 Jäkärlä; 5 Early Asbestos Ware; 6 Typical Comb Ware (Ka II); 7 'Russian Pitted Ware' (*i.e. *Pit-Comb Ware); 8 Uskela (Ka III:1); 9 Sipilänhaka (Ka III:2); 10 Pyheensilta; 11 East-Swedish Pitted Ware; 12 'Late Comb Ware of the Middle Zone'; 13 Kierikki; 14 Pöljä; 15 Corded Ware; 16 Kiukainen; 17 Middle Zone Ceramics; 18 Jysmä; 19 'fine Lausitz-influenced pottery'; 20 Otterböte; 21 Morby* etc.*; 22 Sarsa-Tomitsa (Textile Ware); 23 Säräisniemi 2; 24 Pseudo Textile Ware; 25 Paimio; NP – no pottery.***

2 Recently, some signs of the need to move the MN–LN boundary towards this direction have been seen, although at what point in time it has been placed and why are still varied (see *Lavento 2012; Seitsonen* et al. *2012; Halinen 2015; Vanhanen, Pesonen 2016*).

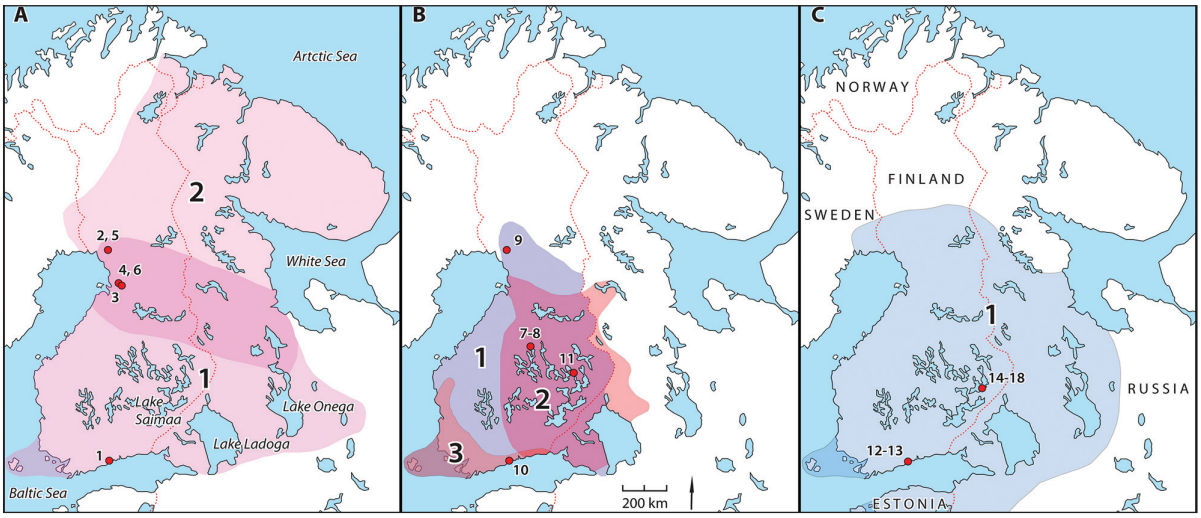
### *Early Neolithic,* c. *5200–3900 cal BC*

The first ceramics appear in Finland in the form of two types. The southern type, Sperrings 1 Ware (or older Early Comb Ware, style I:1; also known as Ka I:1), occupies most of Finland up to southern Lapland, and the corresponding area in north-west Russia (Map 1A, Fig. 3a–b). The northern type, Säräisniemi 1 Ware (or Sär 1), overlaps with Sperrings 1 in the north and is distributed up to the shore of the Barents Sea (Fig. 3c–e). The definition of Sperrings 1 is based on early research (*Europaeus-Äyräpää 1930*; also *Äyräpää 1956; Luho 1957*), and later studies of the type are few in Finland (but see *German 2002; 2011* for Russian Karelia). In contrast, the basic research on Säräisniemi 1 was carried out only recently (*Torvinen 2000; 2004; Skandfer 2005; 2011*). In Finland, Sperrings 1 dates to the earlier part of the EN, from 5300–5200 up to 4500–4400 cal BC (*Pesonen, Leskinen 2011; Pesonen* et al. *2012; Piezonka 2015; Nordqvist, Mökkönen 2016; 2017a*). The use of Säräisniemi 1 starts at the same time, 5300–5200 cal BC, but its final dating is still unclear. Most of the reliable dates are older than 4400 cal BC, although individual dates as young as 3800 cal BC exist (*Torvinen 2000; Skandfer 2005; 2011; Pesonen, Leskinen 2011; Pesonen* et al. *2012; Nordqvist, Mökkönen 2016; 2017a*).

Around 4500 cal BC, new pottery types enter the scene. Sperrings 2 Ware (or younger Early Comb Ware, style I:2, also Ka I:2) was defined alongside Sperrings 1 (*Europaeus-Äyräpää 1930*), and, similarly, subsequent research of this pottery type has been very limited (*Luho 1957; Rankama 1982*) (Fig. 3f). At the same time, the use of local asbestos minerals starts in the inland lake district and results in the emergence of an asbestos-tempered variant of Sperrings 2 Ware (Fig. 3h). Its distribution is mostly confined to Finland and the Karelian Isthmus (Russia) (Map 1B). The end of Sperrings 2 use is dated to *c.* 4000 cal BC, although the use of an asbestos-tempered variant may have continued for some centuries longer (*Pesonen, Leskinen 2011; Pesonen* et al. *2012; Nordqvist, Mökkönen 2016*).

Another asbestos-tempered early pottery type is called Kaunissaari Ware (Fig. 3g). Its first appearance is dated to *c.* 4300 cal BC, while production terminates *c.* 3800 cal BC (*Pesonen, Leskinen 2011; Oinonen* et al. *2014; Nordqvist, Mökkönen 2016*). The distribution of Kaunissaari Ware is centred on the eastern lake area of Finland, but the type is also present in Ostrobothnia. Even though Kaunissaari Ware was recognised already in the early 20th century (*Pälsi 1915*), the basic research was done only in the 1990s (*Pesonen 1996*). Asbestos-tempered Sperrings 2 and Kaunissaari Wares have been usually discussed under the common term Early Asbestos Ware (*Pesonen 1996*), although these two pottery types do not have much common, except the application of asbestos. They are known only in small amounts in western Russian Karelia, where much of the 5th millennium cal BC is characterised by Pit-Comb Ware (see *Tarasov* et al. *2017*).

In coastal south-western Finland, an early ceramic type called Jäkärlä Ware was identified as a local parallel to Sperrings 1 and 2 potteries (*Edgren 1966;*




***Map 1. A: The first half of the Early Neolithic. 1 – Sperrings 1 Ware; 2 – Säräisniemi 1 Ware. B: The second half of Early Neolithic. 1 – Sperrings 2 Ware; 2 – Asbestos-tempered Sperrings 2 and Kaunissaari Wares; 3 – Jäkärlä Ware. C: Early Middle Neolithic. 1 – Typical Comb Ware. The dots mark the locations of sites with datings 1–18 (see Appendix 1. Map designed by K. Nordqvist).***

*1992*). Its dating and cultural contextualisation are problematic. Based on shoreline displacement, Jäkärlä Ware is dated roughly to 4300–3000 cal BC (no AMS dates have been published) and considered as a western variant of Comb Wares (*Asplund 1995; 2008; cf. Pesonen, Leskinen 2011*). Thus, it seems that after the earliest phase marked by Sperrings 1 and Säräisniemi 1 Wares, Finland divided into four coeval and partly overlapping pottery traditions: Kaunissaari Ware in the east, Sperrings 2 Ware in the southern and central parts of the country, Jäkärlä Ware in south-western Finland, and Säräisniemi 1 Ware in the north, in addition to which Karelian Pit-Comb Ware influence reached eastern Finland.

***Early Middle Neolithic,* c. *3900–3500 cal BC***

The EN–MN border is nowadays marked by the appearance of Typical Comb Ware (also Ka II, styles II:1 and II:2), dated to 3900–3400 cal BC (*Pesonen 2004; Pesonen, Leskinen 2011; see also Nordqvist, Mökkönen 2017a*) (Fig. 3i–j). As the material culture connected with Typical Comb Ware is distinctive and archaeologically highly visible, the pottery type was identified already in the early 20th century (*Ailio 1909; Pälsi 1915*) and more closely defined in the 1920s (*Europaeus-Äyräpää 1930*). Typical Comb Ware is considered a widely distributed and uniform cultural entity that covers the whole of Finland up to southern Lapland (Map 1C). However, regional variation in decoration, temper and shapes is recognisable, and in the light of now-existing material the original definition is inadequate and generalising and does not acknowledge this diversity (*Nordqvist, Mökkönen 2015a; 2015b*).

Originally, Typical Comb Ware and Late Comb Ware (also Ka III) were regarded as chronologically subsequent styles (*Europaeus-Äyräpää 1930*; see also *Vikkula 1981*). AMS dates, however, revealed that they are partially contemporaneous: Late Comb Ware dates to 3600–3200 cal BC (*Pesonen 2004*) or even as late as 2800 cal BC (*Pesonen, Leskinen 2011; Seitsonen* et al. *2012*). At the moment, the pottery typologies after Typical Comb Ware are more or less




***Fig. 3. Early and Middle Neolithic pottery from Finland: a–b Sperrings 1 Ware; c–e Säräisniemi 1 Ware; f Sperrings 2 Ware; g asbestos-tempered Kaunissaari Ware; h asbestos-tempered Sperrings 2 Ware; and i–j Typical Comb Ware. Collection numbers (KM– the National Museum of Finland): a KM 6114:275; b KM 24750:571; c KM 24377:218, 245; d KM 30561:786; e KM 25731:385; f KM 24465:220; g KM 25817: 135; h KM 25817:46; i KM 30319:754; j KM 30319:934. Scale 3cm (photos by T. Mökkönen).***

in a state of confusion (see *Mökkönen 2011; Nordqvist 2015*). Some EN pottery types overlap with Typical Comb Ware and local traditions remain visible in many places. For example, the use of asbestos temper continues in Typical Comb Ware in the eastern lake district, and from at least 3600 cal BC onwards, predominately asbestos-tempered pottery types (Kierikki Ware in Finland, Voynavolok Ware in Karelia) become visible again (see *Zhul'nikov 1999; Pesonen 2004; Pesonen, Leskinen 2011; Nordqvist, Mökkönen 2017a; 2017b*).

## Discussion

Large-scale periodisations, just like pottery types, are always artificial generalisations. Even so, a certain correspondence between the frame and the content (*i.e.* archaeological material) is required, because otherwise the framework turns from a helpful assistant into a harmful obstacle that misguides research. As archaeological knowledge is accumulated, the validity of this frame should be re-evaluated every so often; this has been neglected in Finland.

The increasing amount of radiocarbon datings has reduced the actual use of traditional periodisation framework. This is reflected in recent overview papers, in which time is divided according to pottery types and their $^{14}C$ dates, and the phases of Neolithic periodisation are not mentioned at all (see *Carpelan 1999; Pesonen, Leskinen 2011*), or, if applied, used as abstract terms with no definition of their content (see *Pesonen 2004*). That is to say, the building of absolute chronologies has replaced the maintenance of general periodisation. Even if these two chronological frames share certain elements, their essential features do not completely overlap: absolute chronologies set, for example, the temporal limits of certain pottery types, while a general periodisation should also incorporate other archaeological knowledge, such as possible changes in subsistence or settlement patterns, other material culture, *etc*.

In Finland, the basic research on the material culture of several Neolithic phases is at an incomplete stage. At the same time, the growing popularity of research based on the natural sciences has refocused research questions, and periodisation has lost its attraction. Specific answers obtained through technologically-aided research are highly necessary. Nonetheless, a larger framework that takes into account cultural development as a whole is needed to provide the wider context for these results.

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## Appendix 1

**List of EN and early MN datings of charred residues/birch bark tars on pottery shards from mainland Finland (Hel and Hela datings are excluded). KM – the National Museum of Finland.**

| No. | $^{14}$C date (BP) | Calibrated (2σ) | Lab. index | Material | δ13C | Site | Context; dated item | Cultural phase | Reference |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 5925 ± 45 | 4932–4710 | Ua-32194 | Crust | – | Vantaa Palmu | Settlement site, KM 18978:106 | Sperrings 1 | *Leskinen, Pesonen 2008* |
| 2 | 5775 ± 40 | 4720–4528 | GrA-63483 | Crust | –27.79 | Simo Tainiaro | Settlement site, KM 22398:920 | Sperrings 1 | *Nordqvist, Mökkönen 2016* |
| 3 | 6135 ± 40 | 5213–4965 | GrA-63484 | Crust | –26.58 | Oulu Vepsänkangas | Settlement site, KM 30561:802 | Säräisniemi 1 | *Nordqvist, Mökkönen 2016* |
| 4 | 6010 ± 40 | 5000–4796 | GrA-63485 | Crust | –24.91 | Oulu Latokangas | Settlement site, KM 24377: 218+245 | Säräisniemi 1 | *Nordqvist, Mökkönen 2016* |
| 5 | 5735 ± 40 | 4691–4486 | GrA-63480 | Crust | –26.42 | Simo Tainiaro | Settlement site, KM 22398:235 | Säräisniemi 1 | *Nordqvist, Mökkönen 2016* |
| 6 | 5025 ± 35 | 3944–3712 | GrA-63486 | Crust | –27.89 | Oulu Latokangas | Settlement site, KM 25731:385 | Säräisniemi 1 | *Nordqvist, Mökkönen 2016* |
| 7 | 5680 ± 40 | 4669–4400 | GrA-62077 | Crust | –29.20 | Pielavesi Kivimäki | Settlement site, KM 24465:17d | Sperrings 2 | *Nordqvist, Mökkönen 2016* |
| 8 | 5675 ± 40 | 4650–4374 | GrA-62176 | Crust | –27.04 | Pielavesi Kivimäki | Settlement site, KM 24465:206 | Sperrings 2 | *Nordqvist, Mökkönen 2016* |
| 9 | 5615 ± 40 | 4526–4358 | GrA-63478 | Crust | –25.56 | Simo Tainiaro | Settlement site, KM 22398:5a | Sperrings 2 | *Nordqvist, Mökkönen 2016* |
| 10 | 5415 ± 45 | 4354–4072 | Ua-32193 | Crust | – | Vantaa Storskogen | Settlement site, KM 9665:57 | Sperrings 2 | *Leskinen, Pesonen 2008* |
| 11 | 5150 ± 35 | 4041–3808 | GrA-62218 | Crust | –26.60 | Outokumpu Sätös | Settlement site, KM 28153:1445 | Asbestos–tempered Sperrings 2 | *Nordqvist, Mökkönen 2016* |
| 12 | 4920 ± 45 | 3787–3640 | Ua-32198 | Crust | – | Vantaa Sandliden | Settlement site, KM 26173:1508 | Typical Comb Ware | *Leskinen, Pesonen 2008* |
| 13 | 4875 ± 45 | 3766–3536 | Ua-32197 | Crust | – | Vantaa Sandliden | Settlement site, KM 26173:702 | Typical Comb Ware | *Leskinen, Pesonen 2008* |
| 14 | 4740 ± 35 | 3637–3378 | Poz-5872 | Birch bark tar | – | Rääkkylä Vihi 1 | Settlement site | Typical Comb Ware | *Oinonen* et al. 2014 |
| 15 | 5070 ± 40 | 3964–3778 | Poz-5978 | Birch bark tar | – | Rääkkylä Vihi 1 | Settlement site | Typical Comb Ware | *Oinonen* et al. 2014 |
| 16 | 5045 ± 45 | 3957–3714 | Poz-5979 | Birch bark tar | – | Rääkkylä Vihi 1 | Settlement site | Typical Comb Ware | *Oinonen* et al. 2014 |
| 17 | 4980 ± 80 | 3952–3646 | Poz-5980 | Birch bark tar | – | Rääkkylä Vihi 1 | Settlement site | Typical Comb Ware | *Oinonen* et al. 2014 |
| 18 | 4930 ± 35 | 3778–3648 | Poz-6195 | Birch bark tar | – | Rääkkylä Vihi 1 | Settlement site | Typical Comb Ware | *Oinonen* et al. 2014 |



back to contents

# Introduction to the absolute chronology of Neolithic cultures in Eastern Europe

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ABSTRACT – *This paper is an introduction to the discussion of radiocarbon chronology of Neolithic cultures in Eastern Europe. It relates to a number of papers published in this volume.*

KEY WORDS – *Neolithic cultures; radiocarbon chronology; Eastern Europe*

## *Uvod k absolutni kronologiji neolitskih kultur na območju Vzhodne Evrope*

IZVLEČEK – *Članek je uvod v diskusijo o radiokarbonski kronologiji neolitskih kultur v vzhodni Evropi. Nanaša se na tekste, objavljene v tej publikaciji.*

KLJUČNE BESEDE – *neolitske kulture; radiokarbonska kronologija; vzhodna Evropa*

Discussions about radiocarbon dates and the origin of dated materials have led to a revision of the absolute chronology of Neolithic cultures in Eastern Europe (*Mazurkevich* et al. *2016*). On the other hand, it has been suggested that a series of radiocarbon dates should be rejected due to the questionable nature of the dated material, *i.e.* organic material from pottery, food crust *etc*. (*cf. van der Plicht* et al. *2016*). Source criticism as a 'form of cognition' deepens our understanding of facts. However, we appear to be too critical, often forgetting about archaeological/historical possibilities for verifying dates and interpretation of a surprisingly old/young 'absolute' radiocarbon date.

Radiocarbon dates are not just dry figures; they conceal complex physical processes which reflect the natural history of the Earth. The accuracy and validity of radiocarbon dates have become two of the most important subjects recently. The results obtained while dating different materials from archaeological sites are regarded in light of the development of radiocarbon dating methods, the validity of the result obtained (taking into account, for example, the reservoir effect) and the possibility of its use in further reconstructions of historical background.

Discussions about the reservoir effect have a particular importance for the radiocarbon chronology of Eastern Europe, given the complex foraging economy of the ancient inhabitants of this region, where fishing often played a major role. Research of the reservoir effect in Denmark and Northern Germany has shown different values for the reservoir effect for different epochs and regions (*Philippsen, Heinemeier 2013; Philippsen 2013*). The dating of modern samples indicates that the freshwater reservoir effect is great and also variable even on short time scales. It has been suggested that it is impossible to find a single freshwater reservoir age for a given river system (*Philippsen 2013*). Recent research testifies to the difficulties in determining the reservoir effect, which might influence dates, as well as offset values. The detection of aquatic (fish) processing in charred food residue even by the use of the stable isotopes $^{13}C$ and $^{15}N$ (*Boudin* et al. *2010*) may be complicated, or an unlikely prospect.


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Investigations into the reservoir effect and arrays of radiocarbon dates related to Neolithic materials from Eastern Europe illustrate different possible scenarios (see, for example, articles by *Piezonka* et al. and *Dolbunova* et al. *in this volume*). Studies of sites in the Dnepr-Dvina region indicate differences in offset values even for different micro-regions and for different epochs. The comparative $^{14}C$ dating of wooden piles, food-crusts, fish and animal bones at the Serteya II site show that the FRE in Late Neolithic pottery food-crusts is generally negligible for this area (*Kulkova* et al. *2015; 2016*). The reservoir effect may also be absent in some of the regions (*cf. Marchenko* et al. *2015*).

Another problem is related to the calibration of dates and the existence of plateaus. The appearance of the most ancient pottery in Eastern Europe is dated to the first half of the 7th millennium BC, a period with one such plateau, which does not allow a more accurate chronology of this process (*Mazurkevich* et al. *2016*).

The choice of dating material is another important problem. It relates to the reliability of the archaeological context and, hence, the contemporaneity of different events represented by different materials. Events might have overlapped at an archaeological site which was occupied repeatedly. In cases when all artefacts, faunal remains and other objects were not recorded in a 3-D coordinate system, it might be difficult to divide these events, and their contemporaneity may appear to be doubtful. On the other hand, the choice of material for dating sites in Eastern Europe is determined mainly by the absence of a wide range of organic materials (wood, food crust, charcoal), which led to the use of pottery as a popular material for radiocarbon dating. The reliability of this material has been much discussed, although the first attempts to date organic material from pottery were made already at the end of the 1950s (*de Atley 1980.988*). The main problem is that carbon from non-cultural sources may also be present in ceramic materials, and this may effectively dilute the age or otherwise contaminate the cultural sample and, thus, different sources of carbon are possible (*de Atley 1980; Bonsall* et al. *2002; Zaitseva* et al. *2009*).

At first, many dates of pottery for the territory of Eastern Europe were primarily made in the Kyiv radiocarbon laboratory, which allowed a proposed scheme of absolute chronology for regions from where almost no radiocarbon dates had been obtained before (*Vybornov 2008*). These dates and the method itself were highly criticised (*cf. van der Plicht* et al. *2016*). The number of dates for organic material on pottery from different laboratories as well as cross-dating of other materials has now increased dramatically (see article of *Vybornov* et al. *in this volume; Mazurkevich* et al. *2016*). The coincidence of the series of dates obtained in different laboratories by different methods (AMS and conventional dates) and on different materials requires a specific discussion by specialists in this domain. A comparison and coincidence of different dates does not allow us to avoid this discussion or to neglect dates of organic material on pottery (see article of *Vybornov* et al. *in this volume*).

The radiocarbon chronology of Eastern Europe is based mainly on conventional dates, which extend the periods of the earliest ceramic cultures attributed to Neolithic era according to Russian scientific tradition. The correlation of processes dated by conventional dates and more precise AMS dates will allow us to narrow the period covering the appearance and longevity of these traditions.

During the last two decades, radiocarbon dates became the main resource for constructing different chronological and historical-cultural models. These important issues side-lined archaeological proxies, which led to the creation of various mathematical models, with very little consideration of archaeological context (*cf. Davison* et al. *2009; Silva* et al. *2014; Jordan* et al. *2016*). All these models were based on the values of radiocarbon dates and were not corrected with data about archaeological context, the typology of materials, cultural entities or cultural networks identified on the basis of archaeological materials. Thus a reverse trend can be noticed: all 'historical/cultural' connections and processes are adjusted to a certain mathematical (chronological) model.

The reliability of $^{14}C$ dates can be also verified by correlating these dates with typologies which were constructed on the basis of other independent proxies/principles or methods. This is well illustrated by the various discussions about the chronology of Rakushechny Yar, one of the oldest Neolithic sites in Eastern Europe, dated to the 7th–6th millennium cal BC. New investigations, including analysis of the context of dated materials, archive research and archaeological excavations allowed the chronology of this site to be refined and a revision of the notion that the existing chronology of southern Russia is unreliable (see *Tsybrij* et al. *in this volume*).

The radiocarbon dates collected for different periods of the Neolithic challenged our habitual linear scheme, the perception of continuity within the development of the Neolithic period. We can trace the asynchrony of various cultural events in different regions, as opposed to gradual changes in cultures (see *Mazurkevich* et al. *in this volume*). Radiocarbon dates challenge our notions about chronological boundaries between different cultures, as well as epochs. They require us to think more about the possibility that societies with different cultural attributions in different epochs coexisted. It is especially clearly seen on maps showing site distribution according to their chronology (Maps 1–5). Could such a 'striped pattern' have existed in the past? Our interpretation is also greatly influenced by stereotypes about primitive societies, which intentionally opted for such a way of life and preserved society in such a state (*Artemova 2009*). Interpretation is also influenced by our perception of time, when several hundreds of years or one millennium are regarded as a short period, and not as the lifetime of at least forty generations.

New radiocarbon dates will allow us to refine the chronology of different processes and influence much of our interpretation of social changes in the Neolithic era. It is important also to regard arrays of data grouped according to the main river basins of Eastern Europe, which served as waterways in the past, along which major migrations could have occurred.

The tradition of compiling radiocarbon dates has a long history. In Russian historiography, such compilations have been made since the 1970s; Pavel M. Dolukhanov, Vladimir I. Timofeev and Aleksandr M. Miklyaev laid the basis for this tradition (*cf. Dolukhanov* et al. *1969; 1972; 1978; Timofeev* et al. *1978; 2004; Mazurkevich* et al. *2014*). Such data compilation will continue to be published when a 'critical amount' of dates become available, giving rise to new discussions. The articles represented are devoted to different aspects of radiocarbon dating and chronology of Neolithic materials in Eastern Europe from the 7th to the 3rd millennium BC. The territory of research presented in this volume encompasses almost the whole of Eastern Europe, from the Lower Don River and Eastern Ukraine to Finland, from the Dnepr River basin to the Urals. The data and maps presented in the monographs reveals one more problem, about the definition of the Neolithic, the Neolithic revolution, and the Early, Middle and Late Neolithic, their chronological boundaries, which appear to be transparent in many cases, and how they can be distinguished one from another on the basis of archaeological features. The articles devoted to Eastern European chronology presented in this volume do not encompass all known radiocarbon dates for this area, but suggest another, new, point of view of the Neolithic in Eastern Europe.

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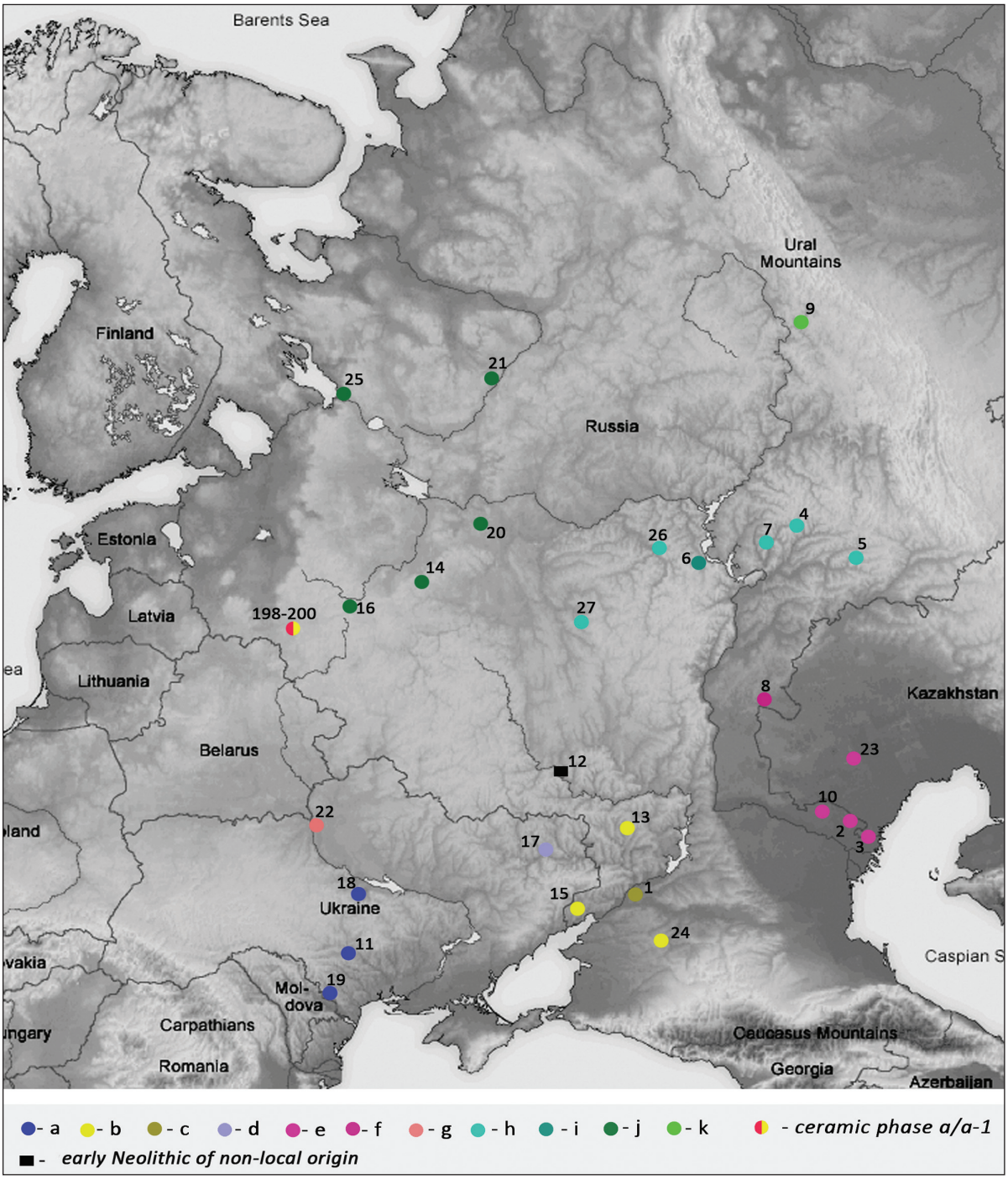
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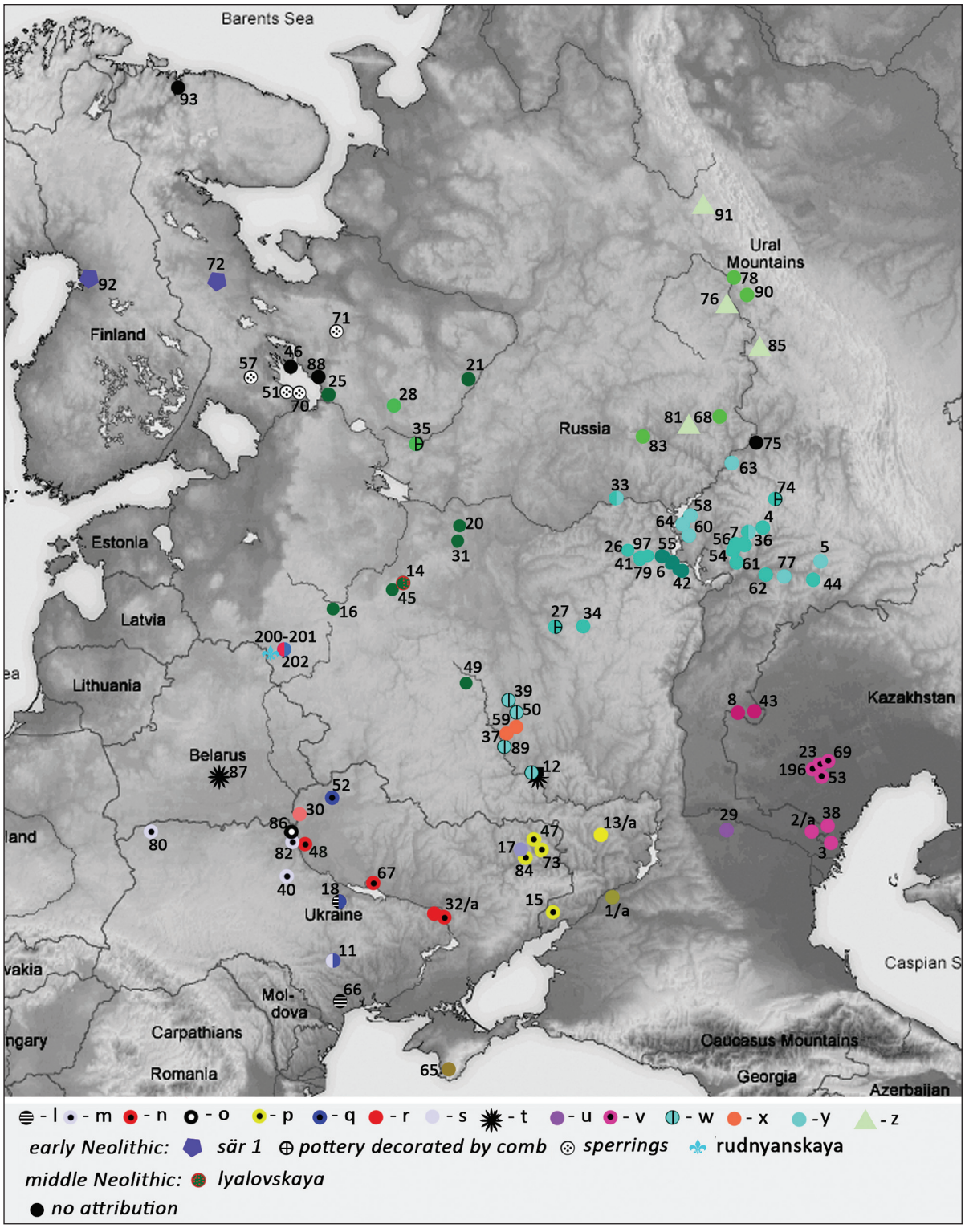
## List of sites shown on Maps 1–5

| | |
|---|---|
| 1 | Rakushechny Yar |
| 1a | Razdorskaya II, site Samsonovskoe |
| 2 | Kairshak III |
| 2a | Kairshak I, IV |
| 3 | Baibek |
| 4 | Chekalino IV |
| 5 | Ivanovka |
| 6 | Ust'-Tashelka |
| 7 | Bolshaya Rakovka II |
| 8 | Varfolomeevskaya |
| 9 | Levshino |
| 10 | Kugat IV, Kulagaisi |
| 11 | Gard VII |
| 12 | Cherkasskaya, Cherkasskaya 3, 5 |
| 13 | Kremennaya II |
| 13? | Kremennaya III |
| 14 | Zamostie 2 |
| 15 | Matveev Kurgan I |
| 16 | Ozerki 5, 17 |
| 17 | Kleshnya 3; Zelena Gornica 1, 6 |
| 18 | Dobryanka 1, 2, 3 |
| 19 | Girzhevo |
| 20 | Stanovoe 4 |
| 21 | Berezovaya Slobodka II-III |
| 22 | Shmaevka |
| 23 | Tenteksor, Tenteksor III |
| 24 | Rassypnaya VI |
| 25 | Tudozero V |
| 26 | V'yunovo ozero I |
| 27 | Imerka VII |
| 28 | Karavaikha 4 |
| 29 | Dzhangar |
| 30 | Pustynka 5 |
| 31 | Sakhtysh 2a |
| 32 | Igren' 8 |
| 32a | Popov mys, Stril'cha Skelya |
| 33 | Dubovskoe III, Otarskoe VI |
| 34 | Ozimenki II |
| 35 | Veksa III |
| 36 | Il'inka |
| 37 | Ivnitsa |
| 38 | Burovaya 42 |
| 39 | Dobroe 1 |
| 40 | Lazarevka |
| 41 | Utyuzh I |
| 42 | Elshanka XI |
| 43 | Algay |
| 44 | Staraya Elshanka II |
| 45 | Okaemovo 5 |
| 46 | Vozhmarikha 1, 26 |
| 47 | Starobelsk, Novoselovka |
| 48 | Khodosovka, Romankiv |
| 49 | Berezovka 4? |
| 50 | Yarlukovskaya protoka (site 222) |
| 51 | Uya III |
| 52 | Studenok |
| 53 | Kachkarstau |
| 54 | Krasny Gorodok |
| 55 | Lugovoe III |
| 56 | Lebyazhinka IV, Kalmykovka I |
| 57 | Sulgu II |
| 58 | II Scherbetskaya |
| 59 | Karamyshevo 5 |
| 60 | Lesnoe Nikolskoe III |
| 61 | Krasny Yar VII |
| 62 | Maksimovka I |
| 63 | II Dubogrivskaya |
| 64 | IV Tetushckaya |
| 65 | Fat'ma-Koba |
| 66 | Mainova balka |
| 67 | Buz'ki |
| 68 | Kyilud II |
| 69 | Kyzylchak |
| 70 | Sheltozero X |
| 71 | Shettima I |
| 72 | Kalmozero II |
| 73 | Tuba 1, 2 |
| 74 | Mullino |
| 75 | Ziarat |
| 76 | Ust'-Zalaznushka II |
| 77 | Vilovatoe |
| 78 | Chashkinskoe ozero VI, VIII |
| 79 | Molebnoe ozero I |
| 80 | Lyadina Mys, Nobel' 1 |
| 81 | Tarchan I |
| 82 | Krushniki |
| 83 | Koshkinskaya |
| 84 | Velika Pererva 1 |
| 85 | Mokino |
| 86 | Plutovische |
| 87 | Kuzmichi 1 |
| 88 | Chernaya Rechka 1 |
| 89 | Universitetskaya 3 |
| 90 | Chashkinskoe ozero IV |
| 91 | Chirvinskaya II |
| 92 | Oulu Vepsänkangas |
| 93 | Keret' XXII |
| 94 | Ust'-Shizhma |
| 95 | Podlesnoye III, IV |
| 96 | Podgorovka |
| 97 | Chernen'koe ozero III |
| 98 | Kovylyai I |
| 99 | Lebyazhinka I |
| 100 | Vasilievsky Kordon 7 |
| 101 | Oulu Latokangas |
| 102 | Ksizovo 6 |
| 103 | Erpin Pudas I |
| 104 | Dubovskoe XII, VII |
| 105 | Zabornoe Ozero |
| 106 | Srednee Shadbegovo |
| 107 | Chernushka |
| 108 | Sheltozero XI |
| 109 | Lyadina 14 |
| 110 | Dubovskoe VII |
| 111 | Borovoe ozero I |
| 112 | Lukomie |
| 113 | Sauz II |
| 114 | Khutorskaya |
| 115 | Vantaa Palmu |
| 116 | Imerka Ia |
| 117 | Ivanovskoe 7 |
| 118 | Vasilyevsky kordon 3, 5 |
| 119 | Imerka III, IV |
| 120 | Gronov 3 |
| 121 | Balakhchinskaya VIa |
| 122 | Berezovaya Slobodka VI |
| 123 | Orovnavolok V |
| 124 | Kladovets Va |
| 125 | Veksa I |
| 126 | Chernashka |
| 127 | Plautino 1 |
| 128 | Kyilud III |
| 129 | Panozero I |
| 130 | Karamyshevo 9 |
| 131 | Serebryanskoe |
| 132 | Simo Tainiaro |
| 133 | Staro-Mazikovskaya III |
| 134 | Chernikovo ozero |
| 135 | Pischiki |
| 136 | Chumoitlo I |
| 137 | Nizhnyaya Orlianka II |
| 138 | Poser |
| 139 | Chashkinskoe ozero I |
| 140 | Kaen-Tubinskaya |
| 141 | Pielavesi Kivimäki |
| 142 | II Lebedinskaya |
| 143 | Imerka III |
| 144 | Dronikha |
| 145 | Shan-Koba |
| 146 | Kryazhskaya |
| 147 | Kaluga 1, 2 |
| 148 | Bukol'nikov 1 |
| 149 | Karavaikha 1 |
| 150 | Podolie 1 |
| 151 | Vozhmarikha 4 |
| 152 | Russko-Azibeyskaya |
| 153 | Nizhnyaya Strelka V, Galankina Gora II |
| 154 | Gulyukovskaya |
| 155 | Vantaa Storskogen |
| 156 | Matveev Kurgan II |
| 157 | Bol'shie Bortniki 1 |
| 158 | Kladovets IX |
| 159 | II Tatarsko-Azibeyskaya |
| 160 | Vasukovo II |
| 161 | Fofanovo XIII |
| 162 | Kurino 1 |
| 163 | Suna XII |
| 164 | Zolotec VI, Zalavruga I, IV |
| 165 | Outokumpu Sätös |
| 166 | Pegrema I, II |
| 167 | Rääkkylä Vihi 1 |
| 168 | Orovnavolok XVI |
| 169 | Yamnoe |
| 170 | Chernaya Guba III, IX, IV |
| 171 | Vigainavolok |
| 172 | Vantaa Sandliden |
| 173 | Asavets 2 |
| 174 | Sosnovaya gora 1 |
| 175 | Sukhaua Vodla I |
| 176 | Inari Vuopaja |
| 177 | Komarin 5 |
| 178 | Voinavolok XXVII |
| 179 | Berezovo XVII |
| 180 | Kladovets (burial) |

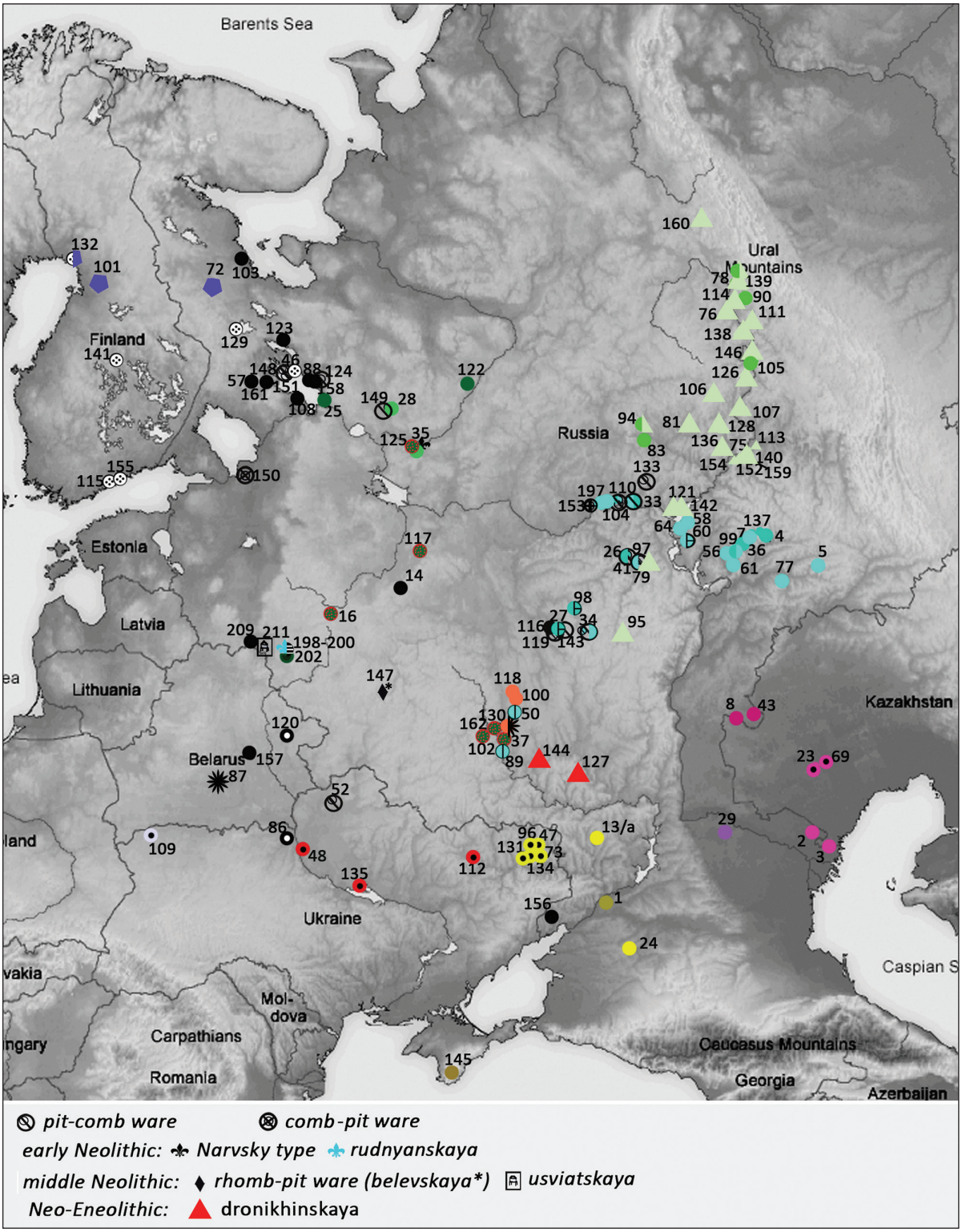
| | | | | | |
|---|---|---|---|---|---|
| 181 | Prorva 2 | 191 | Chernaya Rechka XII | 202 | Serteya XXIV |
| 182 | Pin'guba II | 192 | Lakshezero II, Kudoma X | 203 | Serteya XXIV |
| 183 | Tunguda III, XIV, XVII | 193 | Kostomuksha II | 204 | Serteya VIII |
| 184 | Meieri II | 194 | Vigainavolok II | 205 | Serteya XXXVI |
| 185 | Povenchanka XV, Voinavolok XXIV, Kochnavolok II | 195 | Palaiguba II | 206 | Serteya I, II |
| | | 196 | Zhekolgan | 207 | Serteya XI |
| 186 | Nizhnyaya Olba 1 | 197 | Sutyrskaya V | 208 | koorgan near village Serteya |
| 187 | Orovnavolok XI | 198 | Serteya XIV | 209 | Dubokray V |
| 188 | Kudomguba VII | 199 | Rudnya Serteyskaya | 210 | Dubokray IX, I |
| 189 | Zolotec IX, X, XX | 200 | Serteya X | 211 | Usviaty IV |
| 190 | Chelmuzhskaya kosa XXI | 201 | Serteya XXVII, XXII | 212 | Naumovo |



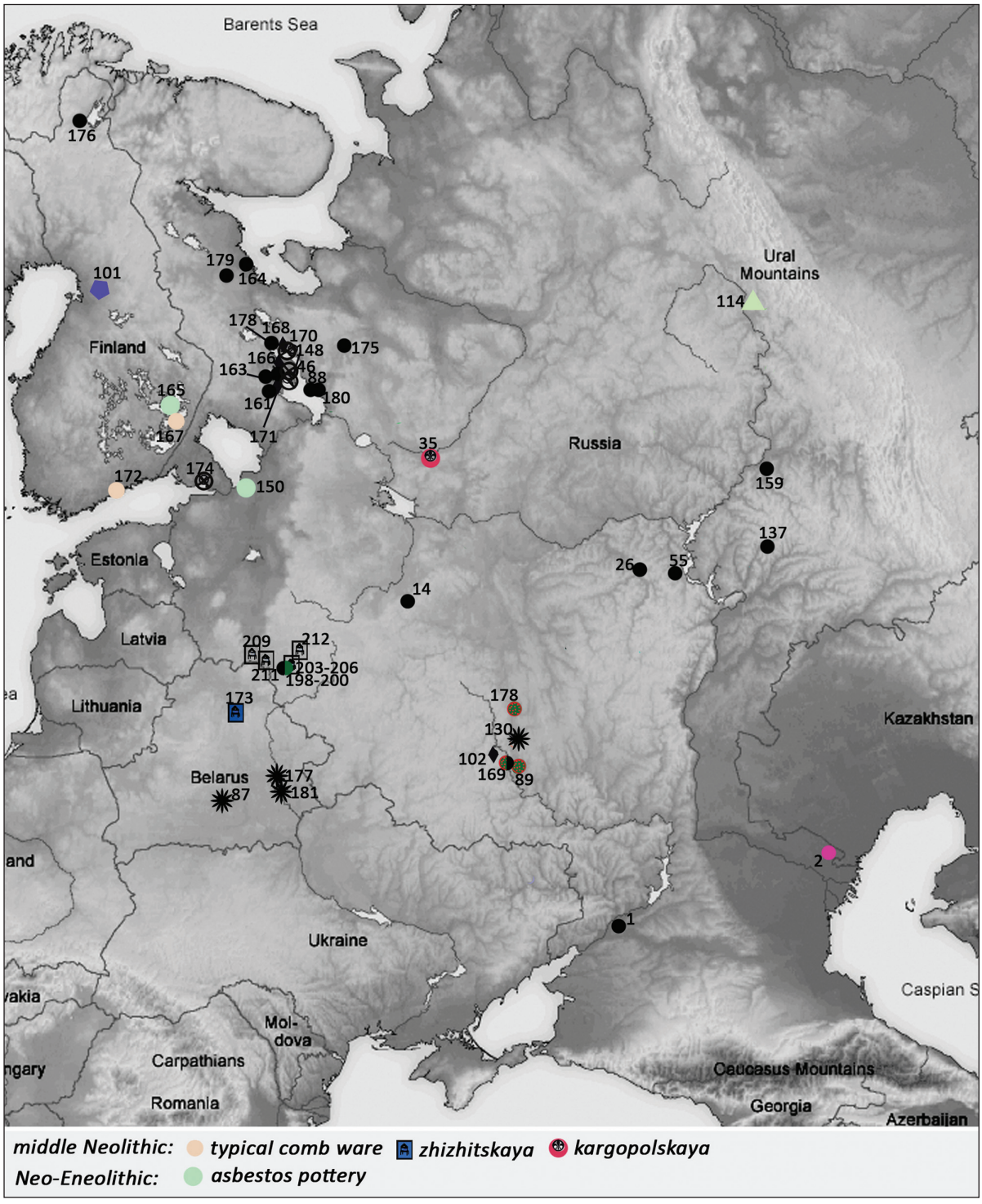

***Map 1. Sites of the 7th millennium BC based on radiocarbon dating (modified from* Mazurkevich *et al.* 2016*).***



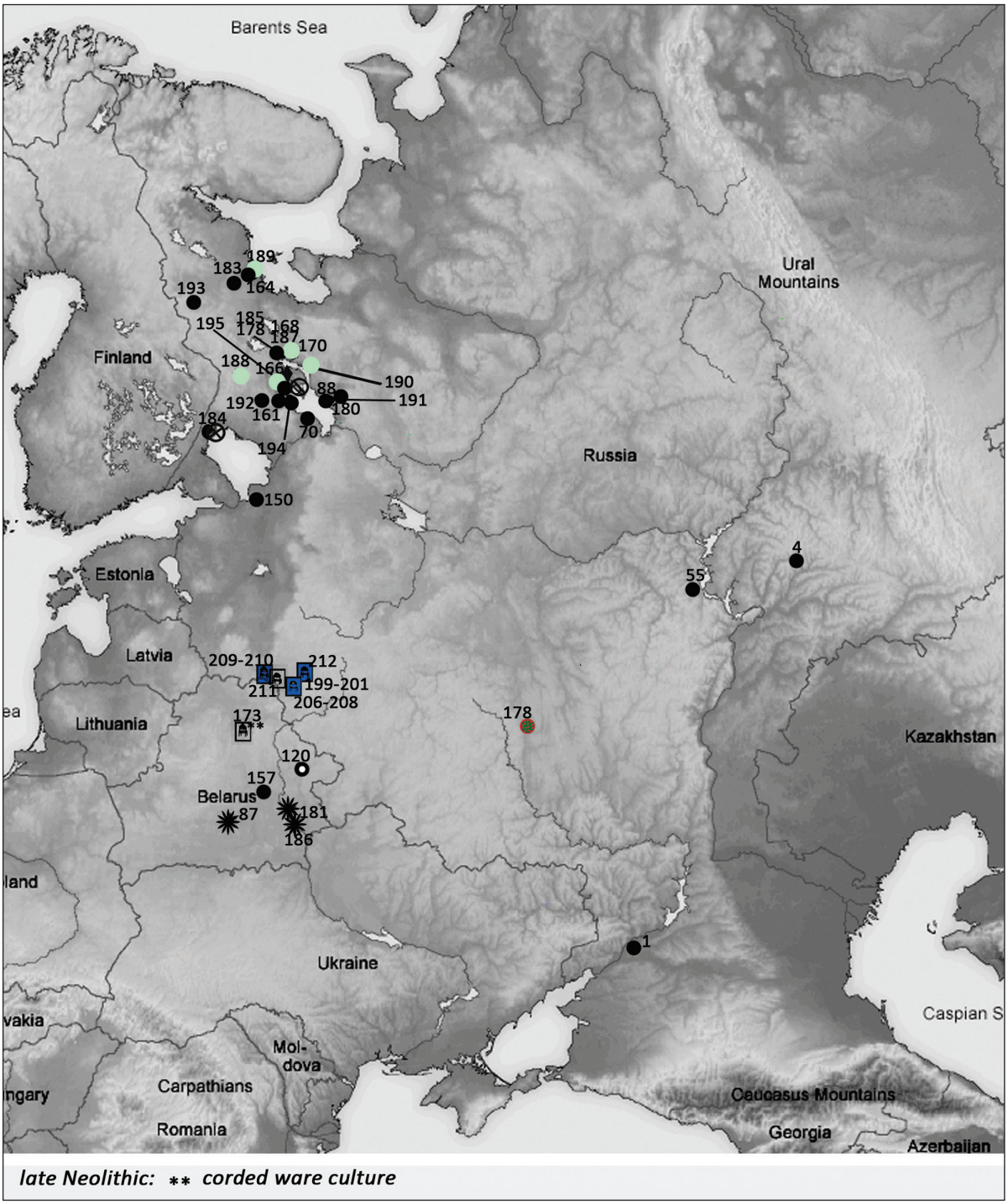

*Map 2. Sites in the turn of the 7th to 6th millennium BC.*




*Map 3. Sites in the turn of the 6th to 5th millennium BC.*




*Map 4. Sites in the turn of the 5th to 4th millennium BC.*




***Map 5. Sites in the turn of the 4th to 3rd–2nd millennium BC.***

# Radiocarbon chronology of the Neolithic-Eneolithic period in the Karelian Republic (Russia)

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ABSTRACT – *This article discusses a radiocarbon-based chronology for the Neolithic–Eneolithic period in the present-day Republic of Karelia (Russian Federation). The main goal is to present all currently available radiocarbon datings, including the previously published dates, as well as the ones recently obtained by the authors. In total, there are 194 dates from 77 sites covering the period from the 6th to the 2nd millennium cal BC. Besides providing an up-to-date list of datings, the article also evaluates their reliability and utility in building a local chronology. Despite several shortcomings, the new AMS-supported chronology enables the study of past cultural dynamics in much greater detail than previously and allows its better integration into the wider north-east European chronological framework.*

KEY WORDS – *Neolithic; Eneolithic; radiocarbon chronology; pottery; Karelian Republic*

## *Radiokarbonska kronologija neolitika – eneolitika v Republiki Kareliji (Rusija)*

IZVLEČEK – *V članku razpravljamo o radiokarbonski kronologiji obdobij neolitika-eneolitika v današnji Republiki Kareliji (Ruska federacija). Predstaviti želimo vse razpoložljive datume, tako tiste že objavljene kot tudi najnovejše datume, ki smo jih pridobili avtorji. Skupno je sedaj na voljo 194 datumov iz 77 najdišč, ki pokrivajo čas od 6. do 2. tisočletja pr. n. št. Poleg novega seznama vseh radiokarbonskih datumov ocenjujemo v članku tudi zanesljivost in koristnost le-teh za oblikovanje lokalne kronologije. Kljub številnim pomanjkljivostim omogoča nova kronologija, ki temelji na AMS radiokarbonskih datumih, veliko bolj natančne študije preteklih kulturnih dinamik, kot je bilo to možno v preteklosti, ter omogoča boljšo integracijo v kronološke okvirje na širšem območju severovzhodne Evrope.*

KLJUČNE BESEDE – *neolitik; eneolitik; radiokarbonska kronologija; lončenina; Republika Karelija*

## Introduction

### *Aims*

This paper presents all radiocarbon dates obtained from the Neolithic and Eneolithic sites (see below) in the present-day Karelian Republic, Russian Federation, and outlines the chronological position of the main groups of archaeological material (*i.e.* pottery types) known in this territory between the 6th and 2nd millennia cal BC. The current paper is a combination of two articles recently published in Russian: the first one providing a discussion of datings available prior to 2016 (*Tarasov, Khoroshun 2016*) and the second one presenting an AMS-based chronology

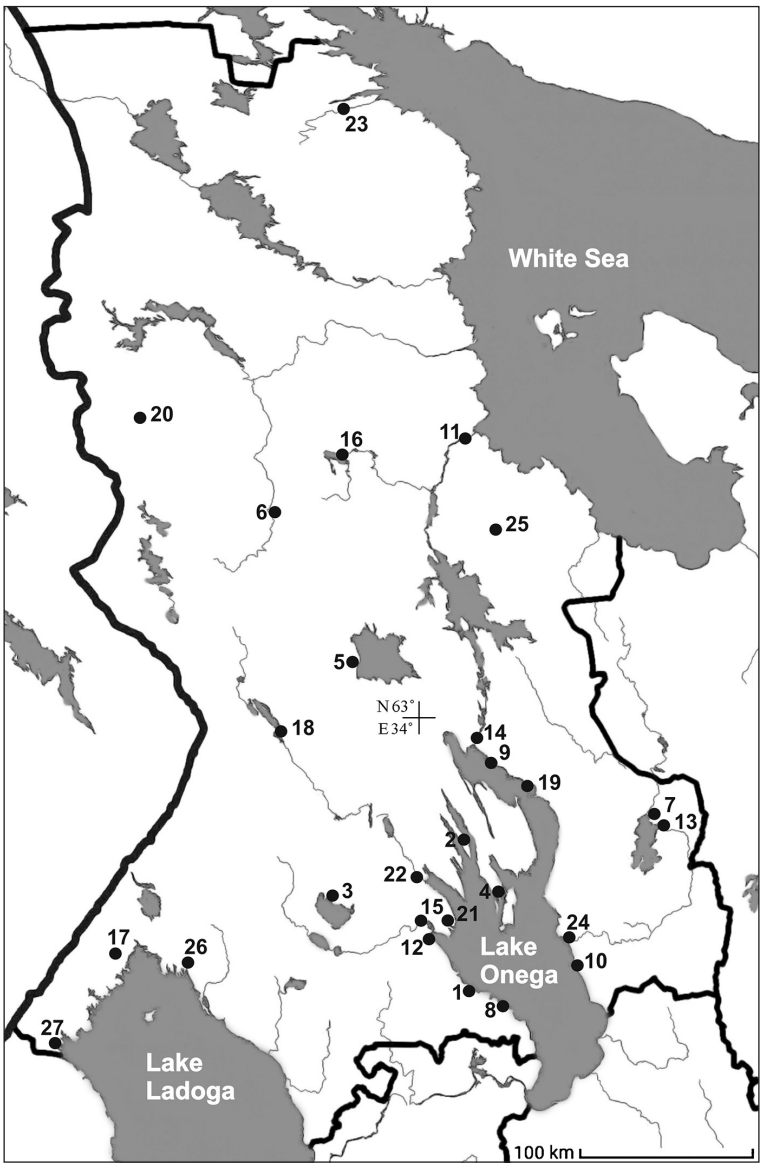

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for the Karelian Neolithic through introduction of 41 new dates (*Nordqvist, Mökkönen 2017a*; see also *Nordqvist, Mökkönen 2016a; 2016b*).

Most of the previous discussions of radiocarbon dates from Karelia have been in Russian (*Kochkurkina 1991; German 2002; 2012; Kosmenko 2003; Lobanova 2004; Vitenkova 2009; Piezonka 2011; Mel'nikov, German 2013; Khoroshun 2015*; but see *Kosmenko 2004; Piezonka 2008; 2015; Zhulnikov* et al. *2012*). An overview of the chronology and periodisation of Karelia published in 1991 comprised a total of 112 conventional radiocarbon determinations from the Mesolithic Stone Age to the Early Middle Ages (*Kochkurkina 1991*), and a special publication devoted to the Neolithic chronology of eastern Europe discussed Karelia some 10 years later and contained 72 dates listed as Neolithic (*Timofeev* et al. *2004*; see also *Kosmenko 2004*). These publications are now out of date, since quite a few AMS dates have been produced in recent years (*e.g., Lobanova 2004; Piezonka 2008; Nordqvist, Mökkönen 2017a*). At the moment, 170 radiocarbon datings with a more or less clear connection to the Neolithic and Eneolithic periods have been obtained from Karelia; in addition, 24 datings have been presented in this context, even if their connection to the periods in question remains equivocal (see below).

Recently-obtained AMS dates have considerably refined the Neolithic chronology in Karelia. This paper is an attempt to compile all the available data and discuss the present state of affairs. The purpose is not to present the final word on the topic, as the number and quality of dates in many cases is still low and there are many ambiguities and problems, as will be shown below. Even if the main focus is on presenting the Karelian material, the chronology is also compared with corresponding chronologies in neighbouring regions, particularly Finland.

The dates that form the basis of this paper are listed in the tables. Table 1 presents the dates which ge-




***Map 1. Location of sites with radiocarbon dates in the territory of Karelian Republic (Russian Federation: 1 Uya III; 2 Pegrema I–III, IX, Palayguba II, X; 3 Sulgu II, Lakshozero II, Kudoma X; 4 Vozhmarikha 1, 4, 19, 21, 26, Bukol'nikov 1, Vorob'i 4; 5 Panozero I; 6 Kalmozero II; 7 Shettima I; 8 Sheltozero V, X–XII; 9 Orovnavolok V, VII, XI, XVI, Chernaya Guba III–IV, IX, Myan'gora I; 10 Chernaya Rechka I, II, IIa, XII, Kladovets IV, Va, IX, Kladovets (cemetery); 11 Yerpin Pudas I, Zalavruga I, IV, Zolotets VI, X, XI, XX, Besovy Sledki, Besovy Sledki II; 12 Vigaynavolok I–II; 13 Sukhaya Vodla I; 14 Voynavolok XXIV, XXVII, XXIX, Kochnavolok II, Povenchanka XV; 15 Fofanovo XIII; 16 Berezovo XVIII, Tunguda III, XIV, XV, XVII; 17 Meyeri II; 18 Kudomguba VII; 19 Chelmuzhskaya Kosa XXI; 20 Kostomuksha II; 21 Pinguba II; 22 Suna XII; 23 Keret' XXII; 24 Pervomayskaya I; 25 Sumozero XV; 26 Koyrinoya 2, 3; 27 Kurkieki 52 (Kuuppala Kalmistomäki), Kurkieki 33 (Kylliäisenlahti W-2) (map created by A. Tarasov).***

nerally correspond with archaeological materials present at the sites. In cases where a sample's connection with particular archaeological materials is unequivocal (*e.g.*, crusts on pottery shards), only this pottery type is mentioned (column 'Typological connection') even if the site contained material from other phases, too. However, if such a clear connection cannot be established, all assemblages present at the site are listed. Table 2 presents dates that do not correspond with any archaeological materials found at these sites. It includes Neolithic/Enolithic dates from sites with no finds from this period or datings from sites with Neolithic/Eneolithic material, but with significantly deviatory (younger) ages. The dates given in Table 2 are not included in the discussion below. The geographical locations of the sites are marked on Map 1. All dates have been calibrated with OxCal v. 4.2 (*Bronk Ramsey 2009*) and the calibration curve IntCal13 (*Reimer* et al. *2013*); in the text, they are given either as median values or with 2σ standard deviation.

### *Periodisation*

The Neolithic finds of Karelia have been traditionally divided into temporal units – archaeological cultures – primarily on the basis of pottery (see *Kochkurkina 1991; Kochkurkina, Kosmenko 1996*). These types coincide with ceramic types recognised in neighbouring territories, especially Finland, although the periodisation schemes used in these areas are quite different, mainly due to differing research traditions (also *Nordqvist 2013; Nordqvist, Mökkönen 2017c*). According to the periodisation applied to Karelia, the Early Neolithic is represented by Sperrings and Säräisniemi 1 Wares, the mid-part of the period by Pit-Comb Ware, and the Late Neolithic by Comb-Pit Ware. The subsequent phases with Rhomb-Pit Ware and ceramics with asbestos and organic tempers are traditionally considered to belong already to another period, the Eneolithic, which has been separated because of small-scale exploitation of native copper originating on the western shores of Lake Onega.

The separation of the Eneolithic introduces some inconsistencies into the periodisation. As will be shown later, sites with Comb-Pit and Rhomb-Pit Wares were, in fact, largely coeval and share fairly similar material cultures and cultural images. Nevertheless, only sites with Rhomb-Pit Ware are traditionally regarded as Eneolithic, whereas sites with Comb-Pit Ware are still Neolithic, as no copper items have been found at 'pure' Comb-Pit Ware sites in Karelia. However, individual copper objects (predominantly amorphous pieces) have been discovered in Comb-Pit Ware (*i.e.* Typical Comb Ware) contexts in Finland and northern Sweden (see *Nordqvist, Herva 2013*). To solve the problem, A. M. Zhul'nikov (*1999*) has suggested that only sites with asbestos- and organic-tempered pottery should be regarded as Eneolithic, as during this time the thermal treatment of copper (including melting and casting) became known; at sites with Rhomb-Pit Ware (and Typical Comb Ware) only evidence of cold hammering and annealing exists (*Zhul'nikov 1999.66*; see *Ikäheimo, Pääkkönen 2009; Ikäheimo, Nordqvist 2017* for Finland). Still, the total amount of copper items remained small and the metal did not change the general cultural image in any significant way. Therefore, the initial adoption of copper should be seen just as another example of a growing interest in the mineral world in general during the Neolithic, not a sign of a separate period (*Nordqvist, Herva 2013.424; Herva* et al. *2014; 2017*).

Because of the controversies associated with the Eneolithic period in Karelia, the dates connected with Rhomb-Pit Ware and asbestos- and organic-tempered pottery are included in this paper as well. In other words, the period covered, from the (later) 6th to the (earlier) 2nd millennia cal BC, is equivalent to the Neolithic and the Eneolithic (or the Neolithic and the earlier part of Early Metal Period) according to traditional Karelian periodisation (Fig. 1).

## Overview of Karelian radiocarbon data

### *Context datings*

Most Karelian radiocarbon dates (114) are context dates, mostly processed on charcoal and originating in cultural layers and different features (pits, fireplaces, dwelling constructions) of settlement sites. The reliability of these dates is seriously questioned by the fact that the majority of settlement sites in Karelia are multi-component, non-stratified locations, which contain material from several habitation episodes whose typological dating may span several millennia. This situation is explained by the geological and hydrological settings and the Stone Age and Early Metal Period economy: the groups of fisher-hunter-gatherers preferred to settle near water, which in the Karelian situation meant living mainly on lake shore terraces. As the shorelines of the majority of Karelian lakes remained fairly stable during the Holocene, areas suitable for settling remained almost the same up to the present time. This is characteristic even of such a large lake as Lake Onega, where numerous regressions and transgres-

sions took place, but affected parts of its coasts in different ways (*e.g., Devyatova 1986; Saarnisto, Vuorela 2007*).

Due to mixed multi-component assemblages, as well as the rough excavation and documentation methods employed, especially earlier, in most cases it is not possible to establish an unequivocal connection between a charcoal sample and particular archaeological materials identified at a site. This is evident in the case of charcoals collected from the cultural layer, but even in the case of samples originating in fireplace-like or other features it is not possible to fully exclude the possibility of forest fires or other post-depositional contamination.

The old-wood effect might also affect dates processed on charcoal from clear structures, such as dwelling remains. Because tree species and the origins (branch, trunk) of dated charcoals have not been determined, further estimating its presence and magnitude is not possible. As the log-based houses were made with stone tools, the timbers used to build them are unlikely to have been dry deadwood or thick live trunks with significant age. However, repairing and reuse may have introduced material of different ages into the houses and, again, later (natural) mixing cannot be ruled out. Thus, even if the dates from burnt constructions (walls) of dwellings are likely linked to human activities and even if they may be considered as the most reliable charcoal context dates, especially at single-component sites, they may yield widely varying ages. This is well illustrated by dwelling 1 at the Sumozero XV site (*Zhul'nikov 2005.85–88*): seven samples of charcoal and birch bark were taken from a burnt house construction (Tab. 1), but the determinations spread over half a millennium, at the minimum. All in all, the number of dates from dwellings is not very big: 35 dates in total (21 from burnt walls), most deriving from Late Neolithic/Eneolithic contexts.

***Datings of charred residues and burnt bones***

The introduction of the AMS technique has revolutionised dating and local chronologies in many fields. However, in Karelia the number of AMS dates has risen only in recent years (see *Nordqvist, Mökkönen 2017a*). At the moment, there are 60 AMS determinations related to pottery (44 charred residue/food crust, 14 birchbark tar, one paint-like substance, one unknown) and seven dates of bone (six of them burnt). In addition, 13 dates of charred crusts established by conventional method exist.

The dated samples are clearly of anthropogenic origin, and their archaeological context is usually unquestionable, although in the case of bones, the connection with specific archaeological phenomena may remain uncertain at multi-component sites. Also, sampling and laboratory-related issues, contamination by (younger) organics (which may affect all other types of samples as well), and the influence of the (freshwater) reservoir effect may reduce the accuracy of the dates.

The reservoir effect has been intensively studied recently on the basis of archaeological and experimental materials (*e.g., Fischer, Heinemeier 2003; Olsen* et al. *2010; Philippsen, Heinemeier 2013; Kulkova* et al. *2015; Philippsen 2015*). In Karelia, the existence of the freshwater reservoir effect was hypothesised in connection with Late Neolithic/Eneolithic asbestos- and organic-tempered wares, and it was proposed that the crust dates are mainly affected by the freshwater reservoir effect, as they tend to date somewhat older than charcoal dates (*Zhulnikov* et al. *2012*). However, this tendency remains speculative, as the study contained almost no comparable AMS or conventional datings from the same sites, not to mention the same contexts (see also *Nordqvist, Mökkönen 2017a*).

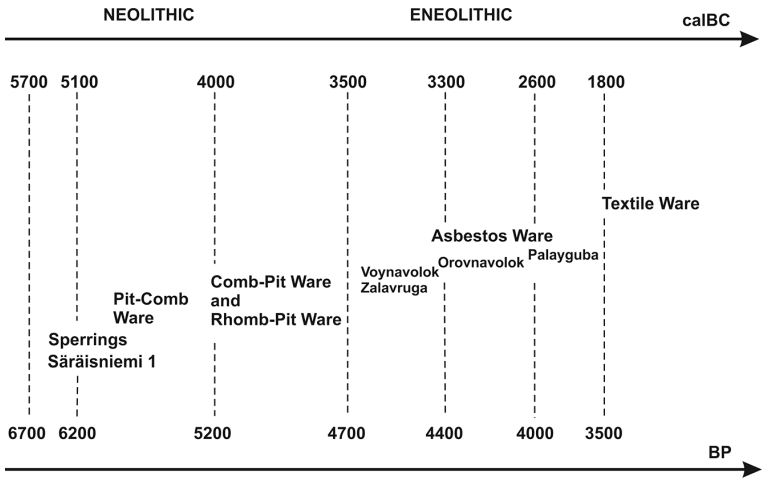



***Fig. 1. Simplified chronology of the leading Neolithic and Eneolithic ceramic types in Karelia (designed by A. Tarasov).***

The differences between AMS dates and conventional dates connected with the same cultural phases vary from zero up to 500–600 $^{14}$C-years or even more. It is not possible to say that AMS dates would always be

older than context dates – it may also be the other way round – and the results also highlight the inconsistency of context dates at several locations. At many sites, AMS dates are spread over 50–200 $^{14}$C-years: currently, it is not possible to decide whether this is due to prolonged or recurrent use of the locations, or to limitations in measurement accuracy, the properties of calibration curves, or reservoir effects.

One way to control for the presence of the (freshwater) reservoir effect has been the study of bulk stable isotopes. Even if this provides a rather crude tool compared to the more sophisticated analyses of compound-specific values, they are nevertheless thought to allow some level of estimate of the components included in the dated samples. Unfortunately, isotopic data are scarce, and only $\delta^{13}$C values have been published for the recently-obtained AMS dates: they range between –24‰ and –30‰, the average being –27.5‰ (see *Nordqvist, Mökkönen 2017a*). In previous studies the boundary between residues of marine and terrestrial/freshwater origin is often set at –26‰ (*Fischer, Heinemeier 2003. 460*). As most Karelian dates have values below this, they could be expected to include terrestrial and/or freshwater components, also hinted at by the sites' location beside lakes and rivers. Still, the values are on average fairly moderate. The only dates with a marine component have been obtained from sites located in the White Sea area, but none of these give obviously divergent results.

The magnitude of the (freshwater) reservoir effect in north-eastern Europe, low on natural limestone, has been considered fairly small (*Pesonen* et al. *2012. 665*), but the topic has not been specifically studied. It was proposed recently that low alkalinity of water does not automatically mean that the freshwater reservoir offset would not be present, as other factors such as the depth of basins, prolonged ice coverage and glacial meltwaters may have contributed to the phenomenon (*Philippsen 2015.160*). In northern central Europe, southern Scandinavia and south-eastern Baltic, the estimates and measured results of the (freshwater) reservoir offset range from some centuries to thousands of years (*e.g., Fischer, Heinemeier 2003.461; Olsen* et al. *2010.640; Hartz* et al. *2012. 1041; Philippsen, Heinemeier 2013.1098; Piličiauskas, Heron 2015.539*). Nevertheless, these results cannot be directly applied to Karelian material, as the magnitude is strongly dependent on the geographical location and geological and natural environment, as well as on the period in question (*e.g., Keaveney, Reimer 2012.1314; Philippsen 2015.160–162*). A possible range of error in Karelia is illustrated by an Early Neolithic (Säräisniemi 1) vessel from the Kalmozero II site (Tab. 1): two dates from samples taken from the outer and inner surfaces of the same shard produced an offset of two to three centuries (*Piezonka 2008.69, Abb. 2*; also *Hartz* et al. *2012.1043*)

***Evaluation***

The material available is biased: datings concentrate in certain areas and pottery types. Another major problem is the large share of conventional charcoal dates with poor link with actual archaeological materials. The standard errors of these conventional $^{14}$C-ages are generally large and vary from 20 to 150 (even 600) years, with the average between 80–90 years. This causes wide distributions in calibrated ages, at times providing accuracy of a millennium only. Laboratory-related issues are more difficult to assess, but as almost all conventional datings (over 98% of the dates listed in *Kochkurkina 1991* and *Kosmenko 2003*) originate from the same laboratory, *i.e.* Radiocarbon Laboratory of the Institute of Geology at the University of Tartu (see *Liiva* et al. *1975*), they should be consistent. Nevertheless, the general quality of these datings can be expected to be fairly low by default, although no systematic evaluation of their reliability has been done (see *e.g., Kuzmin, Tankerslay 1996; Pettitt* et al. *2003; Seitsonen* et al. *2012*). Similar uncertainties apply to crust dates obtained through the conventional method – re-dating of some shards with AMS showed that the unduly small samples used in the original dates made them unreliable and resulted in too young ages (*Nordqvist, German 2017*).

AMS-dated samples from clear archaeological contexts and with generally smaller standard errors (30–70 years BP, average 40 years BP) are also not free of problems. The potential reservoir effect is an important topic and no modern or ancient materials are currently available that could be used to reliably verify the offset in different reservoirs in the territory of Karelia. As AMS dates cluster quite nicely in many cases, it may be proposed that they still point towards the most likely use periods of different pottery types, whereas conventional dates have the tendency to disperse over a much wider period. Nevertheless, the current low number of AMS dates alone cannot be expected to provide precise dating for every cultural type and period.

With all this in mind, it can be stated that the chronology presented below operates within a margin

of error of 100–200 years, and in some cases the offset may be even greater. Even if the initial and terminal dates of some pottery types must be considered tentative, the general tendencies are correct and the proposed timeframes are also generally accord with chronologies obtained in neighbouring areas.

## Radiocarbon chronology of the Karelian Republic

### *Sperrings and Säräisniemi 1 Wares*

The oldest pottery in the Karelian Republic is Sperrings Ware, known also in Finland (where it is called older Early Comb Ware, style I:1, also Sperrings 1) (*e.g., German 2011; Pesonen, Leskinen 2011*). The earliest dates – charcoal from Uya III (6770±80 BP, TA-2352) and a burnt bone from Sulgu II (6670± 35 BP, KIA-35900) – may be related to Mesolithic occupation at the sites and therefore reasonably questioned (*Kosmenko 2003.32; German 2011.273–274; Piezonka 2015.54*). The charcoal date from Pegrema IX (6510±150 BP, TA-1161) is usually referred to as the oldest certain date for Sperrings (*Vitenkova 1996.78; German 2002.265, Tab. 1; Kosmenko 2003.32; Vereshchagina 2003.149*), but it suffers from a large standard error. The earliest AMS dating also derives from Uya III (6225±40 BP, GrA-63566) (Fig. 2), and is compatible with datings from Finland and Karelian Isthmus, which place the beginning of Sperrings Ware there to around 5300–5200 cal BC (*Pesonen* et al. *2012.664, Tab. 2; Piezonka 2015. 198–199, Abb. 170; Nordqvist, Mökkönen 2016a. 204*).

All the remaining conventional dates for Sperrings Ware originate in mixed contexts containing also partly temporally overlapping Pit-Comb Ware (see below) and date between 5500–4400 cal BC (medians 5400–4600 cal BC). The majority of crust/tar dates group around 5200–4500 cal BC (medians 5200–4600 cal BC). The youngest date (5507±50 BP, KIA-35901) derives from a vessel slightly differing from the remaining Sperrings material at Vozhmarikha 26 (see *Mel'nikov, German 2013.109*). It is somewhat younger than the dates obtained in the surrounding areas, placing the end of Sperrings Ware at around 4400 cal BC (*Pesonen* et al. *2012. 664, Tab. 2; Seitsonen* et al. *2012.110; Piezonka 2015.199, Abb. 170*).

Almost coeval with Sperrings is Säräisniemi 1 Ware, which is characteristic of the northern Karelian Republic, Finland and Norway (*e.g., Torvinen 2000; German 2011; Skandfer 2011*). At the moment only three AMS dates exist for this type in Karelia – two dates of one shard from Kalmozero II (6340±70 BP; KIA-35899A and 6080±45 BP; KIA-35899B; the former date may include the reservoir effect, see above) and one date from Besovy Sledki (5775±40 BP; GrA-63547) (Fig. 3). All context dates previously connected with Säräisniemi 1 Ware derive from Yerpin Pudas I. They date between *c.* 5600–4000 cal BC (medians 5500–4100 cal BC) and may also be connected with other components present at the site, especially Pit-Comb Ware.

Dates from Karelia do not differ significantly from the range given for Säräisniemi 1 Ware in other re-




***Fig. 2. Sperrings Ware (designed by T. Mökkönen).***

gions, *i.e.* 5300–4500 cal BC (*Pesonen* et al. *2012.664, Tab. 2; Piezonka 2015.208–209, Abb. 174; Nordqvist, Mökkönen 2016a.204*).[1] In the light of current dates, it seems plausible that there is no significant temporal difference between Sperrings (Early Comb) and Säräisniemi 1 Wares in the north; in fact, in some areas, Säräisniemi 1 Ware precedes Sperrings Ware (also *Pesonen* et al. *2012.670*). This further corroborates the recently-presented idea that Säräisniemi 1 Ware is not just a late northern variant of Sperrings Ware (see *Pesonen 1991.84; Vitenkova 1996.81; Torvinen 2000.16; German 2006.234–236; Pesonen, Leskinen 2011.300*), but that these pottery types have different origins and development histories (*Piezonka 2015.208–209*). Furthermore, a few Finnish dates indicate that in some areas the use of Säräisniemi 1 Ware may have continued as late as the early 4th millennium cal BC (*Torvinen 1999.238; Carpelan 2004.29; Piezonka 2015.244; Nordqvist, Mökkönen 2016a.204*).

Besides Sperrings and Säräisniemi 1 Wares, a few other pottery types dating to the 5th millennium cal BC have been reported from Karelia: younger Early Comb Ware style I:2 (also Sperrings 2; see *German 1998*, who calls this pottery 'Early Comb Ware') and Kaunissaari Ware (also discussed under the umbrella term of Early Asbestos Ware; see *Pesonen 1996.24*). Both types have their predominant distribution areas in Finland, where they are considered to be mostly younger than Sperrings Ware and dated between 4500 and 3800 cal BC (*Pesonen* et al. *2012.664, Tab. 2; Oinonen* et al. *2014.4, Tab. 1; Nordqvist, Mökkönen 2016a.204–205*). No dates exist for these types in Karelia and, in general, they occur there very rarely.

### *Pit-Comb Ware*

The emergence of Pit-Comb Ware in Karelia is traditionally connected with the Lyalovo culture, widespread in central and north-western Russia in the 5th millennium cal BC, and probably especially with its later stage (*Smirnov 1991; 1996; Gurina, Kraynov 1996; Vitenkova 2016.128; Smol'yaninov 2013.238*). At the moment, the chronology of Pit-Comb Ware is based mainly on context dates, as only four AMS dates exist from Besovy Sledki and Besovy Sledki II in the White Sea region (Fig. 3). Three of these date to the second half of the 5th millennium cal BC, which has often been considered the main use period of this pottery type (*Kosmenko 2003.32; Lobanova 2004.254, 259*), but the fourth one is younger (see below).

According to Nadežda V. Lobanova (*2004.256; 2009.58–59*), who sees the first stage of Pit-Comb Ware as synchronous with Sperrings Ware, the oldest date that can be associated with Pit-Comb Ware comes from Chernaya Rechka I (6200±100 BP, TA-1634). In addition, there are also some other early context dates, but the connection between all these dates and Pit-Comb Ware contexts has been challenged (*German 2002.264; Filatova 2012*; see also *Sidorov 1997.103–105*). Accepting the early dates would also

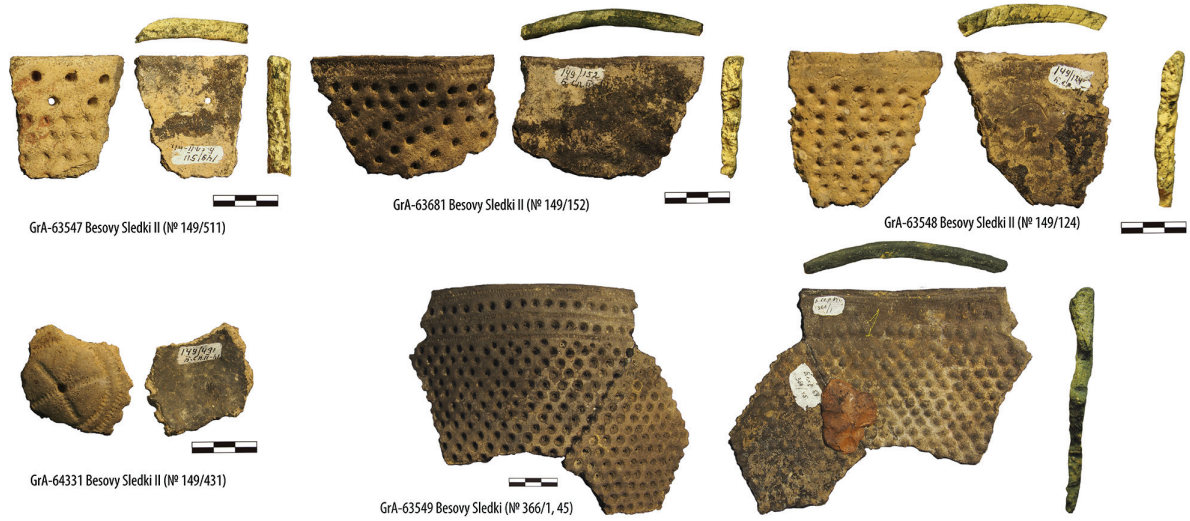



***Fig. 3. Säräisniemi 1 Ware (upper left) and Pit-Comb Ware (designed by T. Mökkönen).***

1 Also, older AMS dates have been presented for Säräisniemi 1 Ware from northern Norway (*e.g.*, 6570±60 BP, TUa-3018 and 6330±50 BP, TUa-3021; *Skandfer 2011.356, Tab. 12.1*), but these are affected by the marine reservoir effect (see *Pesonen* et al. *2012.667–668; Piezonka 2015.208*).

mean that Pit-Comb Ware in Karelia would be contemporaneous with the appearance of Lyalovo culture in the Upper-Volga region, currently dated to the very late 6th millennium or to the turn of the 5th millennium cal BC (*Zaretskaya, Kostyleva 2011. 180–182; Hartz* et al. *2012.1045*).

Context dates connected with Pit-Comb Ware cover almost the whole of the 5th millennium cal BC, but due to the above-mentioned uncertainties, the initial date must be placed only roughly in the first half of the 5th millennium cal BC. Typologically, the final stage of Pit-Comb Ware has been seen to overlap with Comb-Pit and Rhomb-Pit Wares (*Lobanova 2004.261; Khoroshun 2013.126–127*), and a series of dates obtained from Vorob'i 4 showed that at least in some areas the use of Pit-Comb Ware continued during the first two or three centuries of the 4th millennium cal BC.

In addition, there are dates which seem 'too young'. These include a crust date from Besovy Sledki II (4785±45 BP, GrA-64331). Typologically, this shard fits the characteristics of Pit-Comb Ware, but such a long continuation of use of this type seems very improbable (see also *Nordqvist, Mökkönen 2017a* for discussion). A coeval context date of charcoal exists from Chernaya Rechka I (4700±80 BP, TA-1633), but as there are two even much younger dates from the same site (with no corresponding archaeological material) it cannot be given much value. Finally, several crust dates produced by conventional methods from Vorob'i 4 are too young due to insufficient sample sizes (see *Nordqvist, German 2017* for discussion).

***Comb-Pit and Rhomb-Pit Wares***

Comb-Pit Ware, corresponding to Typical Comb Ware of the eastern Baltic and Finland (*Yanits 1959; Nordqvist, Mökkönen 2015*), and Rhomb-Pit Ware, which finds analogies elsewhere in north-western and central Russia (*Smirnov 1991; Smol'yaninov 2009; Vitenkova 2016*), followed Pit-Comb Ware in Karelia. Traditionally, they were seen as subsequent types also among themselves, but the introduction of more accurate dating has shown them to be more or less contemporary (*Zhul'nikov 2005.25; Khoroshun 2013.117; Vitenkova 2016.118*). Currently, their chronology is based on many AMS and context dates, although the latter often originate from sites with mixed complexes of Comb-Pit and Rhomb-Pit Wares and cannot be attributed to only one of them. Based on some dates and stratigraphical observations (site Chernaya Guba III) it has been proposed that the appearance of Comb-Pit Ware would be slightly older, but the available data are too vague to draw such conclusions. In fact, it is not even known if the two assemblages at the same sites indicate the repeated use of these locations by two different groups or if both types were used by the same population (*Vitenkova 2016.121*).

Based on AMS dating, Comb-Pit Ware in Karelia dates to 4000–3600 cal BC (medians 4000–3700 cal BC) and Rhomb-Pit Ware 3900–3400 cal BC (medians 3800–3500 cal BC) (Figs. 4, 5). Most of the context dates fall between 4000–3100 cal BC (medians 3900–3300 cal BC), within which the main use period of these types belongs. Such dating also fits the results from Finland, where an extensive dating programme has defined the use period of Typical Comb Ware from 3900 up to 3400 cal BC (*Pesonen 2004. 90; Oinonen* et al. *2014*; authors' unpublished data). Chronology of Rhomb-Pit-related pottery is poorly known outside Karelia, and the only available direct dating (made of ceramic matrix) suggests that it existed between 3600–3100 cal BC (*Skorobogatov* et al. *2016.247*).

However, there are context dates which date slightly older (Pegrema I, 5145±110 BP, TA-541 and Pegrema II, 5070±120 BP, TA-811) or even considerably younger (*e.g.*, Pegrema I, 4200±50 BP, TA-493; Pegrema III, 4240±90 BP, TA-813).[2] Even if they are at least partly related to other activities at these sites (*e.g., Kosmenko 2003.25; Nordqvist, Mökkönen 2016b.232*), it seems probable that, just as in some parts of Finland (*Mökkönen 2008.123–124*; also *Seitsonen* et al. *2012.111*), Comb Ware tradition continued in Karelia in some form and in some areas until the early 3rd millennium cal BC. Still, for example, the date from Lakshezero II (3920±60 BP, TA-1520), presented also as the final date for Comb-Pit Ware, probably belongs to the later asbestos pottery-related use of this site (*Vitenkova 2002.142*).

In addition to uncertain context dates, one AMS dating from Chernaya Guba III (6060±40 BP, GrA-

2 The young dates from Pegrema I and Pegrema III are problematic because they have been presented quite differently in different publications. The date of 4240±90 BP has also been given as 4200±90 BP, with index ID TA-813 or with no index ID; the date 4250±50 BP (TA-493) has also been published as 4200±50 BP. Moreover, the date TA-813 has been said to originate from both of these sites (see *Zhuravlev 1977; 1979; 1984; 1991; Zhuravlev, Liiva 1980; Kochkurkina 1991; Vitenkova 2002; Timofeev* et al. *2004*).

63539) is problematic, as it is almost a millennium older than expected. The reservoir effect cannot be ruled out (the $\delta^{13}C$ value is –27.84‰), and there is always the possibility of typological misinterpretation, even if in this case the dated shard fully fits the characteristics of Comb-Pit Ware. If the date is even tentatively connected with the Pit-Comb Ware, recovered in small amounts at this site (*Vitenkova 2002.29*), it would also be by far the oldest direct date of Pit-Comb Ware in Karelia. Furthermore, two conventional dates of pottery crust from Vozhmarikha 21 may date to the end phase of Comb-Pit Ware use, but may also suffer from the same problems discussed in connection with the Pit-Comb Ware dates from Vorob'i 4.

Finally, a date measured on birch bark found in a grave at Bukol'nikov 1 (4740±60 BP, LE-9391) has been connected with Comb-Pit Ware (*Mel'nikov, German 2013.120*), even if no Comb-Pit Ware was found at the site. The grave goods, *e.g.,* amber jewellery and a bifacial flint point, may be seen to support this connection. However, the assemblage from the site includes mostly Pit-Comb Ware and some asbestos-tempered pottery of possibly Voynavolok type – within the temporal limits provided by the date, the burial could also be connected with the latter phase.

### *Zalavruga, Voynavolok, Orovnavolok and Palayguba Wares*

Previously, all asbestos- and organic-tempered pottery in Karelia was discussed under the one heading of Asbestos or Classic Ware (*Gurina 1961.161; Kosmenko 1992.131*). Such a view does not permit the tracing of cultural dynamics during the 4th–2nd millennia cal BC, and since then four types of pottery have been separated from the material: Zalavruga, Voynavolok, Orovnavolok and Palayguba Wares (*Zhul'nikov 1991; 1999; 2005*). These types have varying distributions mainly in Karelia and find some parallels in the Finnish types of Kierikki and Pöljä. They have also contemporary analogues in the east, and generally the emergence of asbestos- and organic-tempered pottery in Karelia has been connected with the development of the Volosovo cultural entity in the Volga-Oka region (*Zhul'nikov 1999.6–7* and references cited). The starting point of Volosovo in the Upper Volga region is dated to around 3600 cal BC (*Kostyleva, Utkin 2010.248–250*).

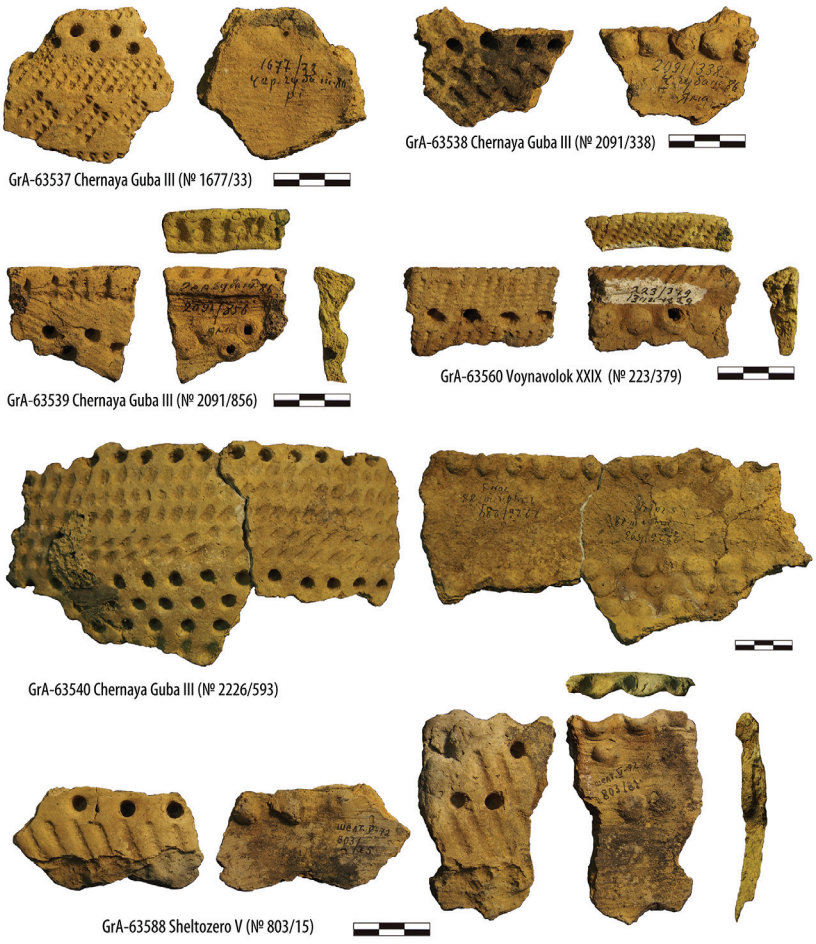



***Fig. 4. Comb-Pit Ware (designed by T. Mökkönen).***

Asbestos- and organic-tempered wares are relatively well dated by AMS and context dates (including numerous dates from burnt dwelling constructions), although the dates are unevenly distributed among the pottery types. There are also notably many 'non- fitting' dates connected to sites with these pottery types or their use periods (see Table 2).

The oldest date connected with asbestos- and organic-tempered pottery in Karelia is a tar date related to Voynavolok Ware (Pervomayskaya I, 4710±35 BP, GrA-63682) (Fig. 6). Generally, AMS dates for this type fall between 3600–2900 cal BC (medians 3500–3000 cal BC) and cluster into two groups between 3600–3400 cal BC and 3400–2900 cal BC. The first cluster corresponds neatly with older ideas of a short use period of

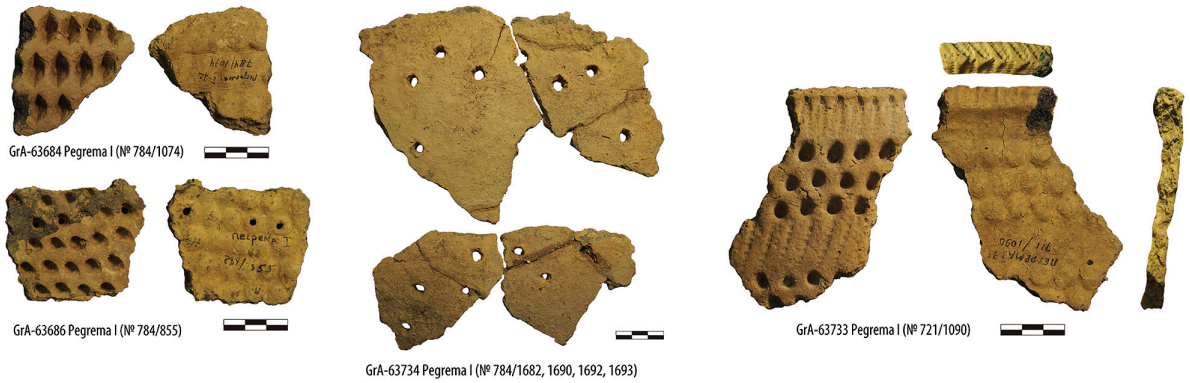



***Fig. 5. Rhomb-Pit Ware (designed by T. Mökkönen).***

this pottery type, just a few centuries in the mid-4th millennium cal BC (*Zhul'nikov 1999.47, 76–78*; also *Zhul'nikov, Tarasov 2014.262*). The second cluster is contemporary with the few available context dates from burnt dwelling constructions (3300–2600 cal BC, medians 3100–2900 cal BC).

In other words, the beginning of Voynavolok Ware may be dated to the mid-4th millennium cal BC. Such dating is also supported by Finnish material, where Kierikki Ware is dated between 3600 and 2900 cal BC (*Pesonen 2004.90, 92; Nordqvist, Mökkönen 2017b; Mökkönen, Nordqvist in prep.*). Like Voynavolok Ware, Kierikki Ware is seen as a descendant of the Comb Ware tradition, and some of the heterogeneous material classified as Kierikki bears considerable resemblance to Voynavolok Ware (*Nordqvist, Mökkönen 2017b; Mökkönen, Nordqvist in prep.*). Furthermore, some pottery labelled (erroneously) as Kierikki is actually pure Voynavolok type (pottery from Vuopaja; *Zhulnikov* et al. *2012.127*; this is the oldest AMS-dated Voynavolok shard, 4805±85 BP, Ua-4364; *Carpelan 2004*).

The end date of Voynavolok Ware should be placed in the first centuries of the 3rd millennium cal BC, at the latest. However, the youngest dates (Voynavolok XXVII, 4280±80 BP, GrA-63562 and Fofanovo XIII, 4470±60 BP, GrA-62484) derive from shards that also allow typological attribution to Orovnavolok Ware or represent a so-called 'transitional type' between these two (see *Zhul'nikov, Tarasov 2014.261; Tarasov 2015.250*; also *Nordqvist, Mökkönen 2017a* for discussion). Respectively, the same reason, in addition to a possible freshwater reservoir effect, explains the overlap of Voynavolok type and the oldest dates connected with Orovnavolok Ware (Orovnavolok XVI, 4770±40 BP, Beta-117966; Fofa-




***Fig. 6. Voynavolok Ware (designed by T. Mökkönen).***

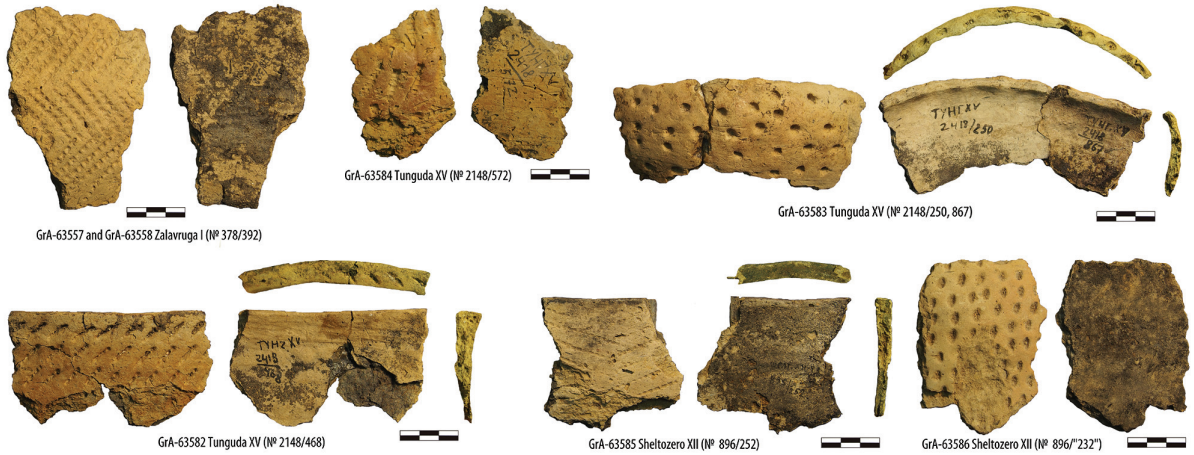



***Fig. 7. Orovnavolok Ware and Palayguba Ware (bottom row) (designed by T. Mökkönen).***

novo XIII, 4585±35 BP, GrA-62059; Tunguda XV, 4570±35 BP, GrA-63583) (Fig. 7). This typological overlap is well-evidenced by material and dates from Fofanovo XIII, where, however, Voynavolok pottery has generally been recovered in lower stratigraphic layers than the Orovnavolok type (*Zhul'nikov, Tarasov 2014; Tarasov 2015*).

The remaining AMS dates of Orovnavolok Ware fall between 3300–2700 cal BC (medians 3200–2900 cal BC) and are roughly congruent with the majority of context dates from dwelling constructions, 3100–2600 cal BC (medians 2800 cal BC). Still, there are a few dates some centuries younger, although it is highly implausible that at least the youngest date (Voynavolok XXIV, 3560±80 BP, TA-819) would anymore represent the use period of Orovnavolok Ware.

In sum, the start of this type should be a bit later than Voynavolok Ware and probably dates to around 3400 cal BC, although the nature of the 'transitional type' remains ambivalent. The end date can probably be placed in the first half of the 3rd millennium cal BC, and no later than 2500 cal BC. Thus, in addition to Kierikki and Voynavolok Wares, it belongs to the same chronological horizon as Pöljä Ware of Finland, with which it also shares some typological and stylistic similarities (pure Orovnavolok Ware has been recognised in Finland on some occasions; *Nordqvist, Mökkönen 2017b; Mökkönen, Nordqvist in prep.*; see also *Zhul'nikov 2005.29*). Pöljä Ware is dated by AMS dates to 3500–2500 cal BC, but including context datings, its end has been extended to *c.* 1900 cal BC (*Pesonen 2004.90, 92*; authors' unpublished data).

Zalavruga Ware of the White Sea area has been considered a northern parallel to Voynavolok pottery (*Zhul'nikov 2005.27*). Its dating is based on a few crust/tar dates only, as all context dates derive from mixed sites and have no definite connection with this pottery (Fig. 8). AMS dates fall between 3500 and 2900 cal BC (medians 3400–2900 cal BC), whereas conventional dates date to 3700–1800 cal BC. In other words, the main use period of Zalavruga Ware is the second half of the 4th millennium cal BC.




***Fig. 8. Zalavruga Ware (designed by T. Mökkönen).***

It is largely contemporary with Voynavolok Ware, but also overlaps with Orovnavolok Ware, as also evidenced by coeval datings from the Zalavruga I site. Zalavruga Ware shares some features with Kierikki Ware and the organic-tempered Comb Ware of northern Finland, but their relationships remain unresolved (*Zhul'nikov 2007.123; Nordqvist, Mökkönen 2017b; Mökkönen, Nordqvist in prep.*).

The youngest type of Neolithic/Eneolithic asbestos- and organic-tempered potteries is Palayguba Ware. Currently, only two AMS datings exist for it (Sheltozero XII, 3815±35 BP, GrA-63585 and 3725±35 BP, GrA-63586) (Fig. 7). In this case, context dates from dwellings suggest a somewhat earlier dating. The oldest derives from Kudomguba VII (4010±80 BP, TA-1893), but the most dates from clear Palayguba contexts date younger than 2600 cal BC and up to the first centuries of the 2nd millennium cal BC (2900–1700 cal BC, medians 2500–1900 cal BC). Thus, it seems to overlap little with Orovnavolok Ware, to which it has been also genetically connected, as well as with Corded Ware/Fat'yanovo cultures, which have been seen to influence it too (*Zhul'nikov 1999*). Temporally, Palayguba Ware is largely coeval also with Pöljä Ware, and the end date proposed for the latter, 1900/1800 cal BC, may well apply to most Palayguba pottery.

However, there are even younger dates connected with Palayguba Ware (the youngest date is from Palayguba II, 3150±100 BP, TA-1007), although some of these may already belong to the context of subsequent Textile Ware present at some sites. No genetic relationship has been proposed between these two pottery types, and their overlap remains an open question. In Karelia, the oldest context dates connected with Textile Ware date to the turn of the 3rd and 2nd millennia cal BC or the first half of the 2nd millennium cal BC (Kelka III, 3520±80 BP, TA-2269 and 3100±70 BP, TA-2268; *Zhul'nikov 1999.77*). They are fairly consistent with the earliest AMS dates of Textile Ware from Finland, starting from the early 2nd millennium cal BC onwards (*Lavento 2001.102, Fig. 6.11, 106*). AMS dates for Textile Ware in Karelia fall between *c*. 1500–1300 cal BC (*Kosmenko 2003*).

## Final remarks

The data presented in this paper are still limited in temporal and spatial coverage, and do not allow the study of regional and temporal differences in the distribution of various phenomena in detail. In an area as large as the Karelian Republic, it is not reasonable to assume that development (*e.g.*, appearance or disappearance of a pottery type) would have been simultaneous or similar everywhere. Instead, there might have been large differences (for example, some pottery types may have existed for longer periods in certain areas), which can cause inconsistency in the data and 'deviatory' initial and terminal dates.

Similarly, the data are too thin to provide reliable evidence of the temporal differences of some pottery types proposed on typological grounds, or to be used in statistical analyses defining certain event sequences. Also, potential sources of error – like the old wood and the (freshwater) reservoir effect – must be studied in the future, as this might also clarify the reason behind the differences between residue-based AMS and conventional charcoal dates.

Despite the numerous problems and unanswered questions, the currently available radiocarbon dates enable the study of chronological sequences in Karelia in much greater detail than was possible even two or three years ago. Nowadays, it is also possible to correlate the Karelian chronology more or less precisely with the general north-east European chronological framework. All this creates a better foundation for understanding the cultural dynamics between the later 6th and the early 2nd millennia cal BC of north-western Russia.

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*Tab. 1. Neolithic–Eneolithic radiocarbon dates, which generally correspond with archaeological materials and contexts present at these sites.*

| No. on map | Site | $^{14}$C date (BP) | Lab. Index | Context/dated item | Calibrated date (cal BC; 2σ) | Typological connection | References |
|---|---|---|---|---|---|---|---|
| 1 | Uya III | 6770±80 | TA-2352 | Charcoal from fireplace, depth :1m | 5837–5538 | Mesolithic (?), Sperrings | *Kosmenko 2003* |
| | | 6225±40 | GrA-63566 | Crust on pottery | 5304–5059 | | *Nordqvist, Mökkönen 2016a* |
| | | 6160±40 | GrA-63581 | Black paint on pottery | 5217–5000 | | *Nordqvist, Mökkönen 2016a* |
| | | 5970±40 | GrA-63546 | Birch bark tar on pottery | 4956–4729 | | *Nordqvist, Mökkönen 2016a* |
| 3 | Sulgu II | 6670±35 | KIA-35900 | Calcinated bone, elk or reindeer | 5646–5527 | Sperrings | *Piezonka 2008* |
| | | 6085±30 | KIA-36724 | Birch bark tar of food crust on pottery | 5202–4857 | | *Piezonka 2008* |
| | | 6015±30 | KIA-33925 | Birch bark tar on pottery | 4995–4810 | | *Piezonka 2008* |
| 2 | Pegrema IX | 6510±150 | TA-1161 | Charcoal from fireplace, depth 0,6m | 5730–5081 | Sperrings | *Zhuravlev 1984* |
| 11 | Yerpin Pudas I | 6510±120 | TA-344 | Unknown | 5660–5227 | Säräisniemi 1, Pit-Comb, Comb-Pit, asbestos-tempered | *Devyatova 1976* |
| | | 5990±100 | TA-799 | Charcoal from fireplace | 5210–4624 | | *Devyatova 1976* |
| | | 5860±100 | TA-472 | Unknown | 4981–4493 | | *Devyatova 1976* |
| | | 5825±80 | TA-413 | Unknown | 4896–4490 | | *Devyatova 1976* |
| | | 5460±80 | TA-800 | Charcoal from fireplace | 4459–4057 | | *Devyatova 1976* |
| | | 5240±50 | TA-795 | Charcoal from fireplace at the bottom of cultural layer | 4231–3965 | | *Devyatova 1976* |
| 8 | Sheltozero XI | 6480±70 | TA-1312 | Charcoal from cultural layer, depth 0,75–0,93m | 5605–5316 | Sperrings, Pit-Comb, Voynavolok | *Pesonen 1988* |
| | | 5960±70 | TA-1313 | Charcoal from cultural layer, depth 0,75–0,8m | 5024–4691 | | *Pesonen 1988* |
| 8 | Sheltozero X | 6400±80 | TA-1308 | Charcoal from pit | 5509–5218 | Sperrings, Pit-Comb | *Kochkurkina 1991* |
| 27 | Kurkieki 33 (Kylliäisen-lahti W-2) | 6400±600 | LE-6928 | Charcoal from pit | 6591–4045 | Mesolithic, Sperrings, asbestos-tempered | *Seitsonen, Gerasimov 2008* |
| 7 | Shettima I | 6400±150 | TA-1552 | Charcoal from fireplace, depth 0,3–0,4m | 5628–5024 | Sperrings, Pit-Comb, small amount of Voynavolok and Orovnavolok | *Pesonen 1988* |
| 6 | Kalmozero II | 6340±70 | KIA-35899A | Crust on pottery | 5478–5081 | Säräisniemi 1 | *Piezonka 2008* |
| | | 6080±45 | KIA-35899B | Crust on pottery | 5207–4846 | Säräisniemi 1 | *Piezonka 2008* |
| 26 | Koyrinoya 3 | 6262±40 | Hela-2827 | Calcinated bone, mammal | 5320–5076 | Mesolithic, Sperrings | *Takala* et al. *2016* |
| | | 6209±43 | Hela-2829 | Calcinated bone, beaver | 5300–5051 | | *Takala* et al. *2016* |
| 10 | Chernaya Rechka I | 6200±100 | TA-1634 | Charcoal from fireplace | 5373–4851 | Pit-Comb, small amount of Palayguba | *Lobanova 1988* |
| | | 5950±100 | TA-1648 | Charcoal from fireplace | 5201–4555 | | *Lobanova 1988* |
| | | 5800±100 | TA-1550 | Charcoal from fireplace, depth 0,6–0,85m | 4929–4408 | | *Lobanova 1988* |
| | | 5500±100 | TA-1651 | Charcoal from fireplace, depth 0,5–0,8m | 4544–4055 | | *Lobanova 1988* |
| | | 4700±80 | TA-1633 | Charcoal from fireplace, depth 0,3–0,5m | 3652–3196 | | *Kochkurkina 1991* |
| | | 3240±100 | TA-1649 | Charcoal from fireplace, depth 0,6–1,15m | 1751–1266 | | *Kochkurkina 1991* |
| 9 | Orovnavolok V | 5945±40 | GrA-63735 | Birch bark tar on pottery | 4932–4725 | Sperrings | *Nordqvist, Mökkönen 2016a* |
| | | 5850±80 | TA-2265 | Charcoal from fireplace, depth 0,4–0,55m | 4931–4519 | Sperrings, Pit-Comb | *Kosmenko 2003* |
| | | 5720±60 | TA-2266 | Charcoal from fireplace, depth 0,5–0,6m | 4716–4449 | | *Kosmenko 2003* |

| No. on map | Site | $^{14}$C date (BP) | Lab. Index | Context/dated item | Calibrated date (cal BC; 2σ) | Typological connection | References |
|---|---|---|---|---|---|---|---|
| 10 | Chernaya Rechka IIa | 5930±80<br>5420±100 | TA-2353<br>TA-2203 | Charcoal from cultural layer, depth 0,3–0,4m<br>Charcoal from pit, depth 0,6–0,9m | 5016–4604<br>4454–4001 | Pit-Comb | *Kochkurkina 1991*<br>*Kochkurkina 1991* |
| 8 | Sheltozero V | 5870±40<br>5045±35 | GrA-63587<br>GrA-63588 | Crust on pottery<br>Crust on pottery | 4839–4617<br>3956–3715 | Sperrings<br>Comb-Pit | *Nordqvist, Mökkönen 2016a*<br>*Nordqvist, Mökkönen 2017a* |
| 10 | Kladovets Va | 5850±80 | TA-1450 | Charcoal from 'ritual' pit in a burial, depth 0,25–0,35m | 4931–4519 | Pit-Comb | *Lobanova 1988* |
| 5 | Panozero I | 5795±35 | KIA-33924 | Birch bark tar on pottery | 4722–4548 | Sperrings | *Piezonka 2008* |
| 11 | Besovy Sledki II | 5775±70<br>5635±40<br>5410±40<br>4785±45 | GrA-63547<br>GrA-63681<br>GrA-63548<br>GrA-64331 | Crust on pottery<br>Crust on pottery<br>Crust on pottery<br>Crust on pottery | 4783–4465<br>4542–4367<br>4348–4076<br>3653–3381 | Säräisniemi 1<br><br>Pit-Comb<br> | *Nordqvist, Mökkönen 2016a*<br>*Nordqvist, Mökkönen 2016a*<br>*Nordqvist, Mökkönen 2016a*<br>*Nordqvist, Mökkönen 2016a* |
| 4 | Bukol'nikov 1 | 5600±25<br>4740±60 | LE-8908<br>LE-9391 | Charcoal from fireplace<br>Birch bark from burial | 4487–4361<br>3641–3372 | Pit-Comb, asbestos-tempered | *Mel'nikov, German 2013*<br>*Mel'nikov, German 2013* |
| 4 | Vozhmarikha 4 | 5560±45 | LE-6604 | Charcoal from fireplace | 4487–4336 | Pit-Comb, Comb-Pit | *Mel'nikov, German 2013* |
| 11 | Besovy Sledki | 5550±40 | GrA-63549 | Crust on pottery | 4458–4338 | Pit-Comb | *Nordqvist, Mökkönen 2016a* |
| 4 | Vozhmarikha 26 | 5507±50 | KIA-35901 | Crust on pottery | 4456–4261 | Sperrings | *Piezonka 2008* |
| 4 | Vorob'i 4 | 5360±70<br>5136±120<br>5135±45<br>5115±120<br>5100±120<br>5030±60<br>5000±40<br>4948±110<br>4790±120<br>4779±110<br>4641±120<br>4632±150<br>4626±120<br>4427±150 | GrA-68145<br>SPb-1786<br>GrA-67742<br>SPb-1822<br>SPb-1785<br>GrA-68144<br>GrA-67744<br>SPb-1775<br>SPb-1783<br>SPb-1777<br>SPb-1781<br>SPb-1778<br>SPb-1782<br>SPb-1779 | Crust on pottery<br>Crust on pottery<br>Crust on pottery<br>Crust on pottery<br>Crust on pottery<br>Crust on pottery<br>Crust on pottery<br>Crust on pottery<br>Crust on pottery<br>Crust on pottery<br>Crust on pottery<br>Crust on pottery<br>Crust on pottery<br>Crust on pottery | 4341–4005<br>4238–3666<br>4040–3799<br>4231–3660<br>4229–3653<br>3961–3700<br>3945–3665<br>3976–3520<br>3938–3138<br>3904–3142<br>3652–3025<br>3691–2927<br>3647–3021<br>3621–2678 | Pit-Comb | *Nordqvist, German 2017*<br>*Nordqvist, German 2017*<br>*Nordqvist, German 2017*<br>*Nordqvist, German 2017*<br>*German 2016*<br>*German 2016*<br>*German 2016*<br>*German 2016*<br>*German 2016*<br>*German 2016*<br>*German 2016*<br>*German 2016*<br>*German 2016*<br>*German 2016* |
| 10 | Kladovets IX | 5310±80 | TA-2288 | Charcoal beneath a dweliing | 4327–3981 | Pit-Comb, small amount of Orovnavolok | *Lobanova 2004* |
| 9 | Orovnavolok VII | 5260±70 | TA-2267 | Charcoal from cultural layer | 4314–3958 | Pit-Comb | *Lobanova 2004* |
| 15 | Fofanovo XIII | 5220±80<br>5150±80<br>4685±35 | SPb-784<br>SPb-783<br>GrA-62060 | Charcoal from fireplace, depth 0,8m<br>Charcoal from fireplace, depth 0,7m<br>Crust on pottery | 4259–3804<br>4229–3766<br>3627–3369 | Pit-Comb (singular fragments), Voynavolok, Orovnavolok<br><br>Voynavolok | *Tarasov 2015*<br>*Tarasov 2015*<br>*Nordqvist, Mökkönen 2017a* |

| No. on map | Site | $^{14}$C date (BP) | Lab. Index | Context/dated item | Calibrated date (cal BC; 2σ) | Typological connection | References |
|---|---|---|---|---|---|---|---|
| 15 | Fofanovo XIII | 4585±35 | GrA-62059 | Crust on pottery | 3501–3112 | Orovnavolok | *Nordqvist, Mökkönen 2017a* |
| | | 4535±35 | Poz-85971 | Calcinated bone, indet fr, mammalia | 3364–3102 | Pit-Comb (singular fragments), Voynavolok, Orovnavolok | This publication |
| | | 4470±60 | GrA-62484 | Crust on pottery | 3355–2934 | Voynavolok | *Nordqvist, Mökkönen 2017a* |
| | | 4454±42 | Hela-2812 | Crust on pottery | 3341–2937 | Orovnavolok | *Zhulnikov* et al. *2012* |
| | | 4025±35 | GrA-63891 | Bone, humerus sin diaphysis fr, beaver | 2831–2468 | Pit-Comb (singular fragments), Voynavolok, Orovnavolok | This publication |
| 11 | Zolotets VI | 5160±150 | TA-421 | Unknown | 4325–3662 | Comb-Pit, Rhomb-Pit, Zalavruga | *Savvateev* et al. *1974* |
| | | 4620±60 | TA-391 | Charcoal from cultural layer | 3629–3106 | | *Savvateev* et al. *1974* |
| | | 4150±80 | TA-793 | Charcoal from cultural layer, depth 0,2–0,45m | 2901–2496 | | *Devyatova 1976* |
| | | 3780±150 | TA-801 | Charcoal from cultural layer, depth 0,1–0,3m | 2624–1771 | | *Devyatova 1976* |
| 9 | Chernaya Guba III | 6060±40 | GrA-63539 | Birch bark tar on pottery | 5195–4842 | Comb-Pit | *Nordqvist, Mökkönen 2017a* |
| | | 5155±35 | GrA-63538 | Crust on pottery | 4042–3811 | | *Nordqvist, Mökkönen 2017a* |
| | | 4950±100 | TA-1890 | Charcoal from fireplace in a dwelling | 3968–3527 | Pit-Comb, Comb-Pit, Rhomb-Pit | *Kochkurkina 1991* |
| | | 4925±35 | GrA-63540 | Birch bark tar on pottery | 3775–3646 | Comb-Pit | *Nordqvist, Mökkönen 2017a* |
| | | 4895±35 | GrA-63537 | Birch bark tar on pottery | 3762–3637 | | *Nordqvist, Mökkönen 2017a* |
| 2 | Pegrema I | 5145±110 | TA-541 | Charcoal from pit | 4236–3705 | Rhomb-Pit | *Zhuravlev 1984* |
| | | 4980±60 | LE-1029 | Charcoal from pit | 3943–3653 | | *Zhuravlev 1984* |
| | | 4825±35 | GrA-63684 | Birch bark tar on pottery | 3694–3523 | | *Nordqvist, Mökkönen 2016b* |
| | | 4780±50 | TA-492 | Charcoal from pit | 3655–3378 | | *Zhuravlev 1984* |
| | | 4730±35 | GrA-63686 | Birch bark tar on pottery | 3635–3377 | | *Nordqvist, Mökkönen 2016b* |
| | | 4720±35 | GrA-63733 | Birch bark tar on pottery | 3634–3375 | | *Nordqvist, Mökkönen 2016b* |
| | | 4695±35 | GrA-63734 | Crust on pottery | 3630–3370 | | *Nordqvist, Mökkönen 2016b* |
| 2 | Pegrema II | 5070±120 | TA-811 | Charcoal from cultural layer | 4227–3640 | Sperrings, Pit-Comb, Rhomb-Pit | *Zhuravlev 1984* |
| | | 4750±120 | TA-810 | Charcoal from cultural layer | 3794–3110 | | *Zhuravlev 1984* |
| | | 4550±90 | TA-808 | Charcoal from cultural layer | 3618–2937 | | *Zhuravlev 1984* |
| 2 | Pegrema I / III | 4240±90 | TA-813 | Charcoal from dwelling | 3091–2575 | Rhomb-Pit | *Zhuravlev 1976* |
| | | 4200±50 | TA-493 | Charcoal from dwelling | 2904–2631 | | *Zhuravlev 1976* |
| 14 | Voynavolok XXIX | 5030±35 | GrA-63560 | Birch bark tar on pottery | 3946–3713 | Comb-Pit | *Nordqvist, Mökkönen 2017a* |
| 9 | Orovnavolok XVI | 5080±70 | Beta-117965 | Charcoal from a lens close to entrance of a dwelling | 4036–3707 | Comb-Pit, Rhomb-Pit | *Lobanova 2004* |
| | | 4970±50 | Beta-117964 | Crust on pottery | 3939–3650 | | *Lobanova 2004* |
| | | 4870±50 | Beta-117962 | Crust on pottery | 3771–3530 | Rhomb-Pit | *Lobanova 2004* |
| | | 4840±50 | Beta-117963 | Crust on pottery | 3748–3518 | | *Lobanova 2004* |
| | | 4770±40 | Beta-117966 | Crust on pottery | 3644–3381 | Orovnavolok (?) | *Khoroshun 2013* |
| | | 4390±50 | Beta-117961 | Crust on pottery | 3325–2901 | | *Khoroshun 2013* |
| | | 4200±20 | TA-828 | Charcoal from the burnt wall of a dwelling | 2891–2698 | Orovnavolok | *Kochkurkina 1991* |

| No. on map | Site | $^{14}$C date (BP) | Lab. Index | Context/dated item | Calibrated date (cal BC; 2σ) | Typological connection | References |
|---|---|---|---|---|---|---|---|
| 12 | Vigaynavolok I | 4940±30 | KIA-33930 | Crust on pottery | 3777–3654 | Rhomb-Pit | *Khoroshun 2013* |
| | | 4725±30 | KIA-33931 | Birch bark tar on pottery | 3634–3377 | | *Khoroshun 2013* |
| 4 | Vozhmarikha 1 | 4900±130 | LE-848 | Charcoal from fireplace in a dwelling | 3965–3376 | Comb-Pit | *Mel'nikov, German 2013* |
| | | 4420±60 | LE-9393 | Unknown | 3336–2911 | | *Mel'nikov, German 2013* |
| 9 | Chernaya Guba IX | 4840±80 | TA-2023 | Charcoal from fireplace in a dwelling | 3793–3377 | Pit-Comb, Comb-Pit, Rhomb-Pit | *Kochkurkina 1991* |
| | | 4340±80 | TA-2140 | Charcoal from the wall of a dwelling | 3336–2708 | Voynavolok | *Kochkurkina 1991* |
| 13 | Sukhaya Vodla I | 4810±60 | TA-1553 | Charcoal from fireplace, depth 0,35–0,4m | 3706–3379 | Pit-Comb, Rhomb-Pit, small amount of Orovnavolok and Palayguba | *Pesonen 1988* |
| 11 | Zalavruga I | 4775±70 | TA-393 | Charcoal from a washed fireplace | 3694–3372 | Rhomb-Pit, Zalavruga, Orovnavolok, Palayguba | *Savvateev* et al. *1974* |
| | | 4580±35 | GrA-63559 | Crust on pottery | 3499–3111 | Zalavruga | *Nordqvist, Mökkönen 2017a* |
| | | 4570±35 | GrA-63551 | Crust on pottery | 3496–3104 | | *Nordqvist, Mökkönen 2017a* |
| | | 4495±35 | GrA-63555 | Crust on pottery | 3352–3037 | | *Nordqvist, Mökkönen 2017a* |
| | | 4295±35 | GrA-63552 | Crust on pottery | 3012–2878 | | *Nordqvist, Mökkönen 2017a* |
| | | 4285±35 | GrA-63557 | Crust on pottery | 3013–2873 | Orovnavolok | *Nordqvist, Mökkönen 2017a* |
| | | 4255±40 | GrA-63558 | Crust on pottery | 3007–2694 | | *Nordqvist, Mökkönen 2017a* |
| | | 4010±70 | GIN-130 | Charcoal from fireplace | 2861–2304 | Rhomb-Pit, Zalavruga, Orovnavolok, Palayguba | *Devyatova 1976* |
| 24 | Pervomayskaya I | 4710±35 | GrA-63682 | Birch bark tar on pottery | 3632–3373 | Voynavolok | *Nordqvist, Mökkönen 2017a* |
| | | 4685±35 | GrA-63592 | Crust on pottery | 3627–3369 | | *Nordqvist, Mökkönen 2017a* |
| | | 4615±35 | GrA-63683 | Crust on pottery | 3517–3144 | | *Nordqvist, Mökkönen 2017a* |
| | | 4610±35 | GrA-63590 | Crust on pottery | 3516–3136 | | *Nordqvist, Mökkönen 2017a* |
| 4 | Vozhmarikha 21 | 4700±120 | SPb-1784 | Crust on pottery | 3709–3096 | Comb-Pit | *German 2016* |
| | | 4487±110 | SPb-1776 | Crust on pottery | 3507–2901 | | *German 2016* |
| 14 | Voynavolok XXVII | 4693±35 | Hela-2428 | Crust on pottery | 3629–3370 | Voynavolok | *Zhulnikov* et al. *2012* |
| | | 4605±35 | GrA-63565 | Crust on pottery | 3515–3128 | | *Nordqvist, Mökkönen 2017a* |
| | | 4410±150 | TA-1748 | Charcoal from the burnt wall of a dwelling | 3518–2666 | | *Pankrushev 1988* |
| | | 4365±35 | GrA-63562 | Crust on pottery | 3090–2903 | | *Nordqvist, Mökkönen 2017a* |
| | | 4280±80 | TA-1726 | Charcoal from the burnt wall of a dwelling | 3265–2620 | | *Pankrushev 1988* |
| 27 | Kurkieki 52 (Kuuppala Kalmistomäki) | 4620±60 | SU-2651 | Charcoal from cultural layer | 3629–3106 | Sperrings, Pit-Comb, Comb-Pit, Late Comb, asbestos-tempered, Textile | *Saarnisto 2003* |
| 11 | Zolotets XX | 4610±35 | GrA-63550 | Birch bark tar on pottery | 3516–3136 | Zalavruga | *Nordqvist, Mökkönen 2017a* |
| 16 | Berezovo XVII | 4600±100 | TA-2271 | Charcoal from a layer buried under the embankment of a dwelling related to Orovnavolok | 3634–3026 | Comb-Pit, Rhomb-Pit, Zalavruga, Orovnavolok | *Zhul'nikov 1999* |
| 9 | Chernaya Guba IV | 4580±60 | TA-2024 | Charcoal from fireplace in a dwelling | 3517–3097 | Pit-Comb, Comb-Pit, Rhomb-Pit | *Kochkurkina 1991* |

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|---|---|---|---|---|---|---|---|
| 16 | Tunguda XV | 4570±35 | GrA-63583 | Crust on pottery | 3496–3104 | Orovnavolok | *Nordqvist, Mökkönen 2017a* |
| | | 4515±35 | GrA-63582 | Crust on pottery | 3357–3097 | | *Nordqvist, Mökkönen 2017a* |
| | | 4435±35 | GrA-63584 | Crust on pottery | 3330–2926 | | *Nordqvist, Mökkönen 2017a* |
| 11 | Zalavruga IV | 4430±80 | TA-392 | Unknown | 3343–2914 | Rhomb-Pit, Zalavruga, Orovnavolok, Palayguba | *Savvateev* et al. *1974* |
| | | 3810±50 | TA-794 | Charcoal from cultural layer | 2460–2064 | | *Devyatova 1976* |
| | | 3700±100 | TA-797 | Charcoal from cultural layer | 2458–1784 | | *Devyatova 1976* |
| 16 | Tunguda XVII | 4370±60 | TA-2289 | Charcoal from the burnt wall of a dwelling | 3326–2888 | Orovnavolok | *Zhul'nikov 1999* |
| | | 3920±60 | TA-2290 | Charcoal from the burnt wall of a dwelling | 2571–2208 | | *Zhul'nikov 1999* |
| 16 | Tunguda III | 4350±100 | TA-2270 | Charcoal from the burnt wall of a dwelling | 3354–2697 | Orovnavolok | *Zhul'nikov 1999* |
| | | 4220±60 | TA-2200 | Charcoal from the burnt wall of a dwelling | 2924–2620 | | *Kochkurkina 1991* |
| 16 | Tunguda XIV | 4340±80 | TA-2019 | Charcoal from the burnt wall of a dwelling | 3336–2708 | Orovnavolok | *Kochkurkina 1991* |
| | | 4210±60 | TA-2018 | Charcoal from the burnt wall of a dwelling | 2917–2620 | | *Kochkurkina 1991* |
| 4 | Vozhmarikha 19 | 4330±120 | SPb-1780 | Crust on pottery | 3354–2631 | Orovnavolok | *German 2016* |
| 17 | Meyeri II | 4300±100 | TA-1518 | Charcoal from fireplace | 3332–2624 | Comb-Pit | *Kochkurkina 1991* |
| 14 | Voynavolok XXIV | 4250±70 | TA-820 | Charcoal from dwelling | 3080–2622 | Orovnavolok | *Zhuravlev 1977* |
| | | 4200±80 | TA-846 | Charcoal from dwelling | 3009–2500 | | *Zhuravlev 1984* |
| | | 3560±80 | TA-819 | Charcoal from the burnt wall of a dwelling | 2135–1692 | | *Zhuravlev 1977* |
| 18 | Kudomguba VII | 4010±80 | TA-1893 | Charcoal from the wall of a dwelling | 2865–2296 | Palayguba | *Kochkurkina 1991* |
| 11 | Zolotets XI | 3990±60 | TA-798 | Charcoal from cultural layer, depth 0,2–0,4m | 2837–2299 | Orovnavolok | *Devyatova 1976* |
| 19 | Chelmuzhskaya Kosa XXI | 3980±90 | TA-1783 | Charcoal from the wall of a dwelling | 2862–2207 | Palayguba | *Kochkurkina 1991* |
| | | 3750±100 | TA-1947 | Charcoal from the wall of a dwelling | 2466–1920 | | *Kochkurkina 1991* |
| | | 3540±80 | TA-1948 | Charcoal from the floor of a dwelling | 2132–1667 | | *Kochkurkina 1991* |
| 25 | Sumozero XV | 3950±60 | Beta-? | Charcoal from the construction of a dwelling | 2620–2213 | Palayguba | *Zhul'nikov 2005* |
| | | 3935±105 | TUa-? | Charcoal from the construction of a dwelling | 2860–2136 | | *Zhul'nikov 2005* |
| | | 3875±55 | TUa-? | Charcoal from the construction of a dwelling | 2485–2151 | | *Zhul'nikov 2005* |
| | | 3750±60 | Beta-? | Charcoal from the construction of a dwelling | 2400–1972 | | *Zhul'nikov 2005* |
| | | 3690±60 | Beta-? | Charcoal from the construction of a dwelling | 2279–1916 | | *Zhul'nikov 2005* |
| | | 3670±65 | TUa-? | Charcoal from the construction of a dwelling | 2275–1886 | | *Zhul'nikov 2005* |
| | | 3540±70 | Beta-? | Charcoal from the construction of a dwelling | 2118–1690 | | *Zhul'nikov 2005* |
| 10 | Chernaya Rechka XII | 3930±80 | TA-1784 | Charcoal from fireplace, depth 0,25–0,75m | 2832–2147 | Pit-Comb, small amount of Palayguba | *Kochkurkina 1991* |
| 3 | Lakshezero II | 3920±60 | TA-1520 | Charcoal from fireplace | 2571–2208 | Small amount of Sperrings, Comb-Pit and asbestos-tempered | Vitenkova 1986 |
| 26 | Koyrinoya 2 | 3870±33 | Hela-2831 | Calcinated bone, mammal | 2466–2211 | Orovnavolok | *Takala* et al. *2016* |
| 8 | Sheltozero XII | 3815±35 | GrA-63585 | Crust on pottery | 2452–2140 | Palayguba | *Nordqvist, Mökkönen 2017a* |
| | | 3725±35 | GrA-63586 | Crust on pottery | 2275–2024 | | *Nordqvist, Mökkönen 2017a* |

| No. on map | Site | $^{14}$C date (BP) | Lab. Index | Context/dated item | Calibrated date (cal BC; 2σ) | Typological connection | References |
|---|---|---|---|---|---|---|---|
| 3 | Kudoma X | 3530±80 | TA-1258 | Charcoal from cultural layer, depth 0,3–0,6m | 2126–1661 | Sperrings, Pit-Comb, Comb-Pit, Rhomb-Pit, Orovnavolok, Textile | *Pankrushev 1988* |
| 10 | Kladovets IV | 3400±60 | TA-1410 | Charcoal from fireplace, depth 1–1,1m | 1881–1534 | Mesolithic, Sperrings (singular fragments), Pit-Comb, Rhomb-Pit, asbestos-tempered (singular fragments) | *Pankrushev 1988* |
| 12 | Vigaynavolok II | 3370±110 | TA-? | Charcoal from dwelling | 1940–1430 | Pit-Comb (singular fragments), Comb-Pit and Rhomb-Pit (singular fragments), Palayguba | *Zhuravlev 1977* |
| 11 | Zolotets X | 3300±60 | TA-390 | Unknown | 1736–1447 | Palayguba, Textile | *Savvateev* et al. *1974* |
| 14 | Kochnavolok II | 3260±70 | TA-831 | Charcoal from dwelling | 1731–1409 | Palayguba | *Pankrushev 1988* |
| 2 | Palayguba II | 3150±100 | TA-1007 | Charcoal from fireplace | 1657–1128 | Palayguba | *Zhuravlev 1984* |

*Tab. 2. Radiocarbon dates from Neolithic-Eneolithic contexts with deviatory age, and dates with Neolithic–Eneolithic age, but no correspondence with archaeological materials found at these sites. These dates have been included in many previous works on Karelian chronology, even if their suitability for building a chronology is virtually non-existent.*

| No. on map | Site | $^{14}$C date (BP) | Lab. Index | Context/dated item | Calibrated date (cal BC/AD; 2σ) | Typological connection | References |
|---|---|---|---|---|---|---|---|
| 18 | Kudomguba VII | 6720±90 | TA-1724 | Charcoal from a pit, depth 0,45m | 5775–5483 | Palayguba | *Kochkurkina 1991* |
| | | 1000±40 | TA-1725 | Charcoal from cultural layer | AD 975–1155 | | *Kochkurkina 1991* |
| 4 | Vozhmarikha 1 | 6410±50 | LE-7231 | Charcoal from hearth in a dwelling | 5476–5312 | Mesolithic, Pit-Comb, Rhomb-Pit | *Mel'nikov, German 2013* |
| | | 6370±140 | LE-849 | Charcoal from fireplace | 5613–5008 | | *Mel'nikov, German 2013* |
| 23 | Keret' XXII | 6130±50 | LE-8047 | Charcoal from fireplace | 5216–4941 | Non-ceramic | *Tarasov 2008* |
| 9 | Myan'gora I | 5880±80 | TA-1079 | Charcoal from cultural layer | 4944–4545 | Mesolithic | *Kochkurkina 1991* |
| 22 | Suna XII | 5160±70 | TA-1310 | Charcoal from cultural layer and pit, depth 0,3–0,65m | 4228–3785 | Mesolithic | *Kochkurkina 1991* |
| 26 | Koyrinoya 3 | 4884±37 | Hela-2828 | Calcinated bone, ringed seal | 3763–3543 | Mesolithic, Sperrings | *Takala* et al. *2016* |
| 10 | Kladovets (cemetery) | 4560±80 | TA-1785 | Charcoal from a burial, depth 0,3m | 3619–3020 | Pit-Comb | *Kochkurkina 1991* |
| 21 | Pinguba II | 4400±60 | TA-1409 | Charcoal from fireplace | 3332–2902 | Medieval | *Pesonen 1988* |
| 8 | Sheltozero X | 4300±80 | TA-1311 | Charcoal from cultural layer, depth 0,4–0,9m | 3322–2635 | Sperrings, Pir-Comb | *Kochkurkina 1991* |
| 14 | Povenchanka XV | 4270±60 | TA-1519 | Charcoal from fireplace, depth 0,25–0,35m | 3084–2669 | Mesolithic | *Kochkurkina 1991* |
| 9 | Orovnavolok XI | 4210±50 | TA-929 | Charcoal from cultural layer, depth 0,45m | 2910–2632 | Mesolithic | *Kochkurkina 1991* |
| 11 | Zolotets XX | 3670±80 | TA-792 | Turf from the site | 2293–1781 | Pit-Comb, Comb-Pit, Rhomb-Pit, Zalavruga | *Kochkurkina 1991* |
| 20 | Kostomuksha II | 3600±80 | TA-963 | Charcoal from cultural layer, depth 0,4–0,5m | 2197–1745 | Mesolithic | *Kochkurkina 1991* |
| 10 | Chernaya Rechka II | 3430±80 | TA-2202 | Charcoal from fireplace, depth 0,8–1,15m | 1938–1531 | Sperrings (singular fragments), Pit-Comb | *Kochkurkina 1991* |
| 15 | Fofanovo XIII | 3288±70 | SPb-781 | Charcoal from fireplace, depth 0,6m | 1741–1426 | Pit-Comb (singular fragments), Voynavolok, Orovnavolok | *Tarasov 2015* |
| | | 3158±80 | SPb-782 | Charcoal from fireplace, depth 0,6m | 1616–1226 | | *Tarasov 2015* |
| 9 | Orovnavolok XVI | 3060±70 | TA-827 | Charcoal from fireplace in a dwelling | 1495–1116 | Orovnavolok | *Pankrushev 1988* |
| | | 3050±60 | TA-829 | Charcoal from fireplace in a dwelling | 1434–1126 | | *Pankrushev 1988* |
| 2 | Palayguba X | 2670±120 | TA-1444 | Charcoal from fireplace | 1124–430 | Orovnavolok | *Zhuravlev 1984* |
| 10 | Chernaya Rechka I | 2080±60 | TA-1650 | Charcoal from fireplace, depth 0,5–0,75m | 352 BC–AD 55 | Pit-Comb, small amount of Palayguba | *Kochkurkina 1991* |
| 14 | Kochnavolok II | 1480±60 | TA-831 | Charcoal from cultural layer, depth 0,45–0,55m | AD 428–655 | Palayguba | *Pankrushev 1988* |
| 2 | Pegrema III | 1150±70 | TA-1260 | Charcoal from cultural layer, depth 0,45m | AD 695–1017 | Rhomb-Pit | *Kochkurkina 1991* |

back to contents

# The Early and Middle Neolithic in NW Russia: radiocarbon chronologies from the Sukhona and Onega regions

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ABSTRACT – *The onset of the Neolithic period in the Russian North is defined by the emergence of pottery vessels in the archaeological record. The ceramics produced by mobile hunter-gatherer-fisher groups in the north-eastern European forest zone are among the earliest in Europe, starting around 6000 cal BC. After the initial mosaic of local styles in the Early Neolithic, including sparsely decorated wares and early Comb Ware, the Middle Neolithic period, starting in the 5th millennium cal BC, saw the development and spread of larger, more homogenous typological entities between the Urals and the Baltic, the Comb-Pit and Pit-Comb wares. Absolute chronologies, however, are still subject to debate, due to a general lack of reliable contextual information. Direct 14C dating of carbonised surface residues ('food crusts') on pots can help to address this problem, as it dates the use of the pottery; but if aquatic foods were processed in the vessels, the respective radiocarbon ages can appear to be too old due to the freshwater reservoir effect. In this paper, we discuss the radiocarbon chronologies of four important stratified archaeological complexes in the region between Lake Onega and the Sukhona basin, Berezovaya Slobodka, Veksa, Karavaikha, and Tudozero. A growing series of dates, including AMS dates, sheds new light on the onset and further periodisation of the Early and Middle Neolithic in this important area between Eastern Fennoscandia, Central Russia and the Far North-East of Europe, although problems concerning the absolute chronology of the initial Neolithic remain.*

KEY WORDS – *Northern Russia; hunter-gatherer-fishers; early pottery; Early and Middle Neolithic; radiocarbon chronology; stratigraphy; 7th–5th millennium cal BC*

## *Zgodnji in srednji neolitik v SZ Rusiji: radiokarbonske kronologije iz regij Sukhona in Onega*

IZVLEČEK – *Začetek neolitika je na severu Rusije definiran s pojavom lončenih posod, ki so jih izdelovale mobilne skupine lovcev-nabiralcev-ribičev na območju gozdne cone na severovzhodu Evrope, in so ene najstarejših v Evropi, saj se pojavijo ok. 6000 pr. n. št. Po začetnem mozaiku lokalnih stilov v zgodnjem neolitiku, ki vključuje manj okrašene posode in zgodnjo glavničasto keramiko, sta se v srednjem neolitiku, z začetkom v 5. tisočletju pr. n. št., pričela razvoj in širitev večje in bolj homogene tipološke entitete med Uralom in Baltikom, t. i. skupine z vdolbinami in glavničastim okrasom na keramiki. Zaradi pomanjkanja zanesljivih podatkov o kontekstih je absolutna kronologija za ta čas še vedno stvar debate. Direktni 14C datumi zoglenelih organskih ostankov hrane na površini posod so nam sicer v pomoč, saj neposredno datirajo uporabo teh posod; vendar so lahko datumi ostankov hrane (vodni organizmi) prestari zaradi učinka rezervoarja ogljika v tekočih vodah. V članku razpravljamo o radiokarbonskih kronologijah štirih pomembnih arheoloških kompleksov v regiji med jezerom Onega in kotlino reke Sukhone; to so najdišča Berezovaya Slobodka, Veksa, Karavaikha in Tudozero. Naraščajoče število datumov nam bolje osvetli začetek in nadaljnjo periodizacijo zgodnjega in srednjega neolitika na tem pomembnem območju med vzhodno Fenoskandijo, centralno Rusijo in severovzhodno Evropo, kljub temu da še vedno ostajajo težave, povezane z absolutno kronologijo začetnega neolitika.*

KLJUČNE BESEDE – *severna Rusija; lovci-nabiralci-ribiči; zgodnja lončenina; zgodnji in srednji neolitik; radiokarbonska kronologija; stratigrafija; 7.–5. tisočletje pr. n. št.*


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## Introduction

The onset of the Neolithic period in north-eastern Europe is defined by the emergence of pottery vessels in the archaeological record (*Oshibkina 1996. 6; Chairkina, Kosinskaya 2009*). This definition is rooted in the development of eastern European and Soviet scientific terminologies and differs from the understanding of the Neolithic period in western European archaeology, where the main criterion is the transition from a foraging to a productive economy with agriculture and/or animal husbandry (*Oshibkina 2006; Piezonka 2017; Timofeev* et al. *2004.8–11*). In the north-east European forest zone, the pottery produced by mobile hunter-gatherer-fisher groups is among the earliest in Europe, probably appearing by the end of the 7th millennium cal BC in the Upper Volga region of central Russia and possibly even earlier in the Dvina-Lovat' interfluve in western Russia (*Hartz* et al. *2012; Mazurkevich, Dolbunova 2015*). The earliest ceramic vessels in this region appeared in a cultural environment based on a foraging economy and seasonal mobility. In most parts of the forest zone of north-eastern Europe, the hunter-gatherer-fisher lifestyle continued also in the Middle and Late Neolithic and into the Early Metal Age.

Stratigraphic observations and the typological evolution of pottery styles and lithic industries provide the main tools for building relative archaeological chronologies of the Neolithic. On this basis, regional sequences of cultural units have been worked out in more or less detail for various parts of north-eastern Europe (for overviews, see *Mazurkevich, Dolbunova 2015; Piezonka 2015*). Absolute chronologies, however, are still subject to debate, due to a general lack of dependable dates and reliable contextual information. Therefore, one of the foremost tasks in current research is to build reliable chronological frameworks for the emergence and further evolution of early ceramics and their cultural contexts. An important step was taken recently with the publication of an edited volume summarising the current state of knowledge of radiocarbon chronologies for European Russia (*Zaitseva* et al. *2016*)

Until relatively recently, the absolute chronology of the appearance and evolution of early pottery in this region and thus of the development of the Neolithic was largely based on radiometric $^{14}C$ measurements, often with large uncertainties, from samples such as charcoal, wood, and organic sediment, found in more or less reliable association with the pottery concerned. In recent years, AMS $^{14}C$ dating of carbonised food crusts on pottery has become widespread, as it provides dates directly associated with the various types of pottery that are typologically relevant for understanding cultural developments (*Piezonka 2008*). However, this method compels us to confront another problem: that carbon in freshwater food chains is often subject to large and variable freshwater reservoir effects (FRE). So if fish were cooked in pots, some $^{14}C$-depleted carbon is likely to have been incorporated into food crusts, causing dating results that can be too old compared to the actual age of the dated samples (*Fischer, Heinemeier 2003; Heron, Craig 2015; Piezonka* et al. *2016*). This question is addressed in various ways: 1) discrepancies between calibrated $^{14}C$ ages and the relative chronology of the samples based on archaeological information; 2) paired samples of different materials; 3) the percentage of carbon in each sample derived from aquatic sources under certain cir-

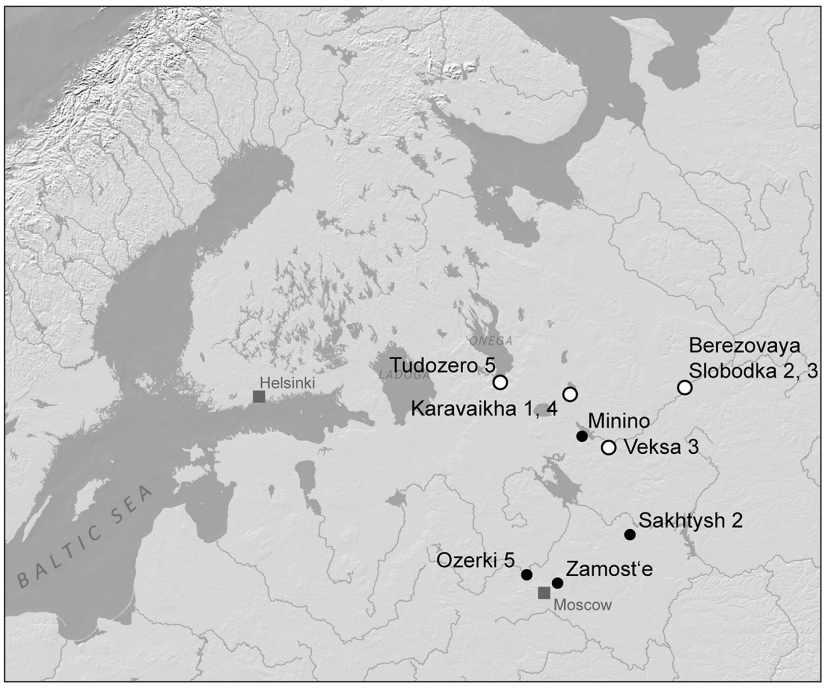



***Fig. 1. Sites in north-eastern Europe with radiocarbon dated Early and Middle Neolithic pottery complexes discussed in the text (white dots) and other sites mentioned (black dots).***

cumstances can be estimated from Elemental Analysis-Isotope Ratio Mass Spectrometry results; 4) qualitative and semi-quantitative analytical techniques (microscopy and biomolecular analyses) may be used to attribute components of food crusts to terrestrial or aquatic sources.

In this paper, we discuss the radiocarbon chronologies for Early and Middle Neolithic complexes of four key sites in northern Russia: Berezovaya Slobodka in the Middle Sukhona region, the stratified complexes of Veksa 1 and 3 in the Upper Sukhona basin, the sites of Karavaikha 1 and 4 in the Lake Vozhe basin, and the stratified dune site of Tudozero 5 on the southern shore of Lake Onega (Fig. 1). This area is an important intermediate region, because the Baltic, Polar, and Caspian hydrological basins are divided here by the Main European Watershed. This makes the area central for understanding cultural links, trajectories and developments in the later Stone Age between Eastern Fennoscandia, Central Russia and the Far North-East of Europe up to the Polar Urals and the Barents Sea.

## Early and Middle Neolithic complexes of the Sukhona and Onega regions

### *Sukhona basin*

The River Sukhona is one of the larger rivers in Northern Russia. Rising in Lake Kubena, it runs 558km north-east before flowing into the Malaya Severnaya Dvina. The Sukhona basin is part of the Barents Sea drainage system, although through short passages across watersheds, it is also closely connected to the Volga basin to the south, which is part of the drainage area of the Caspian Sea (Fig. 1). In terms of geomorphology, the Sukhona basin can be divided into upper, middle and lower parts. The upper and middle portions are linked by tributaries of River Kostroma to the upper Volga region, while the lower course of the Sukhona is connected via the River Jug to the middle Volga, Kama and Urals regions. Thus the Sukhona basin is an important contact zone in North-Eastern Europe, connecting the environmental and cultural spheres of the Baltic, the Volga and the Urals. In this paper, two archaeological complexes which are pivotal for the study of the Neolithic in this region are discussed, Berezovaya Slobodka by the lower course of the Sukhona, and Veksa in the Upper Sukhona basin.

### *Berezovaya Slobodka II-III, VI*

The archaeological sites of Berezovaya Slobodka II-III and VI are located on the bank of the lower Sukhona in the Nyuksensky district of Vologda region (Fig. 1). The Neolithic settlement of Berezovaya Slobodka VI is situated around 1 km upstream from the stratified multi-period complex of Berezovaya Slobodka II-III. The first archaeological finds were made close to the village of Berezovaya Slobodka by Myk-

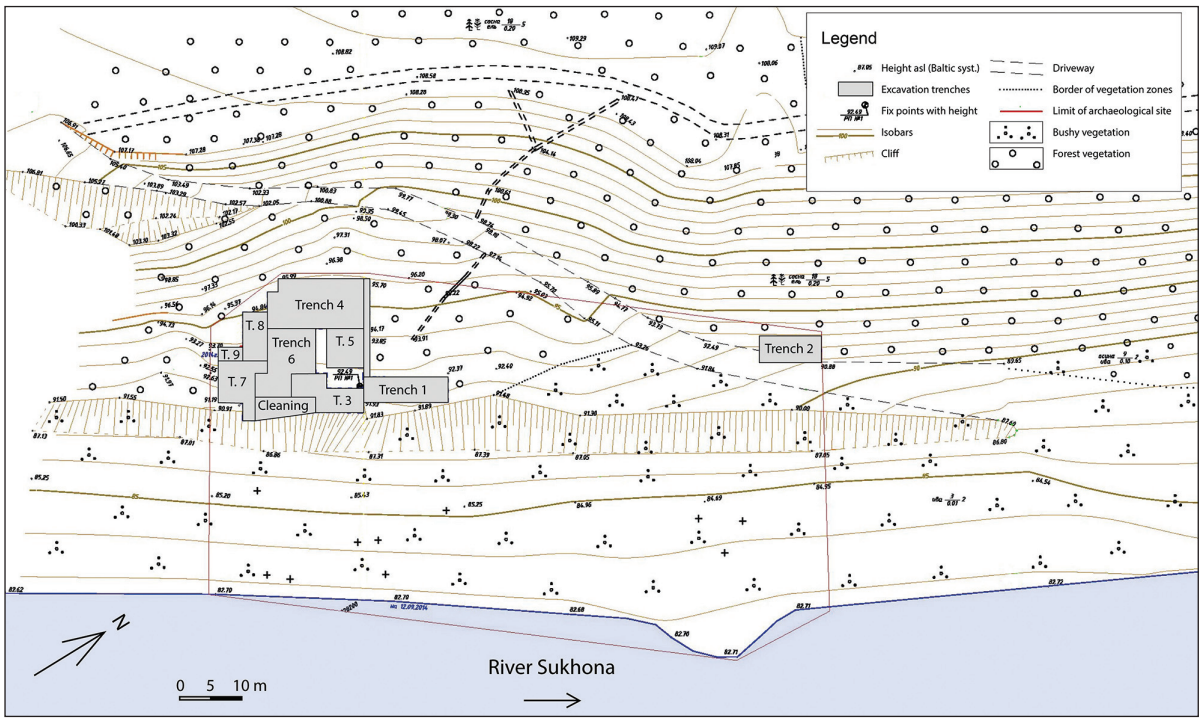



***Fig. 2. Berezovaya Slobodka II-III, Vologda province, Russia. Excavated area on the north bank of the River Sukhona (designed by M. Ivanishcheva, based on a survey completed by V. A. Lobanov in 2014).***

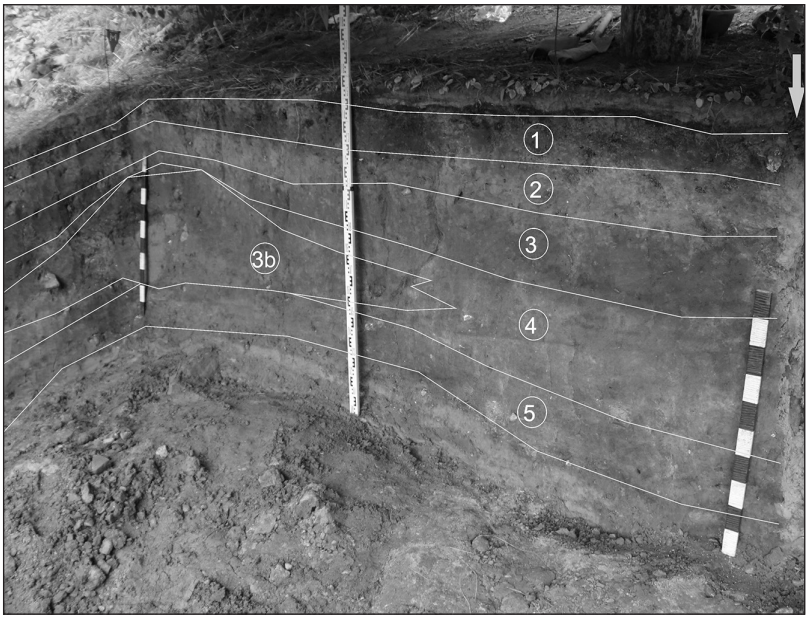



***Fig. 3. Berezovaya Slobodka II-III, Vologda province, Russia. Stratigraphy of trench 9 of 2014 in the south-western part of the site: 1 topsoil; 2 cultural layer of the Bronze Age and Eneolithic; 3 Early Neolithic cultural layer; 3b layer with relocated materials of the Final Palaeolithic; 4 sterile horizon; 5 Mesolithic cultural layer; 6 subsoil (designed by M. Ivanishcheva).***

haylo Ya. Rudinsky in 1941. In 1977, the Moscow archaeologist and Stone Age specialist Svetlana V. Oshibkina documented a Mesolithic settlement site in the centre of the village on the left bank of River Uftyuga. Since 1995, Marina V. Ivanishcheva and her team have discovered and investigated numerous archaeological sites on the right bank of the river, among them the Berezovaya Slobodka IV, V and IX Mesolithic sites, the Berezovaya Slobodka VI Neolithic site, the Early Iron Age settlement of Berezovaya Slobodka I, and the multiperiod site of Berezovaya Slobodka II-III, with evidence from the Late Palaeolithic to the Early Iron Age (*Ivanishcheva, Ivanishchev 2006*).

*Archaeological background of Berezovaya Slobodka II-III*

The Berezovaya Slobodka II-III site occupies the slope of the river terrace between 8 and 13m above the water level. Altogether covering some 4800m², a total of 507m² of its southern part has been excavated (Fig. 2). The stratigraphy of cultural layers amounts to 1.7–2.2m in thickness, and encompasses material from the Mesolithic to the Bronze Age and in places to the Iron Age (Fig. 3). The upper part of the stratigraphy comprises silty sediments up to 0.7m thick, while the lower part features clayey soils and clays up to 1.5m thick. The Early Neolithic horizon consists of dark grey silts up to 0.6m thick. It occupies an area of some 400m² and is covered by sediments with archaeological material from later periods. In the Early Neolithic horizon, successive occupations over a considerable time span are indicated by the various pottery types, including undecorated, pricked, and comb-impressed wares. To date, the ceramic collection comprises a minimum of 21 vessels with either no decoration or pricked decoration (Fig. 4), three to five vessels with comb decoration (*Ivanishcheva 2006.91, Fig. 7*), and eight to ten vessels with a specific comb-pitted decoration that is associated with the later phase of the Early Neolithic (*Nedomolkina, Ivanishcheva 2014. 16, Fig. 3*).

In the area close to the river, two separate layers can be distinguished within the Early Neolithic horizon, separated by a sterile band. The lower layer has revealed several hearths and fireplaces, as well as ceramic fragments and other finds. The pottery includes fragments of three to four vessels with thin walls, polished surfaces and bands of small round impressions below the rim. The vessels measure up to 20cm in diameter and have a low flowerpot-like shape, with broad flat bases. One base bears radial ornamentation formed by small triangular impressions. The fabric is either tempered with grog and organics or contains no artificial temper.

*Dated samples and results*

The absolute chronology of the lower Early Neolithic layer is based on two radiocarbon dates (Fig. 5; Tab. 1). One stems from a fireplace (Le-6713, 7340±200 BP), and one from a hearth beside which the above-mentioned decorated pottery base was found (Le-6707, 7340±90 BP) (*Ivanishcheva 2009.278–279*). Falling in the second half of the 7th and the beginning of the 6th millennium cal BC, these two dates are among the oldest for a pottery-bearing complex in the Northeast European forest zone.

In the upper layer of the Early Neolithic horizon at Berezovaya Slobodka II-III, excavations revealed the remains of a rectangular sunken-floor house with two hearths and an associated domestic pit (*Ivani-*

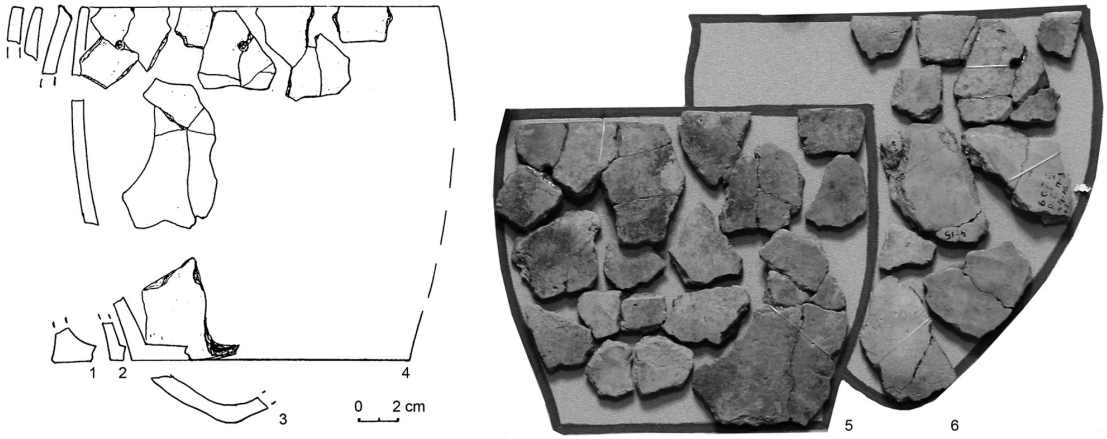



***Fig. 4. Berezovaya Slobodka II-III, Vologda province, Russia. Undecorated pottery from Early Neolithic layer 1. 1–4 graphic reconstruction of pottery from a ceramic concentration in the corner of a house pit and from a nearby household pit; 5 fragments of one vessel from the household pit; 6 fragments of one vessel from the household pit and two vessels from the pottery concentration. Radiocarbon date from one flat-based vessel from the pottery concentration: Ki-16392a (designed by M. Ivanishcheva).***

*shcheva 2006.88–89, Fig. 1*). In the infill of the house pit, fragments were found of at least three flat-based, flowerpot-shaped ceramic vessels, decorated with small pitted or dot-like impressions (*Ivanishcheva 2006.95, Fig. 2–1*). Fragments of four to five undecorated vessels with polished surfaces, among them two crushed pots found *in situ*, were discovered in a spread of burned sand in the south-eastern corner of the house pit, and in the pit outside the house perimeter (see Fig. 4).

On the basis of these observations it can be suggested that there was a grog-tempered technological tradition within the complex of undecorated pottery, and that the date of the pottery does not seem to represent the earliest examples of this group (*Ivanishcheva* et al. *2016.399*). However, dating of the bulk organic content (TOCC) of pottery often appears to give anomalous results (for a critical discussion of this method, see, for example, *Karmanov* et al. *2014*; a more favourable view is proposed in *Zaitseva* et al. *2016*).

*Archaeological background of Berezovaya Slobodka VI*

The Neolithic settlement of Berezovaya Slobodka VI is located on the a terrace approx. 8m above the water level. To the north and south, it is flanked by small streams running into the river. The archaeological site covers approx. 1500m², of which a total of 148m² have been excavated. A three-chambered dwelling of 50m², a household area and a burial were found in the trenches (*Ivanishcheva, Ivanishchev 2006.287–288*). Early Neolithic pottery is represented by at least 31 vessels with pricked ornamentation. The vessels have simple flowerpot-like shapes, with flat or flat but slightly curved bases, and rim diameters of 18 to 20cm. All of them have burnished surfaces (*Ivanishcheva, Ivanishchev 2006.290, Fig. 3*). The decoration consists of square or round pit- or dot-like impressions and are concentrated in the zone below the rim, while decoration closer to the base is rare. The clay used for these pots was tempered with grog that contains grog, and in some cases additionally with organics. Altogether, the clay fabric within this group seems rather homogenous.

*Dated sample and results*

One pottery fragment from this complex has been radiocarbon dated, yielding an age of 5850±90 BP (Ki-16392) (Fig. 5; Tab. 1).

## *Veksa 1, 3*

*Archaeological background*

The multi-period settlement of Veksa is a key site with regard to the cultural development of north-western Russia. Located in the upper Sukhona basin, some 20km east of the provincial capital, Vologda (Fig. 1), the site extends along the left bank of the River Vologda on both sides of a small tributary, the Veksa. The area west of the mouth of the Veksa is called Veksa 1, while the stretch to the east is named Veksa 3 (Fig. 6). Geographically, Veksa is conveniently located by an important river confluence and at the same time is not far from the Main European Watershed. Its exceptional importance is due to the clearly stratified sequence of archaeological layers up to 3m thick, which encompasses all periods from the Early Neolithic via the Eneolithic, Bronze and Iron Ages through to the Medieval period (*Nedomol-*

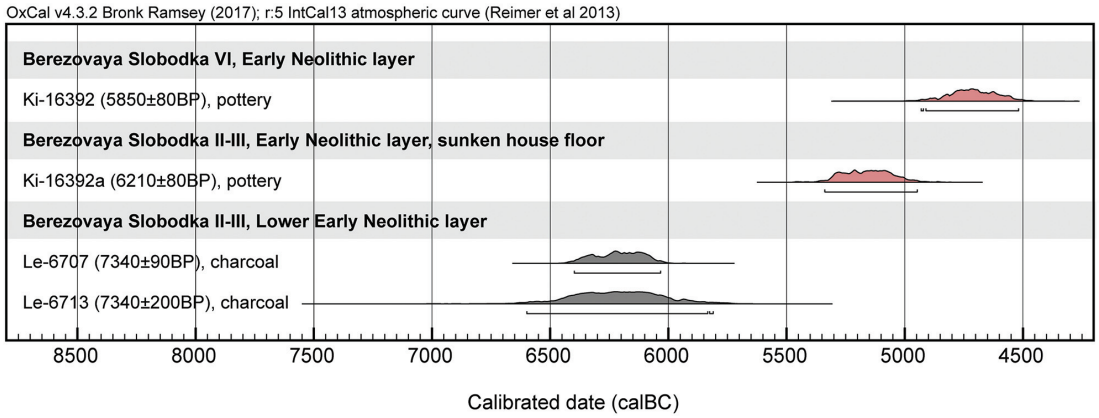



***Fig. 5. Berezovaya Slobodka, Vologda province, Russia. Calibrated radiocarbon dates from Early Neolithic contexts. Dated materials: grey – charcoal; red – pottery (TOCC).***

*kina 2000*). The Stone Age remains, which are especially well preserved due to partial water-logging, even include concentrations of wooden stakes and piles directly next to the river bank. The Veksa thus yields a rare opportunity to follow local cultural, typological and economic developments and their links to environmental history over eight millennia.

Initial archaeological work at Veksa started in 1981. Since 1993, the investigations have been directed by Nadezhda G. Nedomolkina of the Vologda State Museum-Preserve, resulting in an increased understanding of the cultural/ historical developments in the region (*Nedomolkina 2000; 2004*). Starting in 2007, joint Russian-German investigations have concentrated on multi-disciplinary research at the site, including AMS radiocarbon dating, isotope and archaeochemical analyses of various materials (bone, charred pottery crusts, *etc.*), archaeobotany and palynology, dendrochronology, geomorphology and pedology (*Lorenz* et al. *2012; Nedomolkina* et al. *2015*). This work was intensified in 2015, when a larger research project was supported by the German Research Foundation (DFG), enabling new test trenching at the site, as well as targeted research aimed at diachronic assessment of human-environment interactions and palaeolandscape reconstructions (DFG grant no. PI 1120/2–1). During two seasons of fieldwork, several test trenches were excavated, which produced dating material from various stratigraphic units, including finds from the Early Neolithic phase at Veksa 3, trench 1 (Fig. 7; Fig.8. 1, 7).

The stratigraphic sequences at Veksa 1 and Veksa 3 are distinct from each other, as not all cultural layers are present in every section of the river bank (Fig. 7). At Veksa 1, fifteen cultural layers have been distinguished, five of which date to the Neolithic peri-

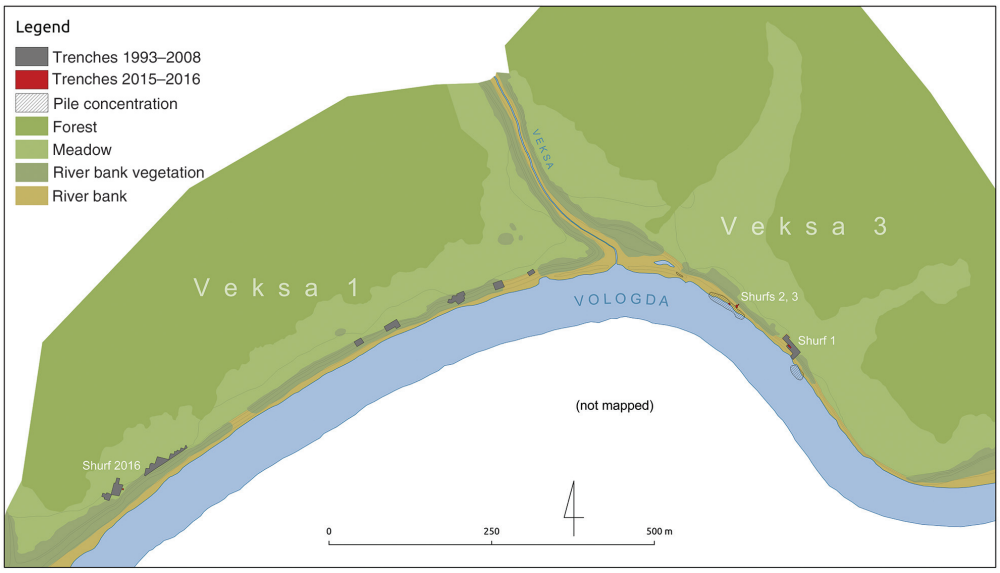



***Fig. 6. Veksa 1 and 3, Vologda province, Russia. Location of old excavation trenches (grey) and new test trenches excavated in 2015 and 2016 (red) (designed by N. G. Nedomolkina and C. Engel).***

od, and at Veksa 3, nine layers were identified, with five of them stemming from the Neolithic and Eneolithic phases (*Nedomolkina 2004*). Geomorphological analyses have shown that all cultural layers at Veksa are embedded in floodplain sediments that developed in the Sukhona basin after a large periglacial lake dried up in the Early Holocene and a river landscape formed (*Lorenz* et al. *2012*). The oldest archaeological complex is associated with layer 9 at Veksa 3, located between 1.9 and 2.8m below the present land surface. This layer contains several dark organic lenses at various heights, indicating successive instances of human activity on the river bank. According to the archaeological materials, these remains were connected to seasonal settlement and/or ritual activities of groups of hunter-gatherer-fishers who were already producing and using ceramics. The features in this horizon include rectangular post constructions with small wall trenches, repeatedly used, partly stone-lined hearths, pits, ochre, animal and fish bones in charred sediments and artefacts of various materials. The lithic finds include trapezoidal microliths; among the bone artefacts, points and fish hooks are noteworthy. Typologically, the pottery resembles the early to late phases of the Upper Volga culture, including an early complex of sparsely decorated ware, with small vessels partly with flat bases, and the typologically later so-called 'first Comb Ware complex', characterised by long vertical comb impressions and generally conical bases. This latter type is associated with the upper part of layer 9 and the lower part of layer 8 above. The '2nd Comb Ware complex' at Veksa 3, as labelled by the excavator N. Nedomolkina, is present in layer 8 between 1.8 to 1.6m below the present surface. Its genesis is still not fully understood, as the complex shows typological links with the early phase of the Pechora-Dvina culture in the far northeast of Europe between the Polar Urals and the Barents Sea, and to the early Comb Ware of Tudozero 5 towards the north-west. The next layer, no. 7, at Veksa 3 contains comb-pitted ware of the so-called 'Northern types', which are also known from the upper Volga region and which have close analogies in the Säräisniemi 1 ware of northern and eastern Fennoscandia and in pit-comb ware complexes of the far northeast of Europe. Partly parallel to these 'Northern types', materials of the early phase of pit-comb ware complexes with mineral temper with affinities with the pottery of the Lyalovo and Kargopol' cultures are associated with cultural horizon L at Veksa 1, between 1.8 and 1.5m below the present surface. In the trench excavated in 2016, this horizon related to layer 7. At Veksa 3, similar Pit-Comb Wares have been found in layer 5, although this complex is less prominently represented here. This complex already demarcates the transition to the Middle Neolithic. At Veksa 3, the Middle Neolithic period is also represented by stray finds of organically tempered ware with rather coarse, widely spaced impressed decoration, which has its closest parallels in coeval Narva pottery of the south-eastern Baltic region (*Piezonka 2008*).

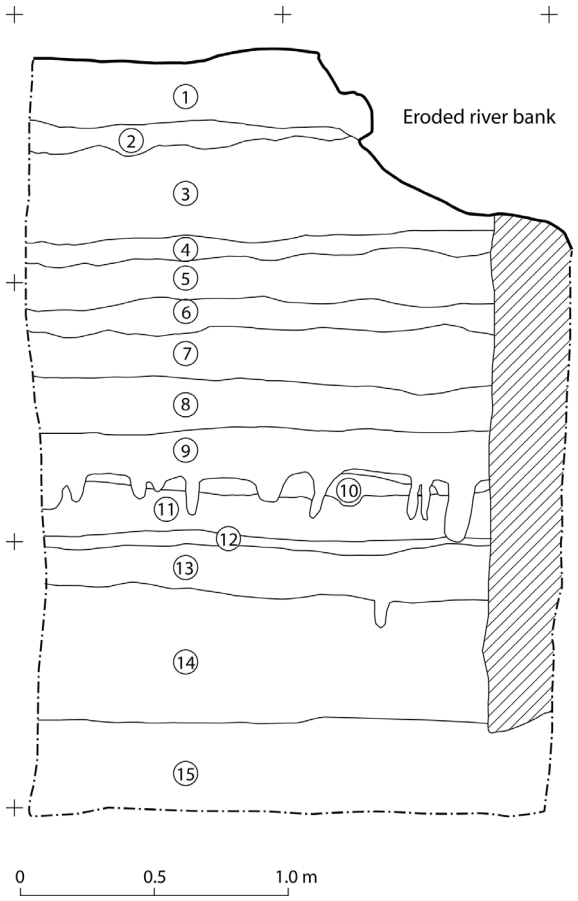



***Fig. 7. Veksa 3, Vologda province, Russia. Stratigraphy at the south-eastern wall of test trench 1: 1 spoil heap of previous excavations; 2 topsoil; 3 layer 1; 4 layer 2; 5 layer 3; 6 Eneolithic cultural layer 4 with 'Porous Ware'; 7 Middle Neolithic cultural layer 5 with Pitt-Comb Ware complex; 8 layer 6; 9 Early Neolithic cultural layer 7, with pottery of the 'Northern types'; 10 Early Neolithic cultural layer 8 (upper part) with pottery of the '2nd Comb Ware complex', 11 Early Neolithic cultural layer 8 (lower part) with '2nd Comb Ware complex' and developed Upper Volga culture ware; 12 transitional zone between cultural layers 8 and 9; 13 Early Neolithic cultural layer 9, dark lens with early, sparsely decorated, and developed Upper Volga culture ware; 14 lower part of Early Neolithic cultural layer 9, sterile floodplain sediments with some anthropogenic organic lenses; 15 clayey subsoil; hatched – excavation trench 2000/2001 (designed by C. Engel).***

*Dated samples and results*

A central aspect of the ongoing research at Veksa concerns the relative and absolute chronology of the anthropogenic remains, but also of their temporal interrelatedness with developments of the natural environment. A general problem for radiocarbon dating at Veksa is the poor preservation of collagen in bone from the mineral soil, making it impossible to date bone and antler artefacts from much of the stratigraphy. Previous research has resulted in a sequence of 19 radiocarbon dates (both AMS and conventional) for the Early to Middle Neolithic complexes, 18 from Veksa 3 and one from Veksa 1 (*Nedomolkina, Piezonka 2016; Piezonka 2015; Piezonka* et al. *2016; Timofeev* et al. *2004.97*) (Fig. 9; Tab. 1). Nine conventional radiocarbon dates were obtained on charcoal samples from layers 9, 8, 6 and 5 at Veksa 3. All of them have large uncertainties, one further date with an error of ±700 radiocarbon years is not shown in Fig. 9 (see Tab. 1). The general stratigraphic sequence is reflected in the dates, although a more precise assessment of the absolute chronological position of the respective layers is hindered by the wide ranges of the calibrated ages. As to the onset of the archaeological sequence at Veksa 3 represented by the anthropogenic lenses in layer 9, it most likely falls in the first half of the 6th millennium cal BC. Henny Piezonka *et al.* (*2016*) reported AMS and EA-IRMS (%C, %N, $\delta^{13}C$ and $\delta^{15}N$) results for eight food crusts on Early and Middle Neolithic pottery vessels from Veksa 3, including a second sample from a previously dated sherd and EA-IRMS results for two published AMS dates (KIA-33926; KIA-33927; KIA-33928; *Piezonka 2008*). Most of these sherds were from surface collections, but were sufficiently typologically diagnostic to be placed in stratigraphic sequence (*Piezonka 2015.Fig. 41*). EA-IRMS data were obtained for two food crusts which were too small to date (KIA-49789, KIA-49790) and three other food-crust samples (KIA-49797, KIA-49798, KIA-49799; *Piezonka* et al. *2016*) were dated. The dated vessels encompass an early type of Comb-Pitted Ware associated with layer 9, vessels of the '2nd Comb Ware complex' mainly found in layer 8, as well as fragments of the 'Northern types', of Lyalovo pottery, and of an organically tempered ware resembling Narva culture pottery of the eastern Baltic region. Charcoal from a pit in layer 9, the lowest cultural horizon, was also dated, to provide a *terminus post quem* for the entire sequence (KIA-33929; *Piezonka 2008*). Charred crust from one Middle Neolithic vessel of Lyalovo type found as a stray find at

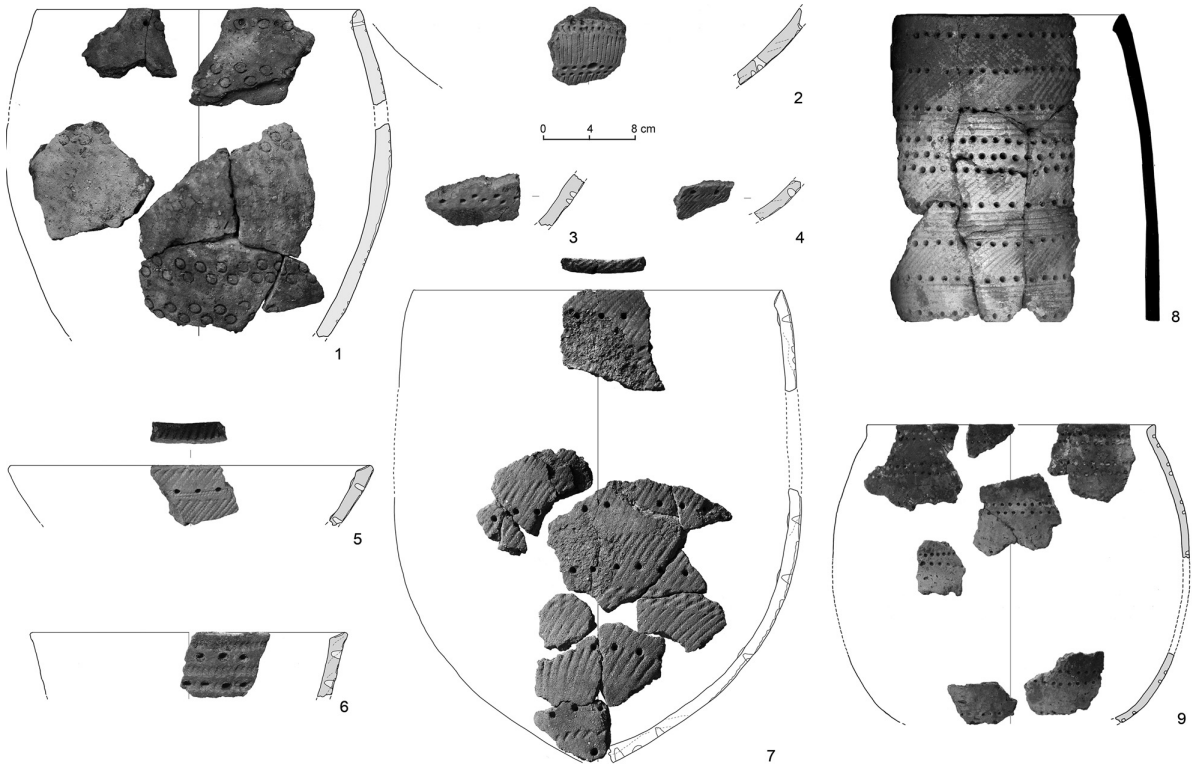



***Fig. 8. Veksa 1, 3, Vologda province, Russia. Fragments of pottery from which organic residue samples were dated: 1 sample MAMS-25493; 2 sample KIA-49797; 3 sample KIA-49798; 4 sample KIA-49799; 5 sample KIA-33927; 6 sample KIA-33928; 7 samples MAMS-27311 and MAMS-27319; 8 sample SPb-1691; 9 samples KIA-33926 and KIA-49796 (designed by N. Nedomolkina and H. Piezonka).***

Veksa 1 was dated conventionally (SPb-1691; *Nedomolkina, Piezonka 2016*).

In the course of the new excavations in 2015 and 2016, a total of 17 AMS dates from stratified contexts at Veksa 3 and one radiocarbon date from Veksa 1 were added to this series (*Nedomolkina, Piezonka 2017*) (Fig. 10; Tab. 1). The stratigraphic units encompass archaeological layers, and in some cases also artificial removal horizons within the layers ('plast'), and features ('object'). The dates from stratified contexts in the test trench 1 at Veksa 3 help to test the previous chronological assumptions. The series includes ten dates on charcoal, four dates on pottery food crust, and two dates on charred seeds from edible plants (Fig. 10). One further date on charcoal (Poz-92582, 4255±35BP, see Tab. 1) from the lowest anthropogenic context in the trench (layer 9, 'plast' 5, object 509) appears more than 2000 radiocarbon years too young for this stratigraphic unit and is not shown in Fig. 10. Since the sample provided a comparatively small amount of carbon (0.9mg,) a certain loss of dating precision can be expected, although this does not explain the large age offset (see Tab. 1). Previous research on food-crust samples from Veksa have shown that in some cases, a substantial freshwater reservoir effect has apparently affected samples that include components of aquatic origin (*Piezonka* et al. *2016*). Charcoal dates are not affected by freshwater reservoir effects, although here, an old wood effect might influence the reliability of the dates in comparison to the stratigraphic units. Among the potentially more reliable dates would be the results from the charred seeds of edible terrestrial plants from closed contexts, since aquatic reservoir effects as well as old wood effects can be ruled

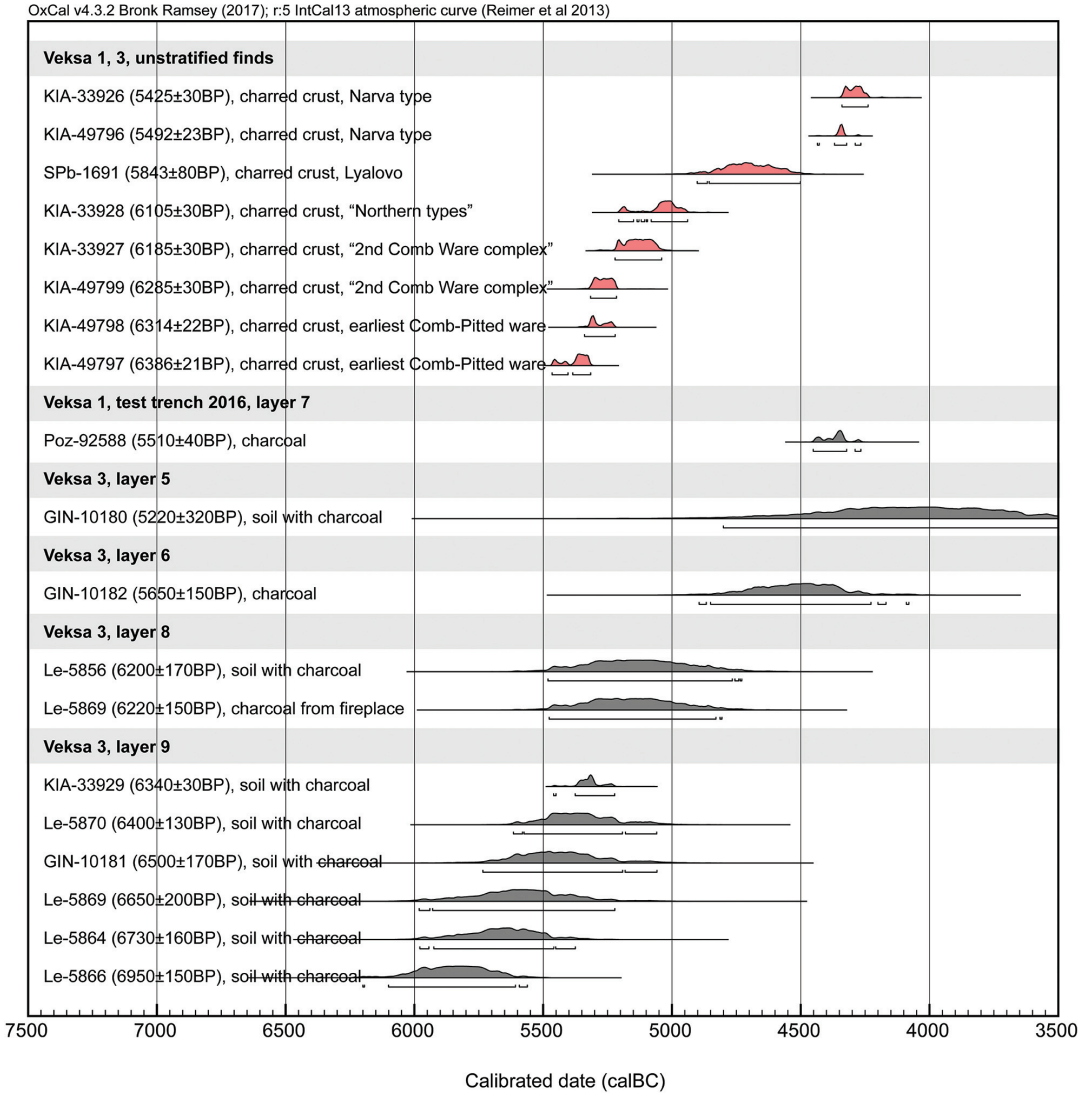



***Fig. 9. Veksa 1, 3, Vologda province, Russia. Calibrated radiocarbon dates from Early and Middle Neolithic layers from old trenches and the test trench of 2016 at Veksa 1, and typologically associated material from surface collections. Dated materials: grey – charcoal; red – charred crust adhering to pottery.***

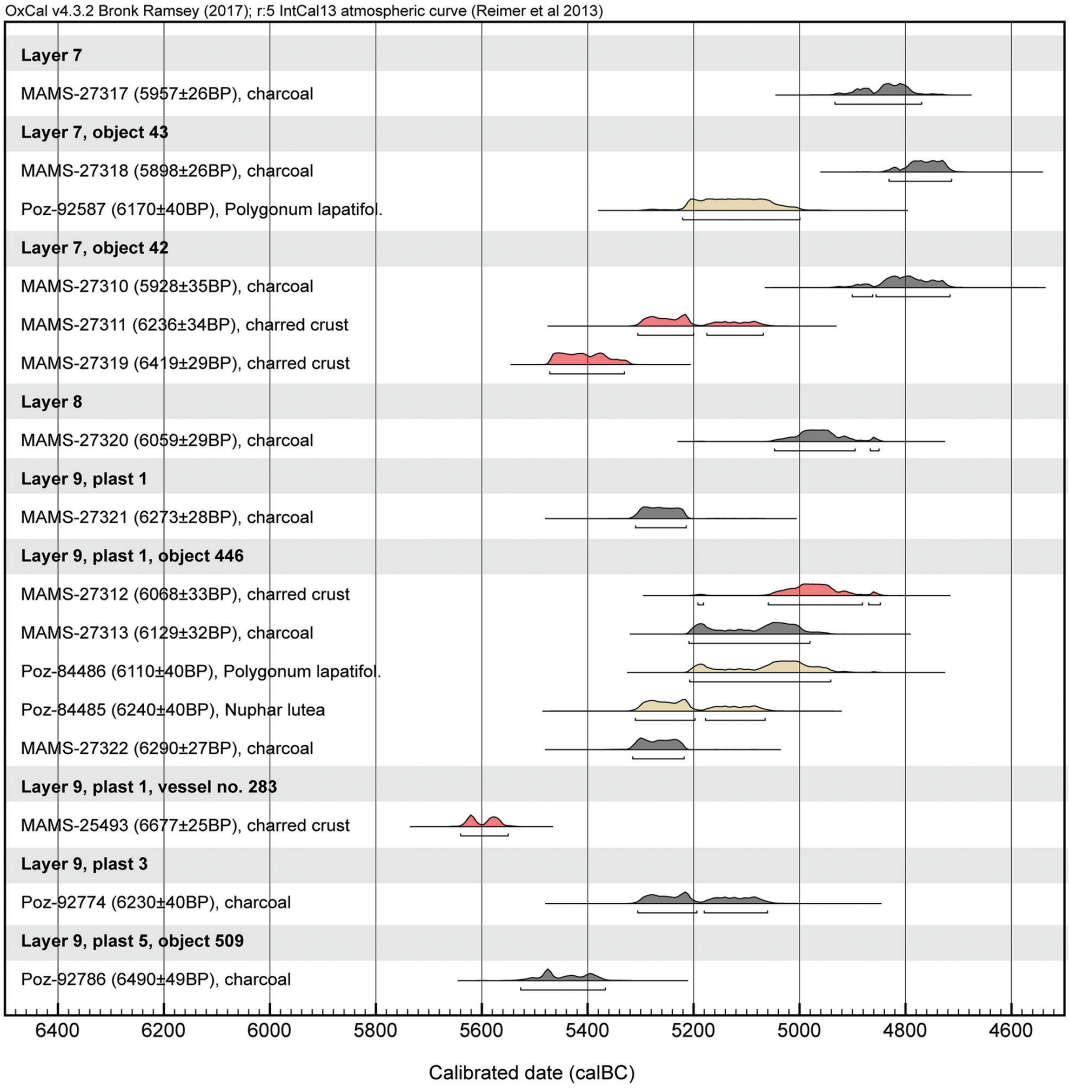



***Fig. 10. Veksa 3, Vologda province, Russia. Calibrated AMS radiocarbon dates from Early Neolithic layers in test trench 1 of 2015/2016. Dated materials: grey – charcoal; red – charred crust adhering to pottery; beige – charred seeds of edible plants.***

out for these. From the lowest layer, 9, eight AMS dates from various contexts and stratigraphic units exist. 'Plast' 5 of layer 9 belongs to the earliest phase of activity documented in this trench, stemming from a lens at approx. 1.95 to 2m below the surface. This is reflected by the oldest AMS date on charcoal in the series, dated to the start of the second half of the 6th millennium cal BC (Poz-92786, 6490±49 BP). This lens (object 509), which had already been partly excavated in the previous excavation trenches at Veksa 3, did not contain pottery. Thus the question arises as to whether this feature might actually represent the latest pre-pottery phase in this region. 'Plasts' 1 to 3 of layer 9 are probably associated with one and the same, somewhat later, episode of human activity on the river bank, as they encompass the dark anthropogenic horizon at the topmost part of layer 9, between 1.6 and 1.8m below the modern surface (see Fig. 7.13). Here, the charcoal and plant seed dates accord well with each other, ranging between *c.* 5300 and 4950 cal BC (oldest date: MAMS-27322, 6290±27 BP; youngest date: Poz-84486, 6110±40 BP). The two food-crust dates from pottery in the stratigraphic unit do not accord with this range, one being substantially older (MAMS-25493, 6677±40 BP), and one being statistically consistent with the latest charcoal result (MAMS-27312, 6068±33 BP). The older date stems from a vessel that represents the earliest, sparsely decorated type of ceramics at Veksa (Fig. 8.1); a freshwater reservoir effect is thought to have affected the dating result. The charcoal sample from layer 8 is younger than the main reliable sequence from Layer 9, dating to the very end of the 6th or the beginning of the 5th millennium cal BC (MAMS-27320, 6059±29 BP). From layer 7 following above, three charcoal samples, two food-

crust samples (the latter from one and the same vessel, Fig. 8.7) and one charred seed of *Polygonum lapathifolium* have been dated. The two food-crust dates from pot object 42 encompass a range between *c.* 5500 and 5080 cal BC and are most probably too old (MAMS-27319, 6419±29 BP; MAMS-27311, 6236±34 BP). The two dates differ from each other so substantially that they are statistically inconsistent with a single $^{14}$C age. The best explanation for this would be that the results are distorted by reservoir effects, which can be different in the two samples due to heterogeneity of remains from various sources within the food crust. The three charcoal samples are in good accordance with each other in the second and third centuries of the 5$^{th}$ millennium cal BC (range: MAMS-27317, 5957±26 BP; MAMS-27318, 5898±26 BP), including one sample stuck directly to pottery vessel object 42, from which the two food-crust dates were obtained. They are thus between *c.* 300 and 500 radiocarbon years younger than the food-crust dates. The *Polygonum lapathifolium* sample (Poz-92587, 6170±40 BP) from the substantial activity zone, object 43, yielded a date almost two hundred years older than the charcoal date from this context and the other two charcoal dates from layer 7. It rather accords with the above-mentioned date of a similar charred seed from Layer 9 (Poz-84485, 6170±40 BP). One explanation could be that the dated seed was originally deposited in layer 9 and was subsequently dug up by later activities during the phase in which layer 7, and with it object 43, formed. Of the documented postholes reaching down from layer 7, however, only very few are deep enough to reach layer 9 (Fig. 7).

From the trench excavated in 2016 at Veksa 1, one charcoal sample (Poz-92588, 5510±40 BP) from Middle Neolithic layer 7, which is associated with Pit-Comb Wares of Lyalovo type, adds to the existing three dates from Middle Neolithic finds and contexts at Veksa (Fig. 9). Dating to the third quarter of the 5$^{th}$ millennium cal BC, it is more than 300 radiocarbon years younger than the food-crust date of a Lyalovo vessel found as a stray find on the river bank at Veksa 1 (Fig. 8.8) (*Nedomolkina, Piezonka 2016*). This difference might reflect part of the time depth of the Lyalovo phase at Veksa, which at the moment still lacks further radiocarbon evidence, but a freshwater reservoir effect in the food-crust date could also play a role here. The two food-crust dates on the Narva type vessel (Fig. 8.9), a stray find from the river bank at Veksa 3, are marginally younger than the date from layer 7 at the Veksa 1 trench of 2016. It is not clear, however, whether they could be too old due to a reservoir effect, as for this ware there is no reliable stratigraphic correlate at the moment.

### *Lake Vozhe basin: Karavaikha 1 and 4*

*Archaeological background*

Lake Vozhe is situated in the north of Vologda province in Kirillov district. It is connected to the White Sea via a system of rivers and lakes. The Lake Vozhe basin can be regarded as an archaeologically well preserved landscape as recent human impact has been very slight, and it contains an astonishing wealth of preserved dryland and wetland sites. An impressive example of such good preservation sites is provided by the concentration of various sites in the locality of Karavaikha. This group of sites is located on the bank of the River Eloma, some 18km upstream from its mouth at Lake Vozhe (Fig. 1). It is situated on a slightly elevated area (approx. 1–1.5m above the mean water table) which extends approx. 100m along the river bank. Aleksandr Ya. Bryusov carried out excavations in this area in the 1930s to 1950s (*Bryusov 1951; 1961*). He interpreted the archaeological remains as a settlement and a cemetery of the Neolithic period. Today, the site excavated by Bryusov is known as Karavaikha 1. Archaeological investigations in Lake Vozhe basin have been conducted since 2002 as a joint expedition of the State University Cherepovets and Cherepovets Museum, directed by Natalya V. Kosorukova. In the course of this work, a number of new sites were discovered in the vicinity of Karavaikha 1 (*Kosorukova 2007; Kiryanova, Kosorukova 2013*).

One of the most interesting of these sites is Karavaikha 4, a wetland site which has been investigated since 2003, with excavations continuing today (*Kosorukova 2008; 2014; Kosorukova, Venediktova 2014*). Located approx. 150m downstream from Karavaikha 1 on the opposite, *i.e.* left river bank, the site occupies a low, boggy section of the bank. A total of 502m$^2$ were excavated between 2003 and 2015 (Fig. 11). The main cultural complex here dates to the Early Neolithic. It is located under layers of peat and gyttja at 1.2 to 1.4m below the modern surface. The find horizon is associated with a thin layer of sand between the gyttja and the clayey subsoil in the riverbank area of the site, or between the gyttja and a dark brown, peaty palaeosoil farther away from the river (Figs. 12 and 13). This sandy layer is merely 1 to 2cm thick in most places, occasionally reaching 3 to 5cm. While most of the archaeological finds are located within this layer, some have been found higher up in the lower part of the overlying gyttja.

Two elongated narrow depressions rising up from the river have come to light in the excavated area (Figs. 11 and 12.A). Along the edges and within these depressions, several upright piles have been driven deep into the subsoil, which are the remains of wooden constructions (Figs. 11 and 12.B-C). In some cases, rows of piles apparently run across the depressions, possibly stemming from divisions or substructures of footbridges. Outside the depressions, there are some additional posts which do not display any discernible order. The depressions with the pile constructions are regarded as the remains of fishing devices placed in former inlets. This interpretation is supported by the abundance of further wooden artefacts within and around the depressions, including bark net weights and concentrations of wooden laths that could be the remains of fish fences and fish traps. Fragments of three woven fishing baskets were found lying at the base of the depressions. Archaeological finds of other materials, too, were concentrated in the depressions, most of them lying at their very bottom within a thin sandy layer and only a few in the woody layer just above it. The finds include bone and antler artefacts, flint and slate items, pottery fragments, animal and fish bones.

On the basis of the current evidence, it is assumed that the wooden piles, the finds from the wood-rich layer and from the thin sandy layer below are all part of a single chronological unit, designated as the 'lower cultural layer'. It seems that this complex accumulated during the active use of this area by the ancient population that occupied the bank of the river or possibly, at that time, small lake. Human activity in later periods is attested to by sporadic finds higher up in the stratigraphy of the fill of the depressions, among them a peculiar fishing 'sledge' from the upper part of the lower fill (*Kosorukova, Venediktova 2014.32–33, 38*), and two wooden artefacts with carved animal heads from the middle and upper sections of the fill (Fig. 14.7–8).

*Dated samples and results*

Thus far, a total of 29 radiocarbon dates for Karavaikha 4 have been received, among them 26 dates from the 'lower cultural layer'. Although this lower cultural horizon is regarded on archaeological grounds as a closed context of the Early Neolithic period, the $^{14}$C dates on samples attributed to this layer span a long period, from the last quarter of the 7$^{th}$ millennium cal BC to the first third of the 5$^{th}$ millennium cal BC (Tab. 1; Fig. 15). Most of these $^{14}$C dates are

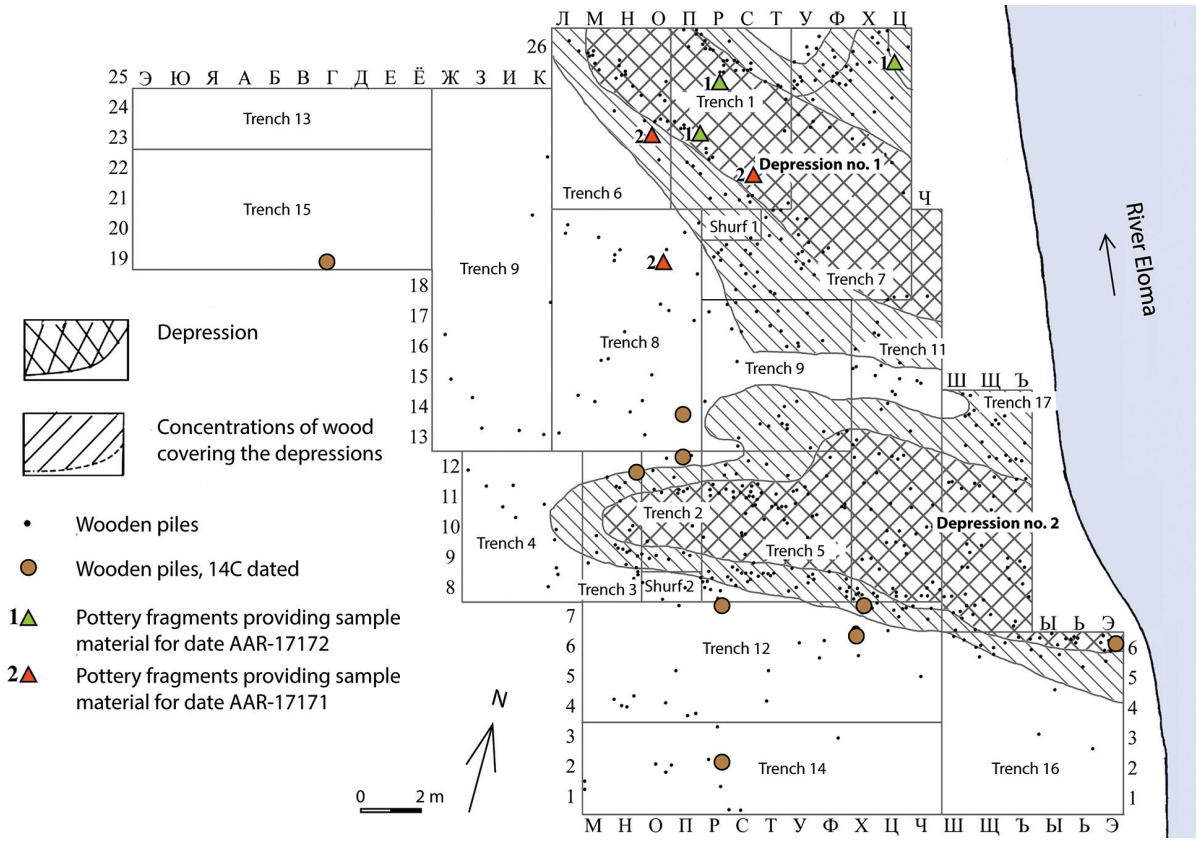



***Fig. 11. Karavaikha 4, Vologda province, Russia. Excavated areas, depressions 1 and 2, upright wooden posts, and dated posts and pottery fragments on the bank of the River Eloma (designed by N. Kosorukova).***

conventional dates on wooden samples, but two AMS dates stem from charred crust on pottery fragments, and one further AMS date is from a bone artefact (*Kosorukova 2007; Kiryanova, Kosorukova 2013; Kosorukova, Piezonka 2014; Kosorukova* et al. *2016; Piezonka* et al. *2016*).

Eight dates were received for upright wooden piles driven into the subsoil. Most of the sampled piles were located along the edges of depression 2, one was situated farther away from the river, beyond the depressions (Fig. 11). The dates from the piles encompass a long period, between 7190±160 BP (Le-10766) and 6310±40 BP (Le-10771), raising the question as to whether the earliest of them might actually belong to a Late Mesolithic activity phase at this site, before the advent of pottery in the region demarcated the onset of the Neolithic. Other dated wooden samples from the lower cultural horizon include wooden planks, rods and other worked timber from various levels below, in and above the main concentration of artefacts (see Tab. 1). While they span more or less the same time range as the wooden posts, between 7050±60 BP (SPb-1300) and 6030±130 BP (GIN-12514), their individual dates are not necessarily in accordance with the stratigraphic sequence: While the second-oldest date of such a wooden artefact stems from a fragment found in the gyttja above the main level of artefacts (Le-7119, 7030±35 BP), the latest date on wood from this horizon, which is approx. 1000 years younger, is associated with a wooden batten also found in the lower part of the gyttja just above the subsoil (GIN-12514, see above) (see Tab. 1).

A bone dagger also belonging to the lower cultural complex was dated (Fig. 14.9). The dating result of 7009±40 BP (AAR-17170) is among the oldest from this site, which is in accordance with the stratigraphical position of the artefact, at the very bottom of the archaeological sequence, at the border between the gyttja layer and the clayey subsoil below (Tab. 1). According to the stable isotope results, the sample is from a bone of a terrestrial herbivore, rendering any freshwater reservoir effect unlikely. Of the two dated food-crust samples, one is from a vessel resembling comb-decorated ware of the middle phase of the Upper Volga culture (AAR-17172, 6672±31 BP; Fig. 14.1–3) and one from a typologically less specific vessel, decorated with alternating rows of various imprints of natural materials (AAR-17171, 6222±30 BP, Fig. 14.4–6). All sampled sherds were found in or near depression 1 (Fig. 11). Most of them were found in the lower part of the gyttja that overlies the find-rich sandy layer (for more detailed information, see Tab. 1). They are thus associated with a stratum higher up the sequence than the dated bone artefact, which is reflected by their younger ages.

From the upper cultural horizon at Karavaikha 4, two conventional $^{14}C$ dates were obtained on the above-mentioned wooden artefacts with carved animal heads (Fig. 14.7–8).

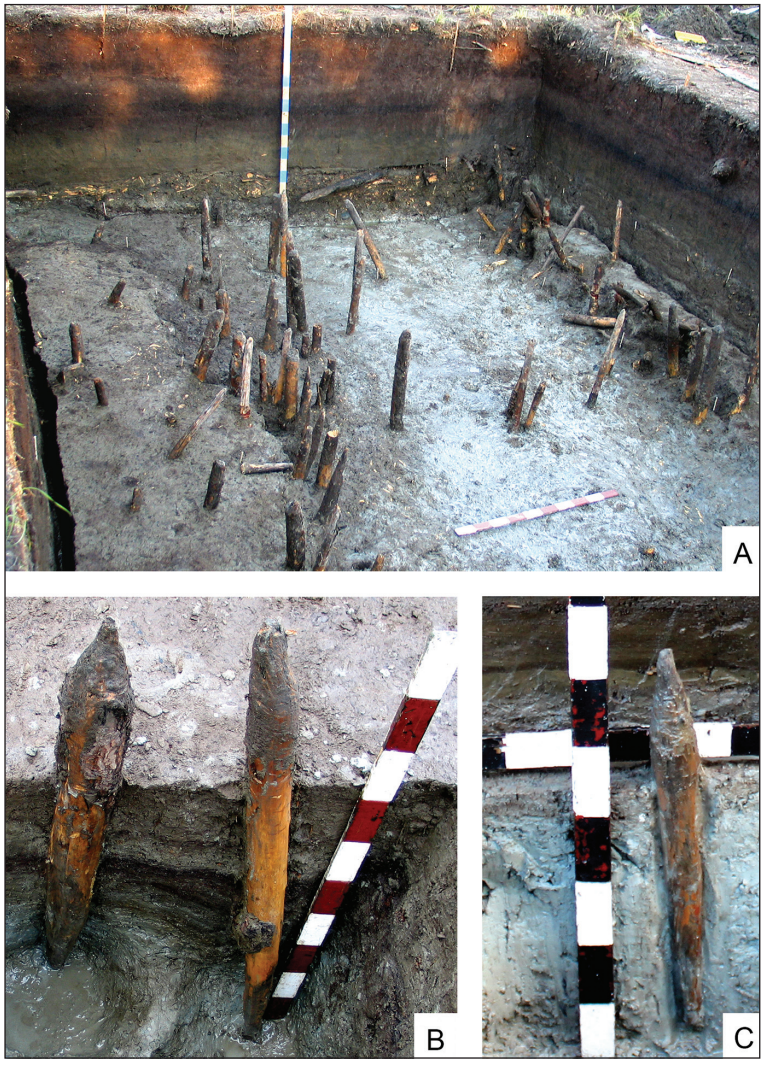



***Fig. 12. Karavaikha, Vologda province, Russia. A stratigraphy and part of depression 2 in trench 5; B long posts, square M-16, trench 8; C short post, square G-19, trench 15 (photos by N. Kosorukova).***

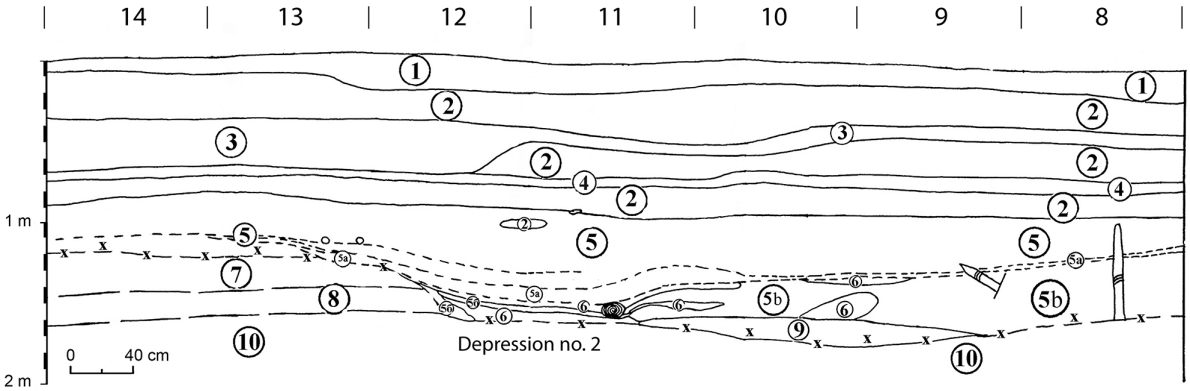



***Fig. 13. Karavaikha, Vologda province, Russia. Stratigraphy at part of the eastern wall of trench 11: 1 topsoil; 2 brown peat; 3 grey brown peaty silty clay; 4 black peaty silty clay; 5 dark green peaty gyttja; 5a dark green gyttja without peat; 5b dark green peaty gyttja with wood chips; 6 light green gyttja without peat; 7 grey clay; 8 dark brown buried peat; 9 grey sand with stones; 10 light-blue clay, dashed line – sand layer, x – main level of finds (designed by N. Kosorukova).***

With their $^{14}$C ages of 6010±50 BP (Le-10043) and 5990±100 BP (Le-10044), they date to the end of the 6th and/or the beginning of the 5th millennium cal BC (Tab. 1).

At Karavaikha 1, situated on the opposite bank of the river, a Neolithic-Eneolithic cemetery and settlement remains from various periods have been excavated (*Utkin, Kostyleva 2001*). Recent test trenches at this site have yielded settlement evidence of the Middle Neolithic Kargopol culture. Charred residue from a Kargopol' potsherd was dated (AAR-17169, 5588±32 BP; Fig. 14.10), corresponding to a date in the third quarter of the 5th millennium cal BC.

In conclusion, it may be assumed on the basis of the dating evidence that human activity at Karavaikha 4 had already started in the Late Mesolithic in the first half of the 6th millennium cal BC, just before the introduction of ceramics. An early pottery phase is also present, and later Early Neolithic activity is attested to by the dated wooden sculptures. At Karavaikha 1, the Middle Neolithic is dated to the mid- to the later 5th millennium cal BC.

### *The southern part of Lake Onega basin: Tudozero 5*

*Archaeological background*

Tudozero 5 is located on the south-eastern bank of Lake Onega in the north of Vologda province in Vytegra district (Fig. 1). In Early Neolithic archaeology, it is the eponymous site for a group of sites with specific comb-decorated pottery. The stratified settlement remains are situated on a sandy spit approx. 1km south of the connection between Lake Onega and Lake Tudozero. The first archaeological site was discovered on the shore of Lake Tudozero by Igor S. Polyakov during an expedition of the Imperial Rus-

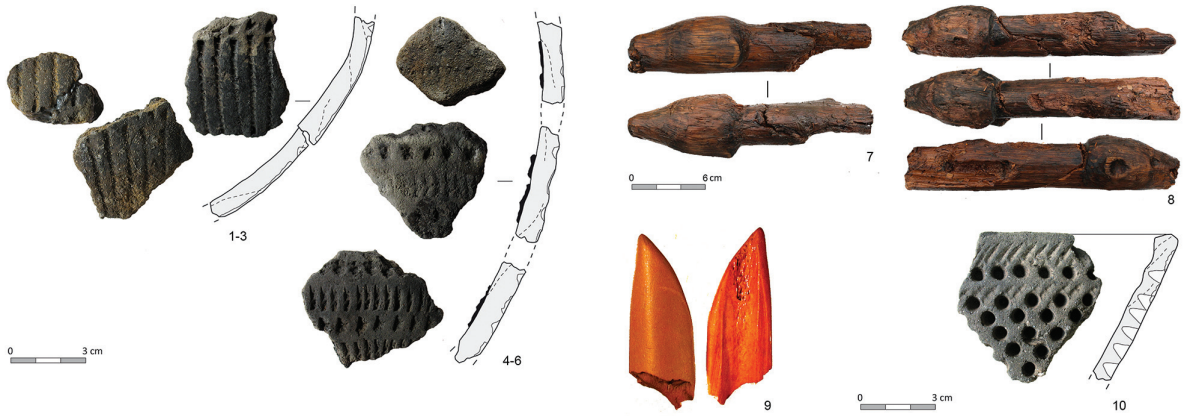



***Fig. 14. Karavaikha, Vologda province, Russia. Dated artefacts from Karavaikha 4 (1–9) and Karavaikha 1 (10). 1–6 fragments of Early Neolithic pottery; 7–8 wooden artefacts with sculpted animal heads; 9 fragment of bone tool; 10 fragment of Middle Neolithic Pit-Comb ware. 1–3 sample AAR-17172; 4–6 sample AAR-17171; 7 sample Le-10043; 8 sample Le-10044); 9 sample AAR-17170; 10 sample AAR-17169 (designed by N. Kosorukova and H. Piezonka).***

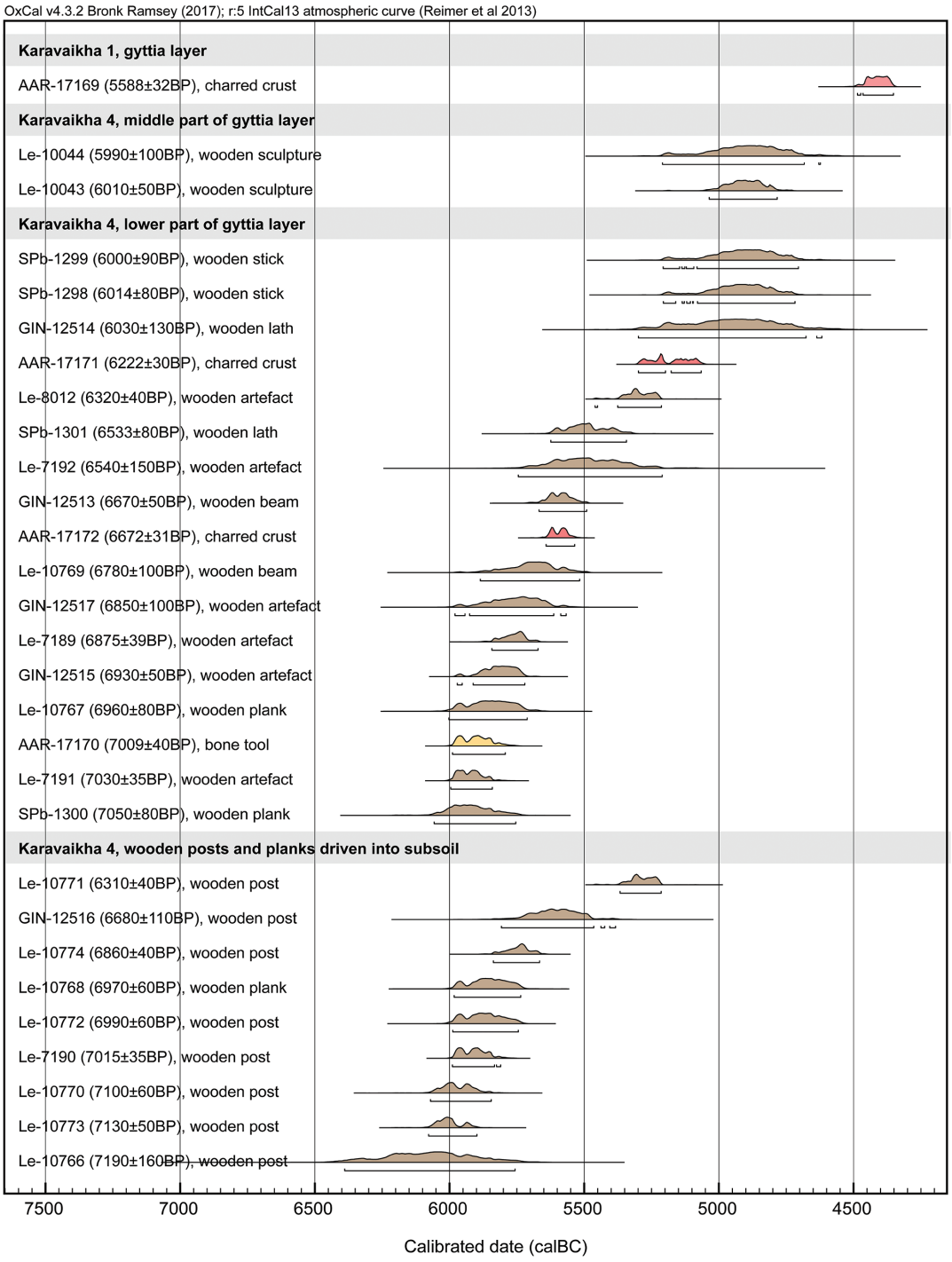



***Fig. 15. Calibrated $^{14}C$ dates from Karavaikha 1 and 4. Brown – wood; red – charred crust on pottery; yellow – bone.***

sian Geographic Society. This site, which today is referred to as Tudozero 8, was the first known Stone Age archaeological site in the Russian north. Other sites at Tudozero were investigated by Aleksandr Ya. Bryusov in the 1940s and by Grigorii A. Pankrushev in the 1970s. The work of the Northern Archaeological Expedition of the Institute of Archaeology of the Academy of Sciences of the USSR, which was directed by Svetlana V. Oshibkina, included investigations of a medieval settlement led by Nikolai A. Makarov. Since 1986, the investigations of archaeological remains at Tudozero have been carried out by the Vytegra team of the Northern Archaeological Expedition, directed by Aleksander M. Ivanishchev. In the course of these works, a large area has been excavated at the multi-period stratified site of Tudozero V. Recently, geochemical and palynological studies have been conducted at Tudozero in order to

reconstruct the changing environmental conditions and to better understand human-environment interactions in the southern Onega region (*Ivanishcheva* et al. *2015*).

The archaeological site is partly located in a natural depression on the spit which opens up to Lake Onega. The site encompasses an area of approx. 2800m², 1276m² of which have been excavated (Fig. 16). To the north of the depression on higher ground, a Stone Age cemetery spanning the Mesolithic and Early Neolithic periods has been investigated (*Ivanishchev, Ivanishcheva 2006*). The archaeological sequence of the settlement site comprises evidence from the Mesolithic through to Medieval times; it reaches up to 2.9m below the modern land surface (*Ivanishcheva* et al. *2015*) (Fig. 17). The so-called 'lower cultural horizon' on top of the sandy subsoil includes Mesolithic and Early Neolithic cultural layers. The cultural horizon of the Early Neolithic period, which is especially well represented in the lower-lying part of the ancient depression, lies above the Mesolithic layer, separated from it by a sterile layer of dark yellow sand. It is overlain by a substantial sterile layer of yellow sand up to 1.5m thick. In the upper part of the stratigraphy, cultural remains from the Middle Neolithic, characterised by Pit-Comb Ware, through to the Middle Ages are intermixed.

In the Early Neolithic horizon, which is of interest here, two cultural layers can be distinguished in parts of the site. They are separated from each other by a band of sterile sand between 0.25 and 0.4m thick, and differ both in artefact density and the archaeological objects contained in them (*Ivanishcheva 2014.256; Ivanishcheva* et al. *2015*) (Fig. 17.strata 10 and 8). Altogether, no fewer than 290 pottery vessels are represented in the ceramic material from this horizon. Of the 161 pottery vessels found in the lower Early Neolithic layer (stratum 10 in Fig. 17), 101 belong to a pre-Sperrings type of early Comb Ware characterised by comparatively small vessel sizes with conical bases, relatively thin walls and straight rims. The decoration covers the entire surface, and consists mainly of horizontal or oblique bands of short comb stamp impressions set closely together (see Fig. 18.1). The tempering material includes mineral and organic components and, to a lesser extent, grog. The archaeological features documented in this layer include numerous hearths, ash concentrations, and domestic and ritual pits, as well as steps leading into the natural depression, which were repeatedly strengthened by wooden constructions. The excavators interpret the evidence from this layer either as the remains of long-term, possibly year-round habitation, or of repeated visits over a long period (*Ivanishcheva* et al. *2016*). According to the geochemical and palynological results, the period in which this layer formed is connected to the onset of warmer and more humid climatic conditions in the Atlantic period (*Ivanishcheva* et al. *2015. 287–288*). The upper Early Neolithic layer (stratum 8 in Fig. 17) is less rich in finds. The artefacts were concentrated mainly in amorphous hearth-like features, with dark fills that contained ochre, burnt sand and charred organic materials, and in kitchen debris around these hearths. This layer is thought to have originated from short-term stop-overs by fishers at the lake shore (*Ivanishcheva 2015; Ivanishcheva* et al. *2016*). The pottery in this layer includes vessels with impressions of fish vertebrae that are typical of the early phase of the Sperrings culture of Karelia and southern Fennoscandia (*Nordqvist, Mökkönen 2016; Piezonka 2015*) (see Fig. 18.2). Here, the decoration consists of horizontal rows of impressions that cover most of the vessel surface, but with a blank strip below the rim. Secondary motifs such as single rows of pit-like impressions sometimes overprint the main ornamentation, a feature highly typical feature of Sperrings ware. According to the geochemical results, the formation of this cultural layer coincided with a drier and cooler climatic episode (*Ivanishcheva* et al. *2015.288*).

*Dated samples and results*

A total of eight radiocarbon dates have been received for materials from the two Early Neolithic cultural layers at Tudozero 5, including two AMS dates on charred food crusts on pottery and six conventional dates on charcoal from hearths and other features (*Ivanishcheva* et al. *2016; Piezonka* et al. *2016*) (Fig. 19; Tab. 1). The two pottery vessels sampled for AMS dating represent the two chronotypological groups in question, the pre-Sperrings Early Comb Ware from the lower layer (Fig. 18.1, AAR-17174, 6660±32 BP), and a typical Sperrings vessel from the upper Early Neolithic horizon (Fig. 18.2, AAR-17173, 6241±30 BP). Both the charred crust and the charcoal dates are in accordance with the stratigraphical observation in parts of the site that two Early Neolithic phases occur at Tudozero 5 (Fig. 19). Altogether, most of the dates suggest that the chronological position of the lower Early Neolithic layer with the Early Comb Ware complex lies in the second quarter of the 6th millennium cal BC (AAR-17174, 6660±32 BP and Le-6700, 6600±25 BP), and a time bracket for the upper Early Neolithic layer with the Sperrings complex falls in the last quarter of the 6th

and the beginning of the 5th millennium cal BC (GIN-8050, 6250±50 BP to Le-6699, 6075±20 BP). However, one conventional date that also stems from the lower Early Neolithic horizon appears unexpectedly old (TA-2354, 7240±60 BP, 6226–6022 cal BC). The dated material is charcoal from a wooden plank that lay at the base of the lower Early Neolithic layer (*Ivanishcheva* et al. *2016.408*); an old-wood effect or a re-location from the Mesolithic complex at this site could be responsible for the age offset. For the Mesolithic layer below, a conventional radiocarbon date on charcoal produced an age of 8280±35 BP (Le-6701, 7459-7186 cal BC) (*Ivanishcheva* et al. *2015.287*). The age difference of around one thousand years between the two latter dates is in general accordance with the stratigraphic sequence. Geochemical analyses point to human activities at the site also during the period when the sterile layer between the Mesolithic and the Early Neolithic cultural horizons were formed (*Kulkova* et al. *2014.197*). Thus the date in question might also be connected to these intermediate activities, for which further archaeological evidence is not yet available.

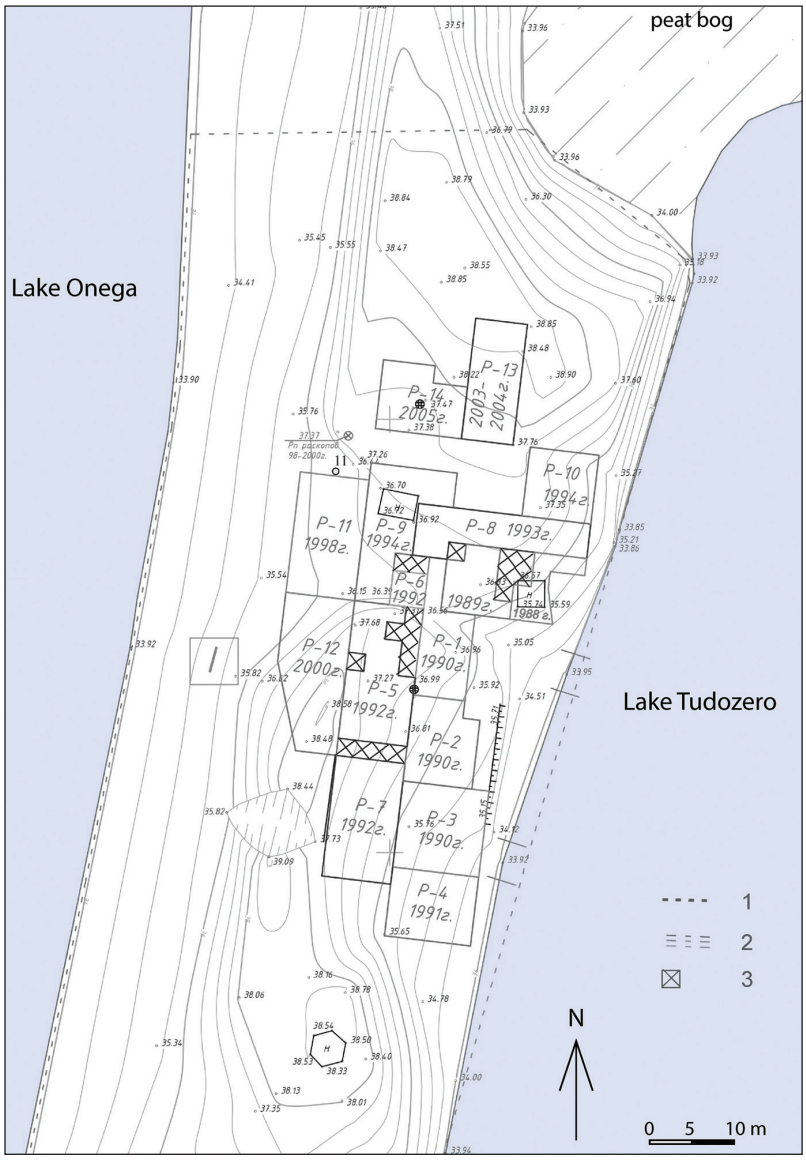



***Fig. 16. Tudozero 5, Vologda province, Russia. Excavated area on the sandy spit between Tudozero and Onega lakes: 1 limit of settlement site; 2 borders and numbers of excavation squares; 3 squares not excavated (designed by A. Ivanishchev, M. Ivanishcheva).***

## Discussion

### *Early Neolithic*

The radiocarbon dating evidence for the Early Neolithic between the Sukhona and southern Onega regions of northern Russia has been expanded in recent years by a number of AMS dates, and today, more than 70 dates exist for the most important archaeological sites. While many of these dating results are consistent with the stratigraphy and the expected typological sequences, two dates at Berezovaya Slobodka by the River Sukhona and one date at Tudozero at the southern end of Lake Onega, as well as several dates from Karavaikha 4 that are thought to be stratigraphically associated with the Early Neolithic phase appear to predate the end of the 7th millennium cal BC. None of these early dates is unquestionably associated with pottery at the sites. Direct dates on pottery start only in the second quarter of the 6th millennium cal BC, and even these are in some cases suspected to be too old due to reservoir effects. Compared to the evidence from surrounding regions, an onset of pottery use, and with it of the Neolithic period, as early as *c.* 6000 cal BC in these northern areas would appear surprisingly early. In the Upper Volga region, recent dating programmes on the site of Zamost'e indicate an initial appearance of ceramics around 5700 cal BC (*Meadows* et al. *2015*), and at Sakhtysh 2a and Ozerki 5, dates that predate 5800 cal BC are thought to be possibly affected

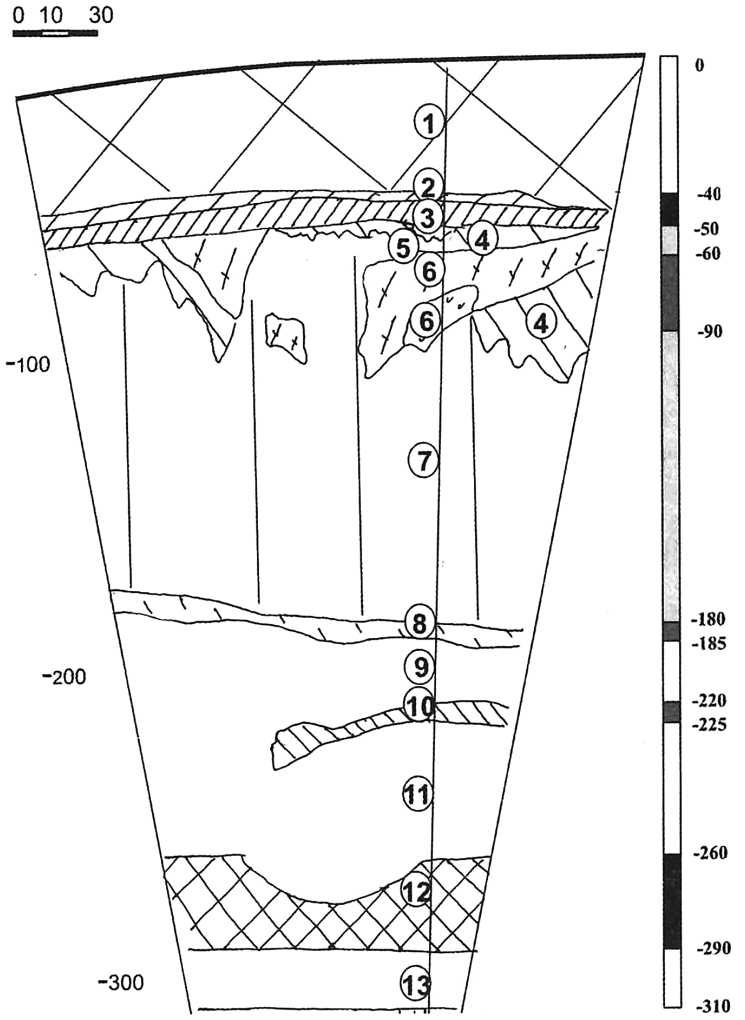



***Fig. 17. Tudozero 5, Vologda province, Russia. Stratigraphy: 1 topsoil (dune sand); 2 Late Medieval cultural layer; 3 cultural layer of developed Medieval period; 4 pinkish sand, without finds; 5 dark yellow sand, without finds; 6 Early Iron Age cultural layer; 7 dark yellow sand, without finds; 8 Early Neolithic cultural layer 1, with Comb Ware and Sperrings pottery; 9 dark yellow sand, without finds; 10 Early Neolithic cultural layer 2, with Comb Ware; 11 dark yellow sand, without finds; 12 Mesolithic cultural layer; 13 light yellow sand, subsoil (designed by M. Ivanishcheva).***

by reservoir effects (see *Hartz* et al. *2012*). Farther east, west and north, the earliest pottery appears only from the middle of the 6th millennium cal BC onwards (*Karmanov* et al. *2014; Zajtseva* et al. *2016;* see also *Piezonka 2015*).

The food-crust dates appear to have been distorted by freshwater reservoir effects in some cases, but it is difficult to assess the scale of this problem without more precise chronologies, particularly for shorter phases of occupation. In long occupational sequences, without tight stratigraphic control over all dated materials, it is difficult to detect radiocarbon age offsets of a few hundred years. Assuming that food-crust stable isotopes and elemental abundances reflect those in the original ingredients, the dated food crusts from Veksa appear to show an increasing use of fish over time, with more terrestrial values from the earliest samples (*Piezonka* et al. *2016*). We have no direct evidence yet that there was a significant FRE at Veksa in the Neolithic. However, two recent fish from the Vologda River, collected in September 2015, were dated by AMS; both have apparent $^{14}$C ages of *c.* 1100 years (Tab. 2). If mid-Holocene fish were similarly depleted in $^{14}$C, the ages of food crusts from this region where fish was a major dietary component would appear to be centuries older than contemporaneous terrestrial plants and animals as sources of carbon. At nearby Minino, the large dietary reservoir effects in prehistoric human remains (*Wood* et al. *2013*) imply that early-mid Holocene fish had very high FREs. In the case of Veksa, however, we can rely on the stratigraphic sequence of $^{14}$C dates from wood and charcoal samples to provide a realistic chronology for the Neolithic pottery types.

At Karavaikha 4, fourteen $^{14}$C dates from the lower cultural horizon, most of them on wooden artefacts, span a very long period from 7050±80 BP (SPb-1300) to 6030±130 BP (GIN-12514), contradicting the assumption that this horizon represents a confined Early Neolithic episode of human activity (Fig. 15). The date of the bone dagger (AAR-17170, 7009±40 BP) is among the oldest (Tab. 1), indicating a human presence at the site in the first third of the 6th millennium cal BC, a period associated with the aceramic Late Mesolithic in these parts of Northern Russia (*Filatova 2006*). The earliest date directly associated with pottery at Karavaikha 4 stems from the food crust from vessel 5 (AAR-17172, 6672±31 BP), which is typologically similar to pottery of the second phase of the Upper Volga culture. This date forms a group with four broadly contemporary conventional dates from wood samples. Compared to dates for the developed phase of Upper Volga pottery elsewhere, however, the date from Karavaikha 4 seems too early. Food-crust dates for typologically connected

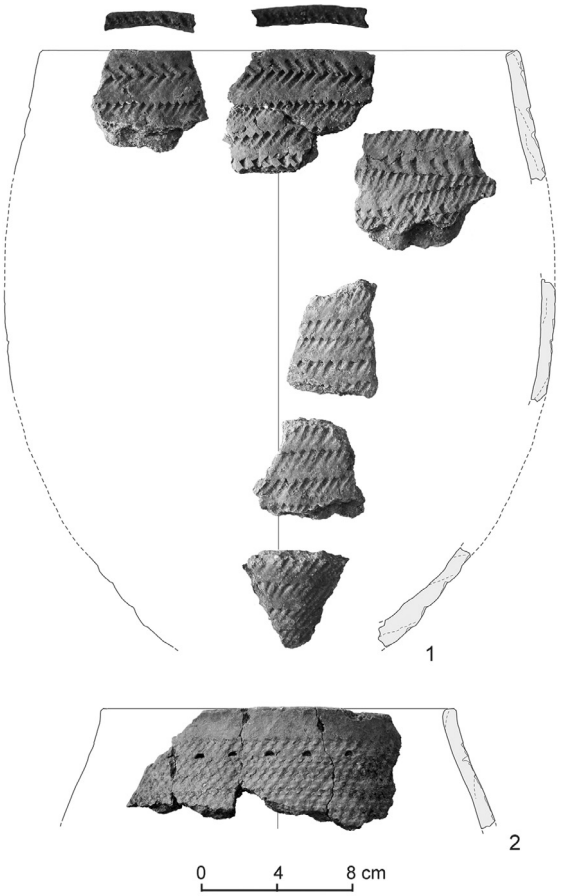



***Fig. 18. Tudozero 5, Vologda province, Russia. Fragments of pottery from which organic residue samples were taken: 1 sample AAR-17174; 2 sample AAR-17173 (designed by H. Piezonka).***

wares and their contexts from Veksa 3, Sakhtysh 2a and Ozerki 17 (*Hartz* et al. *2012*) are approx. 400 $^{14}$C years younger. Therefore, a significant FRE could have affected AAR-17172. The second food-crust date from Karavaikha 4 (AAR-17171, 6222±30 BP) is the second-youngest date associated with the lower cultural horizon. Its typological attribution is not as straightforward as with other vessel unit. While the composition of the decoration stylistically resembles the 'Northern Types', the use of irregular stamps instead of large, deep pits, is an atypical feature. The dating result appears marginally older than that for 'Northern Type' pottery from Veksa (KIA-33928). There are no other dates for contexts with this type of pottery at Veksa or in the Upper Volga region. Altogether, the chronology of the lower cultural horizon at Karavaikha 4 is not fully understood, and it seems possible that several phases of activity during the Late Mesolithic and Early Neolithic are represented. To understand the chronological setting of the pottery associated with it and to judge the possible presence of FREs in its food crusts, dating of securely associated terrestrial material will be necessary.

The two food-crust dates from Tudozero 5 fit both the stratigraphic sequence and existing conventional $^{14}$C dates from the respective layers (Fig. 19). They thus appear to confirm the assumption that the local early Comb Ware is associated with an Early Neolithic horizon dating to the second quarter of the 6$^{th}$ millennium cal BC, while Sperrings pottery dates to a later phase of the Early Neolithic in the last third of the 6$^{th}$ millennium cal BC. Altogether, the stratigraphic and typological evidence and associated $^{14}$C dates suggest that no substantial FRE has affected the food-crust dates from Tudozero 5. At the same time, the EA-IRMS results and especially the high $\delta^{15}$N values suggest a significant aquatic component. Here, too, comparative dating of terrestrial and aquatic materials from closed contests would help to better understand these questions, and radiocarbon dating of modern fish would also provide a general impression whether or not FREs have to be taken into account for aquatic materials from the local water systems.

### *Middle Neolithic*

In the present study, five radiocarbon dates from Middle Neolithic contexts or finds are discussed. The dating of food-crust from a typical Lyalovo culture vessel that was found as a surface find at Veksa 1 resulted in an age in the second quarter of the 5$^{th}$ millennium cal BC, which is within the chronological range of the early phase of the Lyalovo culture.

| Laboratory code | Sample | AMS $\delta^{13}$C (‰) | Conventional $^{14}$C Age | Apparent $^{14}$C Age |
|---|---|---|---|---|
| KIA-51318 | Vologda fish #41 (small white fish) | –30.44±0.13 | 912±23 | 1065±23 |
| KIA-51319 | Vologda fish #42 (perch) | –34.41±0.11 | 932±31 | 1085±31 |

Apparent $^{14}$C age calculation based on atmospheric $^{14}$C activity of 1.0193±0.0004 F$^{14}$C, average of May-August atmospheric data for 2015 (Hammer, Samuel, and Ingeborg Levin. 2017. Monthly mean atmospheric $\Delta^{14}CO_2$ at Jungfraujoch and Schauinsland from 1986 to 2016. heiDATA Dataverse)

***Tab. 2. AMS results from samples of dry fish flesh. Both fish were caught in September 2015 in the Vologda River, Vologda City, Russia. The samples were freeze-dried and combusted for dating without further pretreatment.***

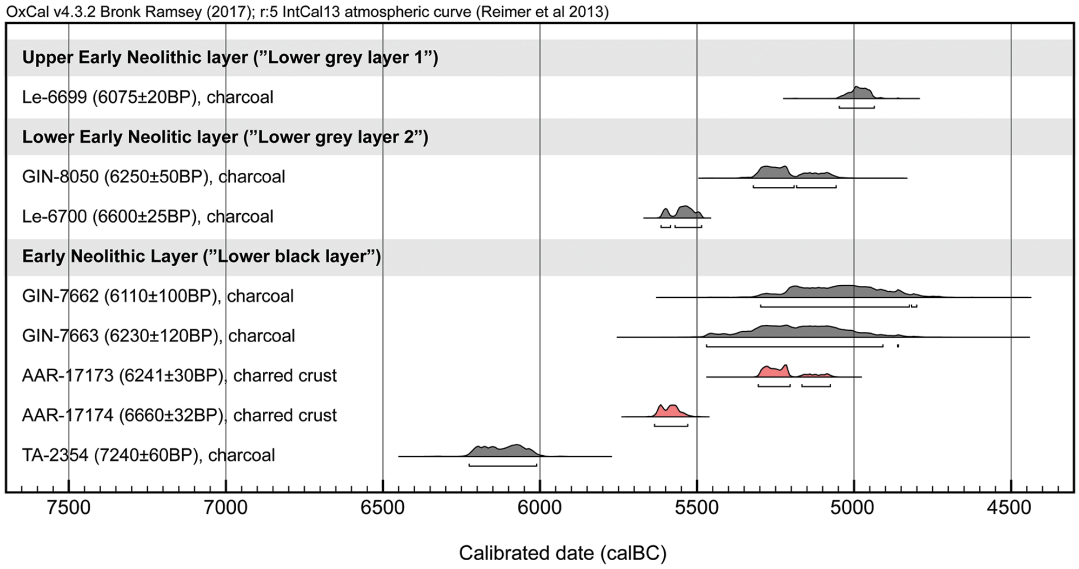



***Fig. 19. Tudozero 5, Vologda province, Russia. Calibrated $^{14}$C dates from the Early Neolithic layers. Grey – charcoal; red – charred crust.***

It is not clear whether a freshwater reservoir effect might have influenced this date. A charcoal sample from the Lyalovo layer excavated in a new test trench at Veksa 1 in 2016 provided a somewhat younger age, in the third quarter of the 6th millennium. Two dates on a stray find vessel from Veksa 3 which typologically resembles Narva pottery also lie in the 3rd quarter of the 5th millennium cal BC; here, too, reservoir effects might play a role and the actual date of the vessel could be younger.

The $^{14}$C age of the food crust on the Kargopol culture sherd from Karavaikha 1 (AAR-17169, 5588±32 BP) is in broad accordance with its expected position in the early phase of this Middle Neolithic culture, although the contextual and typological information on chronology is in this case not detailed enough to decide whether a FRE might have affected the date or not.

## Conclusions and perspectives

The radiocarbon dating evidence of the Early and Middle Neolithic between the Sukhona and southern Onega regions of northern Russia has been expanded in recent years by a number of AMS dates, and today, almost 80 dates exist for the four key archaeological localities of Berezovaya Slobodka, Veksa, Karavaikha and Tudozero. These data help to understand the onset and initial development of ceramic production more precisely (the main criterion for the Neolithic in this region), and the cultural developments among the pottery-producing hunter-gatherer-fisher groups in these northern areas far beyond the world of the agricultural Neolithic farther south and west.

While our knowledge of the absolute chronology of these processes has greatly advanced with the increasing number of radiocarbon dates, a number of obstacles remain concerning the reliability both of the dates themselves, and of the archaeological context that they are dating. Dates on pottery food crusts appear to have been distorted by freshwater reservoir effects in some cases, resulting in dates that can be centuries too old. To build better chronologies from food crust dates, we need to determine which $^{14}$C results are potentially subject to freshwater reservoir effects, *i.e.* to distinguish crusts derived mainly from aquatic ingredients from those composed mainly of terrestrial foods. Integrating laboratory analyses with relative chronologies based on typology and stratigraphy, but also by determining local aquatic reservoir ages can help to assess the extent of freshwater reservoir effects on food-crust dates. To understand the potential variability in food-crust freshwater reservoir effects, we also need to date multiple fish remains from closely dated contexts.

The examples of the four localities presented here also show that another problem concerns the ultimately unreliable association between the dated context samples and the early pottery phase. Are the most ancient dates from the horizons regarded as Early Neolithic really already associated with the early pottery phase at Berezovaya Slobodka, or at Karavaikha 4? Does the earliest anthropogenic lens at Veksa 3, test trench 1, belong to the pre-pottery

period, or is it merely coincidental that no fragment of the new material (which was still rare initially) has been left or lost in this activity zone?

While many of the radiocarbon results are consistent with stratigraphies and expected typological sequences, several charcoal dates from Berezovaya Slobodka by the River Sukhona and from Tudozero on the southern end of Lake Onega that are stratigraphically associated with Early Neolithic horizons appear rather old, dating to the end of the 7th millennium cal BC. Further investigations are needed to follow up the question of whether in these northern regions sparsely decorated, flat-based wares appeared more or less contemporaneously with the typologically connected Early Upper Volga culture pottery several hundred kilometres farther south, which is thought to begin in the early 6th millennium cal BC (*Hartz* et al. *2012*). Likewise, the phenomenon of a pre-Sperrings Comb ware, its typological origins and links and its chronological position need to be further investigated. Only on the basis of a reliable chronology will it be possible to better understand the cultural processes, regional and supra-regional interactions in the early to mid-Holocene that are reflected in various early pottery types and that later led to the formation of larger typological units, including Typical Comb Ware and Pit-Comb Wares at the onset of the Middle Neolithic period in north-eastern Europe in the 5th millennium cal BC.

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***Tab. 1. Radiocarbon dating results on organic material from***

| Site | Context | Chrono-typological association | Material |
|---|---|---|---|
| Beresovaya Slobodka II-III | Trench 7, 2002, squ. C-2, –92, depth 140cm, dark sandy loam, Early Neolithic, layer 2, from a fireplace, close to flat-based ceramic vessel with pin-point decoration | Early Neolithic | charcoal |
| Beresovaya Slobodka II-III | Trench 7, 2002, squ. C-2, –87, depth 165cm, dark sandy loam, Early Neolithic, layer 2, close to flat-based ceramic vessel with pin-point decoration | Early Neolithic | charcoal |
| Beresovaya Slobodka II-III | Trench 6, 2004, squ. P-4, +34, depth 40cm, dark sandy loam, Early Neolithic layer, fragment of undecorated, grog-tempered vessel | Early Neolithic | pottery |
| Beresovaya Slobodka VI | Trench 2, 2007, squ. Z-9, –37–41, depth 20cm, yellow sandy loam, Early Neolithic layer, depth 40cm, dark sandy loam, Early Neolithic layer, accumulation on thick wall fragment of pin-point decorated, grog-tempered vessel | Early Neolithic | pottery |
| Karavaikha 1 | 2002, test trench 1, peaty depression, pit-decorated pot sherd (find no. 3942) from gyttia layer | Middle Neolithic (Kargopol') | foodcrust |
| Karavaikha 4 | 2014, trench 14, squ. E-6, fragment of wooden pile beaten into the clay subsoil in wall of depression no. 2 with fishing constructions | Late Mesolithic or Early Neolithic (?) | wood |
| Karavaikha 4 | 2011, trench 12, squ. P-7, fragment of wooden pile beaten deep into the clay subsoil beyond the depressions, south of depression no. 2 | Late Mesolithic or Early Neolithic (?) | wood |
| Karavaikha 4 | 2012, trench 15, squ. G-19, fragment of relatively short wooden pile beaten into clay subsoil far from the riverbank, to the west of the depressions | Late Mesolithic or Early Neolithic (?) | wood |
| Karavaikha 4 | 2012, trench 15, squ. JA-19, flat wide thin board in the lowest part of the gyttja at its contact zone with the subsoil below (peaty loamy clay) | Late Mesolithic or Early Neolithic (?) | wood |
| Karavaikha 4 | 2004, trench 2, squ. P-11, wooden artefact in the lower part of the gyttia, above the main level of artefacts | Late Mesolithic or Early Neolithic (?) | wood |
| Karavaikha 4 | 2004, trench 3, fragment of woden pile beaten into the clay subsoil close to the edge of depression with fishing constructions | Late Mesolithic or Early Neolithic (?) | wood |
| Karavaikha 4 | 2005, trench 5, squ. F-10, horizon 8, fragment of bone tool with asymmetrical point, at the contact between gyttja and clay subsoil | Late Mesolithic or Early Neolithic (?) | bone (indeter-minate ungulate) |
| Karavaikha 4 | 2011, trench 12, squ. X-6, fragment of wooden pile beaten into the clay subsoil south of depression no. 2, not far from its edge | Late Mesolithic or Early Neolithic (?) | wood |
| Karavaikha 4 | 2014, trench 16, squ. Š-6, wooden board beaten either vertically or at an angle into the clay subsoil at the edge of depression no. 2, part of a fishing construction | Late Mesolithic or Early Neolithic (?) | wood |
| Karavaikha 4 | 2014, trench 16, squ. E-6, long wooden board, placed at an angle on the clay subsoil at the edge of depression no. 2 with fishing constructions | Late Mesolithic or Early Neolithic (?) | wood |
| Karavaikha 4 | 2004, trench 1, depression no. 1, wooden artefact in the upper part of sand layer which lay between gyttja and clay subsoil | Late Mesolithic or Early Neolithic (?) | wood |
| Karavaikha 4 | 2004, trench 1, squ. P-22, wooden artefact in the lower part of the gyttja layer | Late Mesolithic or Early Neolithic (?) | wood |
| Karavaikha 4 | 2011, trench 12, squ. X-7, fragment f wooden pile beaten into clay subsoil at the sloping edge of depression no. 2 | Mesolithic or Early Neolithic (?) | wood |
| Karavaikha 4 | 2004, trench 2, depression no. 2, wooden artefact in the upper part of the sand layer which lay between the gyttja and the clay subsoil | Mesolithic or Early Neolithic (?) | wood |
| Karavaikha 4 | 2014, trench 16, squ. B-6, long wooden beam that lay at an angle at the edge of depression no. 2 | Mesolithic or Early Neolithic (?) | wood |
| Karavaikha 4 | 2004, trench 2, depression no. 2, wooden pile beaten into the clay subsoil | Mesolithic or Early Neolithic (?) | wood |
| Karavaikha 4 | Charred crust combined from three fragments of pottery probably belonging to one vessel with comb ornament: 1) 2006, trench 7, squ. C-25, lower part of dark green peaty gyttja under concentration of wood, 15cm above main level of artefacts; 2) 2004, trench 1, squ. P-25, in lower part of gyttja 35cm above main level of artefacts; 3) 2003, trench 1, squ. P23, in lower part of gyttja 35cm above main level of artefacts | Early Neolithic | foodcrust |
| Karavaikha 4 | Trench 1, fragment of wooden beam from gyttja above main level of artefacts | Early Neolithic | wood |
| Karavaikha 4 | 2004, trench 1, squ. C22, wooden artefact lying in gyttja above main level of artefacts | Early Neolithic | wood |
| Karavaikha 4 | 2012, trench 15, squ. B20, wooden lath from accumulation of small wooden laths lying at the contacts zone between gyttia and clay subsoil | Early Neolithic | wood |

***Early and Middle Neolithic complexes in northwest Russia.***

| Lab. No. | Yield (%)* | %C§ | %N§ | atomic C/N | $\delta^{13}C$ (‰)§ | $\delta^{15}N$ (‰)§ | Conventional $^{14}C$ age BP* | Maximum age cal BC ¶ (95,4 % probability) | Reference |
|---|---|---|---|---|---|---|---|---|---|
| Le-6713 | | | | | | | 7340 ± 200 | 6600–5810 | *Ivanishcheva 2006* |
| Le-6707 | | | | | | | 7340 ± 90 | 6400–6030 | *Ivanishcheva 2009* |
| Ki- 16392a | | | | | | | 6210 ± 80 | 5340–4950 | *Ivanishcheva 2009* |
| Ki- 16392 | | | | | | | 5850 ± 80 | 4930–4520 | *Ivanishcheva 2009* |
| AAR-17169 | | 16.4 | 3.5 | 5.5 | –27.90 | 9.75 | 5588±32 | 4490–4350 | *Piezonka* et al. *2016* |
| Le-10766 | | | | | | | 7190±160 | 6390–5760 | *Kosorukova* et al. *2016* |
| Le-10773 | | | | | | | 7130±50 | 6080–5900 | *Kosorukova* et al. *2016* |
| Le-10770 | | | | | | | 7100±60 | 6070–5850 | *Kosorukova* et al. *2016* |
| Spb-1300 | | | | | | | 7050±80 | 6060–5760 | *Kosorukova* et al. *2016* |
| Le-7191 | | | | | | | 7030±60 | 6020–5770 | *Kosorukova* et al. *2016* |
| Le-7190 | | | | | | | 7015±35 | 5990–5810 | *Kosorukova* et al. *2016* |
| AAR-17170 | | | | 3.2 | –21.72 | 4.6 | 7009±40 | 5990–5790 | *Kosorukova* et al. *2016* |
| Le-10772 | | | | | | | 6990±60 | 5990–5750 | *Kosorukova* et al. *2016* |
| Le-10768 | | | | | | | 6970±60 | 5980–5740 | *Kosorukova* et al. *2016* |
| Le-10767 | | | | | | | 6960±80 | 6000–5710 | *Kosorukova* et al. *2016* |
| GIN-12515 | | | | | | | 6930±50 | 5970–5720 | *Kosorukova* et al. *2016* |
| Le-7189 | | | | | | | 6875±39 | 5840–5670 | *Kosorukova* et al. *2016* |
| Le-10774 | | | | | | | 6860±40 | 5840–5670 | *Kosorukova* et al. *2016* |
| GIN-12517 | | | | | | | 6850±100 | 5980-5570 | *Kosorukova* et al. *2016* |
| Le-10769 | | | | | | | 6780±100 | 5890–5520 | *Kosorukova* et al. *2016* |
| GIN-12516 | | | | | | | 6680±110 | 5810–5380 | *Kosorukova* et al. *2016* |
| AAR-17172 | | 36.6 | 6.7 | 6.5 | –25.74 | 10.21 | 6672±31 | 5640–5540 | *Piezonka* et al. *2016* |
| GIN-12513 | | | | | | | 6670±50 | 5670–5490 | *Kosorukova* et al. *2016* |
| Le-7192 | | | | | | | 6540±150 | 5750–5210 | *Kosorukova* et al. *2016* |
| SPb-1301 | | | | | | | 6533±80 | 5630–5340 | *Kosorukova* et al. *2016* |

| Site | Context | Chrono-typological association | Material |
|---|---|---|---|
| Karavaikha 4 | 2007, trench 8, wooden object from lower part of gyttia | Early Neolithic | wood |
| Karavaikha 4 | 2004, trench 1, squ. P2, short wooden pile beaten into the clay subsoil south of depression no. 2 | Early Neolithic | wood |
| Karavaikha 4 | Charred crust combined from three fragments of pottery probably belonging to one vessel with impressed decoration by natural stamps: 1) 2007, trench 8, squ. O19, horizon 5, from lower part of gyttja; 2) 2004, trench 1, squ. C22, from lower part of gyttja 25cm above main level of artefacts; 3) 2005, trench 6, squ. O23, from contact zone between gyttja and clay subsoil | Early Neolithic | food-crust |
| Karavaikha 4 | 2003, trench 1, squ. P21, wooden lath from concentration of laths which probably represent remains of a fish trap, lying on the subsoil in the lower part oft he gyttia | Early Neolithic | wood |
| Karavaikha 4 | 2012, trench 15, squ. A19, wooden stick from lower part of gyttia almost in contact zone with peaty clay subsoil | Early Neolithic | wood |
| Karavaikha 4 | 2012, trench 15, squ. JA19, fragment of wooden sculpture in middle part of gyttia substantially above main level of artefacts | Early Neolithic | wood |
| Karavaikha 4 | 2012, trench 15, squ. G20, wide flat wooden stick from lower part of gyttia almost in contact zone with peaty clay subsoil | Early Neolithic | wood |
| Karavaikha 4 | 2012, trench 15, squ. JA19, fragment of wooden sculpture in middle part of gyttia substantially above main level of artefacts | Early Neolithic | wood |
| Tudozero 5 | 1989, squ. G0/1, –178, depth 190cm from ancient surface, charred wooden plank from base of lower black Early Neolithic layer with pottery | Early Neolithic (?) | charcoal |
| Tudozero 5 | 1990, trench 1, squ. E1, charred organic crust from inside of comb-decorated conical vessel, lower black Early Neolithic layer | Early Neolithic (earliest Comb Ware) | foodcrust |
| Tudozero 5 | 2000, trench 12, squ. A1, –397, depth 340cm from ancient surface, lower grey early Neolithic layer 2, hearth | Early Neolithic | charcoal |
| Tudozero 5 | 1993, trench 8, squ. B1/2, –258, depth 220cm from ancient surface, lower grey early Neolithic layer 2, hearth | Early Neolithic | charcoal |
| Tudozero 5 | 1989, squ. A2, charred crust from inside of rimsherd with fish vertebra impressions, lower black Early Neolithic layer | Early Neolithic (Sperrings) | foodcrust |
| Tudozero 5 | 1992, trench 5, squ. E4, –318, depth 260cm from ancient surface, lower black Early Neolithic layer, hearth | Early Neolithic | charcoal |
| Tudozero 5 | 1992, trench 6, squ. B3, –329–350, depth 310cm from ancient surface, lower black Early Neolithic layer, hearth | Early Neolithic | charcoal |
| Tudozero 5 | 1998, trench 11, squ. B/G6/7, –328, depth 170cm from ancient surface, lower grey Early Neolithic layer 1, hearth | Early Neolithic | charcoal |
| Veksa 1 | River bank slope, segment 9, charred organic crust from vessel with pitted ornamentation, Lyalovo culture | Early to Middle Neolithic (Lyalovo) | foodcrust |
| Veksa 1 | 2016, test trench, layer 7 | Middle Neolithic (Lyalovo) | charcoal |
| Veksa 3 | 2000, squ. 170-I, layer 9, charcoal concentration | Early Neolithic | soil with charcoal |
| Veksa 3 | 2000, squ. 167-Z, layer 9, pit | Early Neolithic | soil with charcoal |
| Veksa 3 | 2015, trench 1, squ. L-167, layer 9, charred crust from inside a sparsely ornamented Early Upper Volga culture vessel (vessel no. 2015/17) | Early Neolithic (Upper Volga) | foodcrust |
| Veksa 3 | 2000, squ. 171-I, layer 9, pit | Early Neolithic (Upper Volga) | soil with charcoal |
| Veksa 3 | 1997, squ. 167, from charcoal-rich lens | Early Neolithic (Upper Volga) | soil with charcoal |
| Veksa 3 | 2016, trench 1, squ. L-166, layer 9, removal 5, feature 509 | Early Neolithic (Upper Volga) (?) | charcoal |
| Veksa 3 | 2015, trench 1, squ. L-167, layer 7, feature 42, charred crust from inside of pottery vessel with comb impressed ornament (same vessel as sample MAMS-27311) | Early Neolithic ("2nd comb ceramic complex"/ "Northern types") | food-crust |
| Veksa 3 | 2000, squ. 171-I, layer 9 | Early Neolithic (Upper Volga) | soil from charcoal-rich layer |

| Lab. No. | Yield (%)* | %C§ | %N§ | atomic C/N | $\delta^{13}C$ (‰)§ | $\delta^{15}N$ (‰)§ | Conventional $^{14}C$ age BP* | Maximum age cal BC ¶ (95,4 % probability) | Reference |
|---|---|---|---|---|---|---|---|---|---|
| Le-8012 | | | | | | | 6320±40 | 5460–5210 | *Kosorukova* et al. *2016* |
| Le-10771 | | | | | | | 6310±40 | 5370–5220 | *Kosorukova* et al. *2016* |
| AAR-17171 | | 57.2 | 3.2 | 20.9 | –26.15 | 0.89 | 6222±30 | 5300–5077 | *Piezonka* et al. *2016* |
| GIN-12514 | | | | | | | 6030±130 | 5300–4620 | *Kosorukova* et al. *2016* |
| SPb-1298 | | | | | | | 6014±80 | 5210–4720 | *Kosorukova* et al. *2016* |
| Le-10043 | | | | | | | 6010±50 | 5040–4780 | *Kosorukova* et al. *2016* |
| SPb-1299 | | | | | | | 6000±90 | 5210–4710 | *Kosorukova* et al. *2016* |
| Le-10044 | | | | | | | 5990±100 | 5210–4620 | *Kosorukova* et al. *2016* |
| Ta-2354 | | | | | | | 7240±60 | 6230–6010 | *Ivanishchev, Ivanishcheva 2000* |
| AAR-17174 | | 17.3 | 2.0 | 10.1 | –27.24 | 10.68 | 6660±32 | 5640–5530 | *Piezonka* et al. *2016* |
| Le-6700 | | | | | | | 6600±25 | 5620–5490 | *Ivanishcheva 2014* |
| GIN-8050 | | | | | | | 6250±50 | 5320–5060 | *Ivanishchev, Ivanishcheva 2000* |
| AAR-17173 | | 48.9 | 6.6 | 8.6 | –26.95 | 13.89 | 6241±30 | 5310–5080 | *Piezonka* et al. *2016* |
| GIN-7663 | | | | | | | 6230±120 | 5470–4860 | *Ivanishchev, Ivanishcheva 2000* |
| GIN-7662 | *Ivanishcheva 2000* | | | | | | 6110±100 | 5300–4800 | *Ivanishchev,* |
| Le-6699 | | | | | | | 6075±20 | 5050–4940 | *Ivanishchev, Ivanishcheva 2000* |
| SPb-1691 | | | | | | | 5843±80 | 4900–4500 | *Nedomolkina, Piezonka 2016* |
| Poz-92588 | | | | | | | 5510±40 | 4450–4270 | Unpublished |
| Le-5866 | | | | | | | 6950 ± 150 | 6200–5560 | *Nedomolkina 2004* |
| Le-5864 | | | | | | | 6730 ± 160 | 5980-5380 | *Nedomolkina 2004* |
| MAMS-25493 | | | | | –20.1 | | 6677±25 | 5640–5550 | *Nedomolkina, Piezonka 2016* |
| Le-5869 | | | | | | | 6650±200 | 5980–5220 | *Nedomolkina 2004* |
| GIN-10181 | | | | | | | 6500±170 | 5740–5060 | *Nedomolkina 2004* |
| Poz-92786 | | | | | | | 6490±49 | 5540–5340 | Unpublished |
| MAMS-27319 | | | | | –31.4 | | 6419±29 | 5470–5330 | Unpublished |
| Le-5870 | | | | | | | 6400±130 | 5620–5060 | *Nedomolkina 2004* |

| Site | Context | Chrono-typological association | Material |
|---|---|---|---|
| Veksa 3 | 1996, charred organic crust from Upper Volga pottery sherd, surface find on river bank | Early Neolithic (Upper Volga) | foodcrust |
| Veksa 3 | 2002, layer 9, pit | Early Neolithic | organically enriched soil |
| Veksa 3 | Surface find on river bank, charred organic crust from Upper Volga pottery sherd | Early Neolithic (earliest Comb-Pitted ware) | foodcrust |
| Veksa 3 | 2015, trench 1, squ. L-168, layer 9, feature 446 | Early Neolithic (Upper Volga) | charcoal |
| Veksa 3 | 1996, surface find on river bank, charred organic crust from pottery sherd of the "2nd comb ware complex" | Early Neolithic ("2nd comb ceramic complex") | foodcrust |
| Veksa 3 | 2015, trench 1, squ. L-166, layer 9, removal 1 | Early Neolithic (Upper Volga) | charcoal |
| Veksa 3 | 2015, trench 1, squ. L-166, layer 9, removal 1, feature 446, charred seeds of *Nuphar lutea* | Early Neolithic (Upper Volga) | charred seeds |
| Veksa 3 | 2015, trench 1, squ. L-167, layer 7, feature 42, charred crust from inside of pottery vessel with comb impressed ornament (same vessel as sample MAMS-27319) | Early Neolithic ("2nd comb ceramic complex"/ "Northern types") | food-crust |
| Veksa 3 | 2016, trench 1, squ. L-166, layer 9, removal 3 | Early Neolithic (Upper Volga) | charcoal |
| Veksa 3 | 2000, squ. 168-I, layer 8, hearth | Early Neolithic ("2nd comb ceramic complex") | soil from hearth |
| Veksa 3 | 2000, squ. 169-I, layer 8 | Early Neolithic ("2nd comb ceramic complex") | soil with charcoal |
| Veksa 3 | 1996, surface find on river bank, charred organic crust from pottery sherd of the "2nd comb ware complex" | Early Neolithic ("2nd comb ceramic complex") | foodcrust |
| Veksa 3 | 2015, trench 1, squ. L-168, layer 7, feature 43, charred seeds of *Polygonum lapathifol*. | Early Neolithic ("2nd comb ceramic complex"/ "Northern types") | charred seeds |
| Veksa 3 | 2015, trench 1, squ. L-168, layer 9, feature 446 | Early Neolithic (Upper Volga) | charcoal |
| Veksa 3 | 2015, trench 1, squ. L-166, layer 9, removal 1, feature 446, charred seeds of *Polygonum lapathifol*. | Early Neolithic (Upper Volga) | charred seeds |
| Veksa 3 | 1996, surface find on river bank, charred organic crust from pottery sherd of the "Northern types" | Late Early Neolithic ("Northern types") | food-crust |
| Veksa 3 | 2015, trench 1, squ. L-168, layer 9, feature 446, charred crust from inside of potsherd | Early Neolithic (Upper Volga) | food-crust |
| Veksa 3 | 2015, trench 1, squ. L-166, layer 8, removal 4 | Early Neolithic ("2nd comb ceramic complex") | charcoal |
| Veksa 3 | 2015, trench 1, squ. L-167, layer 7 | Early Neolithic ("2nd comb ceramic complex"/ "Northern types") | charcoal |
| Veksa 3 | 2015, trench 1, squ. L-167, layer 7, feature 42, charcoal adhering to vessel from which stem samples MAMS-27311 and MAMS-27319 | Early Neolithic ("2nd comb ceramic complex"/ "Northern types") | charcoal |
| Veksa 3 | 2015, trench 1, squ. L-168, layer 7, feature 43 | Early Neolithic ("2nd comb ceramic complex"/ "Northern types") | charcoal |
| Veksa 3 | 2000, squ. 168-I, layer 6 | Late Early Neolithic ("Northern types") | soil with charcoal |
| Veksa 3 | 1997, squ. 166-I, layer 6 | Late Early Neolithic ("Northern types") | charcoal |
| Veksa 3 | 1996, shore segment 6, surface find on river bank, charred organic crust from Narva type pottery vessel (same vessel as KIA-33926) | Middle Neolithic (Narva) | foodcrust (outer surface) |
| Veksa 3 | 1996, shore segment 6, surface find on river bank, charred organic crust from Narva type pottery vessel (same vessel as KIA-49796) | Middle Neolithic (Narva) | foodcrust (inner surface) |
| Veksa 3 | 1997, 170-I, layer 5 | Middle Neolithic (Kargopol') | soil with charcoal |

§ EA-IRMS measurements from School of Life Sciences, University of Bradford, England (Veksa 3) and AMS $^{14}$C Dating Centre at Aarhus University (Karavaikha, Tudozero). Italics: isotope determination in the course of AMS dating.

* Measurements from the Leibniz Labor for AMS Dating and Stable Isotope Research, Christian Albrechts University, Kiel, Germany.

| Lab. No. | Yield (%)* | %C§ | %N§ | atomic C/N | $\delta^{13}C$ (‰)§ | $\delta^{15}N$ (‰)§ | Conventional $^{14}C$ age BP* | Maximum age cal BC ¶ (95,4 % probability) | Reference |
|---|---|---|---|---|---|---|---|---|---|
| KIA-49797 | 68 | 60.3 | 4.0 | 17.5 | –27.38 | 8.05 | 6386 ± 21 | 5470–5320 | *Piezonka 2015* |
| KIA-33929 | 18 | 62* | | | –24.3 | | 6340 ± 30 | 5460–5220 | *Piezonka 2008* |
| KIA-49798 | 62 | 51.4 | 5.0 | 12.1 | –27.76 | 6.31 | 6314 ± 22 | 5340–5220 | *Piezonka 2015* |
| MAMS-27322 | | 13.4 | | | –27.2 | | 6290±27 | 5320–5220 | Unpublished |
| KIA-49799 | 62 | 54.1 | 54.1 | 7.7 | –28.10 | 9.42 | 6285 ± 30 | 5320–5220 | *Piezonka 2015* |
| MAMS-27321 | | 30.6 | | | –23.3 | | 6273±28 | 5310–5220 | Unpublished |
| Poz-84485 | | | | | | | 6240±40 | 5310–5070 | Unpublished |
| MAMS-27311 | | | | | –24.5 | | 6236±34 | 5310–5070 | Unpublished |
| Poz-92774 | | | | | | | 6230±40 | 5310–5060 | Unpublished |
| Le-5868 | | | | | | | 6220±150 | 5480–4810 | *Nedomolkina 2004* |
| Le-5856 | | | | | | | 6200±170 | 5480–4730 | *Nedomolkina 2004* |
| KIA-33927 | 71 | 53.4 | 8.7 | 7.2 | –29.34 | 10.27 | 6185 ± 30 | 5220–5040 | *Piezonka 2008* |
| Poz-92587 | | | | | | | 6170±40 | 5220–5000 | Unpublished |
| MAMS-27313 | | | | | –23.9 | | 6126±32 | 5210–4980 | Unpublished |
| Poz-84485 | | | | | | | 6110±40 | 5210–4940 | Unpublished |
| KIA-33928 | 61 | 56.3 | 4.7 | 14.1 | –30.88 | 10.33 | 6105 ± 30 | 5210–4940 | *Piezonka 2008* |
| MAMS-27312 | | | | | –24.7 | | 6068±33 | 5190–4850 | Unpublished |
| MAMS-27320 | | | | | –28.4 | | 6059±29 | 5050–4850 | Unpublished |
| MAMS-27317 | | | | | –21.3 | | 5957±26 | 4930–4770 | Unpublished |
| MAMS-27310 | | | | | –25.5 | | 5928±35 | 4900–4720 | Unpublished |
| MAMS-27318 | | | | | –23.8 | | 5898±26 | 4830–4710 | Unpublished |
| Le-5857 | | | | | | | 5700±700 | 6100–3010 | *Nedomolkina 2004* |
| GIN-10182 | | | | | | | 5650±150 | 4900–4080 | *Nedomolkina 2004* |
| KIA-49796 | 52 | 56.3 | 9.4 | 7.0 | –28.54 | 11.87 | 5492 ± 23 | 4440–4270 | *Piezonka 2015* |
| KIA-33926 | 61 | 48.8 | 9.2 | 6.2 | –30.51 | 12.66 | 5425 ± 30 | 4340–4240 | *Piezonka 2008* |
| GIN-10180 | | | | | | | 5220 ± 320 | 4800–3350 | *Nedomolkina 2004* |

¶ The results have been calibrated using OxCal v4.2.4 (*Bronk Ramsey 2009*) and the IntCal13 (*Reimer* et al. *2013*) calibration data, with date ranges rounded outwards to the nearest 10 years. The carbonized surface residue cannot be older than this date range. If the $^{14}C$ age is subject to a freshwater reservoir effect, the true date of the carbonized surface residue could be significantly more recent.

# Chronology of Kama Neolithic culture

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ABSTRACT – *The concept of the Kama Neolithic culture was proposed by Otto Bader, but lacked radiocarbon dates in the 20th century. Now, we have more than 50 radiocarbon dates that can be attributed to the Kama Neolithic culture. The results of radiocarbon analysis of organogenic materials of the Kama culture allow us to determine its chronological limits between the second quarter of the 6th and the beginning of 4th mill. cal BC. The early phase of the Kama culture is now dated between the second quarter of the 6th and the beginning of the 5th mill. cal BC, the middle phase is dated to the first half of the 5th mill. cal BC, and the late phase is dated between the second half of 5th and the beginning of 4th mill. cal BC.*

KEY WORDS – *Kama Basin; Neolithic; radiocarbon dating; comb ware pottery; stone tools; dwellings*

## *Kronologija neolitske kulture Kama*

IZVLEČEK – *Koncept neolitske kulture Kama je predlagal Otto Bader, vendar je bila kultura v 20. stoletju brez radiokarbonskih datumov. Danes imamo zanjo že več kot 50 radiokarbonskih datumov. Rezultati radiokarbonskih analiz organskih ostankov nam omogočajo, da postavimo njene kronološke meje med drugo četrtletje 6. tisočletja in začetkom 4. tisočletja pr. n. št. Zgodnja faza kulture Kama je trenutno postavljena med drugo četrtletje 6. in začetek 5. tisočletja pr. n. št., srednja faza je datirana v prvo polovico 5. tisočletja pr. n. št. in zadnja, njena pozna faza, je datirana med drugo polovico 5. in začetkom 4. tisočletja pr. n. št.*

KLJUČNE BESEDE – *porečje reke Kama; neolitik; radiokarbonsko datiranje; lončenina z glavničastim okrasom; kamena orodja; bivališča*

## Introduction

The study area is situated in the Cis-Urals flatlands in the basin of the Kama River (Fig. 1). This is a high plain intersected with river valleys and hollows. The Kama, Vishera, Chusovaya, Belaya, and Vjatka rivers are the largest in the area. Shallow-lying resistant Pre-Quaternary rocks outcropping in the sides of the river valley form specific relief features. The valleys cut into these deposits and therefore have box-shape cross sections: relatively wide bottoms composed of loose alluvium, and steep solid sides, including cliffs of basement terraces.

The climate of the study area is moderately continental. Precipitation is relatively high for this latitude and longitude due to the piedmont position of the area. The peak of the hydrologic regime of the rivers is mostly during the spring flood; in the winter season, the rivers are frozen. The landscapes of the floodplain are comprised mostly of willow-poplar forests on sod-fibrous sand floodplain soils. The high right bank landscape is forest-steppe (grassland); the left bank terrace is covered with pine forest (*Lychagina* et al. *2013b.210*).


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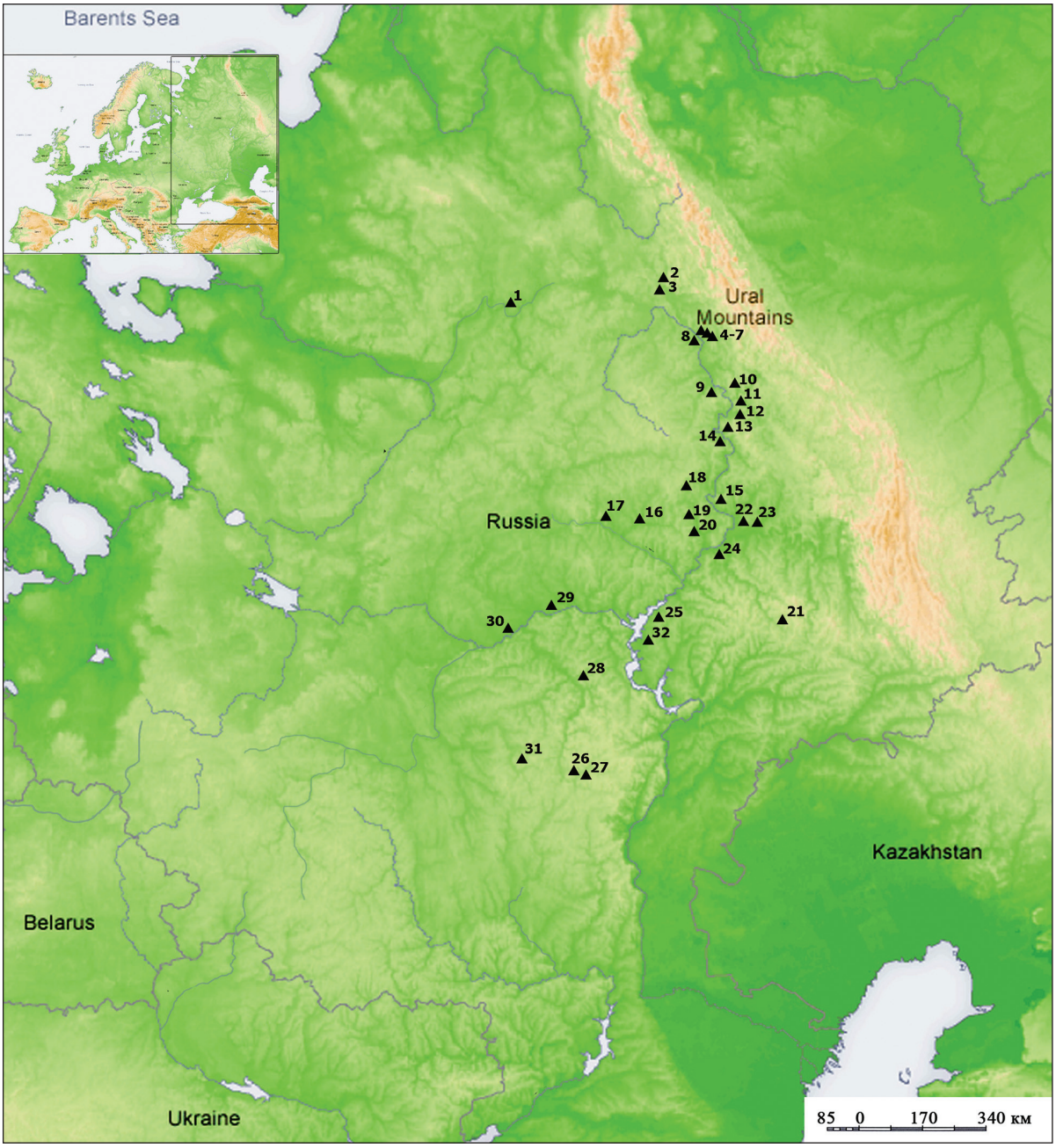



***Fig. 1. Map of the research area. 1 Pezmog IV; 2 Chirva II; 3 Vasjukovo II; 4 Khutorskaya; 5 Lake Chashkinskoye I; 6 Lake Chashkinskoye IIIa; 7 Lake Chashkinskoye VI; 8 Ust-Zalaznushka II; 9 Posyor; 10 Lake Borovoe I; 11 Lyovshino; 12 Mokino; 13 Krjazhskaya; 14 Chernashka; 15 Chernushka; 16 Tarhan I; 17 Ust-Shizhma; 18 Srednee Shadbegovo; 19 Kyilud III; 20 Chumoytlo; 21 Mullino; 22 Ziarat; 23 Sauz II; 24 Caen-Tubinskaya; 25 II Lebedinskaya; 26 Podlesnoe III; 27 Podlesnoe IV; 28 Lake Molebnoe I; 29 Otarskaya VI; 30 Nizhnaya strelka V; 31 Ozimenki II; 32 Lesnoe-Nikolskoe III).***

The 'Neolithic package' in the Kama region includes the emergence of pottery, new kinds of stone tools, an increase in subterranean dwellings, the transition to sedentism through the development of active fishing and hunting without a transition to a productive economy, and changes in worldview.

The concept of the Kama Neolithic culture was proposed by Otto Bader (*Bader 1970.165–169*). Based on the results of typological analyses and stratigraphic evidence, he proposed two stages of this culture: the Khutorskoy stage (developed or middle Neolithic) and the Lyovshinskiy stage (Late Neolithic) (*Bader 1978.72–74*). Early Neolithic sites were discovered in the Kama basin in the 1970 and 1980s. At present, Kama culture is divided into three stages: Early Neolithic, Khutorskoy and Lyovshinskiy stages (*Lychagina 2013a.55–67*).

Unfortunately, no radiocarbon dates were available for this culture in the last century. Therefore, the chronological frameworks of the culture were based on analogies with other cultures, for example, Poludenskaya, Dnieper-Donets culture, and others. Otto Bader dated the Khutorskoy (middle) stage to the second half of the 4th millennium BC (5500–5000 BP) and the Lyovshinskiy (late) to the first half of the 3rd mill. BC (5000–4500 BP) (*Bader 1978.73*). At the beginning of the present century, extensive radiocarbon dating of the Neolithic in the Kama region was done. These studies allowed a chronology of Kama culture to be created.

**Early phase of the Kama culture**

*Basic sites:* Mokino, Ust-Bukorok, Ziarat, Ust-Shizhma I, Tarkhan I, Scherbet II, Mullino, Podlesnoe III, and Pezmog IV.

*Site location:* Most of the sites are located on the remnants of the floodplains of small rivers flowing into the Kama and Vyatka rivers, or on the first terrace of the Kama River and its tributaries (Fig. 1).

*Dwellings:* The remains of Kama dwellings were discovered at the Ust-Bukorok and Tarkhan I sites. They were 25.5–66m² in area and had rectangular ground plans. Their sunken floors were cut *c.* 30–40cm into the bedrock, with one fireplace near the exit, and household pits (Fig. 2.1–2).

*Pottery:* The ceramic assemblages are rather small and include only up to 250 fragments. Irina N. Vasilyeva of the Samara State Academy of Social Sciences and Humanities carried out technological analyses of the pottery from the Ziarat site (Fig. 5). The results show that iron-rich clays were used as raw material. The clay was mixed with tempering materials, resulting in various paste recipes: clay and chamotte in 1:1, 1:2, 1:3 concentrations mixed with an organic solution (*Vasilyeva, Vybornov 2012.36–40*).

The surfaces of all of the vessels were smoothed with a soft object; the average thickness of the wall is 0.9–1cm. The bases are either rounded or bevelled. A slight overlap of a rim was noted only on a vessel from the Mokino site. Most of the vessels have a semi-elipsoid form with a straight or slightly covered neck.

The ornamentation is composed of impressions of small and middle-notched long stamps, with the use of oval short stamp impressions, mostly to divide

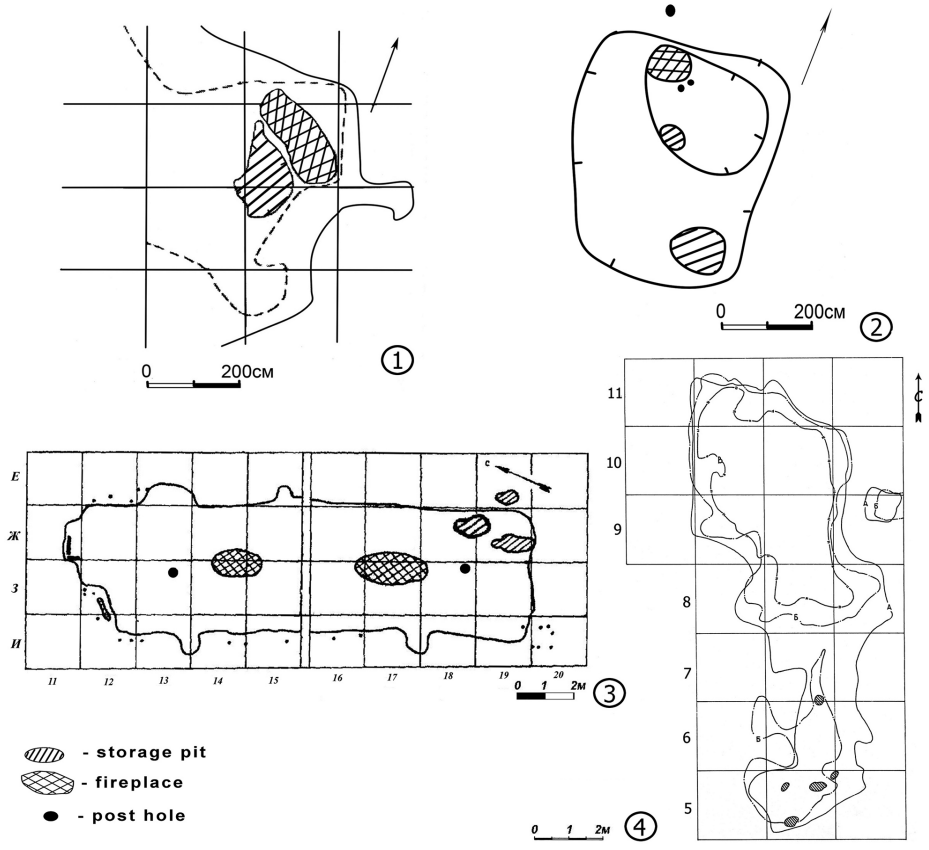



***Fig. 2. Neolithic dwellings. 1 Ust-Bukorok; 2 Tarkhan I; 3 Khutorskaya; 4 Ust-Zalaznushka II.***

the ornamental areas. Rows of oblique stamp impressions, vertical zigzags and rows of long stamp impressions divided by short impressions prevail among the patterns (Figs. 3–5).

The distinctive features of this complex include the prevalence of long stamp impressions, the rare occurrence of the overlap on the rim, and the rare use of 'walking comb' patterns in the vessels' decoration (*Lychagina, Tsygvintseva 2013.23*).

*Stone tools:* The use of pebble and tabular flint as a raw material, as well as mixed blade and flake industry with a prevalence of narrow and medium blade tools are typical of the Kama lithic industry (*Vybornov 1992.98; Gusentsova 1993.141; Mel'nichuk* et al. *2001.154–155, 159; Lychagina, Tsygvintseva 2013.35, Fig. 5*). The main categories of tools are blades and fragmented blades with retouching (Fig. 6.1–6, 11–12), end-scrapers (Fig. 6.7–10), truncation burins made on broken blades (Fig. 6.13–16), and points made on blades. At the same time, the group of bifacially-knapped tools such as knives and arrowheads made of tabular flint, is also quite important (Fig. 6.17–20). Polished tools (axes, adzes) are also found.

The Kama lithic tools bear the features of both the Mesolithic (the active use of blades with edge retouch, end scrapers on blades, truncation burins) and the Neolithic (bifacial tools made of tabular flint and polished tools). Similar tools can be traced at Late Mesolithic sites in the Kama region: Ust-Polovinnoye, Shabunichi, Golyi Mys, and Ust-Mechkar (*Mel'nichuk* et al. *2001.143–153*). All of this shows that the Kama Neolithic culture could have emerged from the local Late Mesolithic.

*Chronology:* There are 14 radiocarbon dates known from seven early Neolithic sites (Tab. 1). Unfortunately, more than half of the dates obtained are based on organic matter in pottery. However, these dates do not contradict the dates obtained from other materials (carbon, organic crust) (*Lychagina* et al. *2013a.247–253*). The earliest dates were acquired for the Pezmog IV site, which is the northernmost Kama site, located in the Vychegda River basin (Fig. 3) (*Karmanov* et al. *2012.331–338; 2014.733–741*). This could be evidence to support the hypothesis of the emergence of

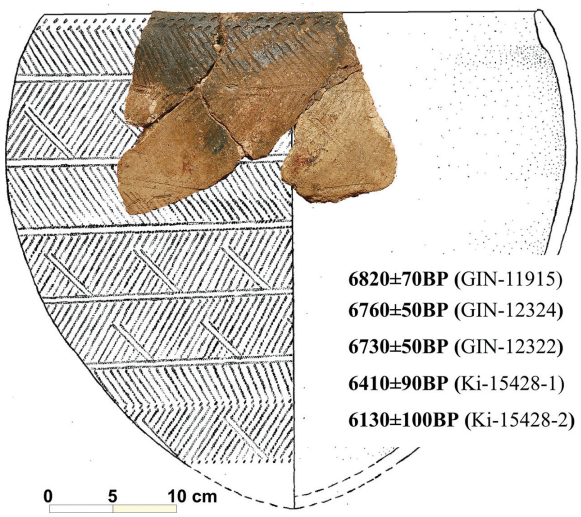



***Fig. 3. Early comb-ware pottery. Pezmog IV site (modified from* Karmanov *et al.* 2014.737, Fig. 4*).***

Kama-type pottery first in the north, and its gradual spread to the south.

The closest analogy to the Kama pottery can be found in the Northern Trans-Ural region, where pottery of Yet-to type has been recorded (*Kosinskaya 2014. 30–40*). The sites of both types were contemporary with each other; however, older dates have recently been obtained for the Yet-to I settlement. Thus, the pottery of Yet-to type can be considered as a possible source for the early comb pottery in the Cis-Ural region. Thus, the early stage can be dated between the second quarter of the 6th and the beginning of the 5th mill. cal BC (*Lychagina 2013b.53; Karmanov* et al. *2012.331–338*).

## Middle (Khytorskaya) phase of the Kama culture

*Basic sites:* Khytorskaya, Lake Borovoe I, Krjazhskaya, Lake Chashkinskoye IIIa, Chirva II, Vasjukovo II,




***Fig. 4. Early comb-ware pottery with crust (1 Ziarat, 2 Mokino).***

Krasnoye Plotbische, Posyor, Kjun II, Sauz II, Lebedinskaya II, Murzihinskaya IV, Kyilud III, Srednee Shadbegovo, Lake Zabornoye, Neprjaha VI, Podlesnoe IV, Kaen-Tubinskaya, and Otarskaya VI.

*Site location:* The sites are located on the lower first terrace or high floodplain on the banks of large rivers (Kama, Vishera, Vyatka, Belaya) and oxbow lakes (Fig. 1).

*Dwellings:* They were rectangular or square, deep in the bedrock at 20–90cm, 40–200m$^2$ in area. One to three long-term fireplaces and household pits were found inside the dwellings (Fig. 2.3).

*Pottery:* The ceramic assemblages exceed 1000 fragments at most sites. The technological analysis has shown that the usage of clays (71%) and silty clays (29%) was typical of vessel manufacture in this period. Both dry and wet raw materials were used. The paste remained unchanged: clay and chamotte in 1:3, 1:4 concentrations mixed with organic solution (*Vasilyeva, Vybornov 2012.36–40*).

The surface of all the vessels was smoothed over with a soft object; the average thickness of the wall is 0.9–1.1cm. Pottery of the Khutorskaya stage is characterised by semi-elipsoid forms, with a slightly rounded or conical bottom and a slightly narrowed neck (Figs. 7–8). The inner sides of about 60–70% of the rims were slightly thickened.

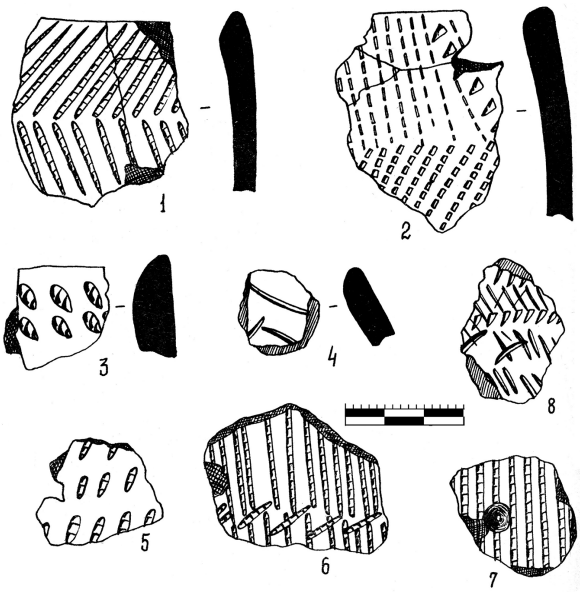


***Fig. 5. Early comb-ware pottery. Ziarat site.***

The outer surface of all pots was densely decorated; decoration included comb stamp impressions along with rounded impressions. The patterns consisted of 'walking comb' impressions (up to half of all vessels), zigzags, verticals, and the inclined and horizontal lines of the stamp (Figs. 7–8). Some vessels' decora-

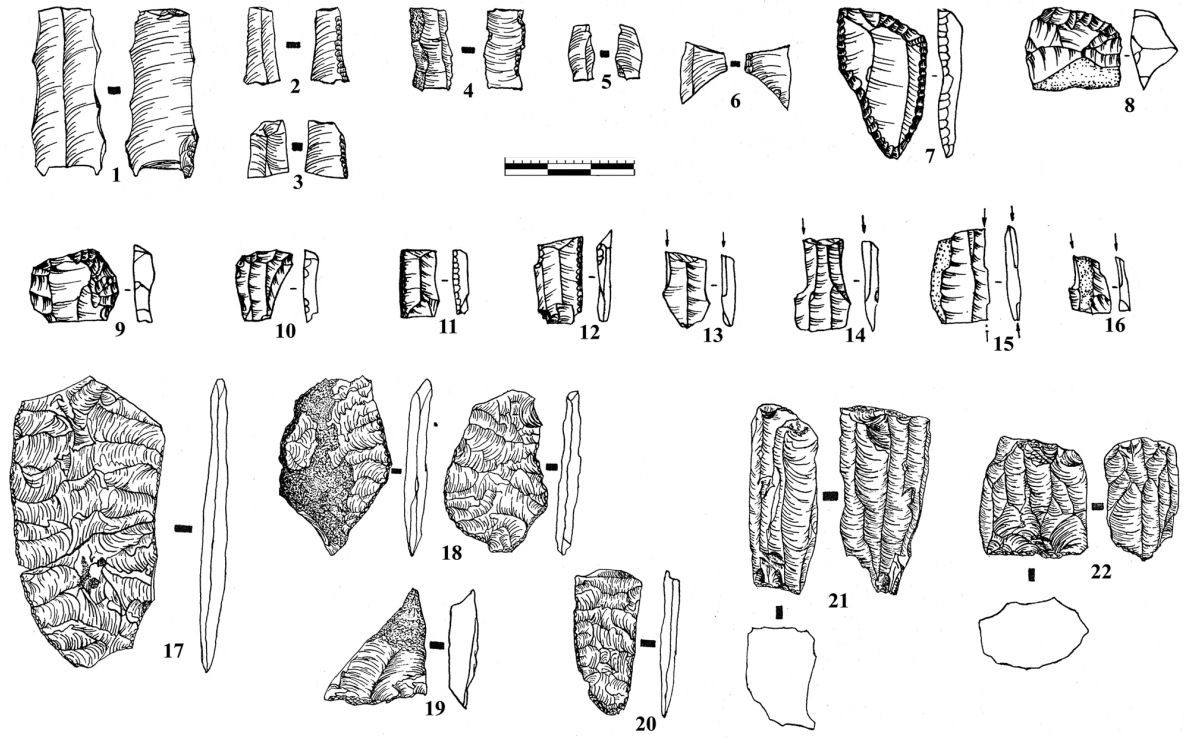


***Fig. 6. Stone implements of the early phase of Kama culture (1–16 Ziarat site; 17–22 Mokino site). Artefacts are numbered according to the discussion in the main text.***

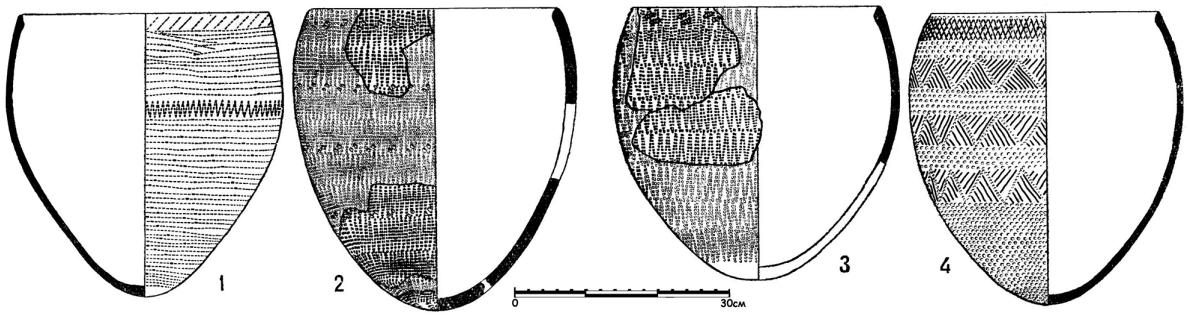



***Fig. 7. Comb-ware pottery of the middle phase of the Kama culture. Khutorskaya site (from* Denisov 1960. 41, Fig. 7*).***

tion was complex, consisting of shaded triangles, diamonds, and rectangles.

*Stone tools:* The stone tools are characterised by blades and flakes, and the use of pebble and tabular flint as a raw material. Approximately a third the tools was manufactured on blades and has an edge-sided retouch. The main categories of tools include knives, arrowheads, chisel tools, and scrapers (Fig. 9). A polishing technique was used to make tools for woodworking: axes, adzes, and chisels (*Bader 1970. 167; Lychagina 2013a.62–63*).

*Chronology:* Twenty-nine dates were obtained for 16 sites attributed to the Khytorskaya stage (Tab. 1). The comparison of dates obtained for various materials showed that the dates of the organic material in the pottery appeared to be nearly 1000 years older than some of the dates obtained on charcoal. It might be supposed that dates from carbon material could have been younger due to the presence of the Chalcolithic complex at the Khutorskaya and Chashkinskoe Lake IIIa sites. In addition, the samples could have been contaminated, because part of the cultural layer was destroyed by modern pits.

This assumption is also supported by the fact that the AMS-date 5705 ± 35 BP (Poz-57870) of organic crust from the pottery from the Posyor site appeared to be contemporary with the dates of the ceramics (Tab. 1). Thus, the middle stage of the Kama culture can be dated to the first half/ middle of the 5$^{th}$ mill. cal BC (*Vybornov 2008.143–146; Lychagina 2011.28–33; 2014.86–92*).

### Late (Lyovshinskaya) phase of the Kama culture

*Basic sites:* Lyovshino, Lake Chashkinskoye VI, Chernashka, Ust-Zalaznushka II, Chernushka, Boitsovo I, Pisanyi Kamen, Kochurovskoye I, Kochurovskoye IV, Chumoytlo, Sauz I, Ryssko-Azibeyskaya, Tetyushskaya II, Balahchinskaya VIa, Neprjaha VII, Bachki-Tau II, Nizhnaya strelka V, Ozimenki II, and Lesnoe – Nikolskoe III.




***Fig. 8. Comb-ware pottery of the middle phase of the Kama culture. Lake Chashkinskoye IIIa site.***

*Site location:* Campsites located on the first terrace of the Kama River and its tributaries, as well as oxbow lakes (Fig. 1).

*Dwellings:* They were rectangular, deep in the bedrock at 20–60cm, 30–60m$^2$ in area. Household pits were found inside the dwellings, whereas hearths were not clearly traced (Fig. 2.4).

*Pottery:* The ceramic assemblages exceed 1000 fragments on most sites. According to the technological analysis of the raw material, the tradi-

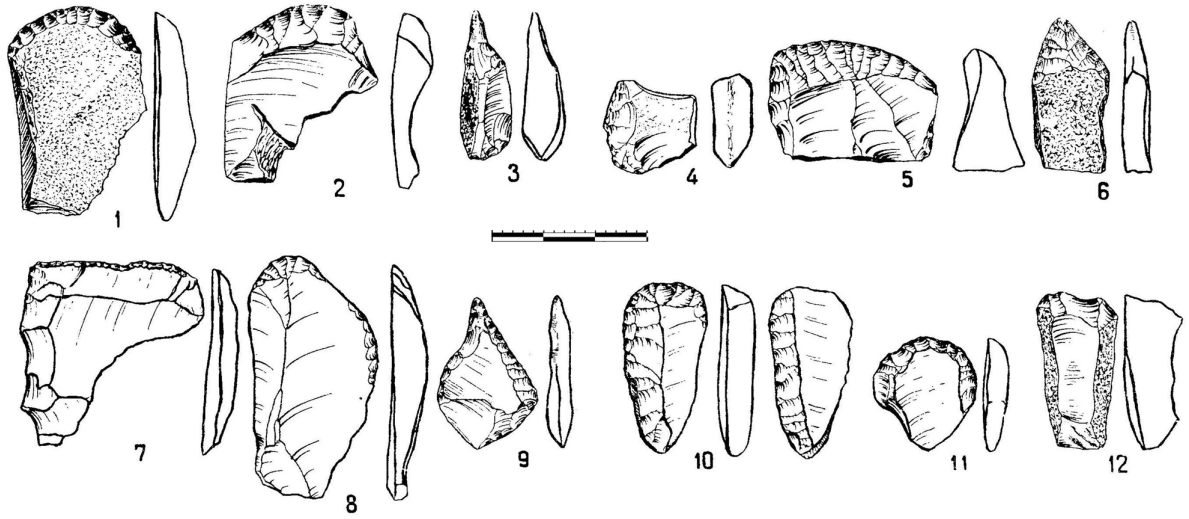


***Fig. 9. Stone implements of the middle phase of Kama culture. Khutorskaya site (from* Denisov 1960.57, Fig. 16*).***

tion of using clay (75%) and silty clay (25%) remained, while there was less use of crushing dry clay. Chamotte and organic solution were still used as a temper, but the concentration of chamotte decreased (*Vasilyeva, Vybornov 2012.36–40*).

The surface of all the vessels was smoothed over with a soft object; the average thickness of the wall is 0.8–1cm. The pottery of the Lyovshinskaya stage is characterised by large vessels ornamented by a comb stamp, with a slightly covered or straight cylindrical neck, with a conical or rounded base, and rims without overlap. The decorative pattern consists of oblique, vertical and horizontal stamp impressions, zigzags and 'walking comb' impressions. Rounded impressions and stamp impressions made at an angle were often used to the divide ornamental areas (Figs. 10–11). The decoration is not as dense as on the pottery of the Khutorskaya stage. Undecorated areas could be up to 2cm (*Lychagina 2013a. 66*).

It should be noted that Kama culture pottery is characterised by its homogeneity and the stability of skills in the manufacturing technique. The use of clays in a dry state tempered with chamotte and organic solution, semi-elipsoid vessel forms, and ornamentation made with comb stamp impressions are typical for this phase. The appearance of other raw materials (silty clay) and technological methods (use of wet raw materials) could be associated with the influence of other cultures (Volga-Kama culture).

*Stone tools:* Tabular flint and flat flint pebbles, an absence of sustainable core forms, and a flake industry typify the stone industry. Bilateral pressure retouch played an important role as a secondary treatment technique (Fig. 12). The main tools included various types of scraper (30–60% of the total number), knives on flakes, leaf-shaped points, chisel tools, arrowheads and polished adzes (*Lychagina 2013a.66*).

*Chronology*: Fourteen dates were obtained for nine sites (Tab. 1). Some of the dates appeared to be beyond the time frames of this stage; perhaps some sites (Chernashka, Ust-Zalaznushka II) should be attributed to an earlier stage. It is necessary to date the organic crust of the comb ware from the Lyov-



***Fig. 10. Late phase Kama culture comb-ware pottery. Lyovshino site.***

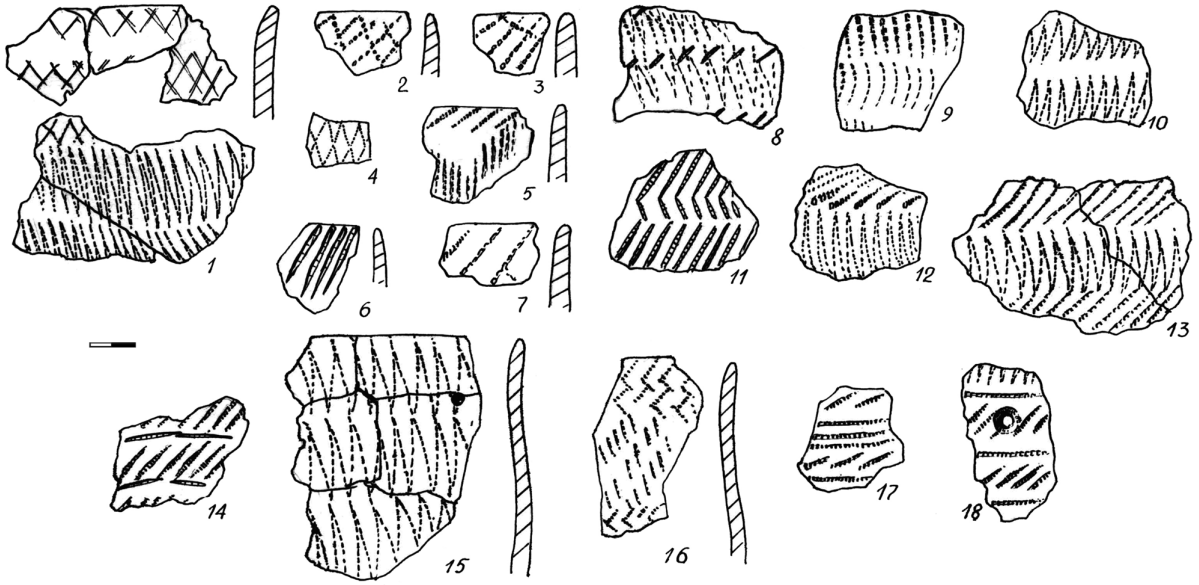


*Fig. 11. Late phase Kama culture comb-ware pottery. Lyovshino site.*

shino site to better define the chronological time-frame of the late stage of the Kama culture. The Lyovshino stage can now be dated approximately to the second half of the 5th and beginning of 4th mill. cal BC (*Vybornov 2008.143–146; Lychagina 2011. 28–33; 2014.86–92*). This subject needs to be further investigated.

## Conclusion

Due to the radiocarbon dating of Neolithic sites in the Cis-Urals region conducted over the past ten years, the Kama culture appeared to be 1000 years older than previously thought. The results of radiocarbon analysis of organogenic materials from the sites attributed to the Kama culture allowed us to precisely fix its chronological boundaries and date it to the second quarter of the 6th and beginning of 4th mill. cal BC. The early phase of the Kama culture can be dated between the second quarter of the 6th and the beginning of the 5th mill. cal BC, the middle phase is dated to the first half of the 5th mill. cal BC, and the late phase is dated between the second half of the 5th and the beginning of the 4th mill. cal BC. In the future, it will be necessary to continue dating various types of organogenic materials from Kama sites in order to better define the chronological time-frames of the different phases and sites.

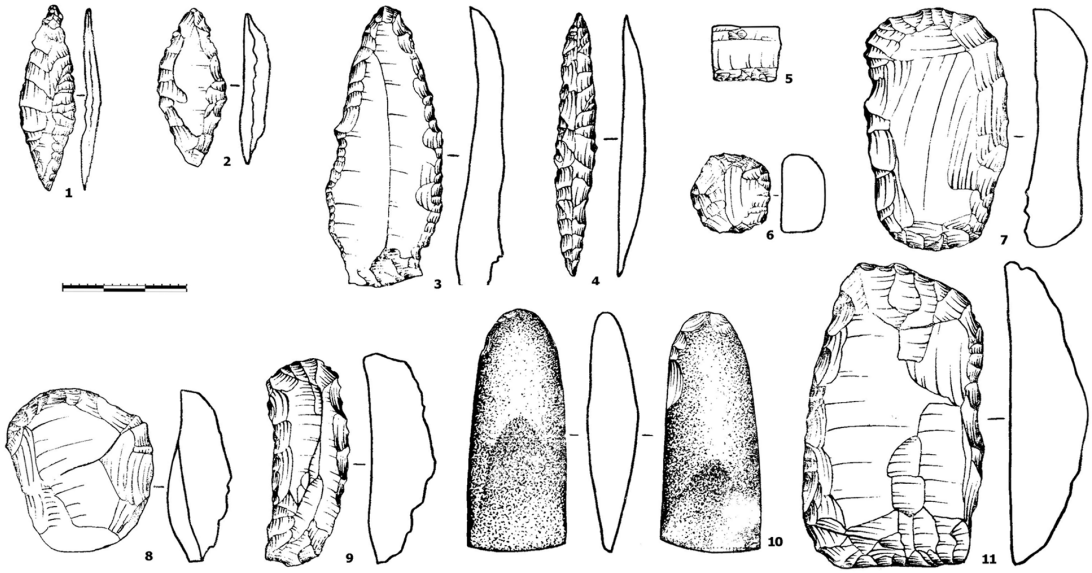


*Fig. 12. Stone implements from the late phase of Kama culture. Boitsovo I site (from* **Bader 1960.127, Fig. 11***).*

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***Tab. 1. Radiocarbon dates for Kama culture sites (comb-ware pottery).***

| No. | Site | Age (BP) | Age, calBC (2 σ) | Index | Material |
|---|---|---|---|---|---|
| 1 | Pezmog IV | 6730±50 | 5724–5603 | GIN-12322 | Charcoal |
| 2 | Pezmog IV | 6760±50 | 5749–5558 | GIN-12324 | Cultural deposit |
| 3 | Pezmog IV | 6820±70 | 5849–5617 | GIN-11915 | Crust |
| 4 | Pezmog IV | 6130±100 | 5307–4830 | Ki-15428-2 | Pottery carbon |
| 5 | Pezmog IV | 6410±90 | 5544–5213 | Ki-15428-1 | Pottery carbon |
| 6 | Mokino | 6219±42 | 5305–5055 | Hela-2990 | Crust |
| 7 | Ziarat | 6323±43 | 5465–5210 | Hela-2991 | Crust |
| 8 | Ziarat | 6110±80 | 5280–4800 | Ki-15087 | Pottery carbon |
| 9 | Ziarat | 6070±80 | 5300–4700 | Ki-15061 | Pottery carbon |
| 10 | Tarhan I | 6280±90 | 5470–4990 | Ki-14433 | Pottery carbon |
| 11 | Mullino | 6290±80 | 5470–5040 | Ki-15638 | Pottery carbon |
| 12 | Ust–Shizhma | 6020±90 | 4940–4490 | Ki-14435 | Pottery carbon |
| 13 | Podlesnoe III | 6110±80 | 5280–4800 | Ki-14565 | Pottery carbon |
| 14 | Podlesnoe III | 6070±90 | 5300–4700 | Ki-14564 | Pottery carbon |
| 15 | Khutorskaya | 5840±80 | 4860–4490 | Ki-14419 | Pottery carbon |
| 16 | Khutorskaya | 5930±80 | 5000–4590 | Ki-14414 | Pottery carbon |
| 17 | Khutorskaya | 5750±80 | 4790–4440 | Ki-15093 | Pottery carbon |
| 18 | Khutorskaya | 5920±90 | 5030–4540 | Ki-14420 | Pottery carbon |
| 19 | Khutorskaya | 5040±130 | 4053–3628 | SOAN-6817 | Charcoal |
| 20 | Khutorskaya | 4990±110 | 3995–3627 | SOAN-6818 | Charcoal |
| 21 | Khutorskaya | 5130±250 | 4500–3300 | GIN-14226 | Charcoal |
| 22 | Lake Borovoe I | 5760±90 | 4810–4440 | Ki-14415 | Pottery carbon |
| 23 | Lake Borovoe I | 5950±80 | 5050–4610 | Ki-15094 | Pottery carbon |
| 24 | Krjazhskaya | 5620±90 | 4690–4320 | Ki-14416 | Pottery carbon |
| 25 | Lake Chashkinskoye I | 5700±80 | 4720–4360 | Ki-16166 | Pottery carbon |
| 26 | Lake Chashkinskoye IIIa | 4920±30 | 1σ 3707–3656 | GIN-14769 | Charcoal |
| 27 | Lake Chashkinskoye IIIa | 5000±60 | 1σ 3806–3705 | GIN-14770 | Charcoal |
| 28 | Lake Chashkinskoye IIIa | 5040±70 | 1σ 3945–3775 | GIN-14771 | Charcoal |
| 29 | Chirva II | 6158±150 | 5500–4700 | Spb-741 | Pottery carbon |
| 30 | Vasjukovo II | 5270±80 | 4260–3950 | Ki-16857 | Pottery carbon |
| 31 | Posyor | 5705±35 | 4620–4458 | Poz-57870 | Crust |
| 32 | Posyor | 4020±110 | 2900–2200 | Spb-742 | Pottery carbon |
| 33 | Srednee Shadbegovo | 5960±90 | 5100–4550 | Ki-14437 | Pottery carbon |
| 34 | Kyilud III | 5820±90 | 4860–4450 | Ki-14438 | Pottery carbon |
| 35 | Sauz II | 5930±80 | 5000–4590 | Ki-14585 | Pottery carbon |
| 36 | Sauz II | 5620±90 | 4690–4320 | Ki-14581 | Pottery carbon |
| 37 | Podlesnoe IV | 5930±80 | 4960–4520 | Ki-14459 | Pottery carbon |
| 38 | Podlesnoe IV | 5920±120 | 5250–4450 | Spb-726 | Pottery carbon |
| 39 | Lake Molebnoe I | 5980±90 | 5250–4600 | Ki-14442 | Pottery carbon |
| 40 | Otarskaya VI | 5890±80 | 4950–4540 | Ki-14423 | Pottery carbon |
| 41 | II Lebedinskaya | 5670±100 | 4720–4330 | Ki-14905 | Pottery carbon |
| 42 | Caen-Tubinskaya | 5680±80 | 4710–4350 | Ki-14107 | Pottery carbon |
| 43 | Caen-Tubinskaya | 5620±80 | 4680–4330 | Ki-14141 | Pottery carbon |
| 44 | Lake Chashkinskoye VI | 5695±80 | 4720–4350 | Ki-14538 | Pottery carbon |
| 45 | Chernushka | 5400±70 | 4360–4040 | GIN-13449 | Charcoal |
| 46 | Chernushka | 5960±80 | 5060–4670 | Ki-14418 | Pottery carbon |
| 47 | Chernashka | 5840±90 | 4860–4490 | Ki-16645 | Pottery carbon |
| 48 | Ust-Zalaznushka II | 6330±40 | 5464–5217 | Poz-52698 | Crust |
| 49 | Ust-Zalaznushka II | 5880±80 | 4940–4540 | Ki-14417 | Pottery carbon |
| 50 | Ust-Zalaznushka II | 5790±100 | 4900–4350 | Spb-738 | Pottery carbon |
| 51 | Lyovshino | 4850±100 | 3950–3350 | Ki-16849 | Pottery carbon |
| 52 | Chumoytlo | 5720±90 | 4730–4360 | Ki-14439 | Pottery carbon |
| 53 | Chumoytlo | 5544±42 | 4460–4330 | Hela-3114 | Crust |
| 54 | Nizhnaya strelka V | 5510±90 | 4550–4210 | Ki-14422 | Pottery carbon |
| 55 | Ozimenki II | 5650±80 | 4690–4340 | Ki-14589 | Pottery carbon |
| 56 | Ozimenki II | 5490±90 | 4500–4040 | Ki-14138 | Pottery carbon |
| 57 | Lesnoe-Nikolskoe III | 5400±90 | 4370–3990 | Ki-14582 | Pottery carbon |

# Chronological timeframes of cultural changes in the Dnepr-Dvina region (7th to 3rd millennium BC)

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ABSTRACT – *Since the 1960s, more than 250 radiocarbon dates have been obtained for materials in the Upper Western Dvina area, which cover a timeframe from the 7th to the 1st millennium BC. Radiocarbon dates for materials of the Dnepr-Dvina area date the appearance and decline of various cultural traditions – from the formation of the most ancient pottery among hunter-gatherer communities until the appearance of the first stock-breeders in the forest zone, the bearers of cultural traditions of the Corded Ware culture. Dates for materials from the Upper Dvina area show both the existence of hiatuses between some cultural-chronological groups coinciding with some significant climatic and environmental changes, and the quasi (?) co-existence of some of the groups. Could these hiatuses also be traced in material culture, or do they appear because of a lack of data?*

KEY WORDS – *Eastern Europe; chronology; Neolithic; earliest pottery; pile-dwellings; Linear Band Keramik (LBK); Bronze Age*

## *Kronološki okvirji kulturnih sprememb v regiji rek Dneper in Dvina*

IZVLEČEK – *Od 60. let 20. stoletja smo pridobili že več kot 250 radiokarbonskih datumov za najdbe iz zahodnega območja reke Dvina, ki sodijo v čas med 7. in 1. tisočletjem pr. n. št. Datumi iz območja rek Dneper in Dvina datirajo pojav in zaton različnih kulturnih tradicij – od oblikovanja najstarejše lončenine pri skupnostih lovcev in nabiralcev do pojava prvih živinorejcev na območju gozdne cone, ki so bili nosilci kulturnih tradicij vrvičaste keramike. Datumi iz območja zgornjega toka reke Dvina kažejo na prekinitve med nekaterimi kulturno-kronološkimi skupinami, ki sovpadajo z nekaterimi pomembnimi klimatskimi in okoljskimi spremembami ter z domnevnim sobivanjem nekaterih skupin. Ali lahko tem prekinitvam sledimo tudi v materialni kulturi ali pa se pojavijo le zaradi pomanjkanja podatkov?*

KLJUČNE BESEDE – *vzhodna Evropa; kronologija; neolitik; najstarejša lončenina; kolišča; kultura linearno trakaste keramike; bronasta doba*

## Introduction

The period discussed in this article is attributed to the Neolithic, more precisely to the epoch also known as the 'Boreal Neolithic', 'Sub-Neolithic', 'Initial Neolithic' (*Davison* et al. *2007.140; Gronenborn 2010; Dolukhanov, Shukurov 2009.36; etc.*). This era is traditionally divided into three stages: early, middle and late. Its beginning is indicated in Eastern Europe by the appearance of pottery, and changes in com-


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plexity of social networks. The Dnepr-Dvina region (Fig. 1) has already been investigated for more than 50 years. At the very beginning of the 1960s, researchers aimed to reconstruct the cultural processes, chronology and natural-climatic conditions in this region (*Miklyaev 1969; Dolukhanov* et al. *1978*). Investigations of the Serteysky micro-region, where different archaeological cultures have been identified, started in the 1990s. The ancient inhabitants here occupied lake shore sites located within a distance of 10km from each other (*Miklyaev 1995; Zaitseva* et al. *2003; 2014; Mazurkevich* et al. *2013; Mazurkevich 2014*) (Fig. 1.b). In such a small microregion, cultural processes that can be traced archaeologically appeared to be very complicated. This is the reason for reconstructing this region's population, the termination of different cultural traditions, the appearance of new traditions, how they intermixed, and the time these processes took. However, a study of a particular time stratification of one region could create an illusion of evolutionary, successive development and changes of cultures.

Radiocarbon dating of definite ceramic types and cultural stages could correct our schemes, compelling a move away from habitual evolutionary and linear schemes. This creates a more complicated story, as will be demonstrated here. The stages and types distinguished in material culture based on typological method were verified by stratigraphic and spatial analysis. Radiocarbon dates were used to determine the absolute ages of these stages.

## Pottery of the 7–6th millennium BC: newcomers (Early Neolithic)

The cultural networks which existed in the 7–6th millennium BC connected this region with other regions of Eastern Europe: the Middle and Upper Volga, Upper, Middle and Lower Don, the Desna and Bug-Dnestr rivers and, later on, the Baltic region (*Mazurkevich, Dolbunova 2015*). These networks were reflected in the different pottery that penetrated into this region with new-comers (?). The pottery types were named phases 'a', 'a-1', 'a-2', 'b' – 'b-5', 'c-1' and 'c-2' (Fig. 2). The appearance of Rudnyanskaya culture phases 'd', 'd-1', and 'e' might reflect changes in cultural connections and the establishment of other directions of interaction, *i.e.* with the Baltics. Various materials were radiocarbon dated: organic crust, burnt bones, and wood. These materials were found in cultural layers with ancient pottery, in sediments with cultural remains, as well as in overlying sediments.

### *Earliest pottery*

Vessels attributed to phases 'a', 'a-1', and 'a-2' are dated to the 7th millennium BC (Fig. 3). Vessels of phase 'a' (Fig. 3.2–3), 'a-1' (Fig. 3.1), which lay at the bottom of cultural layers and was covered by lacustrine-marshy sediments, can be attributed to the earliest pottery in this region. The phase 'a' pottery from Rudnya Serteyskaya was found in a sandy layer, while some fragments were found in a layer of blueish sandy gyttja with shells. Fragments of vessel

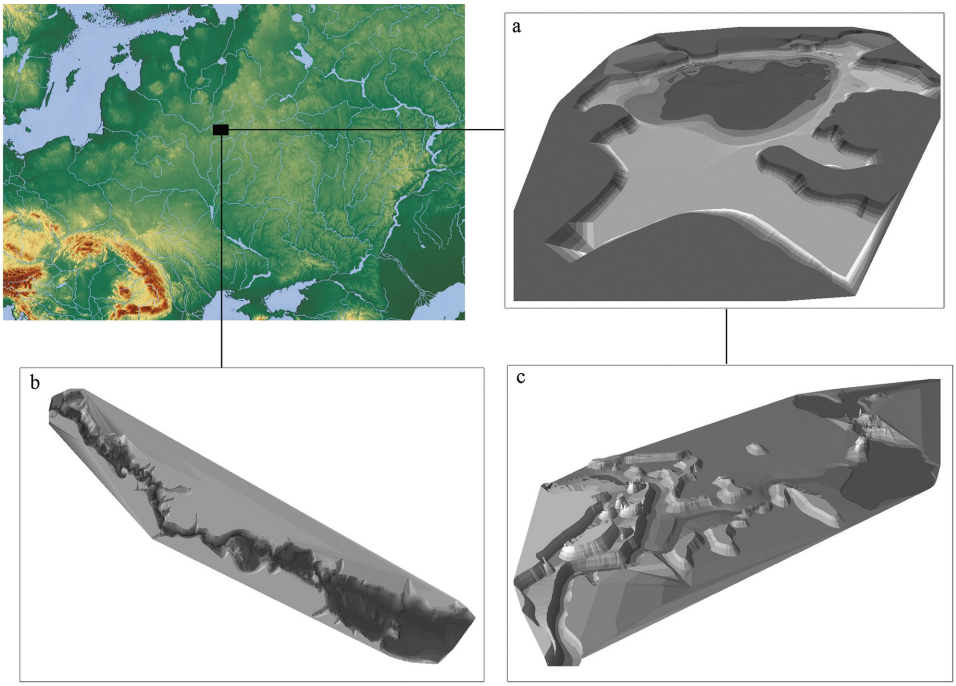



***Fig. 1. Dnepr-Dvina region: a Sennitsky; b Serteysky and c Usviatsky microregion.***

'a-1' were found in a sandy layer above the base layer at Serteya XIV. The sandy layer could have formed during the Boreal period. At this time, there was a regression and a time gap in sedimentation, which has been shown by a pollen diagram (*Dolukhanov* et al. *1989*). These finds were covered by a layer of gyttja dated to when the Holocene (At-1 period) lakes began to flood, according to the pollen analysis (*Dolukhanov* et al. *1989*). At the turn of the 7–6th millennium BC, environmental changes occurred which led to water transgression in a small lake depression (where the Serteya XIV site is located) up to the level of the second terrace. This flooded the preceding sites with pottery of phases 'a' and 'a-1' (*Mazurkevich* et al. *2003.266*).

Pottery from phase 'a' was found at Serteya X in a layer of bluish sandy gyttja rich in shell. The cultural remains lay in three horizons divided by sterile interlayers of bluish-grey sandy gyttja (*Mazurkevich* et al. *2003.261–262*). The gyttja layer deposited on the lake bottom that formed when the ancient sites containing phase 'a' pottery existed on its shores can be dated to 7800±120 BP (Ly-4255, 7032–6456 cal BC) – 7510±140 BP (Ly-4256, 6631–6077 cal BC). The formation of gyttja that covered the sediments at the Rudnya Serteyskaya site, at which finds from layer 'b' of the Serteya X site were found, could be dated to 7380±130 BP (Ly-4258, 6462–6013 cal BC) – 6680±150 BP (Ly-4277, 5890–5342 cal BC) (dates made on the sediments of core no. 63) (*Arslanov* et al. *2009*). Some of the vessels from phase 'a' were found in layer A-2 at Serteya X. They could be synchronous with wood from this layer dated to 7300±180 BP (Le-5260, 6495–5809 cal BC).

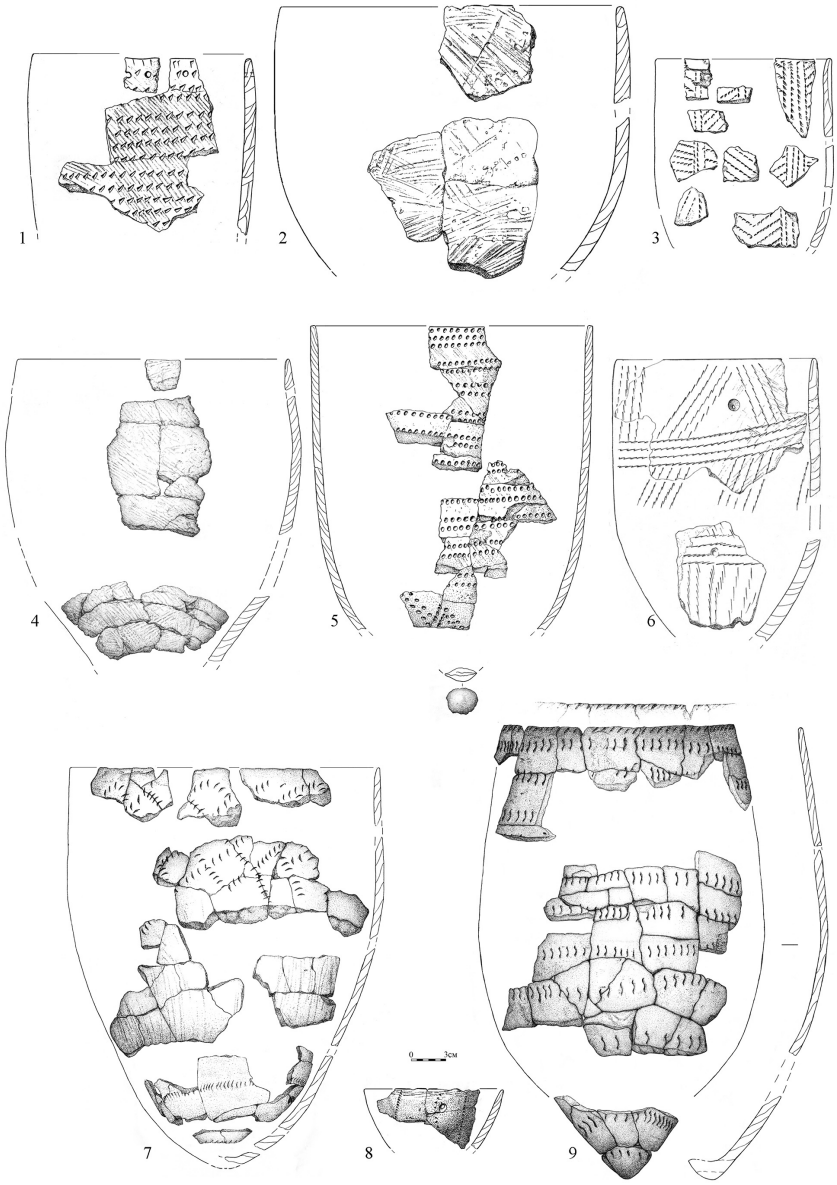



***Fig. 2. Early Neolithic pottery of the forest zone of Eastern Europe: 1, 3, 5, 7 phase 'b-1'; 2 phase 'c-1'; 4 phase 'a-1'; 6 phase 'a'; 8 phase 'b'; 9 phase 'b-4'.***

The organic crust on pottery decorated in a pin-pointed manner from phase 'a' are dated to 7870±100 BP (Ua-37100, 7047–6510 cal BC, $\delta^{13}C$ –31.7‰) from Rudnya Serteyskaya, and 7150±50 BP (Ua-37098, 6200–5905 cal BC, $\delta^{13}C$ –31.2‰) from Serteya X. Thus, we might suppose that materials from phase 'a', typologically one of the most ancient, could date to 7050–5900 cal BC.

Organic crust from pottery from phase 'a-1' (site Serteya XIV) was dated to 8380±55 BP (Ua-37099, 7570–7324 cal BC). This pottery fragment was lying above a sandy layer, which could have been formed during the same Boreal Period, as at the site Rudnya Serteyskaya (*Mazurkevich, Miklyaev 1998*). The value of $\delta^{13}C$ –33.8% could indicate a probable influence of reservoir effect on this date (*Fischer 2003*). Studies of the effect of hard water in this re-

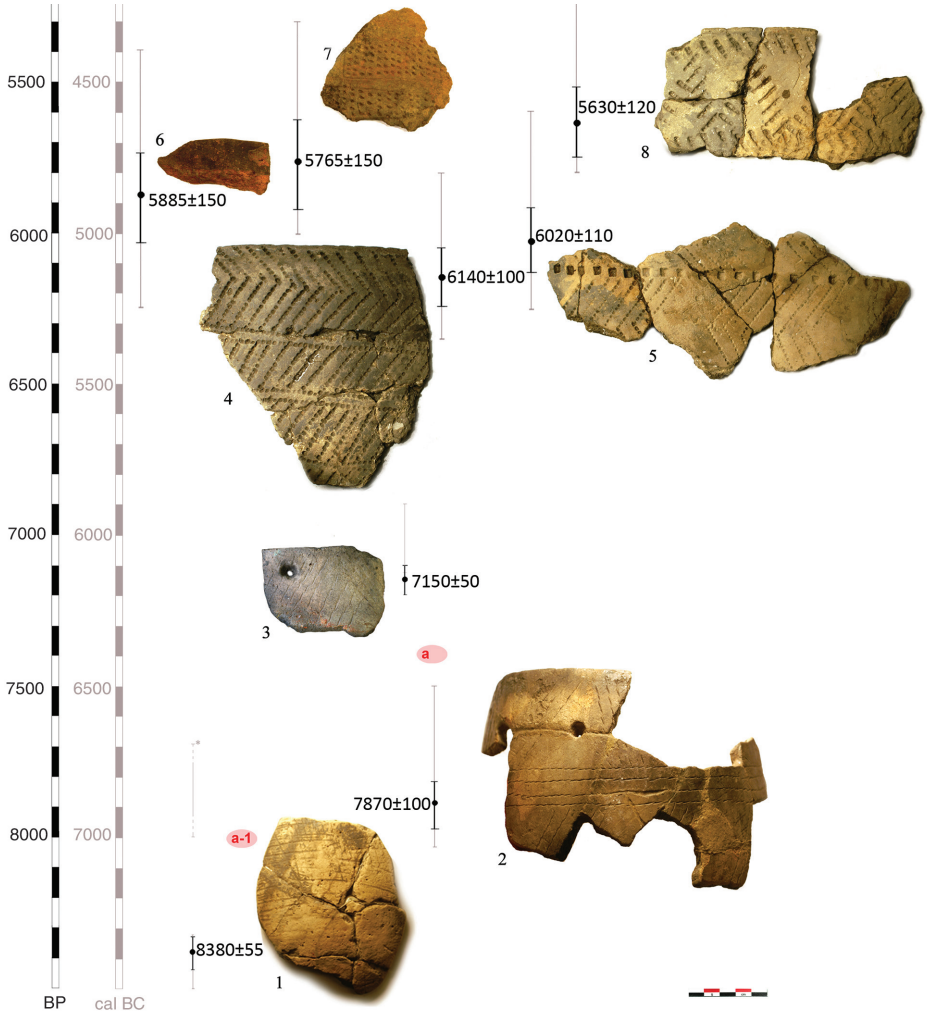



***Fig. 3. $^{14}C$ dated pottery fragments (e.g., organic crust) from the 7th to 5th millennium BC.***

gion allow us to suppose that the age offset could have been 0–585 years (*Kulkova* et al. *2014*). A probable value for this date after correction could be between 7000–6600 cal BC. It is important to notice the rather low negative values of $\delta^{13}C$ for phase 'a'. However, identification of $\delta^{13}C$ alone cannot be a precise marker of the age of a sample, as some vegetation (including from terrestrial milieu) could also have rather low negative values (*Boudin* et al. *2010*). Moreover, studies in this region have shown that the age offset can be very small, even if the $\delta^{13}C$ values for organic crust are rather low (*Kulkova* et al. *2014*).

The vessels from phases 'b' and 'b-1' form a single cultural tradition with vessels from phase 'a'. They differ somewhat in technology (new raw materials and paste recipes used, tradition of sandy paste preserved, and new types of construction) and decoration. We might suppose the co-existence of phase 'b' and 'a' vessels, as some of examples from both phases can often be found together. However, most are found at the sites located on high lake borders, and in upper stratigraphic layers, which could indicate the continuation of this tradition.

The pottery attributed to phases 'b-3' and 'b-5' was dated due to the accumulation of burnt bones, which can be correlated with these vessels according to their stratigraphic position. The burnt bones located the near pottery fragments of phases 'b-1' and 'b-5' (at Serteya XXII) are dated to 6640±110 BP (SPb-750, 5737–5374 cal BC). The bones and pottery could be synchronous, because of their very precise and undisturbed spatial division. The burnt bones found among vessel fragments of phase 'b-3' at Serteya XXVII were dated to 6792±120 BP (SPb-748, 5971–5493 cal BC).

The accumulation of burnt bones found near the vessel 'b-4' at Serteya XX was dated to 7300±120 BP (SPb-749, 6425–5984 cal BC). However, other pottery fragments were found nearby as well, which means this date cannot be attributed to this phase

with great confidence, which is why this date was not included in the scheme.

Taking into account the most ancient and recent dates, the existence of different early Neolithic ceramic types can be dated to the period 7000–5300 cal BC. The few dates made for early Neolithic pottery lie within the intervals 7000–6100 cal BC and 5700–5600 cal BC. However, when the different phases began and ended, as well as their sequence are still not known. If the age of definite ceramic phases could be defined, continuity and interruptions in the occupation of this region could be determined.

***Narva, LBK and Upper Volga cultural influences: destroying the world of the earliest ceramic networks?***

The next cluster of radiocarbon dates lies within the end of the 6th millennium BC. It indicates the existence of early Neolithic Rudnyanskaya culture in this territory, which might have been related to the Early Neolithic Narva culture. Local variants have been identified in the area where Narva culture was present (see *Vankina* et al. *1973; Rimantene 1973; Timofeev 1975*). Rudnyanskaya culture can be assumed to be one of those cultural groups that existed within a large common cultural area. However, Rudnyanskaya culture differs considerably from Narva culture, as described by Nina N. Gurina (*1967*), in technological, morphological and decorative characteristics.

Rudnyanskaya pottery has been divided into three ceramic phases, 'd', 'd-1' and 'e'. They cannot be regarded as pertaining to a single culture, due to differences in the technology, morphology and decoration of the vessels (Fig. 4). Analogies in the pottery, flint and bone assemblage can be traced at sites in the Lubana region (Zvidze, Osa) (*Loze 1988; Zagorskis 1973*). We might suppose that the directions of cultural interaction changed at the end of the 6th millennium BC, and a former cultural network was destroyed.

The cultural layers containing Rudnyanskaya materials cover sediments containing the preceding ear-

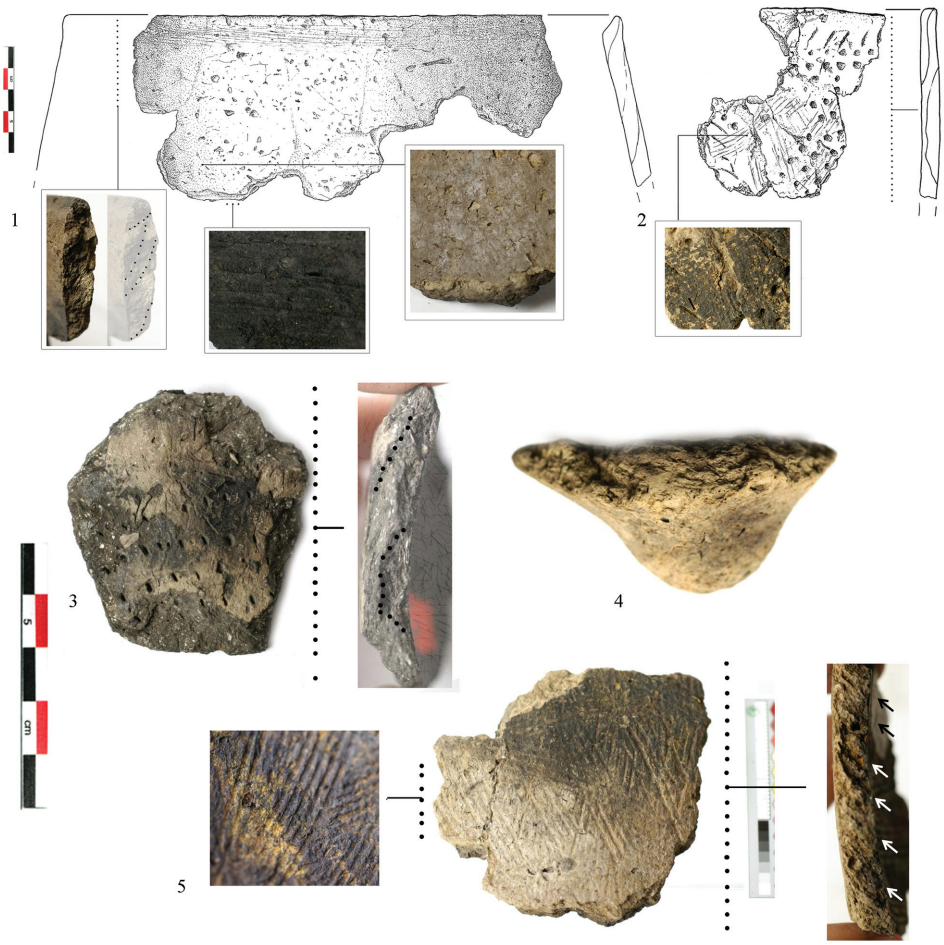



***Fig. 4. Pottery fragments with indications of technological traces: 1, 4, 5 ceramic phase d-1; 2, 3 ceramic phase d. (1–4 Rudnya Serteyskaya site; 5 Serteya XIV site).***

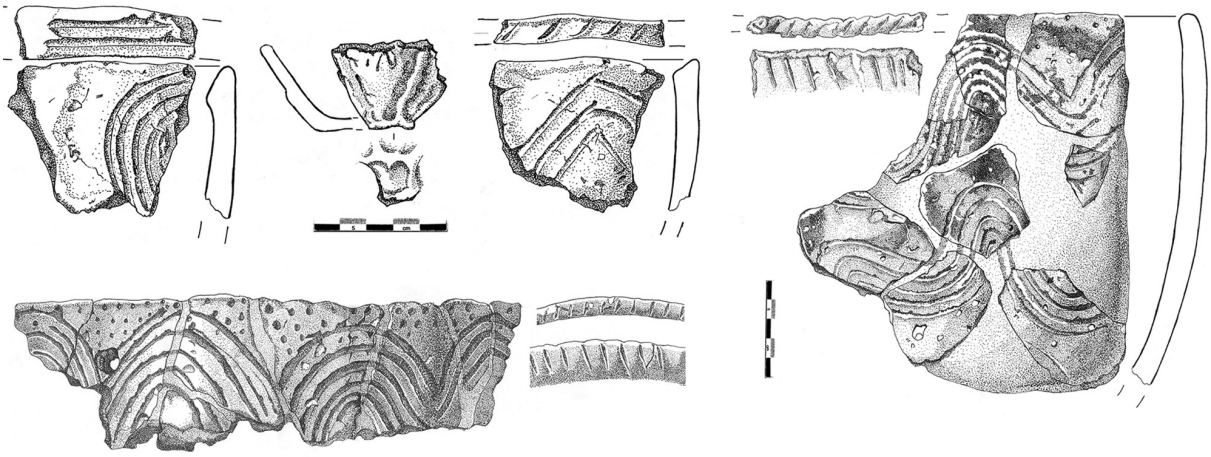


***Fig. 5. LBK pottery found at Dubokray V.***

liest pottery (phases 'a' and 'b'). The dates of the wood from cultural layer 'B' at Rudnya Serteyskaya are 6240±40 BP (Le-3054, 5311–5066 cal BC), 6230±40 BP (Le-2568, 5306–5061 cal BC), 6180± 40 BP (Le-2569, 5286–5002 cal BC), and 6130± 40 BP (Le-2579, 5211–4962 cal BC). The most ancient dates correlate with the finds of Rudnyanskaya pottery; two other dates (Le-2569 and Le-2579) are of wood found in the northern part of the site, where typologically more recent vessels of this culture were found (*Mazurkevich, Miklyaev 1998*). Such 'sensitive' typological features could explain the differences in dates obtained for various parts of the site. Dates obtained from remains of a fish trap found above the cultural layer containing Rudnyanskaya material can be correlated with more recent material of this culture (*Mazurkevich, Miklyaev 1998*). This cultural tradition probably ended in the second quarter of the 5th millennium BC.

When bearers of the LBK cultural tradition appeared in the forest zone of Eastern Europe remains disputable (*Mazurkevich, Miklyaev 1998*). Some of the types of pottery attributed to this culture were found at Serteya XXXIV (Tab. 1.210, 212, available online at http://dx.doi.org/10.4312/dp.44.10), and were dated to the first half of the 5th millennium BC. A shoe-last stone axe typical of this culture was found nearby. The date of other pottery of this culture found at Dubokray V remains unknown (Fig. 5).

Yet another change in cultural tradition visible mainly in pottery occurred in the final stage of Early Neolithic, at the end of the 6th/first part of the 5th millennium BC. This pottery is named 'layer B type at the Serteya VIII and X sites', and can be correlated with materials from the last stage of Upper Volga culture and pottery of the Valdayskaya culture, which was decorated by long comb impressions (Fig. 3.4–5, 8). Analysis of radiocarbon dates allows us to suppose that, in the final stage, bearers of such pottery styles could have co-existed with the Middle Neolithic pile-dwelling Usviatskaya culture (Tab. 1.175–176, 233–234, available online at http://dx.doi.org/10.4312/dp.44.10; Fig. 7. 3–5; Fig. 8.1, 6).

The vessel found near an accumulation of burnt bones at Serteya XXXVI, could be dated to the end of the 5th/first half of the 4th millennium BC (Tab. 1.213, available online at http://dx.doi.org/10.4312/dp.44.10). This vessel was made from a paste tempered by organics. Slab technique was used, it has a polished surface and is decorated by roundish impressions. It does not belong to the Early Neolithic types described above and later Middle Neolithic ones. Its independent position is also attested by its radiocarbon date. It may indicate the existence of a short cultural episode which is still to be determined and characterised.

We can suppose a linear cultural scheme for the Early Neolithic, with periods of continuity in the development of cultural traditions (*e.g.*, phases 'a' to 'b-1'), and periods that mark the disappearance of cultural traditions and emergence of new ones. However, the radiocarbon dates allow one to suggest another scheme whereby different cultural events could have co-occurred such as, for example, the final stage of Rudnyanskaya culture, the LBK, and sites with materials of 'layer B type at the sites Serteya VIII and X sites' and, probably, sites with Rhomb-pit culture pottery. What interpretation could be proposed for such a picture? Is this the result of the co-existence of different societies, or is it the co-existence of societies from different micro-regions within one region, or it is successive occupation? Might the radio-

carbon dates create an illusion of synchronicity? These questions can be solved not only by archaeological methods and more detailed radiocarbon dating, but also with the help of the further development of the radiocarbon method, treatment of dates, and interpretation. Our perception of millennia as brief moments promotes an illusion of continuity of historical events, as well as successive change of cultures. However, if we suppose that dated events concentrate around a 'core' of dates, the discontinuity of events becomes apparent. Some micro-regions appear to be unsettled, and cultures are divided by several hundred years.

## Middle and Late Neolithic: the pile-dwelling phenomenon

The Middle Neolithic is marked by the appearance of the Usviatskaya culture (*Miklyaev 1969; Miklyaev 1995; Mazurkvich 1998*). New dates of organic crust from pottery fragments of the Usviatskaya culture from Usviaty IV allow us to date its appearance to

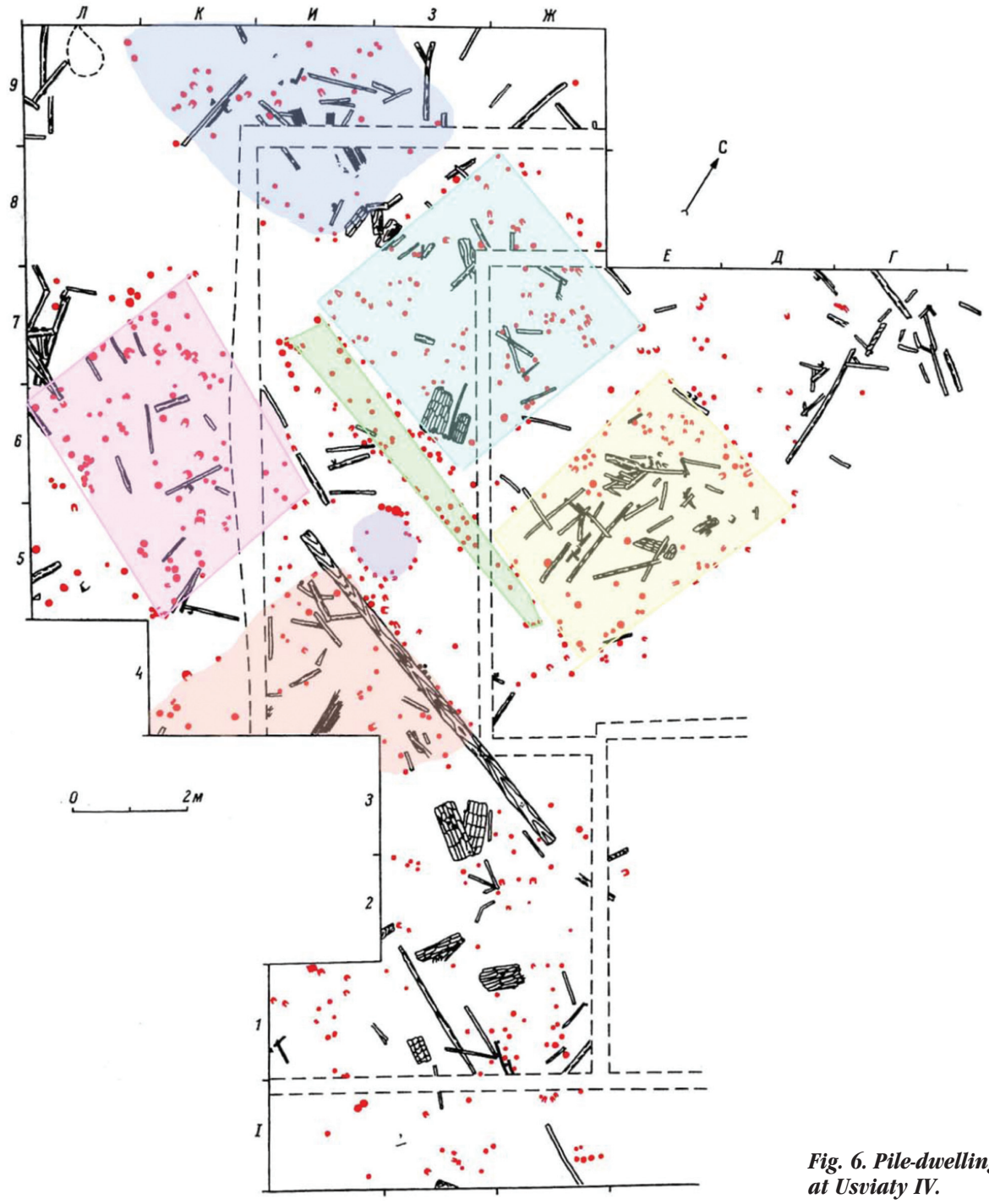



***Fig. 6. Pile-dwellings at Usviaty IV.***

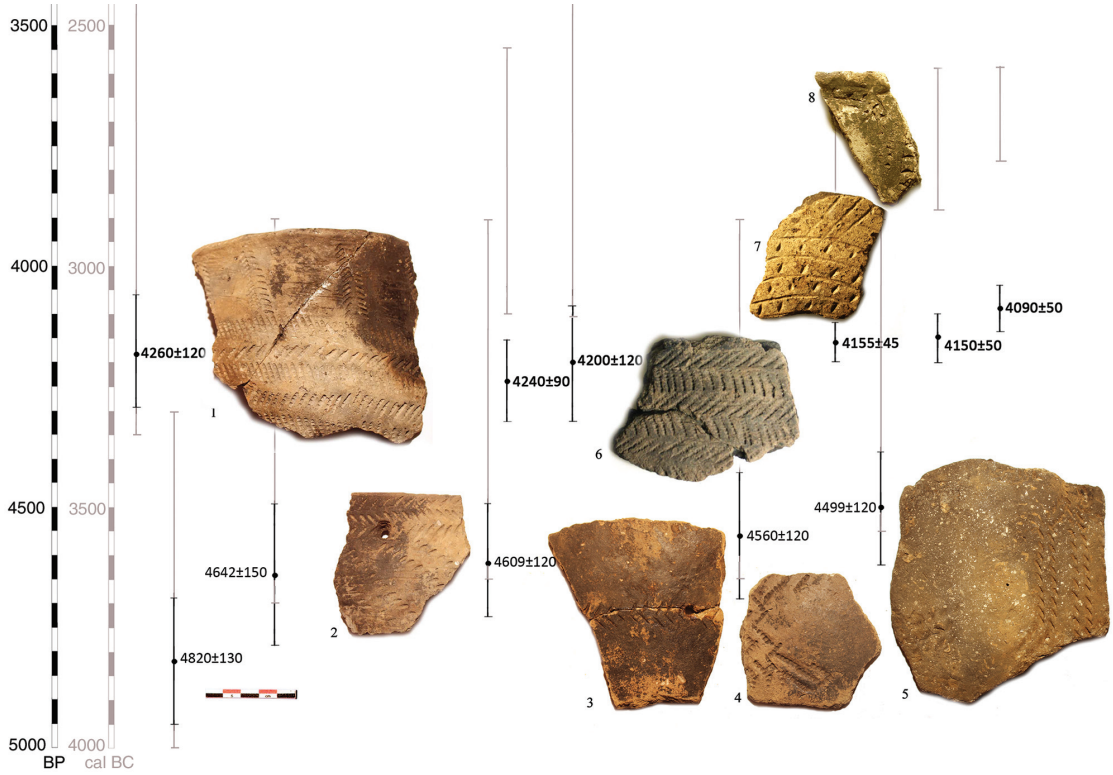



***Fig. 7. $^{14}$C dated pottery fragments (e.g., organic crust) from the 4th to 3rd millennium BC.***

the second quarter of the 4th millennium BC. The Usviatskaya period encompasses almost the whole of the 4th millennium until the turn of the 4th–3rd millennium BC (Figs. 6, 7.2–5, 8.1, 6).

A new cultural tradition known as Zhizhitskaya culture was formed at the turn of the 4th–3rd millennium BC (*Mazurkevich, Dolbunova 2011b*) (Figs. 7.1, 6; 8.4–5; 9). It was a complex cultural event, formed on the basis of different cultural components. It demonstrates another model of cultural genesis in the Neolithic of the forest zone. The material culture (primarily pottery) includes various traits typical of the Usviatskaya, Funnel Beaker, Globular Amphora, Corded Ware cultures (Fig. 9), and the late stage of the Dnepr-Donets culture (*Mazurkevich* et al. *2014*). Amber artefacts attest to connections with the Baltic area (Fig. 10.1–5). Bearers of Balkan agricultural traditions appeared in the Sennitsky and Zhizhitsky archaeological micro-regions at the turn of the 4th–3rd millennium BC, and under their influence, a particular cultural complex was formed, which included vessels with trays, pintadera (Fig. 10.6) and a new system of decoration (Fig. 7.7–8). The dates (Tab. 1.22–36, available online at http://dx.doi.org/10.4312/dp.44.10) are of organic crust from vessels, as well as wood from a cultural layer from the Naumovo site and from overlying and underlying layers (*Mazurkevich 2007*).

The dating of different parts, dwelling remains and other objects at Serteya II, which has been investigated in the last few years, allowed particular patterns and interesting observations about the chronology of this site to be revealed. The cultural layers of the site are located under water and in peat-bog, a unique mode of preservation of material culture dated to the end of the 4th–3rd millennium BC and attributed to the Zhizhitskaya culture. The remains of six dwellings were found in the central part of the site, located under water (Fig. 11). Eighty-nine radiocarbon dates were made for this site on different materials: wood piles and objects, organic crust, animal and fish bones, and chestnuts. The dates of the different materials do not contradict each other, despite the possible influence of the reservoir effect, which appears to be negligible (*Kulkova* et al. *2014*). Sometimes, the results of radiocarbon dating forecast the discovery of older cultural remains. Thus, for example, materials attributed to the late stage of Usviatskaya culture can be found only now, whereas radiocarbon dates of this time have appeared before.

The most ancient dwelling is dated to about 2900–2570 cal BC. Thereafter, the site may have been uninhabited for some time (*Mazurkevich* et al. *2011*). The next construction period is dated to 2570–2330 cal BC. The settlement was most actively populated from 2470 to 2270 cal BC. We might suppose that

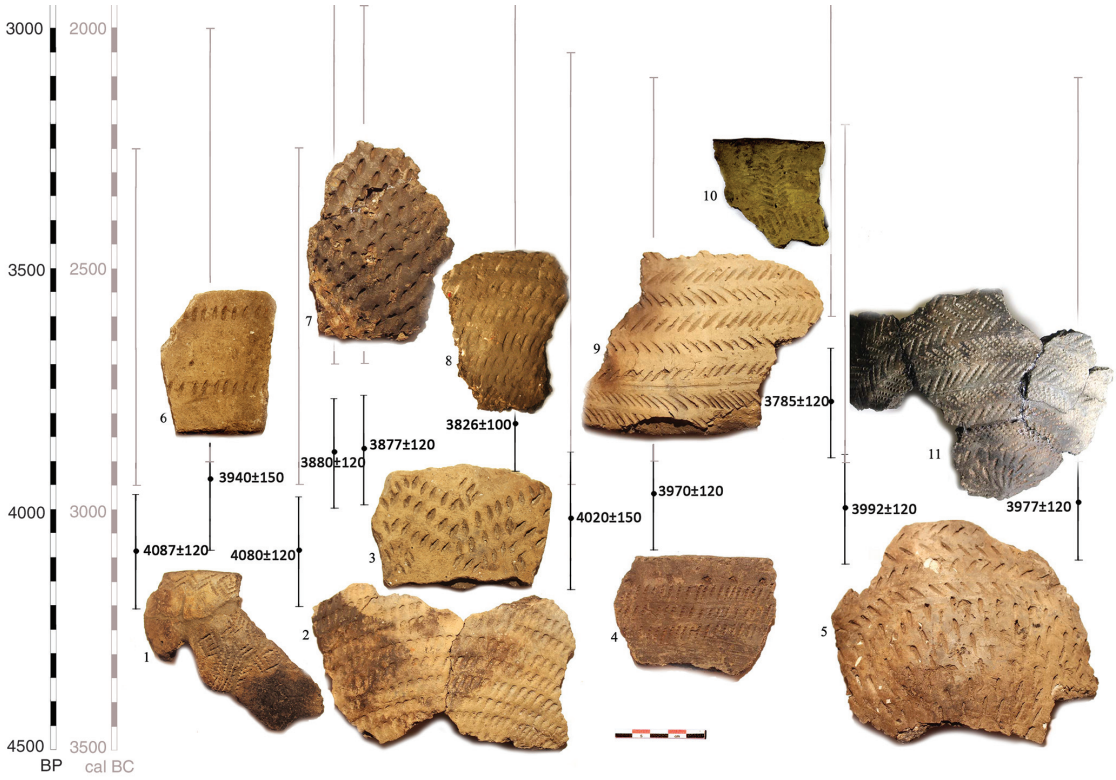



***Fig. 8. $^{14}C$ dated pottery fragments (e.g., organic crust) of the 4th to 3rd millennium BC.***

during this period a small-scale society lived here and successively constructed pile dwellings and/or reconstructed them in the same place. By correlating archaeological observations and radiocarbon dating, we suppose even several periods of occupation in the same places. For example, three groups of piles were distinguished at different depths in peat bog in the eastern part of the site (squares O–P/VIII–IX). Radiocarbon dating of piles from these groups confirmed the chronological difference between them (see the dates of piles no. 276, 245, 285, 342, 265, 291, 313, 294 in Table 1, available online at http://dx.doi.org/10.4312/dp.44.10). We might expect that the biggest group of dates to be divided into several groups by further dating. The dates for different horizons and remains of structures could allow the differentiation of piles of different structures. Further analysis, including dendrochronological research, will allow a more precise time scale for this site to be created.

There are also several dates within the interval 2210–2020 cal BC and 1920–1730 cal BC, which is evidence that this place could have been used later on, which is attested by finds from the shore located 70m from the central part (Serteya II, layer α) of the excavated settlement area. In 2015, two human skeletons were found 40m from the main area, near a mineral cape in lacustrine sediments (Fig. 12). The dates of wood (Tab. 1.160–161, available online at http://dx.doi.org/10.4312/dp.44.10) overlying these skeletons show the period when wood remains accumulated in the shoreline. Thus we suppose that these skeletons were left here before 2279–2059 cal BC. This corresponds to the last stage of the site's existence in the peat-bog.

Serteya II (period of existence of dwellings 1/6–3 existence) might have been the only inhabited site in the middle of the 3rd millennium BC in the Serteysky archaeological micro-region. The materials found at this site on the one hand reflect the particularities of the culture of local inhabitants in this micro-region and, on the other, allow the identification of technological, morphological and decorative features of pottery from different dwellings during the lifetime of several generations (*Mazurkevich* et al. *2014*).

A range of fishing structures and objects existing at different periods of time during the 4th–3rd millennium BC were found at Serteya I, which is 1.5km from Serteya II. Numerous items have been dated: wooden stakes (Tab. 1.66–70, 73, 75–77, 79–81, available online at http://dx.doi.org/10.4312/dp.44.10), elaborate wooden sticks (Tab. 1.72, available online at http://dx.doi.org/10.4312/dp.44.10), a structure made from vertical pine sticks connected by

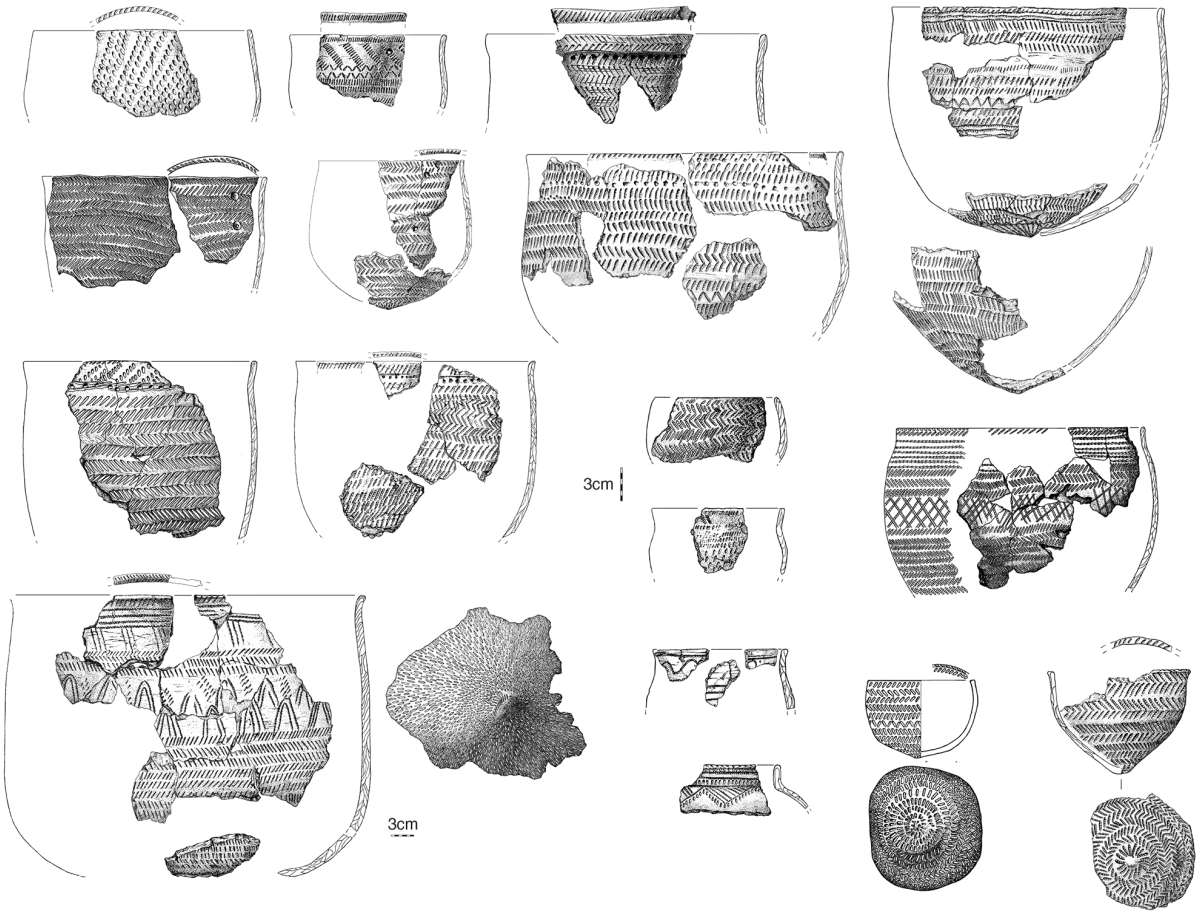



***Fig. 9. Serteya II, ceramic assemblage.***

cords (Tab. 1.71, 74, available online at http://dx.doi.org/10.4312/dp.44.10), a structure made from horizontal fir sticks, sharpened at the edge, 3m in length (Tab. 1.65, available online at http://dx.doi.org/10.4312/dp.44.10) and the remains of a fishing net (Tab. 1.82, available online at http://dx.doi.org/10.4312/dp.44.10) (Fig. 13). According to these dates, this place was repeatedly used for fishing, and this complex of finds cannot be regarded as one assemblage. Given the pottery fragments found here, some of these objects could have been left by occupants of Serteya II.

Particular types of structures dated to the second half of the 3rd millennium BC/beginning of the 2nd millennium BC were also found. These include structures constituting of large stones placed in lines found on Dubokray I (Lake Sennitsa, Pskov region), where several accumulations of stones were found at the bottom of the lake (*Mazurkevich, Dolbunova 2011*). These stones were part of a structure which included stones placed in a circle with rays radiating from it. Small stones, an accumulation of charcoals, flint tools, axes, and pottery fragments were found nearby. An accumulation of charcoal was dated to 3690±50 BP (Le-9537, 2268–1938 cal BC).

In the Serteysky micro-region, a particular structure resembling a mound can be dated to the same time. A mound with a flat surface was made on a natural elevation with a ditch around it, with a passageway from the south-western side (Fig. 14.a). An ash oval

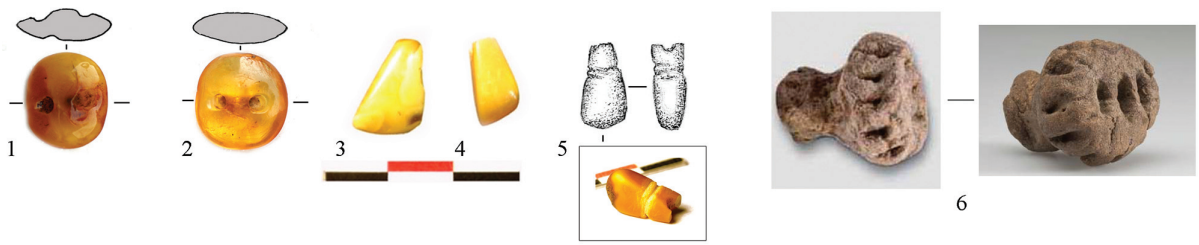



***Fig. 10. Amber pendants (1–5 Serteya II), pintadera (6 Naumovo).***

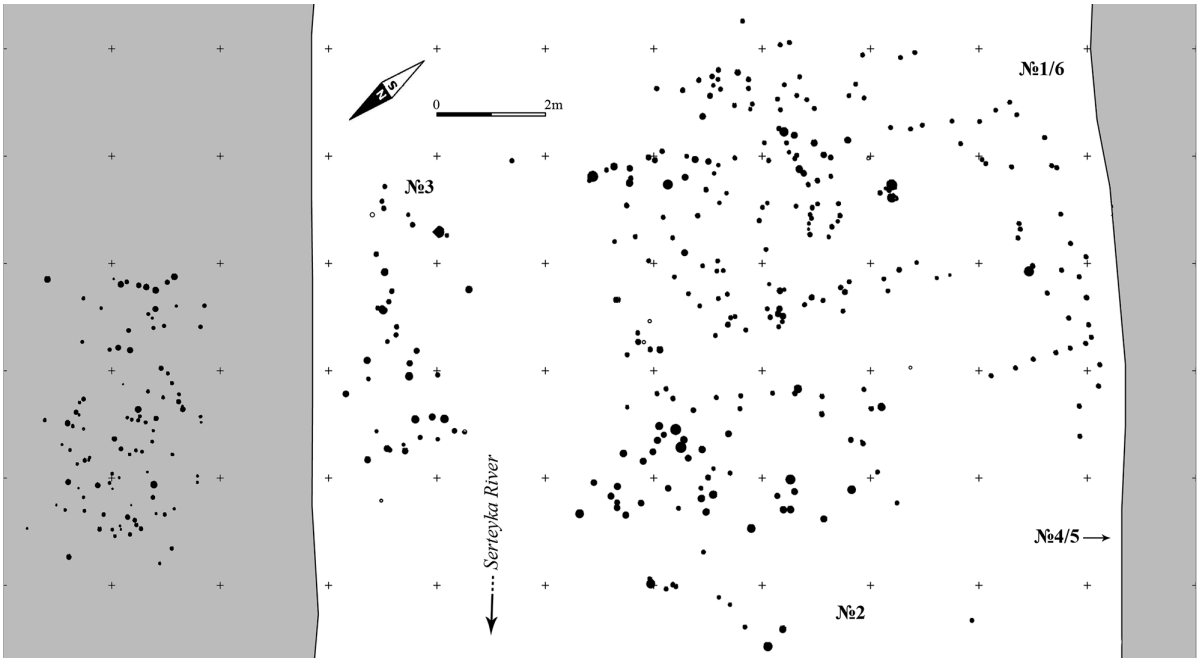



***Fig. 11. Piles distribution with pile dwellings indicated at Serteya II.***

lens 4–14cm thick and 8.20m in diameter was recorded on the surface. This layer was formed here as the result of a large fire-place which was covered during a burning-out or immediately after one. This is attested by inclusions of small pieces of charcoal and ash distributed above the upper part of an ash layer, which could have been formed as the fire-place was filled with sand. Near the passage under the layer of ash interlayer, there was a dense accumulation of burnt bones, probably put in a container which, according to M. V. Sablin, included elk bones. A dark-green patina – bronze oxydes (identified in the Scientific-technical Department of The State Hermitage Museum) – was recorded on parts of the bones. The burnt elk bones were dated to 3743±50 BP (SPb-1194, 2297–1980 cal BC), and the charcoal to 3485±80 BP (SPb-1203, 2024–1621 cal BC). These dates allow us to attribute this stage of the structure to the end of the second half of the 3rd millennium BC/ beginning of the 2nd millennium BC, which correlates it with the last stage of the pile-dwellings. The dates of layers with charcoal from the layers lying above showed this mound was also used during the late Middle Ages and in the 19th century (Tab. 1.219, available online at http://dx.doi.org/10.4312/dp.44.10; Fig. 14.b).




***Fig. 12. Skeletal remains found at Serteya II.***

## Conclusion

We suggest that the prehistory of Dnepr-Dvina River basin has many features in common with the prehistory of other regions of the forest zone in Eastern Europe. The materials and dates presented here show the difficulties in dividing the Neolithic into three periods. Around ten cultural events can be observed in the Early Neolithic which are represented by the most archaic pottery found in this region, si-

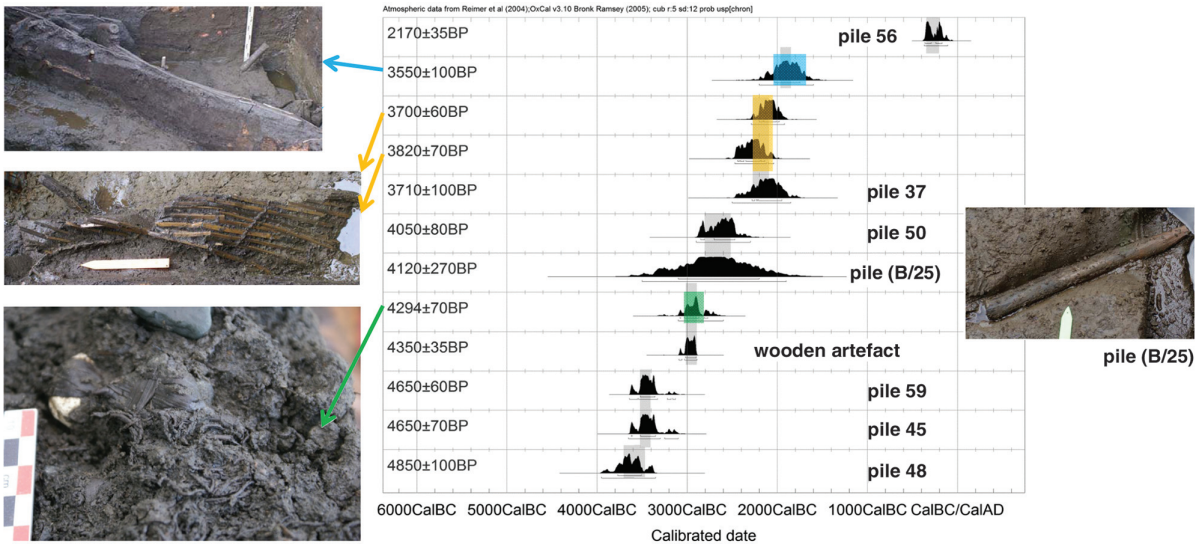



***Fig. 13. Chronological scheme based on dates of wooden piles, fishing structures, wooden artefacts and fishing net from Serteya I.***

milar to early pottery in other parts of Eastern Europe. This is why it is important to discuss archaeological features to identify the different periods within the Neolithic era (*Mazurkevich* et al. *2013*).

The Early Neolithic traditions had some centres of origin in Eastern Europe, which explains the similarity of the Early Neolithic ceramic traditions over a vast area and independently of the area of origin (*Mazurkevich, Dolbunova 2015*). Typological analyses might create an illusion of evolutionary development in the different ceramic traditions over a long period. However, direct radiocarbon dating allows us to devise a non-linear scheme showing how material culture developed. We can suppose that the different cultural traditions clearly traced in pottery existed in the Western Dvina basin for rather short periods. They sometimes co-existed with other traditions, quite often of non-local origin, which did not exist for a long period. All of this shows the complicated process of how innovations settled down in a local Mesolithic milieu due to a scenario completely different from the scenario in Central Europe.

This material might also indicate the penetration of small communities into the forest zone, the take-over of unoccupied land. It appears that some of these newcomers did not settle here, as their material culture did not exist later. Nevertheless, some traditions were established in different areas and, due to their isolated character, particularities of contacts with other cultures and some other features, they led to the formation of the first ceramic cultures in the forest zone of Eastern Europe. At a later stage, regional specificity became so strong that, while in some regions the Early Neolithic continued (for example, in the Dnepr-Dvina basin) and in others (for example, the Low Volga basin) a new epoch was defined, the Eneolithic (*Vybornov 2016*). When did the Early Neolithic period end? What features could serve as markers of this? One of the criteria could be the creation of the first ceramic traditions in different areas. The end of the Early Neolithic for the Dnepr-Dvina basin might be mark-

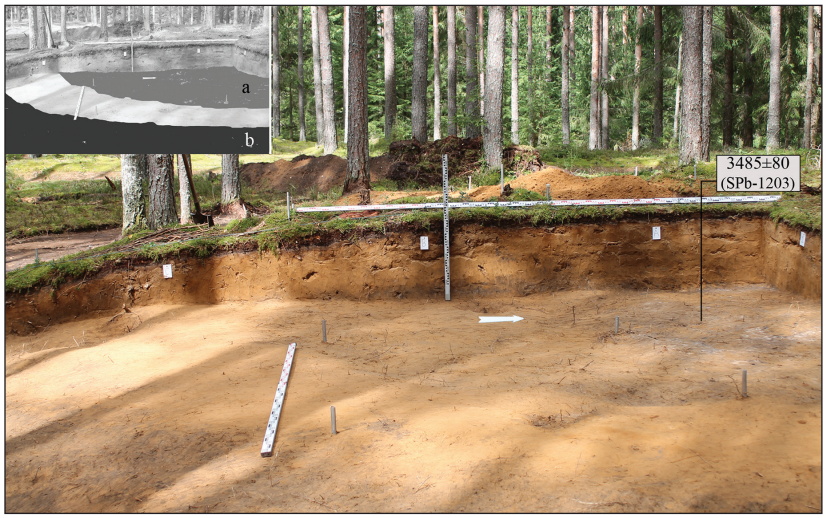



***Fig. 14. Kurgan near Serteya village: platform with the central part covered by ash (a first stage of its construction, Late Neolithic/Bronze Age); slopes of the kurgan with traces of fire (b fourth stage, XIX c).***

ed by the end of ceramic traditions which had their origin in the oldest ceramic traditions of the Low Don, Low Volga and/or Baltic area.

The second indicator could be the appearance of highly sedentary communities and, probably, consequently a rise in population. The beginning of the Middle Neolithic is marked not only by changes in the directions of cultural and social interactions. Settlements became occupied all year round, and radiocarbon dates show a continuous occupation in archaeological micro-regions. $^{14}$C dates also allow us to determine when contacts were established between the Dnepr-Dvina basin and other areas and cultures: Funnel Beaker culture, cultures of Balkan agricultural communities, Globular Amphora culture, communities of the Upper Dnepr basin, and the formation of a very particular culture with pile-dwellings as a prominent architectural form. The Late Neolithic is connected with the appearance of bearers of Corded Ware culture in this region.

However, a clear cultural-chronological scheme even for such a small region seems to be very complicated, because along with archaeological cultures distinguished here, there were singular events which are indicated by particular material culture complexes, and which should be pin-pointed on a cultural-chronological scale and existing networks.

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# Chronology of Early Neolithic materials from Sakhtysh IIa (Central Russia)

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ABSTRACT – *The Upper Volga culture (UVC) in the Volga and Oka basin is one of the earliest pottery cultures in Eastern Europe. The Sakhtysh IIa site is attributed to the core area of the UVC, with pottery encompassing all stages of this culture. A detailed analysis of artefact deposition in different layers allows the creation of chronological models of early pottery development in this region. A series of new radiocarbon dates of food crust on pottery sherds which typologically belong to different stages of UVC at Sakhtysh IIa, as well as an overview of the oldest pottery are presented in this article.*

KEY WORDS – *Early Neolithic; pottery; hunter-gatherers; Upper Volga culture; chronological modelling*

## *Kronologija zgodnje neolitskih najdb iz najdišča Sakhtysh IIa (centralna Rusija)*

IZVLEČEK – *Kultura zgornje Volge (UVC) ob rekah Volga in Oka je ena najstarejših kultur z lončenino v vzhodni Evropi. Najdišče Sakhtysh IIa se nahaja v osrednjem območju njene razprostranjenosti in vsebuje keramične najdbe iz vseh stopenj kulture UVC. Z natančno analizo pozicije najdb v različnih plasteh smo izdelali kronološki model za razvoj najstarejše lončenine v regiji. V članku predstavljamo pregled najstarejše keramike ter serijo novih radiokarbonskih datumov, pridobljenih iz zoglenelih ostankov hrane na keramičnih črepinjah iz najdišča Sakhtysh IIa, ki jih lahko tipološko umestimo v različne stopnje kulture UVC.*

KLJUČNE BESEDE – *zgodnji neolitik; lončenina; lovci in nabiralci; kultura zgornje Volge; kronološko modeliranje*

## Introduction

The Upper Volga culture is an archaeological culture with some of the earliest pottery in Eastern Europe. The culture influenced the development of the earliest ceramic assemblages in the neighbouring regions: Eastern Onega Lake, the Valday Hills, the Dnepr-Dvina basin, Northern Dvina, and the Pechora River basin (for descriptions of these regions and their chronology, see *Mazurkevich, Dolbunova 2015; Piezonka 2014; Zaitseva* et al. *2016; Nedomolkina 2014*). This culture was identified on the basis of particular ceramic assemblages found at well-stratified sites in the Upper Volga basin. Several stages of pottery de-


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velopment attributed to the UVC can be distinguished here based on different features, one of the most important being decorative characteristics (*Krainov 1996; Kostyleva 1986, 1994; Engovatova 1998; Engovatova* et al. *1998; Zhilin* et al. *2002*). The first stage can be divided into two parts: the pottery of stage I.1 is undecorated or decorated by occasional rows of pointed impressions. The pottery has flat or conical bottoms, with straight and flat rims (*Kostyleva 2003*). The materials attributed to the first stage of the UVC reflect the first appearance of pottery in this region, dated to the first half of the 6th millennium cal BC (*Zaretskaya, Kostyleva 2008. 13*). This tradition is supposed to have originated farther south, in the Volga River basin (*Engovatova 1997; Vybornov 2008*). Similarities have been noted with pottery of the Middle Volga culture, late Elshanian culture and Rakushechny Yar (*Kostyleva 2003. 215–216*). Several pottery types were found within the first stage of UVC (see below).

At the end of the first stage (I.2), pottery covered by 'false-cord' decoration, geometrical compositions consisting of drop-like and oval impressions, incised lines, or teeth-stamp impressions appeared (*Kostyleva 1994*). During stage II, pottery decorated by impressions of short-teeth stamps dominated. In stage III, vessels became bigger and were mostly decorated by impressions of different lengths of comb stamp. According to Elena L. Kostyleva, this evolution of the UVC might apply only to the central part of the Volga-Oka region, and may differ on its periphery (Fig. 1) (*Kostyleva 1994.56*). Early Neolithic pottery at the group of Sakhtysh sites is attributed to the core area of the UVC. Materials of all three stages of this culture are represented at these sites (*Kostyleva 1986.139*).

The chronology of different stages and pottery types of the Upper Volga area is still undecided, but can be clarified on the basis of materials from well-stratified sites such as Sakhtysh IIa. In order to refine the dating of this pottery, new dates were made on organic crust sampled from vessels attributed to different types and stages of the UVC from Sakhtysh IIa, combined with previously published dates, and these new and old dates will be discussed in this paper. The spatial distribution of all finds and dates was used to inform the interpretation of the dates, taking into account the complexity of dating organic crust on hunter-gatherer pottery, which is often suspected of being influenced by radiocarbon reservoir effects. A three-dimensional

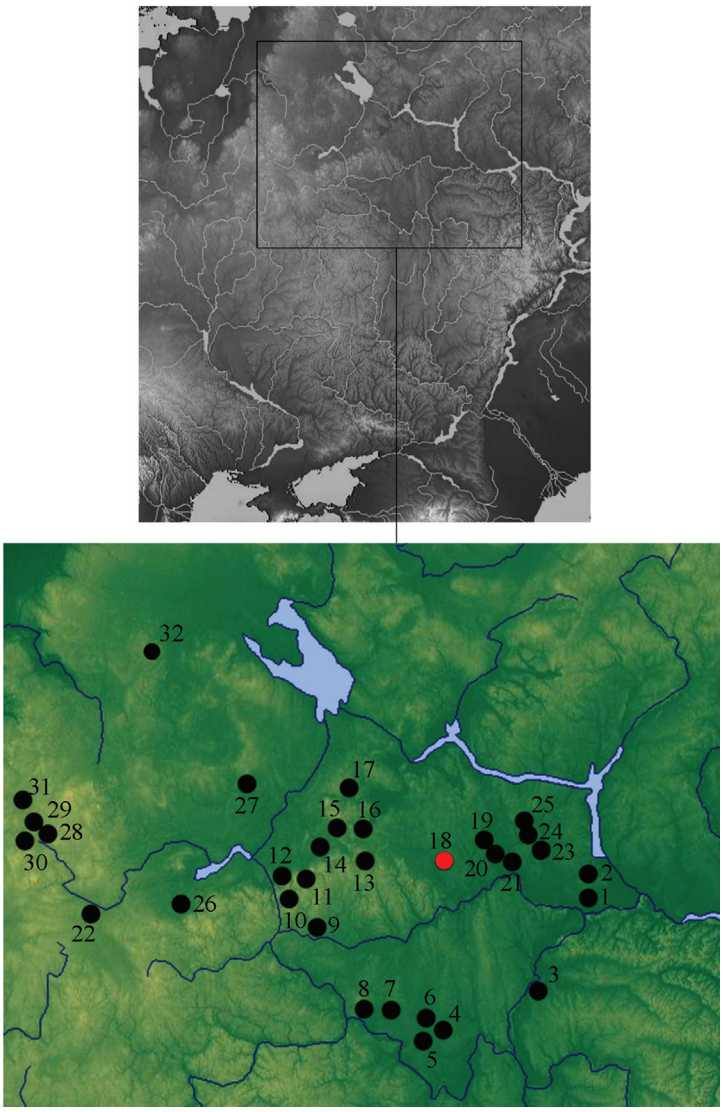



***Fig. 1. Map of archaeological sites with the earliest pottery located in the Volga-Oka interfluve (1–27) and Valday Hills (28–32). 1 Seima I; 2 Shadrino IV; 3 Volosovo; 4 Korenec I; 5 Zhabki III; 6 Teren'kovo III; 7 Belivo II; 8 Maslovo boloto 8; 9 Davydkovo; 10 Davydkovskaya; 11 Zamostje 2; 12 Okaemovo 3, 5, 18; 13 Pol'co; 14 Somino II; 15 Ivanovskoe III, V, VII; 16 Kuhmar' 1; 17 Varos; 18 Sahktysh I, II, IIa, VIII; 19 Kosyachevo I, II; 20 Zav'yalka 1; 21 Bobrinka II; 22 Ozerki 5, layer III; 23 Alekseevskoe I; 24 Strelka I; 25 Malaya Lamna; 26 Al'ba I, III; 27 Yazykovo I; 28 Zales'e I, II, Nizhnie Koticy 5, Zehnovo III, IV, Lanino I; 29 Kotchishe 1,2, Shepochnik; 30 Dubovec (Peno 3); 31 ostrov Koshelev, Zabolot'e I; 32 Zabel'e.***

analysis of artefacts distribution allows the reconstruction of relative chronology, which can be a reliable basis for different chronological models, that will be shown based on Sakhtysh IIa materials.

**Spatial analysis of finds at Sakhtysh IIa**

A previous spatial analysis of pottery attributed to different stages of the UVC and later cultures at various archaeological sites did not show any particular patterning (*Smirnov 2004*). Spatial patterning in pottery decorated by comb and undecorated pottery or ceramics decorated in a pin-pointed technique was identified only at the Ozerki 5 site (*Smirnov 2004.113*). UVC ceramic assemblages are very small at a number of sites, such as Ozerki 5 and 17, Okaemovo 5 and 18, Belivo 2, and Davydkovskaya. At Voimezhnoye, the ceramic assemblage includes 750 fragments, all belonging to one stage (I.2) of the UVC, and deposited in one layer (*Engovatova 1997. 56; Smirnov 2004.113*). Sakhtysh IIa appears to be a unique case, with a large ceramic assemblage, including pottery attributed to all stages of the UVC (797 sherds), Lyalovo culture (476 sherds), and Volosovo culture (48 sherds), as well as flint, bone, and wooden tools, faunal remains and remains of wooden objects, dated to the Mesolithic and Neolithic periods. Using Autocad 3D, a three-dimensional analysis was carried out for the Sakhtysh IIa site in order to refine the relative and absolute chronology of different stages of the UVC. The coordinates and attribution of the artefacts were indicated according to the field plans of 1999, 2004 and 2015, and a field inventory of 1999 made by Kostyleva.

The Sakhtysh group includes 15 sites located on the shore of Lake Sakhtysh and its outflow, the Koika River (Teykovsky district, Ivanovskaya oblast'). Sakhtysh IIa is located on a cape of the first floodplain terrace, on the left bank of the Koika River and in a waterlogged valley of a dried-up spring. The dry elevated part of the site is 3m above the modern water level. Some 700m$^2$ of the dry land area were excavated, where Lyalovo and Volosovo burials of the 4$^{th}$–2$^{nd}$ millennium BC were found. A cultural layer 50cm thick contained finds from the Mesolithic to the Bronze Age (*Zaretskaya, Kostyleva 2008.6–7*). Thirty-six square metres of peat-bog were excavated, including 2m of sediments with cultural layers. Different layers with artefacts were uncovered here, located almost horizontally over the whole surface (Fig. 2).

Pottery of the Middle and Late Neolithic (Lyalovo and Volosovo culture) was found in the upper layer of black peaty loam (Ia) (Figs. 2, 4). Pottery decorated with long comb impressions attributed to the late (III) stage of the UVC was found in the underlying layer of grey clay loam (Ib) and in an ash layer (IIa) which was formed after a peat-bog fire here (*Zaretskaya, Kostyleva 2008.8*). Some downward movement of these fragments into the layer of dark brown peat with wood remains (IIb–IIv) can be also noted, but otherwise almost no finds were found in the upper part of this layer.

Another accumulation of material can be clearly distinguished – with fragments of pottery attributed to stage II of the UVC, early pottery decorated by oval impressions and false-cord decor (stage I.2) – in the lower part of the dark-brown peat layer with wood remains (IIv) and on its border with greenish-brown peat with wood remains (IIg). Different pottery types are deposited together (Fig. 4), which could be evidence that this place was occupied several times, or it could be explained by some other circumstances.

In the eastern part of the (2004) excavation, fragments of pottery decorated with roundish impressions and pottery attributed to stages II and III of the UVC are clearly separated from a layer of undecorated ceramic fragments (stage I.1; Figs. 2, 4) by a sterile gyttja interlayer. Single finds here could have penetrated as the result of some natural processes. Some of the undecorated ceramic fragments were found lying on the border of greenish-brown peat (IIg) and brown peat with wood remains (IIv), or in the lower part of the brown peat with wood remains (IIv). Some fragments could be parts of decorated vessels, as decorated fragments were also found here. Analysis of the finds' position suggests that there were two microstratigraphic horizons with pottery attributed to undecorated UVC pottery.

The final Mesolithic layer (IIIa) cannot be distinguished very easily in the lithology of the site (*Averin* et al. *2009.131*); it was distinguished on the basis of some materials found and $^{14}$C dates. However, one can also suppose that some of the Mesolithic finds could have penetrated into layer IIIa. Taking into account that the Early Neolithic flint industry originated in the Mesolithic, it is also possible that the stone tools found in this layer might be attributed to the Neolithic period, *i.e.* when pottery appeared and other elements of material culture continued without significant changes. This layer was located in the bottom of greenish-brown peat layer, where sand lenses were identified (IIIa, squares 1–4) in the western part of the excavation, and deposited in a

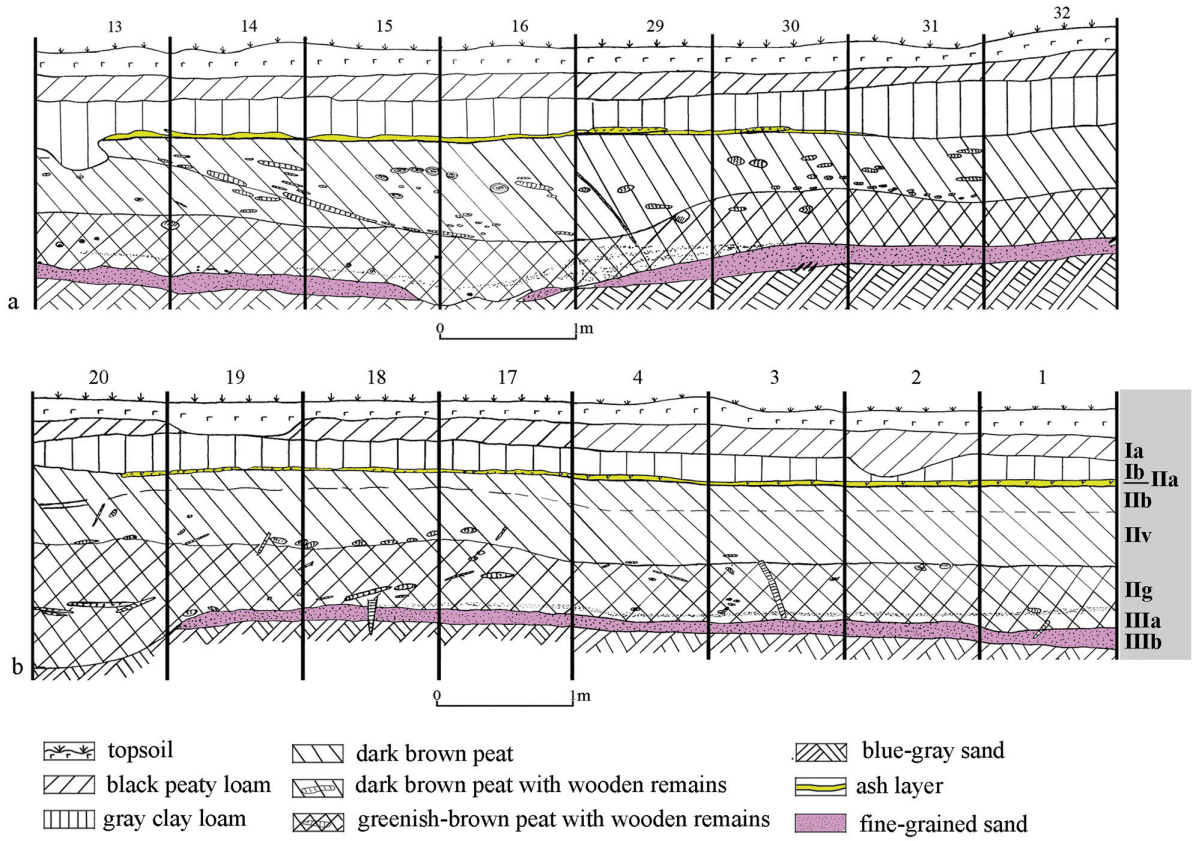



***Fig. 2. Stratigraphy of the Sakhtysh IIa site with numbers of cultural layers indicated (b): a northern wall; b southern wall.***

wellhead part of the stream, which can be traced in the modern relief (*Zaretskaya, Kostyleva 2008.8*). Some of the undecorated pottery fragments attributed, probably, to stage I.1 were found lying in the lower part of greenish-brown peat, in the darker, loose part, which was clearly distinguished during excavations (*Zaretskaya, Kostyleva 2008.9*). It complicates the delineation of the final Mesolithic layer IIIa in the lower part of greenish-brown peat.

The underlying cultural layer, IIIb, corresponds to a fine-grained sandy layer (*Averin* et al. *2009.133*) (Figs. 2, 4). The results of palynological analysis date it to the end of the Boreal, and wood from this layer was dated to 7170–6810 cal BC (GIN-10862, 8060± 50 BP) (*Averin* et al. *2009.133*).

The particularities of lithology and distribution of finds show that the littoral part of the site was located here, and was the base for household activity, including fishing and hunting. Short periods of drying did not lead to the formation of a thick layer of soil, and it cannot be identified now. The setting is a wetland, with sedimentation alternating between gyttja and peat (*i.e.* organogenic sediment) according to water level. Different levels of occupation are, therefore, recognised according to the layering of archaeological material. Frequent (for example, seasonal) washaways of soil might have led to compaction and even some mixing of finds dated to different periods, which are almost not divided by microlayers. The occupants of this site could have pushed some artefacts into deeper levels and mixed some artefacts in the course of household activities on the mud flat. Even taking into account these factors, Sakhtysh II is a particular case of the stratification of various pottery types, which permits a reconstruction of the pottery typo-chronological sequence and history of occupation in the Upper Volga area.

## New $^{14}$C dates

This paper includes a series of new radiocarbon dates of food crust on pottery sherds which typologically belong to different stages of the Upper Volga culture (SPb-1448–1457, KIA-51174). We also report radiocarbon results from three modern fish (KIA-51204–51206), and further measurements of three previously dated food crusts (KIA-39308–39310). In addition, the paper includes two previously unpublished dates for bone artefacts (KIA-39304–39305).

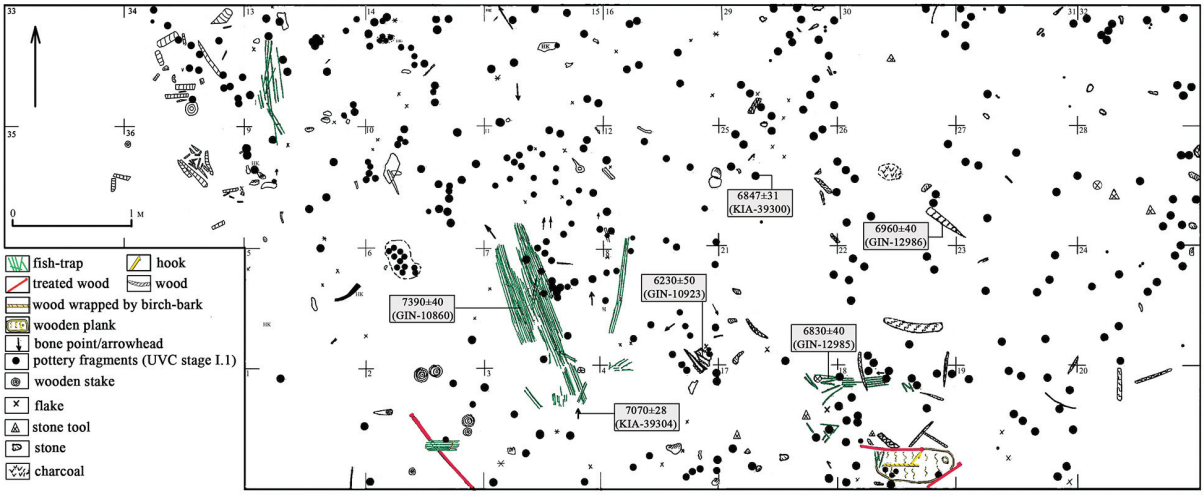



***Fig. 3. Sakhtysh IIa. Plan of the layer IIg with finds and radiocarbon dates obtained for wooden and bone objects, and a willow string on pottery of UVC stage I.1.***

Samples SPb-1448–1457 were pre-treated by the normal acid-base-acid procedure (*Nakamura* et al. *2001; Boudin* et al. *2010*), combusted and converted to benzene for liquid scintillation counting of $^{14}C$ activity, at the Herzen State Pedagogical University radiocarbon laboratory, St Petersburg, Russia. Their $\delta^{13}C$ values were measured by IRMS in the same laboratory by combusting another aliquot of the pre-treated extract. The IRMS-measured $\delta^{13}C$ values were then used to correct the measured $^{14}C$ activity for isotopic fractionation.

The other samples were dated by accelerator mass spectroscopy at Christian-Albrechts-University, Kiel, Germany, with $\delta^{13}C$ correction based on the $^{13}C/^{12}C$ ratio measured simultaneously by AMS. The fish were steamed for an hour on site, defleshed and stored in cooking salt (99.7% NaCl) for transport. In the laboratory, a fragment of flesh from each individual was frozen, freeze-dried and combusted, before reduction to graphite for AMS measurement (Tab. 2).

Archaeological samples were first extracted with a series of solvents to remove lipids and waxes, including possible conservation agents, before acid-base-acid pre-treatment (food crusts) or collagen extraction (bone) (*Grootes* et al. *2004*). Food crust extracts were typically 40–50% of the starting weights, with carbon contents >50%, which are characteristic values for well-preserved samples. The collagen yields for the bone artefacts were good to excellent (6–14% by weight). An aliquot of each extract was combusted and graphitised for AMS measurement.

Three of the new AMS results were from new combustions in 2016 of the same extracts which were dated in 2010 (*Hartz* et al. *2012*). These samples (KIA-39308–39310) gave the earliest known AMS dates for Upper Volga pottery, and they were regarded as important to confirm the original results (Tab. 3). In two cases, the new results are consistent with the 2010 measurements, and in this paper we use the weighted means of the 2010 and 2016 results as

| Laboratory number | Sample | AMS $\delta^{13}C$(‰) | $F^{14}C$ | Conventional $^{14}C$ Age* |
|---|---|---|---|---|
| KIA-51204 | fresh fish flesh (cyprinid, probably young *Leuciscus cephalus*), caught summer 2015 | –33.59 | 0.9822 ± 0.0024 | 144 ± 19 BP |
| KIA-51205 | fresh fish flesh (cyprinid, probably young *Leuciscus cephalus*), caught summer 2015 | –32.58 | 0.9789 ± 0.0023 | 171 ± 19 BP |
| KIA-51206 | frozen freshwater carp flesh, caught 2014 | –32.30 | 0.9851 ± 0.0024 | 121 ± 19 BP |

* According to Hammer and Levin (2017) the average $^{14}C$ activity of atmospheric $CO_2$ during the May-August growing seasons in the Northern Hemisphere was 1.0193±0.0004 $F^{14}C$ in 2014 and 1.0134±0.0016 $F^{14}C$ in 2015. Apparent $^{14}C$ ages (more comparable to freshwater reservoir effects than conventional $^{14}C$ ages, which are calculated assuming an atmospheric $^{14}C$ activity of 1.000 $F^{14}C$)) are therefore 251±23 (KIA-51204), 278±23 (KIA-51205) and 274±19 (KIA-51206), the weighted mean of which is 269±13.

***Tab. 2. Radiocarbon results of modern fish samples and combustion samples.***

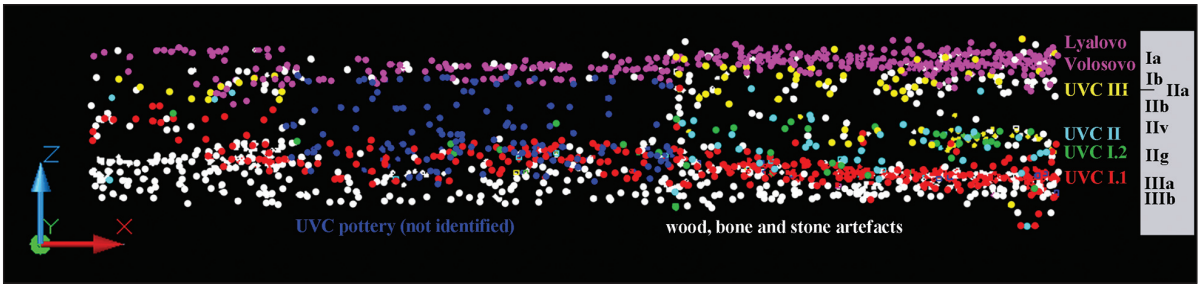



***Fig. 4. Sakhtysh IIa. 3D reconstruction of finds from the Sakhtysh IIa site.***

the best estimates of each sample's radiocarbon age. In the third case, KIA-39310, the 2016 result is even older than the 2010 result, suggesting some inhomogeneity in the extract. The 2010 result was already considered to be misleadingly old (*Hartz* et al. *2012*). Moreover, one of the new radiometric dates, SPb-1452, is from another sherd of the same vessel as KIA-39310, and there is a large discrepancy between the AMS and radiometric dates. We are currently unable to provide a satisfactory explanation for this pattern, but Henny Piezonka *et al.* (*2016*) showed that the KIA-39310 extract has stable isotope and elemental concentration values consistent with it being derived from fish, and the AMS results may therefore be heavily influenced by freshwater reservoir effects.

The modern fish, taken from the Koiko River close to the site, are all depleted in $^{14}C$ with respect to the atmosphere, by a similar amount, equivalent to an average apparent radiocarbon age of approx. 270 years (Tab. 2). If this relatively modest freshwater reservoir effect were applicable to fish caught at Sakhtysh during the Early Neolithic, we should not find large radiocarbon age offsets in food crusts consisting mainly of terrestrial ingredients, and even those dominated by aquatic ingredients should typically produce radiocarbon ages which are only 200–300 years too old. Although no detailed biomolecular analyses have yet been undertaken on pottery from Sakhtysh, EA-IRMS results suggest that most food crusts may have been predominantly composed of terrestrial ingredients (*Piezonka* et al. *2016*). We therefore assume that the food crust radiocarbon ages, with the exception of KIA-39310/SPb-1452, are generally reliable, although individual cases of significant reservoir effects cannot be excluded.

A series of new dates was available for different stages of UVC. Dates of the first half of the 6th millennium BC were obtained for different types of UVC vessels' fragments. Pottery attributed to UVC stage I.1 includes three flat, undecorated rim fragments (Fig. 5.1–3; Tab. 1.7–9). Perforated holes were put on each rim (except the fragments with a repair hole – Fig. 5.3). One of the rim sherds, covered partly by red ochre, also has a groove under the rim where the holes were made (Fig. 5.1). The pottery was made from shell-tempered paste (Fig. 5.1–2). A fragment of one vessel (Fig. 5.3) was made from a paste tempered by bones, sand and grog, according to the petrographic analysis (made by M. A. Kulkova). Organic crust from similar pottery was also dated previously (Tab. 1.11–18, 21) (*Zaretskaya, Kostyleva 2008.9–10; Hartz* et al. *2012.6.5–7*). Some of the dates were made on the total organic content of sherds of undecorated shell-tempered pottery (Tab. 1.25–27, 38) (*Vybornov, Kostyleva 2009.32*). One date, 5471–5046 cal BC (Ki-14555, 6290±90 BP; Table 1.38), which was made on the sherd of, probably, the same or a similar vessel, appeared to be much more recent than the others (Tab. 1.25–27).

Dated pottery attributed to stage I.2 includes one rim fragment decorated by impressions in diagonal rows (Fig. 5.4; Tab. 1.10), fragments decorated by

| Sample | Measurement | AMS $\delta^{13}C$ (‰) | Conventional $^{14}C$ Age | weighted mean |
|---|---|---|---|---|
| KIA-39308 | 2010 combustion | –20.91 | 7018±45 BP | 7008±28 BP |
| | 2016 combustion | –22.19 | 7002±34 BP | |
| KIA-39309 | 2010 combustion | –20.10 | 7037±26 BP | 7071±22 BP |
| | 2016 combustion | –21.14 | 7125±34 BP | |
| KIA-39310 | 2010 combustion | –29.03 | 7356±29 BP | 7427±23 BP |
| | 2016 combustion | –29.85 | 7510±33 BP | |

***Tab. 3. AMS results from new combustions in 2016 of the same extracts which were dated in 2010.***

drop-like impressions (Fig. 5.5, 11), small triangular impressions applied in a retreating manner (Fig. 5.7). Also, there is a date of 5877–5328 cal BC (SPb-1455, 6669±150 BP) obtained for a fragment decorated by large comb impressions (Fig. 5.9) (stage III). Such an early date for this vessel attributed to the late stage does not match the proposed scheme or period for such pottery. An age offset might be connected with a freshwater reservoir effect, which is suggested by $\delta^{13}C = -27.1‰$ for this sample; almost all the $\delta^{13}C$ values for the other samples are above –25‰.

Another group of dates lying within a time interval of the second half of the 6th millennium BC (Tab. 1.1–3) was obtained for vessels decorated by thin comb impressions (Fig. 5.10) in combination with rounded impressions (III stage) (Fig. 5.8). A similar fragment, decorated by thin comb impressions and rounded impressions (*Hartz* et al. *2012.Fig. 3.2*, similar to the fragment in Fig. 5.8), was dated to 5463–5227 cal BC (KIA-39303, 6348±26 BP).

## Ceramic analysis – another question for chronological issues

Technological analysis of pottery can contribute a great deal to the chronological issues, especially when dealing with undecorated pottery, which appears not to be homogenous and can be divided into different types due to differences in the different stages of the *chaîne opératoire*. It is important to describe how these groups appear to be different and how these differences can be explained – by different potters, culture or chronology.

Undecorated UVC pottery from the Sakhtysh group of sites is of particular interest regarding this question. The 1091 pottery fragments attributed to the first stage of Upper Volga culture were found at Sakhtysh I, II, IIa, VIII. As already recognised (*Kostyleva 1984.51*), this is a small number of ancient undecorated pots. Some fragments could also be part of sparsely decorated vessels (of the I.1, I.2 and II stages of UVC), which complicates analyses of incomplete vessels.

Most undecorated pottery from the Sakhtysh group of sites had flat bottoms, flat rims and, rarely, roundish or pointed rims. Two types of the upper part of pottery can be reconstructed – globular and biconical – of different volumes.

Many vessels were made from paste, tempered with grog or coarse-grained sand (514 fragments) (technological group I). This pottery is similar to pottery of type 1 identified at Zamostje 2 (*Mazurkevich* et al. *2013*). Pottery was made from different types of coils, highly stretched, often with an S-junction of coils. The walls are usually 0.7–0.8cm thick, but there are also thin-walled vessels of 0.4cm thickness. Vessel surfaces are smoothed and polished, and in

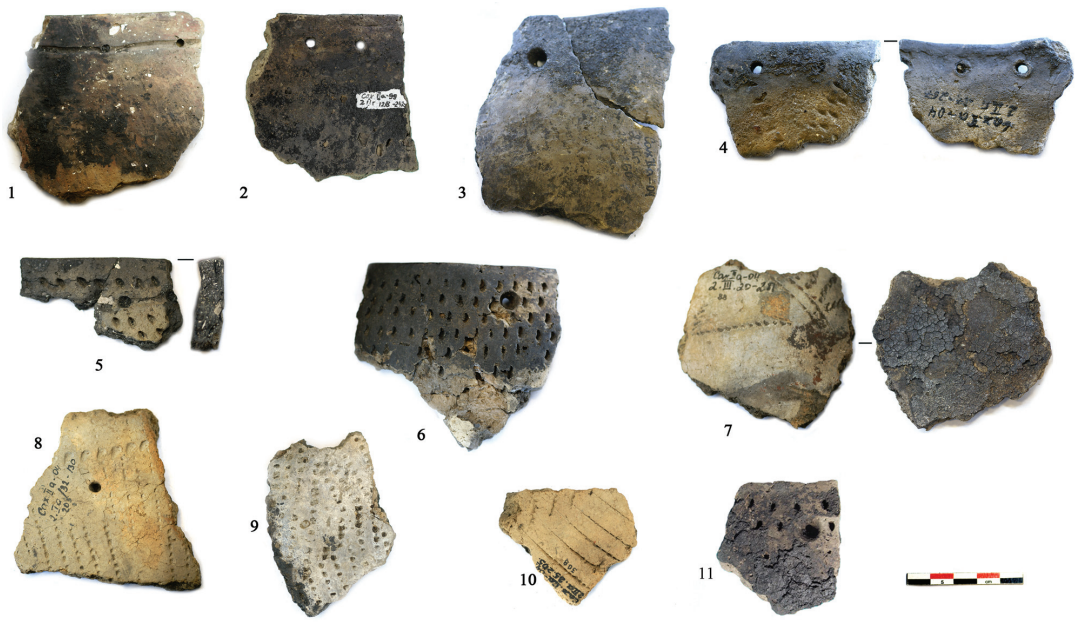



***Fig. 5. Sakhtysh IIa. Pottery fragments, organic crust from which was dated: 1 – 6920±150 BP (SPb-1451); 2 – 7065±150 BP (SPb-1448); 3 – 6874±150 BP (SPb-1450); 4 – 7088±150 BP (SPb-1449); 5 – 6753±150 BP (SPb-1453); 6 – 6411±150 BP (SPb-1452); 7 – 6832±150 BP (SPb-1457); 8 – 6372±150 BP (SPb-1454); 9 – 6669±150 BP (SPb-1455); 10 – 6186±150 BP (SPb-1456); 11 – 6834±34 BP (KIA-51174).***

many cases traces of polishing with a pebble are visible. Fourteen fragments of undecorated pottery flat rims can be attributed to this group. The upper parts of the vessels are closed; biconical forms can be reconstructed, as well as a globular form. Eight flat bases (Fig. 6.1) are attributed to this group; flat bases are typical of the earliest UVC complexes, including those found at Sakhtysh, as was indicated by a previous analysis (*Kostyleva 1986; 1994*). A subgroup of pottery (108 fragments), tempered by shell, could be distinguished. In this case, grog and coarse-grained sand is absent (Fig. 5.1).

Pottery fragments decorated by different impressions made with different techniques (by triangular and oval impressions) (Fig. 6.6), incisions, as well as in retreating manner (stage I.2), by different comb stamps, and by denticulated stamp (stage II) can also be attributed to this group (236 fragments; *Kostyleva 1986*). Decorative compositions include simple horizontal rows and one geometrical (see *Kostyleva 1984; 1986*). Also, a particular pottery fragment was found, which was decorated in a very specific way: with triangular impressions in a retreating manner and single triangular impressions nearby, and a fragment decorated by incised lines with triangular impressions nearby (Fig. 6.8). This decoration is similar to that on pottery from the Lower Volga region (*e.g.*, Varfolomeevka, layer 3). Poorly decorated vessels could have been made from coils with N-technique and with stretched coils (Fig. 6.4–5).

Vessels attributed to the second technological group (202 fragments) were made from paste tempered with organics (traces of burnt vegetation can be seen); the laminated structure of the paste and elaborate polishing (traceable on some fragments) are typical (Fig. 6.9). Most of these vessels have thin walls (0.4–0.6cm), and were made from slabs/short coils, greatly stretched, with an N-junction. Five flat rim fragments and a fragment of a flat base can be attributed to this group. Vessel forms are closed or straight. One vessel was decorated with an incised line.

A particular type consists of fragments of several vessels (27 fragments) made from small coils of sandy paste, with a smoothed or polished surface (Fig. 6.3, 7) (group 3). This group includes 18 fragments of undecorated walls, one fragment decorated by small triangular impressions – not typical of the complex of UVC pottery as a whole – and 2 fragments decorated in a retreat-traced manner. Similar pottery can be found at Zamostje 2 (types 4 and 7, according to *Mazurkevich* et al. *2013*), as well as in materials from the Dnepr-Dvina region (phases 'a', 'b', and probably 'a-1'). This pottery is not abundant at sites in the Upper Volga region, or at sites in other regions. for example, in the Dnepr-Dvina basin and Valday Hills. The absence of organic crust on pottery of some technological types makes refining their chronological position more difficult.

## Chronological modelling

We used the Bayesian chronological modelling package OxCal v.4.3.2, with the IntCal13 calibration curve (*Bronk Ramsey 2009a; Reimer* et al. *2013*) to interpret the Sakhtysh IIa radiocarbon results (Fig. 7). Our model does not rely on stratigraphic relationships between samples, as most of the dated material is from a single layer, IIg; sample depths within this layer are potentially misleading, as the samples were scattered across the excavation area. Instead, our model incorporates the proposed typo-chronological sequence for UVC pottery, in which undecorated or sparsely decorate pottery and pottery decorated with rare oval impressions (I.1 stage) was gradually replaced by pottery decorated by false-cord impressions and traced lines (I.2 stage), then by pottery decorated by short teeth impressions (II stage), which was in turn gradually replaced by pottery decorated by comb-stamp impressions (III stage). Most of the dated food crusts and total organic carbon (TOC) contents were from sherds that could be attributed to one of these stages. OxCal's Trapezium model function (*Lee, Bronk Ramsey 2012*) was developed for this type of sequence. Our model also addresses the risk that some food crust dates may be too old, due to freshwater reservoir effects, and that TOC results could be misleading (*Bronk Ramsey 2009a*). Details of the model structure are shown in Figure 7.

The model output indicates that pottery probably first appeared at Sakhtysh IIa in 6040–5950 cal BC (start of the Early Neolithic start, 68% probability) and that the Early Neolithic phase ended in 5200–5070 cal BC (end of the Early Neolithic, 68%), and therefore lasted 750–890 years (68%). It is difficult to detect any gaps in the calibrated dates, but the large uncertainties in many of the dates do not allow us to exclude significant hiatuses. Undecorated pottery (stage (I.1) predominated until 5840–5640 cal BC (first transition, 68%) and comb-stamp decorated pottery (stage III) predominated after 5460–5330 cal BC (second transition, 68%). The model output suggests a very gradual transition between stages

I.1 and I.2. The relatively sudden transition indicated between stage I.2 and stage III may be misleading, as there are no dates from stage II sherds.

Nevertheless, the model demonstrates that the stratigraphic division of Upper Volga pottery into typochronological phases is justified by radiocarbon ages from food crusts. TOC radiocarbon results are often consistent with these phases, but can also appear to be too old or too recent. Stratigraphic associations between stage I.1 sherds and three organic artefacts (KIA-39304, GIN-12985, GIN-12986) support the attribution of undecorated UVC pottery to the first third of the 6th millennium cal BC, and the date of an elk skull (GIN-10923) is consistent with the dating of most stage III sherds, from the same layer or later, to the last quarter of the 6th millennium cal BC. It is important to note that future chronological models may be different, both because more radiocarbon dates will be available, and because the archaeological-typological information included in models might change.

**Chronology of Upper Volga culture (UVC) pottery**

The relative and absolute chronology of UVC represented on the basis of Sakhtysh IIa materials, can be also supported by the dates from other sites in the Upper Volga region. Similar stratigraphic conditions were described at different sites of the Volga-Oka basin, where a sterile Preboreal-Boreal layer of blue-grey sand (clay) was recorded at Sakhtysh IIa, and Ivanovskoe III and VII. It is important to note that underlying Mesolithic layers have been recorded at many sites in the Upper Volga region.

At Ivanovskoe III, the lower part of a blue-grey sandy layer was dated to 7470–6825 cal BC (Le-3096, 8150 ±100 BP) and 7516–7069 cal BC (Le-3099, 8260± 100 BP) (*Krainov* et al. *1990.30*). It was followed by a layer of grey, peaty sand with Mesolithic finds (bone, wood and flint artefacts), followed by the UVC layer. The Mesolithic layers – III (in dark-olive gyttja and peaty sand) and IV (in the ginger-brown peat layer with an admixture of sand and peaty sand) – were dated to the Boreal period. Pollen analysis showed that the earliest cultural layer (IV) was formed at the beginning of the Boreal period (charcoal from this layer was dated to 8351–8221 cal BC (GIN-7475a, 9070±50 BP), and cultural layer III – to the end of the Boreal period. The trunk of a deciduous tree in square 177, found in the layer of light gyttja which covered cultural layer III, was dated to 7049–6687 cal BC (GIN-8858, 7960±60 BP) (*Sulerzhitskiy* et al. *1998.27*). UVC pottery fragments were found in clearly distinguished buried soil at Ivanovskoe VII (cultural layer II), and were absent beneath it (in cultural layer IIa) (*Zhilin 1998.14*). Part of the site where this layer was deposited had been flooded, which can be attested by an admixture of gyttja in the layer (*Zhilin 1998.14*). Cultural layers II and IIa are attributed to the Atlantic period (*Zhilin 1998. 21*). Samples of peat from cultural layer IIa were dated to 6535–6088 cal BC (Le-1260, 7490±120 BP) and 6590–5918 cal BC (Le-1261, 7375±170 BP). Thus pottery of the UVC found in overlying layer II must be younger than these dates.

At Sakhtysh IIa, the date of a fish trap (#1) (GIN-10 860, 7390±40 BP, 6392–6208 cal BC) (Tab. 1.32) left in a littoral part of the site (Fig. 3), located slightly lower than undecorated UVC pottery in the western part of the trench, could indicate the first stages of site use, probably at the very end of the Mesolithic. It corresponds to the accumulation of a low part of a greenish-brown peat layer (IIg). Pottery use probably began at around 6000 cal BC (see Chronological modelling). It is more difficult to separate the appearance of early pottery decorated with roundish impressions (UVC stage I.1) and falsecord impressions (UVC stage I.2). An elk skull at the Okaemovo 18 site, found at the base of a layer with an accumulation of UVC pottery fragments, decorated by drop-like impressions (UVC stage I.1), was dated to 5813–5617 cal BC (GIN-6416, 6800±60 BP) (*Engovatova* et al. *1998.14*).

One must also take into account the active use of this part of Sakhtysh IIa over a long period, which is evidenced by the dates of several archaeological finds stratified with UVC pottery. Another fish trap no. 2, located slightly higher, in the same layer, IIg, rather close to fish trap no. 1 (Fig. 3) is dated to 5790–5639 cal BC (GIN-12985, 6830±40 BP; Tab. 1.28).

A wooden pile or stake was dated to 5974–5741 cal BC (GIN-12986, 6960±40 BP; Tab. 1.29). It was lying almost horizontally above a layer with undecorated UVC pottery fragments (Fig. 3). This stake is supposed to be more recent than the undecorated UVC pottery fragments, as it lay above them. We might suppose that it was deposited on the level of the ancient land surface, serving as a marker of an upper border of this microstratigraphic horizon. Several dates made on organic crust on pottery fragments found in this level appeared to be slightly

older or synchronous with this date. Also, a bone arrowhead (at -240cm) (Fig. 3) was dated to 6010–5890 cal BC (KIA-39304, 7070±28 BP; Tab. 1.37). It was found just on the border of greenish-brown peat (IIg) and dark-brown peat (IIv) and is dated to the same time as early undecorated UVC deposited here.

A three-dimensional analysis of pottery attributed to stages I.2 and II at Sakhtysh IIa does not clarify their chronological position, as some layers might have been washed away, and possible different periods of occupation were not marked by accumulations of layers or interlayers. A young elk cow skull, dated to 5311–5054 cal BC (GIN-10923, 6230±50 BP; Tab. 1.30), was found in a lower part of the dark-brown peat layer (layer IIv; -227cm – upper part of a skull, deposited at a depth of -241cm; the upper part of the skull is indicated on a 3D model; Figs. 3–4). It could be synchronous with pottery of UVC stage III, which was also found in this part of the layer.



*Fig. 6. Sakhtysh IIa (1–4, 6–9), Sakhtysh II (5, 10). Macrotraces on pottery fragments: 1, 3, 6 different types of bottom construction; 2, 4a, 5, 8b, 7a coils junction; 4c, 5c, 7b N-junction of coils with different degree of coil stretching; 4b, 8a surface treatment; 9b coil/slab technique; 10b S-junction of coils; 9a traces of finger pinching.*

Charcoal from a fire-place with an accumulation of UVC ceramic fragments (I.2 stage) at Voimezhnoe 1 was dated to 5646–5320 cal BC (GIN-6868, 6550±100 BP). Worked wood from this layer was dated to 5476–5327 cal BC (GIN-5926, 6430±40 BP) (*Engovatova* et al. *1998.12*).

At Ozerki 5, wood chip waste from the deeper part of the layer with pottery decorated by long comb impressions and oblique traced lines with oval impressions and short impressions of comb stamp (III stage) was dated to 5674–5044 cal BC (GIN-7215, 6450±160 BP) (*Engovatova* et al. *1998.17*).

## Conclusion

Different chronological schemes have been proposed for the UVC (see *e.g., Engovatova 1998; Zaretskaya, Kostyleva 2008*). The first were based on all the available radiocarbon dates obtained both for archaeological materials and for the deposits where these materials were found. In both cases, these dates might be deemed as not completely adequate, particularly for the case of multiple occupations of the same site (see *Mazurkevich 2009*). This could have created an illusion of the long-term existence of different stages and the evolutionary character of their development. A chronological time scale for different stages of the UVC can now be reconstructed based on the analysis of the radiocarbon dates from Sakhtysh IIa, and their correlation with dates from other sites that correspond precisely with a definite type of UVC. As radiocarbon dates made on organic crust seem to be controversial due to possible reservoir effects, dates made on bones and wood can be regarded as points of reference, assuming these samples were found relatively in situ.

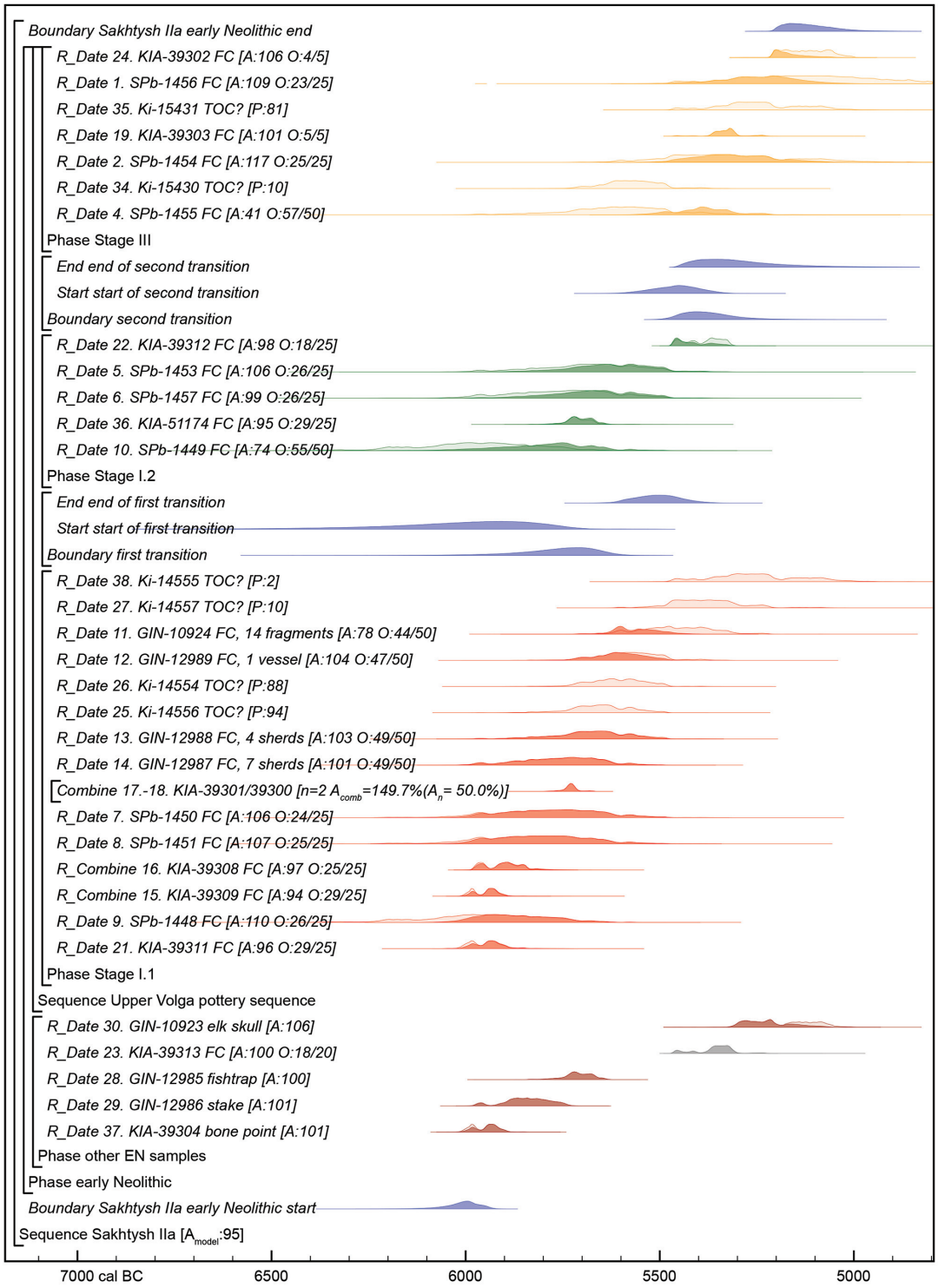



***Fig. 7. Bayesian chronological model of radiocarbon results from Sakhtysh IIa. The model structure shown assumes that there was a typo-chronological sequence of three stages, with gradual transitions between stages (*Lee, Bronk Ramsey 2012*). TOC results are not used in the model, while food crust results have been modelled using a one-tailed type-r Outlier Model that allows for the possibility of freshwater reservoir effects, but is biased towards minimal offsets (*Bronk Ramsey 2009b*; parameters: –Exp(1,–10,0), U(0,2); the chronology obtained without the Outlier Model is almost identical). Pale distributions are simple calibrated dates; intense distributions are modelled dates (posterior density estimates of the dates of samples and associated events). Legend: FC = food crust, TOC = total organic carbon content of pottery; A = OxCal index of agreement between calibrated and modelled date of each sample; P = probability that calibrated date fits this phase in the model; O = posterior/prior % probability that a date is an outlier, given the Outlier Model parameters.***

Sakhtysh II is a particular case of stratification of various pottery types attributed to all stages of UVC, which permits a reconstruction of the pottery typo-chronological sequence and occupation history in the Upper Volga area. The spatial distribution of all finds and dates was used to inform the interpretation of the dates, taking into account the complexity of dating organic crust on hunter-gatherer pottery. Thus, different levels of occupation were therefore recognised according to the layering of archaeological material. Various levels with pottery attributed to different stages of the UVC, evidenced at Sakhtysh IIa, could indicate definite chronological periods of this occupation connected with periodic regressions of paleolakes. Some downward movement of later ceramic fragments might be supposed, based on general patterns of find distribution and single artefacts which are found below their corresponding layers. Further on relative and absolute chronology created for different stages of UVC were interrelated, allowing an independent typo-chronological scheme to be created.

The proposed typo-chronological sequence for UVC pottery implies that undecorated or sparsely decorate pottery and pottery decorated with rare oval impressions (I.1 stage) was gradually replaced by, or co-existed with, pottery decorated by false-cord impressions and traced lines (I.2 stage), then by pottery decorated with short teeth impressions (II stage), and, probably, after some hiatus pottery decorated with comb-stamp impressions (III stage) was deposited here. The proposed model indicates that pottery probably first appeared at Sakhtysh IIa in 6040–5950 cal BC and that the Early Neolithic phase ended in 5200–5070 cal BC. It is difficult at present to separate the appearance of early pottery decorated by roundish impressions (UVC stage I.1) and false-cord impressions (UVC stage I.2). Three-dimensional analysis of pottery attributed to stages I.2 and II at Sakhtysh IIa does not clarify their chronological position, as some layers might have been washed away and possible different periods of occupation were not marked by an accumulation of layers or interlayers. It might be supposed that pottery attributed to stage I.2 could also have existed during the middle of the 6th millennium BC. The second half of the 6th millennium BC is when stage III appeared and further developed. It is difficult to detect any gaps in the calibrated dates, but the large uncertainties in many of the dates do not allow us to exclude significant hiatuses. The model demonstrates that the stratigraphic division of Upper Volga pottery into typo-chronological phases is justified by radiocarbon ages from food crusts. These dates combined with three-dimensional analysis refine the absolute and relative chronological three-stage scheme of Upper Volga culture. Also, some dates of pottery decorated in different traditions – by triangular impressions and long comb stamp – appear to overlap. This must be explained, and further research is needed that includes not only radiocarbon dating, but also analysis of decoration, the technology of pottery making, three-dimensional analysis of pottery distribution, and chemical composition of organic crust that has been dated.

Similarities between the pottery from the Upper Volga region and other ceramic collections found at sites located far away (due to specific decoration and technological features) may be evidence of contact with other cultural traditions. It is important to date these distinct ceramic types and events, which could improve the chronology of ceramic stages of the UVC. We might assume long-distance contacts with communities from other regions either by demic diffusion or diffusion of ideas, reflected in different pottery types that appeared here. Obviously, local 'Mesolithic' inhabitants played an important role in this process.

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## *Tab. 1. Radiocarbon dates for materials from Sakhtysh IIa.*

| No. | $^{14}$C (BP) | cal BC (2σ) | lab-index | dated material | $\delta^{13}$C | information about dated material |
|---|---|---|---|---|---|---|
| 1 | 6186±150 | 5469–4796 | SPb-1456 | food crust | –21.3‰ | excavation of 2004, layer IIa, |
| 2 | 6372±150 | 5617–5001 | SPb-1454 | food crust | –23.4‰ | excavation of 2004, No. 205, |
| 3 | 6411±150 | 5632–5033 | SPb-1452 | food crust | –27.7‰ | excavation of 1999, layer IIg, |
| 4 | 6669±150 | 5877–5328 | SPb-1455 | food crust | –27.1‰ | excavation of 2004, layer IIb, |
| 5 | 6753±150 | 5986–5389 | SPb-1453 | food crust | –24.7‰ | excavation of 2004, No. 223, |
| 6 | 6832±150 | 6001–5491 | SPb-1457 | food crust | –25.2‰ | excavation of 2004, layer III, |
| 7 | 6874±150 | 6033–5522 | SPb-1450 | food crust | –20‰ | excavation of 2004, layer IIg, |
| 8 | 6920±150 | 6074–5554 | SPb-1451 | food crust | –19.1‰ | excavation of 2004, layer IIg, |
| 9 | 7065±150 | 6231–5667 | SPb-1448 | food crust | –22.45‰ | excavation of 1999, layer IIg, |
| 10 | 7088±150 | 6246–5669 | SPb-1449 | food crust | –22.4‰ | excavation of 2004, layer IIg, |
| 11 | 6500±100 | 5632–5300 | GIN-10924 | food crust | | organic crust from 14 fragments shell-tempered), layer IIg |
| 12 | 6650±100 | 5738–5382 | GIN-12989 | food crust | | organic crust from 4 fragments |
| 13 | 6760±110 | 5877–5486 | GIN-12988 | food crust | | organic crust from 4 fragments, |
| 14 | 6850±110 | 5983–5564 | GIN-12987 | food crust | | organic crust from 7 fragments, |
| 15 | 7037±27 | 5991–5849 | KIA-39309 | food crust | –20.1‰ | excavation of 2004, layer Iig, |
| 16 | 7018±45 | 5999–5794 | KIA-39308 | food crust | –20.91‰ | excavation of 2004, layer Iig, |
| 17 | 6860±31 | 5833–5669 | KIA-39301 | food crust | –24.43‰ | sq. 25, depth –249cm, layer IIg |
| 18 | 6847±31 | 5798–5662 | KIA-39300 | Plant (willow string) on pottery (KIA-39301) | –26.88‰ | sq. 25, depth –249cm, layer IIg |
| 19 | 6348±26 | 5463–5227 | KIA-39303 | food crust | –23.37‰ | excavation of 2004, sq. 32, |
| 20 | 7356±30 | 6353–6090 | KIA-39310 | food crust | –29.03‰ | excavation of 2004, sq. 25, impressionsput in gemotric |
| 21 | 7072±36 | 6019–5887 | KIA-39311 | food crust | –24.08‰ | excavation of 1999, sq. 14, |
| 22 | 6395±28 | 5468–5319 | KIA-39312 | food crust | –26.70‰ | excavation of 2004, sq. 29, depth |
| 23 | 6371±30 | 5467–5305 | KIA-39313 | food crust | –26.49‰ | excavation of 2004, layer IIg |
| 24 | 6160±27 | 5213–5030 | KIA-39302 | food crust | –25.01‰ | excavation of 2004, sq. 32, |
| 25 | 6740±90 | 5802–5488 | Ži-14556 | total organic content in sherd | | excavation of 2004, sq. 26, |
| 26 | 6690±90 | 5739–5478 | Ži-14554 | total organic content in sherd | | excavation of 2004, sq. 24, |
| 27 | 6410±90 | 5544–5214 | Ži-14557 | total organic content in sherd | | excavation of 2004, layer IIg, |
| 28 | 6830±40 | 5790–5639 | GIN-12985 | wood (part of the fish-trap #2) | | excavation of 2004, sq. 17/18, |
| 29 | 6960±40 | 5974–5741 | GIN-12986 | wood (stake) | | excavation of 2004, sq. 26, |
| 30 | 6230±50 | 5311–5054 | GIN-10923 | bone (skull of a young elk cow) | | excavation of 1999, sq. 4/8, |
| 31 | 7220±70 | 6231–5986 | GIN-12984 | peat, where a fish-trap #2 (GIN-12985) was found | | excavation of 2004, sq. 17/18, |
| 32 | 7390±40 | 6392–6106 | GIN-10860 | wood (part of the fish-trap #1) | | excavation of 1999, sq. 7, |
| 33 | 7530±60 | 6471–6248 | GIN-10861 | peat, where a fish-trap #1 was found (GIN-10860) | | excavation of 1999, peat where lithological layer, where cultural |
| 34 | 6640±90 | 5726–5389 | Ki-15430 | total organic content in sherd | | pottery fragment decorated |
| 35 | 6280±80 | 5467–5047 | Ki-15431 | total organic content in sherd | | pottery fragment decorated |
| 36 | 6834±34 | 5780–5640 | KIA-51174 | food crust (95mg) | –25.0‰; $\delta^{15}$N 5.6‰ | excavation of 2015; sq. 6, |
| 37 | 7070±28 | 6010–5890 | KIA-39304 | piece with oblique truncation | –19.93‰ | excavation of 1999, layer IIg, |
| 38 | 6290±90 | 5471–5046 | Ki-14555 | total organic content in sherd | | excavation of 2004, layer IIg, |
| 39 | 9500±33 | 8872–8710 | KIA-39305 | bone knife | | excavation of 2004, layer III, |

| | cultural context | publication |
|---|---|---|
| square 25, depth –155cm | Upper Volga culture (III stage) | |
| layer Ia, square 32, depth –130cm | Upper Volga culture (III stage) | |
| square 4, depth –229cm | Upper Volga culture (I.2 stage) | |
| square 27, depth –229cm | Upper Volga culture (III stage) | |
| layer IIg, sq. 28, depth –261cm | Upper Volga culture (I.2 stage) | |
| square 20, depth –281cm | Upper Volga culture (I.2 stage) | |
| square 23, depth –265cm | Upper Volga culture (I.1 stage) | |
| square 26, depth –262cm | Upper Volga culture (I.1 stage) | |
| square 12/8, depth –242cm | Upper Volga culture (I.1 stage) | |
| square 27, depth –257cm | Upper Volga culture (I.2 stage) | |
| of undecorated pottery (with flat bottom and straight rims, | Upper Volga culture (I.1 stage) | *Zaretskaya, Kostyleva 2008* |
| of one vessel, border of the squares 19/23, layer IIg | Upper Volga culture (I.1 stage) | *Zaretskaya, Kostyleva 2008* |
| square 22–24 and 32 | Upper Volga culture (I.1 stage) | *Zaretskaya, Kostyleva 2008* |
| square 23, 18, 19, 24 | Upper Volga culture (I.1 stage) | *Zaretskaya, Kostyleva 2008* |
| sq. 11, depth –244cm (flat bottom) | Upper Volga culture (I.1 stage) | *Hartz* et al. *2012* |
| sq. 18, depth –248cm (undecorated rim sherd) | Upper Volga culture (I.1 stage) | *Hartz* et al. *2012* |
| (same sherd as KIA-39300) (undecorated rim sherd) | Upper Volga culture (I.1 stage) | *Hartz* et al. *2012* |
| (same sherd as KIA-39301) | Upper Volga culture (I.1 stage) | *Hartz* et al. *2012* |
| depth –223cm, layer IIb | Upper Volga culture (III stage) | *Hartz* et al. *2012* |
| depth –294cm, layer IIg (rim fragment decorated by oval compositions) | Upper Volga culture (I.2 stage) | *Hartz* et al. *2012* |
| depth –266cm, layer IIg | Upper Volga culture (I.1 stage) | *Hartz* et al. *2012* |
| –258cm, layer IIg (fragment decorated by a false-cord decor) | Upper Volga culture (I.2 stage) | *Hartz* et al. *2012* |
| | Upper Volga culture | *Hartz* et al. *2012* |
| depth –213cm, layer IIb | Upper Volga culture (III stage) | *Hartz* et al. *2012* |
| depth –262cm, layer IIg | Upper Volga culture (I.1 stage) | Vybornov, Kostyleva 2009 |
| depth –263cm, layer IIg | Upper Volga culture (I.1 stage) | Vybornov, Kostyleva 2009 |
| sq. 28, depth –263cm | Upper Volga culture (I.1 stage) | Vybornov, Kostyleva 2009 |
| layer IIg | Upper Volga culture | *Zaretskaya, Kostyleva 2008* |
| layer IIg | Upper Volga culture | *Zaretskaya, Kostyleva 2008* |
| depth –227 up to 241cm, layer IIv | Upper Volga culture | *Zaretskaya, Kostyleva 2008* |
| layer IIg | – | *Zaretskaya, Kostyleva 2008* |
| –260cm, layer IIIa | final Mesolithic (?) | *Zaretskaya, Kostyleva 2008.10* |
| a fish-trap (GIN-10860) was found, low part of the layer IIg and IIIa are deposited | – | *Zaretskaya, Kostyleva 2008* |
| by a long comb stamp and roundish impressions | Upper Volga culture (III stage) | *Vybornov 2012* |
| by a long comb stamp and roundish impressions | Upper Volga culture (III stage) | *Vybornov 2012* |
| depth –236cm | Upper Volga culture (I.2 stage) | |
| square 3, depth –240cm | Upper Volga culture | |
| sq. 28, depth –263cm | Upper Volga culture (I.1 stage) | *Vybornov, Kostyleva 2009* |
| sq. 30, depth –263cm | Mesolithic | |

back to contents

# Chronology of Neolithic sites in the forest-steppe area of the Don River

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ABSTRACT – *The first ceramic complexes appeared in the forest-steppe and forest zones of Eastern Europe at the end of the 7th–5th millennium BC. They existed until the first half of the 5th millennium BC in the Don River basin. All these first ceramic traditions had common features and also local particularities. Regional cultures, distinguished nowadays on the basis of these local particularities, include the Karamyshevskaya and Middle Don cultures, as well pottery of a new type found at sites on the Middle Don River (Cherkasskaya 3 and Cherkasskaya 5 sites).*

KEY WORDS – *Early Neolithic; Neolithisation; pottery technology; radiocarbon chronology*

### *Kronologija neolitskih najdišč na območju gozdne stepe ob reki Don*

IZVLEČEK – *Prvi keramični kompleksi so se na območju gozdne stepe in gozdov v vzhodni Evropi pojavili na koncu 7. do 5. tisočletja pr. n. št. V dolini reke Don so se ti kompleksi obdržali do prve polovice 5. tisočletja pr. n. št. Vse te prvotne keramične tradicije imajo skupne značilnosti, pa tudi lokalne posebnosti. Med regionalne kulture, ki jih danes ločimo na podlagi teh lokalnih posebnosti, uvrščamo kulturo Karamyshevskaya in kulture na območju srednjega toka reke Don, kakor tudi lončenino novega tipa, ki je bila odkrita na najdiščih Cherkasskaya 3 in Cherkasskaya 5.*

KLJUČNE BESEDE – *zgodnji neolitik; neolitizacija; tehnologija lončenine; radiokarbonska kronologija*

## Introduction

Neolithic sites in the forest steppe Don River basin have been known since the first half of the 20th century. The research conducted in this region, as in other areas of Eastern Europe, allowed the identification of both local cultures and cultural entities, connected to the Neolithisation process and the first appearance of pottery. Pottery appeared to be a marker of transition to the Neolithic in this region, even when flint industry remained the same as during the Mesolithic, which is widely recognised for the European part of Russia. The particularities of pottery types also became the leading feature for differentiating between archaeological cultures (*Sinyuk 1986*).

## Description of the region

The forest-steppe of the Don River basin area (Maps 1, 2) encompasses the Upper and Middle Don River with its tributaries, including those with outflows located within the steppe zone. The Don flows from North to South, which was of crucial importance for contacts between the populations of the Don region


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and the ancient communities of the Azov Sea and Pre- Caucasian regions in the south, the Northern Caspian Sea region (and beyond with the Central Asian region) in the south-east, and finally the Balkan area through the Upper and Middle Dnieper territories – in the west and south-west.

According to the modern administrative division, the forest-steppe of the Don basin is located in Lipetsk and Voronezh regions of the Russian Federation.

The forest-steppe area is a temperate landscape transitional between forest and steppe, characterised by the alternation of closed mostly deciduous trees growing on grey soils and grassland steppe territories in the Black Earth region (*Milkov 1961*). The landscape of the forest-steppe zone changes from north to south. Three sub-zones occur in the central region: northern, typical and southern forest-steppe.




***Map 1. The territory of the forest-steppe in Don region.***

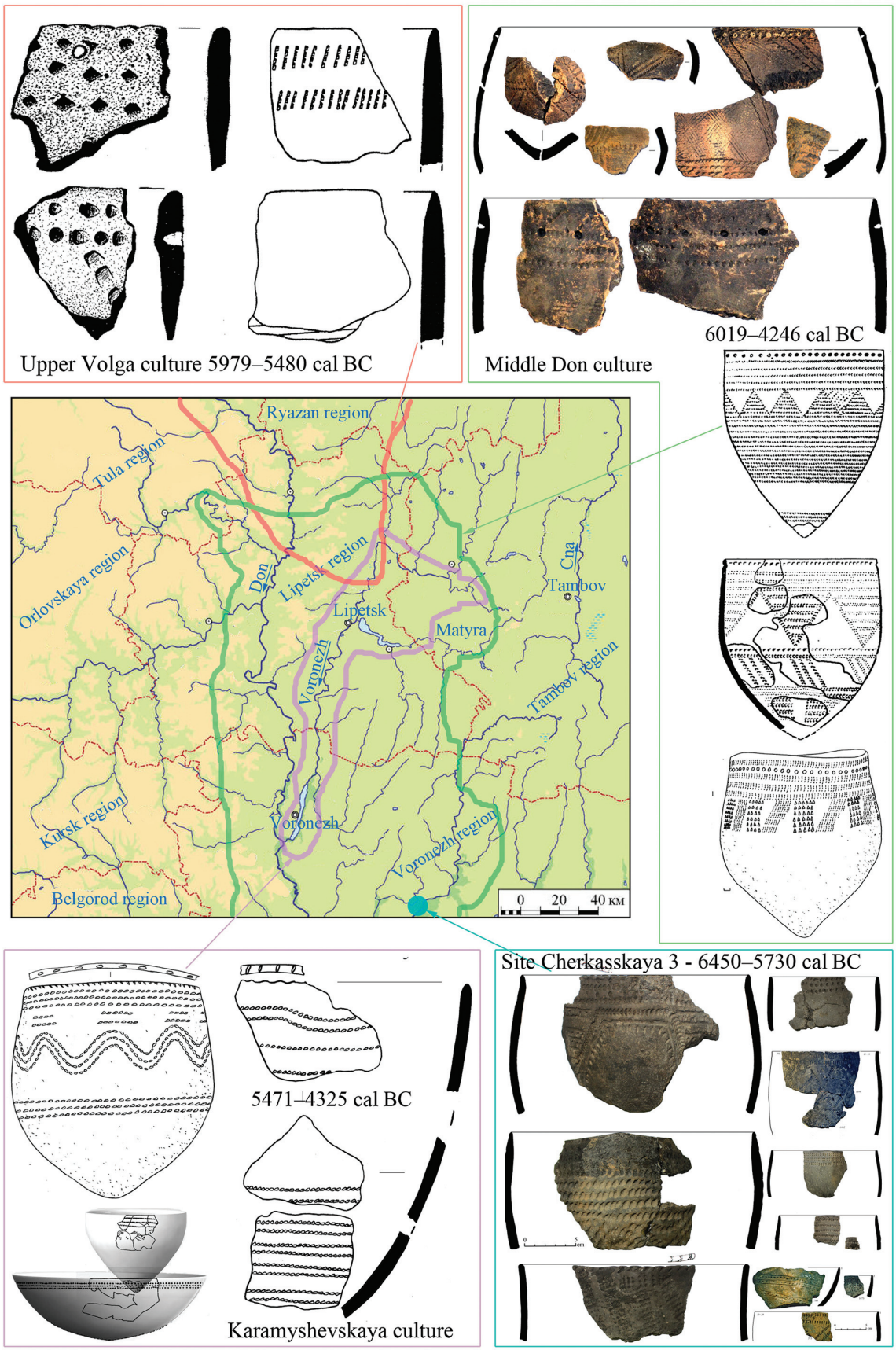
The topography of Neolithic sites is similar throughout the whole region: sites were situated on offshore bars, the upper parts of the first terrace above the flood-plain and sometimes on bedrock shores. Most have been found near the high- water beds of such rivers as the Voronezh, Bityug, Savala, and Tikhaya Sosna.

Neolithic sites in the forest-steppe Don region are arranged into groups in the middle and lower river zones. During spring floods, most of them are covered with water.

## The earliest Neolithic cultures

The modern understanding of the early Neolithic period of the region was formed after studies of Neolithic sites at the beginning of this century. An investigation near the village of Karamyshevo in the Upper Don River basin allowed us to distinguish a very particular pottery type and thence a new archaeological culture called Karamyshevo (*Smol'yaninov 2009*) (Fig. 1). Excavations in the village of Cherkassk (Voronezh region) in the Central Don River area conducted from 2009 to 2015 (Voronezh region) yielded Early Neolithic pottery considerably different from all the known pottery complexes of the forest-steppe Don. It was found at the Cherkassk 5 site at the mouth of the Bityug River (the left tributary of the Don) (*Gapochka, Skorobogatov and Surkov 2015*).

A small part of Cherkassk 5 was excavated in 2014–2015. The cultural layer of this site was found under two-metre-thick alluvial sterile deposits. Pottery tempered by shell, with a polished surface was found at the bottom of the cultural layer (*Gapochka, Skorobogatov and Surkov 2015*). Later on similar pottery was found in the low layer of Cherkassk 3. Two dates were made on one sample at 7474±65 BP (6450–6225 cal BC, Hela-3520) and 7610±45 BP (6570–6398 cal BC, GrA-62165) (Fig. 2.1). Also, organic crust from pottery of this type from Cherkassk 5 was dated to 7115±130 BP (6236–5730 cal BC, SPb-




***Map 2. Distribution map of early Neolithic cultures in the forest-steppe in Don region.***

1465). It is possible to assume the old age of these materials can be explained by the specifics of the dated material (organic crust); however, typologically, this pottery appears to be among the most ancient.

However, from our point of view, pottery moulding skills were mastered as a result of direct contacts with the population of the Elshan culture, which had skills and arrived in the Don region at the close of 6th century BC. The Don population adopted these skills very rapidly.

Materials attributed to the Karamyshevo culture (Fig. 1) were found at 26 sites located only in the basin of the Voronezh River (the left tributary of the Don River). It is supposed to be an Early Neolithic culture, based on stratigraphic data and radiocarbon dates (Tab. 1), and its chronological position coincides with Elshanskaya, Upper Volga and other early Neolithic cultures.

Karamyshevo culture appeared to be one of the oldest within the group of Early Neolithic materials in this region based on radiocarbon dates that range from the beginning of the 6th to the first half of the 5th millennium BC. The oldest dates were acquired from organic crust on pottery from the lower layer of the Ivnitsa site; the latest dates are from pottery from Vasilyevsky Kordon 5 and 7 and Karamyshevo 9. The beginning of the development of Karamyshevo culture might be dated to the same time or a later period of the Elshanskaya culture at Gorodok 1, a site located near the Upper Don (about 40km north of the Don basin): 6760±90 BP (5841–5515 cal BC, Ki-14075) and 6870±100 BP (5983–5621 cal BC, Ki-14114). Radiocarbon dates made on organic crust from pottery of this stage from Ivnitsa – 6940±40 BP (5471–5303 cal BC, Poz-42054) – and Karamyshevo 5 – 6570±60 BP (5790–5230 cal BC, Ki-11088) – confirm this hypothesis.

One of the main indicators of Karamyshevo culture is pottery. The Neolithic/Eneolithic sites contain a few stone tools characteristic of the Upper Don region. Karamyshevo pottery is distinguished by its texture and decoration. In most cases, the pottery has similar production features; it was made with an original type of raw material – a non-sanded high plasticity silty clay with natural inclusions (pottery from different sites varies in the composition of natural inclusions) such as sand, decomposed vegetation debris, undissolved pieces of clay (which were less than 1mm in size), small shell inclusions (in the form of slot-like square holes 2–3mm in size), and reddish brown chalybeate matter less than 1mm in size. The moulding composition contained plastic raw material with organic liquid (holes with rusty friable substance). Pots were formed with sculptural modelling techniques (patch modelling). Surfaces were smoothed with a soft material. The vessels were low-fired, with a short-term exposure to heat at 650–700°C (a 3-layer fracture). The pottery was light brown, with thin walls (no more than 0.7mm thick).

Later, the Karamyshevo pottery was produced from sanded silty clay containing natural inclusions like the pottery of the Middle Don culture. As far as surface finishing is concerned, Karamyshevo pottery can be subdivided into two groups: one with thoroughly smoothed surfaces and burnished exterior surfaces, and one with smoothed surfaces with scratches (sometimes the exterior was smoothed after being decorated with scratches), which also might be a chronological indicator.

Most of the pottery fragments were not decorated. Thus, out of over 500 fragments of pottery from the Vinnitsa site, 62% of the pottery finds were not decorated, about 25% were decorated with oval, triangle and doubled strokes, 11% were decorated with a short-toothed comb, only 21 pottery fragments had thin and shallow incised lines on the surface, and 10 fragments were decorated with a pit pattern. This indicates the relatively early nature of the site, whereas the sites evidencing later cultures such as Karamyshevo 9 or Vasilyevsky Kordon 7 contain more decorated pottery.

Pottery from the late Karamyshevo sites is characterised by the distibution of pit and comb imprints in the decoration, the increase in the decorated surface, the appearance of false cord decoration made with oval impressions arranged in lines. This material was found at sites such as: Karamyshevo 9 where it is dated to 5790±100 BP (4850–4450 cal BC, Ki-12160) and 5630±100 BP (4710–4325 calBC, Ki-12161); VasilyevskyKordon 5, dated to 5870±80 BP (4940–4530 cal BC, Ki-15194) and 5910±90 BP (4940–4530 cal BC, Ki-15625); VasilyevskyKordon 7 where it is dated to 6010±80 BP (5080–4710 cal BC, Ki-15624), 5930±80 BP (5000–4590 cal BC, Ki-15192), 5860±80 BP (4860–4520 cal BC, Ki-15193) and 5770±90 BP (4810–4440 cal BC, Ki-15199); VasilyevskyKordon 3 where it is dated to 5868±120 BP (5036–4458 cal BC, SPb-1638). These sites existed in the Upper Don River basin until the second half of the 5th millennium BC.

Nowadays, Middle Don Culture (Fig. 3.1–3) is not regarded as chronologically older than other cultures in this region, especially regarding materials from the Cherkasskaya 5 site. Currently, more than 100 sites located in the forest-steppe Don are attributed to this culture. However, only a few sites have been excavated and have a clear stratigraphy. The pottery from its early stage (6th millennium BC) is contemporaneous with the pottery of the early stage of Karamyshevo culture. The first stage of Middle Don culture is characterised by archaeological layers with stroke-ornamented pottery (not comb pottery), which was revealed in material from the Monastery site in Pobityuzhye, a lower layer of the Cherkassksite (A. T. Sinyuk's excavation in 1979–1981), and also at Inyasevskaya, Shapkinskaya 6, and Plautinskaya 2 in the Khoper River basin.

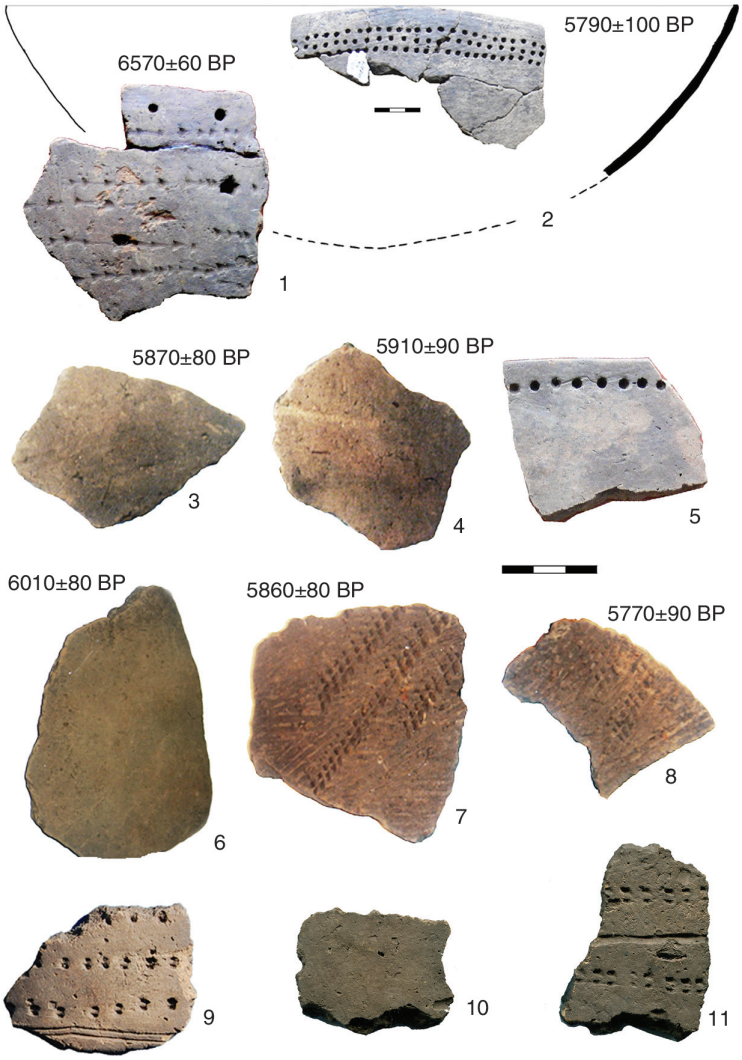



***Fig. 1. Pottery of Karamyshevskaya culture (1 Karamyshevo 5; 2 Karamyshevo 9; 3–5 Vasil'evskii Kordon 5; 6–8 Vasil'evskii Kordon 7; 9–11 Ivnica).***

Similar materials in the Upper Don basin were found only at Yarlukovskaya Protoka, Dobroye 1 and Universitetskaya 3. There are several earlier radiocarbon dates for this stage: for Dobrovsky – 6912±120 BP (6019–5621 cal BC, SPb-1287); site Cherkassk 3, a low layer – 6715±64 BP (5730–5525 cal BC, Hela-3491); Yarlukovskaya Protoka (point 222) – 6774±120 BP (5903–5484 cal BC, SPb-1637) and a late one, which are transitional between the first and second stages, based on pottery from Universitetskaya 3: 6190±100 BP (5400–4800 cal BC, Ki-15959), 6140±90 BP (5300–4840 cal BC, Ki-15432) and 6050±90 BP (5300–4700 cal BC, Ki-15441).

It is also necessary to underline other cultural influences of the Neolithic in this region. The southern periphery of the Upper Volga culture can be traced in the northern part of the Upper Don area. There are a few sites with poor cultural layers. Four sites of the Upper Volga culture are known. Beryozovka 4B, dated by Olga A. Chichagova to 6780±140 BP (5979–5480 cal BC, IGAN 2007), can be attributed to the early stage of Upper Volga culture (*Naumova, Smol'yaninov 2009*).

The Upper Volga and Elshan cultures have similar dates in the 5th century BC (*Zhilin* et al. *2002; Zaretskaya, Kostylyova 2008.5–14*). Having analysed ceramic and stone tools, most researchers define an early stage with plain and stroke-ornamented pottery and late stages with the appearance of pit and comb pottery. Some authors put the early stage of the Upper Volga culture as separate cultures – the Valday culture, according to publications by Nina N. Gurina and the Volga-Oka culture according to Yuri B. Tsetlin (*Tsvetkova 2012*).

The earliest pottery pieces found in the western Upper Volga region and attributed to the Kotchishche type are characterised by a smoothed and burnished surface, chamotte or sometimes organic matter, decorations with isolated strokes, or prints made with a two- or three-pronged comb (*Gurina 1996*).

Pottery decorated by comb impressions and traced lines which is attributed to Dnepro-Donetsk culture can be also distinguished in the forest-steppe Don basin. This type of pottery appeared in the Middle Don River very early, almost at the same time as complexes of Middle Don culture. Organic crust from pottery found on the site Cherkassk 3 was dated to 6851±34 BP (5832–5662 cal BC, KIA-51099). There are two such sites in the Upper Don River basin: near Lipetsk waste treatment facilities and at Karamyshevo 9, but they are later. The appearance of this pottery at Neolithic sites of the region must have been related to intertribal communication networks connecting the communities of the Dnepro-Donetsk culture around the middle of the 5th millennium BC. Two radiocarbon dates were obtained on the same vessel from Karamyshevo 9 in the Upper Don area: 5650±90 BP (4710–4330 cal BC, Ki-15191) and 5160±160 BP (4170–3760 cal BC, Ki-11088).

**Middle Don Culture (second and third stage): contacts with the Eneolithic world**

Small, thin comb impressions along with pin-pointed pattern in decoration of pottery (*Gapochka 2001*) are typical of the second stage. The second stage of Middle Don Neolithic culture must have been related to the expansion of early Eneolithic communities from the Lower Don culture into the Don forest-steppe area (*Skorobogatov 2011a.178–180*). There is much more material from settlements of the second stage, dated to the end of the 6th and the first half of the 5th millennium BC. They are found both on the Voronezh and on the Don rivers: Universitet 3, Universitet 1, Karamyshevo 9, Ksizovo 6, Savitskoye, Kurino 1, Vasilyevsky Kordon 1, Lipetsk Lake, Cherkassk, and Cherkassk 3. Only one date was obtained for the material from Yarlukovskaya Protoka site for this stage – 5770±200 BP (5207–4246 cal BC, SPb-1288), and one from Cherkassk – 5997±33 BP (4985–4795 cal BC, Hela-3771). Meanwhile, only one radiocarbon date was obtained on organic crust from pottery of the Cherkassk type from the Cherkassk site – 5763±32 BP (4710–4535 cal BC, Hela-3884). It is important to note that single $^{14}C$ dates for the early Eneolithic of the Don forest-steppe are contemporaneous with the second stage of Middle Don Neolithic culture (*Skorobogatov 2013.273*).

The beginning of the third stage (the second half of the 5th millennium BC) is marked by an expansion of the people of the Middle Don Culture and active contacts with newcomers from neighboring areas, namely Neolithic communities with comb-pit pottery, and continued contacts with Eneolithic communities of the Middle Don Culture. So far, we have no radiocarbon dates for this stage. The final stage of the Middle Don Culture (a 'vestigial' Neolithic stage) as well as the end of a vestigial/Neolithic stage in this region may be related to the latest Neolithic sites, where mixed ceramic Neolithic-Eneolith complexes have been found. These complexes have clear features of late Middle Don (Dereivsk) and Repinsk cultures, such as Yamnoye, Ksizovo 6, Vasilyevsky Kordon 17, Vasilyevsky Kordon 27 *etc.*, and late stroke and pit-comb complexes, pottery of the Ksizovsky type and rhomb-pit pottery. These materials meanwhile can be roughly dated between the first half and the third quarter of the 4th millennium BC. Four dates were obtained on pottery from the Yamnoye site: 4850±90 BP (3950–3350 cal BC, Ki-16634), 4960±90 BP (3970–3630 cal BC, Ki-16635), 4790± 80 BP (3710–3360 cal BC, Ki-16636), 4910± 80 BP (3950–3620 cal BC, Ki-16637), and also a date for rhomb-pit pottery from the Ksizovo 6 site – 4630+ 90 BP (3635–3100 cal BC, Ki-13309).

It is necessary to point out that starting from the developed Neolithic – the beginning of the second stage of Middle Don Culture (the end of 6th and first half of the 5th millennium BC) the appearance of various Neo-Eneolithic cultures can be traced in the Don forest steppe area, which appears to be one of the particularities of this region. These cultures left

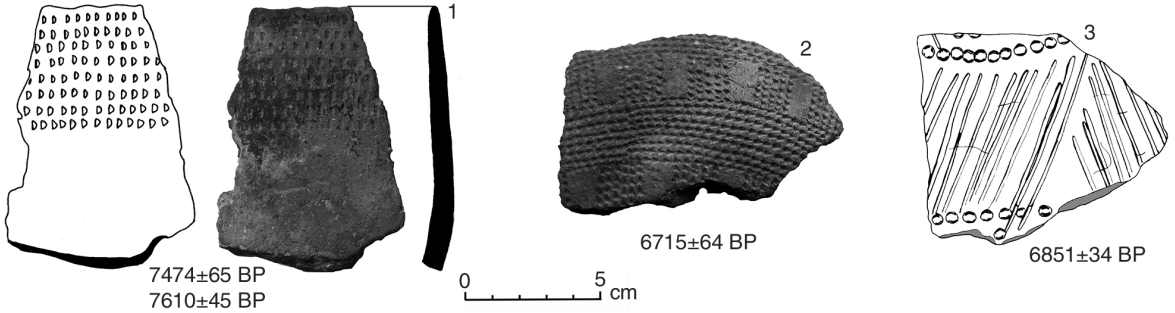



***Fig. 2. Cherkasskaya 3 site. Early Neolithic pottery of non-local origin (1–2) and pottery of the Dnepr-Donetskaya culture (3).***

a clear imprint on the material culture of the local ancient population. Along with pottery attributed to the southern Middle Don culture, there are pottery materials of the Dronikh culture (Fig. 3.5–6) which relate to influences from the south-east (*Surkov 2007.113–114*). Only two dates are currently available for Dronikh pottery; from Plautino 1 – 5830±80 BP (4850–4490 cal BC, Ki-15436), and Dronikh – 5650±80 BP (4690–4340 cal BC, Ki-15437). The appearance of Lyalovskaya culture material in this region is related to northern migration, This pottery type from the Ivnitsa site was dated to 5840±90 BP (4932–4494 cal BC, Ki-16638), and from the Ksizovo site 6 to 5820±130 BP (4995–4371 cal BC, Ki-13307) and 5400±120 BP (4458–3975 cal BC, Ki-13308).

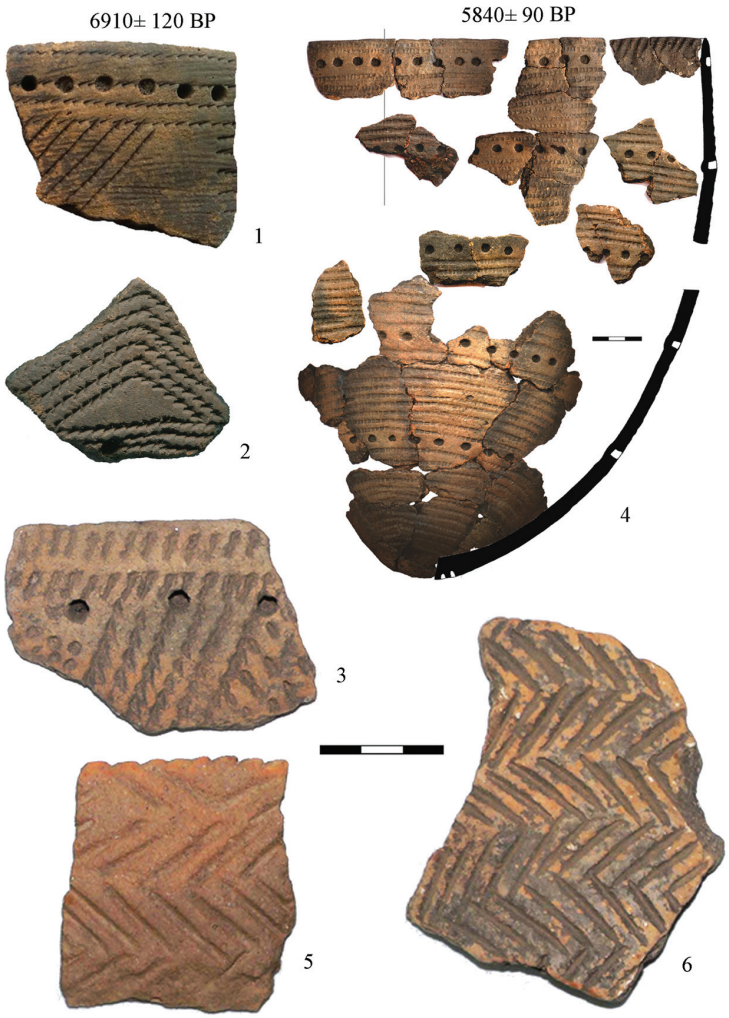



***Fig. 3. Pottery of the Middle Don culture (1–3), Lyalovskaya (4) and Dronikhinskaya (5–6) cultures: 1 Dobroe 1; 2 Ivnica; 3 Universitetskaya III; 4 Ivnica; 5 Plautino 1; 6 Droniha.***

## Conclusions

On the basis of the foregoing discussion, we can conclude that the first pottery complexes appeared in the forest-steppe and forest zones of Eastern Europe at the end of the 7th or beginning of the 6th millennium BC, and they existed in the Don River basin until the first half of the 5th millennium BC. All of these early ceramic complexes had a number of common features bearing certain specific features. These particularities are represented in the local cultures that are now identified. Thus it was possible to distinguish between Karamyshevo and Middle Don cultures, and also the new type of pottery found at the sites located in the Middle Don basin (Cherkassk 3 and Cherkassk 5). We can also suppose that the beginning of the second Neolithic stage in this region (the Neo-Eneolithic period, according to Dmitry Ya. Telegin (*2004*)) can be connected with the cultural influence of the Lower Don culture. The third stage can be related to the appearance of the Lyalovsk culture (Fig. 3.4), which is represented by pottery decorated by pit and comb impressions.

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***Tab. 1. Radiocarbon dates of sites from the forest-steppe area of the Don River.***

| No. | $^{14}C$ (BP) | (2σ) (cal BC) | lab-index | dated material | $^{13}C$ | site | information about dated material | cultural context | references |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 7474±65 | 6450–6225 | Hela-3520 | organic crust (Fig. 2.1) | –29,6 | Cherkasskaya 3 | Surface finds (No. 45) | nonlocal early neolithic | *Skorobogatov 2012* |
| 2 | 7610±45 | 6570–6398 | GrA-62165 | organic crust (Fig. 2.1) | | Cherkasskaya 3 | Surface finds (No. 45) | nonlocal early neolithic | *Skorobogatov 2012* |
| 3 | 6530±120 | 5703–5231 | SPb-1978 | organic crust | | Cherkasskaya 3 | Surface finds (No. 45) | nonlocal early neolithic | *Skorobogatov 2012* |
| 4 | 6827±110 | 5978–5550 | SPb-1463 | organic crust | | Cherkasskaya 5 | Surface finds (No. ČS-5-12, PM) | nonlocal early neolithic | *Gapochka, Skorobogatov and Surkov 2015.Fig. 1.1* |
| 5 | 6687±110 | 5837–5389 | SPb-1466 | organic crust | | Cherkasskaya 5 | Excavation of 2014, depth –253cm (No. 338) | nonlocal early neolithic | *Gapochka, Skorobogatov and Surkov 2015* |
| 6 | 7115±130 | 6236–5730 | SPb-1465 | organic crust | | Cherkasskaya 5 | Excavation of 2014, depth –260cm (No. 376) | nonlocal early neolithic | *Gapochka, Skorobogatov and Surkov 2015* |
| 7 | 6380±40 | 5471–5303 | Poz-42052 | organic crust | | Ivnitsa | Excavation of 2010 (No. 1268), square M12, depth –35cm, layer 3 – gray-brown sandy loam | karamyshevskaya | *Surkov 2013* |
| 8 | 6720±40 | 5716–5607 | Poz-42053 | organic crust | | Ivnitsa | Excavation of 2010. No. 1379, square I14, depth –33cm, layer 3 – gray-brown sandy loam | karamyshevskaya | *Surkov 2013* |
| 9 | 6940±40 | 5904–5731 | Poz-42054 | organic crust | | Ivnitsa | Excavation of 2010. No. 1399, square I14, depth –34cm, layer 3 – gray-brown sandy loam | karamyshevskaya | *Surkov 2013* |
| 10 | 6570±60 | 5790–5230 | Ki-11088 | pottery (Fig. 1.1) | | Karamyshevo 5 | Excavation of 2002, square 10, depth –72cm | karamyshevskaya | *Smolyaninov, Surkov 2014* |
| 11 | 5870±80 | 4940–4530 | Ki-15194 | pottery (Fig. 1.3) | | Vasilievsky Kordon 5 | Excavation of 2007, square 105, depth –35cm | karamyshevskaya | *Smolyaninov, Surkov 2014* |
| 12 | 5910±90 | 4940–4530 | Ki-15625 | pottery (Fig. 1.4) | | Vasilievsky Kordon 5 | Excavation of 2007, square 104, depth –31cm | karamyshevskaya | *Smolyaninov, Surkov 2014* |
| 13 | 6010±80 | 5080–4710 | Ki-15624 | pottery (Fig. 1.6) | | Vasilievsky Kordon 7 | Excavation of 2007, No. 3819, square B2, depth –70cm | karamyshevskaya | *Surkov 2008*; *Smolyaninov, Surkov 2014* |
| 14 | 5930±80 | 5000–4590 | Ki-15192 | pottery | | Vasilievsky Kordon 7 | Excavation of 2007, No. 4427, square B2, depth –77cm | karamyshevskaya | *Smolyaninov, Surkov 2014* |
| 15 | 5860±80 | 4860–4520 | Ki-15193 | pottery (Fig. 1.7) | | Vasilievsky Kordon 7 | Excavation of 2007, No. 4135, square B4, depth –72cm | karamyshevskaya | *Smolyaninov, Surkov 2014* |
| 16 | 5770±90 | 4810–4440 | Ki-15199 | pottery (Fig. 1.8) | | Vasilievsky Kordon 7 | Excavation of 2007, No. 5134, square D16, depth –32cm | karamyshevskaya | *Surkov 2008*; *Smolyaninov, Surkov 2014* |

| No. | $^{14}$C (BP) | (2σ) (cal BC) | lab-index | dated material | $^{13}$C | site | information about dated material | cultural context | references |
|---|---|---|---|---|---|---|---|---|---|
| 17 | 5790± 100 | 4850–4450 | Ki-12160 | pottery (Fig. 1.2) | | Karamyshevo 9 | Excavation of 2002–2003, No. 5134, square D16, depth –32cm | karamyshevskaya | *Smolyaninov, Surkov 2014* |
| 18 | 5630± 100 | 4710–4325 | Ki-12161 | pottery | | Karamyshevo 9 | Excavation of 2002–2003, above base layer | karamyshevskaya | *Smolyaninov, Surkov 2014* |
| 19 | 5868± 120 | 5036–4458 | SPb-1638 | pottery | | Vasilievsky Kordon 3 | Excavation of 2012, construction 1, layer 2 | karamyshevskaya | *Smolyaninov 2013*; *Smolyaninov 2016* |
| 20 | 6780± 140 | 5979–5480 | IGAN-2007 | ground | | Berezovka 4B | Excavation of 1999. Low layer of the test-pit 4 sq.m., depth 120–125cm | Upper volga culture | *Smolyaninov, Naumova 2009* |
| 21 | 6851± 34 | 5832–5662 | KIA-51099 | organic crust (Fig. 2.3) | | Cherkasskaya 3 | Excavation of 2012. No. 4218. Low layer, depth –296cm | Dnepr-Donetsk culture | *Skorobogatov 2012* |
| 22 | 5160±160 | 4170–3760 | Ki-11088 | pottery | | Karamyshevo 9 | Excavation of 2002–2003. Square 605, depth 30–40cm | Dnepr-Donetsk culture | *Smolyaninov 2009*; *Smolyaninov, Klokov 2005* |
| 23 | 5650±90 | 4710–4330 | Ki-15191 | pottery | | Karamyshevo 9 | Excavation of 2002–2003. Square 605, depth 30–40cm | Dnepr-Donetsk culture | *Smolyaninov 2009*; *Smolyaninov, Klokov 2005* |
| 24 | 6910± 120 | 6019–5621 | SPB-1287 | pottery (Fig. 3.1) | | Dobroe 1 | Excavation of 1985. Square 3, depth –60cm | Middle Don culture | *Sinyuk 1986* |
| 25 | 6715±64 | 5730–5525 | Hela-3491 | organic crust (Fig. 2.2) | –29,5 | Cherkasskaya 3 | Excavation of 2012. No. 3330. Square Ž3, low layer, depth –270cm | Middle Don culture with non-local infiltrations | *Skorobogatov 2012* |
| 26 | 5997±33 | 4985–4795 | Hela-3771 | organic crust | –28,2 | Cherkasskaya | Excavation of 2010. No. 10492. Square A12, depth –213cm. | Middle Don culture | *Skorobogatov 2011b* |
| 27 | 6190±100 | 5400–4800 | Ki-15959 | pottery | | Universitets-kaya 3 | Excavations of A. T. Sinuk in 1968-1970 | Middle Don culture | *Vybornov, Surkov 2009*; *Sinyuk 1986* |
| 28 | 6140± 90 | 5300–4840 | Ki-15432 | pottery | | Universitets-kaya 3 | Excavations of A. T. Sinuk in 1968-1970 | Middle Don culture | *Vybornov, Surkov 2009*; *Sinyuk 1986* |
| 29 | 6050± 90 | 5300–4700 | Ki-15441 | pottery | | Universitets-kaya 3 | Excavations of A. T. Sinuk in 1968-1970 | Middle Don culture | *Vybornov, Surkov 2009*; *Sinyuk 1986* |
| 30 | 6774±120 | 5903–5484 | SPB-1637 | pottery | | Yarlukovskaya protoka (site 222) | Excavations of V. P. Levenok, layer 6 | Middle Don culture | *Levenok 1973* |
| 31 | 5770±200 | 5207–4246 | SPB-1288 | pottery | | Yarlukovskaya protoka (site 222) | Excavations of V. P. Levenok, layer 5 | Middle Don culture | *Levenok 1973* |
| 32 | 5840±90 | 4932–4494 | Ki-16638 | pottery (Fig. 3.4) | | Ivnitsa | Prospections of A. N. Merkulov in 2009. Test-pit | Iyalovskaya | *Surkov 2013* |

| No. | $^{14}$C (BP) | (2σ) (cal BC) | lab-index | dated material | $^{13}$C | site | information about dated material | cultural context | references |
|---|---|---|---|---|---|---|---|---|---|
| 33 | 5820±130 | 4995–4371 | Ki-13307 | pottery | | Ksizovo 6 | Excavation of 2005. Excavation 2, square 29, depth –364cm. | lyalovskaya | *Lavrushin* et al. *2009* |
| 34 | 5400±120 | 4458–3975 | KI-13308 | pottery | | Ksizovo 6 | Excavation of 2005. Excavation 2, square 31, depth –315cm. | lyalovskaya | *Lavrushin* et al. *2009* |
| 35 | 5225±90 | 4319–3802 | KI-13313 | pottery | | Kurino 1 | Excavation of A. N. Bassudnov in 1991. Square 376, depth –40cm. | lyalovskaya | *Bessudnov 1996* |
| 36 | 6000±50 | 5200–4800 | Gin-13546 | human bone | | Ksizovo 6 | Excavation of 2005. Excavation 2, burial 2 (a child 12 years old) | | *Lavrushin* et al. *2009* |
| 37 | 6000±50 | 5200–4800 | Gin-13544 | human bone | | Ksizovo 6 | Excavation of 2005. Excavation 2, burial 4 (a man 40-45 years old) | | *Lavrushin* et al. *2009* |
| 38 | 5830± 80 | 4850–4490 | Ki-15436 | pottery | | Plautino 1 | Prospections of A. V. Surkov in 2002 | dronikhinskaya | *Surkov 2007*; *Vybornov, Surkov 2009* |
| 39 | 5650±80 | 4690–4340 | Ki-15437 | pottery | | Dronikha | Excavation of A. T. Sinuk in 1980 | dronikhinskaya | *Surkov 2007*; *Vybornov, Surkov 2009* |
| 40 | 5763±32 | 4710–4535 | Hela-3884 | organic crust | –30,3 | Cherkasskaya | Excavation of 2010. No. 10736. Square B15, depth –209cm. | cherkasskyi type | *Skorobogatov 2011a*; *Skorobogatov 2011b* |
| 41 | 4850±90 | 3950–3350 | Ki-16634 | pottery | | Yamnoe | Excavation of 2008. Square K8, depth –70cm. | lyalovskaya | *Surkov, Skorobogatov 2012.Fig. 23* |
| 42 | 4960±90 | 3970–3630 | Ki-16635 | pottery | | Yamnoe | Excavation of 2007. Square I7, depth –78cm. | pin-pointed pottery | *Surkov, Skorobogatov 2012.Fig. 34.3* |
| 43 | 4790±80 | 3710–3360 | Ki-16636 | pottery | | Yamnoe | Excavation of 2009. Square B'25, depth –38cm. | lyalovskaya | *Surkov, Skorobogatov 2012.Fig. 38.2* |
| 44 | 4910±80 | 3950–3620 | Ki-16637 | pottery | | Yamnoe | Excavation of 2009. Square B19, depth –29cm. | pin-pointed pottery | *Surkov, Skorobogatov 2012.Fig. 22* |
| 45 | 4630±90 | 3635–3100 | Ki-13309 | pottery | | Ksizovo 6 | Excavation of 2005. Square B19, depth –29cm. | rhomb-pit pottery | *Lavrushin* et al. *2009* |
| 46 | 5080±125 | 4250–3600 | Le-1013 | wood | | Universitets-kaya 3 | Excavations of A. T. Sinuk in 1968–1970 | lyalovskaya | *Arkheologiya. Neolit Severnoy Evrazii 1996.209* |
| 47 | 4770±60 | 3660–3370 | Le-725 | stick from a fish-trap | | Podzorovo | Excavations of M. E. Foss in 1959, and V. P. Levenok in 1969 | lyalovskaya | *Arkheologiya. Neolit Severnoy Evrazii 1996.209* |

# Radiocarbon chronology of Neolithic in the Lower Don and North-eastern Azov Sea

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ABSTRACT – *So far, four different cultural-chronological groups of sites have been identified in the North-eastern Azov Sea and Lower Don River areas, including sites of the Rakushechny Yar culture, Matveev Kurgan culture, Donets culture, and sites of the Caspian-Ciscaucasian region. An analysis of all known dates, as well as the contexts and stratigraphies of the sites, allowed us to form a new perspective of the chronology of southern Russia, to revise the chronology of this region, and change the concept of unreliability of dates for this area.*

KEY WORDS – *Neolithic; chronology; earliest pottery; Lower Don; North-Eastern Azov Sea*

## *Radiokarbonska kronologija neolitika na območju spodnjega toka reke Don in v severovzhodnem delu Azovskega morja*

IZVLEČEK – *Na območjih severovzhodnega dela Azovskega morja in spodnjega toka reke Don so bile do danes prepoznane štiri različne kulturno-kronološke skupine najdišč, ki vključujejo najdišča kulture Rakushechny Yar, kulture Matveev Kurgan, kulture Donets in druga najdišča v kaspijsko – ciskavkaški regiji. Z analizo vseh znanih radiokarbonskih datumov, njihovih kontekstov in stratigrafij na najdiščih, smo lahko oblikovali nove poglede na kronologijo južne Rusije, revidirali staro kronologijo in spremenili odnos do datumov, ki so veljali za nezanesljive.*

KLJUČNE BESEDE – *neolitik; kronologija; najzgodnejša lončenina; spodnji tok reke Don; severovzhodni del Azovskega morja*

## Introduction

The Neolithic period of the North-eastern and Eastern Azov Sea areas has been investigated for more than 50 years, and over 100 radiocarbon dates are available (Tab. 1). Four different cultural-chronological groups of sites are now distinguished here. They include sites of the Rakushechny Yar culture (the Lower Don River), Matveev Kurgan culture (Mius River), sites of Donets culture (Low Siversky Donets River) and of the Caspian-Ciscaucasian cultural group (*Tsybrij 2008; Belanovskaya 1995; Krizhevskaya 1991*; for the areas of these cultures' distribution, see *Gorelik* et al. *2016*). Each of these cultures is repre-


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sented by several sites (see *Tsybrij 2008*). In the majority of cases, the Neolithic period in this region is marked by the appearance of pottery, an intensification of sedentism, the appearance of 'wattle and daub' architecture (at some sites), specific anthropomorphic and zoomorphic plastics, and new features in the stone industry. The previous determination of domesticated animals at the Matveev kurgan I site dated to the end of the 7th millennium BC were re-examined (*Krizhevskaya 1991; Gorelik* et al. *2016. 149*); evidence of domesticated animals at the Rakushechny Yar site are under discussion (*Tsybrij* et al. *2017*).

This article will give an overview of chronological frameworks of these cultures, with a particular focus on Rakushechny Yar (Fig. 1). An analysis of all the known dates, as well as a context and stratigraphy, allowed a new view and revision of the chronology of south-western Russia, as well as changes of the concept of unreliability of dates for this region (*cf. Motuzaite Matuzeviciute* et al. *2015.657–658*) based on the Rakushechny Yar case study.

## Rakushechny Yar: in search of old excavations and new studies

Rakushechny Yar culture was distinguished by Tatyana D. Belanovskaya on the basis of materials from the Rakushechny Yar site, which yielded a very particular set of finds related to a complex subsistence system (*Belanovskaya 1983; 1995*). Only few sites are attributed to this culture: an early phase (7th–6th millenium BC), including Rakushechny Yar (layers 23–11) and Razdorskoe I (layer 1). The later Neolithic phases (5th millenium BC) include Rakushechny Yar (layer 5) and Samsonovskoe (layer 6) (*Tsybrij 2008.51–52*).

Rakushechny Yar is located in the Rostovsky region, on the island of Porechny near the village of Razdorskaya. Porechny is of non-homogeneous geomorphological structure (*Velichko* et al. *2011*). The north-western part is located in a high flood-plain area, and the south-western part on a low flood-plain. These two flood plains can be clearly seen from the opposite bank of the Don River. It might be suggested that the outer part of the right river bank where the site was located became separated when a new riverbed was forming, and thus the island appeared (*Velichko* et al. *2011*). Much of the site has been destroyed and is still being destroyed. This can be clearly seen by comparing images of the island on 19th century maps and photos of the 1960s, and modern investigations.

The site was discovered in 1956 by Leonid T. Agarkov, a teacher at Razdorskaya village. It was excavated in 1959–1966, 1968, 1971, 1976–1977, and 1979 by Leningrad University expeditions headed by Belanovskaya; the various excavations were made that acquired different names (Fig. 2)[1]. Collections obtained during excavations by Belanovskaya in the 1960s–1970s (*Belanovskaya 1995*) and later (*Aleksandrovsky* et al. *2009; Tsybryi* et al. *2014*) helped creating a typology of these materials (*Mazurkevich, Dolbunova 2015*), and an analysis of the site's stratigraphy and chronology. In 2008–2013 and 2016–2017, new excavations were conducted (*Tsybrij* et al. *2014*), and the stratigraphy that was revealed appeared to be very similar to that described by Belanovskaya of excavations I–III and a trench made by Dmitry Y. Telegin in 1975, which was located, according to archive data, between trenches IV–V made by Belanovskaya (Figs. 2–4).

The geological deposits on the site are up to 6m deep and the cultural layers up to 5m. According to Bela-




***Fig. 1. Site distribution in the Lower Don and North-eastern Azov Sea area (only sites indicated in Table 1 are presented here).***

1 Usually only the materials from excavation I are presented in the publications.

novskaya, the cultural layers can be traced to a distance of 240m to the south-east. The borders of the site inside the island are not clearly defined. The layers are not distributed uniformly and their number varies in different parts of the island. Only the upper layers (1–5) are deposited uniformly, whereas the layers below are isolated and vary in depth and area and are often separated by sterile layers of sand. This is what complicates the correlation of layers of excavations in different parts of the island. From the very outset, Belanovskaya noted that only the layers of excavations I–III can be correlated based on stratigraphic observation. This is why each part that was excavated has its own numbering system, which can be correlated only on the basis of $^{14}C$ dates from precise layers (see Fig. 3). Future excavations and the connection of all of the excavated areas will allow us to correlate stratigraphic units of different parts.

The surface excavated in the 1960s–1970s amounted to 1000m$^2$ (*Belanovskaya 1995.9–12*). The main trench (trench I) was in the northern part of the island (Fig. 2). Six horizons were distinguished here based on a very precise lithology, included cultural layers, often separated by sterile interlayers. The upper cultural layers of the Eneolithic and Later Neolithic period (layers 4 and 5) include thick layers filled by Viviparus dilluvianus shells, which were cemented together and protected the underlying layers from being destroyed (*Belanovskaya 1995*). The low horizon (correlated with horizon VI of Telegin; Fig. 3a) included several thin lithological layers (2–25cm) (Fig. 3f). Cultural layers 23–12 were separated by sterile sand interlayers, and layers 12–10 by sandy clay 5–10cm thick. No remains of structures were found in layers 23–18, besides shell piles with a great amount of fish and animal bones, charcoal and artefacts inside and nearby. Post pits, fire-places on clay platform-floors, shell piles, daub fragments from the walls/roofs of dwellings were found in layers above. The particularities of microstratigraphy and the spatial distribution of finds allows us to suppose that the inhabitants of this ancient settlement had to leave this place periodically (at least the part excavated), probably due to seasonal flooding of the paleoriver, but then they returned (*Belanovskaya 1995.13*). A particular material culture was revealed in the Neolithic layers, with flat-bottom pottery, predominantly undecorated, flint borers, slate chisels, and numerous bone points and antler hoes (Figs. 5–8).

Cultural layers 6–23 were attributed to the Neolithic (*Belanovskaya 1995*). Telegin identified six lithological horizons here, attributing horizons 4–6 to Early Neolithic layers (*Telegin 1981*) (Fig. 3a). This is a very important point, because the numbering of layers, indicated by Telegin, does not correspond to the now widely used layer numbering system pro-

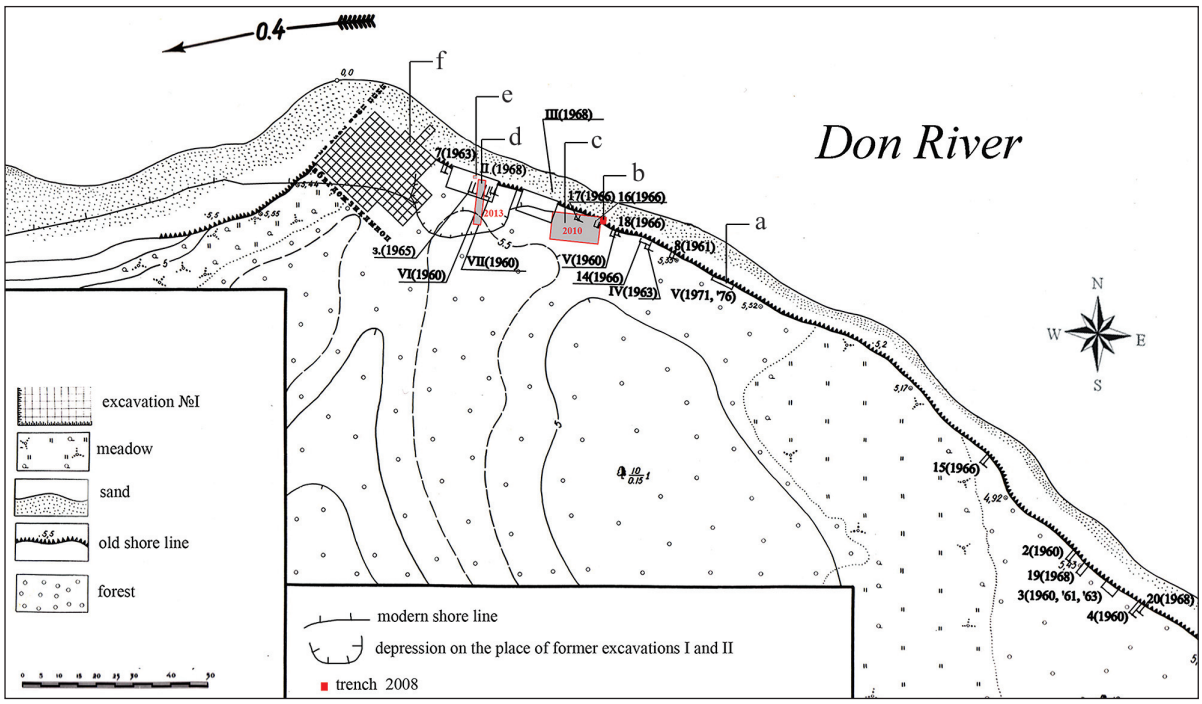



***Fig. 2. Rakushechny Yar site. Plan of excavations in the 1960–1970s, and new excavations in 2008–2016 (for a–f see Fig. 3).***

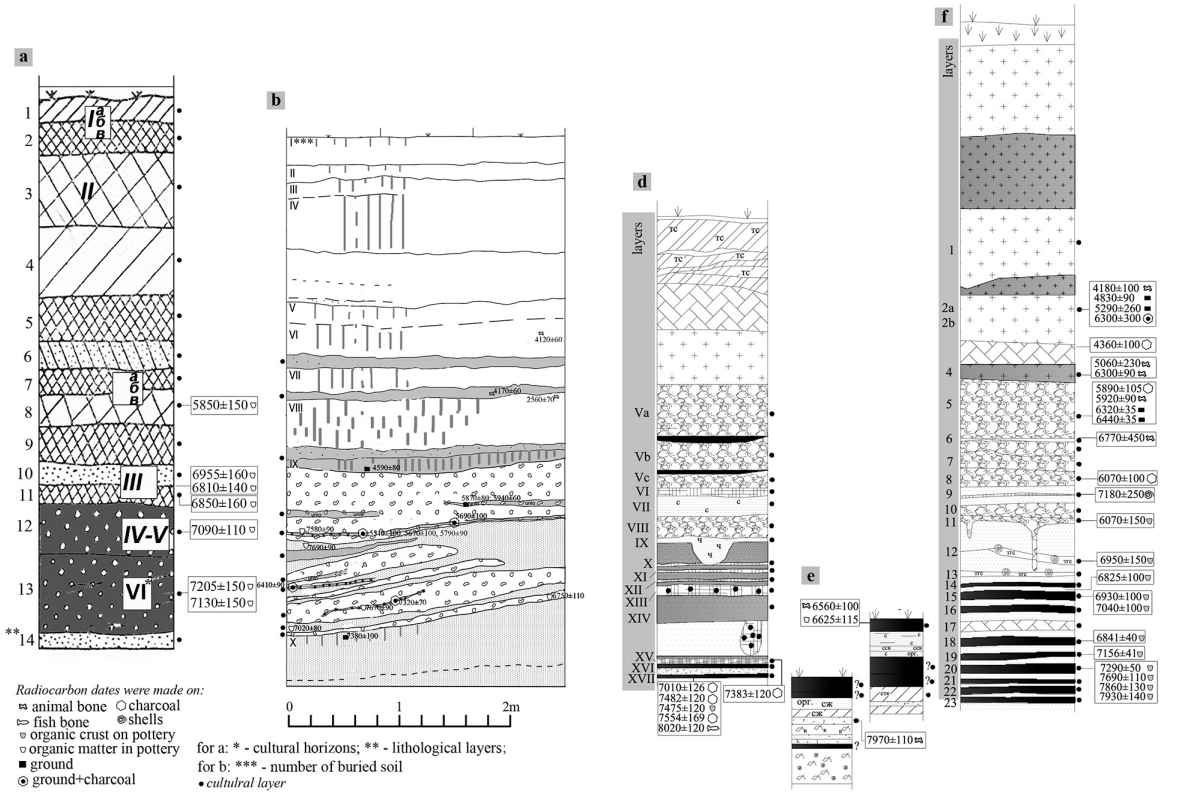



***Fig. 3. Rakushechny Yar. a stratigraphy of Telegin's excavation (from* Telegin 1981*); b stratigraphy of excavation of 2008 (modified from* Aleksandrovky *et al.* 2009*); d stratigraphy of trench 2013; e sondages #1, #2 and new excavations of 2016–2017; f excavation I by Belanovskaya in 1966 (modified from* Belanovskaya 1995*; the lower layers 16–23 were drawn according to description). See the description of the lithological layers in the text.***

posed by Belanovskaya, so dates made on materials with the firmer index system cannot be correlated with other dates without a special analysis of materials and discussion (*cf. Kotova 2002; Manko 2006 etc.*).

In order to refine the stratigraphy of the site and its chronology, which remained a subject of discussion, a stratigraphic trench was made in 2013, and further excavations carried out during 2016–2017, which allowed us to precisely place the previous excavations by Belanovskaya, to correlate the stratigraphy of different parts of the settlement and obtain new materials for radiocarbon dating.

## Chronology of the Rakushechny Yar site

The chronology of the settlement can be reconstructed based on radiocarbon dates made on different materials – charcoal, bone, soil and organic crust – from trench I of the 1960s (*Belanovskaya* et al. *2003; Belanovskaya, Timofeev 2003*), from the trench dug in 2008 (that might be located near excavation 16 made by Belanovskaya) and enlarged in 2010, and from the trench dug in 2013 at the location of the II by Belanovskaya (*Tsybrij* et al. *2014*) (Fig. 3). The stratigraphy of different excavations was correlated in order to refine the chronology of the site, new samples were selected, and artefacts, including dated samples, were spatially analysed.

Most of the radiocarbon dates of the organic materials from excavation I correlate rather well with each other (Tab. 1; Fig. 9). They show the dynamics of occupation of the site. The dates of materials from layer 20 might reflect different periods of occupation of the site. Only the dates of shells, and some dates of mixed samples of charcoal and soil could have been influenced by some postdepositional processes, and these do not reflect the real date of the layers' formation. Comparing the dates of fish bones and other materials from one layer, it is evident that the dates of the former appear to be older (Tab. 1.29). However, it must be noted that there is not enough data and materials to discuss the possibility and extent of the reservoir effect on this site.

Another set of dates was obtained from materials from the lower layers of the trench dug at excavation II in 2013, from the trench of 2008, and pottery

from excavations by Telegin in 1975 (*Telegin 1981*), which allowed us to establish the radiocarbon chronology of different parts of the site. Charcoal from a shell pile (layer XVII, trench of 2013) was dated to 7554±169 BP (Ua-48460) ($\delta^{13}C$ -22.6) and 7010±126 BP (Ua-48461) ($\delta^{13}C$ -23.0) (6590–6230 and 6000–5760 cal BC). It is clear in Figure 3 that a direct correlation of lithological layers in the lower part of the sediments of this site is impossible due to the different number and features of lithological and cultural layers. A direct correlation of layers based on their height values is also impossible, as the layers lie in an oblique position, at different heights in different places (Fig. 4). The radiocarbon date of an elk bone of 7970±110 BP (SPb-729) (7179–6596 cal BC) (Fig. 3e) allows its synchronisation with layers 21–23 (excavation No. I of Belanovskaya). Radiocarbon dates and stratigraphic observations on the area of excavations I–III allowed us to date the earliest stages of occupation to 7186–6472 cal BC.

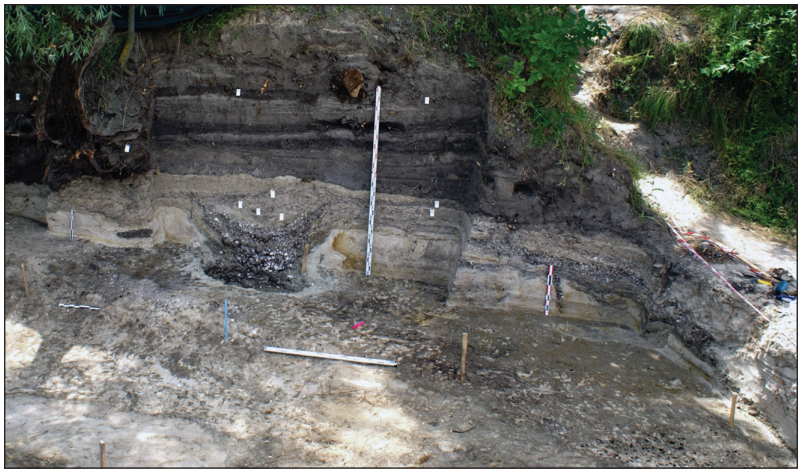


***Fig. 4. Rakushechny Yar. Stratigraphy of the excavation at the site of trenches II–III by T. D. Belanovskaya (excavation 'e'. 2016).***

Another group of dates of various materials (bones, pottery, soil with charcoal and soil) from the trench of 2008 presents a completely different picture (Fig.




***Fig. 5. Rakushechny Yar. Vessel forms in layers 23–14 (after* Mazurkevich, Dolbunova 2015*).***

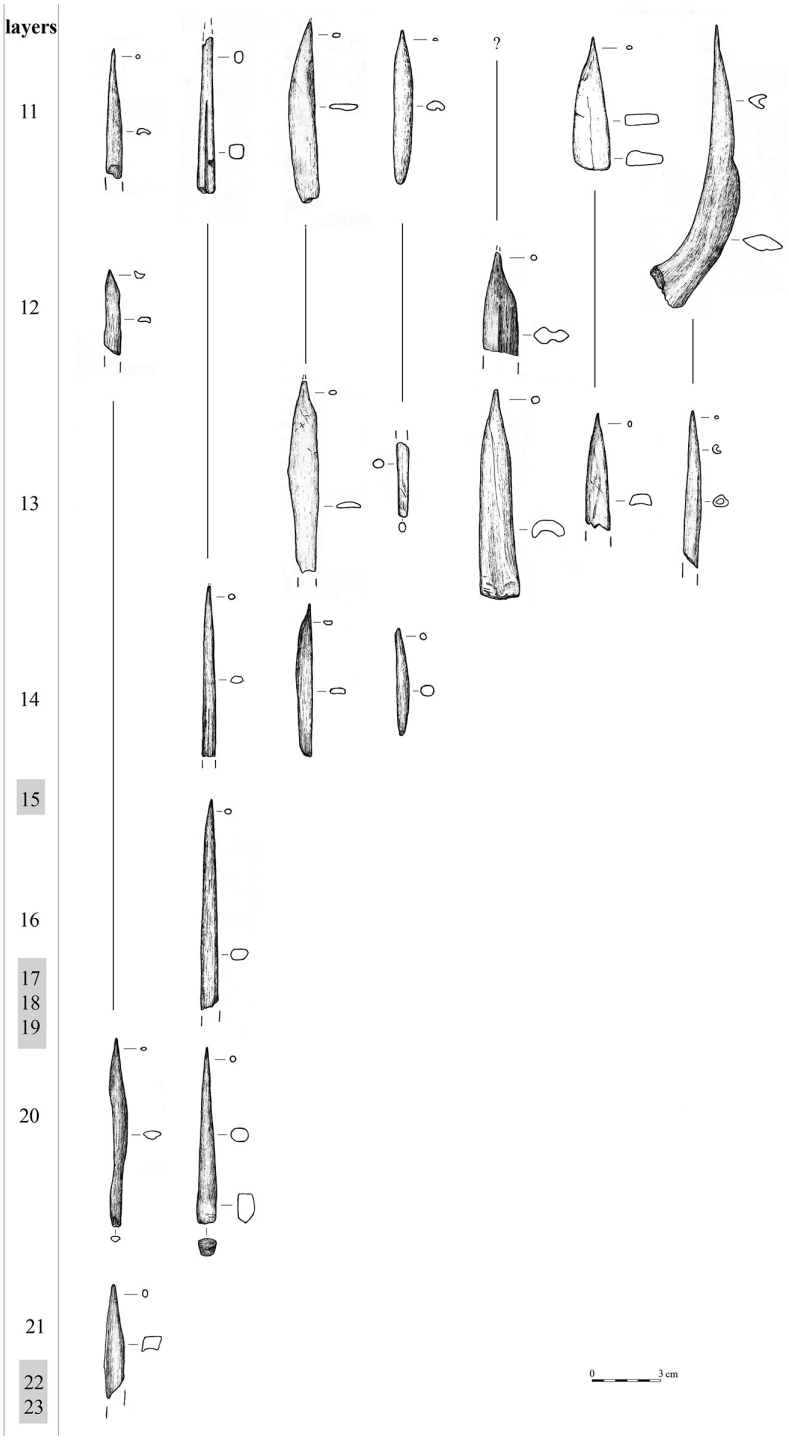



***Fig. 6. Rakushechny Yar. Bone points in layers 23–11.***

3b). The trench is located to the south-east of the excavation I–III (Fig. 2). The dates of the soil and soil with charcoal are in chronological correspondence. In most cases, the dates of pottery and bones from dated charcoal interlayers are older, and slightly younger in only few cases. This needs to be discussed further and can be explained only after new excavations on this part. This is why we will base our chronological reconstructions for this part on the dates of soils and charcoal from cultural layers. The buried soil No. X from the trench of 2008, lying on the bottom of cultural layers, was dated to 7380±100 BP (Ki-15181) (6431–6061 cal BC), *i.e.* this part was inhabited approx. 600 years later than the low layers from the place where excavations I–III by Belanovskaya were made. According to Alexander L. Aleksandrovsky, the process of soil formation started here later, as it was located lower than excavation I and occurred over a period of 100–200 years. Only when the area of excavation I was inhabited did the soil start to form here. We might synchronise the beginning of occupation and the formation of a cultural layer, which occurred between the period of layers 20 and 19 (excavation I – Fig. 3f) and during the period of layer XVI (location of excavations II–III – Fig. 3d). Further short periods of occupation, marked by thin sandy layers with Unio shells under the buried soil (IX – Fig. 3b) can be synchronised with layers 11–9 (excavation I – Fig. 3f).

The last group of dates were made on materials from the trench of Telegin dug in 1975 (Fig. 3a), located in the same place as excavation V by Belanovskaya, far to the south-east of the main area of excavation (trenches I–II). The stratigraphy of this trench is similar to that of the trench dug in 2008 (Fig. 3b). The dates were made on organic matter in pottery, and they show that this place might have been first inhabited at approximately the same time as the low layer of the trench dug in 2008. The typology of the dated vessels also supports this assumption.

Various layers traced in different parts of the island (Figs. 2; 3.a–f) can be correlated precisely on the basis of radiocarbon dates, as artefacts attributed to the Early Neolithic comprise a rather homogenous complex that preserved a range of features that seem

to survive through centuries. Nevertheless, more dating of different materials and the connection of different excavation areas are needed in order to refine the chronology of this part of the site, and the correlation of the various layers.

The differences in radiocarbon dates, number and character of cultural layers support suggestion of Belanovskaya's that the cultural layers revealed on the shore line and in different trenches cannot be correlated directly, and such 'diversity' shows that this part of the modern island was inhabited repeatedly during different periods. Taking into account that different parts of the site were excavated, their correlation is problematic, as their length and thickness varies, especially in lower layers. This is a departure point for discussing the validity of the dates derived from material from different layers of the site (*Motuzaite Matuzeviciute* et al. *2015.662*; for example, dates presented in *Motuzaite Matuzeviciute 2012*. *Tab. 1* for Rakushechny Yar are attributed to layers of different areas of the site and cannot be presented together). The main problem is that the dates were obtained from material from different excavated areas located in different parts of the island that cannot be correlated with each other, and not that some processes have influenced the dates. Moreover, it is important to consider the particularities of the layers' formation and seasonal occupation of this site over a long period. For example, given their thickness, layers 5 and 4 could have been accumulated during a long period.

The dates also point to another important problem: the time of accumulation of cultural layers and deposition of materials. The lower cultural layers of excavations I–III are filled with piles of Unio shells, fish scales and bones, animal bones and artefacts covered by thin and sterile sandy interlayers. The cultural layers could have been buried under thin sandy layers either after a single seasonal event or accumulated over longer periods. Different parts of the shore zone might have been inhabited, which can be archaeologically traced in radiocarbon dates. It is important to note that objects are recorded mostly *in situ* in the cultural layers (Fig. 8); the distribution of finds indicates only a slight disturbance of the cultural layers.

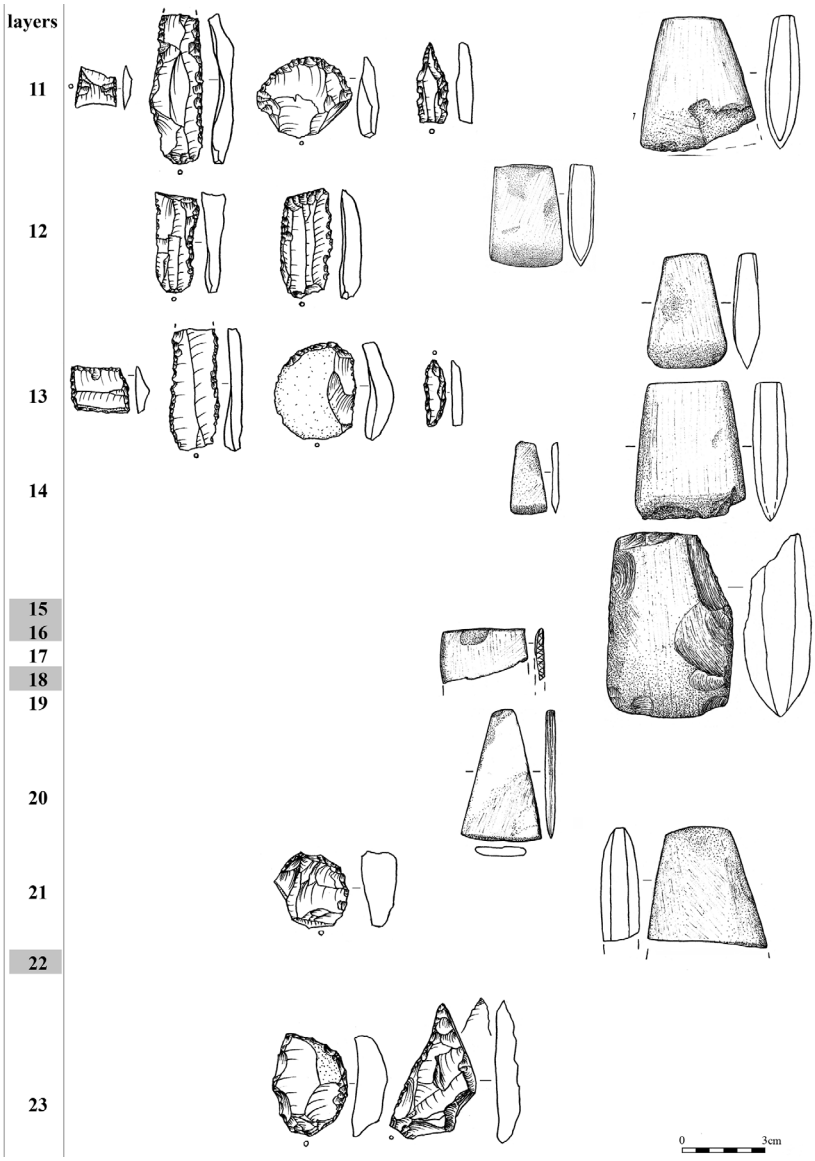



***Fig. 7. Rakushechny Yar. Flint and slate tools in layers 23–11 (from* Lozovsky 2014; *drawings done by V. M. Lozovsky and E. Dolbunova).***

Razdorskaya II is located on the right bank of the Don River, six kilometres downstream from Rakushechny Yar (*Tsybrij 2008*). It is a multilayered site, with predominantly Viviparus shell accumulation, and is rich in fish bones, charcoal, artefacts, and faunal remains. Fishing activity occupied an important place in the economy of Razdorskaya II, as it did at Rakushechny Yar. This is evident from the particu-

larities of the cultural layer (Fig. 10), with stratified shell piles and an inventory which includes a large number of sinkers, axes and bone spears. No pottery was found here, although small ceramic figurines were found. Due to the particular material culture of this site, it was attributed to a specific cultural type. Radiocarbon dates were made on materials from the middle and low cultural layers (*Aleksandrovsky* et al. *2009*) (Fig. 10). The early stages of this site are attributed to the earliest aceramic Neolithic phase at the end of the 8th – beginning of the 7th millennium BC. That this site continued to be occupied is evidenced by $^{14}$C dates within the range of the 7th and the beginning of the 6th millennium BC (Tab. 1), which suggest it was contemporaneous with Rakushechny Yar.

**Matveev Kurgan culture, Donets culture and sites of the Caspian-Ciscaucasian cultural group**

Matveev Kurgan culture was named after Matveev Kurgan I and II sites, located in North-Eastern Azov Sea area, which were excavated in the 1970–1980s by Lija Y. Krizhevskaya (*Krizhevskaya 1991*). Some similarities can be traced with the Lower Don River Neolithic sites. It can be attributed to the very beginning of Neolithic era and dated to the middle – second half of the 7th millennium BC, although more $^{14}$C dates would be needed to refine the chronological position of this culture. Later stages were not found here.

Donets culture was discovered in 1952 by Aleksandr Y. Brusov and was later re-analyzed and re-interpreted in the 1960s to 1990s (*Brusov 1952; Telegin 1968; Danilenko 1969; Gorelik 1984; 1997*). One of the typical features of this culture is the survival of archaic traits in the stone industry for a long period and a small amount of pottery. Complexes attributed to the early phases of Donets culture can be synchronised with Matveev Kurgan culture and dated to the end of the 7th millennium BC. Later phases can be dated to the second half of the 6th and the first half of the 5th millennium BC, and synchronised with layer 5 at Rakushechny Yar site (the chronology is based on typological correlation of materials).

The Caspian-Ciscaucasian cultural group includes material from Kremennaya II and III, Rassypnaya VI and Lagutinskaya, as well as finds from the basins of the steppe rivers of the Rostov oblast' (*Tsybrij 2008.60*). The stone items are similar to material from the Northern Ciscaucasian, North-Western and Northern Caspian area. The pottery is not abundant. Kremennaya II and Rassypnaya VI are attributed to early stages of the Neolithic period, and Kremennaya III to a later stage.



***Fig. 8. Rakushechny Yar. Low part of a flat bottom-vessel standing on the Unio shell layer No. XVI (excavation 'd' 2013).***

Kremennaya II is located in the Gnilaya River basin, near the village of Zolotovsky (Milutinsky district, Rostovskaya oblast'). The stone industry of the site is characterised by a blade and microlith inventory, including different types of geometrical microliths with secondary treatment: segments, parallelograms, trapezes and backed trapezes. The pottery is not abundant. More than 50 dug-out hearths were found in the base of cultural layer – 15 of which were dated (Fig. 11) – which reveal different stages of occupation of this site during the Neolithic from the 6th to the 5th millennium BC.

Kremennaya III is located near Kremennaya II, at a low hypsometric level. The pottery is not abundant, the flint tools are larger and are similar to tools at Kremennaya II. New tools appeared: polished flint heavy duty tools and arrowheads. A fragment of a copper plate was found in a cultural layer (*Tsybryi 2008*). Four radiocarbon dates were made on animal bones, also revealing different periods of occupation at this site: the end of the 7th to the first half of the 6th millennium BC, and during the 5th millennium BC.

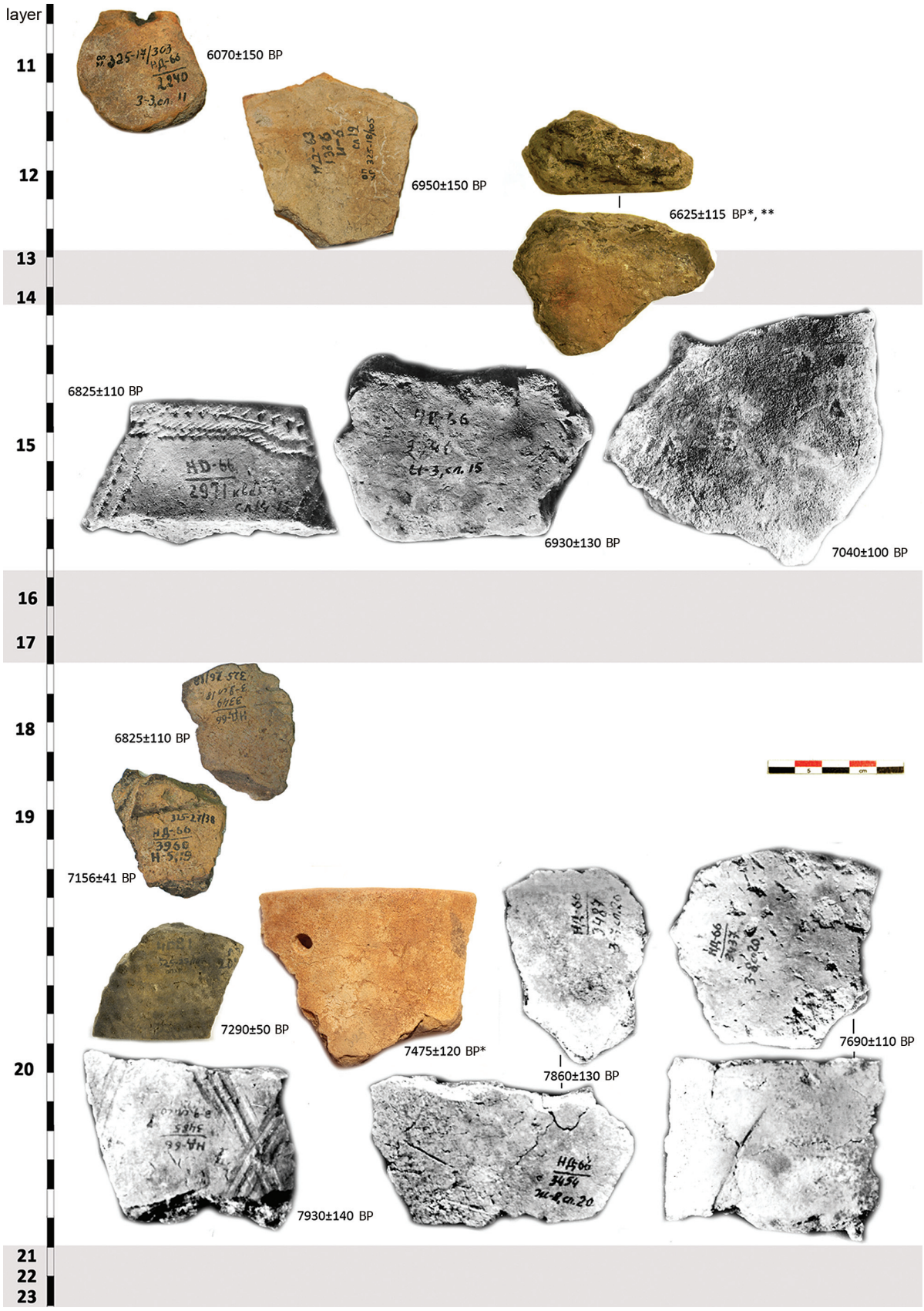



***Fig. 9. Fragments of $^{14}C$ dated pottery (material for dating – organic crust) from excavation I, with an indication of the layers where they were found. * fragments from the excavation of 2013; ** pottery fragment was dated.***

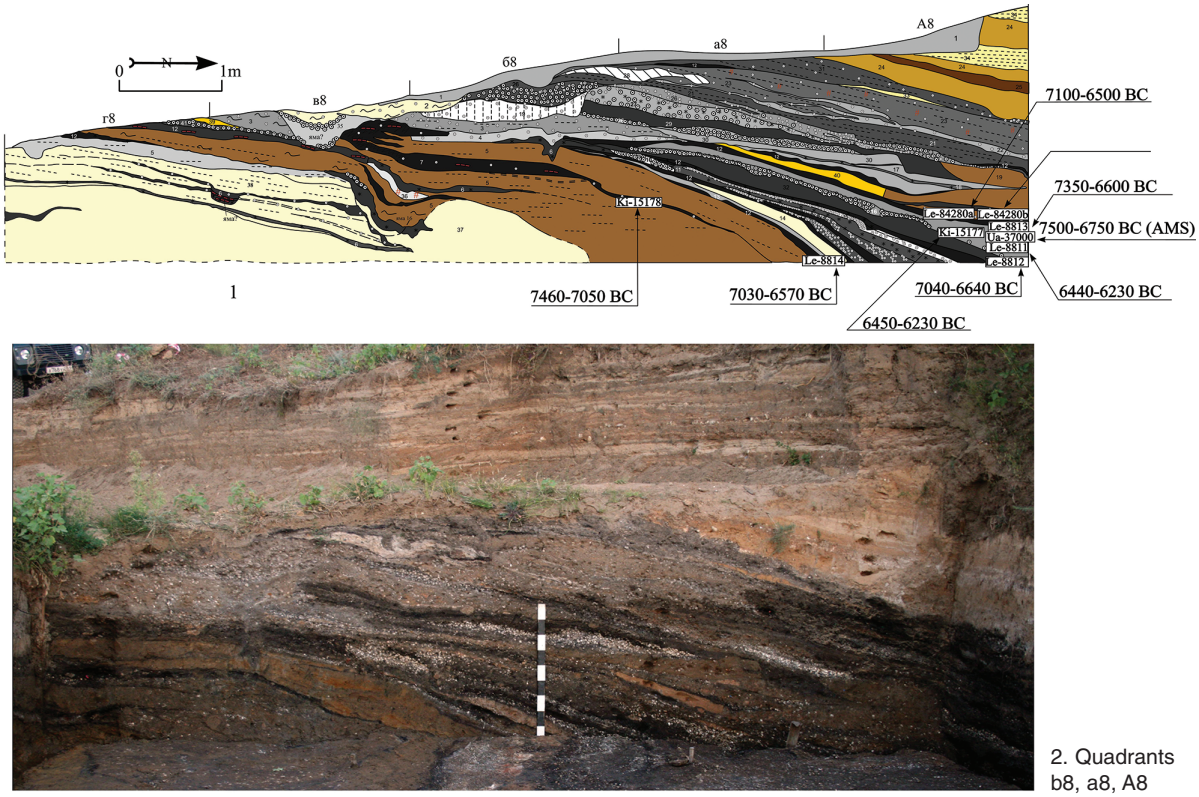



***Fig. 10. Razdorskaya II. Stratigraphy profile, with indication of places where samples for dating were taken.***

Rassypnaya VI is located in the Rassypnaya valley (*Tsybrij 2003*). The flint industry is similar to that at Kremennaya II and III and other sites in the Eastern Azov basin (Rassypnaya 1, Zhukovskaya 2, *etc*.). Microlithic tools predominate, including segments, parallelograms and trapezes, including backed trapezes. The pottery is not abundant; it was decorated by comb stamp and traced lines organised in simple compositions. Dates were made on five animal bones and one bone from burial 1, found at the bottom of cultural layer of the site (Fig. 12). Given the typology, we can suppose that most material can be dated to the last quarter of the 6th to the first quarter of the 5th millennium BC. Although this site was probably also visited/inhabited during the 7th and second half of the 5th millennium BC.

## Conclusion

The Lower Don River and North-eastern Azov Sea encompass several archaeological cultures, including Rakushechny Yar, Matveev Kurgan, Donets and the Caspian-Ciscaucasian cultural group. The chronological timeframes of these cultures are contemporaneous, which indicates the mosaic cultural character of this area during the period between the 7th and 5th millennium BC. The small number of radiocarbon dates for such a long period prevents us from refining the chronology of the different cultural groups and definite ceramic types within this area.

The Razdorskaya II site located in the Lower Don River basin is supposed to be one of the most ancient sites attributed to the Neolithic era (see discussion of the term 'Neolithic' in *Mazurkevich, Dolbunova 2015*), having a particular stone industry and complex subsistence strategy, predominantly fishing, but with no pottery. The early stages of this site are attributed to the earliest non-ceramic Neolithic phase, at the end of the 8th and beginning of the 7th millennium BC. This site was inhabited later, during the 7th and beginning of the 6th millennium BC, which suggest its contemporaneity with Rakushechny Yar. New research of the latter site allowed us to revise its stratigraphy, archaeological context and chronology. The differences in radiocarbon dates, number and character of cultural layers which were revealed support Belanovskaya's suggestion that the cultural layers located on the shore line and different trenches cannot be correlated directly. Such 'diversity' shows that this part of the modern island was inhabited repeatedly during different periods.

The Rakushechny Yar culture existed, probably, for approx. 1500 years, during the 7th and 6th millennium BC. It must be noted that the material culture

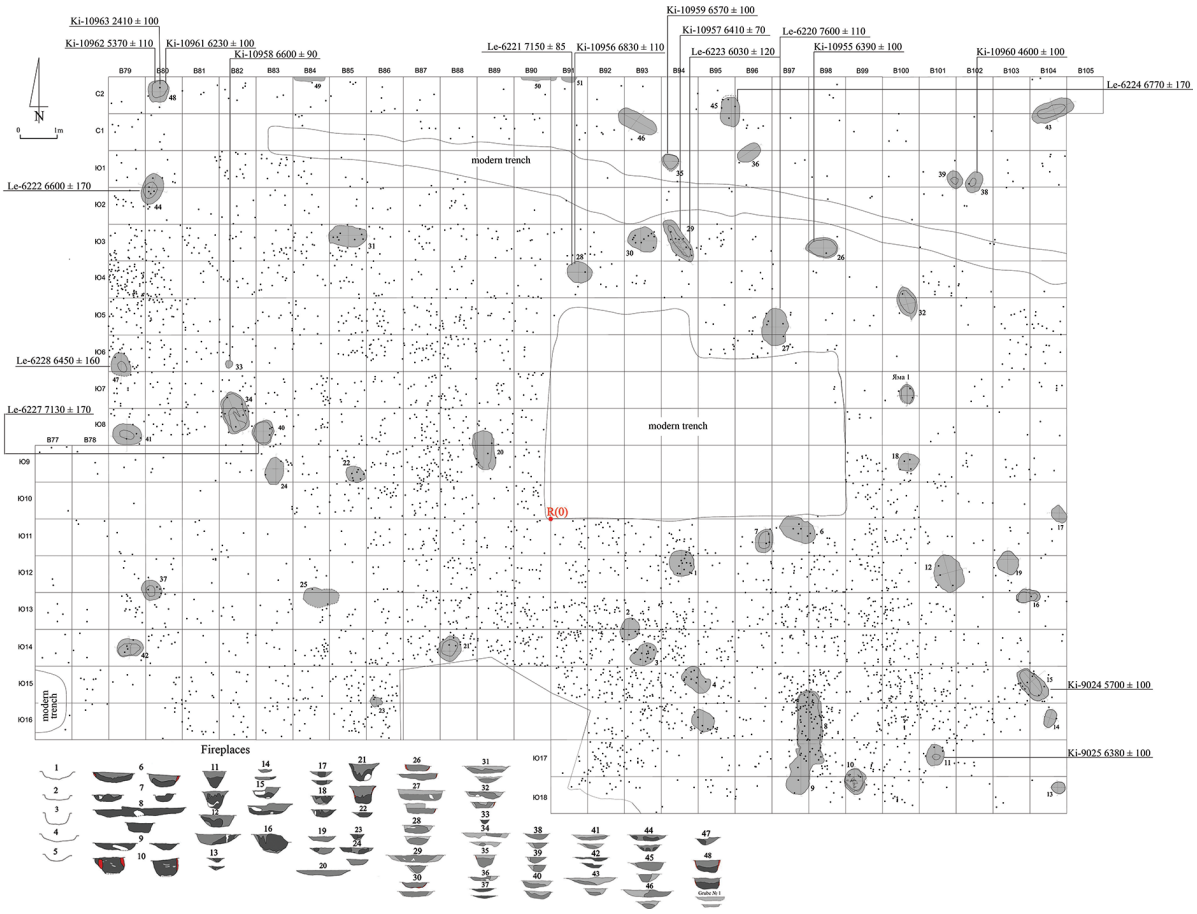



*Fig. 11. Kremennaya II. Plan of the excavation 2, with the objects dated.*

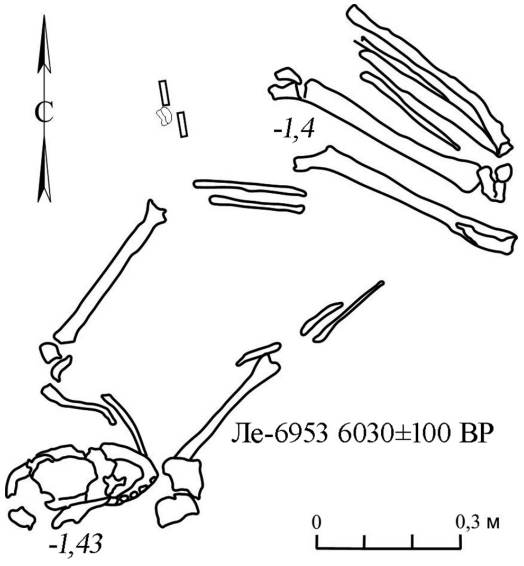



*Fig. 12. Rassypnaya VI. Excavation 2, burial 1.*

was very conservative and retained a number of specific traits through centuries. New dates and the analysis of radiocarbon dates, taking into the account stratigraphy of excavations and spatial analysis of finds, point to the first half of the 7th millennium BC as the period when Rakushechny Yar appeared, with one of the earliest ceramic in Eastern Europe. The excavated area was a seasonal site with a particular set of finds, including different animal and fish bones, hearths, 'wattle and daub' architecture, and an anthropomorphic figurine made on horse pastern. Previous discussions about the estimated dates made for this site arose not because of the validity of dates, but their presentation as they were analysed out of context. Our analysis of archived materials and new excavations allowed us to refine the chronology of this site and change the idea of unreliability of radiocarbon dates for this site.

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*Tab. 1. Radiocarbon dates of the Neolithic in the Lower Don River and North-eastern Azov Sea.*

| No. | $^{14}$C (BP) | cal BC | lab-index | dated material | $^{13}$C | site | information about dated material | Archaeolo. culture | references |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 5290±260 | 4715–3536 | Le-5327 | Charcoal | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 2* | | *Timofeev* et al. *2004.76* |
| 2 | 4830±90 | 3797–3372 | Le-5387 | Charcoal | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 2* | | *Timofeev* et al. *2004.76* |
| 3 | 6300±300 | 5787–4547 | Le-5343 | Ground with charcoal | | Rakushechny Yar, excavation I (after T.D. Belanovskaya) | Layer 2* | | *Timofeev* et al. *2004.76* |
| 4 | 4180±100 | 3011–2480 | Le-5428 | Animal bone | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 2* | | |
| 5 | 4360±100 | 3357–2702 | Bln-1177 | Charcoal | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 3* | | *Timofeev* et al. *2004.75* |
| 6 | 5060±230 | 4361–3365 | Le-5340 | Animal bone | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 4* | | *Timofeev* et al. *2004.76* |
| 7 | 6300±90 | 5471–5056 | Le-5482 | Animal bone | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 4* | | *Timofeev* et al. *2004.76* |
| 8 | 6440±35 | 5479–5342 | Le-5582a | Ground | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 5*, square A-2 | | *Timofeev* et al. *2004.76* |
| 9 | 6320±35 | 5366–5220 | Le-5582b | Ground | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 5*, square A-2 | | *Timofeev* et al. *2004.76* |
| 10 | 5920±90 | 5016–4553 | Le-5479 | Animal bone | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 5* | | *Timofeev* et al. *2004* |
| 11 | 5890±105 | 5019–4501 | Ki-955 | Charcoal | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 5* | | *Timofeev* et al. *2004.76* |
| 12 | 6770±450 | 6611–4725 | Le-5481 | Animal bone | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Under the layer 5* | | *Timofeev* et al. *2004* |
| 13 | 6070±100 | 5282–4728 | Bln-704 | Charcoal | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 8* | | *Timofeev* et al. *2004.75* |
| 14 | 7180±250 | 6563–5622 | Le-5344 | Shells | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 9* | | *Timofeev* et al. *2004.76* |
| 15 | 6070±150 | 5344–4616 | SPb-751 | Organic crust | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 11* | Rakushehno-yarskaya culture | |
| 16 | 6950±150 | 6201–5562 | SPb-752 | Organic crust | | Rakushechny Yar, excavation I (after T.D. Belanovskaya) | Layer 12* | Rakushehno-yarskaya culture | |
| 17 | 6825±100 | 5974–5558 | Ki-6479 | Organic crust | | Rakushechny Yar, excavation I (after T.D. Belanovskaya) | Layer 14-15* | Rakushehno-yarskaya culture | *Timofeev* et al. *2004.76* |
| 18 | 7040±100 | 6085–5720 | Ki-6480 | Organic crust | | Rakushechny Yar, excavation I (after T.D. Belanovskaya) | Layer 15* | Rakushehno-yarskaya culture | *Timofeev* et al. *2004.76* |
| 19 | 6930±100 | 5999–5647 | Ki-6478 | Organic crust | | Rakushechny Yar, excavation I (after T.D. Belanovskaya) | Layer 15* | Rakushehno-yarskaya culture | *Timofeev* et al. *2004.76* |
| 20 | 6625±115 | 5739–5358 | SPb-747 | Pottery fragment | | Rakushechny Yar, nearby the excavation II (2012, test-pit 2) | Layer XV** | Rakushehno-yarskaya culture | |
| 21 | 6560±100 | 5657–5326 | SPb-731 | Animal bone | | Rakushechny Yar, nearby the excavation II (2012, test-pit 2) | Layer XV** | Rakushehno-yarskaya culture | |

| No. | $^{14}$C (BP) | cal BC | lab-index | dated material | $^{13}$C | site | information about dated material | Archaeolo. culture | references |
|---|---|---|---|---|---|---|---|---|---|
| 22 | 6841±40 | 5809–5643 | Ua-41365 | Organic crust | –28,0** | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 18* | Rakushehno-yarskaya culture | |
| 23 | 7156±41 | 6092–5923 | Ua-41364 | Organic crust | –28,0** | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 19* | Rakushehno-yarskaya culture | |
| 24 | 7383±120 | 6451–6031 | SPb-1177 | Charcoal | | Rakushechny Yar, nearby the excavation II (stratigraphical section of 2013) | Layer XV* (due to stratigraphy of 2013) | Rakushehno-yarskaya culture | |
| 25 | 7475±120 | 6566–6075 | SPb-1176 | Organic crust | | Rakushechny Yar, nearby the excavation II (stratigraphical section of 2013) | (Layer XVII* (due to stratigraphy of 2013)) layer 19-20* | Rakushehno-yarskaya culture | |
| 26 | 7554±169 | 6813–6051 | Ua-48460 | Charcoal | | Rakushechny Yar, nearby the excavation II (stratigraphical section of 2013) | (Layer XVII* (due to stratigraphy of 2013)) layer 19-20* | Rakushehno-yarskaya culture | *Tsybryi* et al. *2014.207* |
| 27 | 7010±126 | 6200–5643 | Ua-48461 | Charcoal | | Rakushechny Yar, nearby the excavation II (stratigraphical section of 2013) | (Layer XVII* (due to stratigraphy of 2013)) layer 19-20* | Rakushehno-yarskaya culture | *Tsybryi* et al. *2014.207* |
| 28 | 7482±120 | 6568–6080 | SPb-1178 | Charcoal | | Rakushechny Yar, nearby the excavation II (stratigraphical section of 2013) | (Layer XVII* (due to stratigraphy of 2013)) layer 19-20* | Rakushehno-yarskaya culture | |
| 29 | 8020±120 | 7315–6640 | SPb-1185 | Fish bones | | Rakushechny Yar, nearby the excavation II (stratigraphical section of 2013) | (Layer XVII* (due to stratigraphy of 2013)) layer 19-20* | Rakushehno-yarskaya culture | |
| 30 | 7290±50 | 6241–6051 | Ua-37097 | Organic crust | –28,6 | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 20* | Rakushehno-yarskaya culture | |
| 31 | 7690±110 | 6900–6261 | Ki-6475 | Organic crust | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 20* | Rakushehno-yarskaya culture | *Timofeev* et al. *2004.76* |
| 32 | 7860±130 | 7062–6466 | Ki-6477 | Organic crust | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 20* | Rakushehno-yarskaya culture | *Timofeev* et al. *2004.76* |
| 33 | 7930±140 | 7186–6472 | Ki-6476 | Organic crust | | Rakushechny Yar, excavation I (after T. D. Belanovskaya) | Layer 20* | Rakushehno-yarskaya culture | *Timofeev* et al. *2004.76* |
| 34 | 7970±110 | 7179–6596 | SPb-729 | Animal bone | | Rakushechny Yar, nearby the excavation II (2012, test-pit 1) | Layer XVII** | Rakushehno-yarskaya culture | *Tsybryi* et al. *2014.207* |
| 35 | 4020±90 | 2872–2301 | Le-10473 | Animal bone | | Rakushechny Yar, excavation of 2010 (near excavation No. 16, 17 of 1966) | Layer 2B* | | |
| 36 | 2560±70 | 835–430 | Ki-15184 | Animal bone | | Rakushechny Yar, excavation of 2010 (near excavation No. 16, 17 of 1966) | Layer 2* | | |
| 37 | 4120±60 | 2881–2497 | Ki-15180 | Animal bone | | Rakushechny Yar, excavation of 2010 (near excavation No. 16 of 1966) | Layer 2* | | |
| 38 | 4170±60 | 2894–2581 | Ki-15183 | Animal bone | | Rakushechny Yar, stratigraphical trench of 2008 (near excavation No. 16 of 1966) | Layer 2* | | |

| No. | $^{14}$C (BP) | cal BC | lab-index | dated material | $^{13}$C | site | information about dated materia | Archaeolo. culture | references |
|---|---|---|---|---|---|---|---|---|---|
| 39 | 4590±80 | 3628–3030 | Ki-15182 | Ground | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 3* | | |
| 40 | 5870±80 | 4940–4542 | Ki-15942 | Ground | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 14* | Rakushehnoyar-skaya culture (?) | |
| 41 | 7580±90 | 6599–6245 | Ki-15189 | Pottery fragment | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 14* | Rakushehnoyar-skaya culture (?) | *Aleksandrovsky* et al. *2009* |
| 42 | 5940±60 | 4983–4696 | Ki-15940 | Ground | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 14* | Rakushehnoyar-skaya culture (?) | |
| 43 | 6410±90 | 5544–5214 | Ki-15944 | Ground with charcoal | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 15* | Rakushehnoyar-skaya culture (?) | |
| 44 | 5790±90 | 4876–4450 | Ki-15947 | Ground with charcoal | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 15* | Rakushehnoyar-skaya culture (?) | |
| 45 | 5690±100 | 4766–4345 | Ki-15941 | Ground with charcoal | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 15* | Rakushehno-yarskaya culture | |
| 46 | 7690±90 | 6746–6385 | Ki-15186 | Pottery fragment | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 18* | Rakushehno-yarskaya culture | *Aleksandrovsky* et al. *2009* |
| 47 | 5540±100 | 4652–4075 | Ki-15946 | Ground with charcoal | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 18-19* | Rakushehnoyar-skaya culture | |
| 48 | 5670±100 | 4726–4336 | Ki-15945 | Ground with charcoal | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 18-19* | Rakushehnoyar-skaya culture | |
| 49 | 6750±110 | 5876–5482 | Ki-15187 | Pottery fragment | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 21-22* | Rakushehnoyar-skaya culture | *Aleksandrovsky* et al. *2009* |
| 50 | 6890±80 | 5976–5641 | Ki-15185 | Pottery fragment | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 21-22* | Rakushehnoyar-skaya culture | |
| 51 | 7670±90 | 6695–6367 | Ki-15188 | Pottery fragment | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 22* | Rakushehnoyar-skaya culture | |
| 52 | 7020±80 | 6026–5736 | Ki-15190 | Pottery fragment | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 23* | Rakushehnoyar-skaya culture | *Aleksandrovsky* et al. *2009* |
| 53 | 7320±70 | 6367–6052 | Ki-15943 | Ground with charcoal | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 23* | Rakushehno-yarskaya culture | |
| 54 | 7380±100 | 6431–6061 | Ki-15181 | Ground | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 23*/ buried soil X | Rakushehnoyar-skaya culture | |
| 55 | 6450±90 | 5564–5227 | Le-8422 | Ground | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 21-22* | Rakushehnoyar-skaya culture | |

| No. | $^{14}$C (BP) | cal BC | lab-index | dated material | $^{13}$C | site | information about dated materia | Archaeolo. culture | references |
|---|---|---|---|---|---|---|---|---|---|
| 56 | 5900±220 | 5307–4348 | Le-8468 | Animal bone | | Rakushechny Yar, stratigraphical cut of 2008 (near excavation No. 16 of 1966) | Layer 21-22* | Rakushehnoyarskaya culture | |
| 57 | 5850±150 | 5197–4365 | Ki-11092 | Pottery fragment | | Rakushechny Yar, excavation of D. Y. Telegin of 1975 (supposedly on the place of exc. No. V of T. D. Belanovskaya) | Layer 8* (layers' numbering – according to D. Y. Telegin) | Rakushehnoyarskaya culture (?) | *Manko 2006.16* |
| 58 | 6955±160 | 6206–5563 | Ki-11091 | Pottery fragment | | Rakushechny Yar, excavation of D. Y. Telegin of 1975 (supposedly on the place of exc. No. V of T. D. Belanovskaya) | Layer 10-11* (layers' numbering – according to D. Y. Telegin) | Rakushehnoyarskaya culture (?) | *Manko 2006.16* |
| 59 | 6810±140 | 5983–5491 | Ki-11096 | Pottery fragment | | Rakushechny Yar, excavation of D. Y. Telegin of 1975 (supposedly on the place of exc. No. V of T. D. Belanovskaya) | Layer 10-11* (layers' numbering – according to D. Y. Telegin) | Rakushehnoyarskaya culture (?) | *Manko 2006.16* |
| 60 | 6850±160 | 6023–5487 | Ki-11095 | Pottery fragment | | Rakushechny Yar, excavation of D. Y. Telegin of 1975 (supposedly on the place of exc. No. V of T. D. Belanovskaya) | Layer 11* (layers' numbering – according to D. Y. Telegin) | Rakushehnoyarskaya culture (?) | *Manko 2006.16* |
| 61 | 7090±110 | 6210–5742 | Ki-11090 | Pottery fragment | | Rakushechny Yar, excavation of D. Y. Telegin of 1975 (supposedly on the place of exc. No. V of T. D. Belanovskaya) | Layer 12* (layers' numbering – according to D. Y. Telegin) | Rakushehnoyarskaya culture (?) | *Manko 2006.16* |
| 62 | 7205±150 | 6395–5789 | Ki-11093 | Pottery fragment | | Rakushechny Yar, excavation of D. Y. Telegin of 1975 (supposedly on the place of exc. No. V of T. D. Belanovskaya) | Layer 13* (layers' numbering – according to D. Y. Telegin) | | *Manko 2006.16* |
| 63 | 7130±150 | 6354–5721 | Ki-11094 | Pottery fragment | | Rakushechny Yar, excavation of D. Y. Telegin of 1975 (supposedly on the place of exc. No. V of T. D. Belanovskaya) | Layer 13* (layers' numbering – according to D. Y. Telegin) | Rakushehnoyarskaya culture (?) | *Manko 2006.16* |
| 64 | 7505±210 | 7021–5931 | GrN-7199 | Charcoal | | Matveev Kurgan I | | | *Timofeev* et al. *2004.76* |
| 65 | 7180±70 | 6221–5916 | Le-1217 | Charcoal | | Matveev Kurgan I | Fireplace, depth 1.5 m | | Ibid |
| 66 | 5400±200 | 4685–3795 | Le-882 | Charcoal | | Matveev Kurgan II | | | Ibid |
| 67 | 7460±200 | 6770–5906 | IGAN-726 | Ground | | site Samsonovskoe | | | Ibid |
| 68 | 9470±340 | 10013–7846 | IGAN-722 | | | Razdorskoe I | | | *Kremenetsky 1991.117* |
| 69 | 7490±60 | 6447–6238 | Ki-15177 | Charcoal | | Razdorskaya II | 2008, square A5, layer 12, fireplace | Rakushehnoyarskaya culture (?) | *Aleksandrovsky* et al. *2009* |
| 70 | 8210±80 | 7460–7059 | Ki-15178 | Charcoal | | Razdorskaya II | 2008, square A7-B7, layer 11, fireplace | Rakushehnoyarskaya culture (?) | Ibid |

| No. | $^{14}$C (BP) | cal BC | lab-index | dated material | $^{13}$C | site | information about dated materia | Archaeolo. culture | references |
|---|---|---|---|---|---|---|---|---|---|
| 71 | 7840±80 | 7029–6503 | Ki-15179 | Charcoal | | Razdorskaya II | 2008, layer 11, fireplace | Rakushehnoyarskaya culture (?) | Ibid |
| 72 | 8145±110 | 7479–6777 | Ua-37000 (AMS) | ? | | Razdorskaya II | sqaure A5, layer 12, depth -0,82-0,84 | Rakushehnoyarskaya culture (?) | Ibid |
| 73 | 7920±110 | 7080–6508 | Le-84280 a | Hot humic acids | | Razdorskaya II | 2008, square 7, depth 0,58-0,64 | Rakushehnoyarskaya culture (?) | Ibid |
| 74 | 8130±100 | 7454–6775 | Le-84280 b | Cold humic acids | | Razdorskaya II | 2008, square 7, depth 0,58-0,64 | Rakushehnoyarskaya culture (?) | Ibid |
| 75 | 7640±120 | 6767–6232 | Le-6873 | ? | | Razdorskaya II | 2003, square AI, depth –1,35/ –1,4 | Rakushehnoyarskaya culture (?) | Ibid |
| 76 | 7450±100 | 6467–6088 | Le-6950 | ? | | Razdorskaya II | 2003, square AI | Rakushehnoyarskaya culture (?) | Ibid |
| 77 | 7930±50 | 7035–6661 | Le-6952 | ? | | Razdorskaya II | 2003, square AI | Rakushehnoyarskaya culture (?) | Ibid |
| 78 | 7850±50 | 7023–6590 | Le-8814 | Ground | | Razdorskaya II | 2009, fireplace 2, square a6, depth 110 | Rakushehnoyarskaya culture (?) | |
| 79 | 7850±50 | 7023–6590 | Le-8813 | Ground | | Razdorskaya II | 2009, northern part of the square B4/B5, depth 110 | Rakushehnoyarskaya culture (?) | |
| 80 | 7900±60 | 7032–6642 | Le-8812 | Ground | | Razdorskaya II | 2009, northern part of the square B5, depth 110 | Rakushehnoyarskaya culture (?) | |
| 81 | 7470±60 | 6439–6232 | Le-8811 | Ground | | Razdorskaya II | 2009, northern part of the square A7, depth 99 | Rakushehnoyarskaya culture (?) | |
| 82 | 7100±100 | 6209–5759 | SPb-1467 | Charcoal | | Razdorskaya II | 2003, square B2, depth –140 | Rakushehnoyarskaya culture (?) | |
| 83 | 6390±100 | 5551–5078 | Ki-10955 | Charcoal | | Kremennaya II | Excavation 1, fireplace 26 | Caspian-ciscaucasian cultural area | |
| 84 | 6830±110 | 5980–5553 | Ki-10956 | Charcoal | | Kremennaya II | Excavation 1, fireplace 28 | Caspian-ciscaucasian cultural area | *Tsybryi 2011.Tab. 1* |
| 85 | 6410±70 | 5490–5226 | Ki-10957 | Charcoal | | Kremennaya II | Excavation 1, fireplace 29 | Caspian-ciscaucasian cultural area | Ibid |
| 86 | 6600±90 | 5701–5374 | Ki-10958 | Charcoal | | Kremennaya II | Excavation 1, fireplace 33 | Caspian-ciscaucasian cultural area | Ibid |
| 87 | 6570±100 | 5665–5328 | Ki-10959 | Charcoal | | Kremennaya II | Excavation 1, fireplace 35 | Caspian-ciscaucasian cultural area | Ibid |
| 88 | 4600±100 | 3634–3026 | Ki-10960 | Charcoal | | Kremennaya II | Excavation 1, fireplace 38 | Caspian-ciscaucasian cultural area | Ibid |
| 89 | 6230±100 | 5466–4939 | Ki-10961 | Charcoal | | Kremennaya II | Excavation 1, fireplace 48 | Caspian-ciscaucasian cultural area | Ibid |
| 90 | 5370±110 | 4445–3971 | Ki-10962 | Charcoal | | Kremennaya II | Excavation 1, fireplace 48 | Caspian-ciscaucasian cultural area | Ibid |
| 91 | | | | Charcoal | | Kremennaya II | Excavation 1, fireplace 48 | Caspian-ciscaucasian cultural area | Ibid |
| 92 | 2410±100 | 797–235 | Ki-10963 | Charcoal | | Kremennaya II | Excavation 1, fireplace 48 | Caspian-ciscaucasian cultural area | Ibid |
| 93 | 5700±100 | 4770–4350 | Ki-9024 | Charcoal | | Kremennaya II | Excavation 1, fireplace 15 | Caspian-ciscaucasian cultural area | Ibid |
| 94 | 6380±100 | 5533–5075 | Ki-9025 | Charcoal | | Kremennaya II | Excavation 1, fireplace 11 | Caspian-ciscaucasian cultural area | Ibid |
| 95 | 7600±110 | 6650–6233 | Le-6220 | Charcoal | | Kremennaya II | Excavation 1, fireplace 27 | Caspian-ciscaucasian cultural area | Ibid |
| 96 | 7150±85 | 6221–5848 | Le-6221 | Charcoal | | Kremennaya II | Excavation 1, fireplace 28 | Caspian-ciscaucasian cultural area | Ibid |
| 97 | 6600±170 | 5871–5219 | Le-6222 | Charcoal | | Kremennaya II | Excavation 1, fireplace 44 | Caspian-ciscaucasian cultural area | Ibid |
| 98 | 6030±120 | 5294–4685 | Le-6223 | Charcoal | | Kremennaya II | Excavation 1, fireplace 29 | Caspian-ciscaucasian cultural area | Ibid |

| No. | $^{14}$C (BP) | cal BC | lab-index | dated material | $^{13}$C | site | information about dated materia | Archaeolo. culture | references |
|---|---|---|---|---|---|---|---|---|---|
| 99 | 6770±170 | 6008–5381 | Le-6224 | Charcoal | | Kremennaya II | Excavation 1, fireplace 45 | Caspian-ciscaucasian cultural area | Ibid |
| 100 | 7130±170 | 6372–5715 | Le-6227 | Charcoal | | Kremennaya II | Excavation 1, fireplace 40 | Caspian-ciscaucasian cultural area | Ibid |
| 101 | 6450±160 | 5674–5044 | Le-6228 | Charcoal | | Kremennaya II | Excavation 1, fireplace 47 | Caspian-ciscaucasian cultural area | Ibid |
| 102 | 7060±190 | 6356–5625 | Le-6871 | Bone | | Kremennaya III | Excavation 1, square c10e43, bottom of the cultural layer | Caspian-ciscaucasian cultural area | *Tsybryi 2008.92* |
| 103 | 5540±100 | 4652–4075 | Le-6868 | Bone | | Kremennaya III | Excavation 1, square c10, bottom of the cultural layer | Caspian-ciscaucasian cultural area | Ibid |
| 104 | 7440±160 | 6599–6009 | Le-6956 | Bone | | Kremennaya III | Excavation 1, square c8, bottom of the cultural layer | Caspian-ciscaucasian cultural area | Ibid |
| 105 | 6582±120 | 5716–5321 | SPb-1250 | Bone | | Kremennaya III | Excavation 1, No. 214, 593, 60 | Caspian-ciscaucasian cultural area | |
| 106 | 8120±120 | 7456–6701 | Le-6869 | Bone | | Rassypnaya VI | Excavation 1, square 31, conventional layer 6, No. 1557 | Caspian-ciscaucasian cultural area | *Tsybryi 2008.92* |
| 107 | 5880±150 | 5207–4406 | Le-6870 | Bone | | Rassypnaya VI | Excavation 1, horizon 6–8, depth –0,6–0,8m | Caspian-ciscaucasian cultural area | Ibid |
| 108 | 5160±500 | 5291–2872 | Le-6872 | Bone | | Rassypnaya VI | Excavation 1, square 55, bones accumulation 1, depth –0,9m | Caspian-ciscaucasian cultural area | Ibid |
| 109 | 7250±110 | 6381–5913 | Le-6955 | Bone | | Rassypnaya VI | Excavation 2, sq. 12, find No. 719, depth –1,1m | Caspian-ciscaucasian cultural area | Ibid |
| 110 | 5420±110 | 4460–3991 | Le-6954 | Bone | | Rassypnaya VI | Excavation 2, square 13, layer 9, depth –1,05m, No. 738 | Caspian-ciscaucasian cultural area | Ibid |
| 111 | 6030±100 | 5214–4716 | Le-6953 | Bone | | Rassypnaya VI | Excavation 2, burial 1 | Caspian-ciscaucasian cultural area | Ibid |

* numbering of layers of each excavation of Rakushechny Yar site is different, they cannot be correlated with each other

** numbers of layers in sondages #1 and #2

# Radiocarbon chronology of the Neolithic in the Povolzhye (Russian Eastern Europe)

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ABSTRACT – *The radiocarbon dates obtained on materials from archaeological sites of the Low and Middle Povolzhye are presented in this article. The analysis of the complex of radiocarbon dates allowed a determination of the most appropriate dates for forming chronological schemes of cultural development in this region. The chronological frameworks of the Early Neolithic in the Low Povolzhye were determined from 6600–5500 cal BC; in the Middle Povolzhye they are from 6500 to 4600 cal BC.*

KEY WORDS – *Neolithic; Lower Volga region; Forest-steppe Volga region; reservoir effect; absolute chronology*

## *Radiokarbonska kronologija neolitika v porečju reke Volge (vzhodni del ruske Evrope)*

IZVLEČEK – *V članku predstavljamo rezultate radiokarbonskih datacij zbirov iz arheoloških najdišč na območju spodnje in srednje Volge. Z analizo kompleksnih radiokarbonskih datumov smo lahko določili tiste datume, ki so najbolj ustrezni za oblikovanje časovnega okvirja kulturnega razvoja v regiji. V spodnjem toku reke Volge ga postavljamo v čas med 6600 in 5500 pr. n. št., na območju srednjega toka reke Volge pa med 6500 in 4600 pr. n. št.*

KLJUČNE BESEDE – *neolitik; spodnji tok reke Volge; območje gozdne stepe; efekt rezervoarja; absolutna kronologija*

## Introduction

Povolzhye is located in the Volga River basin. In the south, this region borders the Caucasus and Middle Asia, the Don River basin in the west, the Urals region in the east, and the Kama region in the north (Fig. 1). The Povolzhye region has an important meaning for investigations, because during the Neolithic period strong cultural interconnections between people from these regions were established. Thus, the chronology of these cultures has a priority aspect for the study of Neolithisation of Eastern Europe. Russian archaeologists consider the Neolithic of Eastern Europe as the period when pottery appeared. The main problem of radiocarbon dating sites in the steppe and forest-steppe zone is the lack of the necessary quantities of organic material for dating, which has not been preserved in the cultural layers. Until 2007, there were less than 20 radiocarbon dates for the numerous archaeological sites of this region, most of which were doubtful. Therefore the radiocarbon dating of organics from pottery was used, as well as dating of other organic materials (charcoal, bone, charred crusts). In the last ten years, 290 radiocarbon dates have been obtained: 70 for the Northern Caspian region; 41 for the Low Volga River region; 89 for the forest-steppe of the Middle Volga region; 31 for the Sura region; 34 for the Pri-


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***Fig. 1. Map of the Povolzhye region: 1 Kairshak III; 2 Baibek; 3 Tenteksor; 4 Kugat IV; 5 Kulagaysi; 6 Jangar; 7 Tu-Buzgu-Huduk; 8 Orlovka; 9 Varfolomeevskaya; 10 Algay; 11 Ivanovskaya; 12 Vilovatovskaya; 13 Chekalino IV; 14 B. Rakovka II; 15 Kalmykovka I; 16 Krasniy Gorodok I; 17 Niznaya Orlyanka II; 18 Krasniy Yar; 19 Vjunovo lake I; 20 Utuzh I; 21 Imerka VII; 22 II Sherbetskaya; 23 Dubovskaya III.***

mokshanie, and 24 for the forest zone of the Middle Volga region. This complex of radiocarbon dates allows us to establish the validity of dates obtained, especially the acceptability of dates on the organics from pottery and to determine the chronological frameworks of Neolithic cultures in the Povolzhye. The dates presented in the Table 1 were obtained for the most significance and etalon sites. They are representative for these sites and have coincidence on the base of different organic materials. The dates which did not been included in the Table 1 were published elsewhere earlier.

## Neolithic cultures of the Povolzhye region

The detailed characteristics of artefacts, cultures and cultural types of Neolithic complexes of Povolzhye have been presented in numerous publications (*e.g., Mamonov 2000.147–176; Morgunova 2004.214–216; Vybornov 2008; Vybornov* et al. *2009a.71–80; 2009b.81–88; Grechkina* et al. *2014.79–90; Andreev 2015.1–16; Andreev* et al. *2016a.130–139; Yudin* et al. *2016.61–68*).

### *The Northern Caspian region*

In Figure 1 we present the sites where the Kairshak pottery type dated to *c.* 7th millennium BC was found in the semi-desert northern coast of the Caspian Sea (Fig. 1), This type of pottery is archaic in style. The flat-bottomed vessels were made of organic-rich silt and have geometric ornamentation. The stone industry is closely analogous to the local Mesolithic stone industry, which is characterised by artefacts such as geometric microliths in the form of segments and parallelograms. These features of material culture are evidence of the local origin of this Neolithic culture (*Kozin 2002.1–16*).

In the north-western part of the Caspian Sea coast, the earliest sites of the earliest stage of Jangar type (Tubuzgukhuduk site) (Fig. 1.site 7) date to the first part of the 7th millennium BC according to P. M. Koltsov (*Koltsov 2005*). According to the features of the flint tools and some pottery characteristics, the Neolithisation of this territory began from the Caucasus; for example, the arrowheads and trapezes of the north-western Caspian Sea and the Caucasus are similar (*Koltsov 2005*). At the same time, some innovations were linked to local populations. The main innovation was the appearance of pottery-making traditions. In the middle of the 7th millennium BC, the populations which produced the Kairshak type migrated from the northern Caspian Sea region towards the steppe region of the Volga River basin and the north-western coast of the Caspian. This process was probably triggered by paleoclimatic changes. The bearers of the Kairshak and Jangar cultures influenced the formation of the Orlovskaya culture in the lower part of the Volga basin (Varfolomeevskaya site) (Fig. 1.site 9). Three cultural layers were identified at the Varfolomeevskaya site: lower (3), middle (2), and upper layer (1). Microliths (such as

| No. | Site | $^{14}$CAge (BP) | Age, cal BC (2 σ) | $\delta^{13}$C (‰) | Lab index | Material |
|---|---|---|---|---|---|---|
| 1 | Kairshak III | 7775±42 | 6690–6490 | –28,7 | Ua-41359 | Food crusts |
| 2 | Kairshak III | 7700±100 | 6830–6370 | n/d | SPb_377 | Food crusts |
| 3 | Kairshak III | 7300±100 | 6505–5746 | n/d | SPb_422 | Pottery |
| 4 | Kairshak III | 7190±80 | 6230–5890 | n/d | Ki-14633 | Animal bone |
| 5 | Kairshak III | 7870±100 | 7050–6500 | n/d | Ki-16401 | Carbonates from pottery |
| 6 | Kairshak III | 7290±190 | 6500–5750 | n/d | Ki-1600 | Organics from pottery |
| 7 | Baibek | 7937± 48 | 7037–6684 | –29,3 | Ua-50262 | Food crusts |
| 8 | Baibek | 6827±100 | 5917–5604 | n/d | SPb-1712 | Charcoal |
| 9 | Baibek | 7350±50 | 6373–6070 | n/d | Poz-57060 | Food crusts |
| 10 | Baibek | 6955±80 | 6002–5708 | n/d | SPb-1709 | Animal bone |
| 11 | Baibek | 6948±120 | 6034–5634 | n/d | SPb-1713 | Charcoal |
| 12 | Baibek | 6986±44 | 5983–5759 | –10 | Ua-50260 | Charcoal |
| 13 | Baibek | 6925±120 | 6021–5626 | n/d | SPb-1716 | Pottery |
| 14 | Tenteksor | 6695±40 | 5680–5530 | –27,7 | Ua-35277 | Food crusts |
| 15 | Tenteksor | 6540±100 | 5640–5310 | n/d | SPb-315a | Animal bone |
| 16 | Tenteksor | 6640±80 | 5720–5470 | n/d | Ki-14101 | Pottery |
| 17 | Tenteksor | 6650±100 | 5740–5460 | n/d | SPb-423 | Pottery |
| 18 | Kugat IV | 7680±100 | 6690–6380 | n/d | Ki-14501 | Pottery |
| 19 | Kugat IV | 7560±90 | 6600–6220 | n/d | Ki-14500 | Pottery |
| 20 | Kulagaysi | 7380±120 | 6450–6027 | n/d | SPb-1725 | Pottery |
| 21 | Jangar layer 3 | 7080±90 | 6090–5710 | n/d | Ki-14639 | Pottery |
| 22 | Jangar layer 3 | 6990±90 | 6030–5710 | n/d | Ki-14640 | Pottery |
| 23 | Jangar layer 2–3 | 6870±130 | 6010–5550 | n/d | IGAN-2819 | Charcoal |
| 24 | Jangar 2 | 6100±70 | 5220–4840 | n/d | Le-2564 | Charcoal |
| 25 | Jangar 2 | 6780±90 | 5840–5510 | n/d | Ki-14641 | Pottery |
| 26 | Jangar 1 | 5890±70 | 4940–4580 | n/d | Le-2901 | Charcoal |
| 27 | Jangar 1 | 6564±44 | 5575–5470 | –27,5 | Hela-3255 | Crust |
| 28 | Varfolomeevskaya 3 layer | 6980±200 | 6250–5500 | n/d | Gin 6546 | Charcoal |
| 29 | Varfolomeevskaya 3 layer | 7250±80 | 6250–5980 | n/d | Ki-14109 | Pottery |
| 30 | Algay | 7284±80 | 6271–6008 | n/d | SPb-2144 | Humid acids |
| 31 | Varfolomeevskaya 2b layer | 7100±110 | 6220–5740 | n/d | SPb-941 | Food crusts |
| 32 | Varfolomeevskaya 2B layer | 7034±41 | 6010–5830 | –28,0 | Ua-41360 | Food crusts |
| 33 | Varfolomeevskaya 2 B layer | 6850±40 | 5816–5659 | n/d | Poz-52697 | Food crusts |
| 34 | Algay | 6800±40 | 5741–5631 | n/d | Poz-65198 | Food crusts |
| 35 | Algay | 6820±80 | 5889–5614 | n/d | SPb-1510 | Animal bone |
| 36 | Algay | 6577±80 | 5641–5374 | n/d | SPb-1478 | Animal bone |
| 37 | Orlovka | 6647±150 | 5846–5315 | n/d | SPb-1727 | Pottery |
| 38 | Varfolomeevskaya 2A layer | 6544±38 | 5620–5580 | –25,1 | Ua-41361 | Food crusts |
| 39 | Algay | 6490±40 | 5527–5367 | n/d | Poz-76004 | Charcoal |
| 40 | Varfolomeevskaya 2A layer | 6363±150 | 5650–4950 | n/d | SPb-937 | Food crusts |
| 41 | Varfolomeevskaya (upper) | 5800±150 | 5050–4300 | n/d | SPb-939 | Crust |
| 42 | Algay | 5875±60 | 4856–4580 | n/d | SPb-1968 | Animal bone |
| 43 | Varfolomeevskaya | 5870± 90 | 4950–4490 | n/d | Ki-14614 | Pottery |
| 44 | Ivanovskaya | 7680±90 | 6733–6374 | n/d | Ki-14567 | Pottery |
| 45 | Chekalino IV | 7660±200 | 7047–6202 | n/d | SPb-424 | Pottery |
| 46 | B. Rakovka II | 7613±120 | 6750–6200 | n/d | SPb-1733 | Pottery |
| 47 | Ivanovskaya | 7560±70 | 6566–6248 | n/d | SPb-587 | Pottery |
| 48 | Chekalino IV | 7250±60 | 6229–6016 | n/d | Poz-42051 | Carbon from Pottery |
| 49 | Chekalino IV | 7127±150 | 6400–5700 | n/d | SPb-1731 | Pottery |
| 50 | Vjunovo lake I | 7222±58 | 6220–6004 | – 27 | AA-96017.1 | Pottery |
| 51 | Vjunovo lake I | 7160±40 | 6092–5927 | n/d | Poz-47870 | Pottery |

***Tab. 1. Radiocarbon dates for Neolithic sites in the Povolzhye region.***

| No. | Site | $^{14}$CAge (BP) | Age, cal BC (2 σ) | $\delta^{13}$C (‰) | Lab index | Material |
|---|---|---|---|---|---|---|
| 52 | Imerka VII | 7205±60 | 6220–5980 | –28,4 | Hela-3521 | Food crusts |
| 53 | Krasniy Yar | 6700±70 | 5730–5490 | n/d | SPb-755 | Food crusts |
| 54 | Kalmykovka I | 6643±110 | 5740–5370 | n/d | SPb-1415 | Pottery |
| 55 | Utuzh I | 6568±49 | 5620–5470 | n/d | Ua-44377 | Food crusts |
| 56 | Utuzh I | 6500±100 | 5640–5290 | n/d | SPb-834 | Pottery |
| 57 | Dubovskaya III | 7000±150 | 6250–5600 | n/d | SPb-1290 | Pottery |
| 58 | Dubovskaya III | 6892±40 | 5890–5700 | –28,1 | Ua-44724 | Food crusts |
| 59 | II Sherbetskaya | 6620±90 | 5720–5460 | – | Ki-14134 | Pottery |
| 60 | Imerka VII | 6546±60 | – | n/d | Hela-3253 | Food crusts |
| 61 | Vilovatovskaya | 6320±90 | 5476–5061 | n/d | Ki-14090 | pottery |
| 62 | Vilovatovskaya | 6160±100 | 5322–4842 | n/d | Ki-14088 | pottery |
| 63 | Vilovatovskaya | 5960±80 | 5056–4618 | n/d | Ki-14089 | pottery |
| 64 | Kalmykovka I | 5950±120 | 5250–4500 | n/d | SPb-1759 | pottery |
| 65 | Kalmykovka I | 5989±70 | 5060–4710 | n/d | SPb-1876 | bone |

n/d – $\delta^{13}$C‰ was not determined. –25‰ was used for age calculation.

***Tab. 1. Continue ...***

geometric microliths and trapezes) similar to the Kairshak type were found in the lower part of the third cultural layer at Varfolomeevskaya. Organic silt (probably from the river floodplain) was the basic raw material used in pottery making. The pottery is flat-bottomed, with pinned and incised ornamentation. In this area, the Kairshak culture contributed to the further development of the Varfolomeevskaya and Jangar traditions. This can be traced in the pottery, ornamentation technique and types of decoration of ceramics.

### *The Volga River region*

The earliest Neolithic sites on the border between the steppe and forest steppe in the Volga River basin are indicated by complexes of Elshanka-type pottery (Fig. 1). Elshanian culture had two stages, an earlier and later. The most important sites of the early cultural stage are at Ivanovskaya in the Samara River basin and Chekalino in the Sok River basin. The pottery was made of silt clay; the bases are pointed and decoration sparse, with pits and incised lines. The $^{14}$C dating of different materials (charred crusts, bones, pottery) confirms the appearance of this pottery as early as the beginning of the 7$^{th}$ millennium BC (Tab. 1). The typology and technological characteristics of the Elshanka pottery type show their non-local origin. The closest analogues to this type can be found on the eastern coast of the Caspian and the Central Asian interfluves, at the Uchaschy, Daryasay, and Dzhebel sites (*Kholmatova 2012.106–110*). Radiocarbon dates on the earliest Neolithic materials in Central Asia are of the same age (*Brunet* et al. *2012.118–124*). Specific geometric microliths are also evidence of Neolithiation. There are several reasons for assuming frequent and diachronic impulses during the Neolithisation process in this region. At the end of the 7$^{th}$ millennium BC, some Elshanka tribes directly influenced the process of pottery making in the north-western Middle Volga region, in the Sura River valley (*e.g.*, Vyunovo Lake I and Utuzh sites) and in the Moksha River basin (the Imerka VII site) (Fig. 1). So, there are numerous Early Neolithic sites in the Middle Volga basin with pottery similar to the Elshanka type. They have common characteristics: methods of vessel moulding; the shape of rims and bases of vessels; near absence of ornamentation; small pressed pits between incised decorations, and ornamental elements and motifs. Elshanka culture existed in the forest-steppes of the Volga and Sura river basins probably until the 6$^{th}$ millennium BC.

New sites have been excavated recently in this region. Their stratigraphy, archaeological finds and radiocarbon dating provide new data for modelling a detailed chronology of the Neolithic cultures in this region.

## Methods and materials

Radiocarbon dating of ancient ceramics is an important research topic both for radiocarbon analysis and for archaeology. Pottery is the most abundant material found during excavations of Neolithic sites in Eastern Europe. The various organic materials used for radiocarbon dating, such as charcoal, bone, wood, or soil, are sometimes not associated with the archaeological context of a settlement or cultural layer. However, the radiocarbon dating of organics from pottery has other problems. Firstly, the pottery can




***Fig. 2. The Northern Caspian Sea region. Pottery from the Kugat IV (1) and Kairshak III sites (2–9).***

be contaminated by younger organics from the soil, such as humic acids, during burial (*Stott* et al. *2001. 191–197*). Sometimes secondary carbonates can be formed inside pottery pores. Older carbonates can be found in the clay composition or as a temper in the form of shell, or carbonate minerals such as calcite or dolomite, and sometimes they cannot be removed by chemical pretreatment (*Evin* et al. *1989. 276*). In other cases, these contaminations can be removed by special chemical pretreatment methods (*Hedges* et al. *1992.906–915; Anderson* et al. *2005. 1–9*).

The efficiency of this process depends on the ceramic types, methods and duration of pretreatment (*Hedges* et al. *1992.906–915; Delquè Kolic 1995. 275–284; Stott* et al. *2001.191–197; Anderson* et al. *2005.1–9; Bonsall* et al. *2002.47–59*). The carbon inside a ceramic sherd whose age is comparable with the time of pottery making or use can be tested after older and younger carbon contaminants have been removed (*Kul'kova 2014.115–122*). One of the organic residues connected with ancient cooking processes is carbon from charred food crusts on pottery walls (*Nakamura* et al. *2001.1129–1138*). The ra-




***Fig. 3. The Northern Caspian Sea region. Pottery from the Baibek site.***

diocarbon dating of charred food crusts gives good results if freshwater, sea fish or seafood were not used during cooking. Otherwise, the reservoir effects lead to older radiocarbon ages of food crusts (*Fischer, Heinemeier 2003.449–466; Boudin* et al. *2010.697–705; Kunikita* et al. *2013.1334–1340*). The measurements of carbon and nitrogen stable isotopes in food crusts may help to determine the type of food in the pottery. Corrections for the reservoir effect on food crust age is done experimentally (*Hart* et al. *2013.536–552; Philippsen 2013*). Another carbon component forming in the pottery during use is soot on the outer walls of vessels. The application of soot for radiocarbon dating has yielded comparable results (*Delquè Kolic 1995.275–284*). But only AMS dating can be applied for dating this component because of the small amounts of carbon. It should be noted that food crusts or soot are not always found on pottery walls. Sometimes the amounts of food crusts and soot are too little for radiocarbon dating. Therefore, some authors consider radiocarbon dating the organic material from the core of the sherd (*Hedges* et al. *1992.905–915; Anderson* et al. *2005.1–9; Messili* et al. *2013.1391–1402*). In this case, there is still the problem of reservoir effects if the pottery was used to cook fish or contents with aquatic organics. In this case, the stable isotope analysis can give additional information about the reservoir effect. In addition, clay with older organic inclusions from ancient deposits could be used for pottery making, and the radiocarbon age of such a sherd would be older than expected. In the most cases, the raw materials extracted for early Neolithic pottery making in Eastern Europe were chosen from sources that were modern to ancient people (*Vybornov 2008.490*). Early pottery was fired at a temperature of 600–800°C. The decomposition of organic components and the formation of coal and soot particles occurs in these conditions. The cores of these sherds are grey or black, depending on the amount of unburned organic material.

Carbon from pottery can therefore correspond to the age of its production and use, or it can be older. Radiocarbon dating experiments on pottery yield inconsistent results (*Hedges* et al. *1992.905–915; Delquè Kolic 1995.275–284*). Sometimes radiocarbon dates of pottery carbon do not correspond to radiocarbon dates on other organic materials from the same archaeological sites. Some authors (*Messili* et al. *2013.1391–1402*) consider pottery carbon as suitable material for radiocarbon dating. According to Lamia Messili *et al.* (*2013.1391–1402*) the accuracy of pottery $^{14}C$ dates is a direct function of the temper/clay organic matter ratio: the higher it is, the weaker the influence of the organic matter bound to the clay and the more reliable the $^{14}C$ dating. Jeanette M. O'Malley *et al.* (*1999.19–24*) presented a stepwise heating technique to extract only a temper carbon fraction from the interior and exterior parts of potsherds, and obtained preliminary $^{14}C$ ages for pottery from the Russian Far East (*Nakamura* et al. *2001.1129–1138*). Stepped-combustion dating of earliest pottery from the Russian Far East is also presented by Yaroslav V. Kuzmin *et al.* (*2001*).

Samples were pretreated with diluted HCl acid (1.2N) and NaOH (0.1N) to remove contaminants such as




***Fig. 4. The Northern Caspian Sea region. Pottery from the Tenteksor site.***

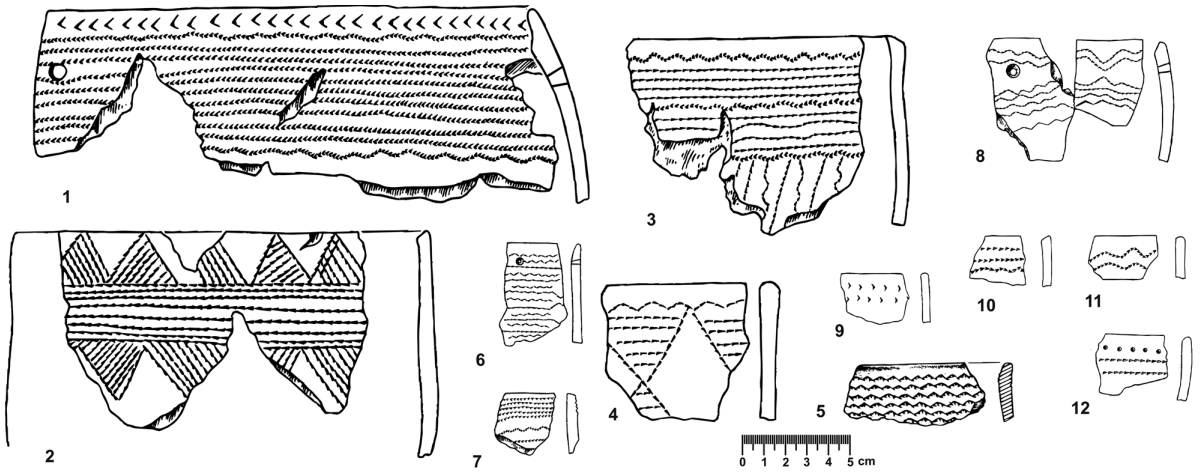



***Fig. 5. The North-Western Caspian Sea region. Pottery from the Jangar (1–2 upper layer; 3–5 middle layer; 6–8 lower layer) and Tu-Buzgu-Huduk sites (9–12).***

carbonates and organic acids from the soil originating from decomposed organic matter. The $CO_2$ produced from samples is then graphitized before being dated by accelerator mass spectrometry (AMS) at the LMC14 (*Cottereau* et al. *2007.291–299*).

For LSC dating, Zaitseva *et al.* (*2009.796*) describe the extraction of carbon for LSC dating of pottery as follows: pottery samples of 200– 400g with a carbon content of 1– 3% were taken from vessel walls, and, rarely, from the bottom. The ground samples (10–22mm in diameter) were treated with 0.5N hydrofluoric acid in a Teflon® container for 2–5 hours at room temperature. In the initial and final stages, the samples were subjected to 10 minutes of ultrasonic exposure. The samples were then finely ground, dried at under 150–180°C, and mixed with a calculated amount of manganese dioxide; gaseous products were absorbed by lithium. Lithium carbide was synthesised by vacuum pyrolysis. Benzene was synthesised in a stainless steel reactor under 0.1–2atm of pressure. When the temperature rises above 550°C, the manganese dioxide disintegrates with a uniform release of active oxygen in a wide temperature range of 550–940°C. The fine-dyspersated carbon is oxidised, forming carbon oxide and dioxide, which are absorbed by the melted metallic lithium. The lithium carbide is subjected to hydrolysis, and the released acetylene is turned into benzene with a vanadium catalyst (*Skripkin, Kovalukh 1998.211–214; Kovalukh, Skripkin 2007.120–126; Zaitseva* et al. *2009.795–801; 2011. 383–385*). The benzene cocktails were measured on liquid scintillation counting Quantulus 1220.

In our investigations, the series of radiocarbon dates on pottery carbon from the Early Neolithic sites of Eastern European Russia correlate well with the radiocarbon dates on other organic materials from the




***Fig. 6. The Lower Volga region. Pottery from the Algay (1–2) and Varfolomeevskaya sites (3–6 from the upper part (2A) of the middle layer; 7–10 from the lower part (2B) of the middle layer; 11–14 from the lower layer).***

same archaeological settlements and with the existing archaeological periodisation (*Vybornov 2008.490; Vybornov* et al. *2012.795–799; 2013.13–20; 2014.242–248; Andreev* et al. *2012.193–199; 2016.155–163; Zaitseva* et al. *2009.795–801; 2011.383–385*). For this reason, these pottery carbon dates were compared to $^{14}C$ values obtained from charred crusts on the surface of pottery, organics inside vessel's walls, and from bones measured at different laboratories (at the universities of Arizona, St. Petersburg, Uppsala, Poznan, Helsinki, and Aarhus). Similar values were received from these laboratories (Tab. 1). The chronological phases of the different cultures were calculated by means of Bayesian statistics with the help of OxCal 4.2 (*Bronk Ramsey 2009.337–360*) (Figs. 11–15).

## Results and discussion

### *The Northern Caspian region*

In the last ten years, 70 radiocarbon dates have been obtained for 12 Neolithic sites in the Northern Caspian region. There are 37 dates for organics from pottery, 9 for charred crusts and 5 for charcoal; 9 of these dates were obtained by the AMS technique (*Baratskov* et al. *2012.200–204; Vybornov* et al. *2014.242–248; Andreev* et al. *2016a.130–139*).

The pottery of Kairshak III type (Fig. 2) from Early Neolithic sites in this region was dated to 6505–5746 cal BC (Tab. 1.3). Several studies (*Kuzmin* et al. *2013*) have suggested that the geological carbon from clay-silt deposits is the reason for the older dates obtained on the organics from pottery. Kairshak pottery was moulded from an organic silt containing shell. The carbonate fraction from pottery is a radiocarbon dated to 7050–6500 cal BC, while the organics from this pottery date to 6500–5750 cal BC (Tab. 1.5–6). A date of 6690–6490 cal BC (Tab. 1.1) was obtained on the charred crusts, which can probably be explained by the reservoir effect ($\delta^{13}C$ = –28.7‰). This is supported by the date on shell from pottery (Fig. 11). A date of 6230–5890 cal BC (Tab. 1.1–4) was obtained on kulan bones which were found together with pottery. So, the most appropriate age for the Kairshak III cultural tradition is 6500–5750 cal BC.

Late Neolithic period sites also exist in this region. Tenteksor type sites (Fig. 1) are located near to Kairshak. Several radiocarbon dates for these sites have been obtained in different laboratories and on different organic materials. The organics from the Tenteksor type pottery have dates of 5720–5470 cal BC and 5740–5460 cal BC (Tab. 1.16–17). The radiocarbon date on the charred crusts is *c.* 5680–5530 cal BC (Tab. 1.14). The radiocarbon date on bones is 5640–5310 cal BC (Tab. 1.15). All these dates correlate well between each other. Typologically earlier sites of Tenteksor type have dates from 5900–5700 cal BC (*Vybornov 2008.490*). The typology of pottery and the chronological frameworks of surrounding sites did not allow us to accept the younger dates *c.* 4500 cal BC (*Zaitseva* et al. *2009.795–801*) obtained earlier for the Late Neolithic layers at the Tenteksor site. These dates were obtained on humid acids from soils and on bones calcinated by dia-

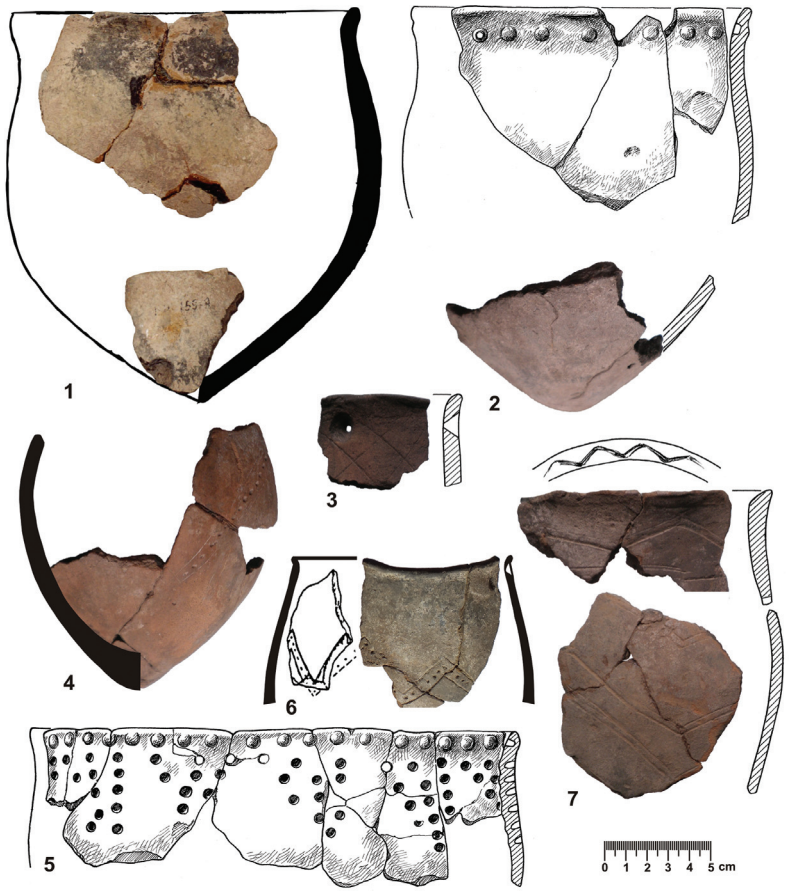



***Fig. 7. The forest-steppe of the Volga region. Pottery from the Ivanovskaya (1), Chekalino IV (2, 6–7), B. Rakovka II (3) and Niznaya Orlyanka II (4–5) sites.***

genetic carbonate, and are younger. The date on the shell from pottery is *c.* 6200 cal BC, and the last date is older than the date on the organics from this sherd (*c.* 5700 cal BC) (*Zaitseva* et al. *2009.795–801*).

Materials from the Baibek site (*Grechkina* et al. *2014.79–90*) complement the chronology of the Early Neolithic of the Northern Caspian region (Fig. 3). There are two dates on charred crusts: 7037–6684 and 6373–6070 cal BC (Tab. 1.7, 9). These dates are probably influenced by the reservoir effect, because the date on the bones is 6002–5708 cal BC (Tab. 1.10) and the dates on charcoal from different laboratories are 5917–5604 and 5983–5759 cal BC (Tab. 1.8, 12). The date on the organics from pottery is 6021–5626 cal BC (Tab. 1.13), which correlates well with dates on bones and food crusts. These results fall into the chronological gap between ages of the Early Neolithic complex of Kairshak type and the Late Neolithic of the Tenteksor sites. Typologically earlier materials from Kairshak III are dated to as early as 6200 cal BC. The sites at Kugat IV (Fig. 2.1) and Kulgaisi with typologically earlier materials are dated on the basis of organics from pottery to 6600–6220 cal BC and 6450–6027 cal BC, respectively (Tab. 1.10, 20). The mesolithic characteristics of flint tools found here are good evidence for this earlier chronology (*Vybornov 2016.161–166*).




***Fig. 8. The forest-steppe of the Volga region (1) and Sura region (2–5). Pottery from the Krasniy Gorodok I (1), Vjunovo lake I (2–3) and Utuzh I (4–5) sites.***

Thus, the earliest chronological boundary for the beginning of the Neolithic in the Northern Caspian Sea region will be about 6600 cal BC and the latest around 5500 cal BC. Until recently, the accepted chronological framework of the Early Neolithic stage for this region was between 5900–4500 BC. The recently excavated archaeological materials and the radiocarbon dates do not support this framework.

Material from the Jangar site (*Koltsov 2004*) in the north-western Caspian region have also been dated (Fig. 5). The date obtained for organics from pottery in the bottom of layer 3 (Fig. 5.6–8) is 6090–5710 cal BC (Tab. 1.21–22), for upper layer 2 (Fig. 5.3–5) the date is 5840–5510 cal BC (Tab. 1.25). The date on the charcoal found between these layers is 6010–5550 cal BC (Tab. 1.23), while the date on charred crusts from pottery in the upper layer (Fig. 5.1–2) is 5575–5470 cal BC (Tab. 1.27).

Thus, the chronological frameworks of the Early Neolithic of the north-western Caspian region are from around 6000–5500 cal BC. Previous research suggested that the Early Neolithic period was about 5500–4900 cal BC (*Koltsov 2004*). There are typologically earlier archaeological finds, and we can suggest an earlier time from the beginning of the Early Neolithic in the north-western Caspian. The earlier age of artefacts is based on an analysis of the flint tool typology; the flint artefacts are similar to Mesolithic examples, but this material has not been confirmed by radiocarbon dates yet.

### *The Volga River region*

The steppe region of Low Povolzhye is located in the north of the Caspian region, in the low Volga basin. Until 2007, there were just 7 radiocarbon dates from one site (Varfolomeevskaya); four of these dates contradicted archaeological expectations. The time-frame for the Orlovskaya Neolithic culture in the Low Po-

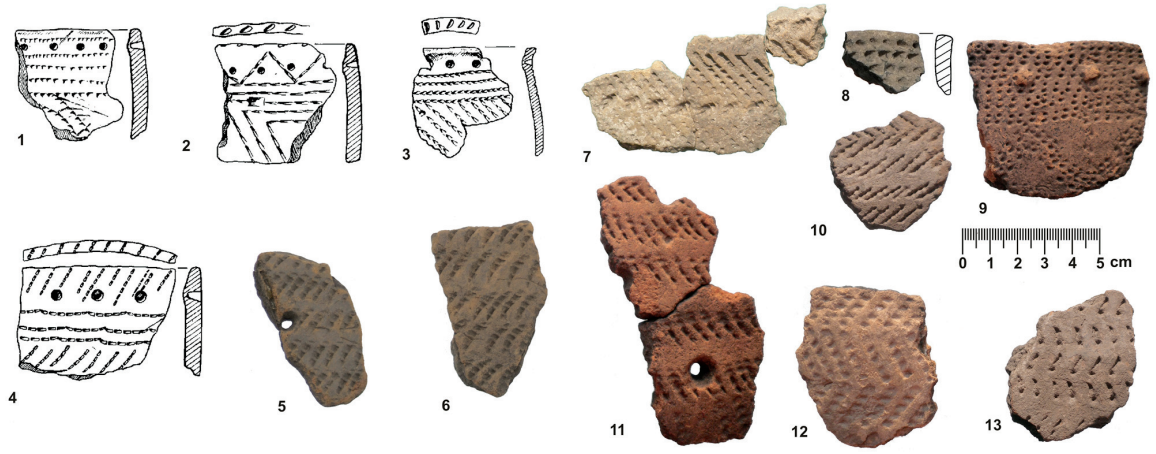



***Fig. 9. The forest-steppe of the Volga region. Pottery from the Vilovatovskaya (1–6) and Kalmykovka I (7–13) sites.***

volzhye was estimated to be around 5900–4200 cal BC (*Yudin 2004*). In the last ten years, 41 dates have been obtained for this culture: 19 dates on the total organic carbon content of pottery, 12 dates on charred food crusts, 7 dates on bones, and 3 dates on charcoal. Eleven dates were obtained by the AMS technique (*Vybornov* et al. *2013.13–20; 2014.242–248*).

The bottom layer (3) of the Varfolomeevskaya site (Fig. 6, 9–14) is dated to 6250–5500 cal BC (Tab. 1.28) on charcoal. Almost the same date was obtained on pottery from the same layer, which is 6250–5980 cal BC (Tab. 1,29). In the bottom layer of the Algay site, the artefacts belonged to the same culture recently found at the Varfolomeevka site (*Yudin* et al. *2016.61–68*). The age of the cultural layer is 6271–6008 cal BC (Tab. 1.30). These results allow us to determine the beginning of the Low Volga Neolithic to the second half of the 7th millennium.

The middle layer (2B) at the Varfolomeevskaya site (Fig. 6.6–8) was dated earlier, from *c.* 5750–5400 cal BC. Otherwise, the dates on the organics from pottery are from *c.* 6080–6020 cal BC (*Vybornov 2008.490*). These dates are supported by dates obtained recently on charred crusts (6220–5740 cal BC and 6010–5830 cal BC; Tab. 1.31, 32). The upper layer (2A) of this site (Fig. 6.3–5) relates to the period from *c.* 5650–4950 to 5050–4300 cal BC (Tab. 1.38–41). The material from the Algay site supports this assumption. The date from charred crusts on pottery from 2B layer at the Varfolomeevskaya site (5816–5659 cal BC; Tab. 1.33) is close to the date on charred crusts from the lower layer of the Algay site (5741–5631 cal BC; Tab. 1.34) (Fig. 6.1). The dates on the organics from pottery and bones at the Algay site correspond with each other (Tab. 1.34–36). The upper layers of the Varfolomeevskaya and Algay (Fig. 6.2) sites are dated to 5050–4300 and 4856–4580 cal BC, respectively (Tab. 1.41–43).

These results allow us to determine more precisely the time-frame for each stage of the Orlovskaya culture in this region. The Orlovskaya culture existed from 6000–5500 cal BC, and it coincides with the period of the Early Neolithic in the northern Caspian region. Based on archaeological data, *i.e.* ceramic typology, researchers supposed the simultaneous de-

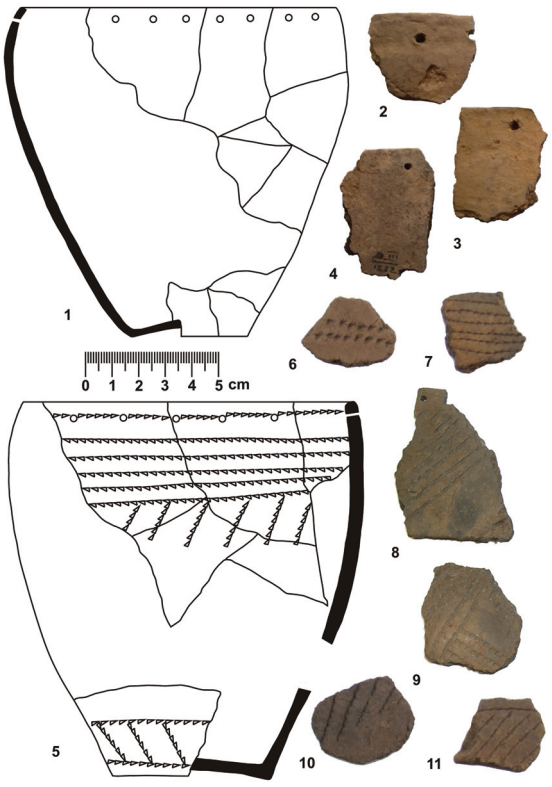



***Fig. 10. The forest zone of Volga region. Pottery from the Dubovskaya III (1–5) and II Sherbetskaya (6–11) sites.***

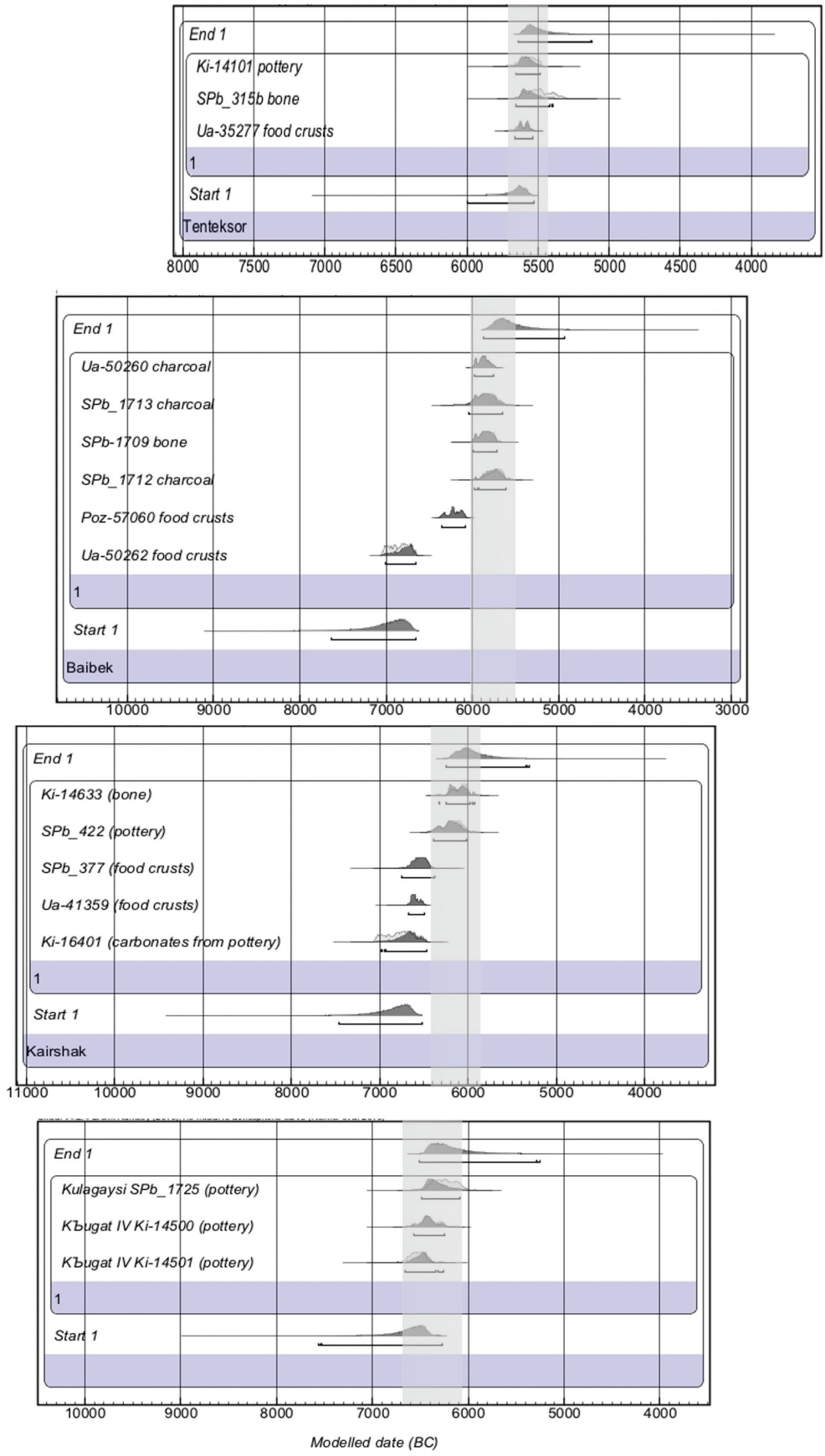



***Fig. 11. The distribution of radiocarbon dates (cal BC) for the Early Neolithic cultures of the Northern Caspian Sea region. The grey tone denotes the most appropriate age.***

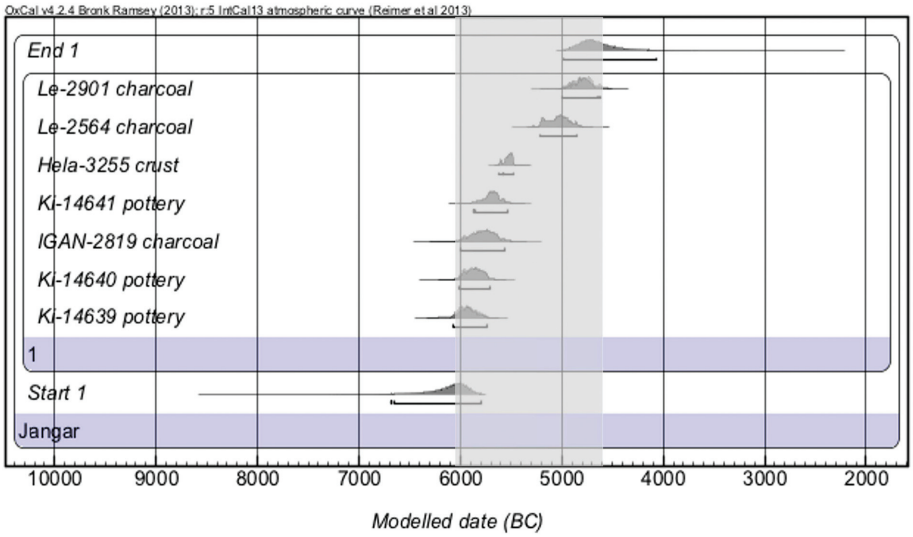



***Fig. 12. The distribution of radiocarbon dates (cal BC) for the Jungar culture of the North-Western Caspian Sea region. The grey tone denotes the most appropriate age.***

velopment of these cultures in the northern and north-western Caspian region and in the Lower Volga, especially for the last cultural stages. These suggestions were supported recently by new radiocarbon dates. For the eponymous site of the Orlovskaya culture (Orlovka) there is a date of 5846–5315 cal BC (Tab. 1.37), which correlates well with the dates of late complexes at the the Tenteksor site (Tab. 1.14), from the upper layer of the Jangar site (Tab. 1.27) and from the upper layer (2A) of the Varfolomeevskaya site (Tab. 1.38).

Ten radiocarbon dates were obtained from four Neolithic sites of the forest-steppe Volga region. They were determined in the interval from 7900–7000 cal BC, which is why they were interpreted as the oldest sites in this region. However, nine of them were obtained on shell and could be subject to reservoir effects. Beginning from 2007, 161 dates were obtained from 30 sites of the Elshanian culture in this region. Sixteen dates were obtained by AMS dating. Elshanian culture sites extend from the Ural River to the east to the Moksha River to the west (Fig. 1). The date on the organics from pottery for the most easterly site of the Ivanovskaya site (Fig. 7.1) is 6566–6248 cal BC (Tab. 1.47). For the most westerly, from the Vjunovo Lake site (Fig. 8.2–3) and the Imerka VII site, several dates obtained on the organics from pottery are *c.* 6220–6004 and 6092–5927 cal BC according to the AMS technique

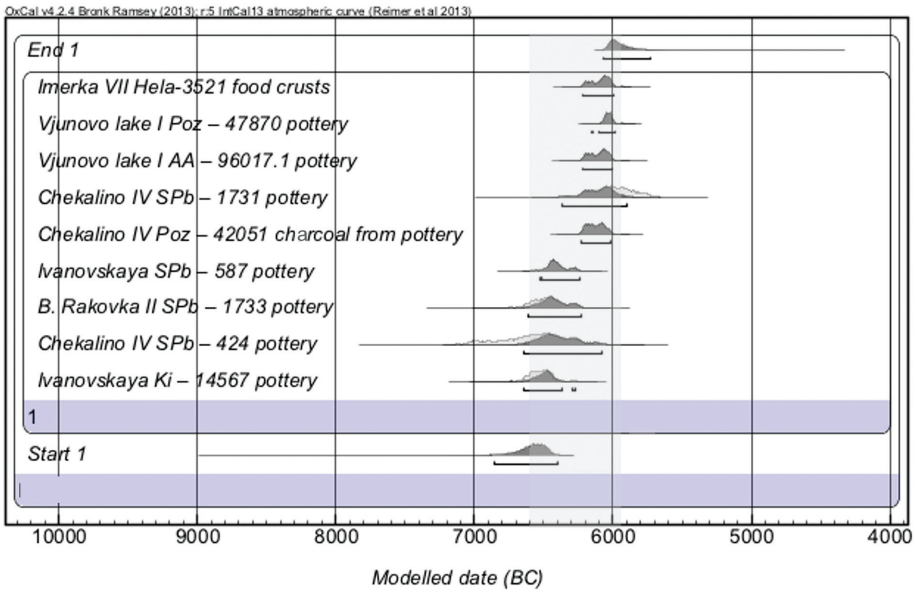



***Fig. 13. The distribution of radiocarbon dates (cal BC) for the Early stage of Elshanian culture in the Povolzhye. The grey tone denotes the most appropriate age.***

(the Vjunovo Lake site; Tab. 1.50–51). The date on the charred crusts from the Imerka VII site is 6220–5980 cal BC (Tab. 1.52). Most of the Elshanian culture sites were excavated in the Samarskoe Povolzhye, in the region of Samara (Fig. 1). The dates on the organics from pottery are 6750–6200 cal BC (Bolshaya Rakovka II site; Fig. 7.3), 7047–6202, and 6400–5700 cal BC (Chekalino IV site; Fig. 7.2,6,7; Tab. 1.46, 45, 49 respectively). Elshanian culture pottery was moulded from clay with organics, without shell inclusions. Therefore, the date on pottery of 7047–6202 cal BC (Tab. 1.45) seems to be older. The most acceptable date for this site is 6229–6016 cal BC (Tab. 1.48), obtained on charcoal from pottery by the AMS technique.

The series of dates for typologically later sites of the Elshanian culture fall into the interval of 6000–5700 cal BC. What is important is that the dates on the organics from pottery correspond with the dates on the charred crusts from the pottery of the same type, taking into account the error of measurement and reservoir effect (5730–5490 and 5740–5370 cal BC, respectively, (Tab. 1.53–54).

The late stage of the Elshanian culture in the Lugovoe III site was dated in the 1980s to 3500 cal BC (*Vybornov 2008.490*). However, these dates contradict archaeological data and the chronology of the forest-steppe Neolithic. At present the series of dates obtained on the material from the late stage, including from the Lugovoe site, are in the interval 5700–5500 calBC (*Vybornov 2008.490*). Material of the Elshanian type from the Utuzh I site (Fig. 8.4–5) located in the basin of the Sura River is dated on the organics from the pottery to *c.* 5640–5290 cal BC (Tab. 1.56). The date of 5620–5470 cal BC (Tab. 1.55) on charred crusts from the same fragment of pottery was obtained by the AMS technique.

Thus the chronological period of the spread of Early Neolithic Elshanian culture is from 6500–5500 cal BC.

The Elshanian culture was replaced by the Srednevolzhskaya culture (*Vybornov 2008.490*) (Fig. 9). On the base of a large series of radiocarbon dates, the period of this culture's development can be determined from 5500–4700 cal BC (Tab. 1.59–63). There is a good correlation between dates obtained on the organics from pottery and bones (Tab. 1.64– 65).

In the southern steppe region of Povolzhye, the Early Neolithic period is dated between 6500–6000 cal BC and the Late Neolithic period between 6000–5500 cal BC. In the forest-steppe zone, the Early Neolithic is dated between 6500–5500 cal BC, but the Late Neolithic lasted from 5500–4700 cal BC.

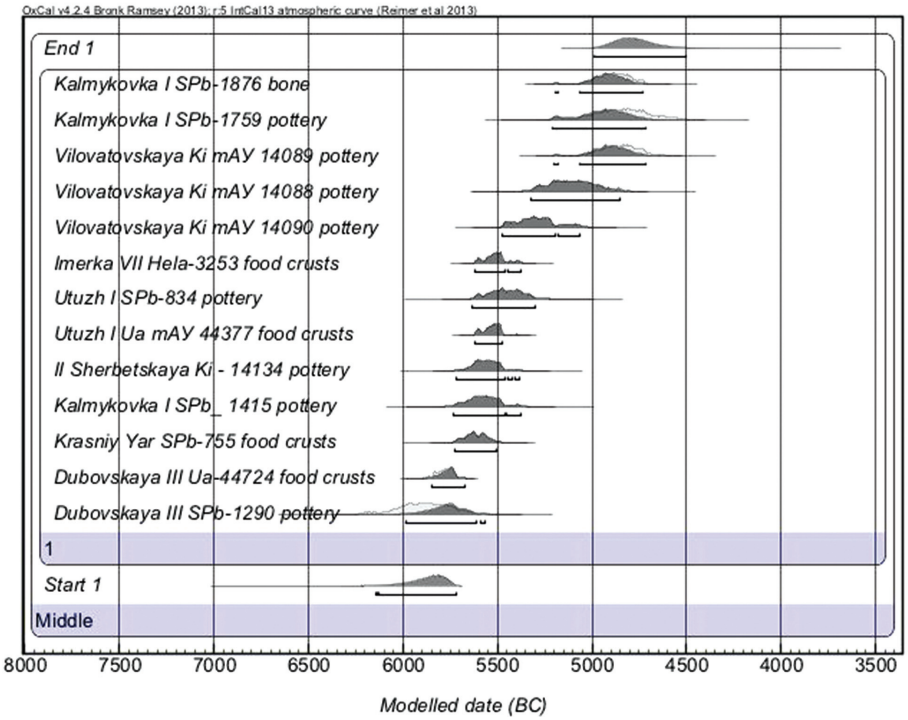



***Fig. 14. The distribution of radiocarbon dates (cal BC) for the Late stage of Srednevolzhskaya culture in the Povolzhye. The grey tone denotes the most appropriate age.***

In the forest zone of the Middle Volga region the Early Neolithic has been dated to *c.* 5000 cal BC. At present, there are the 24 dates from the 8 sites. Typologically the earliest pottery from the Dubovskaya III site (Fig. 10.1–4) has the date of 5925±325 cal BC (Tab. 1.57). The charred crusts from this fragment of pottery date to 5795 ± 95 cal BC (Tab. 1.58). Pottery actually appeared in the forest zone of the Middle Volga region 1000 years earlier than it was thought to have done several years ago, and this pro-

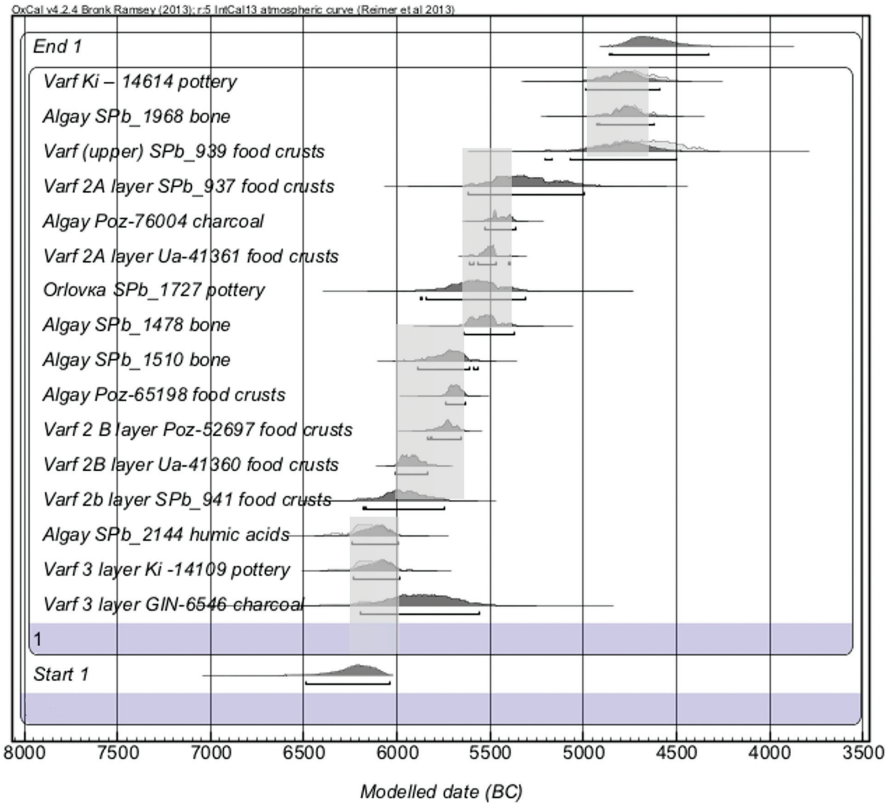



***Fig. 15. The distribution of radiocarbon dates (cal BC) for the Orlovskaya culture in the Lower Povolzhye. The grey tone denotes the most appropriate age.***

cess occurred 200–500 years later than in the southern forest-steppe zone.

## Conclusion

An array of radiocarbon dates on different organic material from almost all the Povolzhye Neolithic sites has been obtained in the last 10 years. The analysis of these dates has shown a good correlation between most of the dates on the charcoal, food crusts, bone, and organics from ceramics from different sites. The correlation of these radiocarbon dates with stratigraphic successions of cultural layers at the sites and the pottery typology allow us to correct the chronological frameworks of the Neolithic in the Low and Middle Povolzhye region. This schema differs from the schema accepted until 2007. The chronological frameworks of the Neolithic in the steppe Povolzhye date from 6500–5500 cal BC, In the forest-steppe zone of Middle Povolzhye, the Neolithic period is dated from 6500–4700 cal BC, and in the forest zone of the Middle Povolzhye, the Neolithic period lasted from 6000–4300 cal BC.

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# Do $^{14}$C dates always turn into an absolute chronology? The case of the Middle Neolithic in western Lesser Poland

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ABSTRACT – *In the late 5th, 4th, and early 3rd millennia BC, different archaeological units are visible in western Lesser Poland. According to traditional views, local branches of the late Lengyel-Polgár complex, the Funnel Beaker culture, and the Baden phenomena overlap chronologically in great measure. The results of investigations done with new radiocarbon dating show that in some cases a discrete mode and linearity of cultural transformation is recommended. The study demonstrates that extreme approaches in which we either approve only those dates which fit with our concepts or accept with no reservation all dates as such are incorrect.*

KEY WORDS – *western Lesser Poland; Middle Neolithic; absolute chronology; $^{14}$C dating*

## *Ali $^{14}$C datumi vedno predstavljajo tudi absolutno kronologijo? Primer iz srednjega neolitika na zahodu Malopoljske*

IZVLEČEK – *V obdobju poznega 5., 4. in zgodnjega 3. tisočletja pr. n. št. lahko na območju zahodne Malopoljske prepoznamo različne arheološke enote. Glede na tradicionalne poglede se v tem času kronološko prekrivajo enote poznega kompleksa Lengyel-Polgár, kulture zvončastih čas in badenskega fenomena. Novi radiokarbonski datumi kažejo, da je v nekaterih primerih potreben diskreten pristop z linearnimi kulturnimi spremembami. V članku pokažemo, da so ekstremni pristopi, pri katerih uporabimo oz. izključimo bodisi tiste datume, ki sodijo v naše koncepte, bodisi vse datume brez zadržkov, pri razlagah datumov nepravilni.*

KLJUČNE BESEDE – *Malopoljska; srednji neolitik; absolutna kronologija; $^{14}$C datiranje*

## Introduction

Radiocarbon dating is the basic method for elaborating the absolute chronology of prehistoric events in the Younger Stone Age (*Walanus, Goslar 2009; Taylor* et al. *2014*). Certainly, this is not an ideal method. It is characterised by a number of limitations, faults, and imperfections. Awareness of their existence varies among archaeologists and other scientists using this method. However, no method that would be a viable alternative for radiocarbon dating has been invented so far[1]. This is why it is very important to approach the results of radiocarbon dating correctly. These results must undergo multi-dimensional analyses and interpretations, which take into account many internal factors (*i.e.* arising from the me-

1 This inevitably connotes Winston Churchill's famous saying about democracy: "*Democracy is the worst form of government except for all those others that have been tried*". In fact, it perfectly reflects the place of the discussed method in archeology (and not only in archaeology), *i.e.* to paraphrase this saying, we could say that radiocarbon dating is the worst form of dating except for all those others that have been tried.


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thod itself) as well as external (*i.e.* arising from the context of a sample, and even from the specificity of a given laboratory).

Perhaps, above all, we must remember that, the result of radiocarbon dating and calibration, is a wider or narrower time range, and not, contrary to a common view, a specific point in time. Particular segments of the range are usually characterised by varying probability.

In our analyses, we may consider dates at face value, and determine the timeframe formally covered by ranges resulting from calibration procedures. Alternatively, we can add up the probabilities of each calibrated distribution. The result will usually be similar to the previous one. If we rely on individually calibrated date ranges or sum-calibrated distributions, we usually obtain longer timeframes than expected (*Marsch* et al. *2017.120*), when based on typological premises. Consequently, it appears that many archaeological units, contrary to conventional patterns, develop partially or completely in parallel.

However, $^{14}$C dates treated in this way could be misleading. Natural imperfections and the risks connected with $^{14}$C method, compounded by the laws of statistics, can result in the emergence of extreme values. These extreme values will deviate from the most typical and ordinary ones, and therefore will not reflect the actual chronology of the context from which they originate. In other words, the actual chronological diversity is not as advanced as it could appear. In terms of the prehistoric chronology, a good illustration of this matter is the comparison of radiocarbon and dendrochronological dates, with the latter giving clearly narrower intervals (*Włodarczak 2008c.Fig. 7*). In the quoted author's opinion (*Włodarczak 2008c.125–126*), uncritical acceptance of formal indications of radiocarbon dating results in an apparent lengthening of chronology and an apparent synchronicity of archaeological groupings. Based on such premises and thoughts, a 'reductionist' approach in the interpretation of radiocarbon dates may be suggested, in which extreme values are considered to be fictitious (*e.g., Domboróczki 2009. 80–91; Müller 2002; Włodarczak 2008c*). Therefore, modelling procedures can also be executed which will verify whether the available set of dates is characterised by internal cohesiveness (grouping) and, in effect, may designate a compact period of time. Undoubtedly, Bayesian modelling has become the most prevalent in recent years (*Bayliss 2015; Bayliss* et al. *2007; Bronk Ramsey 2009a; 2009b*), and we will use it in this contribution.

Admittedly, this approach is only an assumption, particularly when dates do not come from the same site or context. However, the concept of a phase can be applied to many sites combined, as dates can be related to an "*unordered group of events/parameters*" and to "*a random scatter of events between a start and an end boundary*" (*Bronk Ramsey online*). Moreover, the supposition of continuity of development within an archaeological unit is not an illogical idea. One can conclude that the vast majority of prehistoric phenomena were characterised by a consistent continuation and cohesiveness of development (*e.g., Marsch* et al. *2017*). Bayesian models have great potential to improve chronologies, but they have to be connected with critically analysed external circumstances (prior assumptions), *i.a.* with stratigraphic and typological contexts, as well as with already existing dating schemes of phenomena important for the issue investigated. The outcome of such procedures will quite frequently be a shortening of the timeframes of archaeological units under consideration. Chronologically, they will become more discrete units once again, and 'traditional', typological data will regain its importance. There may also be shifts in the dating of some prehistoric and historic events with respect to the common views.

To analyse problems of this kind, we decided to take into account the region of western Lesser Poland in a period that, in the local circumstances, can be called 'Middle Neolithic' (or alternatively 'Early Eneolithic'). Additionally, the 'Late Neolithic' Corded Ware culture will be utilised as a kind of 'upper' chronological boundary (Fig. 1). The timeframe under scrutiny is the period from the late 5$^{th}$ to the early 3$^{rd}$ millennium BC. In this period, significant changes to settlement and economic patterns took place, but probably also within the ideological and social spheres. These changes can be described as 'Eneolithisation'. Therefore, a comprehensive chronological interpretation of archaeological facts is also important and helpful for correct anthropological and historical interpretations of these processes.

## Archaeological setting

Loess uplands covered by fertile soils predominate in western Lesser Poland, so it was and still is a very favourable area for agriculture. Hence, since the beginning of the Neolithic until today the area is characterised by very dense human settlement. What is more, this area was and is located at a crossroads of main communication routes, intersecting basins of the Vistula and Oder rivers. In the Neolithic, cultu-

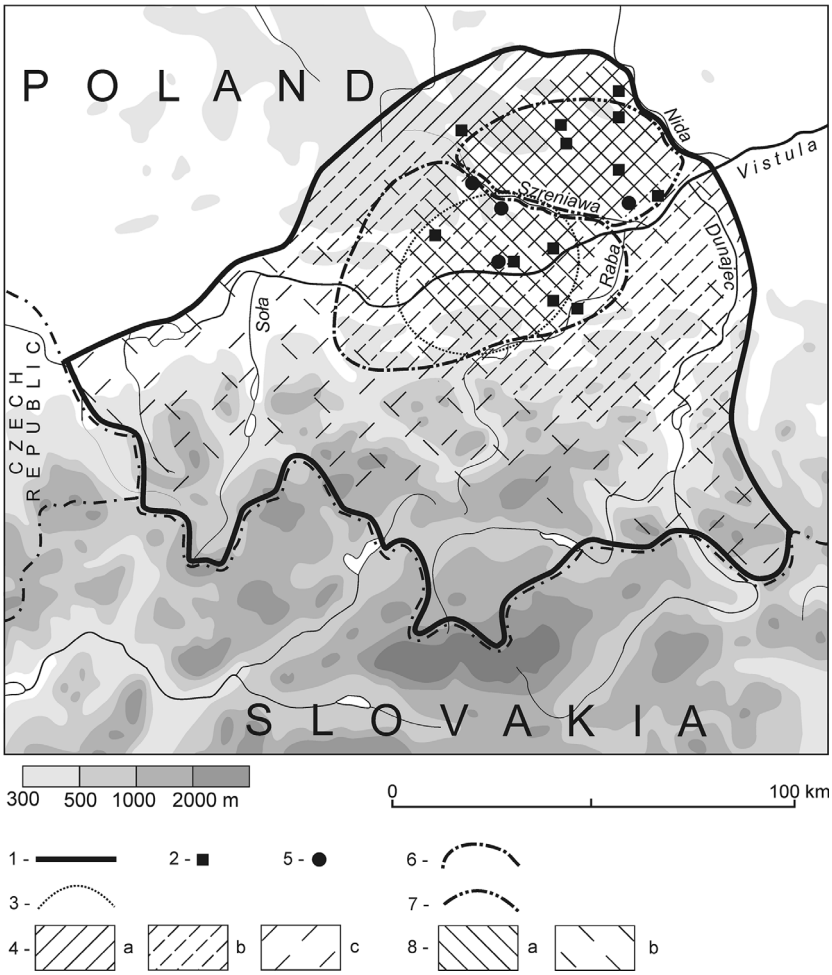



***Fig. 1. Territory of western Lesser Poland and the main archaeological units in the late 5th, 4th and early 3rd millennia BC: 1 borders of the area discussed in the paper; 2 sites of the Lublin-Volhynian culture; 3 the Wyciąże-Złotniki group; 4 the Funnel Beaker culture (a dense settlement typical of 'loess' upland; b more dispersed settlement typical of foothills, alluvial plains/basins and 'jurassic' zones; c highly dispersed settlement typical mainly of mountainous zone); 5 sites with the Wyciąże/Niedźwiedź materials; 6 the Baden culture, 7 the Beaker/Baden assemblages; 8 Corded Ware culture (a relatively dense settlement typical mainly of 'loess' upland; b highly dispersed settlement typical of other ecological zones).***

ral transmissions and human migration met and mingled here; they came from virtually all directions. As a result, the formation of specific, syncretic units took place fairly frequently. It was also the output area of a number of transmissions and migrations, also in virtually all directions.

Within the defined space and time, a number of archaeological units have been recorded (Fig. 1), almost all of which are local components of large groupings belonging to different Central-European cultural traditions. As is usual in the case of the Neolithic, especially in the 'continental' (cultural-historical) approach, these units and traditions were discerned long ago on the basis of pottery. From the perspective of the Anglo-American literature they would be described rather as pottery styles, not separate entities. Indeed, there are some shared elements of 'non-ceramic' material culture. However, there also are some other elements of material culture as well as patterns of settlement systems and, particularly, of burial practices which fit with the pottery classification very well (compare *Włodarczak 2017*). Thus, we are entitled to assume that in great measure this pottery classification reflects actual past divisions and categorisations.

In the early part of the period considered we are dealing with entities that belong to the last stage of the so-called Lengyel-Polgár complex (L-PC). The term is applied to groups that developed in the 5th millennium and in the first half of the 4th millennium BC, in the basins of the Vistula and Oder rivers (*e.g., Kamieńska, Kozłowski 1990*). These groups were subjected to very strong influences from the Carpathian Basin, reflected primarily in pottery. However, from the perspective of other elements of material culture, settlement, economy, and the as yet few genetic analyses (*Lorkiewicz* et al. *2015; Juras* et al. *2017*), they show evident connections with the first Neolithic culture in central Europe, the Linear Band Pottery culture (LBK). For this reason, they are thought to have formed a later part of the same cultural continuum, denoted as so-called Danubian Neolithic, to apply Gordon Childe's (*1929.220*) terminology. In Polish regions, apart from the Linear Band Pottery culture and Lengyel-Polgár complex, the Stroke Band Pottery culture is also usually in-

cluded in the Danubian Neolithic. However, it is not represented in the region under consideration. Therefore, the ultimate disappearance of the Lengyel-Polgár complex in Lesser Poland is in fact the ultimate disappearance of the continuous development of the Danubian Neolithic, which lasted from approx. the mid-6th millennium BC to approx. the mid-4th millennium BC.

The late Lengyel-Polgár units in western Lesser Poland comprise the Wyciąże-Złotniki group (W-ZG) (Fig. 2) and the Lublin-Volhynian culture (L-VC) (Fig. 3), or rather its westernmost extent, to be more precise (Fig. 1) (*Kadrow, Zakościelna 2000; Nowak 2009; 2014; Zakościelna 2010*).

The central part of our timeframe is characterised by the presence of the Funnel Beaker culture (TRB) (Figs. 4–5). This culture constitutes a quite new cultural tradition, being the outcome of complicated interactions between the later Danubian Neolithic and still 'non-Neolithised' late Mesolithic societies, which took place in the south-western Baltic zone in the late 5th millennium BC (*e.g., Kabaciński* et al. *2015*). In lowland parts of central Europe, it indicates the further development of the Neolithic, connected on the one hand with Eneolithisation processes, but on the other, with the inclusion of late hunter-gatherer populations in the Neolithic way of life ('second stage of neolithisation' – *Nowak 2009*). The Funnel Beaker culture differs from the Danubian Neolithic not only in pottery. Sites of this culture are dispersed more evenly in the landscape, *i.e.* communities of this culture settled and utilised almost all ecological zones (Fig. 1). A number of other factors also make a difference from the Danubian Neolithic, such as: i) the emergence of big settlements with an area of 20–40 hectares, ii) the appearance of monumental burial structures, and iii) the extensive pattern of agriculture of the slash-and-burn type (*Kruk, Milisauskas 1999; Milisauskas, Kruk 1984*). As a consequence of the latter factor, we have clear signs of the human transformation of the environment, mainly of deforestation. Certainly, the emergence of this culture in western Lesser Poland was associated with an impact from the Polish Lowland zone. The balance between cultural transmission and migration within this impact remains a matter of speculation.

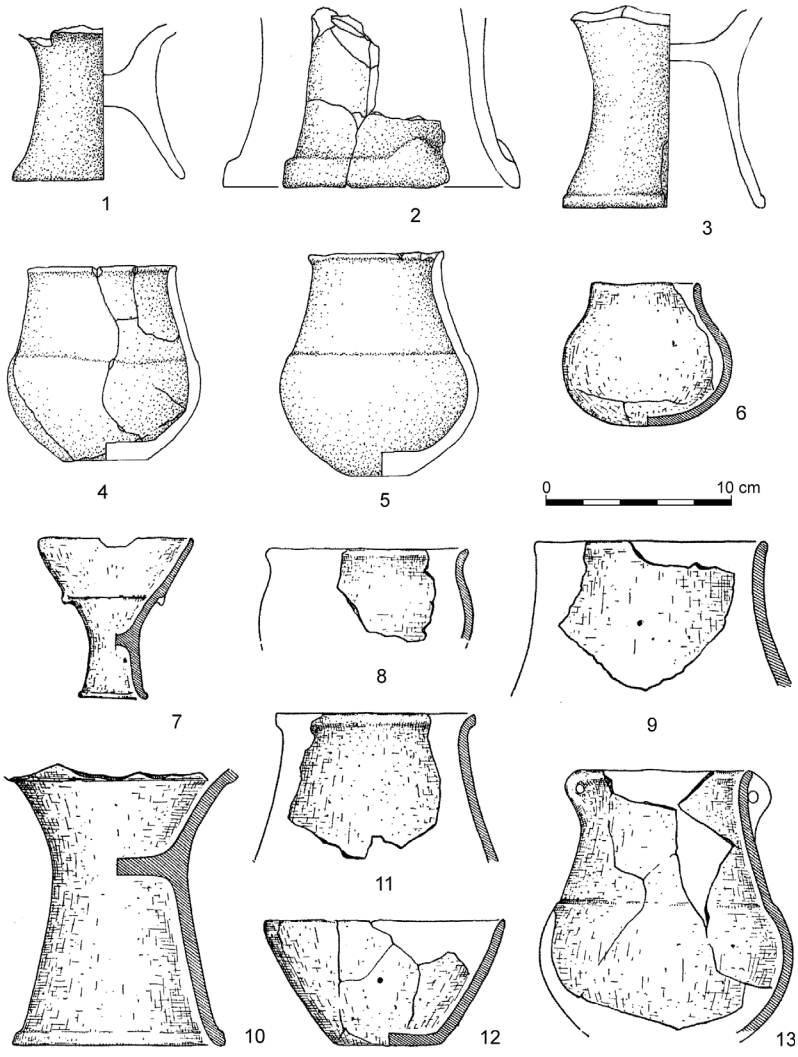



***Fig. 2. Selected pottery of the Wyciąże-Złotniki group: 1–5 Podłęże 17 (from* Nowak *et al.* 2007*); 6–13 Złotniki (from* Dzieduszycka-Machnikowa 1966*).***

The last part of the period under discussion is characterised by phenomena connected with the Baden culture (BaC) (Fig. 6), which was a unit covering basically the whole of the middle Danube basin. The Baden phenomena have an important position in the Late Eneolithic of east-central Europe, and not only because of their new ceramics. There are many new elements in settlement and economic patterns and in funeral rites; these can be linked to new social structures, both in the horizontal and vertical dimensions. For many reasons, the Baden cultural model must have

been attractive. This factor makes it is possible to explain the relative cultural unification of almost the whole Carpathian Basin and some of the surrounding areas in the period *c*. 3600–2900 cal BC. This had also to be the reason for the enthusiastic acceptance of Baden patterns in regions situated far to the north of the middle Danube basin. This is visible in the new fashion in pottery, but also in other elements, such as the enlargement of some settlements, fortifications and collective burials.

The term 'Baden phenomena' is used here because – as a matter of fact – at least three versions of the 'Badenian' materials can be distinguished in Lesser Poland (Fig. 1). Firstly, we are dealing with the Baden culture proper (Fig. 6) in a small area in and around Kraków (*Zastawny 2015a*). Secondly, features of the Baden culture can easily be noticed within the late Funnel Beaker materials. This is evident primarily in ceramics, but not only in western Lesser Poland. However, only there did the Baden ceramic style became extremely popular within local late Funnel Beaker communities. This fashion was accepted so enthusiastically and en masse that at least some archaeologists have discerned a quite separate local cultural unit called Beaker/Baden assemblages (TRB/BaC, B/BA on Figs. 18, 21) (Fig. 7), in the more eastern part of the area under consideration (*Kruk, Milisauskas 1999; Milisauskas, Kruk 1989*). Thirdly, we are also dealing with materials that combine some late Lengyel-Polgár, Baden and possibly Funnel Beaker features. They are referred to by different terms; there is no universal agreement on this matter (*Burchard 1977; Godłowska 1979.305–306; Kozłowski 1971; 1989b; Włodarczak 2008b; 2013; Zastawny 2011*). The notion of 'materials of the Wyciąże/Niedźwiedź type' (in a shorter, more convenient, version: 'Wyciąże/Niedźwiedź materials') will be used in this contribution (Fig. 8)

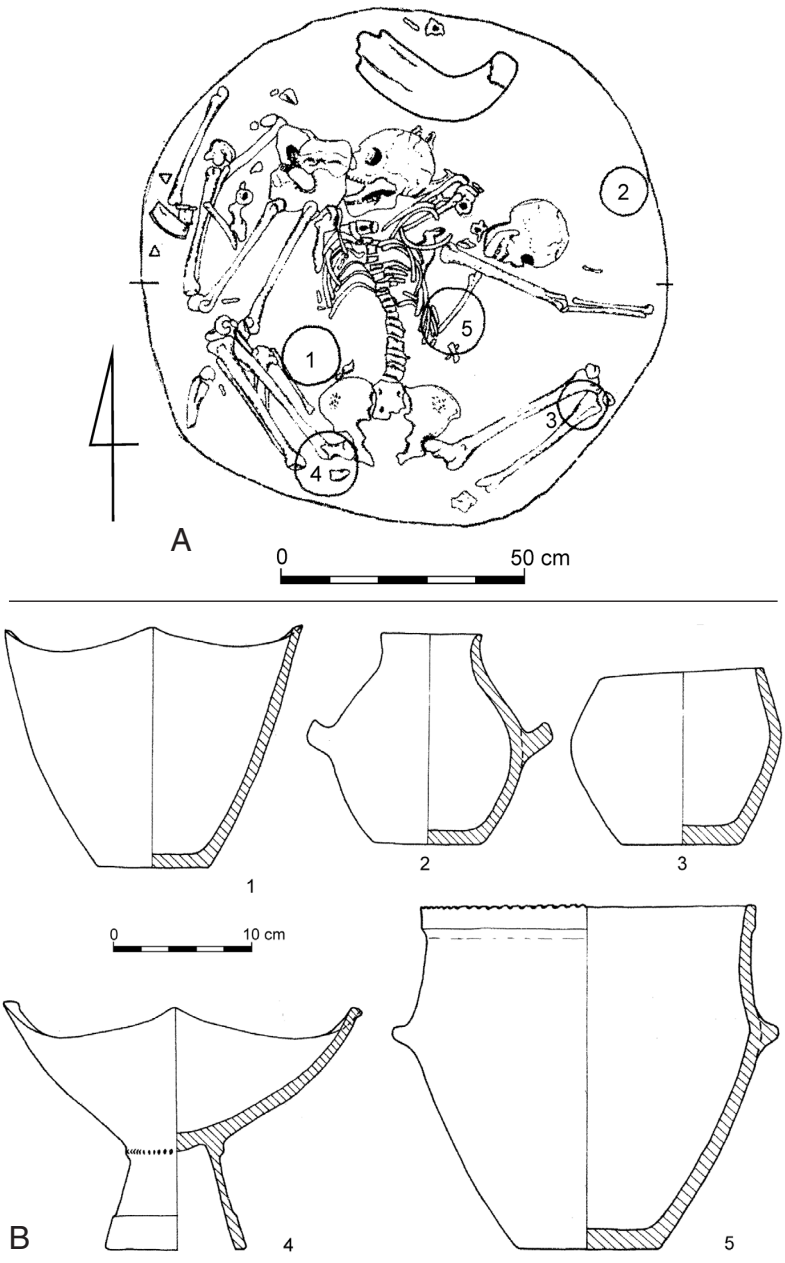



***Fig. 3. Collective grave of the Lublin-Volhynian culture at Bronocice (A) and pottery found there as grave goods (B) (from* Kruk, Milisauskas 1985*).***

The development of Funnel Beaker culture and Baden phenomena (the Middle Neolithic development) seems to end with the appearance of the Corded Ware culture (CWC). It is obviously defined again by new ceramics, but frequently appear in unprecedented forms of funeral rites (barrows and niche graves). This culture, including its branch known from southern Poland, is quite commonly considered to be evidence of nomadic, pastoral populations. In contrast to previous Neolithic communities, their social structure was distinguished by a greater social stratification. The ruling social stratum, endowed with privileges, would have

been a stratum of adult men, warriors, who were buried under barrows (*Włodarczak 2006a*). There are more and more indications, including genetic ones (*Allentoft* et al. *2015; Haak* et al. *2015*), that the genesis of the Corded Ware culture in central Europe was associated with western migrations from the steppe and forest-steppe zone of eastern Europe.

Until around 2005, views on the absolute chronology of Middle Neolithic units in Lesser Poland were defined rather vaguely. Fairly general terms were in use, such as first or second half of the millennium, the beginning of the millennium, the middle part of the millennium, *etc*. These views were based first and foremost on typological premises and around 40 radiocarbon dates. Available $^{14}$C dates were unevenly distributed between archaeological groupings. Actually, most originated from one site of the Funnel Beaker culture and Beaker/Baden assemblages, *i.e.* from Bronocice (*Kruk, Milisauskas 1983; 1990*). Hence, it was difficult to make a reasonable, both detailed and more holistic description of absolute chronology.

However, in recent years there has been a significant increase in the number of radiocarbon dates of the Middle (and Late) Neolithic in western Lesser Poland (Fig. 9). At present, there are over 150 dates (Tab. 1 is available at http://dx.doi.org/10.4312/dp.44.15). More importantly, the first series of dates have been obtained for units previously almost deprived of absolute dates, such as the Wyciąże-Złotniki group, Lublin-Volhynian culture, and Baden culture, as well as Wyciąże/Niedźwiedź materials. For this reason, it seems necessary to make a new estimate of the absolute chronology of this segment of the Neolithic in western Lesser Poland, making use of Bayesian modelling, among other things.

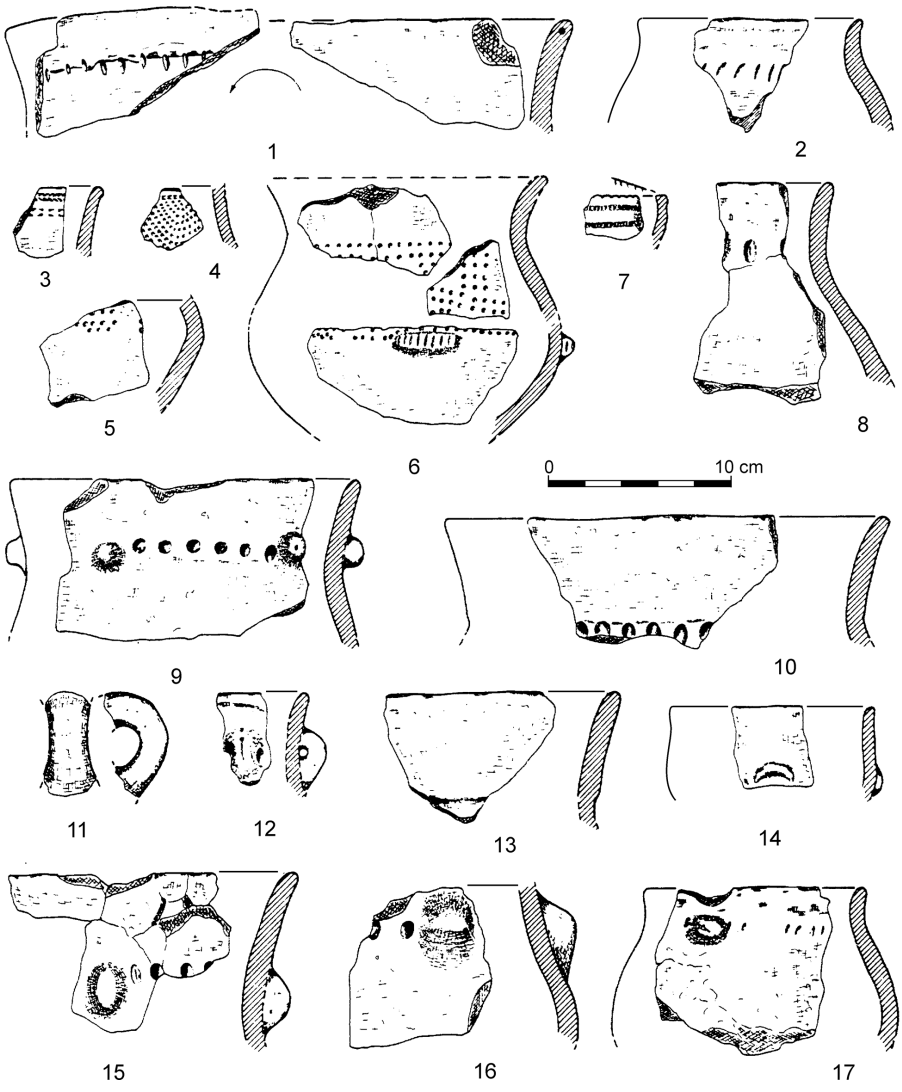



***Fig. 4. Pottery of the earliest Funnel Beaker culture at Bronocice (phase BR I) (from* Kruk, Milisauskas 1990*).***

Descriptions of all the dates used for their credibility are demonstrated in Table 1, available online at http://dx.doi.org/10.4312/dp.44.15. Of course, these dates are very different in this regard. Those obtained by the early 1980s usually have large standard errors and come from not very evident contexts. However, some newer dates do have the same drawbacks. On the other hand, quite a lot of our collection has a high degree of credibility, *i.e.* dates with small standard deviations obtained from bones or short-lived plants from a certain cultural context. Taking all of this into account, it was decided to conduct chronological analysis in three variants. The first is based on all dates; the second is based on dates with standard deviations of less than 100 years which originate from a confirmed context; this group of dates is denoted as group B (see Table 1, available online at http://dx.doi.org/10.4312/dp.44.15). The third variant is based exclusively on dates originating from the same confirmed context, but obtained only on bones and short-lived plants; such dates are labelled as group A (see Table 1, available online at http://dx.doi.org/10.4312/dp.44.15).

## Direct dating

In the case of the Lublin-Volhynian culture in western Lesser Poland, we had until recently only one radiometric date from the Bronocice site (Tab. 1.4, available online at http://dx.doi.org/10.4312/dp.44.15), with a very broad standard deviation of 240 years (*Kruk, Milisauskas 1985*). Fortunately, three other dates (Tab. 1.1–3, available online at http://dx.doi.org/10.4312/dp.44.15) obtained on bones from the same site were published in 2016 (*Kruk* et al. *2016; Milisauskas* et al. *2016*). Overall, all these dates formally cover a time range from *c.* 3950 to 3350 cal BC (Tab. 2; Fig. 10). For three dates of group B and also A, this range is almost the same: *c.* 3950–3380 cal BC.

Similarly, for the Wyciąże-Złotniki group, only one $^{14}$C date had been obtained before 2009, from the site of Złotniki (Tab. 1.15, available online at http://dx.doi.org/10.4312/dp.44.15), of not very high value.[2] This unit could also be associated with a date obtained from the palynological profile at Kraków-Pleszów (Tab. 1.5, available online at http://dx.doi.org/10.4312/dp.44.15) (*Wasylikowa* et al. *1985.53; Godłowska* et al. *1987.137*). However, the number of radiocarbon dates of this group has recently increased due to archaeological investigations on road works (Tab. 1.6–14, available online at http://dx.doi.org/10.4312/dp.44.15). All these dates formally cover a time range from *c.* 4300 to 3500 cal BC (Tab. 2; Fig. 11). The range for six dates included in group B has the same lower limit, while the upper is about 350 years earlier (Tab. 2). No date met group A requirements.

To the Funnel Beaker culture in western Lesser Poland, we can attribute 59 radiocarbon dates (Tab.

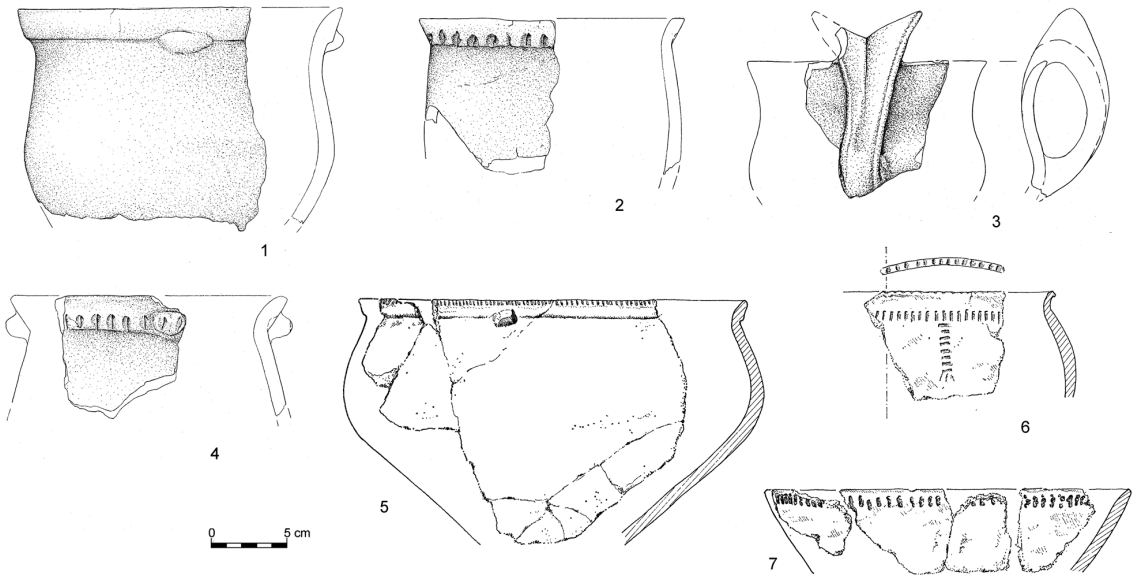



***Fig. 5. Selected pottery of the Funnel Beaker culture: 1–4 Mozgawa (unpublished, drawn by M. Korczyńska); 5–7 Kraków-Prądnik Czerwony (from* Rook, Nowak 1993*).***

2 In addition, this date is, unfortunately, often quoted with an incorrect standard deviation as 4810±120 BP (*e.g., Kozłowski 1989a. 198; Kamieńska, Kozłowski 1990.85; Nowak 2009.137 – mea culpa*). Its actual value is 4810±200 BP (*Crane, Griffin 1970.177*).

1.16–74, available online at http://dx.doi.org/10.4312/dp.44.15). Formally, all of them outline the time span of *c*. 3700–3250 cal BC (Tab. 2; Fig. 12). The dates of groups B and A provided results with upper limit slightly moved down to 3280 and 3270 cal BC, respectively.

At this point, an important issue must be explained. In the case of the site at Bronocice, some of the radiocarbon dates attributed in the literature to the Funnel Beaker culture are from graves. However, identifying the cultures of most of these graves found there is very difficult due to a complete absence of grave goods. For this reason, we cannot be sure whether such graves should be associated with the Funnel Beaker or with Beaker/Baden phases of the settlement. If we compare consecutive publications, we see differences in this classification. There are even differences between the chapters of the same publications (compare, for example, Table 4 on p. 51 and Table 1 on p. 57 in *Milisauskas* et al. *2016*). For this reason, a chronological evaluation of nine graves in which grave goods were not found, including Bayesian modelling (see below for a description) was performed (Tab. 2, Fig. 13). It follows that we are dealing here with three chronological horizons. The first is placed around 3700 cal BC and is represented by grave no. XX. The second is situated between *c*. 3500 and 3350 cal BC and is represented by graves no. XIV and XVIII. Finally, the third horizon is dated to *c*. 3350–2900 cal BC; graves no. VII, VIII, XV, XVI, XXIII and XXIX should be included in it. On the basis of this classification, the last group of graves was added to the Beaker/Baden assemblages, while graves XIV, XVIII and XX were rated as connected with the Funnel Beaker culture. We are aware that this categorisation does not fully accord with the proposals of Kruk and Milisauskas (*Kruk* et al. *2016; Milisauskas* et al. *2016*), especially the transfer of graves VIII and XV to the Beaker/Baden assemblages. Nevertheless, we believe that the presented modelling gives the proposed categorisation a good basis. Accordingly, dates from grave XIV, XVIII and XX were included in the group of all dates of the Funnel Beaker culture, while the remaining dates are from graves with Beaker/Baden assemblages. This arrangement will also be valid in the Bayesian modelling for all dates in other parts of the contribution.

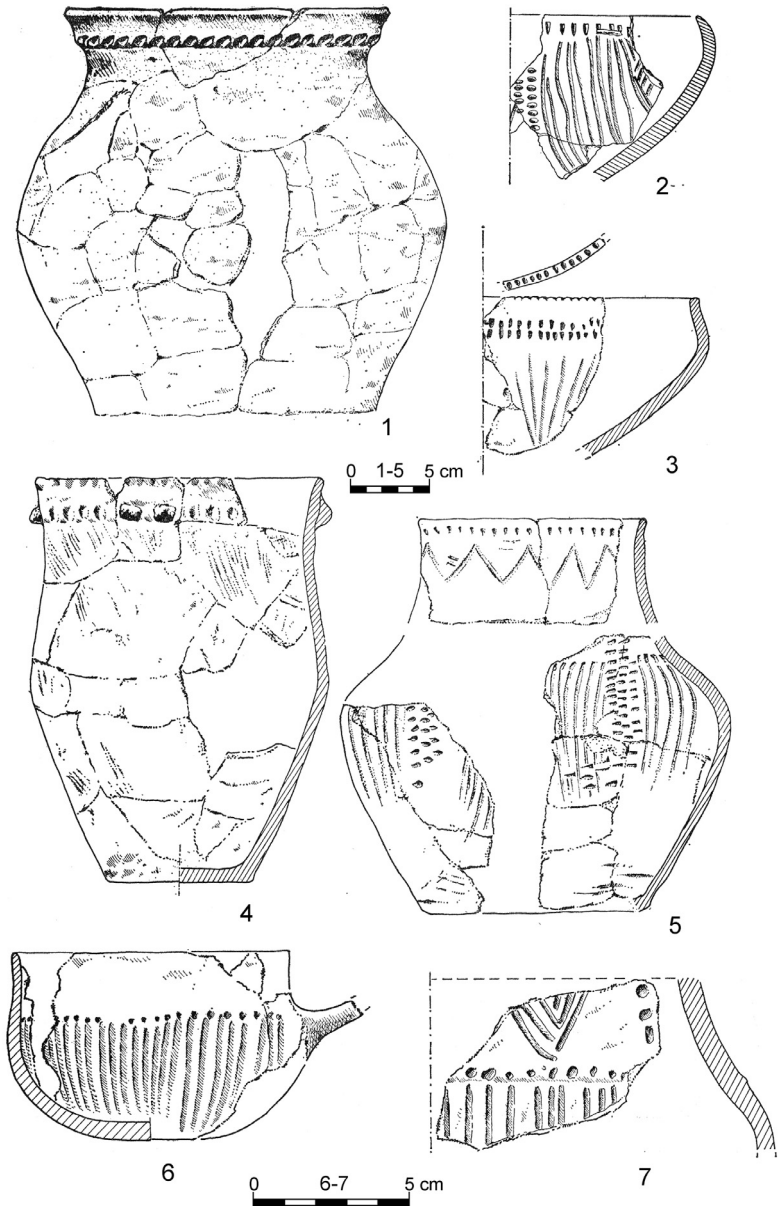



***Fig. 6. Selected pottery of the Funnel Beaker culture (1) and Baden culture (2–7) at Kraków-Prądnik Czerwony (from* Rook, Nowak 1993*).***

On the other hand, all nine dates were excluded from groups B and A, despite the fact that they were obtained from human bones. After all, we have to bear in mind that the above modelling of dates from these nine graves is merely an indirect indication of their cultural context.

Three dates, which can be linked to the Wyciąże/Niedźwiedź materials (Tab. 1.75–77, available online at http://dx.doi.org/10.4312/dp.44.15), indicate the interval of *c.* 3500–3000 cal BC (Tab. 2; Fig. 14); these dates meet the requirements of both group B and A.

Until recently, because of the scarcity of radiocarbon dates one could encounter quite diverse views on the absolute chronology of the Baden culture in western Lesser Poland. However, quite a large number of dates obtained in the past few years (Tab. 1.78–103, available online at http://dx.doi.org/10.4312/dp.44.15) (*Zastawny 2015b*) allow us to set it in a relatively reliable way. The time span formally covered by all 26 dates should be estimated to *c.* 3100–2800 cal BC (Tab. 2; Fig. 15). Interestingly, the same timeframes have been obtained in the case of 24 dates connected to group B and 19 dates classified as group A.

The absolute chronology of the Beaker/Baden assemblages can be analysed first and foremost on the basis of data from one site, Bronocice (Tab. 1.104–127, available online at http://dx.doi.org/10.4312/dp.44.15) (*Kruk, Milisauskas 1990; Kruk* et al. *2016; Milisauskas* et al. *2016*). To this set we should pos-

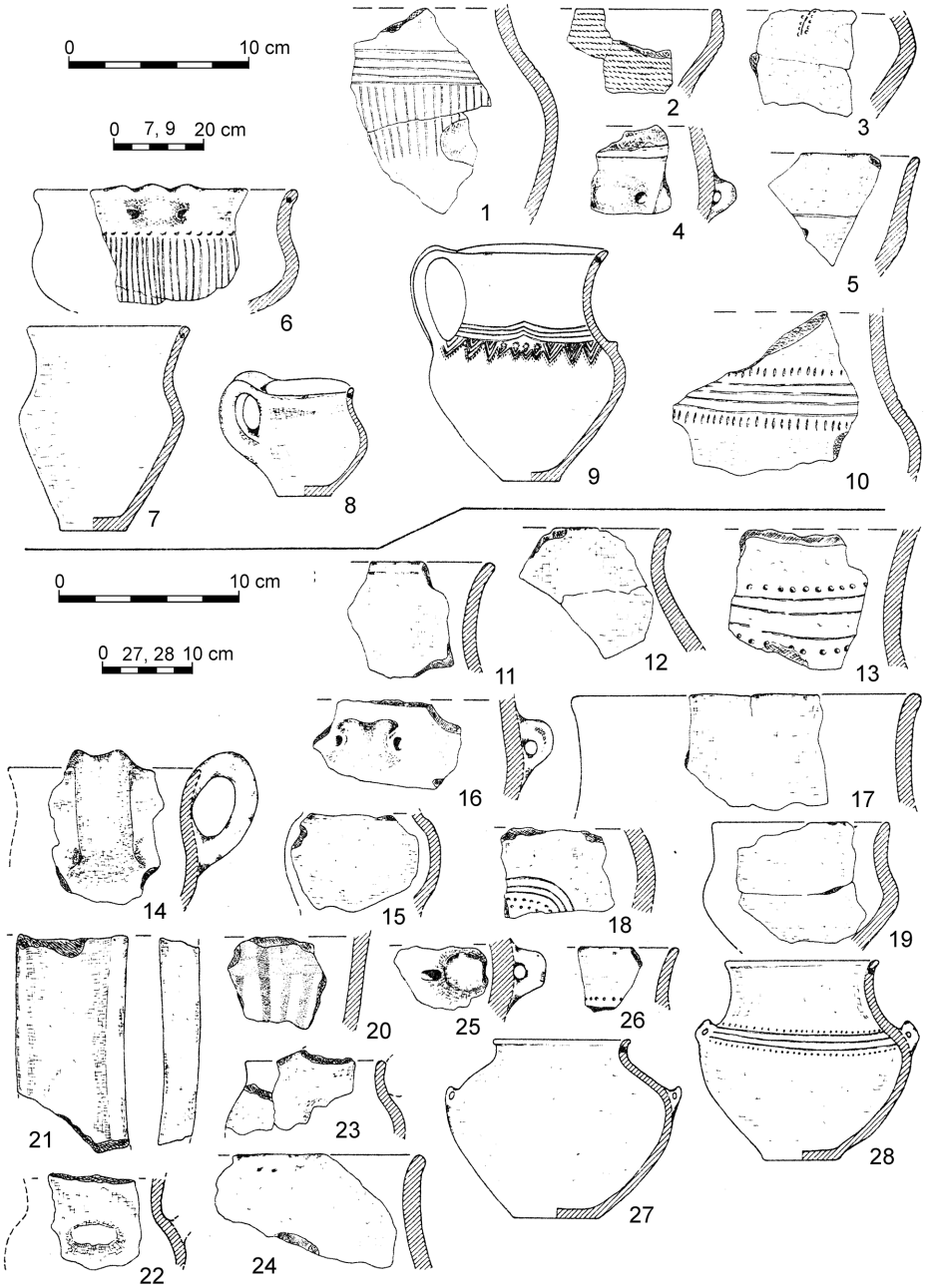



***Fig. 7. Selected pottery of the Beaker/Baden assemblages at Bronocice: 1–10 feature 2-B2; 11–28 feature 1-A5 (from* Kruk, Milisauskas 1990*).***

sibly add two dates from Szarbia, a site located nearby (Tab. 1.128, 129, available online at http://dx.doi.org/10.4312/dp.44.15) (*Włodarczak 2013.379*). Formally, all these 26 dates define a fairly wide interval of *c*. 3350–2650 cal BC (Tab. 2; Fig. 16). On the other hand, the intervals based on dates included in groups B and A are shorter, being *c*. 3350– 2790 cal BC and *c*. 3370–2900 cal BC, respectively. In both cases, the upper limit moved down, by 140 and 250 years.

Regarding the Corded Ware culture, we are interested mainly in dating its origins and early stages as a background to the declining development of the previously discussed units. But to do so, we must use all the dates from this culture. The absolute chronology can be determined on the basis of 24 radiocarbon dates (Tab. 1.130–153, available online at http://dx.doi.org/10.4312/dp.44.15) (*Jarosz, Włodarczak 2007; Tunia, Włodarczak 2002; Włodarczak 2006a*). Formally, all these dates cover the period between *c*. 2700 and 2280 cal BC (Tab. 2; Fig. 17). The timeframes for groups A and B are *c*. 2650–2330 cal BC and 2630–2300 cal BC, respectively.

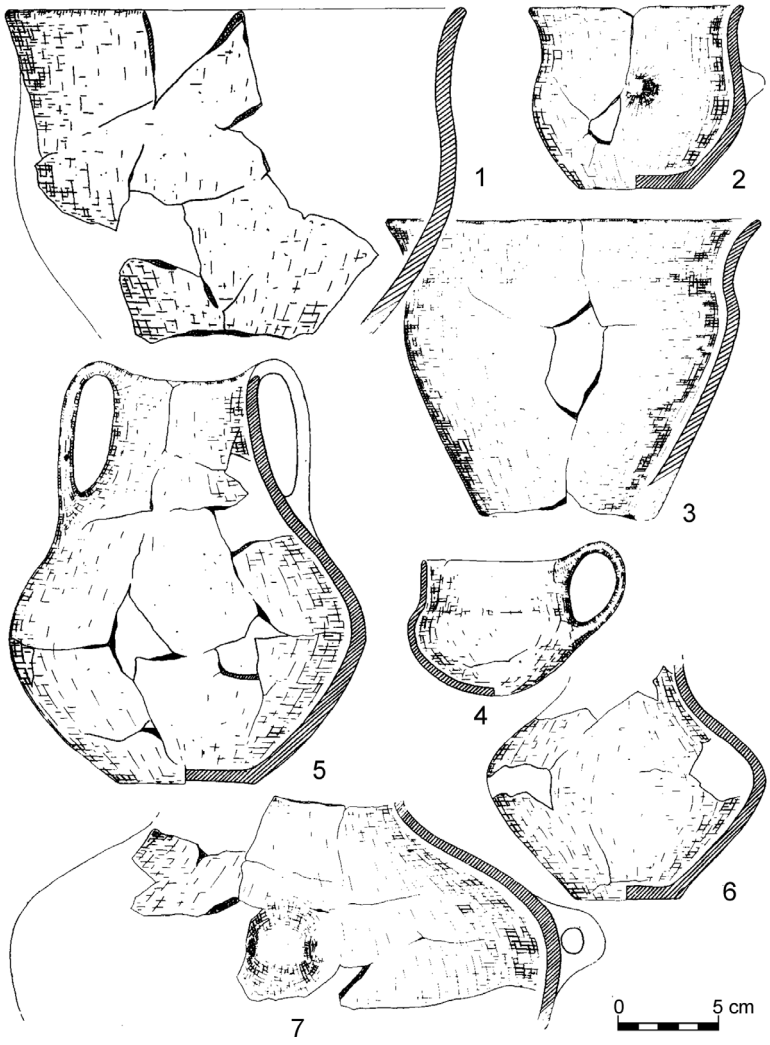



***Fig. 8. Selected pottery of the Wyciąże/Niedźwiedź materials at Niedźwiedź (from* Burchard 1977*).***

By and large, radiocarbon dates, treated directly, with no modelling, support views in light of which local branches of the late Lengyel-Polgár complex, the Funnel Beaker culture and the Baden phenomena overlap chronologically to a great extent. Admittedly, they are not always consistent with views based on individual (the earliest and/or the latest) dates or results from typological premises and stratigraphic observations.

## Separate modelling

In order to determine the most precise chronological frameworks of the discussed archaeological units possible, Bayesian model simulations were performed in which dates obtained for discussed archaeological units (in three groups specified above) were treated as if they constitute one phase (see 'Intrduction'). The chronological data obtained from all of these procedures were analysed and compared. As a result, we decided to discern four kinds of interval based on the properties of generated boundaries (Tab. 2): i) as the interval based on median values; ii) as the widest possible interval, based on extreme points of the 95.4% ranges; iii) as the 'probable'[3] interval, based on extreme points of the 68.2% ranges; and iv) as the narrowest possible interval, based on the end point of the 95.4% start boundary and the start point of the 95.4% end boundary. However, the last version may be impossible to calculate.

3 After, for example, *Krus* et al. *2015.971*, who use this term for 68.2% probability – "*Activity associated with Group 1 on the site is estimated to have ended in calAD 1295–1465 (95% probability; Figure 6; End: SunWatch: Group 1), and probably in calAD 1305–1405 (68% probability)*".

The model for the Lublin-Volhynian culture based on four dates from Bronocice is statistically significant, as are all the individual dates (Fig. 10), but gives a very broad time range (Tab. 2). At maximum span it gives 4460–2760 cal BC. 'Probable' values are 4000 and 3290 cal BC, whereas the 'median' interval is 3890–3400 cal BC. The shortest version of the chronology amounts to only 20 years, *i.e.* 3650–3630 cal BC. Somewhat surprising is the fact that the intervals for three dates of group A and – simultaneously – B turned out to be even longer by several dozen years.

Modelling of the 11 dates of the Wyciąże-Złotniki group also proved to be statistically significant, as did all the particular dates (Fig. 11). Again, this modelling allows us to accept a very large time interval, maximally 4530–3300 cal BC, and in the 'probable' version 4400–3480 cal BC. The narrowest version is demarcated by 4120 and 3640 cal BC, and the 'median' by 4310 and 3530 cal BC (Tab. 2). The above values obtained from direct dating are similar to the 'median' ones. The modelling of group B dates gives intervals shorter by several dozen to two hundred years. The upper limit moves down fairly significantly, to 3690/3940 cal BC, except the widest interval value.

Modelling of 59 dates of the Funnel Beaker culture (Fig. 12) gives the time interval of 3730–3230 cal BC, in the longest version, and the 'probable' interval of 3700–3270 cal BC. The shortest version is 3650–3330 cal BC, and the 'median' version is 3680–3290 cal BC (Tab. 2). None of the intervals differ significantly from direct dating. The model for the TRB is statistically significant, but the level of agreement drops below 60% in the case of the two earliest dates from Bronocice and the latest date from Mozgawa (Fig. 12). As a comment on this observation we quote a sentence from the classic paper by Christopher Bronk Ramsey (*2009b.1025*): *"[...] secondly, an overall agreement index is calculated $A_{model}$ and if this is above 60% it probably indicates that there is no problem with the model as a whole (and therefore no samples need be rejected)*".

The chronological limits modelled on 47 dates of group B do not indicate major differences; they

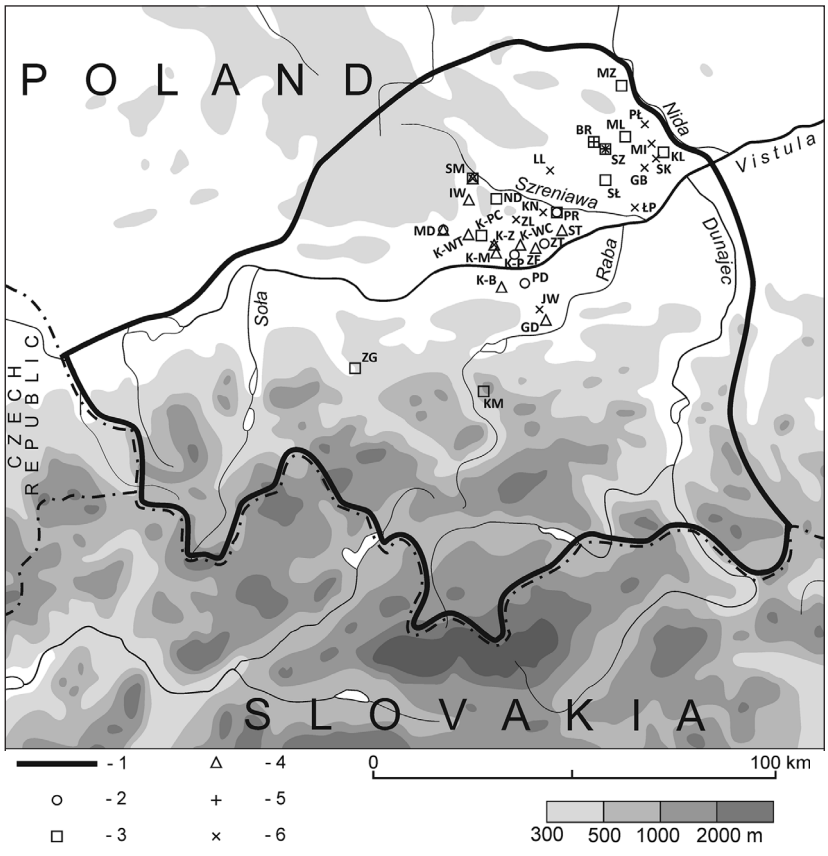



***Fig. 9. Archaeological sites with $^{14}C$ dates used in the paper: 1 borders of the area discussed in the paper; 2 sites of the Wyciąże-Złotniki group and Lublin-Volhynian culture (only Bronocice); 3 sites of the Funnel Beaker culture; 4 sites of the Baden culture and Wyciąże/Niedźwiedź materials (only Kraków-Wyciąże and Smroków); 5 sites of the Beaker/Baden assemblages; 6 sites of the Corded Ware culture; BR Bronocice, GB Gabułtów, GD Gdów, IW Iwanowice, JW Jawczyce, KM Kamiennik, KL Kolosy, KN Koniusza, K-B Kraków-Bieżanów, K-M Kraków-Mogiła 55, K-P Kraków-Pleszów 17: settlement and palinological profile, K-PC Kraków-Prądnik Czerwony, K-WT Kraków-Witkowice, K-WC Kraków-Wyciąże 5, K-Z Kraków-Zesławice 21 and 22, LL Lelowice, ŁP Łapszów, ML Malżyce 30 and 31, MI Miernów, MD Modlnica 1 and 5, MZ Mozgawa, ND Niedźwiedź, PŁ Pełczyska, PD Podłęże, PR Proszowice, SK Sokolina, SŁ Słonowice, SM Smroków, ST Stręgoborzyce, SZ Szarbia, ZG Zagórze, ZL Zielona, ZT Złotniki, ZF Zofipole (for references see Table 1, available online at http://dx.doi.org/10.4312/dp.44.15).***

| Archaeological units; categories of $^{14}$C dates (their amounts); agreement indices($A_{overall}$ and $A_{model}$) | Sum[1] | Interval based on medians | The widest interval | The 'probable' interval | The narrowest interval |
|---|---|---|---|---|---|
| Lublin-Volhynian culture; all dates (4); 101.6%, 100.3% | *c.* 3950–3350 | 3890–3400 | 4460–2760 | 4000–3290 | 3650–3630 |
| Lublin-Volhynian culture; dates of group B = dates of group A[2] (3); 97.6%, 97.4% | *c.* 3950–3380 | 3930–3390 | 4670–2590 | 4070–3260 | 3660–3630 |
| Wyciąże-Złotniki group; all dates (11); 98.5%, 99.5% | *c.* 4300–3500 | 4310–3530 | 4530–3300 | 4400–3480 | 4120–3640 |
| Wyciąże-Złotniki group; dates of group B (6); 88.3%, 88.0% | *c.* 4300–3850 | 4290–3770 | 4600–3460 | 4380–3690 | 4070–3940 |
| Funnel Beaker culture; all dates (59) 76.2%, 74.2% | *c.* 3700–3250 | 3680–3290 | 3730–3230 | 3700–3270 | 3650–3330 |
| Funnel Beaker culture; dates of group B (47); 80.9%, 70.7% | *c.* 3700–3280 | 3680–3280 | 3720–3200 | 3690–3260 | 3640–3330 |
| Funnel Beaker culture; dates of group A (34); 79.6%, 79.6% | *c.* 3700–3270 | 3680–3290 | 3750–3210 | 3700–3260 | 3650–3340 |
| Funnel Beaker culture; Bronocice graves (9); 91.8%, 92.0% | *c.* 3900–3650 and *c.* 3520–2850 | 3800–2870 | 4090–2580 | 3880–2790 | 3650–3080 |
| Wyciąże/Niedźwiedź materials; all dates = dates of group B = dates of group A (3);104.2%, 104.1% | *c.* 3500–3000 | 3330–3130 | 3810–2700 | 3410–3030 | – |
| Baden culture; all dates (26) 74.6%, 76.7% | *c.* 3100–2800 | 3070–2830 | 3130–2780 | 3100–2810 | 2990–2870 |
| Baden culture; dates of group B (24); 72.9%, 70.8% | *c.* 3100–2800 | 3070–2830 | 3140–2780 | 3110–2810 | 2990–2870 |
| Baden culture; dates of group A (19) 67.6%, 67.2% | *c.* 3100–2800 | 3060–2820 | 3130–2770 | 3100–2800 | 2980–2870 |
| Funnel Beaker/Baden assemblages; all dates (26); 104.5%, 104.0% | *c.* 3350–2650 | 3280–2770 | 3400–2610 | 3360–2720 | 3150–2870 |
| Funnel Beaker/Baden assemblages; dates of group B (15); 106.6%, 106.7% | *c.* 3350–2790 | 3250–2790 | 3420–2610 | 3320–2730 | 3120–2880 |
| Funnel Beaker/Baden assemblages; dates of group A (6); 66.2%, 67.2% | *c.* 3370–2900 | 3310–3030 | 3560–2630 | 3390–2850 | – |
| Corded Ware culture; all dates (24); 64.7%, 63.6% | *c.* 2700–2280 | 2670–2330 | 2800–2240 | 2720–2280 | 2580–2420 |
| Corded Ware culture; dates of group B (21); 99.9%, 98.0% | *c.* 2650–2330 | 2630–2330 | 2710–2260 | 2660–2290 | 2580–2420 |
| Corded Ware culture; dates of the A group (20); 84.4%, 81.3% | *c.* 2630–2300 | 2550–2360 | 2670–2270 | 2620–2310 | 2470–2460 |

1 Sum-calibrated intervals were delineated through excluding onset and tail sections of the very low probability density.
2 For characteristics of groups B and A and dates assigned to them see Table 1, available at http://dx.doi.org/10.4312/dp.44.15.

***Tab. 2. Results of direct dating (sums) and of separate modelling of $^{14}$C dates of the Middle and Late Neolithic units in western Lesser Poland (cal BC; rounded by 10 years).***

amount to no more than 30 years. The same applies to group A (34 dates); in this case, the time differences do not exceed 20 years. Apart from the earliest date from Bronocice, which does not comply with the requirements of groups A or B, the same other two dates have agreement indices below 60%. In all versions, the differences from the sum-calibrated intervals are low; only in the case of the narrowest interval do they increase to 60/80 years.

Although we have only three dates which can be connected with the Wyciąże/Niedźwiedź materials, the agreement indexes of modelling are above 60% (Fig. 14). The widest time interval is 3810–2700 cal BC;

the 'probable' interval is 3410–3030 cal BC and the 'median' is based on 3330–3130 cal BC. The narrowest version cannot be calculated (Tab. 2). As may be recalled, these three dates fit groups A and B.

As a result of modelling (Fig. 15), the time span covered by the 26 dates from the Baden culture is consistent and relatively short (only one, the latest date, does not fit the model). It is delimited at 3130 cal BC and 2780 cal BC in the widest version, at 3100 and 2810 cal BC in the 'probable' version, at 2990–2870 cal BC in the narrowest version, and at 3070–2830 cal BC in the 'median' version. The values of direct dating are almost literally consistent with the 'probable' version (Tab. 2). The same can be said of the timeframes modelled on dates belonging to groups A and B; the differences amount to 10 years.

As we already know, the absolute chronology of the Beaker/Baden assemblages can be analysed on the basis of 24 dates from Bronocice and 2 dates from the nearby site of Szarbia. The model for all dates is characterised by high levels of significance (Tab. 2; Fig. 16). All these dates define the widest interval as 3400–2610 cal BC. The 'probable' interval covers 3360–2720 cal BC (and this is almost exactly the same interval as that resulting from direct dating), whereas the narrowest one is 3150–2870 cal BC, and the 'median' one 3280–2770 cal BC (Tab. 2). Some values in the model based on 15 group B dates differ by no more than 40 years. On the other hand, the model generated by 6 dates in group A yields larger differences. Moreover, the values of the 'median' (3310–3030 cal BC) and 'probable' (3390–2850 cal BC) intervals are generally older.

The possible dates of the beginning of the Corded Ware culture resulting from statistically significant modelling of all dates are: 2800, 2720, 2580 and 2670 cal BC (Tab. 2; Fig. 17). The corresponding values for groups B and A are clearly younger. They are respectively: 2710/2670, 2660/2620, 2580/2470 and 2630/2550 cal BC.

Our analyses give rise to the two basic interpretations of an extreme character (Fig. 18).

Firstly, we can accept the whole time or most of the time generated by the modelling procedures. In this case, all archaeological units more or less formally mesh together in time.

Secondly, we can take into account only the short segments of chronological range and reject the remaining parts of these ranges. In this case, the archaeological units would have been arranged roughly into two groups (consisting of contemporary units), and two single units. These four groupings would be ordered linearly, but there would be even breaks in the continuity of cultural development. This scenario goes to some extent back to the linear (traditional) vision of the development of archaeological units.

One group would consist of the Lublin-Volhynian culture, the Wyciąże-Złotniki group and Funnel Beaker culture. The Wyciąże-Złotniki group would perhaps appear earlier, around 4100 BC, while the Lublin-Volhynian culture would appear around 3700 cal BC. These two units would disappear around 3600 cal BC. The Funnel Beaker culture would appear at *c.* 3700/3650 cal BC, so it would (partly) overlap with former units in the 37th century BC. This culture would vanish around 3300/3250 cal BC.

Another group would comprise the Baden culture and Beaker/Baden assemblages, and would be generally dated to the 31st, 30th and part of the 29th cen-

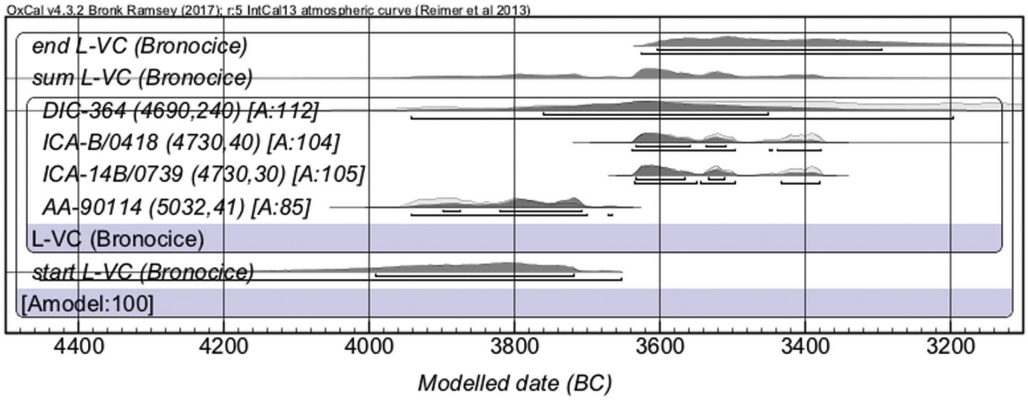



***Fig. 10. Radiocarbon chronology (cal BC) of the Lublin-Volhynian culture (L-VC). The OxCal 4.3.2 package was used for all calibrations and models (*Bronk Ramsey 2009a; online; Reimer *et al.* 2013*).***

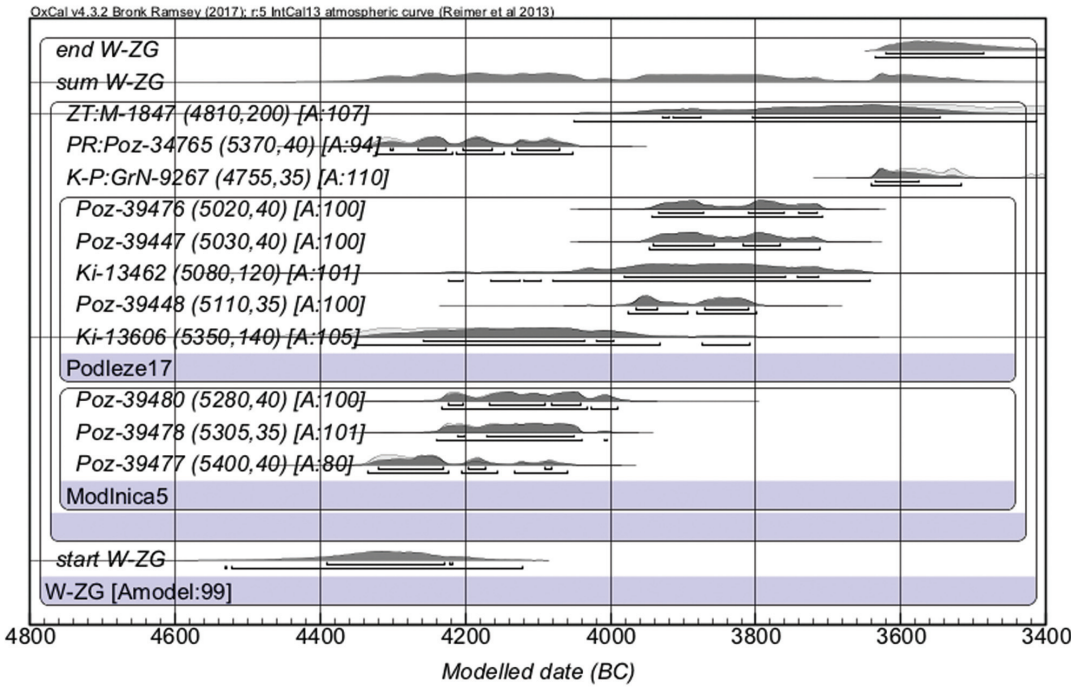



***Fig. 11. Radiocarbon chronology (cal BC) of the Wyciąże-Złotniki group (W-ZG); K-P Kraków-Pleszów, palynological profile, PR Proszowice, ZT Złotniki.***

turies BC, with possible earlier start of the latter unit (*c.* 3250 cal BC).

The Wyciąże/Niedźwiedź materials would be dated to *c.* 3350–3100 cal BC, which would fill the potential gap between the Funnel Beaker and the Baden cultures in the Kraków region in the late 33rd and in the 32nd centuries BC. A hiatus could also be postulated between the second group and the Corded Ware culture, around 2800–2650/2600 cal BC.

## Combined modelling

In our next step, Bayesian models based on 153, 119 (group B) and 85 (group A) dates, were constructed using several relationships resulted from typological data, stratigraphic observations and general knowledge about Neolithic development in east-central Europe (priors). Holistic modelling is justified, because the archaeological units under considerations can depend on each other, both chronologically and territorially. Such dependencies do not appear in the separate modelling. In this arrangement, "*results must be seen as dependent on the assumptions built into the chronological framework*" (*Bronk Ramsey 2009b.348*).

The aforementioned relationships are as follows:

Firstly, some stratigraphic observations on a few sites indicate that Lengyel-Polgár units had to be at least partially coeval with, or even later than, the early stages of the Funnel Beaker culture (*Kaczanowska 1976; Kruk, Milisauskas 1985*). These observations, however, do not refer to radiocarbon dated features. Stratigraphic dependencies in Bronocice demonstrate that the earliest phase of the local Funnel Beaker culture (phase BR I) had to be older than the local Lublin-Volhynian culture (*Kruk, Milisauskas 1985*). Alas, this rule can be utilised only in modelling based on all dates, because the only date of the BR I phase does not meet the requirements of groups B and A. To be clear, there are also situations of an opposite kind in Bronocice, *i.e.* some Lublin-Volhynian features are older than Funnel Beaker features belonging only to phases BR II or BR III.

Secondly, a comparison of general chronologies of the Funnel Beaker culture and Baden culture (*Nowak 2009; Zastawny 2015a*) suggests that the relationship between them is non-linear and assumes parallelism in the second half of the 4th millennium BC.

Thirdly, in case of the beginnings of the Funnel Beaker culture, we decided to replace 'boundary' with 'sigma boundary'. This was done primarily so as to include the possible pattern of the local development of this unit, *i.e.* its quantitatively modest and conspicuously early beginnings (*Nowak 2009*).

Fourthly, some stratigraphic relations in Bronocice (see Table 1, available online at http://dx.doi.org/

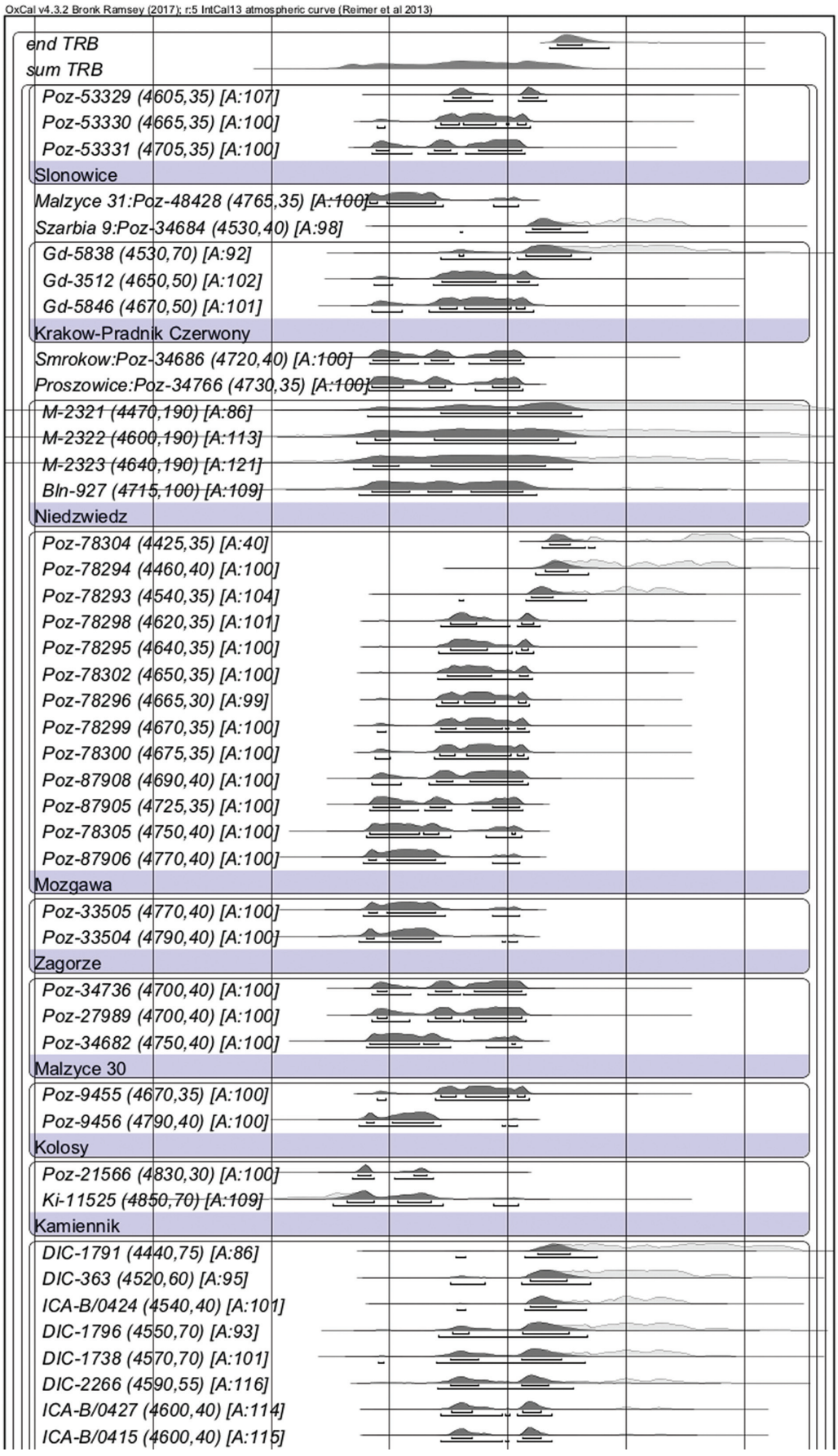



***Fig. 12. Radiocarbon chronology (cal BC) of the Funnel Beaker culture (TRB).***

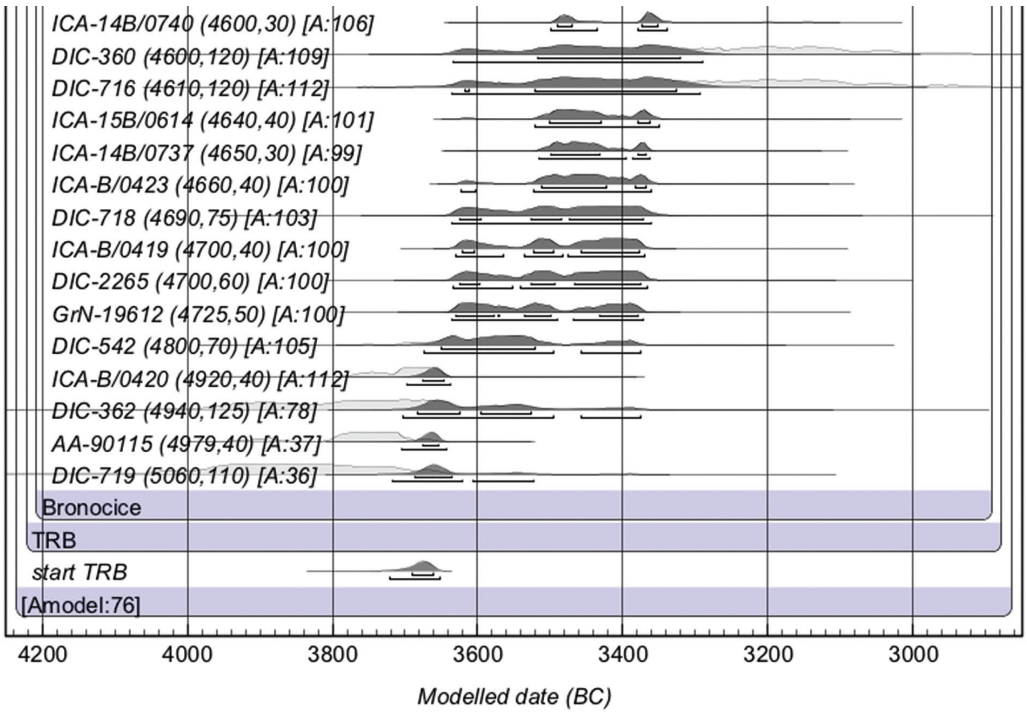



***Fig. 12. Continue ...***

10.4312/dp.44.15) demonstrate younger chronology of the Beaker/Baden assemblages when compared to the Funnel Beaker culture, as well as their typological continuity. The typological data also suggest close continuity between the Wyciąże-Złotniki group and Wyciąże/Niedźwiedź materials. Hence, a 'transitional boundary' was used in these positions.

Fifthly, no elements within the materials of the Corded Ware culture in western Lesser Poland can be derived from other units (*Włodarczak 2008b; 2011*). Consequently, we believe that this culture quite radically closed the earlier development and, therefore, is radically separated from earlier units.

In all models constructed under these assumptions, both indexes of agreement are over the threshold value of 60% (Tab. 3; Fig. 19). Three dates 'drop' below 60% in the case of the 'all dates model' and 'group B model'; in the case of the 'group A model' there are five such dates. Therefore, we can easily take these models as a basis for further analyses and interpretations. Their results have been presented in the same way as for separate modelling (Tab. 3).

For the Lublin-Volhynian culture, we obtained 3990–3100 cal BC in the widest version. The 'probable' values are 3870 and 3360 cal BC, whereas the 'median' ones are 3810 and 3470 cal BC. The narrowest interval covers only 3690–3630 BC. These values are shorter than those obtained in separate modelling, except for the narrowest one. In the modelling of group B, as expected, the origins are earlier, even by over 300 years for the widest interval. By contrast, in group A, the results are virtually identical to the modelling for all dates; differences do not exceed 30 years.

As for the Wyciąże-Złotniki group, modelling for all dates allows us to accept a very large time interval, the maximal version being 4460–3270 BC, and the 'probable' version 4370–3340 cal BC. The dates of 4110 and 3630 BC make the narrowest interval, and 4290 and 3440 cal BC the 'median' one. Modelling for the dates of group B gives similar values (a difference of no more than 50 years), except the narrowest interval, which ends 270 years earlier. There are some differences with separate modelling of several dozens or over one hundred years. Interestingly, the intervals generated in combined modelling are usually not shorter.

Regarding the Funnel Beaker culture, its earliest phase in Bronocice can be placed at the turn of the 5th and 4th millennia BC, or in the first quarter of the 4th millennium BC, as modelled on the basis of one date from the Bronocice phase BR I. Unfortunately, this is the only date of this phase, and is of relatively low reliability.

The other values for the Funnel Beaker culture are very similar in all three models. The widest intervals

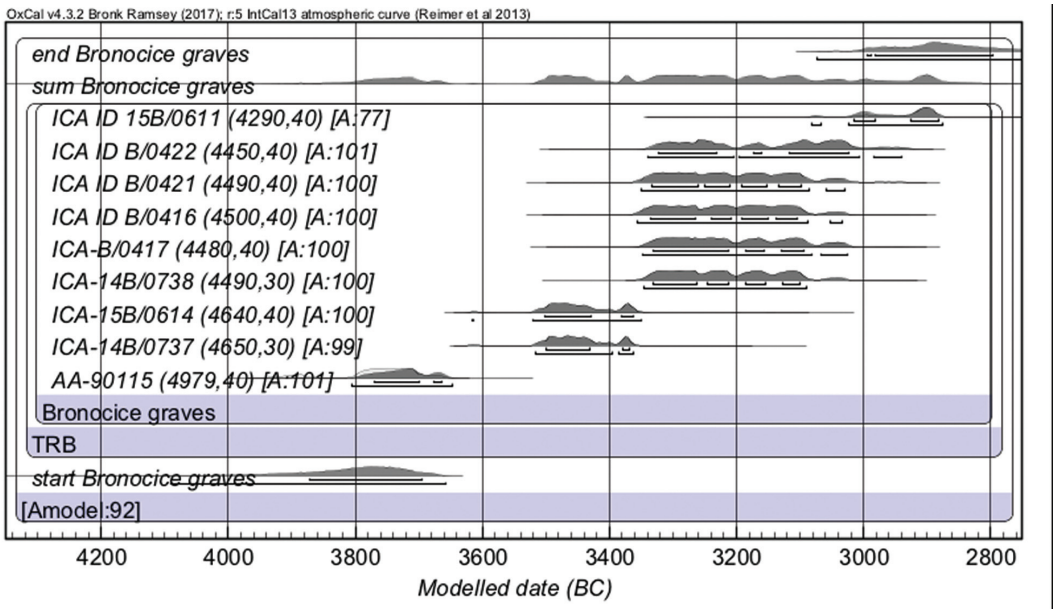



***Fig. 13. Radiocarbon chronology (cal BC) of graves without grave goods at Bronocice.***

covers the period of *c*. 3550/3530–3280/3270 cal BC, the 'probable' intervals 3510/3500–3300/3290 cal BC, the narrowest intervals 3490/3430–3340, and the 'median' intervals 3490/3480–3310 cal BC. Overall, consequently, the Funnel Beaker culture ends several decades earlier than in previous models, except the narrowest interval.

The values of the beginning of the Funnel Beaker culture should be calculated in a slightly different way due to the other type of distribution used, as we already know. In the 'sigma boundary'/'boundary' distribution start dating, *c*. 3500 cal BC should be considered as the beginning of more intensive development.

We have to bear in mind that the agreement indexes of the two earliest dates of the Funnel Beaker culture (DIC-719, AA-90115, see Table 1.16–17) in separate modelling (Fig. 12) were lower than 60%. A situation of this kind can be interpreted in two ways. Either these dates are typical deviations from the norm, appearing in numerous datasets due to the laws of statistics, or they reflect the earliest episode of the presence of a given phenomenon that was isolated in time in relation to the main, continued development. Since the whole model was statistically significant, we could in theory believe that the first alternative is more likely. Regardless, a date DIC-719, approach of this kind can also be defended for another reason. It has been proposed that in the pottery from feature 5-B6 at Bronocice (with the above-mentioned date) elements of the Lengyel-Polgár complex are visible (*Kruk, Milisauskas 1983. 267, 282*). If this is the case, it is possible even to accept the idea that the date should not be bound to the TRB at all.

On the other hand, in the combined modelling, the agreement indexes of these two dates were higher than 60%, so we can say that the pattern of quantitatively modest and conspicuously early beginnings was tested successfully. Therefore, it should be recognised that dates earlier than 4900 cal BP in posteriori version are close to reality (Fig. 20). In this case, the first Funnel Beaker culture occupation probably began around 3750 cal BC, due to the uncertainty of the date DIC-719.

The widest time interval for the Wyciąże/Niedźwiedź materials is 3630–2860 cal BC, the 'probable' interval is 3570–3040 cal BC, and the 'median' based interval gives 3440–3140 cal BC. It is not possible to calculate the narrowest interval. There are no bigger differences in the case of the group A modelling, whereas the start is placed 200/300 years earlier in the group B modelling. Differences appear with separate modelling, which are particularly visible in the group B modelling (over 100 years).

The Baden culture turned out to be delimited similarly in all models. We obtained 3130–2790/2780 cal BC in the widest versions, 3110/3100–2810 cal BC in 'probable' versions, 3000/2980–2870 cal BC in the narrowest versions, and 3070/3060–2830 cal BC in 'median' versions. The differences between separate models are negligible.

The models for the Beaker/Baden assemblages give the widest intervals, of 3340–2770/2690 cal BC, the 'probable' interval of 3330–2850/2750 cal BC, and the narrowest of 3280/3270–2880/2870 cal BC (for all dates and group B). The 'median' interval covers a period of 3310–3030/2790 cal BC, *i.e.* there is a significant difference as to the upper limit. We observe differences with separate modelling up to over one hundred years.

The possible dates of the beginning of Corded Ware culture are: 2740/2670, 2700/2620, 2590/2500 and 2660/2570 cal BC (Tab. 2). Except the values for the widest interval and all dates (2800 cal BC), they are quite similar to those modelled separately.

A summary of this modelling again gives rise to two basic interpretations of the type analogous to the separate modelling (Fig. 21).

Firstly, we can accept the whole period or most of the period generated by modelling procedures. In this case, archaeological units mesh together in time to a greater or lesser extent, but generally two concentrations of coeval units can be noticed. The Wyciąże-Złotniki group would appear at *c*. 4400 cal BC, and would coexist with the Lublin-Volhynian culture from *c*. 4300/4000 BC to *c*. 3250 cal BC. The latter unit would exist longer, until the 31st century BC. The Funnel Beaker culture would appear to a small extent between 4350 and 4100 cal BC, but would develop substantially from *c*. 3750 to 3250 cal BC. In the period *c*. 3900/3800–3250 cal BC we could postulate the co-existence of even four units, because Wyciąże/Niedźwiedź materials would join the remaining ones. The latter unit would exist until *c*. 2900/2800 cal BC.

At around 3350/3300 cal BC, the Beaker/Baden assemblages would appear, *i.e.* it would briefly coexist with the Funnel Beaker culture and Wyciąże-Złotniki group (approx. 100 years) and – for a longer time – with the Lublin-Volhynian culture and Wyciąże/Niedźwiedź materials. On the other hand, from *c*. 3150/3100 to 2800/2750 cal BC, Beaker/Baden assemblages would develop simultaneously with the Baden culture. The overlapping of the Beaker/Baden assemblages and Corded Ware culture would be limited only to the second half of the 28th century BC, but it could not have happened at all. If we accepted the long duration of the Lublin-Volhynian culture and Wyciąże/Niedźwiedź materials, to 3100/3000 and 2850 cal BC respectively, both these units would partially overlap with the Baden culture and Beaker/Baden assemblages.

Secondly, we could again take into account only short segments, 'hard cores', as it were, situated within the widest intervals, and reject their remaining parts. In such a case, archaeological units would be separated more distinctly than in the previous interpretation, and be arranged roughly into four groups consisting mostly of partly contemporary units. These four groupings would be arranged linearly, but there would be even breaks in the continuity of cultural development.

One group would consist of the Wyciąże-Złotniki group and Lublin-Volhynian culture. The former would appear at about 4200/4100 cal BC, and the latter only in the 38th century BC. The end of both units should be placed at *c*. 3550 cal BC.

The Funnel Beaker culture would come into existence at *c*. 3750 cal BC, it would exist simultaneously with previous units for no more than 200 years. The fundamental development of this culture would start at *c*. 3500 cal BC and would last until *c*. 3300 cal BC. Because there is only one $^{14}$C date connected with phase BR I, the question of pos-

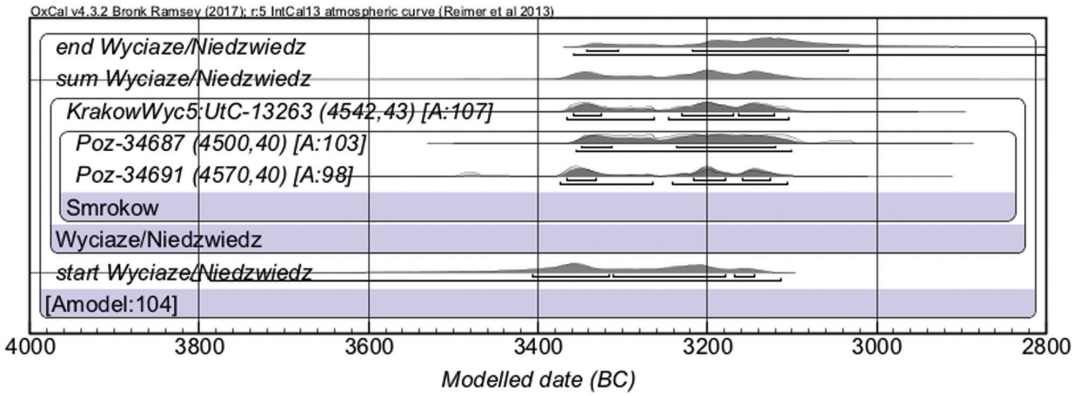



***Fig. 14. Radiocarbon chronology (cal BC) of the Wyciąże/Niedźwiedź materials.***

sible the earlier appearance of the Funnel Beaker culture should be considered as rather doubtful, because stratigraphic anteriority to the Lublin-Volhynian culture could mean nothing more than anteriority to the end of this culture, *c*. 3600/3550 cal BC.

The third group would comprise the Beaker/Baden assemblages and Baden culture, and would be dated to *c*. 3300–2850/2800 cal BC and *c*. 3050–2850 cal BC, respectively. The Wyciąże/Niedźwiedź materials would be placed between 3400 and 3150 cal BC, or rather somewhere within these borders.

A hiatus could be postulated between the Beaker/Baden assemblages and Baden culture on the one hand, and the fourth group, *i.e.* the Corded Ware culture, on the other, *c*. 2800–2650/2600 cal BC.

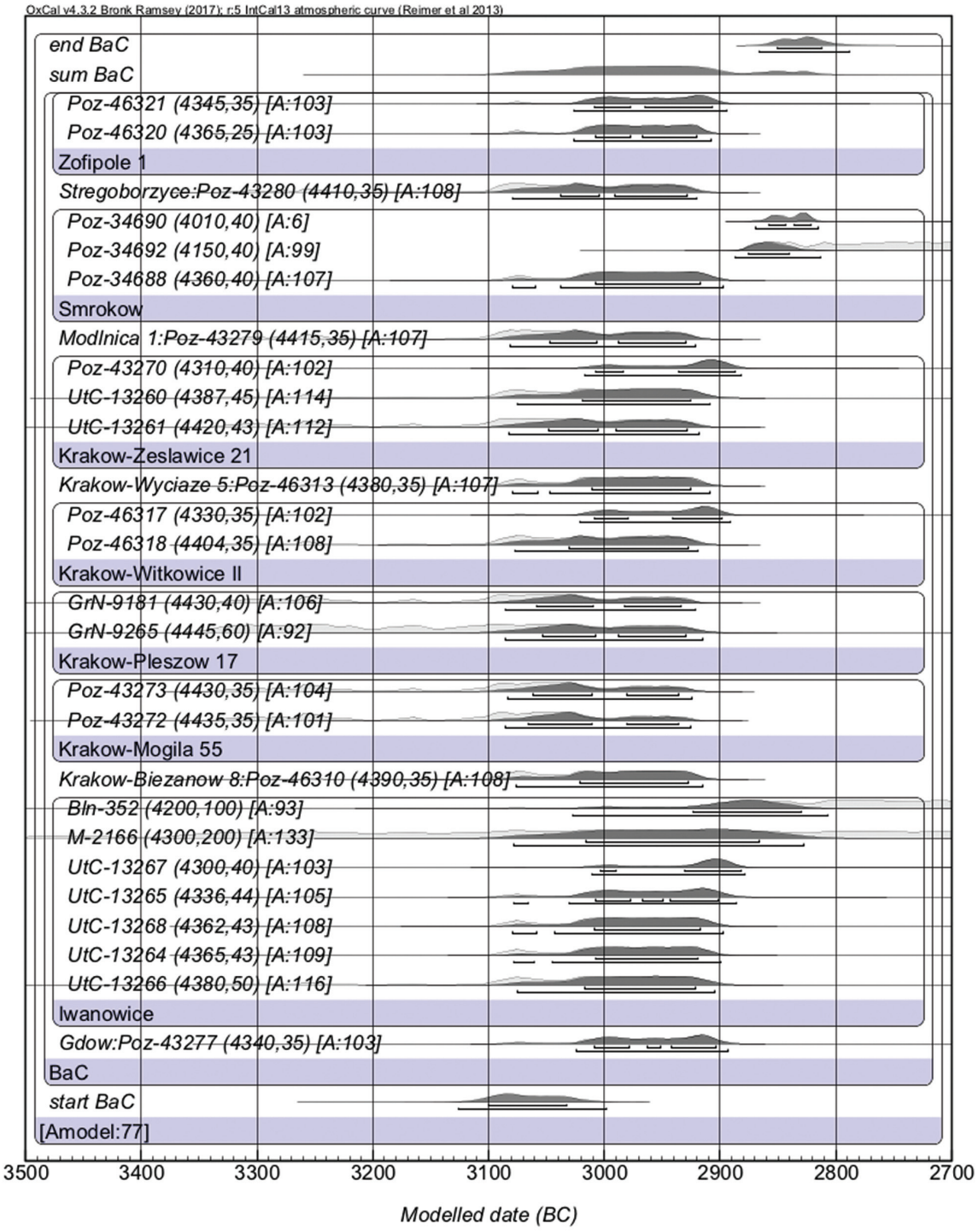



***Fig. 15. Radiocarbon chronology (cal BC) of the Baden culture (BaC).***

## Discussion

While assessing which of the alternative chronological scenarios may be more akin to past reality, we should first highlight some observations and premises.

Firstly, it is very easy to notice that we are dealing with very broad chronological ranges only in the cases of those units which still have a relatively low number of dates (Lublin-Volhynian culture, Wyciąże-Złotniki group, Wyciąże/Niedźwiedź materials). On the other hand, the Funnel Beaker culture, Baden culture, Beaker/Baden assemblages and Corded Ware culture, where this is not the case, give much shorter, compact ranges. In these cultures, a good compromise seems to be values close to the 'probable' and median ones.

Secondly, it is worth noting that, while we are handling large datasets (in our case: radiocarbon dates) extreme values will almost always occur for various reasons (see Introduction). Certainly, Bayesian modelling considerably reduces this, but we cannot be sure that it does so completely.

Thirdly, we must remember that the above summaries of the direct dating, separate modelling and combined modelling are of a generalised and extreme nature. In fact, in every single case, we should take into account the specificity of local conditions. Consequently, one can also imagine some combinations of these two extremes. Thus, some units and phenomena would be limited only to 'hard cores' indeed, but some would not. In other words, in some cases, a discrete mode of cultural transformation should be

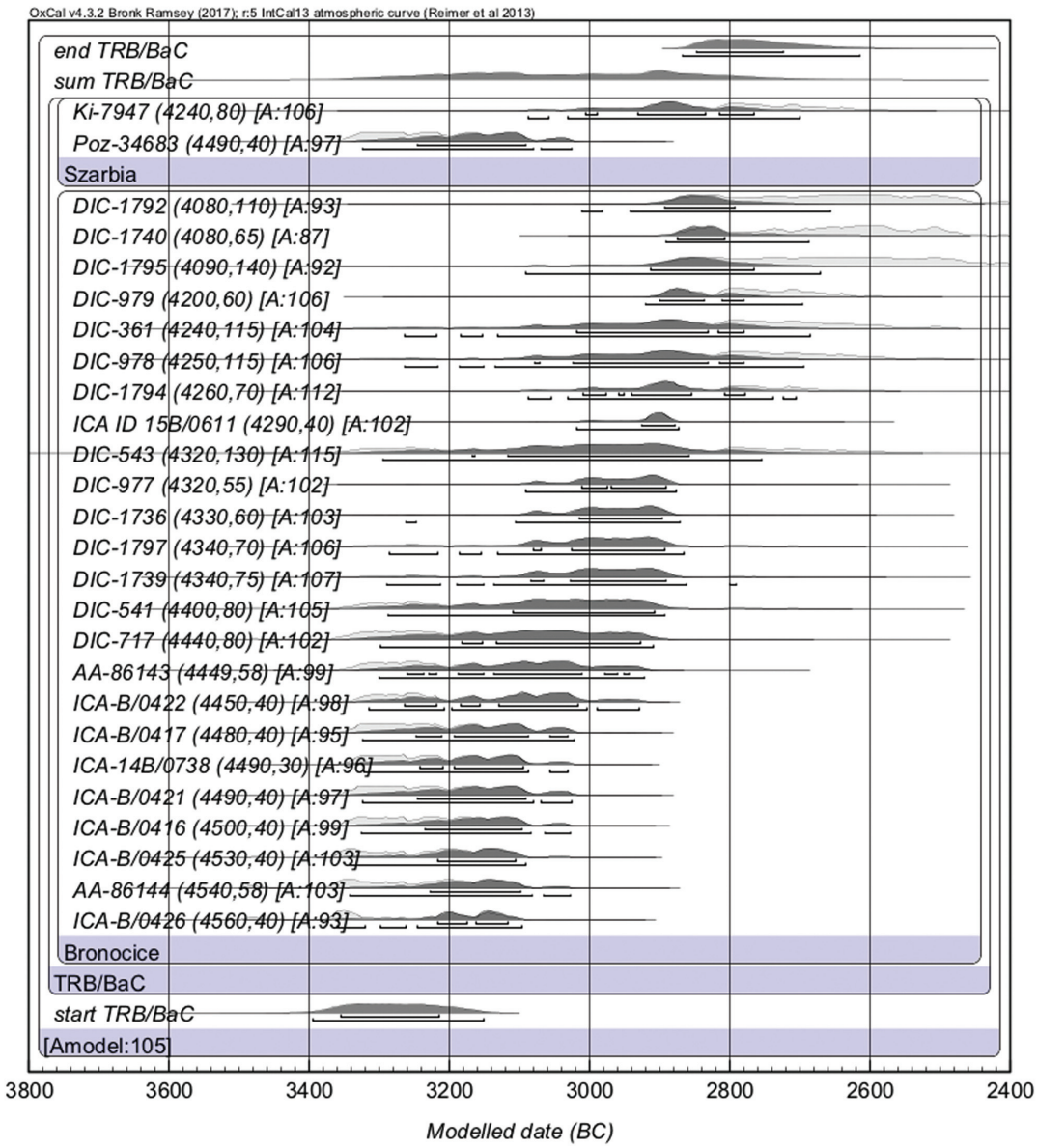



***Fig. 16. Radiocarbon chronology (cal BC) of the Beaker-Baden assemblages (TRB/BaC).***

| Archaeological units and categories of $^{14}$C dates (their amounts) | Interval based on medians | The widest interval | The 'probable' interval | The narrowest interval |
|---|---|---|---|---|
| Funnel Beaker culture, phase BR I; 1 date | 3960–3810 | 4340–3690 | 4070–3720 | – |
| Lublin-Volhynia culture; all dates (4) | 3810–3470 | 3990–3100 | 3870–3360 | 3690–3630 |
| Lublin-Volhynia culture; dates of group B (3) | 3910–3410 | 4300–2940 | 4010–3300 | 3700–3630 |
| Lublin-Volhynia culture; dates of group A (3) | 3800–3470 | 4020–3040 | 3870–3360 | 3660–3630 |
| Wyciąże-Złotniki group; all dates (11) | 4290–3440 | 4460–3270 | 4370–3340 | 4110–3630 |
| Wyciąże-Złotniki group; dates of group B (6) | 4240–3630 | 4450–3280 | 4330–3560 | 4070–3900 |
| Funnel Beaker culture; all dates (58) | 3480–3310 | 3530–3280 | 3510–3300 | 3440–3340 |
| Funnel Beaker culture; dates of group B (47) | 3480–3310 | 3530–3270 | 3500–3290 | 3430–3340 |
| Funnel Beaker culture; dates of group B (34) | 3490–3310 | 3550–3270 | 3510–3290 | 3490–3340 |
| Wyciąże/Niedźwiedź materials; all dates (3) | 3440–3140 | 3630–2860 | 3570–3040 | – |
| Wyciąże/Niedźwiedź materials; dates of group B (3) | 3630–3120 | 3900–2820 | 3860–2990 | – |
| Wyciąże/Niedźwiedź materials; dates of group A (3) | 3320–3140 | 3630–2890 | 3410–3040 | – |
| Baden culture; all dates (26) | 3070–2830 | 3130–2780 | 3110–2810 | 2990–2870 |
| Baden culture; dates of group B (24) | 3070–2830 | 3130–2790 | 3110–2810 | 3000–2870 |
| Baden culture; dates of group A (19) | 3060–2830 | 3130–2780 | 3100–2810 | 2980–2870 |
| Funnel Beaker/Baden assemblages; all dates (26) | 3310–2790 | 3340–2700 | 3330–2750 | 3280–2870 |
| Funnel Beaker/Baden assemblages; dates of group B (15) | 3310–2800 | 3340–2690 | 3330–2750 | 3270–2880 |
| Funnel Beaker/Baden assemblages; dates of group A (6) | 3310–3030 | 3340–2770 | 3330–2850 | – |
| Corded Ware culture; all dates (24) | 2660–2330 | 2740–2250 | 2700–2280 | 2590–2410 |
| Corded Ware culture; dates of group B (21) | 2630–2330 | 2720–2250 | 2670–2290 | 2570–2420 |
| Corded Ware culture; dates of group B (20) | 2570–2350 | 2670–2260 | 2620–2300 | 2500–2440 |

– All dates: $A_{model}$ = 64.3%, $A_{overall}$ = 64.5%; 3 dates with agreement index lower than 60%
– Modelling for dates of group B: $A_{model}$ = 76.2%, $A_{overall}$ = 75.0%; 3 dates with agreement index lower than 60%
– Modelling for dates of group A: $A_{model}$ = 62.1%, $A_{overall}$ = 60.1%; 5 dates with agreement index lower than 60%

***Tab. 3. Results of combined modelling of $^{14}$C dates of the Middle and Late Neolithic units in western Lesser Poland (cal BC; rounded by 10 years).***

recommended, but in other cases continuous development should be proposed.

To these local conditions, as we already know, typological continuations between the Funnel Beaker culture and Beaker/Baden assemblages as well as between the Wyciąże-Złotniki group and Wyciąże/Niedźwiedź materials should be included. This means that these units had to come into contact, but on the other hand, they could not develop simultaneously for a long time. Besides, some stratigraphic observations suggest some contemporaneity between the Lublin-Volhynian culture/Wyciąże-Złotniki group and the Funnel Beaker culture. The remaining assumptions used in combined modelling (see above) are not local, but should of course also be taken into account.

Although these interdependencies had already been used in combined modelling, we are not concerned here with circular reasoning. The result of the combined modelling still gives quite a bit of uncertainty, which must still be interpreted with the application of the aforementioned local conditions. There are also no obstacles to taking these conditions into account in the falsification of direct dating and separate modelling.

Fourthly, reliable external data, referring to both absolute and relative chronology, should be included in our assessment.

Lastly, the shape of the relevant part of the calibration curve is also important for the final selection of timeframes of archaeological units under consideration.

External data are particularly important for the Lublin-Volhynian culture and Wyciąże-Złotniki group. Their extremely early beginnings, reaching almost the mid-5$^{th}$ millennium BC (Figs. 18–19), as well as late endings, reaching the early 3$^{rd}$ millennium BC

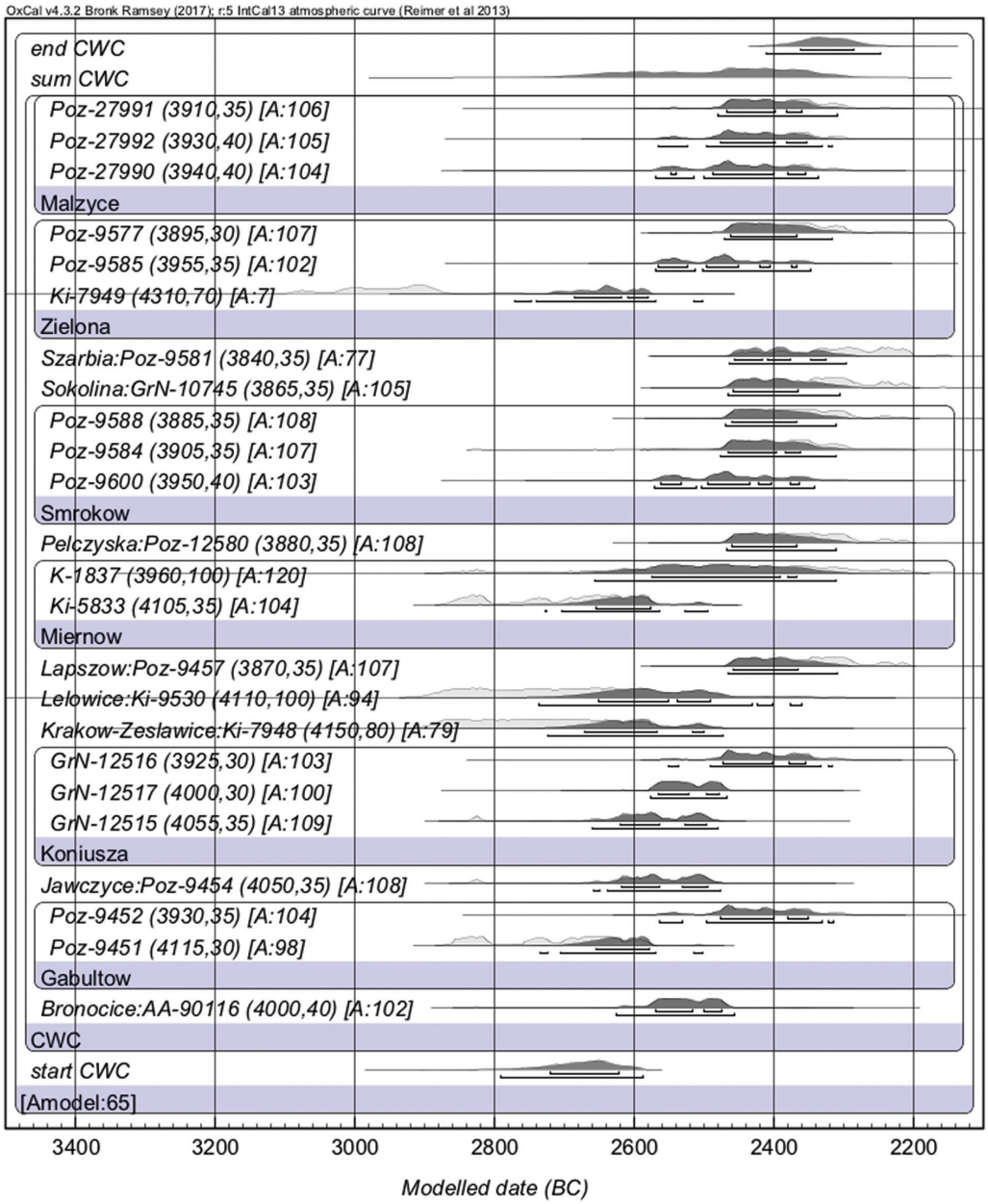



***Fig. 17. Radiocarbon chronology (cal BC) of the Corded Ware culture (CWC).***

in the case of the former and 3300/3200 cal BC in the case of the latter (Figs. 18, 21), are impossible to accept in light of our knowledge on chronology of the Lengyel-Polgár phenomena. For instance, in the recent assessments of the chronology of the Early and Middle Eneolithic in the Carpathian Basin (*Chmielewski 2008.72–76, 86; Nowak 2010.68–79, 82; Raczky, Siklósi 2013*), the timeframes of the Bodrogkeresztúr and Hunyadihalom cultures were placed around 4300/4200–3700 cal BC. This is of great significance, since both these cultures can be described as 'mother' units of the ceramic style of the Wyciąże-Złotniki group. Similarly, new views on the chronology of the Lublin-Volhynian culture (*Chmielewski 2008; Wilk 2014; 2016*), based on the dates from western Volhynia, Nałęczów Plateau and Sandomierz Upland, supported by new schemes from the Carpathian Basin, prove that the traditionally defined phase III of this culture (actually, this is rather pottery styles, not the phase as such) should be placed between *c.* 4200 and *c.* 3700 cal BC. Phase III is important for our subject, because Lublin-Volhynian materials from western Lesser Poland belong to it.

It seems, therefore, that the second approach proposed in the summaries of separate and combined models is more correct for units which provided fewer dates. The intervals delimited by complete ranges in both models and in direct dating should

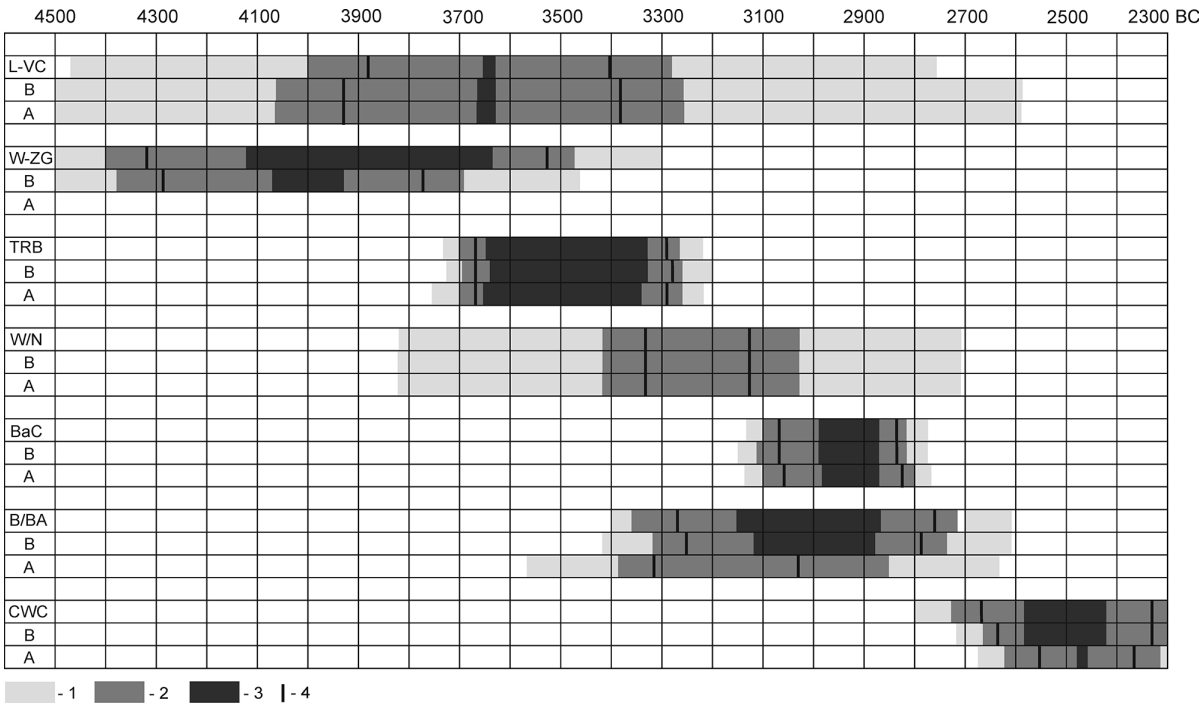



***Fig. 18. Absolute chronologies (cal BC) of the Middle and Late Neolithic (Corded Ware culture) units in western Lesser Poland based on separate Bayesian modelling of all $^{14}$C dates referring to these units (rows with abbreviations), of dates belonging to group B (B) and of dates belonging to group A (A); 1 the widest intervals, based on extreme points of the 95.4% ranges; 2 the 'probable' intervals, based on extreme points of the 68.2% ranges; 3 the narrowest intervals, based on the end point of the 95.4% start boundary and the starting point of the 95.4% end boundary; 4 medians. L-VC Lublin-Volhynian culture, W-ZG Wyciąże-Złotniki group, TRB Funnel Beaker culture, W/N Wyciąże/Niedźwiedź materials, BaC Baden culture, B/BA Beaker/Baden assemblages, CWC Corded Ware culture.***

be considered as indicative of approximate intervals within a segment of which given units actually developed.

Therefore, we should eliminate the long 'onsets' and 'tails' of the Lublin-Volhynian culture and Wyciąże-Złotniki group. If we also take into consideration, the shape of the calibration curve between *c*. 5100 and 4900 cal BP, we can accept the idea that the Lublin-Volhynian culture appeared in western Lesser Poland between *c*. 3950 and 3700 cal BC (*c*. 3800 cal BC could be proposed as the most probable time), because some retardation of more western areas of this culture is highly probable. However, somewhat paradoxically, this does not necessarily refer to the Bronocice site. The Lublin-Volhynian settlement could have appeared later there. Due to stratigraphic relationships, we can assume that it was later than the first phase of the Funnel Beaker culture, which we finally placed around 3750/3700 cal BC (see below). Thus, the Lublin-Volhynian culture at this site can be placed around 3700–3650/3550 cal BC. Admittedly, this chronological position is later than in the schedule developed by Kruk and Milisauskas; they recently dated the Lublin-Volhynian culture at Bronocice to 3800–3700 cal BC (*Milisauskas* et al. *2016.36*). Overall, the end of this culture in western Lesser Poland should be placed within the period of *c*. 3650–3550 cal BC, due to the plateau visible in the calibration curve for 4800–4700 cal BP.

Regarding the absolute dating of the Wyciąże-Złotniki group, the series of nine new $^{14}$C dates led to the transformation of previous opinions. Two 'old' dates from Złotniki and Kraków-Pleszów suggested the late chronological position, *i.e.* the first half of the 4$^{th}$ millennium BC, and particularly the second quarter of that millennium. It seemed even possible to extend this chronology slightly, by about 100/150 years, beyond the date of 3500 cal BC. However, new dates consequently point to an earlier period, *i.e.* at the second half of the 5$^{th}$ millennium and the first quarter of the 4$^{th}$ millennium BC. According to the results of both models (particularly the combined one), and in light of the cited external data, the start of the Wyciąże-Złotniki group should be established at between *c*. 4250 and 4050 cal BC, since a plateau of this length occurs in the calibration curve and retardation to the Tisza basin is reasonable. The value for the end would be within *c*. 3650–3550 cal

BC, at the very latest, *i.a.* some retardation of the cultural development, when compared to the Middle Eneolithic of the Tisza basin, is again acceptable. Moreover, the shape of the calibration curve plays a similar part as in the case of the end of the Lublin-Volhynian culture.

In case of the Wyciąże/Niedźwiedź materials, the very modest amount of data makes it difficult to reliably characterise this unit, including its chronology. We should again employ the above-mentioned 'segment' approach. If we assume the actual presence of Lengyel-Polgár elements there, which originated from the Wyciąże-Złotniki group (*Bober 2004; Furcholt, Machnik 2006.336, 339; Grabowska, Zastawny 2011.134–135*), as well as ther prevoiously mentioned shape of the calibrated curve, then its beginnings should be placed in the timeframes of *c.* 3650–3550 cal BC. The dating of the disappearance of these materials remains a mystery; the value of *c.* 3350–3100 BC can be proposed, based mainly on median values from both models confronted with a wide plateau for 4550–4450 cal BC. Nevertheless, it gives a surprisingly long period for quantitatively insignificant archaeological phenomena. It would mean that Lengyel-Polgár elements were still in use for 400 years even after their disappearance from the Carpathian Basin.

As regards other units, we have quite a different situation due to the larger sets of $^{14}$C datings, which resulted in more compact ranges in all kinds of analyses. Therefore, it seems more probable that either the whole length of these ranges or most of them should be taken into account as the real timeframes of their existence.

As to the dawn of the Funnel Beaker culture, the combination of all analyses carried out above and the shape of the calibration curve indicate that the dates

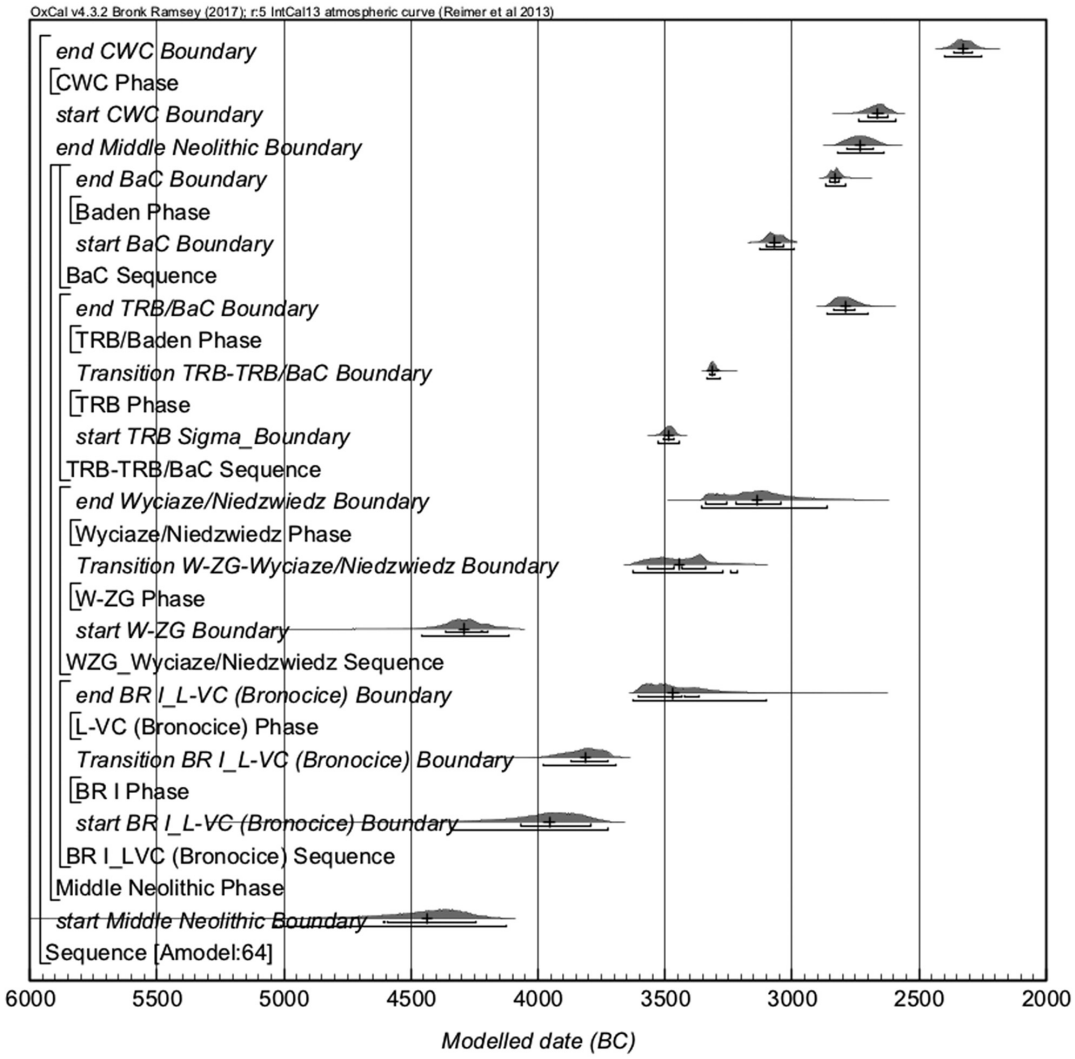



***Fig. 19. Combined modelling of all $^{14}$C dates of the Middle and Late Neolithic (Corded Ware culture) units in western Lesser Poland (cal BC); individual dates are not presented.***

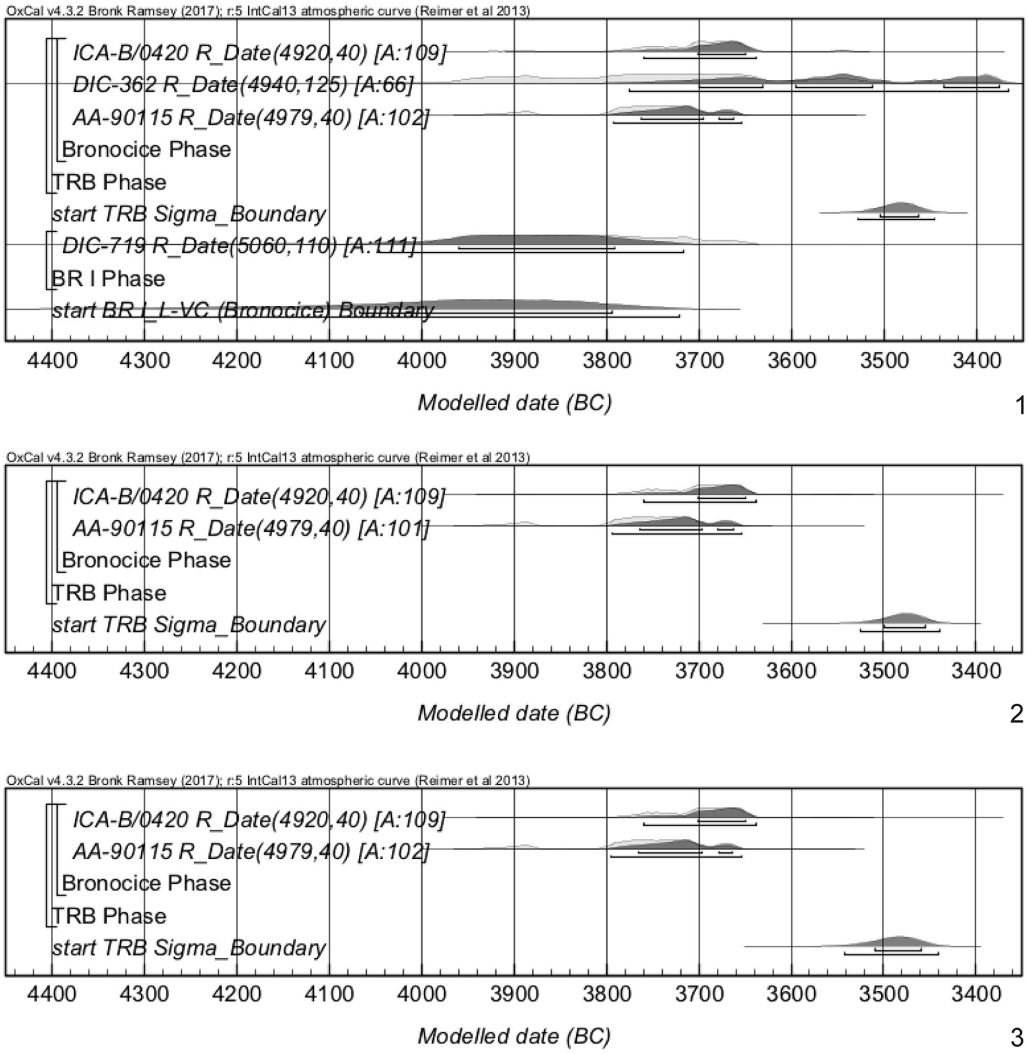



***Fig. 20. Prior and posterior versions of the earliest $^{14}$C dates of the Funnel Beaker culture at of Bronocice: 1 modelling of all dates; 2 modelling of group B dates; 3 modelling of group A dates. These diagrams are enlargements of segments of complete modelling diagrams; in the case of all dates, a simplified version of this is presented on Figure 19.***

of *c*. 3750 and 3700 cal BC should be regarded as the most likely borders of its very beginning. The ceramic typology does not exclude this possibility (*Nowak 2009.334–336*, see further references), although this date is a bit later than the commonly suggested date of 3900/3800 cal BC (*Kruk* et al. *2016; Milisauskas* et al. *2016; Nowak 2009; Włodarczak 2006b*). However, the latter proposal was based only on single dates from 'our' area and other areas in Lesser Poland (*Nowak 2006; Rybicka 2017*) whose reliability can be challenged. The date of 3750/3700 cal BC does not contradict the above-mentioned stratigraphic relations recorded at Bronocice (see above).

The issue of the disappearance of the Funnel Beaker culture from western Lesser Poland and of the importance of the Baden influence on that process is complex. One way or another, it seems very likely that between this culture and the Beaker/Baden assemblages had to function a cultural (typological) continuity, which is well corroborated by separate and combined models. In other words, the Funnel Beaker culture proper, at least in the eastern part of the western Lesser Poland loess uplands, existed until the beginning of the Beaker/Baden assemblages. The value of 3300–3250 cal BC seems very reliable as to that transition (and remains roughly in line with the Bronocice chronology – *Kruk* et al. *2016; Milisauskas* et al. *2016*); however, we cannot exclude that the upper boundary of this interval of uncertainty should be moved up to *c*. 3100 cal BC, due to the shape of the calibration curve described in the case of the Wyciąże/Niedźwiedź materials.

The end of the Beaker/Baden can be situated at *c*. 2800 cal BC, based mainly on the values of medi-

ans obtained in both models. Taking into account the calibration curve, we could transform this date into *c*. 2850–2750 cal BC. The postulated period of *c*. 3300/3250/3100–2850/2750 cal BC roughly fits with recent dating of the BR IV and BR V phases at Bronocice (3300–2900/2800 cal BC – *Kruk* et al. *2016; Milisauskas* et al. *2016*).

The absolute dating of the Baden culture in western Lesser Poland should be delineated by a kind of average of all boundary values, which do not differ between each other very much. The high reliability of $^{14}$C dating enforces such a construction. Most of these dates have been obtained recently in reliable laboratories, mainly from bones, and usually have small standard deviations (*Zastawny 2015b*). Thus, the proposed range could be *c*. 3100–2800 cal BC. The first date does not have to be changed due to the calibration curve (lack of wiggle or plateau); the second can again be stretched to *c*. 2850–2750 cal BC. Let us recall, however, that in A. Zastawny's opinion (*2015.202*), an even shorter slice of time, of *c*. 3100/3050–2900 cal BC, better reflects the Baden chronology, due to some typological constraints. Consequently, it is our belief that the range of *c*. 3100–2850 cal BC reflects the chronology of the Baden culture in the best way.

Admittedly, this is a shorter period than might be expected. Particularly surprising are the late origins of the Baden culture in Lesser Poland. However, credible dating indicates precisely this and no other situation. Also, the proposed time interval does not contradict the overall principles of typological development or current patterns of the absolute chronology of the Baden phenomena (*Horvath, Svingor 2015; Stadler* et al. *2001; Wild* et al. *2001; Zastawny 2008; 2011; 2015a*).

Such dating, especially the relatively late beginnings, convincingly confirm what we had long suspected, namely that the Baden culture proper in western Lesser Poland appeared as the effect of fast (a single wave?) migration from beyond the Carpathians. This migration was of groups coming from the developed (late classic) Baden culture. These people brought

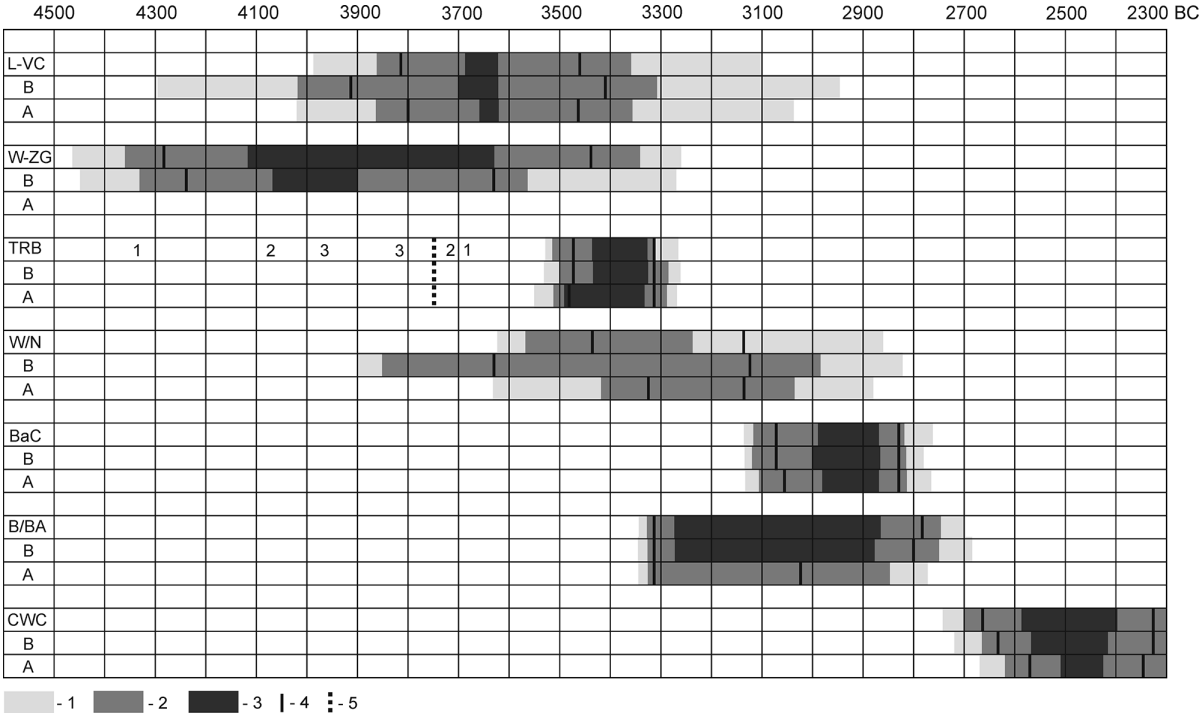



***Fig. 21. Absolute chronologies (cal BC) of the Middle and Late Neolithic (Corded Ware culture) units in western Lesser Poland based on combined Bayesian modelling of all $^{14}$C dates referring to these units (rows with abbreviations), of dates belonging to group B (B) and of dates belonging to group A (A); 1 the widest intervals, based on extreme points of the 95.4% ranges; 2 the 'probable' intervals, based on extreme points of the 68.2% ranges; 3 the narrowest intervals, based on the end point of the 95.4% start boundary and the starting point of the 95.4% end boundary; 4 medians; 5 evaluated beginning of the Funnel Beaker culture (see text). L-VC Lublin-Volhynian culture, W-ZG Wyciąże-Złotniki group, TRB Funnel Beaker culture (boundaries of the widest intervals (1), 'probable' intervals (2) and medians (3) of the phase BR I, based on the date DIC-719), W/N Wyciąże/Niedźwiedź materials, BaC Baden culture, B/BA Beaker/Baden assemblages, CWC Corded Ware culture.***

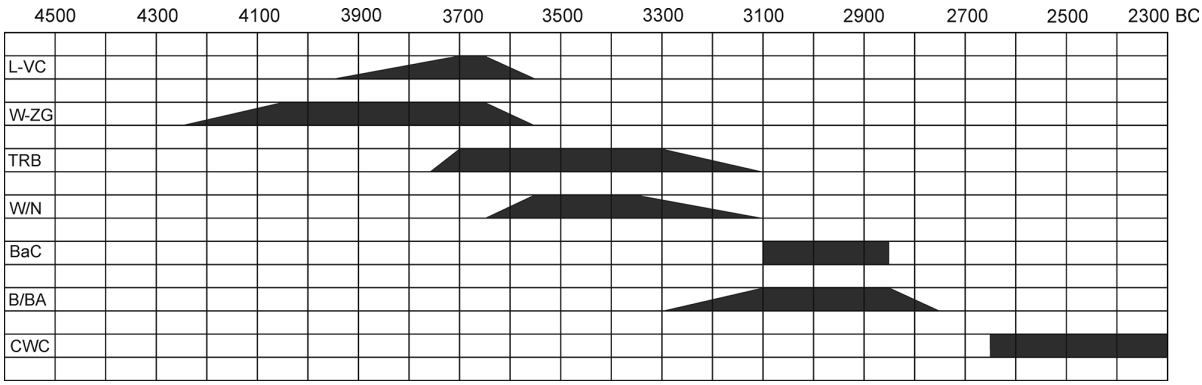



***Fig. 22. The final scheme of the absolute chronology (cal BC) of the Middle and Late Neolithic (Corded Ware culture) units in western Lesser Poland.***

here the model of the developed Baden culture in all its aspects. They settled in a small area within and around Kraków. Consequently, only this stage of development is represented in this area. Thus, we do not observe full cultural (typological) development, with early, developed (classic) and late phases. The cause of the sudden disappearance of Baden culture and the Beaker/Baden assemblages remains unclear. In any case, the results of analyses suggest the occurrence of a hiatus between this disappearance and the origins of the Corded Ware culture.

The possible dates of the beginnings of the Corded Ware culture, resulting from statistically significant modelling, fall within a rather broad interval between 2800 and 2500 cal BC. However, comparing the results of all analyses speaks, in our opinion, for the date of *c*. 2650 cal BC. We are aware that this date seems to be rather late when referring to general views on development of this unit in central Europe, including western Lesser Poland, which usually point to *c*. 2800 cal BC (*Włodarczak 2006a*). We are also aware that the calibration curve makes it possible to alternatively refer several dates earlier than *c*. 3100 to *c*. 2850–2800 cal BC. Nevertheless, we think that the presented results of separate and combined modelling allow us to evaluate the probability of such an option as lower than the probability of the 'later' option. This problem must be analysed in depth in the future.

## Conclusions

The final, modelled scheme of the absolute chronology of the discussed archaeological units in the area under consideration is illustrated on Figure 22. This is the result of analyses which included radiocarbon, typological and contextual facts and their interpretations, as well as more or less arbitrary chronological constructions based on these facts and interpretations and on general knowledge, including the parameters of the calibration curve. It should be emphasised that this graph shows the chronology itself, not the dynamics of cultural processes. In other words, the rising and falling segments of bars reflect intervals of uncertainty in dating the beginning and end of a given unit. These bars do not necessarily mirror the 'birth', 'heyday' and 'decline' of the analysed phenomena.

This scheme unambiguously suggests both the overlapping and contiguous nature of cultural development in western Lesser Poland within the Middle Neolithic. The basic elements of this development are: 1) the Wyciąże-Złotniki group and the Lublin-Volhynian culture, until *c*. 3650–3550 cal BC; 2) the Funnel Beaker culture proper, which appeared *c*. 3750–3700c al BC, and existed until *c*. 3300–3250 cal BC, perhaps accompanied by the Wyciąże/Niedźwiedź materials from *c*. 3650–3550 cal BC; and 3) the Baden culture and the Funnel Beaker/Baden assemblages from 3100 and 3300–3100 cal BC, respectively, until 2850–2750 and 2850 cal BC, with – possibly – later Funnel Beaker culture and Wyciąże/Niedźwiedź materials, existing until *c*. 3100 cal BC.

There is an explicit suggestion in the final scheme that in some cases a discrete (radical) mode of cultural transformation could be proposed; and in other cases, continuous development and/or simultaneous functioning can be suggested. In the author's opinion, this arrangement (particularly the discrete one) means that some archaeological units (perhaps Baden culture and Corded Ware culture) should be considered as reflections of real units of a cultural, population, or even political nature, which were discernible to prehistoric people.

The final scheme shows that the Lublin-Volhynian culture could have coincided with the Wyciąże-Złot-

niki group. In view of the territorial relationship between them, relations from the point of view of material culture, primarily in the field of pottery, become particularly interesting. It is relatively easy to see clear similarities between these units. However, the most evident similarities apply only to some categories of ceramics, including, for example, vessels with Scheibenhenkel handles. What is more, in the period between the late 38th and early 36th centuries BC, the early Funnel Beaker and possibly early Baden influences are superimposed on this Lublin-Volhynian/Wyciąże-Złotniki 'mix'.

The lack of any Funnel Beaker elements in materials of the Baden culture proper is particularly pregnant with meaning. This directly suggests that the Funnel Beaker communities in the western part of the area under consideration could have been expelled or exterminated. A fairly sharp geographical boundary between areas of the Baden culture and Beaker/Baden assemblages (Fig. 1) (see *Zastawny 2008.Fig. 2*; but *cf.* a somewhat different opinion in *Włodarczak 2008b.252*) could also support an interpretation of this kind. As a result, as already mentioned, one can postulate that a substantial migration of Baden people from the south-west took place at about 3100 cal BC.

With reference to the next fundamental cultural change, *i.e.* the appearance of the Corded Ware culture, which we use only as a kind chronological frame, we should emphasise that currently it also is difficult to point to any common or transient characteristics in the pottery of the Funnel Beaker culture, Beaker/Baden assemblages and Corded Ware culture, not to mention the Baden culture (*Włodarczak 2008b.253; 2010.208, 210; 2011.215–220*), contrary to earlier hypotheses (*Machnik 1966.123; Włodarczak 2006a.90–95, 103, 105; Zastawny 2001*). As a kind of summary of this issue, we can quote the opinion by P. Włodarczak, according to which "*a short period of co-existence between the two groups is possible (*c. *2850–2700 BC), although not very likely*" (*Włodarczak 2008b.253*). Altogether, we take a the liberty to express the (unfashionable) view that processes connected with the disappearance of the Beaker/Baden and Baden groups and with appearance of Corded Ware groups were primarily historical (political?) processes.

"*All models are wrong, some models are useful*", as George Box says (*Box 1979.202* – after *Bayliss* et al. *2007*). Hopefully, the final model is useful for many issues, despite some controversial points. Particularly, the precise chronology of the Baden culture, and more precise chronology of the Funnel Beaker culture, Beaker/Baden assemblages, and of the beginning of Corded Ware culture should be highlighted. It is impossible to say this about the remaining units, but the proposed chronological limits can be useful for current knowledge and constitute a good starting point for further analyses and studies.

This scheme, of course, will be more or less changed if new radiocarbon and other data appear. A very recent, extremely surprising discovery of the spectacular collective grave of the Globular Amphorae culture in Koszyce (approx. 30km NE of Kraków) which is dated to *c*. 2900–2600 cal BC (*Przybyła* et al. *2013*) clearly proves that in western Lesser Poland many processes and events happened in the Neolithic period, about which we have so far not acquired any knowledge and which were not even expected.

Obviously, the question posed in the title of this contribution should be answered negatively. Radiocarbon dates as such usually do not determine the actual absolute chronology of a given phenomena. They must pass a rigorous contextual analysis and modelling in combination with other dates, whereby we might be able to come closer to past reality. Extreme approaches in which we either approve only those dates which fit into our concepts or accept without any reservations almost all dates are incorrect.

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back to contents

# Discrepancies between archaeological and $^{14}$C-based chronologies: problems and possible solutions

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ABSTRACT – *$^{14}$C dating of bone collagen is believed to produce the most reliable absolute dates for the Central European Early Neolithic, as the selection of bones in anatomical context minimises taphonomic problems. In contrast, a comparison of three newly published local or regional chronological models as well as a comparison of several series of dates from bone collagen, charcoal and cereals highlights problems probably caused by diagenetic influences, especially on collagen. Therefore, at least the checking of bone collagen $^{14}$C dates against charcoal or cereal dates from the same contexts seems to be indispensable.*

KEY WORDS – *$^{14}$C; taphonomy; diagenesis; Central Europe; Early Neolithic*

## *Neskladnosti med arheološkimi in $^{14}$C kronologijami: težave in možne rešitve*

IZVLEČEK – *Za $^{14}$C datiranje kostnega kolagena velja, da omogoča najbolj zanesljive absolutne datume za srednjeevropski zgodnji neolitik, saj izbor kosti iz anatomsko pravilnih kontekstov zmanjša težave s tafonomijo. V članku opozarjamo na težave, ki lahko nastanejo predvsem pri vplivu diageneza na kolagen, kar prikažemo s primerjavo treh novo objavljenih lokalnih ali regionalnih kronoloških modelov kot tudi s primerjavo številnih datumov, ki so bili pridobljeni iz kostnega kolagena, oglja in žit. Posledično opozarjamo na nujnost preverjanja $^{14}$C datumov, ki so bili pridobljeni iz kostnega kolagena, z datumi, pridobljenimi iz oglja ali žit iz istih kontekstov.*

KLJUČNE BESEDE – *$^{14}$C; tafonomija; diageneza; Srednja Evropa; zgodnji neolitik*

## Introduction

The starting point for some considerations concerning the reliability of $^{14}$C dates are three new studies concerning the absolute chronology of the Central European early and middle Neolithic, all three of which are based mainly or entirely on dates on bone collagen. Two are from the north-western Carpathian basin (*Tasić* et al. *2015; Jukacs* et al. *2016*). The first produced an absolute chronology for the stratigraphic sequence at Vinča-Belo Brdo; the second dated the contact between Vinča A and earliest LBK (eLBK) and between Ražiste and the later LBK at Szederkény from bone collagen dates only and imbedded the results in a wider context.

The Vinča chronology poses no obvious problems. In contrast, the parallelisation of all four different ceramic styles at Szederkény, although pairwise spatially separated, contradicts the usual archaeological chronologies, postulating the (not necessarily direct) sequence Vinča A-Ražište on the one hand, and the eLBK-later LBK on the other. No explanation is given, but three much later bone dates for Ražište from


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Ivandvor are cited, without the consequences being debated. This problem will be discussed later. The site was fixed within the chronology of the Central European eLBK by using dates from varying materials, partially from dubious contexts (such as Eilsleben), some others dating from later contexts (early, but not the earliest LBK (Vedrovice, Kleinhadersdorf)). The beginning of the eLBK and its expansion is dated to about 5350 cal BC. The resulting relative date – slightly earlier than Vinča A in Vinča-Belo Brdo – is not completely contrary to archaeological expectations. The 'formative phase', dated to 5500–5350 cal BC exclusively by charcoal, may be ignored at this point, even more so as its existence as a separate chronological unit is questionable (*Strien 2017*). The last study comprised bone collagen dates for the whole of the lower Alsatian Early and Middle Neolithic sequence (*Denaire* et al. *2017*). The beginning of LBK settlement in this region was probably around 5300 cal BC or the first half of 53$^{rd}$ century.

If we accept these three $^{14}$C-chronologies, we have to face the problem that the start of the earliest LBK in trans-Danubian Hungary dates only 50 years earlier than the start of the early LBK and the settlement of Alsace and the Rhine-Meuse region, and only 150 years earlier than the end of the early LBK (Flomborn) in the West (even taking the upper end of the 95% probability range for the end of phase IIC in Alsace). This is not so much a chronological as a demographical problem. It means that, starting from the relatively restricted area between Lake Balaton and Vienna, the whole area between the Rhine and western Ukraine was densely occupied within only 50 years. Even this time span is probably an overestimate, as on the one hand it starts with the Bíňa phase, which until now has not been attested outside NW Hungary and SW Slovakia, while on the other hand the earliest pits in Alsace in the correspondence analysis are not $^{14}$C dated (*Denaire* et al. *2017.Fig. 5*), so the beginning of the expansion of the eLBK may date later than 5350 cal BC, and the start of the Flomborn earlier than 5300 cal BC.

## Demographic considerations

In south-western Germany (southern Hessen, Lower Franconia, the Neckar Valley) 200 eLBK sites are known, and 100 in Central Germany. In the Neckar Valley 194 Flomborn sites are known, but as only half of all known LBK sites are dated, we have to double this number. Even calculating with an unrealistic population growth rate of 2% per year (too high even when assuming the fast assimilation of the autochthonous hunter-gatherer population), there would have been 20 sites in the first year of eLBK expansion in order to arrive at the number of 400 sites 150 years later – one third of the number of known eLBK sites in the region – and this means 100 sites only in the above-mentioned areas of Germany. Even with a mean of 5 contemporaneous houses per site (too low in the case of sites like Vaihingen with up to 45 contemporaneous houses) and the lowest estimate of 6 inhabitants per house, this would mean that 3000 persons left the Balaton-Vienna area in the first year for south-western and central Germany, and we have to add the thousands of immigrants between Bavaria and Volhynia, an obviously unrealistic number. This calculation still ignores the additional population growth needed for the colonisation of the regions west of the Rhine only two generations after the start of the expansion, *e.g.*, with 36 known sites in Lower Alsace at about 5250 cal BC. Even this simplified demographic estimate shows quite clearly that the three chronologies do not fit together. A start of eLBK expansion not later than 5500 cal BC would fit much better with the date of 5300 cal BC for the start of Flomborn W of the Rhine, and the date of 5350 cal BC for the start of eLBK expansion, with the start of Flomborn in Alsace not earlier than 5150 cal BC. But which chronology is wrong (perhaps all of them?), and even more importantly, why? At first glance there is no evident reason to doubt any of them.

## Dendrochronology, $^{14}$C and relative chronology

Typological correlations with other absolute dates show that the dates for the Alsation chronology are entirely plausible. The pottery of the earliest Phase IIB is quite similar to the pottery from the Flomborn cemetery. The same holds for Vedrovice; so the start of this cemetery can be dated to immediately after the end of eLBK, where it too is placed by a new correspondence analysis of eLBK ceramic inventories (*Strien 2017*). The $^{14}$C dates from Vedrovice suggest a start around 5300 cal BC (*Pettitt, Hedges 2008*), perhaps slightly earlier. So the $^{14}$C age accords well with the Alsatian model. Moreover, this date is backed by dendrochronology. A well was constructed at Leipzig-Plaußig, a site with no traces of eLBK, in 5259/58 den BC (*Friederich [no year].3; Herbig* et al. *2013.268*). Since the well has not been fixed in any relative chronology, this date can serve only as *terminus ante quem* for the start of the early LBK in Western Saxony. This date confirms that the early LBK (Flomborn) settlement of Lower Alsace as well

as the Vedrovice cemetery started no later than in the first half of the 53rd century cal BC.

The pit alignment at Herxheim can be dated with 95.4% probability somewhere in the time span 5208–5053 cal BC (mean of 8 dates, calculated with Oxcal: 6161±10 BP, *Haack 2015.61*; this and all further calibrations done with OxCal 4.3 online). This fits quite well with the Alsatian chronology; the pits produced ceramics of late Palatinate style – phase V (*Jeunesse* et al. *2009*) and respectively V/VI (*Lindig 2002*) – which is most probablly contemporaneous with the Lower Alsatian phases IVa2 and IVb (*Lefranc 2007.Tab. 14*), starting after 5185 cal BC and ending before 5020 cal BC (95% probability, *Denaire* et al. *2017*). And Herxheim enables a further (indirect) dendrochronological control for the $^{14}C$ age with the rich Šarka finds. Šarka itself is contemporaneous with the house generations (HG) XII and XIII of the Rhine-Meuse chronology, shown by imports at Elsloo (*Strien 2010.502*; in a new seriation (*Strien, work in progress*) pit 655 can be dated to HG XIII, and pit complex 653 to HG XII and XIII) and Cologne-Mengenich (*Schröter 1970.Abb. 6, 10*; dated to HG XII). A second well at Kückhoven, built about 5057 den BC, is dated by decorated ceramics from the destruction horizon of the first well (built in 5089 den BC) and from the construction pit, which are both very close together between HG XII and XIII. The well at Altscherbitz, built in 5099 den BC and probably filled in after a relatively short time span – along with other ceramic of the regional late LBK style – contained two pots with a pasted decoration known from Šarka contexts (*Tegel* et al. *2012*). Together, the two wells show an age of about 5080–5030 den BC for Šarka. The $^{14}C$ date for Herxheim and consequently for the Alsatian phase IVb may be slightly too old, but the 95% range of both at least overlaps with the date interpolated from dendrochronology and typochronology, so we should accept the Alsatian $^{14}C$ chronology at least as a good approximation for the both start and the end of the dated part of the Lower Alsace LBK sequence, with only phase V remaining undated.

The same cannot be said for the start of the Middle Neolithic sequence; a date in the 48th century for Hinkelstein is clearly too late, probably by about 200 years. Most chronologies based on typology published in the last 30 years postulate at least an overlap between Hinkelstein and late western LBK, often even a similar end date for both (*e.g., Jeunesse, Strien 2009; Spatz 1996; Lefranc 2007; Stehli 1994*). Sometimes a gradual succession LBK/Hinkelstein can be mapped (*Strien 2013*). This is confirmed beyond doubt by the sequence of Šarka/early Stroked Pottery Culture (SBK) in the East, demonstrated at the household level at Dresden-Prohlis (*Link 2014*); Šarka being contemporaneous with late, but not the latest western LBK, and SBK II/III with Hinkelstein, no time is left for a gap between the LBK and Hinkelstein in the West. This may be the case on a regional scale, but not generally, and not to the extent of up to two centuries.

A closer look at some local series may shed light on the question. Differences between dates from charcoal, cereals and bone collagen can regularly be seen, with dates on bone usually being the youngest group. Even a simple comparison of unweighted means of uncalibrated dates (data list as appendix) shows this effect quite clearly:

- Rottenburg: cereals (2 dates) 6155 BP, bone (12 dates) 5965 BP (*Bofinger 2005.112–120, Tab. 15*) – difference 190 years (cereals/bone);

- Bruchenbrücken (only dates earlier than 5900 BP in order to exclude late LBK intrusions; *Stäuble 2005.Anhang D*): cereals (4 dates) 6215 BP, charcoal (3 dates) 6377 BP, bone (4 dates) 6144 BP – difference 233 years (charcoal/bone) resp. 71 years (cereals/bone). If all dates later than 6200 BP only were excluded, the differences would for the most part disappear, but in this case, the whole bone collagen series from Strögen has to be rejected;

- Strögen pit 5 (*Lenneis, Lüning 2001*): cereals (1 date) 6506 BP, charcoal (2 dates) 6313 BP, bone (4 dates; VERA-896 excluded as an outlier) 6152 BP – 161 years (charcoal/bone) resp. 354 years (cereals/bone);

- Schwanfeld (*Stäuble 2005.Anhang D*; only dates earlier than 5900 BP in order to exclude late LBK intrusions and only dates with a standard deviation of ≤100 years): cereals (1 date) 6380 BP, charcoal (3 dates) 6493 BP, bone (3 dates) 6321 BP– 172 years (charcoal/bone) resp. 59 years (cereals/bone).

A systematic deviation of bone collagen dates to a younger age is clearly visible; even if there were an overlap between the 95.4% ranges of floral and faunal dates (which is often but not always the case, Fig. 1) for each single site, any kind of group calibration would produce a later age for the bone collagen series.

The Middle Neolithic series from Western Germany show the same effect, resulting in a systematic difference between the Lower Rhine area (only charcoal dates) and SW Germany (mainly bone dates; *Friederich 2011.Tab. 89–90*), resulting in a strange chronology: the Middle Neolithic in SW Germany starts with Hinkelstein and in Rhenania only slightly later with late (!) Großgartach. The complete Großgartach-Planig-Friedberg-Rössen-Bischheim sequence, present in both regions, should be delayed in SW Germany by at least 150 years, but follow the same stylistic development in both regions (*Friederich 2011.397–406, Fig. 347*). Here the $^{14}$C-based chronology evidently contradicts the archaeological facts and each plausible reconstruction of cultural history, and it does not become much better by the third, Alsatian chronology for the same time span (Fig. 2).

A special case is the eLBK site at Rottenburg (*Bofinger 2005*). The two dates on cereals and the two earliest dates on bone – both identified as outliers from the rest – are in a range one can argue as perhaps correct (although more probably too young, the lower limit of the 95.4% probability range being 5290 cal BC for the cereals, and 5305 cal BC for the bones), the 10 remaining bone dates are five to six centuries too young, 4846–4722 cal BC (95.4% range) – almost exactly the assumed time span for Hinkelstein in Alsace, which is thought to be too late. The context is quite clear: the bones came from the long pits of the houses, below the preserved lower part of the original soil horizon. On top was a layer mixed from the disturbed upper part of the soil and material that went down the hill slope, dated to the late pre-Roman period, and a Roman road (*Kind 2005.255–262, Fig. 1–5: units 4 and 3*). In this layer, only three small sherds with eroded surfaces of late LBK/Hinkelstein date were identified (along with much more eLBK material and some Roman pieces; data: own analysis), the other, Neolithic, sherds, almost 1800 of them, most from the layers below, are all eLBK (or La Hoguette), as far as can be recognised. So there can be no reasonable doubt that the dated bones belong to the eLBK sherds.

The last example is the Hinkelstein and Großgartach cemetery at Trebur (*Spatz 1999.213–217*). Here we see a difference even between conventional and AMS dates on bone collagen. One outlier excluded nine graves are dated with both methods. The mean difference between the uncalibrated dates is 134 years, with the AMS dates in all nine cases being earlier. Nevertheless, even the AMS dates are considered to be too late (*Spatz 1999.216–217*).

Observations like these are far from new, and only confirm earlier results (*Denaire 2009*). A difference of 160–230 years (uncalibrated) cannot be explained only by the old-wood effect – even the trunk of a 300-year-old oak consists mainly of wood younger than 200 years, not to speak of the branches. This is shown, too, by the dates on cereals from the above-mentioned eLBK sites, which are clearly older than the dates on bone from the same sites. And finally, the old wiggle matching calibration of charcoal dates from Merzbach valley fits quite well with the Alsatian chronology, with a start of Flomborn at around 5300 cal BC (*Stehli 1989*). These dates from the 1970s are not very reliable, but at least they do not show any important old wood effect, in contrast with the Alsatian dates on bone collagen. When bone dates accord with dendrochronologically controlled age, there seems to be no serious difference in charcoal dates.

## Too young, but sometimes too old: the case of Ražište/Sopot IB-II

A look at the Carpathian basin shows that there are rare cases when bone collagen dates are too old. Starting with Ivandvor, a Sopot IB-II/Ražiste-site with the usual pattern (dates from *Jakucs* et al. *2016*):

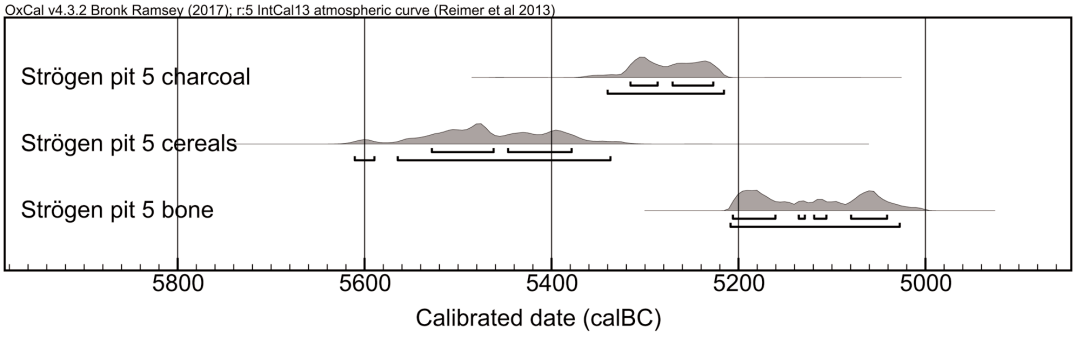



***Fig. 1. Comparison of calibrated ages of charcoal (two dates), cereals (one date), and bone collagen (four dates) from Strögen pit 5.***

charcoal (3 dates) 5947 BP, bone (3 dates) 5717 BP – 230 years older date for charcoal. These dates are not only contradictory in themselves, but do not fit with other $^{14}$C series for the Ražište/Sopot IB-II context: the site was dated by János Jakucs *et al.* (*2016.35*) to "*the second quarter of the fifth millennium*". The Sopot graveyard at Alsónyék is dated somewhere between 5200–5020 cal BC (95% probability for the beginning) and 4850–4680 cal BC (95% probability for the end) (*Oross* et al. *2016.166*), so it dates mainly to the first quarter of the fifth millennium. At Szederkenyi, Ražište is dated "*between the 54th and 52nd centuries cal BC*" (*Jakucs* et al. *2016.32*).

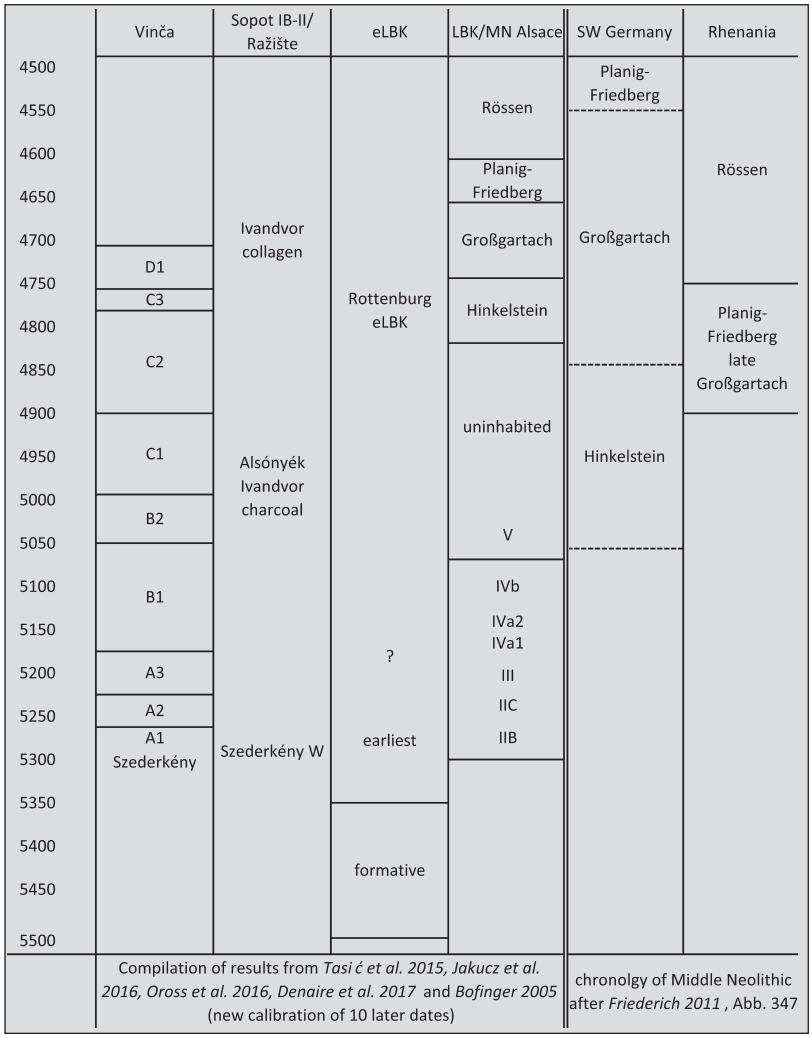



***Fig. 2. Chronological table 5500–4500 cal BC, based on $^{14}$C.***

If all these series are accepted, Sopot IB-II – usually taken as transitional between LBK and Lengyel (*Oross* et al. *2016. 151–152*) and synchronised with late LBK (Šarka) and early SBK in Bohemia (overview in *Gleser 2012*) – would span more than 600 years, ranging from the start of eLBK expansion, about 5350–5300 cal BC, at least until 4700 cal BC or even later, far beyond the latest estimate for the end of late LBK. On the one hand Sopot IB-II is connected typochronologically to Vinča C1 (phase 6 at Vinča-Belo Brdo; *Oross* et al. *2016.158–159*) – dated somewhere between 5040 and 4855 cal BC (*Tasić* et al. *2016. Tab. 8*), almost exactly the minimum time span given for Alsónyék – and on the other hand at Szederkény by $^{14}$C to Vinča A1 resp. A1-A3, although without much contact between the two groups except for some isolated Ražište sherds in Vinča context, but not vice versa (*Jakucs* et al. *2016.30*), which makes later intrusions more probable than contact. In addition, Ražište is associated with later LBK, and Vinča A with eLBK. So there are archaeological arguments that clearly contradict the very early dates from Szederkény, and no other $^{14}$C dates support them, as the authors admit (*Jakucs* et al. *2016. 35*). The dates on charcoal from Ivandvor seem to match with archaeology, the two dates from feature SU 407 dating to 5021–4842 cal BC (95.4%) – the minimum range for Alsónyék – and the single date from feature SU 194 to 4766–4499 cal BC, slightly too late. A date about or shortly after 5000 BC is most plausible, comparing relative chronology (Šarka/early SBK) with dendrochronology (Šarka dating around 5050 den BC, as shown above). So we have two sets of dates (Alsónyék, Ivandvor charcoal) that fit with a dendrochronological age derived from relative chronology, as well as with a $^{14}$C series from a site with the same relative age (Vinča-Belo Brdo), one set much too old (Szederkény) and one too late (Ivandvor bone collagen).

## Why bone collagen?

In the three series with very large differences from expected date – Rottenburg, the Aisne Valley and Trebur (conventional dates) – the common element is geology: all these sites are located on fluviatile sediments, with either thin or no loess coverage. We can even add two more examples. At Ulm-Eggingen

(sited on tertiary sands with a thin loess coverage), the charcoal dates (*Dombek 1989*) are clearly too young: house 12, archaeologically dated shortly after the end of Flomborn, and so some generations earlier than the Kückhoven wells, was dated in the range 4946–4743 cal BC (95.4% probability, one outlier excluded), and the waterlogged wood from the Mohelnice well, with a questionable dendrochronological date around 5600 den BC, but in any case not later than 5400 den BC (*Schmidt, Gruhle 2003.56*), dated to 5364–5007 cal BC (99.7% range; 3 dates from *Neustupný, Vesely 1977*). The possibility of hydrogeological influences on the diagenesis of charred and uncharred organic matter, especially bone collagen, should be taken into consideration. The difference between conventional and AMS dates from Trebur strengthens this idea, as later contaminations had probably been removed much better from material for the AMS dates than from the bigger pieces for conventional dates (*Spatz 1999.217*). It is further reinforced by a fourth date from the Mohelnice well (*Schmidt, Gruhle 2003.56*; KN-4339: 6580±75 BP, not included in the data list by *Jakucs* et al. *2016*), which has an uncalibrated age 300 ¹⁴C-years older than the mean of the other dates. It is the only one that fits with the dendrochronological age (87.7% probability: 5641–5461 cal BC, 7.7%: 5451–5377 cal BC), so we may assume that for this sample the removal of contaminations was much more successful than for the samples dated in the 1970s, and that contamination by water may play an important role even in an undisturbed context.

Szederkény is an interesting case. The dates for the eastern and central part of the site with Vinča A and eLBK ceramics are probably too young. The dates for the western part with Ražište and later LBK finds, on the other hand, are clearly too old as shown above. So far, this is the only case in which the bone dates are too old. Here we possibly see different diagenetic influences on bone collagen in parts of the same site separated by a distance of little more than 100m. A closer look at geological and hydrological properties of the different parts of the site might teach us something about the nature of the diagenetic processes involved. Apart from hydrogeological factors, no other reasons are clearly visible. But as there seem to be regional as well as local differences, it is not very probable that only one factor lies behind the problem. If it is really hydrology, we may even assume the possibility that the lowest levels of a tell – near to groundwater level – are affected, whereas the upper layers yield correct dates. The start of Vinča-Belo Brdo might be dated too late, and the later phases from Vinča B or C onwards might not (at least the date for C1 corresponds to the expected date; Fig. 3).

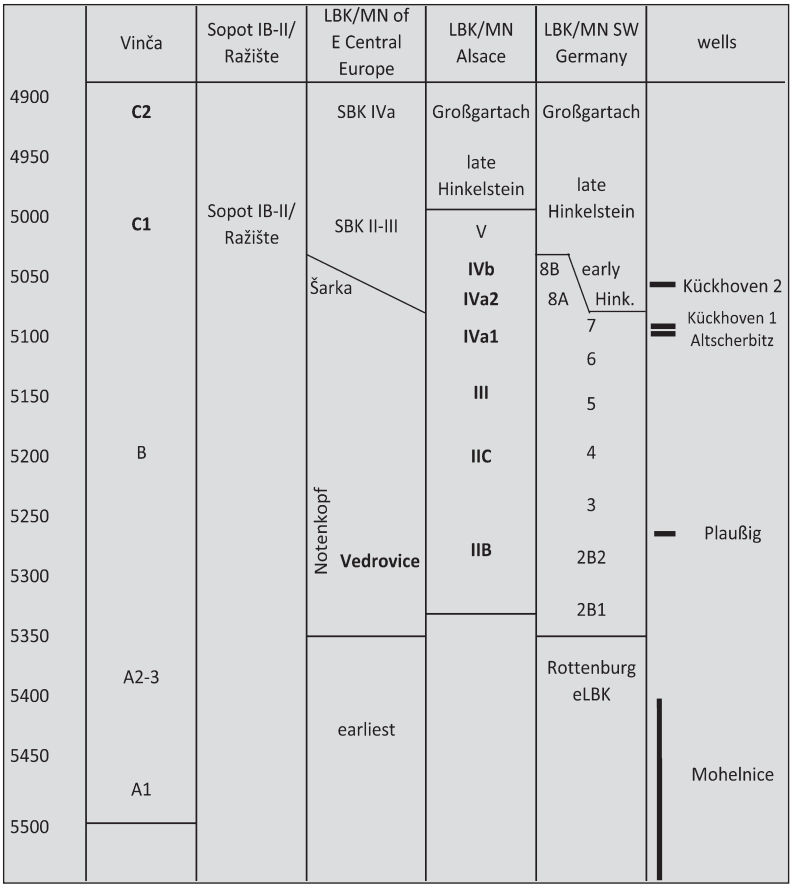



***Fig. 3. Chronological table 5500–4900 BC, based on relative chronologies, archaeological correlations and dendrochronologically dated wells. In bold: date in accordance with ¹⁴C age.***

We may conclude that dates on bone collagen are often too young, but not in every case; the best examples of series that accord with other dates are the Alsatian LBK and Rössen to Epirössen sequences. Compared with the Alsatian chronology, the same holds for the Vedrovice cemetery and the pit alignment at Herxheim. Most other bone collagen series from the Central European Neolithic in the second half of the 6th and the 5th millennia BC are too young, in individual cases even up to 500 years.

## How to solve the problem

Of course, a large-scale study on causes and possible remedies is not only desirable, but even necessary. As long as this study is lacking, we have to look for ways to minimise the risks. The first step is that dates on collagen must always be checked against charcoal or cereal dates from the same context; financial constraints concerning the number of dates are not an excuse for methodological deficits. In the case of differences of more than 50 BP-years between dates from faunal and floral carbon, the bone dates at least should be questioned, if not rejected. From a purely taphonomic point of view, dates from bones in anatomical contact are the best choice, but in the case of settlement pits, it may be preferable to use botanic material for $^{14}$C dating, making taphonomic problems improbable by taking three or more samples from different depths of a column. The higher cost of dating more samples is the price for the time saved collecting the samples compared to the time-consuming identification of bones in anatomical contexts and producing misleading results based on less probable diagenetic processes, without excluding them, as shown by the examples of Ulm-Eggingen and, probably, Rottenburg.

## Archaeology first

Finally, this paper shows that even the most refined, technically advanced methods used by the natural sciences can provide only an additional source of information. Our subject being archaeology, we always have to check the external data to see whether they fit with our archaeological data, and if not, why not. In the last few years there has been a tendency towards an unfounded reliance on $^{14}$C dating alone, culminating in the conclusion concerning the four late and ten extremely late dates from Rottenburg: "*presumably there is a so-far unresolved problem with the detection of later activity*" (*Jakucs* et al. *2016.53*), thus a priori excluding any problem with the dates themselves. As Rottenburg is probably the site with the best preservation of all known eLBK sites, with an unbroken layer of eLBK sherds above the $^{14}$C-dated pits (*Kind 2005.Abb. 3–5*), thoroughly excavated and documented by an experienced excavator, this shows an excessively uncritical attitude to $^{14}$C and distrust in archaeology. Scientific measurements and statistical analyses of them are not necessarily more reliable or accurate than our own methods, even if they are sometimes assumed to achieve a level of obvious pseudo-accuracy, as in the conclusions on Hinkelstein in Alsace: "*the appearance of Hinkelstein ceramics in Alsace was swift: taking 1–115 years (95% probability...)*"; "*Hinkelstein ceramics were probably used in this area for one or two generations*" (*Denaire* et al. *2017.43*); and "*the re-establishment of ways of doing things may have been quite rapid (1–40 years at 68% probability)*" (*Denaire* et al. *2017.71*) – conclusions derived from two graves and one pit included in a seriation, only the two graves being dated by $^{14}$C. How can we get any useful information about time spans and rapid or slow developments from a data base such as this; from a data base which was not checked to ascertain whether the suspected problems with collagen dates (*Denaire 2009*) were real, or enriched by two dates from a site almost 150km away, in another region with a longer duration of Hinkelstein occupation? Calculations like these may be statistically satisfying, but nothing more. The results cannot be the reliable approach to prehistoric reality that should be the aim of our research.

Of course, we may assume that the dates from Vinča and the Hungarian sites (and consequently also those from the early middle Neolithic in Alsace and SW Germany) are correct, shifting the whole sequence by 150–200 years; however, in this case, the LBK and Rössen series from Alsace would be too old, and even worse, the dendrochronological dates from the wells would not fit with the $^{14}$C chronology. And how should we explain a series like Rottenburg? A model that assumes they are all correct (Fig. 2) is completely incompatible with relative chronology (Fig. 3). A serious problem at least with some of the $^{14}$C dates on bone collagen has to be admitted – or a completely new chronological system has to be constructed, with, for example, eLBK lasting for six centuries (5350–4750 cal BC), ending at about the same time as Hinkelstein, as we have no evident reason to discard the dates from Rottenburg while accepting the Ražište dates from Szederkény.

In the light of these results, the 'formative phase' of eLBK in Transdanubia must be reconsidered: the difference of about 150 years between its beginning and the start of the rest of the eLBK might be explained by the different material used for $^{14}$C dating. Looking from the West, a date about 5500 cal BC for the beginning of eLBK expansion seems to be more reliable, while the date of 5350 cal BC based on bone collagen dates is about 150 years too young. Interpreting the 'formative phase' as a regional variant of the eLBK and not as its predecessor – as supposed by typological maps and the results of a correspondence analysis of some 600 features of eLBK

and the intial Flomborn/Notenkopf phases (*Strien 2017*) – both starting at 5500 cal BC, would avoid the demographic problems connected with the late date for the expansion horizon. If this model were accepted, the start date for Vinča-Belo at least Brdo would also be too young.

What becomes evident in this context is the lack in SE Central Europe of any modern typochronology based not only on a clearly defined typology, but also on appropriate statistical instruments. So far, for the whole area between Bylany and Vinča-Belo Brdo no chronology has been published that covers at least a major part of the time span between the start of the LBK and the transition to its successors. The establishment of fine-grained regional typological chronologies and their interregional correlation using classical analyses of foreign forms and importations as well as modern statistical methods (*e.g.,* Procustes analysis of seriations) and additional information like the demographic considerations discussed above, correlated with precise absolute dates from the wells, may and should be supported, but can in no way be replaced by $^{14}$C dating. Radiocarbon dating is not the Holy Grail of prehistoric archaeology, especially as long as environmental influences on its results are neither fully recognised nor understood.

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# Chronology and development of the Chalcolithic necropolis of Varna I

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ABSTRACT – *In the following paper, we present the main results of our now completed studies of the Varna I cemetery, based on the excavations undertaken by Ivan Ivanov in the years 1972–1991. The richness of the assemblages is singular in Old World prehistory. To tackle the question of its internal, chronological development, we applied correspondence analysis (CA) to a newly created database that includes the inventories of all presently known graves, symbolic burials and find deposits. The rank order of the seriated inventories was used to establish a CA-based $^{14}$C-age model for wiggle matching. In combination with topographic observations and social network analysis (SNA), our studies provide a new understanding both of the chronological and spatial distribution of the graves and burial goods, as well as new insights into the social structure, gender roles, individual relationships and ritual practices of the Chalcolithic community.*

KEY WORDS – *Varna cemetery; radiocarbon dating; correspondence analysis; social network analysis; Chalcolithic*

## *Kronologija in razvoj bakrenodobne nekropole Varna I*

IZVLEČEK – *V članku predstavljamo glavne rezultate zaključenih študij grobišča Varna I, ki temeljijo na izkopavanjih Ivana Ivanova. Ta so potekala v letih 1972–1991. Bogastvo najdb je edinstveno v svetovni prazgodovini. Pri analizi podatkov, ki vključujejo inventar vseh trenutno znanih grobnih celot, simboličnih pokopov in drugih najdb smo uporabili korespondenčno analizo (CA), s pomočjo katere smo ugotavljali notranji kronološki razvoj na grobišču. Uporabili smo vrstni red zbirov v seriaciji, da bi s pomočjo »wiggle matching« metode vzpostavili radiokarbonski model, ki temelji na korespondenčni analizi. Naša študija nudi nove razlage tako kronološke kot prostorske razporeditve grobov in grobnih pridatkov na podlagi združevanja topografije in analize socialnih omrežij (SNA), kar vodi tudi v nova spoznanja o družbeni strukturi, vlogi spolov, individualnih odnosih in ritualnih praksah v tej bakrenodobni skupnosti.*

KLJUČNE BESEDE – *grobišče Varna; radiokarbonsko datiranje; korespondenčna analiza; analiza socialnih omrežij; bakrena doba*


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## Introduction

To begin, we would like to mention that a longer paper with a more complete presentation of the applied methods and investigations as well as the complete master-database has been submitted for publication to the Eurasia-Department of the German Archaeological Institute[1], whereby the additional data obtained and the results will be printed in combination with a complete catalogue of all the excavated Varna graves. While awaiting this later publication of the cemetery, we are extremely grateful to Mihael Budja and his editorial team for the chance to present and discuss some of our most important results already here. We chose to focus on the internal chronological development of the burial site. To this end, in the following, we describe the two main chronological components of the Varna cemetery, namely – first – the archaeological contents and statistical properties of the correspondence analysis (CA), and – second – the absolute age-calibration of the CA, which is now based on a large number of radiocarbon dates (filtered: N = 38; unfiltered: N = 78). All other aspects, such as the role of gender and age, social inequality as well as kinship, have been dealt with previously. Hence, in the present context, these facts will be considered to some limited extent only. The focus here is on aspects which we consider relevant to the chronology of the burial ground.

## Overview of the approach taken

In brief, our approach will be as follows. By including the graves of the Varna II cemetery in the CA-analysis of Varna I, we create clear evidence for the chronological validity of the CA. With the application of social network analysis (SNA), we undertake studies that are focused on unravelling the strongly coherent network between the graves, a circumstance that demonstrates the profound community character of the Varna cemetery. The SNA is of particular use in understanding the unique position of Grave 43 on the CA-curve. Essentially, its position is due to the many close connections with the similarly furnished Graves 1, 3, 4, 15, and 97, all of which date to the younger end of the CA. In parallel to some few conservative elements that are operating next to the generally high degree of connection, Grave 43 displays a broad cross-section of the grave goods found in funerary rituals. The specific proximity of Grave 43 to certain older graves is most likely socially connoted, and allows us to reconstruct the persisting memory of a traditional funeral ritual. Finally, we describe the two main chronological components of the Varna cemetery: (1) the archaeological contents and statistical properties of the CA, and (2) the absolute age-calibration of the CA. Based on a large number of seriated $^{14}$C-ages, the cemetery begins at 4590 cal BC and ends at 4340 cal BC. Due to the methodology applied, we achieved a precise dating for all the graves included in the CA, whether directly $^{14}$C-dated, or not. The period of ~250 years for the cemetery, when compared with the overall sum of 270 burials, provides us with guidelines as to the role of the Varna burial ground in its wider *historical-cultural* context: The proportion of burials in comparison with the large number of symbolic burials indicates that Varna I quite probably contains the burials of individuals from different settlements. We should therefore perceive Varna I as a prominent burial site within the larger settlement area of the Kodžadermen-Gumelniţa-Karanovo VI Complex, and which will certainly encompass the known tell settlements in the hinterland of the western coast of the Black Sea.

## Statistical analysis

The cemetery master-database is a simply structured table containing 316 rows which represent the complete set of individual burial contexts (in a wider sense: mainly burials, but also including symbolic graves, and material deposits) of the Varna necropolis, and 193 columns, which contain the entire set of attributes associated with the burial contexts (for example: site-coordinates, dimensions of the grave pit, manner of burial or deposit, burial goods *etc*.). This cemetery master-database was constructed at the Eberhard Karls University of Tübingen in the course of two seminars on statistical methods in the years 2012 and 2013. Additional classification of the individual grave goods is due to the (still now to some extent) preliminary work of several colleagues. At this point, we would like to emphasise the altogether quite profound extent of the Varna project, which covers (and still now involves) the support of, and explicit data entry by, many different experts. In brief, the analysis of the copper tools, weapons and jewellery is in the hands of Kalin Dimitrov (Sofia) taking advantage of older results (*Todorova 1981; Dimitrov 2002*). The anthropological data is provided by Steve Zäuner (Tübingen). Verena Leusch

1 R. Krauß, J. Abele, D. Kirschenheuter, C. Schmid and B. Weninger. *Statistische Auswertung und interne Chronologie der kupferzeitlichen Bestattungen aus Varna I*. Submitted in September 2016.

(Mannheim) has developed a new typology of the gold objects based on the existing classification undertaken by Henrieta Todorova and Ivan Vajsov (*2001*). For the stone tools and weapons, as well as for the ceramic vessels, we developed our own classification. Based on all the available information, as presently stored within the master-database, but which is even now being extended to enable stepwise publication of successive Varna volumes, a wide range of studies has been possible from fields such as artefact description, bi- and multivariate analysis of the find contexts; definition, visualisation and mapping of the different cemetery phases *etc*. In the present article, we put focus on the results of CA and SNA, and their implications for the relative chronology of the cemetery. We also note that, although an earlier published CA of all graves and attributes displayed a rather indifferent statistical distribution of the graves and their inventories (*Krauß* et al. *2014*), in the meantime we recognised that a determined and systematical data reduction (both in terms of graves and variables) allowed us to significantly enhance both the archaeological comprehensibility of the seriation, as well as the achieved temporal resolution. Before continuing, we comment briefly on some of the underlying (general) properties of the Varna cemetery as seen from the perspective of the present master-database.

One of the main factors influencing the database is the highly unequal distribution of the objects among the graves. For example, when examining only gold objects, already one third of all finds originate from the particularly richly furnished Grave 43, and a further third are divided between the rich symbolic graves and deposits 1, 4, 36, 41, and 63a. In addition to the gold objects, stone beads and jewellery made from mussel and snail shells are also extremely unevenly distributed among the graves. What complicates matters, if only from the chronological perspective, is that such differences in furnishing primarily reflect social aspects, whereby such ritual practices contribute little to the targeted chronological order of the graves. On these grounds, when approaching the chronological dimension, we found it useful to work with a carefully binarised data set, which uses only presence-absence relationships. Note that this applies only to the multivariate statistical analyses, not to the contents of the master database itself. With this approach, but as we learnt only after many experiments, even applying a limited amount of data filtering was sufficient to achieve the targeted 'ideal' shape for the CA, in which the factor-scores for the database-rows (graves, symbolic burials, deposits) and for the columns (attributes) are arranged along a parabola-shaped regression curve (Fig. 1 and Tab. 1). During the experiments that finally led us to establish this (altogether quite satisfactory) result, filtering was executed manually by implementing archaeological considerations with respect to the significance of the individual grave goods under study[2]. Looking critically at the achieved CA, we note that the applied manual optimisation method of 'selective sampling without later replacement' may have introduced some unrequested bias (towards certain grave goods, and away from others), but which was unavoidable due to the huge amount of possible permutations. In this respect, the CA results may be improved in the future by applying some kind of automated outlier analysis. For the moment, we are satisfied that the CA achieved thus far is a step forward in comparison to our initial seriation attempts (*Krauß* et al. *2014*).

The next (immediately following) question is now, of course, which end of the CA represents the earliest burials and which are the latest? Assuredly, the wrong way to answer this question is to look at the available $^{14}$C-dates, but this may not be immediately obvious to all readers. We will return to this question below. As a perhaps more viable alternative, we have applied an easy-to-install archaeological method, which is to include in the CA the three graves from Varna II, which count as the predecessors of Varna I (*Ivanov 1978*), and have a quick look at which end of factor 1 the corresponding CA-scores come to lie (Fig. 2). Naturally, the results remain to be independently confirmed. Most striking are the numerous grave goods from Grave 3 (Varna II 3), which, in addition to pottery, contains vessels, stone tools and an antler pick, various items of jewellery from various minerals, spondylus, and dentalium, as well as metal objects, namely a copper armlet, a copper finger ring, and 31 beads of convoluted gold plate. The pottery vessels from Varna II are clearly typologically earlier than those from Varna I. A single carbon date from a red deer tooth from Grave 1 (Varna II 1) independently confirms this (OxA-X-2414-52: 5934±33 BP). Within the CA, Graves 1 and 3 from Varna II lie close to each other at the same end of the curve. On the basis of their inventory, they can be placed in Phase IV of the Hamangia and Sava culture. But what does it mean that the two graves can be included in the CA of Varna I? The link

2 In this way, 59 artefacts and 33 graves were removed from the analysis step by step.

results mainly from the copper and spondylus jewellery, as well as an antler hoe and the stone adzes, hence grave goods which mostly disappear in the later phases of Varna I. They do not, however, give any information about the real age of these finds, but merely confirm that the CA begins at this end with the earliest graves. On account of its scanty burial goods, Grave 2 from Varna II anyway could only be passively included in the CA, and hence it remains meaningless regarding questions of chronology. Mo-

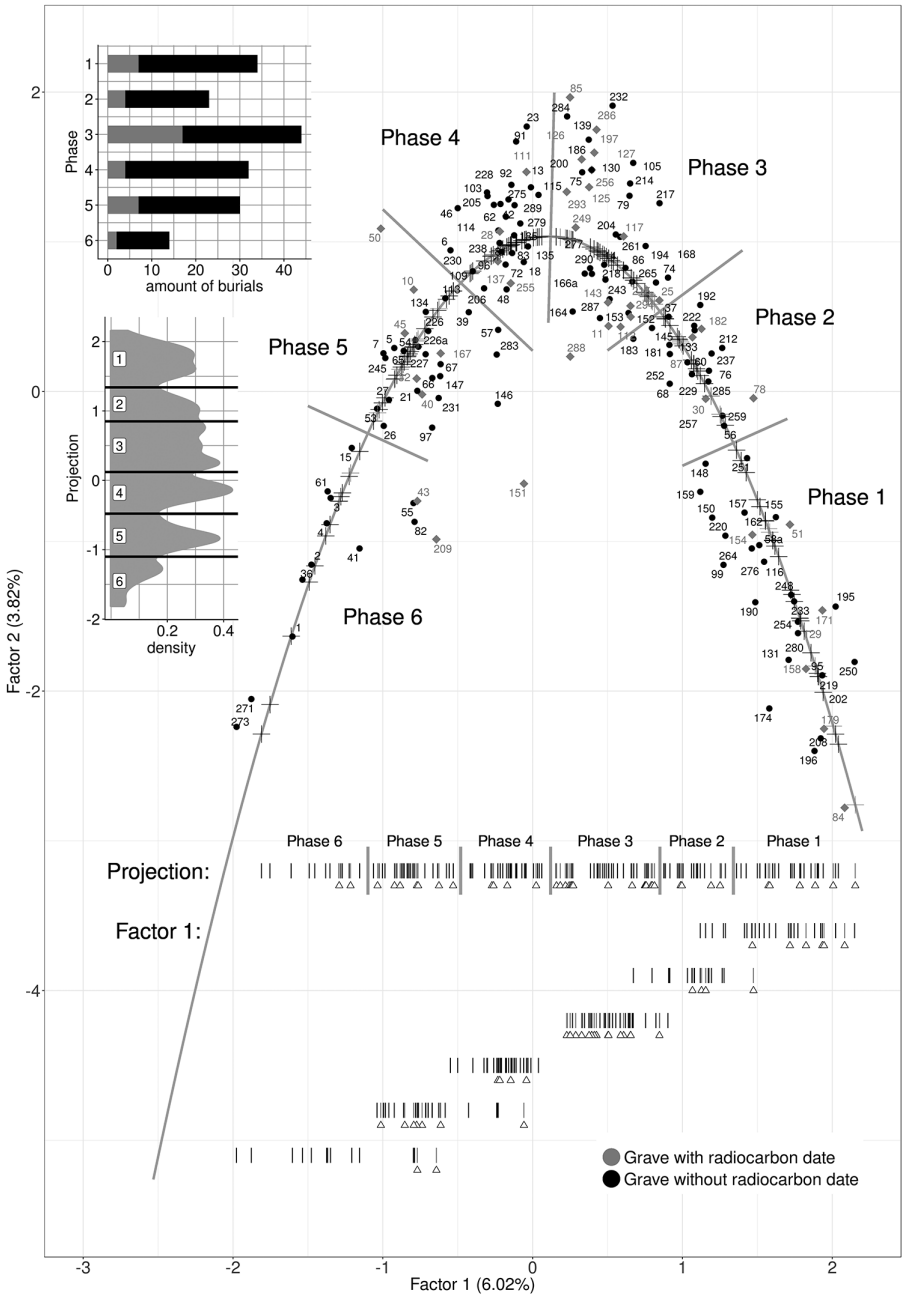



***Fig. 1. Varna I. CA-results based on the filtered data-subset of graves (N = 177) and artefacts (N = 80), with 13 $^{14}$C-dated graves added to the initial selection. Main graph: the CA point cloud is approximated by a parabolic regression curve, with six visually defined phases shown by their borderlines set perpendicular to the parabola. Cross symbols on the curve represent the exact scaling positions of perpendicularly shifted – 'projected' – grave points. Lower: a comparison of the two barcode plots (labelled 'Projection' and 'Factor 1') illustrates the enhanced phase-separation achieved by projecting grave scores onto the parabola. Their vertical projection onto Factor 1 is associated with increased phase-overlap. The small white triangles indicate graves with radiocarbon dates. Top Left: the stacked bar chart displays the number of graves per phase with and without radiocarbon dates (grey = $^{14}$C-dated graves; black = undated). The density plot below shows the date distribution along the x-axis obtained via projection (standard deviation of the smoothing kernel = 0.1).***

reover, the sequence obtained for the Varna I cemetery shows a sensible development of the ceramic vessel shapes (see below). Indeed, in the case of the specific stands and profiled pots, the development corresponds in detail to that known from tell settlements in the region.

The arrangement of the graves and their inventories shows a linear succession along the CA, which is most likely due to the equally linear sequence of the graves themselves. A bipolar interpretation of the grave succession, for example male-female, is equally unlikely and can actually be excluded altogether, due to the known CA location of many of the anthropologically determined burials. Similarly, the different anthropologically determined age groups are also spread quite evenly over the CA. Furthermore, if the CA shape were mainly due to social differences (*e.g.*, quality or choice of the burial goods), then we would expect the observed linear structure only under the condition that the differences between the poorest and richest burials were similarly graduated. In this case, the richest graves would have been grouped in one part of the CA curve and the poor ones in an opposite part, with the area in between showing a tendency from 'rich' to 'poor'. But such bi-polar distinction is clearly not the case: even if one end of the CA does indeed show some exceptionally rich tombs, especially many symbolic tombs, the rich graves occur in all sections of the CA, and the poorer graves are also spread relatively evenly over the curve. A potential CA-bias due to family relationships is also ruled out, since what we observe is a continuous spread of the graves and their inven-

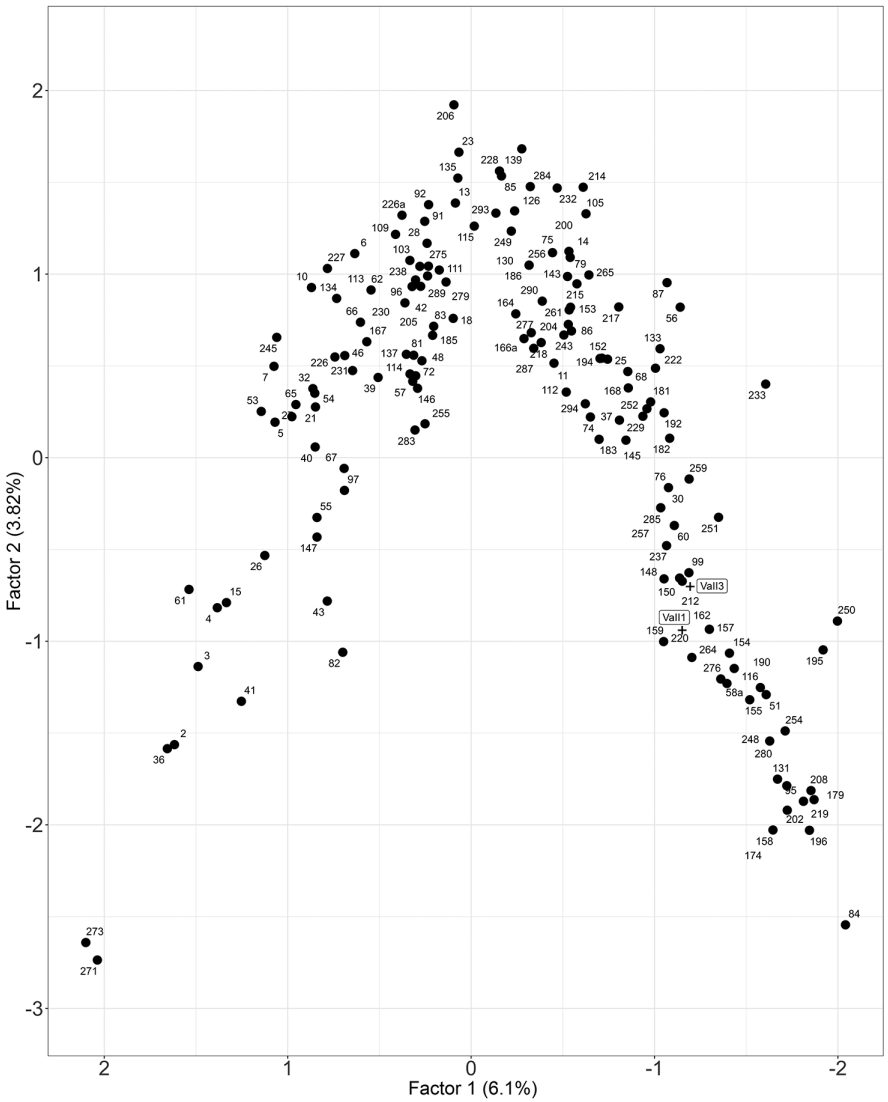



***Fig. 2. Varna I and Varna II. CA based on the filtered data-subset (as in Figure 1 but without the 13 additional graves), with two graves from Varna II added in order to identify the older and younger ends of the CA. The Varna II graves are numbered 1 and 3. Result: knowing that Varna II is older than Varna I, the chronological order represented by the CA plot becomes clear.***

tories, and this is unlikely to have been caused by family structures, at least not over the entire course of the CA. On the other hand, given the total duration of the cemetery of some 250 years, as already indicated by the $^{14}$C-dates prior to any kind of chronological conditioning, it would be anachronistic to assume no internal development of funeral rituals or grave artefacts. It is precisely this long development that can be perceived as representing a linear trend and which, in addition, shows neither a decisive interruption, nor any other kind of discontinuity for that matter. Of course, it is to be expected that existing kinship and other social relations are somewhere reflected in the CA. These relations alone, however, are not sufficient to substantiate the specific position of any of the graves within the CA. The grave position is instead due to the wider and much more elaborate sum of all its relations with all the other graves (see below), and this total relation will naturally be much stronger for burials that are closer together in time than those far apart. Taking all these arguments together, we may finally expect all existing gender, kinship and other social relations to merge together and be henceforth visible, although not separately, and indeed only under statistical conditions; but in combination they represent the most important CA factor, which is calendric time.

To evaluate the CA curve shape as a chronological sequence, two different methods are available, which may also be called different perspectives: one is to analyse the sequence of individual (one-by-one) find

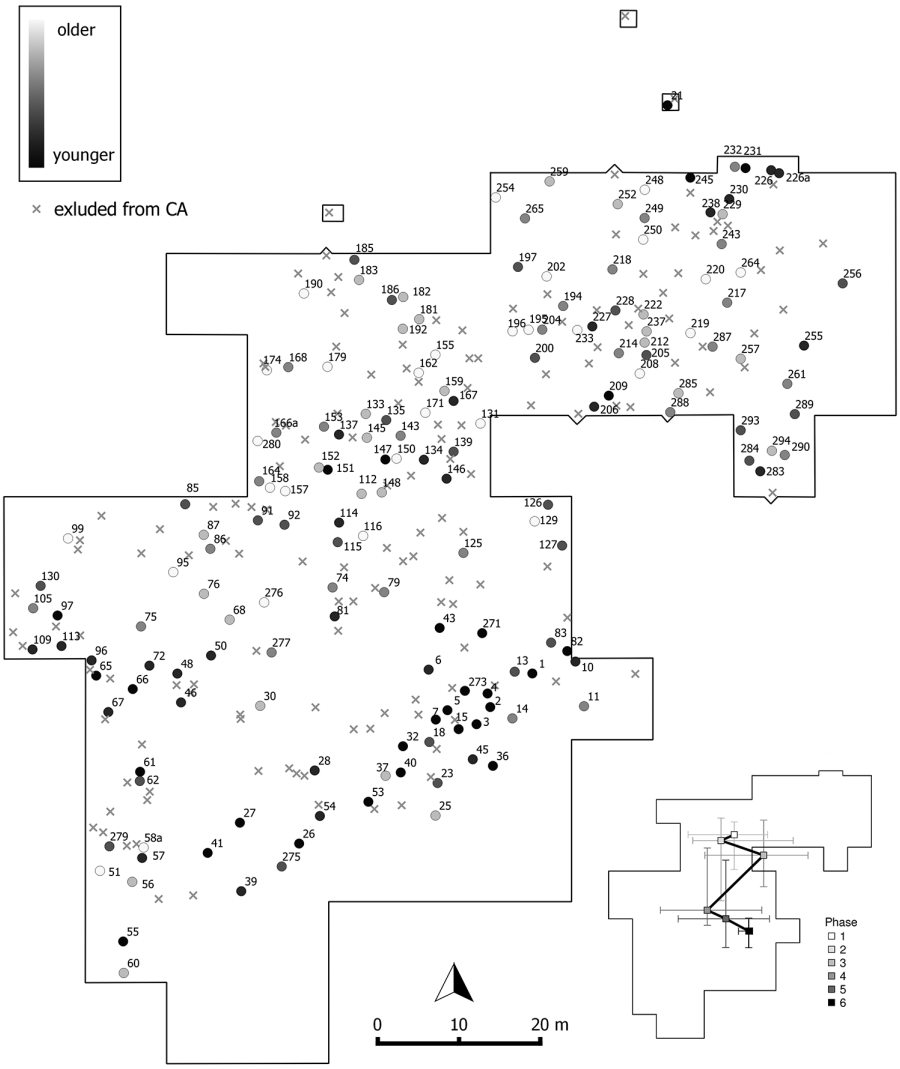



***Fig. 3. Varna I. Topographic map of the Varna cemetery, with graves (labelled by numbers) plotted as dots that have variable greyscale intensity. The grey-scale intensity is digitally calibrated (see inlay) from 'old' (light grey) to 'young' (dark black) according the rank order of each specific grave on the CA parabola (shown in Figure 1). Bottom Right: the small map shows the position of the center points by CA-phase, whereas the center is calculated as the median of the coordinate values and the whiskers display the interquartile range.***




***Fig. 4. Varna I. 1 Flat-pressed clay head of an anthropomorphic half life-size figurine from Grave 2. 2 Analogy of such a clay head from Lake Varna at Ezerovo-Arsenala (from* Slavčev *et al.* 2016.Figs. 8, 14*).***

contexts according to their position on CA factor 1; the other is to define a number of discrete sections on the parabola into which the find contexts can then be grouped. This second method is better suited to describing the overall development of forms within the burial ground, since the subdivision of the parabola into discrete sections enables a comparison of conceived phases. In addition, it is easier to visualise existing gaps and discontinuities between the (2-D) grave clusters on the CA-parabola itself, not by their (1-D) projection onto factor 1. In comparison, any existing differences in rank order are better visualised in (1-D) barcode plots. We show the existence of major differences between the two methods in Figure 1, where the upper barcode graph (named 'Projection') presents the clearly discrete CA clusters as they appear in their arrangement along the parabola, while the lower barcode graph (named 'Factor 1') displays only their partly overlapping order according to the factor 1 projection (Tab. 1). Finally, in order to describe the beginning, middle, and end of any chronological development, it may seem natural simply to choose the corresponding tripartite division. Instead, we decided upon a division into six phases, whereby it is possible to uniquely identify graves which are transitional between the three parts and to achieve a higher resolution for further observations. Based on the radiocarbon analysis, to be described below, we may assume a total duration of Varna I in the order of 250 years, so the average phase duration amounts to 42 years. Although the respective CA positions and lengths of the six phases proposed here follow to some extent naturally from the course of the CA parabola, due to given variations in the density and clustering properties of the CA, the chosen six-fold subdivision nevertheless results in a somewhat uneven distribution of the graves in terms of their targeted uniform assignation to the beginning, middle and end of the cemetery. This could indeed reflect the actual chronological dynamics of the burial sequence. As shown in the bar chart in the upper left of Figure 1, the number of graves assigned to each of the six phases varies between 14 and 44.

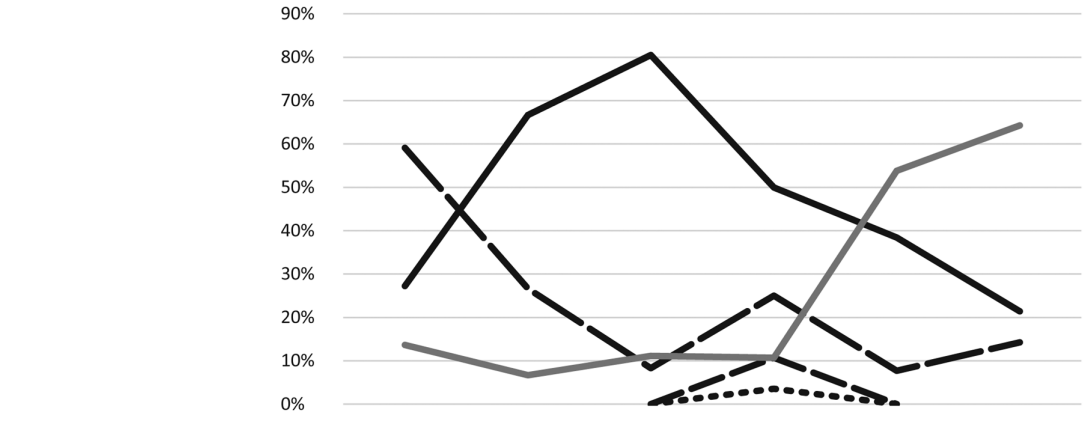
## Topographic development of the graves and burial rites

As a result of the chronological arrangement of the graves that is now available thanks to the CA application, we are immediately provided with some very welcome insights into the topographic (on-site) development of the burial sequence. As can be taken from Figure 3, the burials show a clear tendency to spread over time from the northwest to the southeast parts of the cemetery, in other words from higher to lower ground, and always in towards the bank of Lake Varna. This general trend can also be seen in the sequence of the CA phases' geographic centers (bottom right of Figure 3), which leads us to the interpretation that the first burials were situated in the northwest. Then, during the extensive use of the burial ground, the burials spread widely over the entire space, but mainly in direction of the Lake. This is most evident in the large whiskers of phases 3–5 in Figure 3. At the end period of the necropolis,

a line of very richly furnished symbolic graves and deposits appears that are most clearly distinguishable in the southwest part of the cemetery, and which simultaneously characterise the end of its occupation. Beyond this, as with the centre of the cemetery, there is a slight scattering of graves with no clear topographic tendency. Furthermore, for a number of burials in both the northern area and southern part, no exact sequence from young to old (or vice versa) can be discerned. This topographic structure of the cemetery would have been even more pronounced if we had included in the phase mapping the many graves which were removed from the CA as outliers due to their scanty burial goods.

These specific inventories were deposited in the ground in a number of rituals over a possibly longer time span, but in each case – due to their quite unusual quality – we can clearly identify the demarcation line between the living and the dead. The three symbolic Graves, 2, 3 and 15, each contain depictions of a human head. These depositions mark a prominent section along the line of graves, which itself appears to represent an entrance to the burial ground. As shown by computer tomography (*Slavchev* et al. *2016*), there is no evidence for 'mask graves' (as was previously assumed). What we instead see in these graves are round plastic figures crushed by the pressure of earth (Fig. 4.1). A parallel might be found in the head that was salvaged from the dredging of Lake Varna at Ezerovo-Arsenala (Fig. 4.2). What we can now safely reconstruct as a component of the Varna Group is the existence of roughly half life-size figures with clay heads, which were deposited in this section precisely when this burial site fell into disuse.

When one examines the development of grave types within the six phases, a tendency is evident which, despite the meagreness of only 122 identified graves in the CA, harmonises very well with the general historical development of burial customs in the KGK VI Complex, and in particular within the so-called Varna group (*cf. Lichter 2001.129–132*). At the beginning of the graveyard, crouched burials outnumber supine burials at a ratio of two-to-one, and there are very few symbolic burials (Fig. 5). But already by the second phase, supine burials very clearly dominate, while the rate of crouched burials consistently and continually declines throughout the development of the burial ground. This picture becomes more intelligible with recourse to the burial ground at Durankulak, the advent of which is primarily dominated by supine burials which are seen as a borrowing from the earlier traditions of the Hamangia Culture (*Todorova 2002.41–46*). In Varna I, it seems that, following an early phase with roughly only a third of burials supine, by the second phase this burial custom becomes generally established. In contrast, the crouched position, with the face turned to the right, is pushed back. An increase in symbolic graves is even more significantly displayed in the statistics of the burial customs. In combination, these tendencies provide reasons to conclude that parallel with the development of the site into an area for promi-




| | Phase 1 | Phase 2 | Phase 3 | Phase 4 | Phase 5 | Phase 6 | N= |
|---|---|---|---|---|---|---|---|
| supine | 27,27 | 66,67 | 80,55 | 50,00 | 38,46 | 21,43 | 72 |
| chrouched right | 59,09 | 26,67 | 8,33 | 25,00 | 7,69 | 14,28 | 31 |
| chrouched on chest | 0,00 | 0,00 | 0,00 | 10,71 | 0,00 | 0,00 | 3 |
| chrouched left | 0,00 | 0,00 | 0,00 | 3,57 | 0,00 | 0,00 | 1 |
| symbolic | 13,64 | 6,67 | 11,11 | 10,71 | 53,85 | 64,28 | 34 |
| total | 100% | 100% | 100% | 100% | 100% | 100% | 141 |

***Fig. 5. Varna I. Development of burial rites during cemetery phases 1–6.***

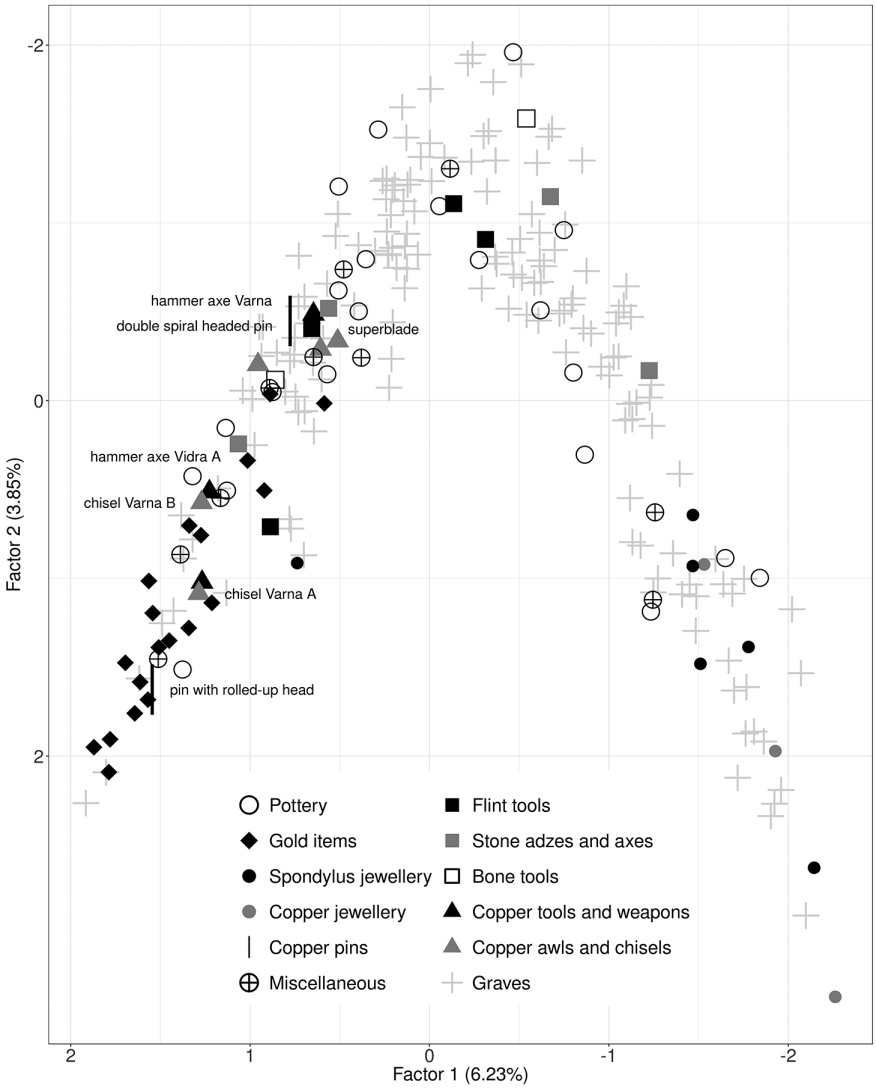



***Fig. 6. Varna I. CA based on the filtered data subset (as in Figure 1 but without the 13 additional graves), showing the different artefact types grouped according to mutually exclusive categories. Some artefact types explicitly mentioned in the text are labelled.***

nent burials, the rituals occurring around the burials also gained strongly in importance.

Especially instructive for the chronological validity of the CA are the copper tools. The first heavy copper tool to appear is the hammer axe of the Pločnik type, which goes on to endure throughout all phases thereafter. Tellingly, this is one of the typologically oldest forms, since it has a large body reminiscent of its stone predecessors (*cf. Vulpe 1975.20; Govedarica 2001.153; Diaconescu 2014*). Thereafter in the CA, and more or less consecutively, the various awls, the hammer axes of the Devnja A and Varna types, and then the hammer axes of the Vidra B, Devnja B and Vidra A types appear (Fig. 6). The end of the sequence is also well established in terms of the copper tools, namely by the occurrence of a hammer axe of Vidra C type and chisels of the Varna A and B variants. In total, the typological spectrum of copper tools and weapons becomes increasingly diverse and technically refined. Starting with modest awls and simple axes (Figs. 7–10), the development in the burial ground of Varna I becomes ever more complex, until even partially hybrid forms of weapons and tools become tangible (Figs. 11–12). At the end of this process, in symbolic Grave 4, we find a elegantly curved axe along with a singular pickaxe (Fig. 12.82), as a metallic realisation of an antler pick (*Krauß* et al. *2014.383, Fig. 10*).

The substitution of stone weapons and tools with copper examples can also be seen in the flint artefacts. Generally, the proportion of flint tools declines over the course of the development of Varna I, with the interesting exception of so-called superblades (*Manolakakis 2005.273–275; Gurova 2013.387–*

*388*), but to which we must ascribe some very different functions and meanings: not only do their numbers increase over the course of the development, but superblades are often associated with gold jewellery and heavy copper tools. Focusing on the polished stone tools, it is the adzes originating from the Neolithic tradition which dominate at the beginning. From the middle of the development until its end, what we observe as characteristic are the many finely shaped stone axes, some of which are so delicately worked that it might be surmised they are the symbolic realisations of copper axes.

Also illuminating is the development of items of jewellery made of gold, copper, dentalium and spondylus. At the beginning of the CA, objects fashioned from spondylus and jewellery created from copper predominate. More interesting, however, is the fact that, with the first appearance of gold objects, copper is used increasingly for tools, but no longer for jewellery (Figs. 7–12). Here, a development may be traced which begins with natural materials (spondylus, stone, antler) and further continues with copper as a raw material, before copper itself is replaced by gold in metal jewellery. Copper jewellery occurs only in the early phases, 1 to 3, and thereafter disappears almost entirely. The only copper adornments from the later phases which still appear are pins with rolled-up heads, and double-spiral-headed pins. Interestingly, and quite unlike other copper jewellery, these pins are always associated with gold. They call to mind some double-spiral-headed pins deriving from burnt houses in Pietrele in trenches B and F (*Hansen* et al. *2009.56–60*). The relevant contexts are dated to 4430–4280 cal BC and 4410–4260 cal BC, respectively (*Hansen* et al. *2010.Fig. 2*). As will be shown below, both these dates correspond to the end of the CA, in which the double-spiral-head pins also occur in Varna I.

From a chronological perspective, the most convincing development which reveals itself in the CA is that of ceramics, which corresponds entirely (*cum grano salis*) with the stratigraphic sequences known from the tell settlements of the KGK VI Complex[3]. This having been stated, we can focus on some difficulties that are evident in the development of certain forms that do not appear in the settlements. Presumably, these ceramic forms were either deliberately (and additionally) produced for funerary use, or they were restricted solely to the distribution region of the Varna Group, where they have comparisons with developments at the burial ground of Durankulak, as well as with the burial group at Varna II. Specific comparisons are the ceramic stands which appear in the CA in a development sequence comparable to that of Durankulak (*Todorova 2002.86–114*). The four-cornered stands of the early phases of Durankulak (Hamangia IV and Varna Group I) are present only at Varna II (Fig. 13). At Varna I, the development begins with such stands, still with very short

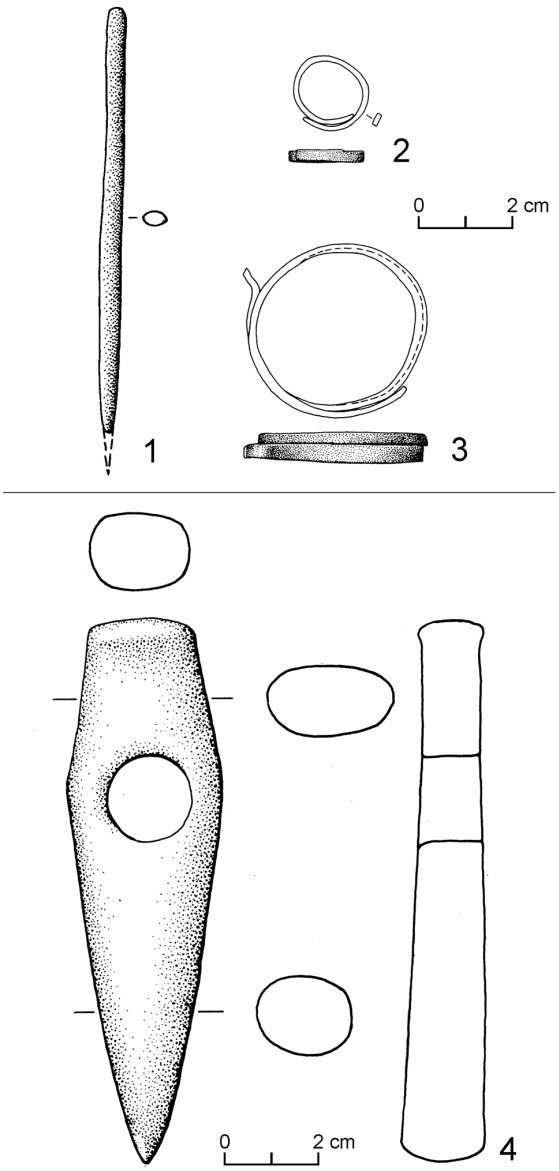



***Fig. 7. Varna I. Typical equipment of metal tools and jewellery for the first phase. 1–3 two copper rings and a copper awl from Grave 51 (♂, 20–40 years, supine); 4 copper hammer-axe type Pločnik from Grave 116 (♂, 7–12 years, supine) (1–3 from* Todorova, Vajsov 2001; Todorova 1981*; 4 drawing made by Moni Möck. Anthropological determination done by Steve Zäuner).***

3 For example, at Goljamo Delčevo V–XVII (*Todorova* et al. *1975.Taf. 41–108*) or Ovčarovo XI–XIII (*Todorova* et al. *1983.Taf. 78–88*).

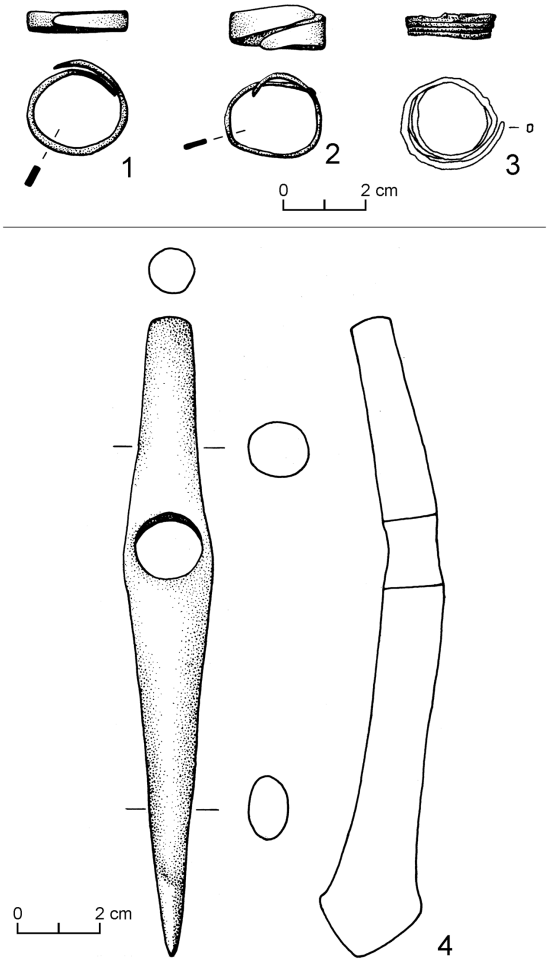



***Fig. 8 . Varna I. Typical metal objects for the second phase. 1–3 three copper rings from Grave 60 (20–40 years, crouched right); 4 copper hammer-axe type Devnja from Grave 229a (anthropologically indeterminable) (1, 2, 4 drawings made by Moni Möck; 3 from* Todorova, Vajsov 2001. *Anthropological determination done by Steve Zäuner).***

points on the rim and the routine incised adornment. From these developed the remaining types over time with their increasingly swollen bodies and increasingly long points, and finally at the very end, ornate examples painted in multiple rows with graphite ornamentation appear. With respect to the vessel inventory from the tell settlements, the Varna vessels, which clearly stand in a Boian tradition, catch the eye at the beginning of the development, including profiled pots, Todorovas 'Steckdosen', spherical-biconic pots, and carinated bowls. Thereafter, classic KGK VI forms follow over the entire development of Varna I. At the end are found bowls with rolled-up or flattened rims, scratch adorned, or graphite painted lids, and fine multi-component pots *i.e.* the entirety of forms which also occur in the tell settlements at the end of their development. Regarding the well-known graphite painting, in general terms this element can be regarded as a constant at Varna I. Already with the Karanovo V chronological phase (Marica Culture), this painting technique was established throughout the entire eastern Balkan region. As in the case of the burial ground at Varna I, it appears we record only a section in the middle of the development of graphite painting, and which might similarly be evidenced in many vessels of the so-called Transitional Phase from the Copper to Early Bronze Age.

## Network analysis

The analytical potential of SNA based on archaeological data has been repeatedly demonstrated (*cf. Sosna* et al. *2012; Collar* et al. *2015*) and therefore requires only minimal introduction. Based on the statistical analysis of relationships between different actors, the fundamental concept of SNA is to reveal the underlying socio-structural aspects and social patterns. Applied to the Varna I dataset, the find contexts can be understood as actors, which in the network analysis are represented as nodes, through

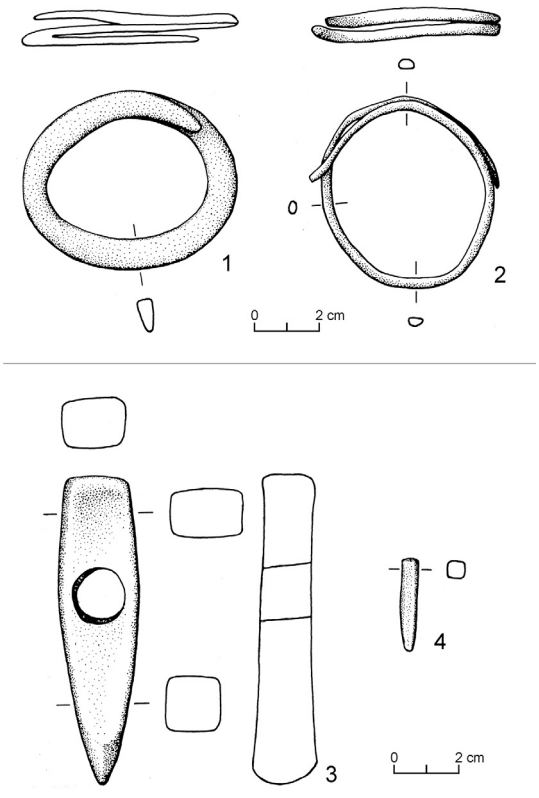



***Fig. 9. Varna I. Typical metal objects for the third phase. 1–2 two copper arm-rings from Grave 126 (♂, 20+ years, supine); 3–4 copper hammer-axe type Pločnik and copper awl from Grave 143 (♂, 30–40 years, supine) (drawings made by Moni Möck. Anthropological determination done by Steve Zäuner.***

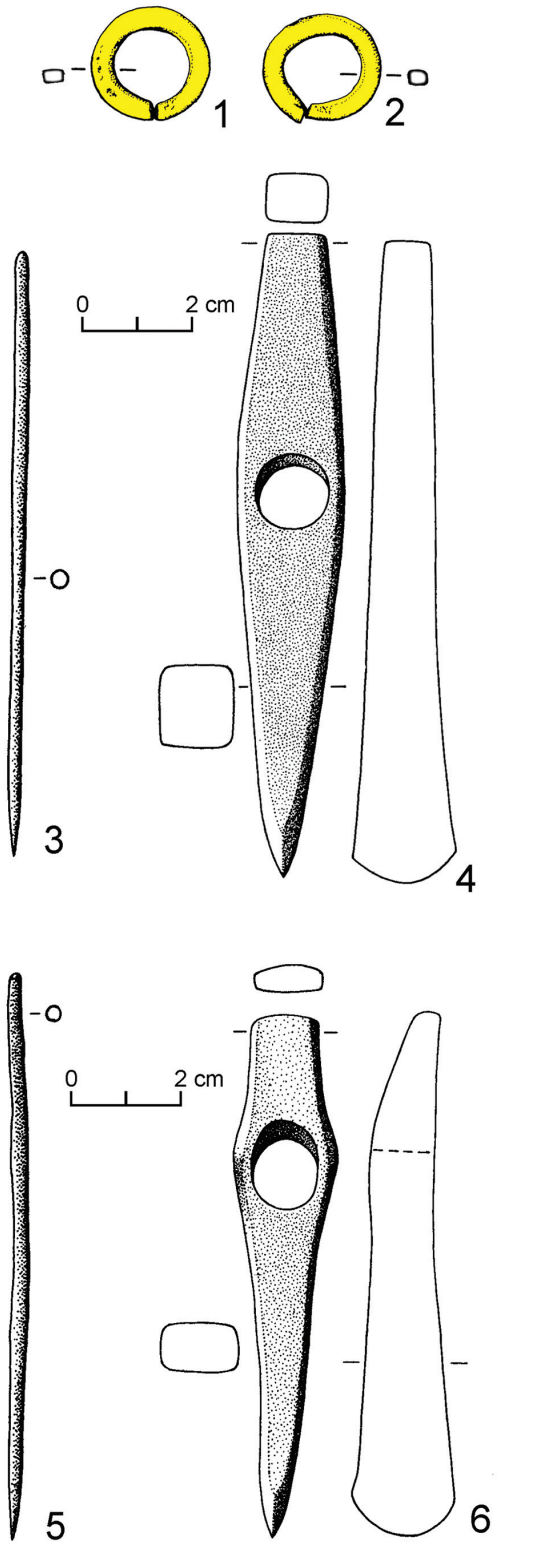



***Fig. 10. Varna I. Typical metal objects for the fourth phase. 1–4 two gold rings, a copper awl and a hammer-axe type Čoka-Varna from Grave 6 (♂?, 30–35 years, supine); 5–6 copper awl and hammer-axe type Vidra B from Grave 92 (♂, 50+ years, supine) (1–2 drawings made by Moni Möck; 3–6 from* Todorova 1981. *Anthropological determination done by Yordan Yordanov (Grave 6) and Steve Zäuner (Grave 92)).***

which the different grave goods (or other characteristics in the grave furnishing) are inter-related (*Serdült 2002.127*). The further analytical premise is that, not only does the exclusivity of individual grave goods or the diversity of grave good inventories depict important social markers, but also that some meaning may be assigned to the individual relationships. Grave 43, for example, evidences a quite unusually large number of connections to other graves, many of which are dispersed over the entire area (Fig. 14). It is hardly surprising, then, that this grave is also closely connected to the immediately neighbouring symbolic Graves 1, 2, 3, 4, and 15. The closest connection, however, is to feature 97, which is spatially located in the western area of the burial ground. What SNA also uncovers is a particular proximity between Grave 43 and the features 283 and 290 in the north-eastern part of the graveyard.

The application of SNA now allows us to further unravel the complex reasons why Grave 43 takes on its specific position on the CA curve. Essentially, the position of Grave 43 is due to its many close connections with the similar furnishing characteristics of Graves 1, 3, 4, 15, and 97, all of which date to the younger end of the CA. Nevertheless, there are a small number of features in Grave 43 which are also characteristic of the beginning of the CA. Through these few conservative elements, if only next to the generally high degree of connection, Grave 43 displays a relatively broad cross-section of the grave goods that are found in the funerary rituals. This is a specific property that Grave 43 has in common with the large majority of over-furnished graves. With the application of SNA, not only does the marked interconnection of Grave 43 within the complete relationship network of the Varna cemetery funerary rituals become clearer, but this presumably partly also explains why Chapman *et al.* developed a $^{14}$C-based chronology for the Varna cemetery which runs backwards in time (*Chapman* et al. *2006; Higham* et al. *2007; 2008*). An additional explanation for this major dating bias may also be due to the independent but chance combination of two major distorting effects: (1) an unduly smoothed construction of the calibration curve for ages around 4380 cal BC, and (2) the human 'old-age' $^{14}$C-residence effect for Grave 43 itself (see below).

## Modelling of the radiocarbon dates

In order to establish a CA-based $^{14}$C-chronology for the Varna I cemetery, we have at our disposal a total of 74 radiocarbon ages for archaeological contexts

from the Copper Age (*Mathieson* et al. *2017; Krauß* et al. *2014. Tab. 2; Higham* et al. *2017.Tab. 1; in print*) (Tab. 2). Two additional dates (Poz-71453; OxA-19872) belong to Bronze Age burials at the site. Another two dates (MAMS-15093; MAMS-15094) were processed on dentalium shells from symbolic graves, but are not further analysed here due to their clear reservoir effects. In the following, we describe the chronological results achieved by applying the 'Gaussian Monte Carlo Wiggle Matching' (GMCWM) method, which is integrated in the $^{14}$C-age calibration software CalPal (Cologne Radiocarbon Calibration and Palaeoclimate Research Package). The present analysis is based on the internationally recommended $^{14}$C-age calibration curve INTCAL 13 (*Reimer* et al. *2013*). Following the often lengthy GMCWM run-times, which typically require some 6–10 hours, the final quality control is performed by visual inspection of the calculated 'best-fit' position of the Varna data sequence, in comparison – not with the calibration curve itself – but with the raw data of the $^{14}$C-AMS laboratories that participated in the construction of INTCAL13. We regularly use this procedure, since it helps in recognising the potentially disturbing impact of remaining weaknesses in the shape of the calibration curve due to variations in data density, for example, or other kinds of statistical unevenness (*e.g.*, over-smoothing of wiggles).

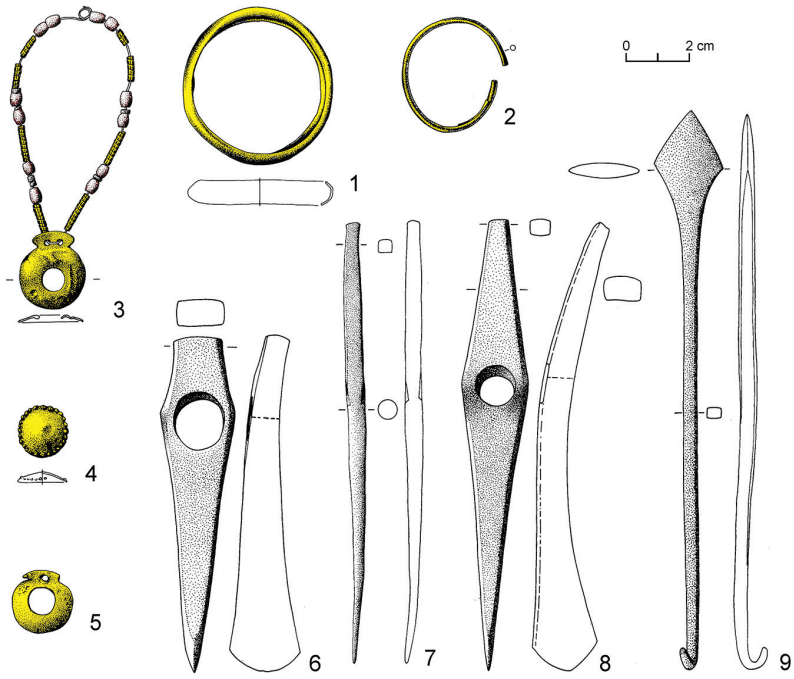



***Fig. 11. Varna I. Typical metal objects for the fifth phase: two golden arm rings, a jewellery chain with a ring idol, a golden appliqué and another golden ring idol, a copper awl, spearhead and hammer-axes of type Vidra B and type Varna from symbolic Grave 97 (1–5 from* Todorova, Vajsov 2001*; 6–9 from* Todorova 1981*).***

The applied GaussWM procedure is based on an extension of the now classical wiggle-matching method (*Pearson 1986*), whereby the archaeological sample sequence is fitted to the calibration curve by minimising the summed distances between the $^{14}$C-ages, as measured on the samples, and corresponding values of the calibration curve, as measured on dendrodated wood samples of potentially the same calendar age. In the present application, the archaeological sequence is based on a uniform-phase model such that, depending on which grave was dated, the corresponding $^{14}$C-age is assigned to one of the six different CA-phases. In modelling, each phase is then assigned an equal calendric time-span, whereby the phase-internal position of each $^{14}$C-age is chosen according to the CA-order (rank along the regression curve). During run-time, the time-span assigned to each phase is stepwise expanded; this is aimed at finding the statistically best-fitting overall time-span. Finally, also during run-time, we quantitatively account for cal-scale errors ($\sigma_{cal}$) in the CA-position of each dated grave, as well as for possible interlaboratory offsets ($\sigma_{BP}$) on the $^{14}$C-scale, by applying Gaussian variability of $\sigma_{cal} = \pm 10$ [a] and $\sigma_{BP} = \pm 10$ [BP] to these parameters. The hypothetical re-measurement of each archaeological $^{14}$C-age is allowed by applying Gaussian variability to the measured $^{14}$C-ages based on given standard deviations.

Notably, in this study we have for the first time applied a data-fitting method known as 'non-central Chi-squared' data fitting, which is described in more detail in the Rogue Wave® Fortran Numerical Libraries (IMSL® Version 6). To be specific, in programming the $\chi^2$-methodology, we use the IMSL® CSNDF library with a (typical) choice of non-centrality variable $\lambda = 5$. The use of non-central $\chi^2$-statistics has proven useful not only for the Varna data, but quite generally for cases when the statistical relation between the $^{14}$C-age calibration curve and the topological structure of the archaeological data is 'asymmetric'. This is best exemplified in the present study by the clearly artificial position of the $^{14}$C-age on the

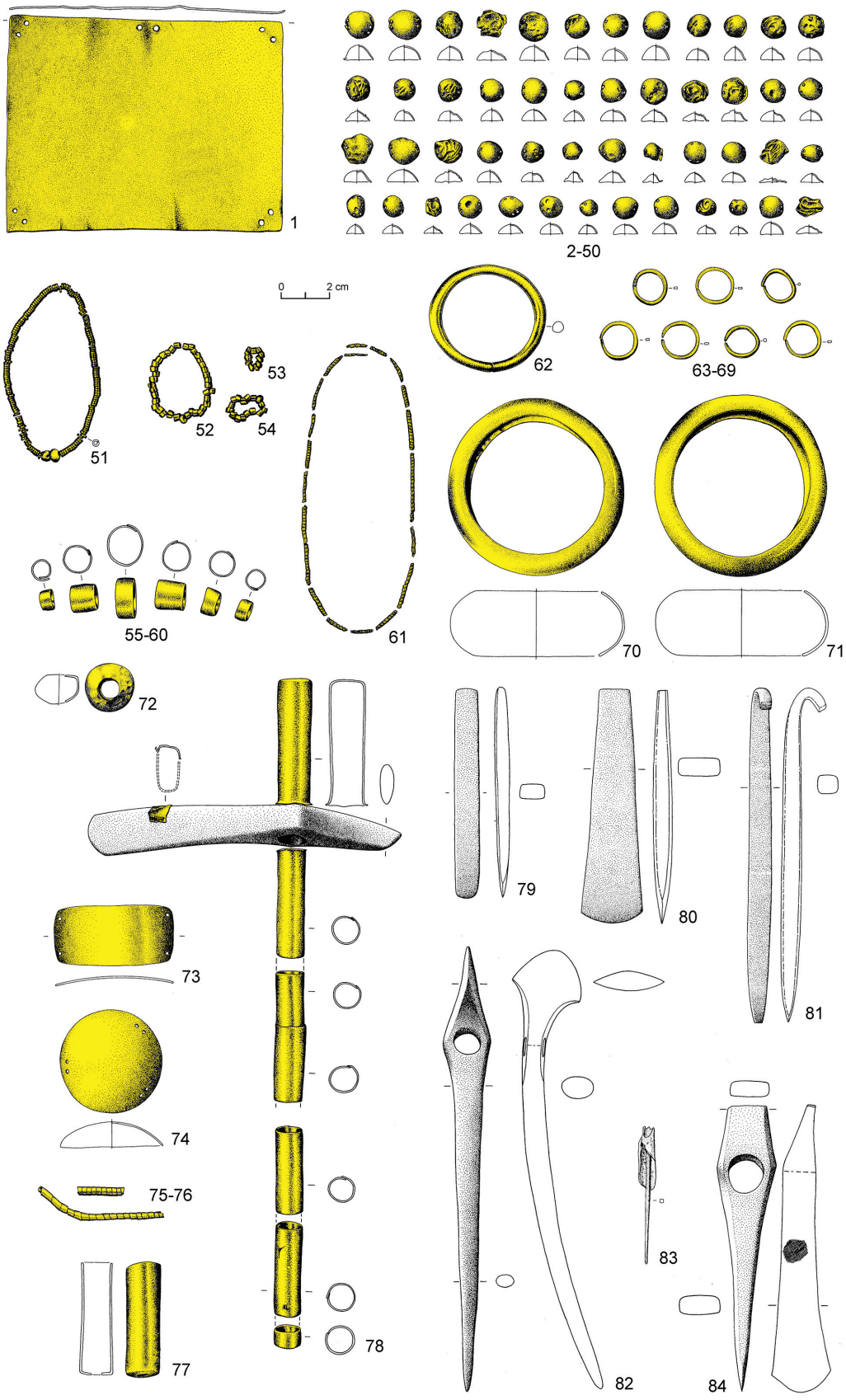



***Fig. 12. Varna I. Typical metal objects for the sixth phase: gold applications, jewellery chains of gold beads, gold rings, golden arm rings, gold clasps of a bow, a stone axe sceptre with gilded shaft, two copper adzes, a shafted copper spike, a copper pick and a hammer-axe type Vidra B from symbolic Grave 4 (1–78 from* Todorova, Vajsov 2001*; 79–84 from* Todorova 1981*).***

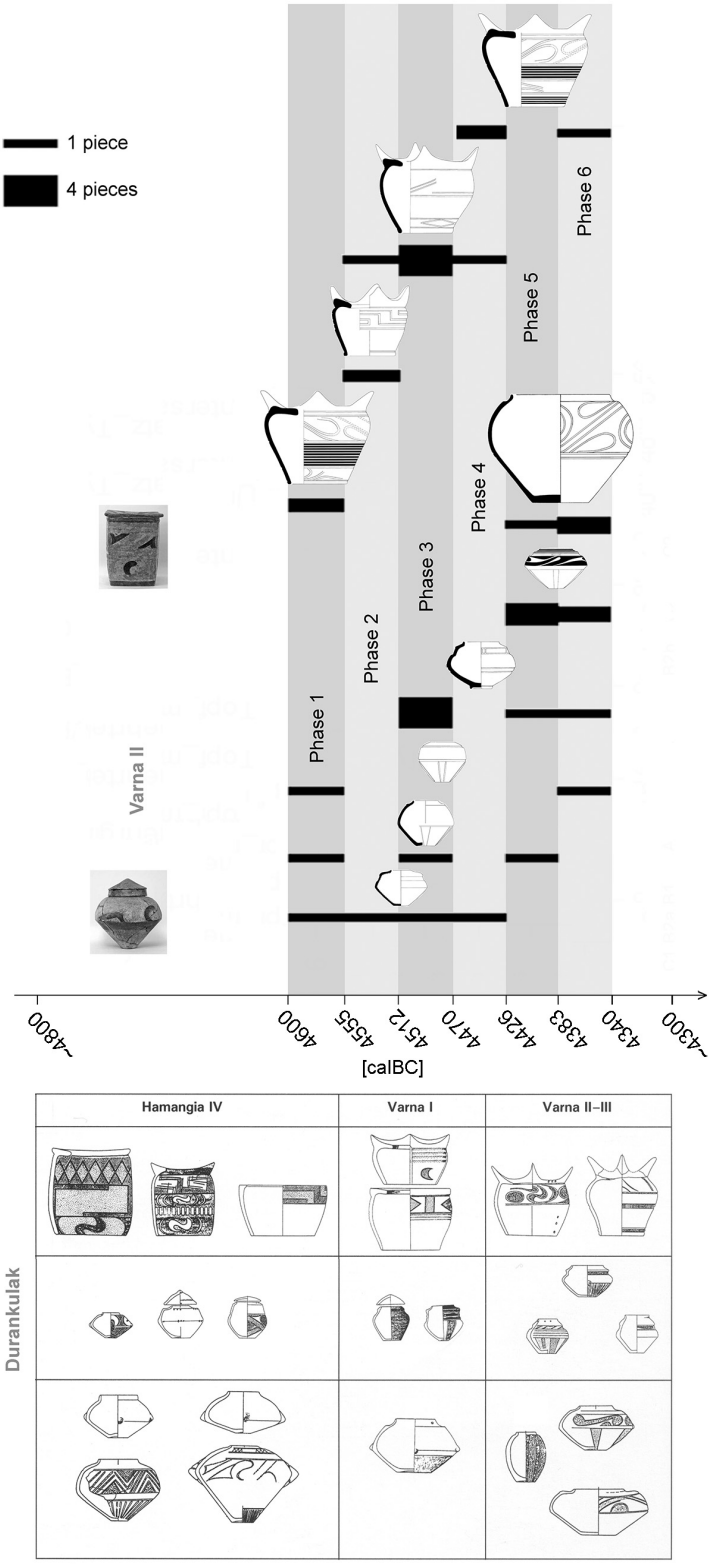



***Fig. 13. Varna I, Varna II and Durankulak. Comparison of the sequence for ceramic stands and profiled pots. The development of forms is based on a spindle diagram of all pottery types in Varna I. The absolute timeline (4300–4800 cal BC) of the pottery development is scaled according to the CA-based $^{14}$C-chronology, with shading details (4340–4600 cal BC) based on the precisely (± 20 yrs) determined time intervals for Varna phases 1–6 (see Figs. 1; 16).***

elderly man (age > 60 yrs) from Grave 43 at a $^{14}$C-value (~5700 BP) that is so high above the (presumably) itself strongly over-smoothed calibration curve that it may even appear to be a major outlier (*cf.* Fig. 15). In our view, such a large $^{14}$C-offset for the burial in Grave 43 can be satisfactorily explained only if we assume an additive combination of (1) the existence of a presently undocumented wiggle in the tree-ring $^{14}$C-age calibration curve at around 4380 ± 20 cal BC, and (2) an additional offset of some 30–50 BP for the senior citizen in Grave 43 due to the human $^{14}$C-residence ('adult') effect (*e.g., Geyh 2001; Hedges* et al. *2007*).

Conspicuously, as can be taken from Figure 15, essentially two different (alternative) solutions exist for the task of deriving a statistically 'optimal' model-chronology for the CA-seriated Varna I data, which we describe as a 'long' (primary) and a 'shorter/older' (secondary) chronology. Ultimately, the existence of such multiple solutions to the task of finding a statistically 'optimal' wiggle-matching result, although seldom discussed in the relevant literature, is not at all unexpected. It is simply a consequence, for larger data sets, analogous to the well-known existence of multiple readings for single $^{14}$C-ages. As it transpired, both solutions are highly robust and producible (as should be the case for larger data sets). For the sake of interest in such 'quantisation properties' of archaeological radiocarbon data, we nevertheless tested the co-existence of these two solutions under a wide spectrum of different methods and conditions (*e.g.*, non-central $\chi^2$ with values $0<\lambda<20$; different age-models; randomising and non-randomising sample order; systematic offsets between male and female *etc.*). Although a fair amount of unexplained variability exists, as it appears, both solutions actually do reflect the characteristic wiggle pattern of the calibration curve in combination with the given data. We finally adopted what can be termed the 'long' Varna I chronology (Fig. 16), for which the analysis most often showed the better statistical values in respect to the two parameters under study

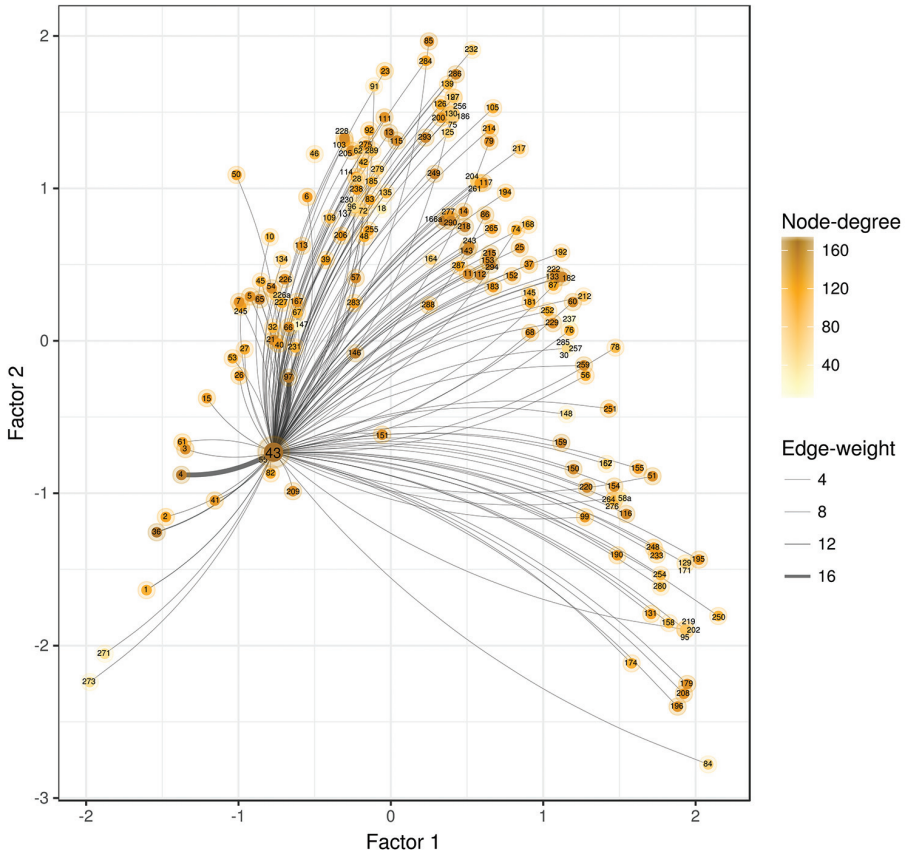



***Fig. 14. Varna I. Results of Social Network Analysis (SNA) mapped onto the CA plot (*cf. *Fig. 1). The graph shows the attributes of grave 43 scaled both according to their chronological development in the CA as well as in relation to the other graves. Node-degree (colour-intensity-scaled) describes the total number of features that are shared by grave 43 and every other (labelled) grave. Edge-weight (line-width-scaled) reflects features common to two graves.***

(probability and precision). The specific advantage of using the non-central $\chi^2$-method (with, for example, $\lambda = 5$) was that, although the results were similar to those achieved by the standard $\chi^2$-method (*i. e.* $\lambda = 0$), the run-time necessary to achieve clearly convergent results was an order of magnitude shorter (1 hour instead of 8). Also noteworthy is that the chronological results are completely robust with respect to any chance random permutation of the established grave order, and also robust regarding the definition of what may or may not be extreme values. We also used random shuffle algorithms to check that the chronological boundaries of the different CA-phases (1–6) change only insignificantly when moving data between neighbouring phases.

Our main result, shown in Figure 16, is not only that the cemetery begins at 4590 cal BC and ends at 4340 cal BC. In addition, by combining the radiocarbon ages with the results of correspondence analysis, we achieved a reasonably precise chronology (decadel-scale errors) for each grave in the CA, whether it is directly $^{14}$C-dated or not. This is important, and deserves repeating with different wording, namely: with the achieved age-calibration of the CA-scale, it is now possible to derive a calendric date for any requested grave (assuming it contains a certain minimal number of grave-goods), simply by looking up its CA position. If we now also generalise our understanding of the previously obtained age reversal, whereby a development from rich graves to poorer burials was postulated (*Higham* et al. *2007*), this is apparently due to the lack of numeric (metric) archaeological information in age-model construction. Whatever the true explanation, this chronology strongly opposes the cultural-historical reality. Only through the applied metric-scaled grave order (used in GMCWM) in contrast to the ordinal-scaled grave order (applied in Bayesian Sequencing), but even then only by applying additional cemetery-external dating knowledge to the CA-results, was it possible to identify the graves belonging to the beginning and end of the necropolis. This order is presumably confirmed by a new series of $^{14}$C-dates with Lab-Codes OxA-23611 to OxA-23626, but which we could not yet include in the analysis.

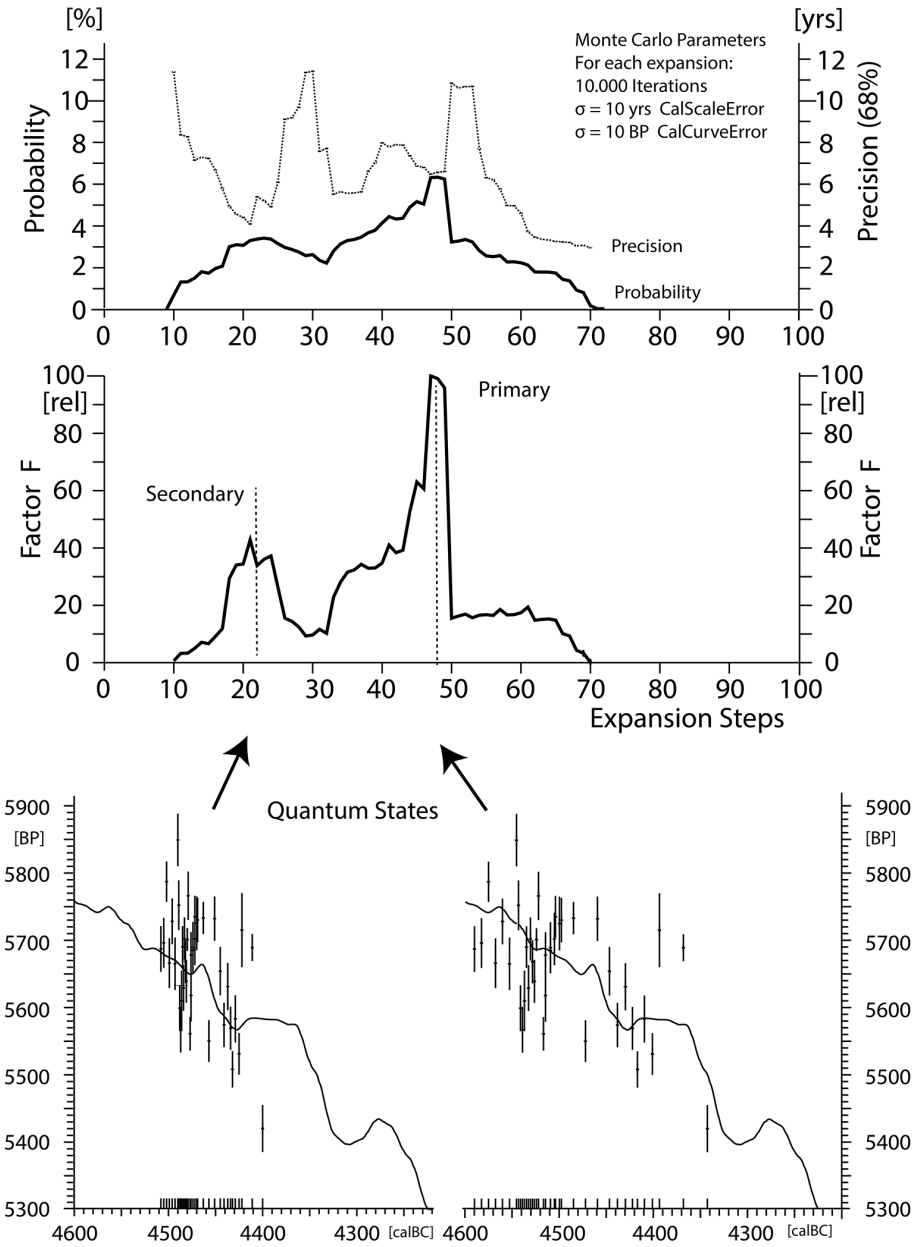



***Fig. 15. Varna I. Three graphs that illustrate the existence of essentially two different solutions for the chronological sequence of Varna I $^{14}$C-ages.***
***GaussWM-Methodology: during run-time (typically 6–8 hrs), the 6-phase Varna age-model is stepwise linearly expanded, whereby for each step the best-fitting overall length of the sample sequence is calculated and stored. Typically, the expansion is run some 1–500 times ('repetitions'); in each case, the complete expansion is subdivided into 1–100 steps, and at each step the entire age-model is varied some 100–10 000 times.***
***Upper Graph: following (in this case) some 600 000 re-modelling calculations (10 000 iterations*60 steps), two graphs are produced, one of which shows the (accumulated) probability as a function of the incremental expansion. The other shows the accumulated precision of best-fitting calendric ages (defined as 68%-width of the corresponding histogram). Middle Graph: when all runs are completed, an optimisation factor = probability/precision is defined, which represents (simultaneously) the maximum in probability and minimum in precision. The bimodal shape of Factor F, which can also be seen independently in probability and precision (cf. Upper Graph), is highly indicative of the existence of two quite distinct 'optimal' solutions (named Primary and Secondary). Both solutions have relatively high maximum Chi-squared probabilities (typically 5–10%, depending on model details), but the Primary solution has the typically higher probability. Lower Graph: schematic comparison of the Primary (P) and Secondary (S) age-models, showing that – in addition to its typically higher probability – the P-model (4345–4590 cal BC) completely encompasses the S-model (4400–4520 cal BC).***

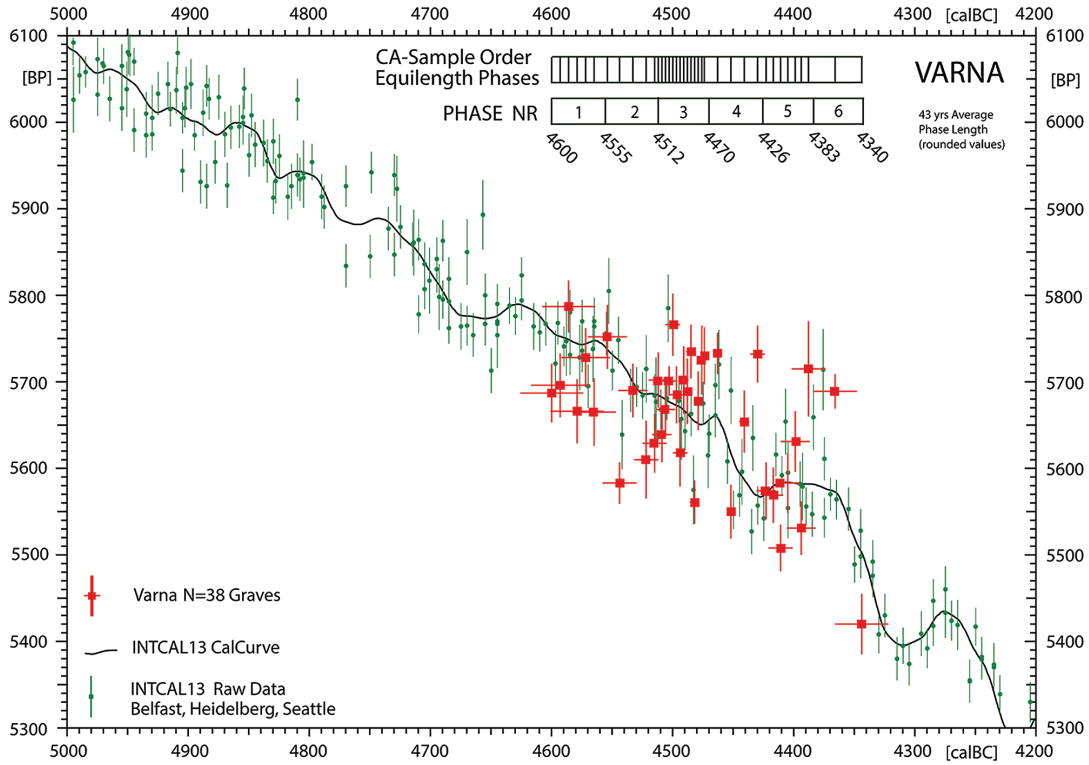



***Fig. 16. Varna I. Radiocarbon chronology based on 38 $^{14}$C-dated graves (Tab. 1) analysed by the method of GMCWM. This graph shows the best-fitting sequence of $^{14}$C-ages when modelled according to the CA-results, both in comparison to the INTCAL 13-curve (*Reimer *et al.* 2013*) and the raw data used in INTCAL13-construction. For the given time-window (4200–5000 cal BC) INTCAL13 is based on measurements by the laboratories Belfast, Heidelberg and Seattle (data available at http://www.radiocarbon.org/IntCal13.htm).***

To conclude, the derived time of around 250 years for the Varna I cemetery, when now compared with the overall sum of 270 (currently known) burials, provides us with a number of guidelines as to the role of the burial ground in the wider context of the KGK VI Complex. Even allowing for remaining unexcavated areas of the burial site, the annual frequency (~1 per year) of presently documented burials is clearly far too low, even if we assumed just a single settlement. To the same question, furthermore, the proportion of burials in comparison with the large number of symbolic burials indicates that a variety of individuals was buried at Varna I, quite possibly from different settlements. The striking importance of the northern littoral of Lake Varna for contemporary Chalcolithic societies is already elucidated in the existence of the Varna II burial group, and this is, of course, further demonstrated by the exceptional richness of Varna I. Also remarkable, however, is the appearance of the symbolic graves on the south-eastern edge of the burial ground, through which the site was finally sacralised. Nevertheless, the search for a settlement that corresponds to the necropolis on grounds of the demographic data and now largely clarified chronological depth may be less expedient than perhaps anticipated. Rather, we should perceive Varna I as a prominent burial site within a larger settlement area of the KGK VI Complex, and which certainly encompasses the known tell settlements in the hinterland of the western Black Sea Coast.

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***Tab. 1. Varna I. Results of CA and rank order analysis of the filtered and enlarged data-subset (cf. Figure 1). The first two result dimensions of the CA are presented in comparison to their 'projected' counterparts. Each grave is assigned a rank and phase according to its position along the regression curve. The coordinates are rounded up to four decimal places.***

| grave | factor 1 | factor 2 | factor 1 projection | factor 2 projection | rank | phase |
|---|---|---|---|---|---|---|
| 273 | −1,9763 | −2,2391 | −1,8103 | −2,2869 | 177 | 6 |
| 271 | −1,8777 | −2,0533 | −1,7528 | −2,0904 | 176 | 6 |
| 1 | −1,6034 | −1,6358 | −1,6116 | −1,6331 | 175 | 6 |
| 36 | −1,5366 | −1,2562 | −1,4912 | −1,2719 | 174 | 6 |
| 2 | −1,4768 | −1,1558 | −1,4534 | −1,1641 | 173 | 6 |
| 41 | −1,1554 | −1,0479 | −1,3809 | −0,9641 | 172 | 6 |
| 4 | −1,3747 | −0,8795 | −1,3523 | −0,888 | 171 | 6 |
| 3 | −1,3485 | −0,7108 | −1,2923 | −0,733 | 170 | 6 |
| 209 | −0,6426 | −0,9865 | −1,2912 | −0,7301 | 169 | 6 |
| 61 | −1,3683 | −0,6666 | −1,28 | −0,7018 | 168 | 6 |
| 82 | −0,7884 | −0,8699 | −1,2699 | −0,6766 | 167 | 6 |
| 55 | −0,7953 | −0,7447 | −1,2249 | −0,5664 | 166 | 6 |
| 43 | −0,7696 | −0,7306 | −1,2157 | −0,5442 | 165 | 6 |
| 15 | −1,2075 | −0,3762 | −1,1538 | −0,3997 | 164 | 6 |
| 26 | −0,9938 | −0,2292 | −1,0616 | −0,1971 | 163 | 5 |
| 151 | −0,0579 | −0,6152 | −1,0352 | −0,1421 | 162 | 5 |
| 53 | −1,0383 | −0,1143 | −1,0249 | −0,1208 | 161 | 5 |
| 97 | −0,6707 | −0,2408 | −1,0025 | −0,0754 | 160 | 5 |
| 27 | −0,9591 | −0,0552 | −0,9856 | −0,0418 | 159 | 5 |
| 40 | −0,738 | −0,0192 | −0,9222 | 0,0798 | 158 | 5 |
| 21 | −0,7698 | 0,0049 | −0,9192 | 0,0854 | 157 | 5 |
| 231 | −0,6273 | −0,0432 | −0,9063 | 0,1091 | 156 | 5 |
| 32 | −0,774 | 0,0866 | −0,8847 | 0,1484 | 155 | 5 |
| 245 | −0,9833 | 0,224 | −0,8761 | 0,1637 | 154 | 5 |
| 7 | −0,9959 | 0,2556 | −0,8659 | 0,1817 | 153 | 5 |
| 66 | −0,6697 | 0,0906 | −0,8567 | 0,1979 | 152 | 5 |
| 147 | −0,617 | 0,1028 | −0,837 | 0,2317 | 151 | 5 |
| 5 | −0,9236 | 0,2909 | −0,8335 | 0,2379 | 150 | 5 |
| 65 | −0,8604 | 0,2721 | −0,8255 | 0,2514 | 149 | 5 |
| 146 | −0,2329 | −0,0817 | −0,8158 | 0,2677 | 148 | 5 |
| 67 | −0,6144 | 0,1829 | −0,7989 | 0,2955 | 147 | 5 |
| 227 | −0,7144 | 0,2493 | −0,7965 | 0,2995 | 146 | 5 |
| 226a | −0,7629 | 0,2995 | −0,7872 | 0,3146 | 145 | 5 |
| 54 | −0,7821 | 0,3442 | −0,7725 | 0,3381 | 144 | 5 |
| 45 | −0,8536 | 0,3891 | −0,7725 | 0,3382 | 143 | 5 |
| 167 | −0,6139 | 0,2553 | −0,7644 | 0,3509 | 142 | 5 |
| 226 | −0,6967 | 0,4046 | −0,7195 | 0,4199 | 141 | 5 |
| 134 | −0,7131 | 0,5323 | −0,6654 | 0,4981 | 140 | 5 |
| 283 | −0,2398 | 0,2472 | −0,6337 | 0,5414 | 139 | 5 |
| 10 | −0,7938 | 0,6799 | −0,6253 | 0,5526 | 138 | 5 |
| 113 | −0,5831 | 0,6232 | −0,5751 | 0,6167 | 137 | 5 |
| 39 | −0,4264 | 0,53 | −0,5569 | 0,6388 | 136 | 5 |
| 50 | −1,0132 | 1,0884 | −0,5307 | 0,6696 | 135 | 5 |
| 57 | −0,2302 | 0,4118 | −0,5288 | 0,6718 | 134 | 5 |
| 206 | −0,324 | 0,6894 | −0,4177 | 0,7883 | 133 | 4 |
| 6 | −0,5485 | 0,9435 | −0,4101 | 0,7954 | 132 | 4 |
| 109 | −0,3992 | 0,8034 | −0,4002 | 0,8045 | 131 | 4 |
| 48 | −0,1739 | 0,6825 | −0,3201 | 0,8721 | 130 | 4 |
| 46 | −0,5 | 1,2247 | −0,2773 | 0,9035 | 129 | 4 |
| 255 | −0,1464 | 0,7236 | −0,2719 | 0,9072 | 128 | 4 |
| 230 | −0,2384 | 0,8771 | −0,2626 | 0,9134 | 127 | 4 |
| 96 | −0,2384 | 0,8771 | −0,2626 | 0,9134 | 126 | 4 |
| 137 | −0,232 | 0,8702 | −0,2613 | 0,9143 | 125 | 4 |
| 72 | −0,1804 | 0,848 | −0,2323 | 0,9328 | 124 | 4 |
| 81 | −0,208 | 0,929 | −0,2159 | 0,9426 | 123 | 4 |
| 238 | −0,2209 | 0,9922 | −0,1988 | 0,9523 | 122 | 4 |
| 114 | −0,2288 | 1,0755 | −0,1734 | 0,9657 | 121 | 4 |
| 28 | −0,2194 | 1,069 | −0,1691 | 0,9679 | 120 | 4 |
| 83 | −0,1368 | 0,9251 | −0,1595 | 0,9725 | 119 | 4 |
| 103 | −0,3011 | 1,3058 | −0,1494 | 0,9773 | 118 | 4 |
| 228 | −0,3045 | 1,3295 | −0,1453 | 0,9792 | 117 | 4 |
| 205 | −0,2587 | 1,2467 | −0,1405 | 0,9814 | 116 | 4 |
| 62 | −0,2148 | 1,2526 | −0,1124 | 0,9931 | 115 | 4 |
| 42 | −0,1786 | 1,1679 | −0,1105 | 0,9939 | 114 | 4 |
| 18 | −0,0591 | 0,8649 | −0,1095 | 0,9943 | 113 | 4 |
| 185 | −0,1234 | 1,0432 | −0,1053 | 0,9959 | 112 | 4 |
| 275 | −0,1611 | 1,283 | −0,0723 | 1,0075 | 111 | 4 |
| 289 | −0,1205 | 1,2445 | −0,0538 | 1,0132 | 110 | 4 |
| 279 | −0,0823 | 1,1225 | −0,0514 | 1,0138 | 109 | 4 |
| 135 | −0,0311 | 0,9691 | −0,0438 | 1,016 | 108 | 4 |
| 92 | −0,1417 | 1,3806 | −0,0434 | 1,0161 | 107 | 4 |
| 91 | −0,1102 | 1,6698 | 0,0059 | 1,0272 | 106 | 4 |
| 111 | −0,0416 | 1,4662 | 0,0234 | 1,03 | 105 | 4 |
| 13 | −0,0114 | 1,3641 | 0,0326 | 1,0314 | 104 | 4 |
| 23 | −0,0396 | 1,7697 | 0,0434 | 1,0327 | 103 | 4 |
| 115 | 0,0391 | 1,3132 | 0,0614 | 1,0344 | 102 | 4 |
| 284 | 0,2302 | 1,8373 | 0,1564 | 1,0338 | 101 | 3 |
| 85 | 0,2497 | 1,9647 | 0,1593 | 1,0336 | 100 | 3 |
| 293 | 0,2277 | 1,3334 | 0,1845 | 1,0305 | 99 | 3 |
| 126 | 0,3271 | 1,5509 | 0,219 | 1,0245 | 98 | 3 |
| 139 | 0,3746 | 1,682 | 0,2282 | 1,0226 | 97 | 3 |
| 200 | 0,3307 | 1,4643 | 0,2306 | 1,022 | 96 | 3 |
| 286 | 0,4266 | 1,7486 | 0,2439 | 1,0189 | 95 | 3 |
| 127 | 0,4118 | 1,5953 | 0,2551 | 1,016 | 94 | 3 |
| 197 | 0,4118 | 1,5953 | 0,2551 | 1,016 | 93 | 3 |
| 130 | 0,3943 | 1,4802 | 0,2622 | 1,014 | 92 | 3 |
| 186 | 0,3943 | 1,4802 | 0,2622 | 1,014 | 91 | 3 |
| 256 | 0,3943 | 1,4802 | 0,2622 | 1,014 | 90 | 3 |
| 75 | 0,3943 | 1,4802 | 0,2622 | 1,014 | 89 | 3 |
| 249 | 0,2876 | 1,0955 | 0,264 | 1,0135 | 88 | 3 |
| 232 | 0,5336 | 1,909 | 0,2687 | 1,0121 | 87 | 3 |
| 125 | 0,3768 | 1,365 | 0,2709 | 1,0114 | 86 | 3 |
| 105 | 0,6715 | 1,5269 | 0,3861 | 0,965 | 85 | 3 |
| 214 | 0,6507 | 1,3895 | 0,4099 | 0,9524 | 84 | 3 |
| 79 | 0,6466 | 1,3072 | 0,4307 | 0,9405 | 83 | 3 |
| 166a | 0,3478 | 0,7877 | 0,4372 | 0,9366 | 82 | 3 |
| 277 | 0,3837 | 0,8233 | 0,4495 | 0,9291 | 81 | 3 |
| 204 | 0,5551 | 1,0488 | 0,4685 | 0,917 | 80 | 3 |

| grave | factor 1 | factor 2 | factor 1 projection | factor 2 projection | rank | phase |
|---|---|---|---|---|---|---|
| 290 | 0,3956 | 0,7862 | 0,4792 | 0,9098 | 79 | 3 |
| 261 | 0,5842 | 1,033 | 0,4919 | 0,9011 | 78 | 3 |
| 117 | 0,6078 | 1,0359 | 0,5042 | 0,8924 | 77 | 3 |
| 14 | 0,4779 | 0,847 | 0,5086 | 0,8892 | 76 | 3 |
| 164 | 0,267 | 0,5345 | 0,5271 | 0,8753 | 75 | 3 |
| 217 | 0,8471 | 1,2578 | 0,5393 | 0,8659 | 74 | 3 |
| 218 | 0,486 | 0,7474 | 0,5665 | 0,8439 | 73 | 3 |
| 86 | 0,6197 | 0,8256 | 0,6055 | 0,8099 | 72 | 3 |
| 194 | 0,7542 | 0,9719 | 0,6065 | 0,8091 | 71 | 3 |
| 243 | 0,5141 | 0,617 | 0,6575 | 0,7605 | 70 | 3 |
| 143 | 0,5034 | 0,5953 | 0,6638 | 0,7541 | 69 | 3 |
| 265 | 0,6655 | 0,7345 | 0,6745 | 0,7432 | 68 | 3 |
| 287 | 0,4493 | 0,4906 | 0,6955 | 0,7212 | 67 | 3 |
| 74 | 0,8232 | 0,728 | 0,7477 | 0,663 | 66 | 3 |
| 288 | 0,2507 | 0,2333 | 0,7493 | 0,6612 | 65 | 3 |
| 215 | 0,6532 | 0,5719 | 0,7528 | 0,657 | 64 | 3 |
| 11 | 0,5065 | 0,4377 | 0,7581 | 0,6507 | 63 | 3 |
| 168 | 0,9035 | 0,7608 | 0,764 | 0,6438 | 62 | 3 |
| 153 | 0,64 | 0,5247 | 0,772 | 0,6341 | 61 | 3 |
| 294 | 0,6546 | 0,4993 | 0,7919 | 0,6098 | 60 | 3 |
| 112 | 0,5871 | 0,4326 | 0,7987 | 0,6013 | 59 | 3 |
| 25 | 0,8462 | 0,6088 | 0,8132 | 0,583 | 58 | 3 |
| 183 | 0,672 | 0,3522 | 0,8762 | 0,4986 | 57 | 2 |
| 152 | 0,7966 | 0,4246 | 0,8845 | 0,487 | 56 | 2 |
| 37 | 0,9076 | 0,4997 | 0,8862 | 0,4846 | 55 | 2 |
| 192 | 1,1188 | 0,5781 | 0,9168 | 0,4405 | 54 | 2 |
| 222 | 1,0785 | 0,4393 | 0,9656 | 0,3667 | 53 | 2 |
| 145 | 0,913 | 0,3117 | 0,9754 | 0,3514 | 52 | 2 |
| 133 | 1,0812 | 0,4093 | 0,9795 | 0,3449 | 51 | 2 |
| 182 | 1,1271 | 0,4187 | 0,9879 | 0,3316 | 50 | 2 |
| 87 | 1,0668 | 0,3625 | 0,996 | 0,3186 | 49 | 2 |
| 181 | 0,916 | 0,2505 | 1,0044 | 0,3049 | 48 | 2 |
| 252 | 1,0334 | 0,1951 | 1,0605 | 0,2108 | 47 | 2 |
| 60 | 1,1945 | 0,2541 | 1,0748 | 0,1859 | 46 | 2 |
| 212 | 1,2653 | 0,2912 | 1,0761 | 0,1835 | 45 | 2 |
| 68 | 0,9152 | 0,0522 | 1,0939 | 0,1521 | 44 | 2 |
| 229 | 1,0634 | 0,1156 | 1,1022 | 0,1371 | 43 | 2 |
| 237 | 1,177 | 0,139 | 1,1187 | 0,1072 | 42 | 2 |
| 76 | 1,1729 | 0,0671 | 1,1475 | 0,0536 | 41 | 2 |
| 257 | 1,1554 | −0,048 | 1,1909 | −0,03 | 40 | 2 |
| 285 | 1,1554 | −0,048 | 1,1909 | −0,03 | 39 | 2 |
| 30 | 1,1554 | −0,048 | 1,1909 | −0,03 | 38 | 2 |
| 78 | 1,4741 | −0,0445 | 1,2513 | −0,152 | 37 | 2 |
| 259 | 1,2674 | −0,1613 | 1,2579 | −0,1659 | 36 | 2 |
| 56 | 1,2784 | −0,2288 | 1,286 | −0,2252 | 35 | 2 |
| 148 | 1,1545 | −0,4819 | 1,3612 | −0,3909 | 34 | 1 |
| 251 | 1,4312 | −0,4446 | 1,3919 | −0,4615 | 33 | 1 |
| 159 | 1,119 | −0,6695 | 1,4256 | −0,5412 | 32 | 1 |
| 150 | 1,1986 | −0,842 | 1,4996 | −0,7228 | 31 | 1 |
| 157 | 1,4144 | −0,8083 | 1,5174 | −0,768 | 30 | 1 |
| 162 | 1,4144 | −0,8083 | 1,5174 | −0,768 | 29 | 1 |
| 220 | 1,2867 | −0,9627 | 1,5533 | −0,861 | 28 | 1 |
| 155 | 1,6236 | −0,8387 | 1,5548 | −0,8649 | 27 | 1 |
| 154 | 1,4664 | −0,9563 | 1,5741 | −0,9159 | 26 | 1 |
| 51 | 1,7175 | −0,8887 | 1,5828 | −0,9391 | 25 | 1 |
| 58a | 1,5128 | −1,0254 | 1,6026 | −0,9923 | 24 | 1 |
| 264 | 1,4629 | −1,0477 | 1,6038 | −0,9957 | 23 | 1 |
| 276 | 1,4629 | −1,0477 | 1,6038 | −0,9957 | 22 | 1 |
| 99 | 1,2739 | −1,1571 | 1,617 | −1,0317 | 21 | 1 |
| 116 | 1,5452 | −1,1364 | 1,6423 | −1,1015 | 20 | 1 |
| 190 | 1,4866 | −1,407 | 1,7212 | −1,3267 | 19 | 1 |
| 248 | 1,7255 | −1,3573 | 1,731 | −1,3554 | 18 | 1 |
| 233 | 1,7456 | −1,4014 | 1,7465 | −1,4011 | 17 | 1 |
| 129 | 1,9341 | −1,4611 | 1,783 | −1,5108 | 16 | 1 |
| 171 | 1,9341 | −1,4611 | 1,783 | −1,5108 | 15 | 1 |
| 195 | 2,0225 | −1,4356 | 1,7841 | −1,5141 | 14 | 1 |
| 254 | 1,7706 | −1,5371 | 1,7896 | −1,5309 | 13 | 1 |
| 280 | 1,7712 | −1,6134 | 1,8122 | −1,6002 | 12 | 1 |
| 131 | 1,7087 | −1,7916 | 1,8582 | −1,7445 | 11 | 1 |
| 158 | 1,8249 | −1,8519 | 1,8859 | −1,833 | 10 | 1 |
| 250 | 2,149 | −1,8054 | 1,901 | −1,8817 | 9 | 1 |
| 95 | 1,9331 | −1,8949 | 1,9074 | −1,9028 | 8 | 1 |
| 202 | 1,9331 | −1,8949 | 1,9074 | −1,9028 | 7 | 1 |
| 219 | 1,9331 | −1,8949 | 1,9074 | −1,9028 | 6 | 1 |
| 174 | 1,5799 | −2,1162 | 1,9394 | −2,0079 | 5 | 1 |
| 179 | 1,9451 | −2,2518 | 2,0063 | −2,234 | 4 | 1 |
| 208 | 1,9231 | −2,3158 | 2,0217 | −2,2874 | 3 | 1 |
| 196 | 1,8816 | −2,4001 | 2,041 | −2,3546 | 2 | 1 |
| 84 | 2,0825 | −2,7792 | 2,1534 | −2,76 | 1 | 1 |

***Tab. 2. AMS dated graves of the Varna I necropolis. For the $\delta^{13}C$ values, see the original publications. The truth-values given in columns 2 and 7 ('heading') indicate whether (T), or not (F), the respective graves are part of the CA and the radiocarbon model. Sex and age determinations were made by Steve Zäuner (Tübingen); burial postures were taken from the catalogue of individual graves made by Ivan Ivanov and revisited by Vladimir Slavchev. Symbols ♀ and ♂ are given for certain, (♀) and (♂) for most likely and ((♀)) and ((♂)) unsure sex determination. For multiple data used for modelling are given the weighted averages (μ) and Chi-Square Probability Test-Values (p).***

| Grave | CA | LabCode | 14C-Age [BP] | Material | Burial Type | Radiocarbon Model | Ref |
|---|---|---|---|---|---|---|---|
| 10 | T | OxA-13687 | 5569±32 | bone human | sex & age unclear, crouched left lying on the back | T | (1) |
| 11 | T | OxA-13686 | 5639±32 | bone human | sex & age unclear, crouched right | T | (1) |
| 25 | T | OxA-19867 | 5629±34 | bone human | ♂ 20–40 yrs, supine | T | (3) |
| 27 | T | MAMS-15093 | 6158±24 | shell Dentalium | symbolic | F | (2) |
| 28 | T | OxA-18575<br>OxA-23611<br>OxA-23612 | 5550±31<br>5574±31<br>5590±31 | bone animal<br>bone human<br>bone deer | 60–70 yrs, posture unclear | T: OxA-18575 | (3) |
| 30 | T | OxA-19868<br>OxA-19869 | 5567±34<br>5599±34 | bone human<br>bone human | (♀) 12–15 yrs, crouched right (?) | T: N = 2 OxA-19868 and OxA-19869, μ = 5583(24) BP, p = 51% | (3) |
| 32 | T | OxA-19870 | 5631±35 | bone human | ♂ 16–19 yrs, supine | T | (3) |
| 33 | F | Poz-71453 | 3585±35 | bone human | (♀) 7±2 yrs, crouched right | F (Bronze Age) | (5) |
| 34 | F | OxA-19871 | 5638±35 | bone human | ♂ 30–40 yrs, supine | F | (3) |
| 38 | F | OxA-19872 | 3728±31 | bone human | (♀) 40+ yrs, crouched left | F (Bronze Age) | (3) |
| 40 | T | OxA-24044 | 5531±31 | animal bone | symbolic (Figurine) | T | (3) |
| 41 | T | MAMS-15094 | 6118±24 | shell Dentalium | symbolic | F | (2) |
| 43 | T | OxA-13685<br>MAMS-15095 | 5720±29<br>5662±27 | bone human<br>bone human | ♂ 50–65 yrs, supine | T: N = 2 MAMS-15098 and OxA-13685, μ = 5689(20) BP, p = 14% | (3)<br>(2) |
| 44 | F | OxA-13692 | 5657±30 | bone human | (♀) 13+ yrs, supine (?) | F | (1) |
| 45 | T | OxA-19873 | 5583±35 | bone human | (♂) 16–25 yrs, supine | T | (3) |
| 46 | T | OxA-23613 | 5585±32 | bone human | (♀) 60+ yrs, crouched on chest | F | (3) |
| 47 | F | OxA-23614 | 5658±32 | bone human | (♂) 20–40 yrs, supine | F | (3) |
| 50 | T | OxA-19874 | 5574±33 | bone human | (♀) 18–25 yrs, supine | T | (3) |
| 51 | T | OxA-19875 | 5849±39 | bone human | (♂) 20–40 yrs, supine | F | (3) |
| 67 | T | OxA-23615 | 5717±32 | bone human | (♂) 40+ yrs, posture unclear | F | (3) |
| | | OxA-23616 | 5719±32 | bone human | | | |
| 69 | F | OxA-19876 | 5608±35 | bone human | ((♂)) 20+ yrs, supine | F | (3) |
| 72 | T | OxA-23617 | 5739±32 | bone human | (♂) 50–60 yrs, crouched lying on the back | F | (3) |
| 78 | T | OxA-19928<br>OxA-19929 | 5752±37<br>5831±39 | bone human<br>bone human | ♂ 20–30 yrs, posture unclear (and bones of a not archaeo-logically recorded second individual: [♂] 20+ yrs) | T: N = 2 OxA-19928 and OxA-19929, μ = 5789(27) BP, p = 14% | (3) |
| 84 | T | OxA-19877 | 5687±34 | bone human | 1–6 yrs, crouched lying on the back (and bones of a not archaeologically recorded second individual: ♀ 13±1 yrs) | T | (3) |
| 85 | T | OxA-19878 | 5730±33 | bone human | (♂) 25+ yrs, supine | T | (3) |
| 87 | T | OxA-24042 | 5690±31 | bone human | (♀) 12–18 yrs, posture unclear | T | (3) |
| 89 | F | OxA-23618 | 5655±32 | bone human | | F | (3) |
| 94 | F | OxA-13250 | 5626±31 | bone human | sex unclear 20-40 yrs, supine | F | (1) |
| 111 | T | OxA-13865<br>OxA-13846<br>OxA-18576 | 5855±34<br>5757±34<br>5710±33 | bone human<br>bone animal<br>antler animal | ♂ 20–60 yrs, supine (and bones of a not archaeologically recorded second individual: [[♂]] 16+ yrs) | T: N = 2 OxA-13846 and OxA-18576, μ = 5733(24) BP, p = 32% | (1)<br>(1)<br>(3) |
| 112 | T | OxA-13251 | 5702±32 | bone human | sex unclear, 25–35 yrs, supine | T | (1) |

| Grave | CA | LabCode | 14C-Age [BP] | Material | Burial Type | Radiocarbon Model | Ref |
|---|---|---|---|---|---|---|---|
| 117 | T | OxA-13848<br>OxA-13811 | 5766±36<br>5530±36 | bone human<br>bone animal | ♂ 35–55 yrs, crouched left on the chest (and bones of a not archaeologically recorded second individual: [[♀]] 20+ yrs) | T: OxA-13848 | (1) |
| 121 | F | OxA-13252<br>OxA-23619 | 5672±34<br>5771±31 | bone human<br>bone human | ♂ 50+, crouched right | F | (1)<br>(3) |
| 125 | T | OxA-13253 | 5685±33 | bone human | sex & age unclear, supine | T | (1) |
| 126 | T | OxA-19879 | 5678±34 | bone human | (♂) 20+ yrs, supine | T | (3) |
| 127 | T | OxA-24041 | 5735±31 | bone human | ♂ 25–35 yrs, supine | T | (3) |
| 129 | T | OxA-19880 | 5728±34 | bone human | (♀) 16±2 yrs, posture unclear | T | (3) |
| 137 | T | OxA-13694 | 5654±36 | bone human | sex & age unclear, supine | T | (1) |
| 139 | T | OxA-23620 | 5668±33 | bone human | (♂) 50–60 yrs, posture unclear | F | (3) |
| 143 | T | OxA-13689<br>OxA-X-225643<br>OxA-13690<br>OxA-X-225831 | 5690±32<br>5725±45<br>5700±30<br>5703±36 | bone human<br>antler animal<br>bone animal<br>antler animal | ♂ 30–40 yrs, supine | T: N = 4 OxA-13689, OxA-X-225643, OxA-13690, and OxA-X-225831, μ = 5701(17) BP, p = 94% | (1)<br>(3) |
| 151 | T | OxA-19931 | 5715±55 | bone human | ♂ 22±3 yrs, supine | T | (3) |
| 154 | T | OxA-19930 | 5665±39 | bone human | (♀) 21±3 yrs, crouched right (and bones of a not archaeologically recorded second individual: ♂ 50+ yrs) | T | (3) |
| 158 | T | OxA-13688 | 5787±30 | bone human | (♀) 5,5–6,5 yrs, crouched right | T | (1) |
|  | T | MAMS-30944 | 5755±24 | tooth human |  | F | (4) |
| 167 | T | MAMS-15097 | 5508±27 | bone human | sex unclear 13+ yrs, crouched right | T | (2) |
| 171 | T | OxA-19923 | 5666±37 | bone human | sex & age unclear, crouched right | T | (3) |
| 174 | T | OxA-23621 | 5658±32 | bone human | ♂ 40±5 yrs, posture unclear | F | (3) |
| 179 | T | OxA-19924 | 5696±37 | bone human | sex unclear 7–8 yrs, crouched right | T | (3) |
| 182 | T | OxA-225644<br>OxA-23622 | 5610±45<br>5659±31 | antler animal<br>bone human | ♂ 50+ yrs, supine | T: OxA-225644 | (3) |
| 197 | T | OxA-19925 | 5689±38 | bone human | ♀ 55+ yrs, posture unclear | T | (3) |
| 209 | T | Poz-71452 | 5420±35 | bone human | ♂ 20+ yrs, supine | T | (2) |
| 215 | T | OxA-13691 | 5668±32 | bone human | (♂) 18–25 yrs, supine (and bones of a not archaeologically recorded second individual: [♂] 60+ yrs) | T | (1) |
| 225 | F | OxA-13693 | 5660±29 | bone human | sex unclear 12–15 yrs, supine | F | (1) |
| 249 | T | OxA-19926 | 5618±39 | bone human | ♂ 40–55 yrs, supine | T | (3) |
| 255 | T | OxA-13254 | 5732±33 | bone human | ♂ 18–25 yrs, supine | T | (1) |
| 256 | T | OxA-19927 | 5702±39 | bone human | ((♂)) 40+ yrs, supine | T | (3) |
| 261 | T | OxA-24043 | 5539±32 | bone human | ♂ 50–60 yrs, supine | F | (3) |
| 286 | T | OxA-18577<br>OxA-X-225645<br>OxA-23623<br>OxA-23624<br>OxA-23625 | 5564±30<br>5555±45<br>5688±32<br>5654±31<br>5646±31 | bone animal<br>antler animal<br>bone human<br>bone human<br>bone human | ((♀)) 17–25 yrs, supine (and bones of a not archaeologically recorded second individual: sex unclear 17+ yrs) | T: N = 2 OxA-18577 and OxA-X-22645, μ = 5561(25) BP, p = 87% | (3) |
| 288 | T | MAMS-15098 | 5472±28 | bone human | ♂ 55+ yrs, supine on the right | F | (2) |
| 293 | T | OxA-X-225646 | 5725±40 | bone animal | ♂ 25–50 yrs, supine on the left | T | (3) |
| 294 | T | OxA-X-225647<br>OxA-23626 | 5860±60<br>5608±32 | antler animal<br>bone human | ♂ 20–40 yrs, supine | F | (3) |

References: (1) *Higham* et al. *2007*; (2) *Krauß* et al. *2014*; (3) *Higham* et al. *2017*; (4) *Mathieson* et al. *2017*; (5) this study

back to contents

# First isotope analysis and new radiocarbon dating of Trypillia (Tripolye) farmers from Verteba Cave, Bilche Zolote, Ukraine

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ABSTRACT – *This paper presents an analysis of human and animal remains from Verteba cave, near Bilche Zolote, western Ukraine. This study was prompted by a paucity of direct dates on this material and the need to contextualise these remains in relation both to the transition from hunting and gathering to farming in Ukraine, and their specific place within the Cucuteni-Trypillia culture sequence. The new absolute dating places the remains studied here in Trypillia stages BII/CI at* c. *3900–3500 cal BC, with one individual now redated to the Early Scythian period. As such, these finds are even more exceptional than previously assumed, being some of the earliest discovered for this culture. The isotope analyses indicate that these individuals are local to the region, with the dietary stable isotopes indicating a* $C_3$ *terrestrial diet for the Trypillia-period humans analysed. The Scythian period individual has* $\delta^{13}C$ *ratios indicative of either* c. *50% marine, or alternatively* $C_4$ *plant inputs into the diet, despite* $\delta^{18}O$ *and* $^{87}Sr/^{86}Sr$ *ratios that are comparable to the other individuals studied.*

KEY WORDS – *Trypillia farming culture; AMS dating; radiogenic isotopes; stable isotopes; diet*

## *Prva analiza izotopov in novi radiokarbonski datumi poljedelcev kulture Tripolje iz jame Verteba, Bilche Zolote, Ukrajina*

IZVLEČEK – *V članku predstavljamo analizo človeških in živalskih ostankov iz jame Verteba blizu kraja Bilche Zolote v zahodni Ukrajini. Študija je nastala zaradi pomanjkljivega števila datumov iz teh ostankov in iz potrebe po kontekstualiziranju najdb v odnosu tako do prehoda iz lovsko-nabiralniške družbe v poljedelsko v Ukrajini kot tudi glede na poseben prostor, ki ga imajo te najdbe znotraj kulturne sekvence Cucuteni-Tripolje. Novi absolutni datumi postavljajo ostanke faze BII/CI kulture Tripolje v čas ok. 3900–3500 pr. n. št., medtem ko je eden od pokopov zdaj ponovno datiran v čas zgodnjega skitskega obdobja, kar pomeni, da gre za ene najstarejših najdb te kulture. Analiza izotopov kaže, da so bili pokojni lokalni prebivalci regije, analiza stabilnih izotopov pa kaže na* $C_3$ *kopensko prehrano ljudi v času kulture Tripolje. Pokop iz skitskega obdobja kaže glede na* $\delta^{13}C$ *vrednosti na ok. 50% morske prehrane, oziroma na* $C_4$ *rastline, vključene v prehrano, kljub temu da so deleži izotopov* $\delta^{18}O$ *in* $^{87}Sr/^{86}Sr$ *primerljivi s preostalimi vzorci ljudi na najdišču.*

KLJUČNE BESEDE – *poljedelska kultura Tripolje; AMS datiranje; radioaktivni izotopi; stabilni izotopi; prehrana*

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## Introduction

This paper presents the results of an analysis of human remains from Verteba Cave in Ukraine, a unique burial site, due to the fact that fragmentary disarticulated material of Trypillia date (*Nikitin* et al. *2010*) are interred in the cave, and pathologies indicative of interpersonal violence are in evidence throughout the assemblage. The material at this site has been dated to the Eneolithic period (4900–2750 cal BC, continuing in use until the early Scythian period at *c.* 780–510 cal BC) (*Nikitin* et al. *2010* and this paper). It is likely that, given their stratigraphic context and associated material culture inventories, the original interments at Verteba belonged to the Trypillia farming groups that existed in this region of Ukraine during the Eneolithic period. However, despite a number of previous studies that consider the palaeopathology and ritual significance of this location (*e.g., Karsten* et al. *2014; 2015a; 2015b, Kadrow* et al. *2003, Kadrow, Pokutta 2016*), most of these skeletal materials are undated in absolute terms, being placed in a late chronological position within the Trypillia sequence on the basis of ceramic typology and evidence from late period settlement sites (see *Nikitin* et al. *2010* and *Kadrow, Pokutta 2016* for summaries of the history of investigations at this location).

The finds from this location are of some significance given the recent debate on the nature of the transition to farming in Europe in general (*e.g., Zvelebil 2009; Rowley Conwy 2011*, and papers in both volumes), as Ukraine has good evidence for the indigenous adoption of farming; and in particular, these remains are important in relation to the nature of the Trypillia (Tripolye) farming culture of Ukraine (*Ciuk 2008; Nikitin* et al. *2010; Menotti, Korvin-Piotrovsky 2012; Chapman* et al. *2014a; 2014b; Karsten* et al. *2014; 2015a; 2015b*), as they constitute some of the only human remains from this culture to be found so far.

Whilst Jordan K. Karsten *et al.* (*2014; 2015a; 2015b*) and Slawomir Kadrow and Dalia A. Pokutta (*2016*) have emphasised the ways in which these remains provide comparative materials for consideration of farming versus hunter-fisher-foragers lifeways in Ukraine (*e.g.*, the caries and enamel hypoplasia studies undertaken by Karsten and co-workers), and a unique opportunity to study the lives, deaths and cultural practices of the Cucuteni-Trypillia culture in Western Ukraine (as assessed by Kardow and Pokutta), these studies have, unfortunately, relied on limited absolute dating and a chronology that is primarily developed on the basis of associations between ceramic forms from other Trypillian sites. This is clearly unsatisfactory, as previous work has shown that relative chronologies can have considerable discrepancies when compared to absolute chronologies (*e.g., Telegin* et al. *2002; 2003*), and alongside these observations, the importance of the absolute dating of Verteba's burials can perhaps be further emphasised by noting that, despite the occurrence of over 1000 Trypillia settlement sites from *c.* 5400 cal BC onwards, skeletal remains and burials that date to the period before CII (pre-3400 cal BC) are almost unknown (*Kruts 2008; Korvin-Pietrovskiy 2012*).

As such, the current study not only provides an absolute dated context for human remains that are rare for the Trypillia culture in general, and unique in displaying secure evidence for interpersonal violence and a range of approaches to burial and body processing, but it also undertakes the first mobility ($^{87}Sr/^{86}Sr$, $\delta^{13}C$, $\delta^{18}O$) and dietary ($\delta^{13}C$, $\delta^{15}N$) isotope analyses of these individuals, allowing comparisons to previous studies (*e.g., Lillie, Richards 2000; Lillie* et al. *2003; 2011 etc.*). Due to their disarticulated nature, the precise context of these remains cannot be securely attributed to a late period in the Trypillian sequence (*contra Karsten* et al. *2014; 2015a; 2015b*) without absolute dating, and the diverse range of funerary activities in evidence need to be placed securely within the evolution of this farming culture if their significance is to be accurately interpreted.

In addition, while Karsten *et al.* (*2015b*) have presented a bioarchaeological analysis (dental caries rates) of the dentitions of these individuals, and compared the results to previous analyses in Ukraine (*e.g., Lillie 1996*), the fact that Trypillia populations have been shown to integrate both domesticated plants and animals, fishing, and the consumption of wild resources into subsistence strategies throughout the existence of this culture, and that there is a total absence of isotope analysis to assess the relative proportions of the resources exploited in the diets of these groups, necessitates assessment using the dietary stable isotope studies undertaken here in order to provide realistic comparative insights into subsistence practices, as the consumption of wild resources such as fish will not necessarily be visible from the dentition alone.

Finally, the fact that these remains are considered to represent secondary burials in a very structured ri-

tual context necessitates an analysis of these remains using mobility studies (*e.g.*, strontium ($^{87}Sr/^{86}Sr$), oxygen ($\delta^{18}O$) and carbon analyses ($\delta^{13}C$)) to distinguish between individuals of local and non-local origin (*Slovak, Paytan 2011*) in order to determine whether these individuals are in fact local to the region, and also to establish that they can realistically be shown to equate to the cultural groups in this region in the Eneolithic period. As such, this paper represents the first stages of an integrated scientific approach to the study of Verteba.

The AMS dating outlined below provides an absolute chronological age for each of the human individuals studied, enabling the current analyses to be considered from a precise, as opposed to relative (*e.g., Karsten* et al. *2014.19*) chronological perspective. As will be demonstrated, the absolute dating of comingled and disturbed skeletal remains is of fundamental importance when attempting to provide a secure and accurate interpretation of the evidence recovered at sites like Verteba.

### *The Trypillian Culture and Verteba Cave*

The Trypillian culture is the Ukrainian element of the Eneolithic (Copper Age) Cucuteni-Trypillia culture that expanded across a significant area of eastern Romania, Moldovia and western Ukraine, from Transylvania and the Carpathians in the east following the zonation of the forest-steppe in north-easterly direction up to the Dnieper River (*Korvin-Piotrovskiy 2012*). From south to north, the culture covers the Black Sea lowlands, extending some 150km up the Dnieper system to the north of Kiev. In the west, the Trypillia culture encompasses the River Prut to the foothills of the Carpathians, along with much of the Dniester and Bug (Buh in Ukrainian) river systems (Fig. 1). The initial formation of the culture is linked back to intensive contact with, and the expansion of, Balkan-Danube agricultural groups. The culture's name derives from the key sites of Trypillia in Ukraine and Cucuteni in Romania. Chronologically, the Trypillia culture spans the period *c.* 5000–2750 cal BC. In 1949, Tatiana S. Passek developed chronological phasing for the Trypillia culture (originally using ceramic typologies), with this being subdivided into stages A (5000–4300 cal BC), B and C, and further subdivided into BI (4300–4100 cal BC) and BII (4100–3600 cal BC), and CI (3600–3200 cal BC) and CII (3200–2750 cal BC) (*Zbenovich 1996; Burdo, Kovalyukh 1998; 1999; Rassamakin 1999; 2012; Videiko 2004; Nikitin* et al. *2010; Korvin-Piotrovskiy 2012*).

In terms of subsistence strategies, the economy of Trypillia farmers was mixed, with the exploitation of both domesticated animals and plants occurring alongside the gathering of wild foodstuffs, hunting of wild animals, and fishing (*Pashkevych 2008; Markova 2008*). Material recovered from the fired clay floors of Trypillia culture houses includes imprints from hulled wheat and hulled six-row barley (*Lillie 2008.13*), and other species have been recorded, including bread wheat, broomcorn millet, pea, bitter vetch, pulses and grapes. Gathered wild plant species include cornelian cherry, plum, hawthorn, pear and wild grape (*Pashkevych 2008*). Domesticated animals include the characteristic range of species, such as cattle, sheep/goat and pig, with the wild fauna component including red deer, roe deer, wild pig and horse (*Markova 2008*). It is important to note that even during the middle phase of the culture, across stages BII-CI, when the 'mega-sites' discussed below were flourishing, at sites such as Kolomyïshchina II (stage BII) and Kolomyïshchina I (stage CI) wild animals accounted for *c.* 80% of their faunal assemblages (*Ellis 1984; Lillie 2004*).




***Fig. 1. Map showing the extent of the Trypillia culture of Ukraine and neighbouring countries, key sites and the location of Verteba Cave ©WAERC University of Hull.***

Settlement sizes varied from small settlements in the earliest phases of the culture to the 'mega-sites' of the middle phase (phase BII-CI at 4000–3200 BC) (*Korvin-Pietrovskiy 2008; Chapman* et al. *2014*), with some 1300 settlements and cemetery sites recorded to date (*Lillie 2008*). The largest settlement site is Taljanky (also spelled Talyanki or Talianki), located between the Buh and Dnieper (Fig. 1), which is reported to have some 2700 buildings and to cover 450ha (*Kruts 2008.58*), a figure modified by the work of John Chapman *et al.* (*2014a.154*) to 340ha. Interestingly, both Taljanky and Maydanetske have been shown to contain between 20–25% more houses than indicated by previous estimates (*ibid. 2014a* and *Kruts* et al. *2011*).

Vladimir Kruts (*2008.55*) has reported that at sites such as Luka Ustynska, Soloncheny II, Veremye, Nezvysko and Lipkany, only a few solitary interments have been found for the early and middle stages of Trypillia, between *c.* 4900–3400 cal BC, and that most of these finds are poorly preserved. This observation reinforces the significance of Verteba Cave to studies of the Trypillia culture. Therefore, the new ultrafiltration AMS dates and stable isotope evidence presented here are of considerable importance to studies of Eneolithic Trypillia culture farming in Eastern Europe, and the fact that there is evidence for interpersonal violence, and evidence of the processing of human remains for burial on some of the remains from this cave also adds to the significance of this site in providing new insights into the nature of Ukraine's first farmers (*Lillie* et al. *2015*).

Verteba Cave has a long history of investigation. It was originally discovered in 1822, although human remains were first recovered from a topsoil horizon of approx. 0.45m which covered the cave floor during excavations in 1876. Subsequent work recovered Trypillia material culture remains during a 3-year excavation period between 1890 and 1892, and then during excavations from 1898–1904. The material from these excavations is housed at the Museum of Archaeology in Krakow, Poland. Additional finds of human skeletal material were made during excavations in 1914, and reported in Polish language literature (*Stojanowski 1948*), as this region shifted in sovereignty between Poland and Ukraine.

The Verteba sequence comprises three cultural horizons which, on the basis of the material culture inventory, appear to date to the BII (4100–3600 cal BC), CI (3600–3200 cal BC) and CII (3400–2750 cal BC) periods of the Trypillian chronology, representing three local groups of this culture: Schypynetska (BI/CI – 3900–3450 cal BC), Koshylovetska (CII – 3450–3100 cal BC), and Kasperivska (CII – 3125–2775 cal BC) (*Nikitin* et al. *2010.11*). Unfortunately, repeated investigations in the cave from the 1800s onwards have resulted in the mixing of cultural horizons, such that the skeletal remains cannot be attributed to an archaeological period on stratigraphical grounds alone, despite the fact that there are areas in the deposits where some stratigraphic integrity appears to remain (*Karsten* et al. *2015b.566*).

Recent research undertaken by Karsten *et al.* (*2014; 2015*) discusses the nature of pathology of the fragmentary remains from 21 individuals recovered during excavations undertaken in 2008 and 2012. However, it should be noted that, in failing to account for the probability that the remains represent different population groups from different periods, when comparing the Verteba remains to the earlier prehistoric (Mesolithic and Neolithic) populations interred in the Dnieper-Donets Mariupol-type cemeteries along the Dnieper and its tributaries (*Lillie 1996; 1998; Potekhina 1998; 1999; Telegin* et al. *2002; 2003*), these authors erroneously conclude that significantly shorter bone lengths, in addition to higher rates of enamel hypoplasias (which are non-specific indicators of stress; *Goodman* et al. *1984; Goodman, Rose 1991*) suggest that the Trypillian farming lifestyle was more stressful in terms of physiological perturbations when contrasted with the hunter-fisher-foragers of the Dnieper Rapids region. Given the fact that the earlier Mesolithic and Neolithic Dnieper-Donets populations were tall, with massive skeletons and very wide faces (with two variants in evidence – dolichocrany and mesocrany (*Potekhina 1998*)), and that Inna Potekhina (*1998.67–68; 1999;* also *Telegin* et al. *2002; 2003*) has shown that the Dnieper-Donets populations differed markedly from the Trypillia, Sredny Stog and Kemi-Oba populations, with Trypillia populations being of smaller stature and more gracile, it is apparent that using long-bone lengths as a measure of population stress between groups that are distinct in both anthropological and chronological terms is a fundamentally flawed approach.

By extension, the comparison of hypoplasia rates between the Trypillia farming population at Verteba and the Dnieper-Donets hunter-fisher-foragers is also not necessarily a viable approach as, again, these are distinct groups (and sub-groups) with very different diets. Importantly, however, the nature of the subsistence strategies being followed by Trypil-

lia groups varies over time, and in the earlier to middle stages of this group's development, wild fauna, plants and fish have been shown to make up a significant proportion of their diets. While in many regions throughout Europe, farming is synonymous with elevated incidences of stress and caries *etc.*, with hunting and gathering lifeways usually associated with low levels of stressors (*Meiklejohn, Zvelebil 1991; Lillie 1998*), the variable nature of Trypillia subsistence strategies demands that the absolute dating of the population being studied is known in order to assess the developmental and subsistence stage that is being analysed.

The evidence for inter-personal violence on these skeletal remains consists of unhealed depression fractures on at least twelve of the twenty-one individuals analysed by Karsten *et al.* (*2015*). In this sample, four skulls were shown to exhibit two or more fractures, while four skulls were also shown to have evidence of healing. This latter observation is important in indicating that, while a significant number of these injuries were due to peri-mortem events, in at least four cases the evidence suggests more than one occurrence of inter-personal violence. Malcolm Lillie *et al.* (*2015*) reported the case of a young adult, possibly a female (aged around 18–22 years at death; and probably towards the lower end of this range) who exhibited multiple peri-mortem injuries, including penetrating impact damage on the back of the vault at lambda, with blunt force compression in evidence and fragmentation of the vault (comminuted fracture, *i.e.* a break or splinter of the bone into more than two fragments) (*ibid. 2015.57*). The cranium of this individual also has evidence of the removal of bone from the right side of the vault, and cut marks on the left side of the vault, superior and posterior to the mastoid process, indicating cutting of the attachments of the neck muscles and tendons in order to detach the head from the body (*Lillie* et al. *2015.58*).

While it has been suggested that during stage CII of Trypillia, *i.e.* during the final stages of cultural development, evidence of conflict is attested through the development of fortifications at a number of settlement sites (*Korvin-Piotrovskiy 2012.6–18*), the complete lack of dating of the Verteba skeletal remains studied by Karsten *et al.* (*2014; 2015*) again means that there are no secure chronological grounds from which to attribute the interpretations of the inter-personal (peri-mortem) violence to this (CII) stage of Trypillia (*contra Karsten* et al. *2014; 2015*). As such, the current dating programme is aimed at redressing this oversight, while also determining the timing of the inter-personal violence and assessing the subsistence stage that these individuals represent in the Trypillia cultures development.

## Material and methods

The finds reported here were recovered during excavations undertaken by two of us (MPS, AGN) between 2005 and 2008 when *c.* 64m$^2$ of the cave sediments were excavated. All of the finds were allocated specimen numbers, as presented in Tables 1 and 2 (below). One if us (MPS) curates the finds; they are accessible by arrangement with the Borschiv Regional Museum, Ministry of Culture and Arts of Ukraine, Podillya Region, Ukraine.

Excavations between 2007 and 2008 were undertaken at a distance of *c.* 70m from the cave entrance. In addition to the crania discussed here, at the time of the excavations there were post-cranial skeletal remains in association, including ribs and rib fragments, vertebrae, sacrum and fragments of long bone (comprising a total of fourteen samples, which were originally analysed by Alexey G. Nikitin *et al.* (*2010*) for ancient DNA studies). More recent investigations undertaken in 2012 have suggested that a minimum of 36 individuals, recovered as comingled secondary burials, mixed with pottery, ceramic figurines, stone and bone tools, and faunal remains, are represented by the finds from Verteba (*Karsten* et al. *2014*), although as noted below (also *Lillie* et al. *2015*), the complete lack of dating means that contemporaneity has not yet been established for this material.

The analysis of seven crania (one comprising the cranium plus mandible and six that are represented only by the cranium) from the excavations at Verteba Cave included osteology, pathology, cranio-metrics and sampling for laboratory analysis undertaken by two of us (IP, ML) in September of 2011. The initial work entailed the field recording of ageing and sexing data, and the recording, measurement and sampling of the skulls for AMS dating (Tab. 1). Stable isotope analysis was subsequently undertaken on these samples at the University of Oxford (Oxford Radiocarbon Accelerator Unit) (AMS dating and $\delta^{13}C$ and $\delta^{15}N$ stable isotopes analysis) and the Laboratory for Archaeological Chemistry, University of Wisconsin ($^{87}Sr/^{86}Sr$, $\delta^{18}O$, $\delta^{13}C$).

Four of the seven crania considered in the current study were located in a cavity in the floor of the cave. The material at this location included an aurochs

(*Bos primigenius*) horn, apparently resting on a large stone 'pedestal', along with individuals 1 and 4–6. To the north of this material, there was a stone wall about a foot high 'blocking' the passage to the site from the other cave chamber. Cranium 2 was located in the north-eastern quadrant of the excavated area about 1m from the main group of crania. Two other skulls, individuals 3 and 7, were recovered from the south-eastern area of the earlier 2007–2008 excavations approx. 1.4m from the main group. The excavation areas yielded a range of material culture remains, such as charcoal, pottery and faunal material, some of which have been dated by one of us (AGN); this material indicates continued use of the cave from 3950–3540 cal BC, and into the Bronze Age at *c.* 1000–500 cal BC (*Nikitin 2011*) and the Early Scythian period at *c.* 780–510 cal BC (this report).

### *AMS dating*

AMS dating for the seven crania was undertaken at the Oxford Radiocarbon Accelerator Unit with funding from the NERC-AHRC National Radiocarbon Facility (NRCF – Project – No. NF/2011/2/18). Seven samples were processed, using a modified version of the R. Longin (*1971*) method of collagen extraction (see *Brock* et al. *2010*). Approximately 600mg of material was drilled per sample, and these samples were then subject to acid-base-acid wash pre-treatment (using 0.5M hydrochloric acid and 0.1M sodium hydroxide), gelatinized, and ultrafiltered at 30>kDa to remove contaminants at a molecular level (*Brown* et al. *1998*). The samples were then burnt on a CF-IRMS system (see *Brock* et al. *2010*), graphitized using an iron catalyst (see *Dee, Bronk Ramsey 2000*), and run on the *ORAU HVEE AMS* (*Bronk Ramsey* et al. *2004*). The collagen produced from this process was also weighed in triplicate and measured for carbon and nitrogen stable isotope ratios on an Elemental Analyser linked to a continuous flow Sercon dual inlet mass spectrometer. The calibration standard used on the mass spectrometer is alanine. The faunal samples were also processed using a modified version of the Longin (*1971*) method; however, the base wash and ultrafiltration steps were not required. Statistical analysis of the radiocarbon dates was undertaken following guidance in Oxcal, wherein the R_combine function was applied to assess whether the dates represented a single event, *i.e.* where the samples would derive from the same radiocarbon reservoir at the same time (https://c14.arch.ox.ac.uk/oxcalhelp/hlp_analysis_eg.html#r_combine).

### *$^{13}C$ and $^{15}N$ stable isotope analysis of bone collagen*

Stable isotope analysis of carbon and nitrogen from bone collagen allows for a direct assessment of prehistoric dietary pathways and protein source, particularly in the last *c.* 10 years of the individual's life (*Schwarcz, Schoeninger 1991*), although as noted by Robert E. M. Hedges and Linda M. Reynard (*2007*) this is an approximate estimation that is dependent upon the skeletal element analysed. Carbon isotope measurements of human and animal bone collagen reflects the protein component of ingested foods, which can be used to infer potential sources of dietary carbon, alongside providing information regarding ecological niches, vegetation patterning and habitat (*Schoeninger, DeNiro 1984; Lee-Thorp, Van der Merwe 1987*). Stable carbon isotope ratios ($\delta^{13}C$) measured from bone collagen can allow us to distinguish between dietary protein from marine, terrestrial and freshwater resources (*Schwarcz, Schoeninger 1991; Cerling* et al. *1997; Richards 2002; Eriksson* et al. *2008*). In addition, $\delta^{13}C$ values are influenced by the composition of the local vegetation. Plant species that utilise different photosynthetic pathways, *e.g.*, predominantly $C_3$ (Calvin-Benson) and $C_4$ (Hatch-Slack), produce distinct $\delta^{13}C$ values (as the pathways discriminate against $^{13}C$ during photosynthetic fix-

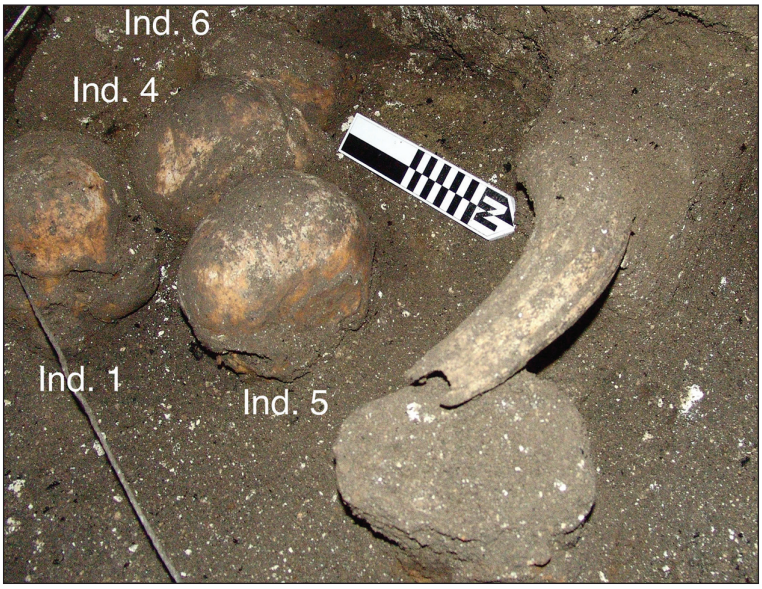



***Fig. 2. Skull deposit at Verteba Cave: four human skulls to the left of the picture, with an auroch horn resting on a large stone pedestal in the centre-right of the image (photo by M. Sokhatsky, 2008).***

ation of $CO_2$ to different extents) (*Park, Epstein 1960*).

In mammalian bone collagen, the isotopic shift between consumer and diet (*e.g.*, $\Delta^{13}C_{diet\text{-}body}$) is approx. 1‰ (*DeNiro, Epstein 1978; Casey, Post 2011*). Nitrogen stable isotope ratios ($\delta^{15}N$) are used to establish the trophic level of an organism in the food web, with $\delta^{15}N$ enrichment of approx. 3–5‰ (*e.g.*, $\Delta^{15}N_{diet\text{-}body}$) observed incrementally through the food chain (*Schoeninger, DeNiro 1984; Mülder, Richards 2005*). One limitation of the study of stable isotopes from bone collagen is that they reflect dietary proteins, but not the full dietary spectrum (*Keegan 1989; Hedges 2003*). In addition, depending on the skeletal element analysed, the rate of collagen turnover (synthesis) varies between cortical and trabecular bone (*Babraj* et al. *2002; Hedges* et al. *2007*). This also varies between different elements, and turnover rates also decrease with age. As such, Table 1 provides the age and sex distribution of the samples analysed (based on dental wear and cranial suture closure – recognising the limitations and caveats that need to be addressed in using these criteria for estimating age, *e.g., Lillie 1998*).

### *Strontium, oxygen and carbon analysis of enamel bioapatite*

Strontium (radiogenic) and oxygen (stable) represent two independent isotopic systems that can be investigated to infer information about mobility (from the local underlying geology) and climate, respectively. Assuming that an individual consumes their food and water mainly from local sources, strontium and oxygen isotopes can be used to characterise their childhood residence (*Montgomery* et al. *2007*). In general, older rocks have a higher ratio, while younger rocks have a lower ratio. The ratio of sediments depends on the ratios of the rocks from which they derive. The ratio $^{87}Sr/^{86}Sr$ moves unaltered from soil nutrients, derived from sediments, into the food chain and the human skeleton. Biosphere strontium values ($^{87}Sr/^{86}Sr$) reflect the age and type of the underlying geology, with factors such as geological drift, dust, and rainwater contributing to (and occasionally heavily influencing) isotopic values (*Price* et al. *2004*). Most of the strontium in our bodies is deposited in our bones and teeth.

Oxygen ($\delta^{18}O$) measurements for humans predominantly reflect the local drinking water, which for the most part is derived from rainwater. Oxygen isotope ratios in rainfall vary, largely based on latitude, elevation, temperature, and distance from source. The heavier isotope ($^{18}O$) precipitates more easily, so the ratio becomes lighter with lower latitudes and elevations, warmer temperatures, and proximity to source. Oxygen isotopes are less geographically specific than strontium and more difficult to interpret. Although oxygen isotope ratios in a region change with climate, $\delta^{18}O$ in modern precipitation are often used as a proxy for the local baseline. In the case of Verteba, the nearest recording station was at Lviv, some 175km northeast, but in the same general landscape as the cave at Verteba. The mean and 1 s.d. $\delta^{18}O$ at Lviv was –10.5‰ ± 2.8, with a wide range between –14.9‰ and –7.6‰. The $\delta^{18}O$ in human tooth enamel is measured in carbonate, using PDB dolomite as a standard, and these values must be converted to be comparable to $\delta^{18}O$ in precipitation.

The chemistry of tooth enamel is measured, as this material develops during early childhood and remains unchanged through life, and in many cases long after death. Thus differences between childhood isotope values in enamel and the isotope ratio of the place of burial indicate mobility during life, *i.e.* movement to a new place (*Montgomery 2002*). The enamel bioapatite of humans (and indeed all mammals) is precipitated from blood biocarbonate, which exchanges freely with body water (*Passey* et al. *2005*). Combined, these factors constitute the pool that determines bioapatite $\delta^{13}C$, $\delta^{18}O$ (*Jeffrey* et al. *2015*), and $^{87}Sr/^{86}Sr$ (*Kohn, Cerling 2002*). In $^{87}Sr/^{86}Sr$, no fractionation is evident between diet and consumer tissues (*Montgomery 2002*). For oxygen ($\delta^{18}O$), the bulk fractionation rate, $\Delta^{18}O_{diet\text{-}body}$ is approximately –9‰ to –8‰ (*Longinelli 1984; Luz* et al. *1984; Pellegrini* et al. *2011*), with the bulk value representing the three oxygen reservoirs present in $PO_4$, $CO_3$, and $OH^-$ groups (which contain oxygen contents of 35%, 3.3%, and 1.6%, respectively) (*Cerling, Sharp 1996*). The fractionation rate for $\delta^{13}C$ measurements ($\Delta^{13}C_{diet\text{-}body}$) of enamel bioapatite is approx. –12‰ (*Cerling, Harris 1999*).

The primary aim of this stage of the analysis was isotopic provenancing of the human remains, to distinguish local from non-local individuals among the samples from the site. Two faunal samples in the form of mandibular molars from domestic pig or wild boar were taken to provide an estimate of the local baseline or background range for strontium isotopes. Statistical analyses for bone collagen isotope values (carbon and nitrogen) and enamel apatite isotope values (strontium, oxygen, and carbon) were performed using the freeware statistics package 'R' (http://www.r-project.org/) by CB.

## Results

### *AMS dating*

The calibrated ultrafiltered AMS dates (Tab. 1) place the skeletal material that was investigated as part of the current study primarily within phase BII of the Trypillian farming culture. This dating indicates that the human skeletal material is in an earlier phase of this culture than has previously been recovered in Ukraine (Figs. 3, 4).

The distribution of the calibrated date ranges (Figs. 3, 4) would appear to indicate that we may well be looking at multiple phases of interment at this location, or alternatively that the material that is found in secondary contexts is derived from multiple phases of interment at a primary location, either elsewhere in the vicinity of the cave, or from within the cave itself.

The R Combine function in OxCal was applied to the AMS dates; this is a tool designed to compile the dates and provide a weighted mean of the $^{14}C$ determinations. OxCal performs a chi-squared test ($\chi^2$) to analyse whether the dates are consistent with being of the same date (*e.g.*, all individuals dying at the same time). For the radiocarbon dates from Verteba, the R Combine function fails (T = 25.210 (5% 12.6)), thus demonstrating that the human AMS dates from the cave site are statistically incompatible with a single event.

Figure 4 highlights the fact that the calibrated dates separate out into what appears to be three discrete phases, an observation that would not be inconsistent with the evidence from the palaeopathology (as discussed above). Individuals M5 and A22 (recovered in 2005) were not dated as part of the current study, but were dated to 3620–2940 cal BC (4550 ± 90 BP – Ki-13388) and 4650–2670 cal BC (4910 ± 400 BP – Ki-14308) during previous work (*Nikitin* et al. *2010*), with M5 recently redated to 781–511 cal BC (2490 ± 30 BP – Beta-465022). The earlier dates have high errors of ± 90 yrs and ± 400 years, respectively, which extend the ranges well beyond the main cluster at Verteba.

### *Stable isotope analysis*

*$\delta^{13}C$ and $\delta^{15}N$ analysis of diet*

Stable isotope analysis of carbon and nitrogen was undertaken on five faunal samples and nine human samples. The results are presented in Figure 5 and Table 2.

The faunal samples analysed had an average $\delta^{13}C$ of –20.3‰ ±1.1 and an average $\delta^{15}N$ value of 7.7‰ ±1.7. The values for $\delta^{13}C$ demonstrate a clear C3 terrestrial diet signal, which is commensurate with the environmental evidence from the region (*Konoplya* et al. *2008*). It is perhaps a little difficult to draw further conclusions from the animal fauna, as the sample size is restricted due to the context and the secure identification of two of the samples beyond those available is limiting. The only caveat to the preceding observation is the pig sample with the more depleted carbon isotope value (which is perhaps due to the consumption of protein resources from under a forest canopy, thereby introducing a canopy effect on carbon isotopes; *Hamilton* et al. *2009*), and the domestic dog sample (–19.8‰ for $\delta^{13}C$ and 9.6‰ for $\delta^{15}N$) which has values very close to that of the humans, suggesting that the dog consumed very similar diet to the human individuals. It would certainly be of further interest to obtain a radiocarbon age for the dog sample to see if it ties in with the human radiocarbon ages.

The humans have an average $\delta^{13}C$ value of –19.2‰ ± 1.1 and a mean $\delta^{15}N$ of 10.1‰ ± 0.5; these values are also commensurate with the consumption of C3 terrestrial protein resources. The large s.d. on the $\delta^{13}C$ value is reduced when the outlier (M5) is re-

| Skeleton No. | Excavation ID | Sex | Individual Age | Lab No. | AMS Age [BP] | Cal BC 2σ |
|---|---|---|---|---|---|---|
| Verteba-1** | 3.17.1 | Male | 35–45 | OxA-25991 | 4985 ± 30 | 3931–3670 |
| Verteba-2* | 3.16.1 | Male | 25–35 | OxA-26201 | 4807 ± 33 | 3654–3522 |
| Verteba-3* | 3.18.1 | Female? | 18–22 | OxA-26202 | 4863 ± 33 | 3709–3537 |
| Verteba-4*ž** | 3.14.1 | Male? | 30–40 | OxA-26203 | 4976 ± 33 | 3911–3659 |
| Verteba-5** | 3.13.1 | Male | 30–40 | OxA-26204 | 4888 ± 32 | 3758–3636 |
| Verteba-6*ž** | 3.15.1 | Male | 14?–20 | OxA-26205 | 4855 ± 32 | 3708–3536 |
| Verteba-7 | 1.1.1 | Male | 20–30 | OxA-26207 | 4925 ± 33 | 3772–3648 |

***Tab. 1. Age and Sex determination on human remains from Verteba collected during the 2007–8 field season with AMS radiocarbon ages calibrated to 2σ. Dates calibrated using OxCal v.4.1 (*Bronk Ramsey 2012*). *Individuals with damage/pathology in evidence; **crania in association.***

moved from the sample, such that values of 19.55‰ ± 0.5 are recorded, while the removal of the $\delta^{15}N$ value for this individual from the sample does not alter the results (Note: new dating has shown that this individual is no longer placed in the Eneolithic period, being Early Scythian on the basis of a calibrated date range of 781–511 cal BC).

The small sample size could influence the applicability of statistical analysis of the data, but a two-tailed

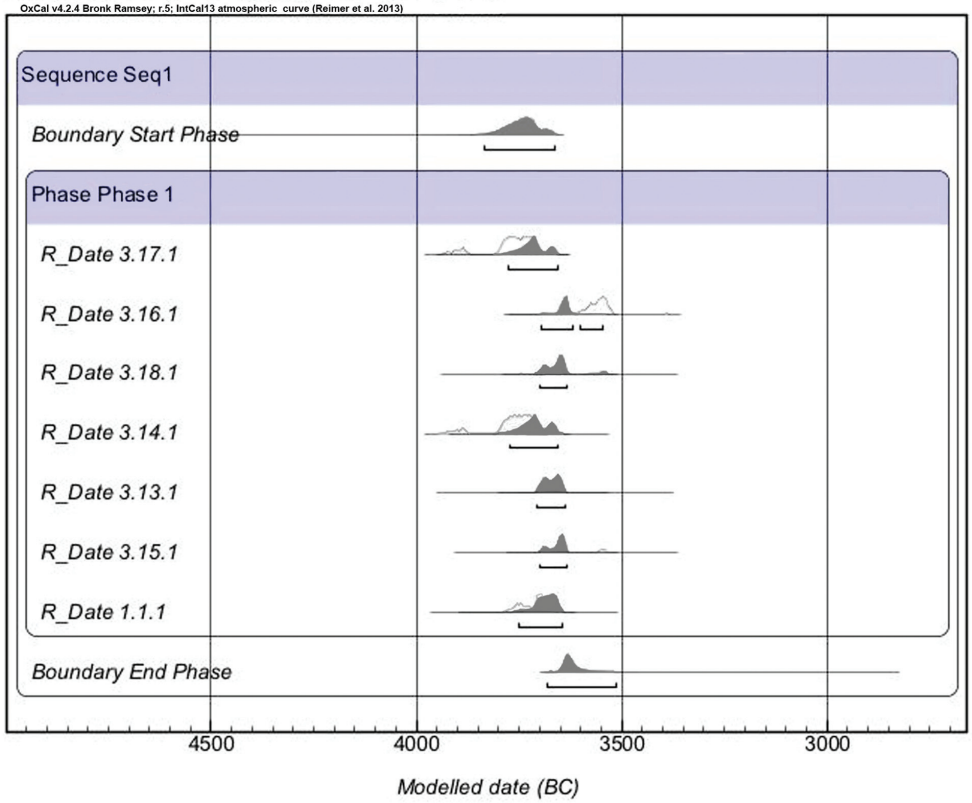



***Fig. 3. Posterior density ages calibrated using the INTCAL13 curve on OxCal version 4.2.4.***

| Sample | Species | Age/Sex | Radiocarbon Age | Lab. Code | $\delta^{13}C$ | $\delta^{15}N$ | C:N | %C | %N |
|---|---|---|---|---|---|---|---|---|---|
| 1 3.17.1 | Human | Male 35–45 | 4985 ± 30 | OxA-25991 | –19.3 | 9.9 | 3.3 | 3.22 | 9.23 |
| 2 3.16.1 | Human | Male 25–35 | 4807 ± 33 | OxA-26201 | –19.5 | 9.7 | 3.1 | 18.57 | 49.99 |
| 3 3.18.1 | Human | Female? 18–22 | 4863 ± 33 | OxA-26202 | –20 | 10.4 | 3.2 | 16.66 | 44.99 |
| 4 3.14.1 | Human | Male? 30–40 | 4976 ± 33 | OxA-26203 | –19.6 | 9.6 | 3.2 | 17.04 | 46.49 |
| 5 3.13.1 | Human | Male 30–40 | 4888 ± 32 | OxA-26204 | –19 | 10.8 | 3.2 | 11.86 | 32.73 |
| 6 3.15.1 | Human | Male 14?–20 | 4855 ± 32<br>4856 ± 33* | OxA-26205<br>26206 | –19.4 | 9.5 | 3.2 | 14.02 | 37.88 |
| 7 1.1.1 | Human | Male 30–40 | 4925 ± 33 | OxA-26207 | –19.6 | 9.9 | 3.2 | 15.44 | 42.48 |
| A22 | Human | Immature (>6yrs) | 4910 ± 400** | Ki-14308 | –19.7 | 10.7 | 3.3 | *** | *** |
| M5 | Human | Male (young) | 4550 ± 90**<br>2490 ± 30**** | Ki-13388<br>Beta-465022 | –16.3 | 9.9 | | *** | *** |
| F2.6.7 | Medium mammal | – | – | | –19.7 | 6.4 | 3.2 | *** | *** |
| F2.6.3 | Large mammal | – | – | | –20.4 | 6.4 | 3.1 | *** | *** |
| F2.6.5 | Pig | – | – | | –22.3 | 6.5 | 3.2 | *** | *** |
| F2.7.5 | Red deer | – | – | | –21.1 | 5.8 | 3.2 | *** | *** |
| F2.6.6 | Domestic dog | – | – | | –19.8 | 9.6 | 3.1 | *** | *** |
| F2.6.2 | Pig | <6mths | | | –19.1 | 9.8 | 3.3 | 36.75 | 14.10 |
| F2.6.4 | Pig | 10–18mths | | | –19.4 | 9.0 | 3.3 | 41.23 | 14.44 |

***Tab. 2. Radiocarbon dates and carbon and nitrogen stable isotope results. * Duplicate date performed as part of internal consistency and quality control at ORAU. ** after* **Nikitin *et al.* 2010.** **** Data not available. **** New dating by AGN for sample M5 at Verteba.***

t-test (assuming equal variance) was undertaken on the human samples for sex differences, and no difference was observed in the p-values. Similarly, the variance in data for the all the humans compared to the fauna was tested (including the dog sample and then subsequently without it) and the difference in carbon was found to be significant with the dog included and removed ($p = 0.02$ and $p = 0.01$, respectively). The difference in nitrogen values proved significant when the dog sample was included (largely due to the extended range it produces when included in the animal group) and, predictably, the difference is not significant with the dog sample removed from the dataset.

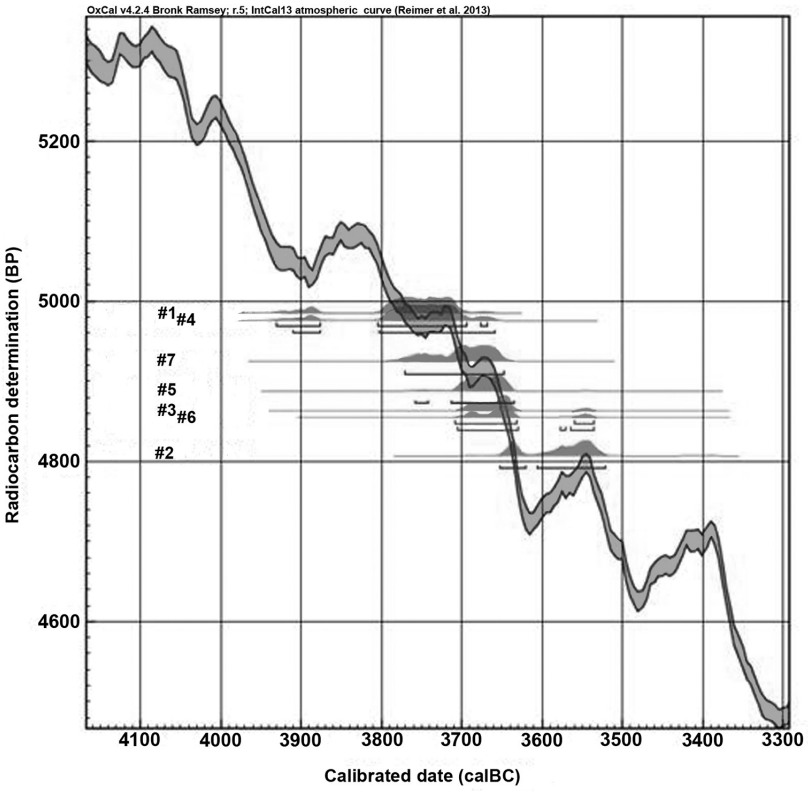



***Fig. 4. Calibrated dates plotted on the radiocarbon curve – note that the location of the dates would indicate at least 2 or 3 discrete phases of deposition for these skulls.***

The human carbon and nitrogen isotope data is commensurate with the consumption of the fauna analysed (excluding the dog and two of the pigs) and the $\delta^{15}N$ spacing is approx. 3‰. If we compare the isotope data to some of the finds from Verteba Cave, namely the presence of BII, CI and CII Trypillian pottery from the local groups of Schypynetska, Koshylovetska and Kasperivska, this would appear to indicate that the Verteba human interments belonged to a population reliant on an agro-pastoral subsistence strategy with some potential inputs from wild resources.

*Strontium, $\delta^{13}C$ and $\delta^{18}O$ analysis*

Strontium analysis of tooth enamel (along with the analysis of $\delta^{13}C$ and $\delta^{18}O$) was undertaken for eight human samples and two pig samples (*Sus domesticus*) at the Laboratory for Archaeological Chemistry at the University of Wisconsin-Madison. Table 3 details the results obtained for the human tooth enamel samples analysed, while Table 4 outlines the descriptive statistics for these samples.

Figure 6 outlines the isotope results for strontium (A), oxygen (B), and carbon (C). No true data outliers are identified for any of the isotope measurements taken (*e.g.*, no individual sample has an isotope values that plots outside the 1.5 quartile range). The datum points in Figure 6 represent individual sample measurements.

One of the major considerations in strontium isotope analysis is the determination of the local background (or bioavailable) ratio from the place of burial. Verteba Cave, which contained the skeletons, is a limestone cavern, one of the largest in Europe, which is located (obviously) in a region of limestone bedrock. Limestone, an ancient marine deposit, has $^{87}Sr/^{86}Sr$ values that correspond to the ratio of seawater at the time of deposition (*Veizer 1989*) ranging from approximately 0.707 to 0.709. Several factors can alter the expected geological signal of a location, such that a direct or proxy measurement of the local range is essential. In the case of Verteba, we measured two pig teeth as a proxy for the local signal. The two teeth measured 0.7091 and 0.7097, and probably provide a good estimate for the local range of values.

The most important aspect of the landscape at Verteba and a large area of this part of Ukraine, in terms of isotopes in humans, is the presence of deep deposits of loess, a fine-grain silt deposit which is carried long distances by the wind and deposited across much of Central and Eastern Europe. Rousseau *et al.* (*2014*) demonstrate that for European loess between 48°N and 52°N, the major sources were in the same latitudinal band and that the loess

was transported at low elevation and only over regional distances. Moreover, they observed a wide range of $^{87}Sr/^{86}Sr$ values in the loess, from 0.710 to 0.726 across that latitudinal band, with the highest value in eastern Ukraine. This high value for the loess in eastern Ukraine differs substantially from the observed values for fauna and human remains from Verteba reported in this study.

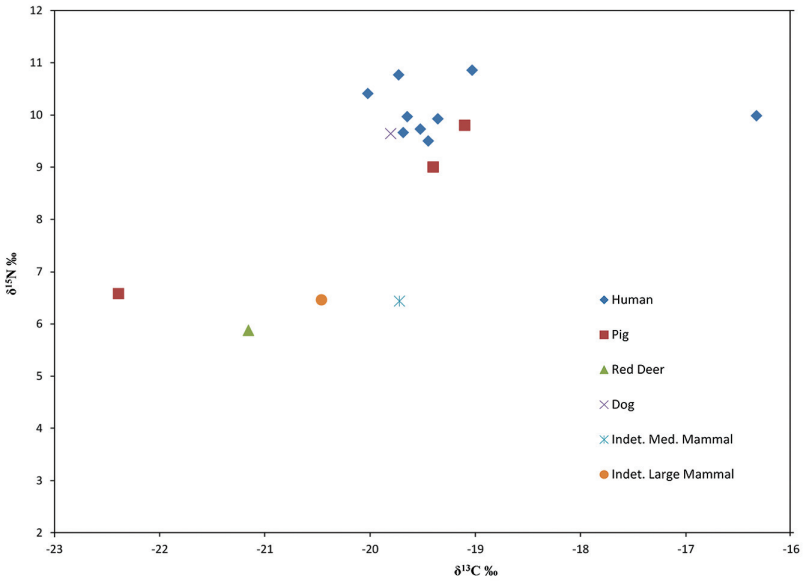



***Fig. 5. $\delta^{13}C$ and $\delta^{15}N$ bone collagen values for humans and fauna at Verteba.***

$^{87}Sr/^{86}Sr$ for human enamel averages 0.7096 with a very low s.d. and narrow range of variation. There were 6 males, 1 female, and one individual of indeterminate sex in the sample. There is no observed correlation between sex and $^{87}Sr/^{86}Sr$ values. Figure 6.a documents the narrow range of variation present and the close correspondence between the faunal and human values. There are no obvious outliers in the strontium isotope data, and the human enamel values appear very homogeneous. The strontium data suggest that there are no non-local individuals among the humans sampled and analysed from Verteba Cave.

One important issue with regard to mobility in this region concerns the nature and distribution of strontium isotope sources. The windblown loess covers large portions of Ukraine, probably with similar or identical strontium isotope ratios over long distances of perhaps hundreds of kilometres. For this reason, individuals coming from other areas, but still from a loess region, might have similar $^{87}Sr/^{86}Sr$ values and would not be identified as a non-local. The carbon and oxygen isotope data provide some suggestion that there may be a non-local individual present. The eight $\delta^{13}C$ values for human enamel (Tab. 2) average –12.1‰ ± 1.3 with a range from –13.1‰ to –9.4‰.

A plot of $^{87}Sr/^{86}Sr$ *vs.* $\delta^{13}C$ (Fig. 7) reveals a single outlier (M5) with a distinctively less negative $\delta^{13}C$ value, which suggests that this person consumed a different diet, containing either marine or $C_4$ plants, as a child, in contrast to the remaining seven individuals who consumed a largely terrestrial diet of $C_3$ plants and animals consuming $C_3$ species. This is mirrored in the dietary isotope data where the nitrogen vales are equivalent, but individual M5 is shown to have a more positive $\delta^{13}C$ of –16.3‰. While this contrast is accounted for by the new dating of this individual to the Early Scythian period, it also indicates an individual who grew up in a different region or perhaps an individual with a distinctive childhood diet. The former would seem to be a more likely possibility, as it is some 450km from Verteba south-eastwards to Odessa on the Black Sea coast, the closest marine environment.

| Species | Individual | Sample ID | Element | Sex | 87/86Sr | $\delta^{13}C$ | $\delta^{18}O$ |
|---|---|---|---|---|---|---|---|
| Human | 7 | V1.1.1 | Max right M2 | M | 0.709660 | –13.12 | –5.80 |
| Human | 3 | V3.18.1 (1.2) | Max left P3 | F | 0.709741 | –12.86 | –6.98 |
| Human | 4 | V3.14.1 | Max right P4 | M | 0.709616 | –11.99 | –6.83 |
| Human | 6 | V3.15.1 | Max Right M1 | M | 0.709692 | –12.86 | –6.48 |
| Human | 2 | V3.16.1 | Max right P3 | M | 0.709312 | –12.64 | –6.31 |
| Human | 1 | V3.17.1 | Max Left M1 | M | 0.709842 | –12.30 | –6.39 |
| Human | 8 | A22 | Incisor | I | 0.709344 | –12.17 | –5.83 |
| Human | 9 | M5 | Mand right PM2 | M | 0.709475 | –9.12 | –5.94 |
| Pig | _ | F2.6.2 | Incisor | <6mths | 0.7091 | _ | _ |
| Pig | _ | F2.6.4 | Mand right PM2 | 10–18mths | 0.7097 | _ | _ |

***Tab. 3. Sr, $\delta^{13}C$ and $\delta^{18}O$ results from human and pig samples at Verteba.***

| | $^{87}Sr/^{86}Sr$ | $\delta^{13}C$ | $\delta^{18}O$ |
|---|---|---|---|
| Average | 0.7096 | −12.1 | −6.3 |
| SD | 0.0002 | 1.3 | 0.4 |
| min | 0.7093 | −13.1 | −7.0 |
| max | 0.7098 | −9.1 | −5.8 |
| Count | 8.0000 | 8.0 | 8.0 |

***Tab. 4. Descriptive statistics for strontium, carbon, and oxygen isotope ratios in Verteba human enamel.***

The oxygen isotope data is also of interest, exhibiting a mean and s.d. of –6.3‰ ±0.4, with a narrow range from –7.0‰ to –5.8‰. A scatterplot of $\delta^{18}O$ *vs.* $^{87}Sr/^{86}Sr$ (Fig. 8) suggests that two groups may be present, one with more positive oxygen and lower strontium isotope ratios and the other with less positive oxygen and higher strontium. At the same time, the range of values for the oxygen isotope ratio is very low, and approximates the range of variation in a normal population. The two groups observed in the plot may not exist in reality. In sum, the isotopic provenance of the human tooth enamel from Verteba Cave generally suggests a pattern of limited mobility, although our ability to identify movement is likely constrained by the widespread distribution of similar $^{87}Sr/^{86}Sr$ in the region. The carbon isotope ratios highlight a distinctive diet for one of the eight individuals examined from Verteba, indicating that this individual may have been non-local, since the diet represented was unlikely to have originated in this area. The oxygen isotopes varied only slightly among the eight samples tested and as such are considered unlikely to provide information on mobility.

## Discussion

A number of the analysed samples from Verteba have been attributed to the Trypillia farming culture of Ukraine, with later periods of activity in evidence. This site is a unique location in relation to this culture, and the evidence for interpersonal violence and processing of the deceased for inclusion in the cave deposits is also unique in light of the dating results discussed below.

### *Dating*

The AMS dates primarily span the period 3800–3600 cal BC, which would place most of these individuals within Mykhailo Videiko's (*2004*) phase BII of the Trypillian culture. The BII stage of the Trypillian chronology began at *c.* 4100 BC, around the time of a major climatic shift in Europe *c.* 4200–3800 BC, which was accompanied by a decrease in solar insolation and a general cooling of the climate and increased aridity (*Perry, Hsu 2000; Brooks 2006*). Incidentally, during this stage, the exploitation of wild resources was particularly marked in areas where crop production or pastoral activities were limited by the environmental context, as at the forest/forest-steppe boundaries, necessitating the integration of hunting, foraging and fishing in order to ensure sustainability (*Markova 2008.80*).

The distribution of the calibrated date ranges (Figs. 3, 4) would appear to indicate that we may well be looking at more than one phase of interment at this location during the Trypillian phases of activity, or alternatively that the material that is found in secondary contexts is derived from multiple phases of

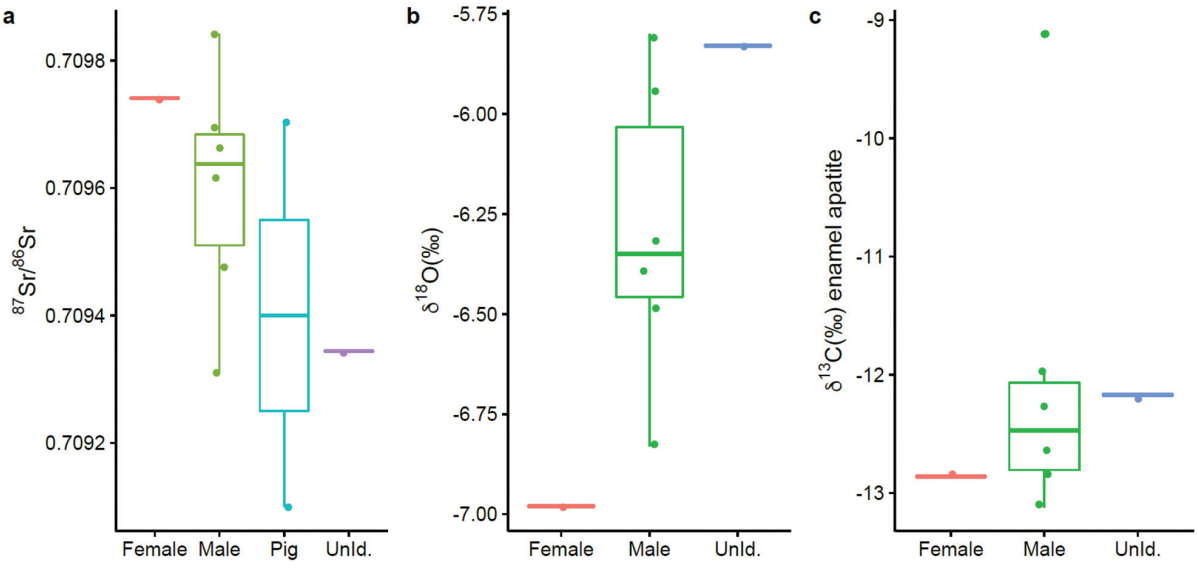



***Fig. 6. Strontium, oxygen, and carbon isotope data for humans and pigs at Verteba.***

interment at a primary location, either elsewhere in the vicinity of the cave, or from within the cave itself (as access to the cave was not restricted until recently). This observation is supported by the chi-squared test ($\chi^2$) which was applied in order to analyse whether the dates are consistent with being of the same date, as the R_Combine function fails (T = 25.210 (5% 12.6)); this demonstrates that the human AMS dates from the cave site are statistically incompatible with a single event.

The fact that a number of the individuals studied exhibit evidence of both peri-mortem and healed injuries would lend support to the possibility that low-level inter-personal violence occurred regularly during this early stage of the Trypillia culture. This observation contradicts the suggestion that Trypillia groups engaged in violent interactions only in the final stages of cultural development (*Korvin-Piotrovskiy 2012.6–18*), and confirms our suggestion at the start of this paper that a lack of absolute dating means that there are no secure chronological grounds from which to attribute the interpretations of the inter-personal (peri-mortem) violence to stage CII of Trypillia, as suggested previously by Karsten *et al.* (*2014; 2015*).

Individual 2 lies across the period 3650–3520 cal BC, thus extending the sample date range into the CI phase of Trypillia. This ties in quite well with the pottery finds from the cave (*e.g.*, BII/CI pottery), but the presence of CI and CII pottery types may suggest that the skulls were in fact interred in the cave at the beginning of its use in the Eneolithic period rather than towards the end of this range. However, as outlined above, it should be noted that a number of the remains from the cave are not yet dated by absolute means, and also that Nikitin *et al.* (*2010*) have analysed a fibula and vertebra of Bronze Age date from this cave, and a mandible of Scythian age (this report), and the full duration of the interment of humans during the Trypillian (and later) periods at Verteba remains to be established, as does the actual chronological age of the remainder of the twenty-one individuals identified by Karsten *et al.* (*2015*). However, what is readily apparent is that the secondary nature of this material means that undated skeletal elements cannot be assigned to a precise Trypillia culture stage with any certainty unless absolute ages are obtained for these remains.

### *Sr, $^{18}O$, $\delta^{13}C$*

The strontium data indicate that all of the individuals were local to the area, and there are no obvious outliers in this sample. Given the suggestion that the samples may represent more than one phase of deposition, and that the current sample is a sub-set of possibly around 30 or so individuals, additional studies may further enhance the resolution of this observation. The $^{18}O$ values, whilst possibly suggesting two discrete groupings, do not exceed the range of variation in a normal population, and again, further resolution might be forthcoming from additional analysis where suitable samples are available. The one outlier (M5) identified in the $\delta^{13}C$ values in this stage of the analysis, also corresponds to a similar outlier value when assessing the dietary isotopes, suggesting that M5 consumed a diet in which up to 50% of the dietary proteins were from non-$C_3$ food sources. The new dating provides some insights into this variation.

### *Diet*

As indicated above, the stable isotope data ($\delta^{13}C$ and $\delta^{15}N$) would indicate that this population was consuming a mixed $C_3$-based diet (again with the exception of M5), which in the case of Trypillia farming groups would include a variety of domesticated animals and plants alongside wild fauna, flora and fish. In addition, gathering and fishing are known to have contributed to the diets of human groups in the earlier stages of the Trypillia culture's development (*Korvin-Pietrovskiy 2012.10*). The presence of red deer and pig in the Verteba assemblage could indicate the consumption of wild fauna species, an observation that may well be reinforced by the fact that two of the pigs at Verteba plot out in the same area as the humans, and a domesticated dog (Fig. 5).

In the earlier stages of the culture's development a range of domesticated plant species were exploited,

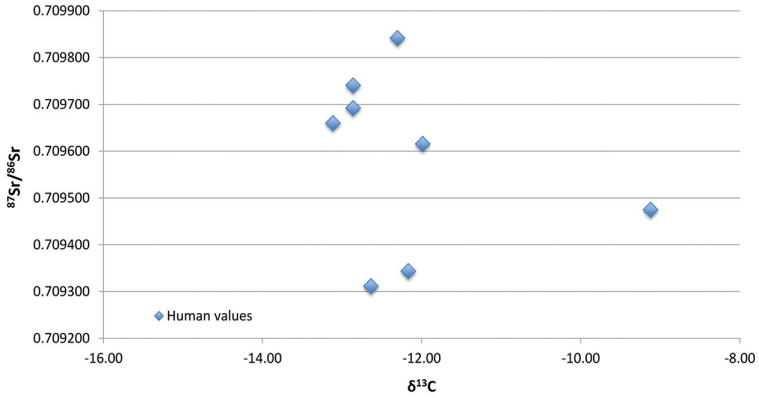



***Fig. 7. Scatterplot $^{87}Sr/^{86}Sr$ vs. $\delta^{13}C$.***

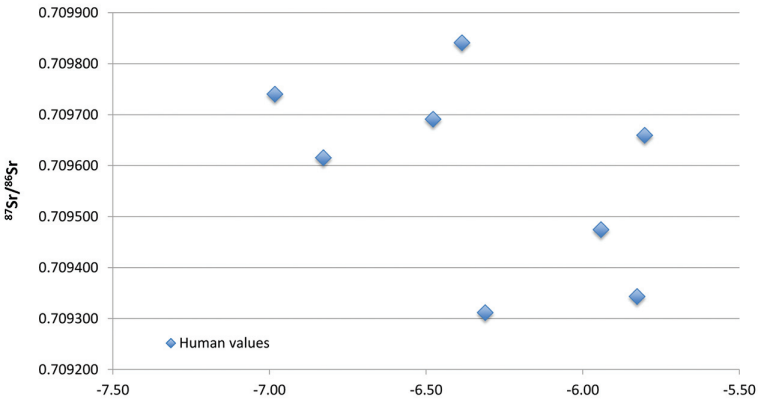



***Fig. 8. Scatterplot $^{87}Sr/^{86}Sr$ vs. $\delta^{18}O$.***

with emmer dominating in early assemblages, and einkorn, spelt, hulled and naked barley, as well as pulses/peas, *Vicia ervilia* (bitter vetch) and lentils, and flax, all attested during the main stage of cultural development (*Pashkevych 2008*). The range of wild plants exploited is outlined above, and given this broad spectrum of resource exploitation, especially in phase BII of this culture, the high incidences of caries and especially hypoplasias recorded by Karsten and co-workers (*2014; 2015*) is perhaps a little surprising, as it is clear that not all of these individuals are attributable to the latter stages of Trypillia. It would appear that further chronological resolution and dietary isotope analysis may be required to determine whether the remainder of the population excavated at Verteba are all attributable to the earlier part of the culture chronology and also whether their diet remains consistent across all phases of activity at this location.

## Conclusions

Verteba cave offers unique insights into Trypillian society and burial practices across the period *c.* 3800–3600 cal BC, and beyond. To date, the failure of studies that integrate absolute dating in order to provide context to analyses of palaeopathology and diet have led to a situation wherein our understanding of the precise nature and significance of these parameters during the periods of interment at Verteba remain fundamentally flawed.

The current study has sought to redress this limitation by applying AMS dating to individuals from this cave, and the initial results appear to indicate that, while we may well be seeing at least three discrete depositional phases in the cave sequences during the Eneolithic, and thus continued low levels of interpersonal violence during stages BII-CII of Trypillia, the new date on individual M5 suggests that material of much later (Scythian) date is also incorporated into these deposits.

The analysis of strontium, $\delta^{13}C$ and $\delta^{18}O$, and the dietary isotope analyses have shown that the individuals interred at Verteba appear to have been local to the study area. The outlier identified in the $\delta^{13}C$ analysis is a young adult male (M5). This individual has been redated to the Early Scythian period at 780–510 cal BC and, as such, an explanation for the differing $\delta^{13}C$ values for this individual when compared to the remainder of the population studied is forthcoming. Importantly, had the mobility and dietary isotope analyses not been undertaken, the redating of this individual would not have been undertaken, as the initial Kiev date appeared valid. With this in mind, studies of dental pathology (*e.g.*, caries rates and incidence of enamel hypoplasias; *Karsten* et al. *2014; 2015a; 2015b*) are called into question, as the rates of expression cannot be guaranteed to relate solely to the Trypillia farming groups in this region.

Despite this observation, it is important to highlight that the significant observation relating to Trypillia is that, on the basis of the dates obtained in the current study, the groups interred at Verteba appear to have engaged in low levels of interpersonal violence from the BII/CI stage of this culture, thus contradicting the dominant theory in relation to this activity in the Trypillia farming culture.

Overall, this study has demonstrated that at Verteba cave we have a unique resource that has the potential to provide information of fundamental importance to our understanding of the first farmers of Ukraine. However, the new dating has shown that, despite the existence of stratified deposits at Verteba, the disarticulated human remains do not conform to either their stratigraphic context or the typological seriation as developed, *i.e.* not only Trypillia farmers were interred at Verteba. In addition, while the isotope analysis for mobility has shown that these individuals were local to the region, the dietary isotope analysis (Fig. 5; Tab. 2) initially suggested that individual M5 differed considerably in terms of diet, this being despite the fact that an initial date on M5 indicated chronological equivalence with the main group. To that extent, the $\delta^{13}C$ ratio from the mobility isotopes part of the study also in-

dicated that this sample was not fully commensurate with the other data from this location. The redating of this individual during the production of this paper has shown that considerable discrepancies exist between the Kiev and Beta dating.

Fundamentally, then, the dating, mobility and dietary isotope analysis has provided considerable chronological, mobility and dietary resolution to the material from Verteba Cave, which on current evidence includes material from the Eneolithic through to Scythian age. The results of previous studies, which failed to undertake dating or isotope analysis, must be considered with caution, as it is clear that a wide range of periods are represented by the Verteba samples, and the diets of the individuals interred at Verteba are not necessarily all related to Trypillia farmers. Further dating, mobility and dietary resolution is clearly needed at this location.

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back to contents

# Diet and subsistence at the late Neolithic tell sites of Sopot, Slavča and Ravnjaš, eastern Croatia

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ABSTRACT – *This paper presents archaeobotanical data from three late Neolithic Sopot Culture (*c. *5200–4000 cal BC) tell sites, Sopot, Slavča and Ravnjaš, located in eastern Croatia. Tell settlements are well suited for exploring aspects of diet and subsistence, as they present a concentrated area with successive generations building upon previous occupation levels. The plant remains from the three study sites suggest a crop-based diet of mainly einkorn, emmer, barley, lentil and pea, as well as evidence of crop-processing activities. This diet was also probably supplemented by wild fruit from the local environment, such as cornelian cherry, chinese lantern and blackberry.*

KEY WORDS – *crop agriculture; archaeobotany; crop processing; charred macro-remains*

## *Prehrana in preživetje na poznoneolitskih najdiščih Sopot, Slavča in Ravnjaš na vzhodu Hrvaške*

IZVLEČEK – *V članku predstavljamo arheobotanične podatke iz treh poznoneolitskih najdišč sopotske kulture (ok. 5200 do 4000 pr. n. št.), in sicer na najdiščih Sopot, Slavča in Ravnjaš, ki so naselbine tipa tell na vzhodu Hrvaške. Naselbine tipa tell so primerne za preučevanje različnih aspektov prehrane in sredstev za preživetje, saj predstavljajo zgoščena območja, kjer so naslednje generacije gradile neposredno na predhodne poselitvene plasti. Rastlinski ostanki in dokazi o aktivnostih, povezanih s predelavo poljščin, kažejo na vseh treh najdiščih na prehrano, ki je temeljila na poljščinah kot so enozrnica, dvozrnica, ječmen, leča in grah. Prehrano so verjetno dopolnjevale še divje rastline iz lokalnega okolja kot so rumeni dren, navadno volčje jabolko in navadna robida.*

KLJUČNE BESEDE – *poljedeljstvo; arheobotanika; predelava poljščin; zogleneli makro ostanki rastlin*

## Introduction

Agriculture is intrinsically linked with Neolithic society, as this was the period when domesticated plants and animals were first introduced, gradually changing the way people lived throughout Europe (see *Özdoğan 2014* for recent summary). By living in permanent settlements new ways of social organisation would have emerged and developed, including activities linked with crop agriculture, storage and food preparation.

Tells first appeared in the Balkans by the late Neolithic (*c.* 5200–4000 cal BC) alongside typical horizontal settlements common in the early Neolithic (*c.* 6000–5300 cal BC). Since the 1950s, tell sites in northern Serbia such as Selevač (*Tringham, Krstić 1990; McLaren, Hubbard 1990*), Divostin (*McPherron, Srejović 1988*), Gomolava (*Jovanović 1988; Van Zeist 2003*), Vinča (*Chapman 1981; Filipović, Tasić 2012*) and


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Opovo (*Tringham* et al. *1985; 1992; Borojević 2006*), and in Bosnia and Herzegovina, such as Okolište (*Müller* et al. *2013*), have provided archaeobotanical datasets that can be used to examine agricultural practices in the region. This is crucial if we are to understand the development of societies during the Neolithic. Unfortunately, the preservation and the absence of sufficient numbers of weed seeds and chaff remains has posed many problems in the interpretation of past human activities at these sites, *e.g.*, crop processing and crop husbandry regimes (see *Hillman 1981; Jones 1984; Van der Veen 1992; Bogaard 2004*), and so many questions remain.

Tell settlements are very useful for exploring aspects of diet and subsistence, as they present a concentrated area with successive generations building on previous occupation levels. However, in Croatia, few tell sites have been excavated and even fewer have conducted archaeobotanical recovery programmes. To date, only five other late Neolithic settlements have yielded archaeobotanical remains from eastern Croatia: Bapska-Gradac (*Burić 2007.45–46*), Otok (*Obelić* et al. *2002*), Ivandvor-Gaj, Tomašanci-Palača and Brezovljani (*Reed 2015*). Both Otok and Bapska-Gradac are tell sites; however, the only published remains from Otok consisted of a single grain of bread wheat (*Triticum aestivum*) $^{14}$C dated to 4620–4350 cal BC; while the archaeobotanical results from Bapska are not yet forthcoming, both emmer (*Triticum dicoccum*) and einkorn (*Triticum monococcum*) have been identified. From the remaining sites, the plant remains suggest that glume wheats, emmer and einkorn, barley (*Hordeum vulgare*), lentil (*Lens culinaris*), pea (*Pisum sativum*) and flax (*Linum usitatissimum*) were all commonly grown (*Reed 2015*). This paper presents the archaeobotanical results from the late Neolithic tell sites at Sopot, Slavča and Ravnjaš, exploring activities linked with crop agriculture, storage and food preparation at the settlements.

## The Late Neolithic in eastern Croatia

The Sopot Culture developed on the foundations of the late Starčevo Culture. It has been suggested that the central area of the classic Sopot Culture is located in the region of eastern Slavonia, between the Drava, Sava and Danube rivers (*Marković 1994.82*). Settlements were often raised on natural elevations on the banks of rivers and streams, such as Sopot, Vinkovci, Privlaka, Orolik, Gaboš, Marinci, or on swampy, flood plains, close to extinct streams, such as at Stari Mikanovci, Otok, Komletinci, Retkovci (*Krznarić Škrivanko 2012.37*). The Sopot culture also expanded into Hungarian Transdanubia (*Bánffy* et al. *2016.290*) and northern Bosnia between the Vrbas and Tinja rivers (*Dimitrijević 1979.334*). A characteristic feature of this culture is black polished biconical and S-profiled vessels, but ceramics were generally undecorated, with only a small percentage being decorated with shallow carvings and tally ornamentation.

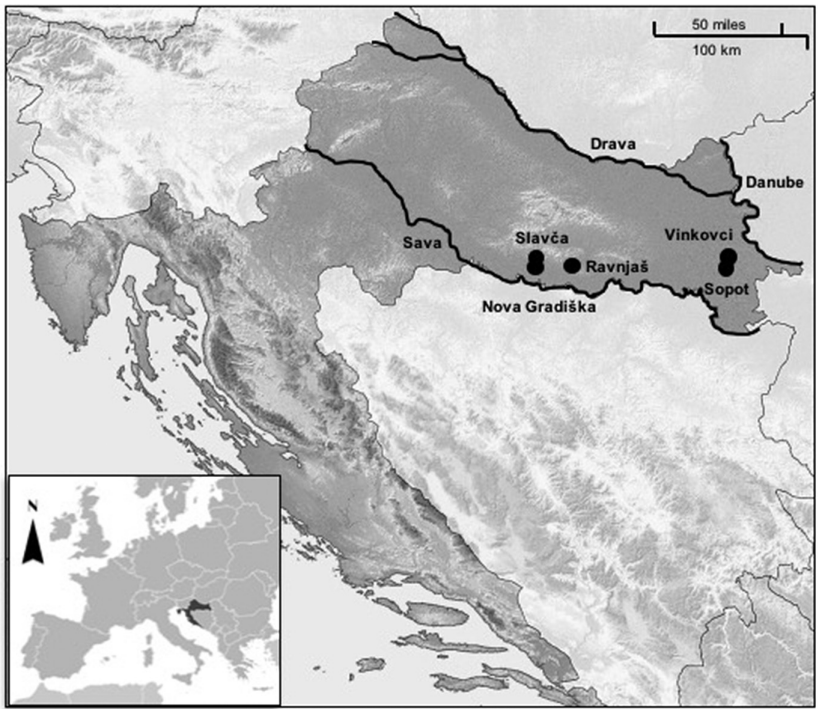



***Fig. 1. The Late Neolithic tell sites of Sopot, Ravnjaš and Slavča.***

Archaeologists divide the Sopot culture into three phases; early (I), middle (II) and late (III). Although, Dimitrijević (*1968*) subdivided the oldest phase into 2 stages (I-A, I-B), while newer investigations at the eponymous site of Sopot distinguish II-A and II-B stages (*Krznarić Škrivanko 2002*), as well as a final horizon of the early Eneolithic (phase IV – the Seče type of the Sopot Culture) (*Mihaljević 2013*), parallel with the Lengyel III and Tiszapolgar cultures (*Marković 1985*). Recent carbon-14 dating of Sopot Culture sites date Phase I-B to a period between 5480 and 5070

cal BC, Phase II-A between 5030 and 4770 cal BC and Phase II-B between 4800 and 4250 cal BC (*Obelić* et al. *2004.Tab. 3*). The earliest series of dates for Phase IV is between 4340 and 3790 cal BC (*Krznarić Škrivanko 2009; Mihaljević 2013*).

## Site descriptions

### *Sopot*

Sopot is situated 3km south-west of Vinkovci, on the right bank of the River Bosut (Fig. 1). The tell site is elliptical, measuring 113 x 98m, and is 3m deep. Sopot was first identified by J. Brunšmid in 1902 (*Brunšmid 1902.121*) and later excavated by M. Klajn in the late 1930s (*Klajn 1961.22*). In 1967, Stojan Dimitrijević led archaeological test-pit excavations at Sopot and took the site of Sopot as the eponym for this cultural phenomenon (*Dimitrijević 1979.264*). The most recent systematic excavations at Sopot were conducted between 1996 and 2008 by Vinkovci Municipal Museum. A total of 376m$^2$ was excavated from a section 37m long transecting the settlement, beginning in the south-west corner (*Krznarić Škrivanko 2000; 2003; 2011*).

Three phases of Late Neolithic Sopot culture have been identified at the site, as well as an early Neolithic Starčevo settlement $^{14}$C dated to 6060–5890 cal BC (*Krznarić Škrivanko 2011*). Two fortified ditches are evident (Fig. 2); an older one of 100 x 80m dates to the early Sopot settlement, which was later filled and replaced by a ditch surrounding an area of 120 x 100m (*Krznarić Škrivanko 2003; Mušič* et al. *2011.85*). The oldest house, excavated above the first ditch and dating to 5050–4780 cal BC (*Obelić* et al. *2004.252–253*), was rectangular, with an area of 6.70 x 4m, and had evidence of internal room divisions (*Krznarić Škrivanko 2003; 2006*). The youngest house, $^{14}$C dated to 4340 and 3997 cal BC (*Obelić* et al. *2004.249*) is a typical Neolithic rectangular house, measuring 6 x 4m (*Krznarić Škrivanko 1998. 31*). Pottery analyses date this phase to the Copper Age, Sopot IV (*Balen 2005; Krznarić Škrivanko, Balen 2006*), and at this time numerous canals appeared (*c.* 4250 and 4030 cal BC), which destroyed some of the earlier house floors (*Krznarić Škrivanko 2009*). Building cycles at the site were often characterised by the burning of an old house, which was then covered with a layer of soil before a new house was constructed. Excavations have shown that most houses were built in the same place as older ones, with small horizontal shifts.




***Fig. 2. Detailed magnetic survey of Sopot, including the position of the 1996–2008 excavation trenches in the bottom left of the settlement. Courtesy of Vinkovci Municipal Museum.***

### *Slavča*

The prehistoric site of Slavča is located approx. 1.5km north of the centre of Nova Gradiška. The site is a fort type, on a flat plateau at the point where the southern slopes of Psunj exceed the Posavina Plain. At an elevation of 240.61m, it offers a strategic position commanding the surrounding area (Fig. 3). The site was first identified in 1907 by the conservator Đuro Szabo. Systematic archaeological excavations by the Department of Archeology, Filozofski fakultet Zagreb (*Vrdoljak, Mihaljević 1999*) started in 1997, and were taken over in 1999 by the Municipal Museum of Nova Gradiška until 2013 (*Mihaljević 2000; 2004; 2005; 2006; 2007; 2008; 2009*).

The site is a multilayered prehistoric settlement with Sopot and Brezovljani type Sopot culture occupation, illustrating the transition from the late Neolithic to the early Eneolithic (Sopot IV), Lasinja, Kostolac and Vučedol culture (*Skelec 1997*). Surveys have revealed segments of the settlement with sectional pit objects, some of which are living, working, storage and waste pits and defensive ditches. Finds include pottery, loom weights, whorls for fishing nets, and stone and chipped artefacts (*Šošić, Karavanić 2004*). Zooarchaeological analyses showed a predominance of cow, sheep/goat and pig remains, with little evidence of hunting (*Mi-*

*culinić, Mihaljević 2003*). Recent $^{14}$C dates of the Sopot levels include 5210–4950 cal BC, from a pit with no ceramics, and 4960–4340 cal BC, as well as 4250–4030 cal BC associated with Sopot IV (*Mihaljević 2013*).

### *Ravnjaš*

Ravnjaš is located on the upper slopes of the Požega hill, north-west of the village of Nova Kapela. Excavations by Nova Gradiška Municipal Museum were carried out between 2006 and 2008, revealing a phase II Sopot Culture tell settlement (*Mihaljević 2006; 2007; 2008*). A series of pit objects and a house (SJ022) were discovered. The rectangular house was oriented north-south, consisting of two rooms containing a large amount of burnt material and large quantities of household items, including millstones, pottery and lithics. In addition, a fireplace of baked clay was discovered at the entrance to the house. Recent $^{14}$C dates indicate a range of 4970 to 4690 cal BC (*Mihaljević 2013*).

## Material and methods

### *Sampling and recovery*

Between 2006 and 2008, 71 samples were collected from a range of contexts from Sopot culture occupation levels at Ravnjaš. At Slavča, 63 samples were collected from contexts associated with a Sopot culture settlement, although seven of the samples were identified as mixed with Lasinja and Kostolac culture material. Sample sizes were not recorded, but a minimum of one bucket (approx. 11 litres) of sediment was collected where possible for each sample. The samples were later processed by bucket flotation using 1mm and 300µm mesh sizes. At Sopot, 144 samples were collected between 1999 and 2008 from a range of contexts, including house floors, pits, a ditch and hearths. The samples were processed by machine flotation, using 1mm and 250µm mesh sizes. Volumes were only partially recorded, but 1–2 buckets (up to approx. 20 litres) per sample were collected where possible.



*Fig. 3. The prehistoric site of Slavča (photo by Marija Mihaljević).*

### *Sorting and species identification*

The flot remains were 100% sorted, except for two at Slavča (Tab. 1 is available online at http://dx.doi.org/10.4312/dp.44.19), and their charcoal volumes were recorded. Carbonised plant taxa were identified with a low power (7–40x) binocular microscope and comparisons made from modern reference collections at the Institute of Archaeology, UCL and the School of Archaeology & Ancient History, University of Leicester.

Identifying the cereal remains at the sites was particularly difficult in some instances due to poor preservation and overlaps in morphology. A few possible rye grains (*cf. Secale cereale*) and spelt glume bases (*Triticum spelta*) had already been identified at Sopot, but they were fragmentary and inconclusive, so they have now been reclassified as cereal indet and *Triticum* sp. In addition, grains of broomcorn millet (*Panicum miliaceum*) and foxtail millet (*Setaria italica*), were also misidentified at all three sites, mainly due to poor preservation and similarities in morphology between foxtail millet and barnyard millet (*Echinochloa crus-galli*), which both have a scutellum extending over approx. two thirds of the grain length. Here the grains had a wider embryo, a flatter apex and an ovoid hilum more commonly seen in barnyard millet (Fig. 4i).

Of particular note in the assemblages was the identification of two-grained einkorn at Sopot, and both the grain and chaff of the 'new type' glume wheat at all three sites (*Jones* et al. *2000; Kohler-Schneider 2003; Kenéz* et al. *2014*). Two-grained einkorn was identified based on the observations of Helmut Kroll (*1992*) and Angela Kreuz and Nicole Boenke (*2002*). The one grain was slightly smaller and narrower in shape compared to emmer, with a flat ventral surface and a distinctive ventral compression near the pointed apex (Fig. 4c).

The identification of the 'new type' of glume wheat grains and glume bases was based on observations made by Glynis Jones *et al.* (*2000*) and Marianne Kohler-Schneider (*2003*). The grains were distinctly more slender than the emmer grains, and in the lateral view were distinctly 'flat', with a more rounded apex and narrower embryo. The dorsal

view was also generally more straight and parallel compared to the emmer grains, which were wider above the embryo (Fig. 4a). Identification of the glume bases were seen from a narrower and deep attachment scar, with a prominent primary keel projecting vertically when viewed from the abaxial face, like einkorn. The secondary keel was also prominent, as in einkorn, but sharply angled, unlike einkorn, in which it is rounded, with a clearly defined vein running along the keel, unlike either emmer or einkorn. These glume bases were also particularly distinct from those of emmer and einkorn, as they seemed more robust (Fig. 4f, g).

Many of the samples were collected from the same context, so the samples from the same trench, stratigraphic unit (SJ) and square were combined (Tabs. 1–3 are available online at http://dx.doi.org/10.4312/dp.44.19). All grains were counted as one, even if only a fragment was present. Glume base fragments were counted as one unless clearly representing part of another glume base, 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 where large seeds were broken and clearly represented the same parts of the same seed (*e.g.*, *Cornus mas*).

## Site formation and the interpretation of the plant remains

In order to understand the archaeobotanical results, it is important to explore the formation processes at the site, so as to identify any possible bias in the samples that may influence interpretations. The plant remains at Sopot, Slavča and Ravnjaš were preserved through 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, the charred remains represent only a small and biased sample of the edible plants probably utilised by the late Neolithic settlements. These 'missing foods' mean that our ability to establish the composition and overall contribution of plants to the diet is inherently biased towards charred remains 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, and the groups proposed by Richard N. L. B. Hubbard and Alan J. Clapham (*1992*) provide a simple way to classify samples: Class A, where remains have been burnt and recovered in-situ; Class B, where remains derive from a single burning event, but were moved (secondary deposition); and Class C, where the assemblage derives from different charring events that were subsequently deposited within the same context. In addition, seed density can be used to reflect the rate of deposition. For example, a low density of plant remains could indicate the slow accumulation of charred items that originated from different burning events, unassociated with the feature in which they are finally deposited (*Miksicek 1987; Jones 1991*). Charred plant remains can also survive for long periods, and archaeobotanical evidence has shown cases of older plant remains being redeposited within younger contexts (*e.g., Pelling* et al. *2015*).

Preservation was generally poor at the study sites, with many of the plant remains being identified through gross morphology only. In total, the three sites contained over 9000 unidentifiable plant fragments and over 1100 unidentifiable cereal fragments. Charcoal density per litre was also generally low, with a mean density of 0.20cm$^3$ at Sopot, 0.24cm$^3$ at Ravnjaš and 1cm$^3$ at Slavča. The mean seed density per litre was also generally low at Sopot and Ravnjaš, 1.1 and 2.8 seeds per litre. However, at Slavča the mean seed density was 15 seeds per litre. This was due to extremely high numbers of glume wheat glume bases in a number of the samples (see below for further details). The low density of plant remains within the contexts suggest a slow accumulation deriving from different charring events, while the high densities seen at Slavča may suggest plant remains deposited from a single burning event (*e.g.*, SJ123 and SJ7). Only the hearths showed evidence of in-situ burning; however, multiple burning episodes would have occurred within these contexts. Thus, the samples from all three sites probably result from Class C remains, where the assemblages derived from different charring events were later deposited within the same context.

In addition, the overall assemblage from the three sites shows that samples from house floors or occupational levels have a higher percentage of grain and fruit remains, while those samples recovered from pit, ditch or other external settlement features are more likely to contain chaff remains (Fig. 5). Thus, the high percentage of cereal grains and fruits within house and hearth features may suggest the preparation of food for human consumption. While,

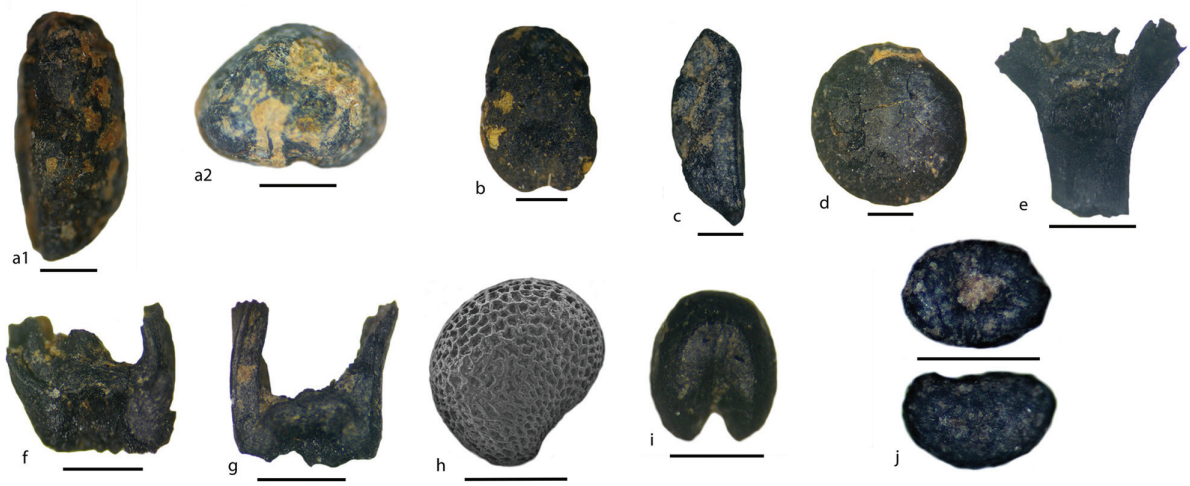



***Fig. 4. Carbonised seeds from the study sites: a1–a2 'New type' glume wheat; b naked wheat (*Triticum aestivum/durum*); c Two-grained einkorn (*Triticum monococcum*); d Lentil (*Lens culinaris*); e Barley rachis (*Hordeum vulgare*); f 'New type' glume wheat glume base; g Emmer glume base (*Triticum dicoccum*); h Chinese lantern (*Physalis alkekengi*); i Barnyard millet (*Echinochloa crus-galli*); j Hedge bedstraw (*Galium sp. mollugo*). Scale bar: 1mm.***

the high chaff content (mainly glume wheat glume bases) within pits and ditches may result from the deposition of crop processing waste (see below for more details).

## Crop husbandry: Which crops were grown

Only five types of cereal grain and chaff were identified from the three sites: barley, emmer, einkorn, 'new type' glume wheat and naked wheat. Of these five, emmer and einkorn dominate the samples both in quantity (Fig. 6) and the frequency with which they are found in the different contexts. This is similar to remains found at Neolithic sites in Albania (*Xhuveli, Schultze-Motel 1995*), Bosnia and Herzegovina (*Renfrew 1979; Kučan 2009*), northern Italy (*Rottoli, Castiglioni 2009*), Serbia (*Filipović, Obradović 2013* for summary) and Slovenia (*Tolar* et al. *2011*).

It is particularly interesting to note the large quantities of glume bases recovered, amounting to nearly 6000 from the three sites, compared to only around 1200 grains, and what this may say about subsistence practices at the sites. For example, since the 1970s, researchers have determined that carbonised plant remains are more likely to result from food production and crop processing rather than from food consumption, and therefore provide a record of the crop husbandry and processing methods employed (*Knörzer1971; Dennell 1972; 1974; 1976; Hillman 1984; Jones 1984*).

Predictive models have since been created to identify which stage of the crop processing sequence an archaeobotanical assemblage represents. This is 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*). Each stage produces two assemblages: a crop product, which continues through each stage, and a crop by-product or residue, which is removed from the remaining processes. Simplified, the stages for processing free-threshing cereals (*e.g.*, naked wheat and barley) are as follows (after *Hillman 1984; Van der Veen 1992*):

- harvesting: to gather the mature crop from the field, possibly by uprooting or cutting the grain-bearing part of the plant;
- threshing: to release the grain from the chaff, possibly by beating with a stick or trampling by cattle;
- winnowing: to remove the light chaff and weeds from the grain, possibly by wind or by shaking in a winnowing basket;
- coarse sieving: to remove larger items such as weed heads, seeds, un-threshed ears and straw with large meshes;
- fine sieving: to remove the small weed seeds from the grain with narrower meshed sieves.

Glume wheats (*e.g.*, einkorn, emmer and 'new type' glume wheat) on the other hand require further processing stages to release the grain from the tight glumes. The additional processes involved in the dehusking of glume wheats are as follows (after *Hillman 1984; Van der Veen 1992*):

- processing stage Rationale;
- parching to dry the grain and render the glumes brittle;
- pounding to release the grain from the glumes, possibly in a wooden mortar or quern;
- second winnowing to remove light chaff and weeds from the grain;
- second coarse sieving to remove the remaining large items, such as unthreshed ears or chaff and remaining culm nodes and large weeds in heads;
- second fine sieving to remove glume bases and remaining small weed seeds.

Put simply, this suggests that a sample with high numbers of cereal grains and not much else, which resulted from one burning and depositional event, would represent the end of the crop processing stages when the grain is ready for consumption. On the other hand, a sample with a high number of glume bases, also resulting from one burning and depositional event, probably represents crop processing waste (*i.e.* where the chaff is removed from the grain).

Examining the study sites, it is clear that many of the samples with low densities resulted from a range of different charring events. However, the high densities seen at Slavča in stratigraphic units 123 and 7 and the fact that over 75% of the samples were made up of glume wheat glume bases may suggest evidence of crop processing waste (see also *Reed 2015*) dumped after being carbonised elsewhere. 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 could have then been deposited outside the houses in pits or ditches around the settlement, so SJ123 and SJ7 may indicate the secondary or tertiary deposition of discarded wheat chaff. If this is the case, then it is likely that the recovery of both einkorn and emmer in the samples represent individual crop remains, rather than crops being grown together (*Jones, Halstead 1995*), especially as recent research suggests that emmer and einkorn ripen at different times if sown simultaneously (*Kreuz, Schäfer 2011*). Furthermore, archaeological finds of querns and flint sickle blades also attest to crop processing activities at the sites.
The recovery of less than ten barley rachis at Slavča and Sopot and the absence of barley at Ravnjaš may suggest that barley was mainly processed away from the settlement, or was only a minor crop at the sites. However, cereal rachis is more fragile than glume

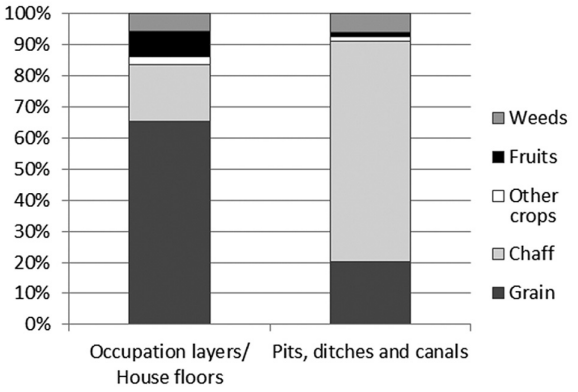



***Fig. 5. Percentage of seeds in each plant category per context group for all three sites.***

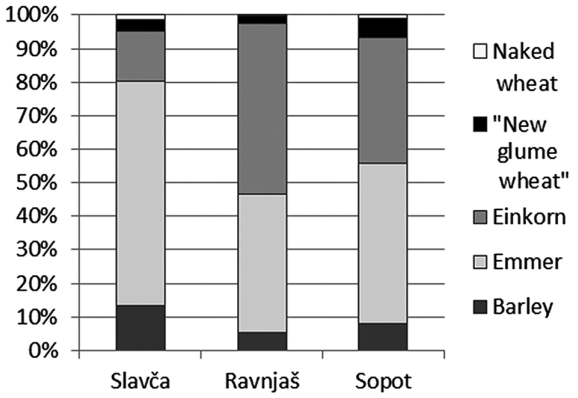



***Fig. 6. Number of grain and glume bases per species at each site (where 1:1 barley rachis/grain; 2:1 einkorn glume base/grain; 1:1 emmer and 'new type' glume wheat:grain).***

bases and may simply have not survived the carbonisation process, resulting in its under-representation at the sites (*cf. Dennell 1976; Hillman 1981; Boardman, Jones 1990*).

The possible cultivation methods (*i.e.* manuring, weeding or irrigating) of the crops was not examined, due to the low numbers of weed seeds recovered from the study sites, as well as the limited identification of seeds to species level (see *Bogaard 2004; Kreuz, Schäfer 2011* for examples of examining cultivation methods of crops at Neolithic sites in central Europe).

### *Other crops*

Lentil (*Lens culinaris*) was the most common pulse crop present at Sopot, Slavča and Ravnjaš. Pea (*Pisum sativum*) was also recovered from Ravnjaš and Sopot, as well as small quantities of grass pea (*Lathyrus sativus*) from Sopot, and bitter vetch (*Vicia ervilia*) from Ravnjaš. Pulse preservation through carbonisation can be under-represented in the archaeological record, but these four species are found con-

tinuously from the early Neolithic onwards in Central and Southeast Europe (*Zohary* et al. *2012.75*). Therefore, it is likely that lentil was commonly grown at the study sites, with the addition of pea at Ravnjaš and Sopot.

Small quantities of flax seeds were identified from Sopot and Slavča. As one of the founder crops, flax is found throughout Southeast and Central Europe from the Early Neolithic onwards and is traditionally used for its oil (linseed) and/or fibres (*Zohary* et al. *2012.101*). The high oil content in flax seeds can make them more susceptible to burning and less likely to be preserved compared to other seeds (*Wilson 1984*) and so their presence even in small numbers could suggest flax cultivation for oil and/or fibre. This is further supported by the recovery of flax textile fragments from the contemporary late Neolithic site at Opovo in Serbia (4700–4500 cal BC) (*Borojević 2006; Tringham* et al. *1992*).

## Crop storage at the tell sites

Year-round occupation of a site almost certainly required some kind of storage facilities for food and fodder. Storage is therefore a mechanism to buffer against seasonal and/or long-term variability in the food supply (*Halstead, O'Shea 1989*). Similarly, the larger the settlement, the more reliance would be placed on stored cereals and pulse crops (*Halstead 1996.304*). The location and size of storage facilities can reveal household behaviours, *e.g.*, domestic storage for domestic use, external storage for communal use or excess goods for exchange. Therefore, the location of storage inside or outside the house or choosing communal storage is also related to the social and economic organisation of the site as a whole (*Halstead 1999*). However, direct evidence for storage practices by prehistoric farmers is rarely seen, due to the poor preservation of organic material and the fact that stored food, unless accidentally burnt in a catastrophic event, would have been consumed. Further problems arise when storage facilities are re-used for other purposes, such as repositories for domestic refuse or human burials. Therefore, the identification of prehistoric storage facilities is usually based on indirect evidence from architectural remains.

From the study sites in Croatia, few houses show evidence of internal storage pits; however, at late Neolithic Sopot, the well-preserved remains of house 23 revealed large vessels ('buda' type), that could have been used for crop storage (*Krznarić Škrivanko 2003*). This is comparable to the neighbouring Vinča culture settlements which also contained large immobile and slightly smaller mobile storage vessels within many of the houses (*Stevanović 1997*). External pits close to the houses at the study sites have also been excavated, and many contained low quantities of plant remains, although the remains do not necessarily indicate storage, as they may have been deposited as waste. Nevertheless, it is probable that both internal and external crop storage was practiced at the Neolithic sites to support the year-round occupation of them.

## Other sources of food

In addition to cultivated crops, a number of other edible species were recovered, which would indicate the continued exploitation of the local environment. This includes cornelian cherry (*Cornus mas*) and Chinese lantern (*Physalis alkekengi*) at Slavča and Sopot, and blackberry (*Rubus fruticosus*) at Ravnjaš and Slavča. Of particular note at Sopot was a relatively large deposit of over 100 seeds of Chinese lantern found in the floor of one of the houses, which may suggest its deliberate collection by the household.
It is difficult to assess the role of wild plants in prehistoric farming communities, but it is likely that they played an important role in subsistence (*College, Conolly 2014*), complementing not only human diet, but also contributing to many other aspects of human life, being used as building materials, medicines, dyes, fuel, animal fodder, crafts or rituals. Edible species found at the study sites may have included the seeds of fat hen (*Chenopodium album*) and the leaves of nettles (*Urtica dioca*). However, the small number of seeds found makes any further interpretation difficult. In addition, many of the weeds recovered from the study sites are commonly found as weeds in cultivated crops. For example, Bandkeramik weed species found regularly in samples associated with manured crops include *Bromus secalinus*, *Chenopodium album*, *Galium aparine*, *Galium Spurium*, and *Polygonum convolvulus* (*Kruez, Schäfer 2011*). A number of these genus and species are also found at the study sites, making it likely that many of the wild species are in fact weeds from the crops rather than collected wild foods.

## Conclusion

Archaeobotanical remains collected from the late Neolithic tell sites at Slavča, Ravnjaš and Sopot indicate a crop-based diet of mainly einkorn, emmer, barley, lentil and pea. The plant- based diet of the

settlements also included wild fruits such as cornelian cherry, Chinese lantern and blackberry. However, the charred remains represent only a small and biased sample of the edible plants probably exploited by the late Neolithic settlements.

An examination of crop-processing activities at the sites suggest that emmer and einkorn grains were semi-cleaned before reaching the site and then processed further on a daily basis to remove the chaff and any remaining weed seeds. The early removal of weeds offsite would also have allowed seed corn to be stored relatively clean, which when sown would reduce weed growth and maintain economic crop yields (*Dennell 1974*). The charring of emmer and einkorn chaff may also indicate the parching of spikelets before processing, but could also result from the occasional use of processing residue as fuel (*Hillman 1981; Van der Veen 2007*).

The low seed densities at the sites had a distinct impact on the level of analysis that could be conducted. Thus, further research is needed to build on these results and to improve our understanding of agriculture and the role agriculture played in underpinning social, cultural and economic changes in the late Neolithic in eastern Croatia.

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back to contents

# The past in the past in the mortuary practice of hunter-gatherers: an example from a settlement and cemetery site in northern Latvia

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ABSTRACT – *During excavations of burials at Zvejnieki in northern Latvia, it transpired that the grave fill included occupation material brought to the grave. It contained tools of a type that could not be contemporaneous with the grave. This is confirmed by the dating of bone tools and other bone finds in the fill. The fill was taken from an older settlement site a short distance away. The fill also included skeletal parts of humans whose graves had been destroyed with the digging of the grave for a double burial. This provides an interesting view of the mortuary practice of hunter-gatherers and an insight into the use of the past in the past.*

KEY WORDS – *hunter-gatherer; mortuary practice; occupation layer; rituals; Mesolithic; Neolithic; Latvia; Northern Europe*

## *Preteklost v preteklosti pri pokopih lovcev in nabiralcev: primer iz naselbine in grobišča v severni Latviji*

IZVLEČEK – *Med izkopavanji grobišča Zvejnieki v severni Latviji smo odkrili, da so bili grobovi zapolnjeni z materialom, ki so ga prinesli iz naselbine. Polnilo je vsebovalo orodja, ki niso sočasna z grobovi. To je potrdilo tudi datiranje koščenih orodij in drugih koščenih najdb v polnilu. Le-tega so prinesli iz starejše naselbine, ki se nahaja v bližini. Polnilo je vsebovalo tudi človeške skeletne ostanke starejših grobov, ki so jih uničili pri izkopu za dvojni pokop. Te najdbe nudijo zanimiv pogled na pogrebne običaje pri lovcih in nabiralcih ter nov vpogled v uporabo preteklosti v preteklosti.*

KLJUČNE BESEDE – *lovci in nabiralci; pogrebni običaji; plast poselitve; rituali; mezolitik; neolitik; Latvija; severna Evropa*

## Introduction

When the phenomenon 'the past in the past' is discussed, it normally concerns the use of clearly observable monuments such as graves and settlements that were well preserved and easily identified at the time, several centuries after erection, when they become incorporated into a new function (*Bradley 2002; Jones 2007*). In this case, we have quite another situation, but still a case where there is evidence of how prehistoric people intentionally used remains left by previous generations.

In a society without enduring monuments, earth is the most permanent of materials (*Helms 2005*). In an archipelagic environment, the distinction between earth and water is clearly established. One lives on earth, and in the occupation layer, the remains of the living society are mixed with soil. Everyday life is buried in the earth, just like the dead members of society. If the same location continues to be settled for a considerable time the remains of the ancestors will still be obvious for several generations. The memory


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of the ancestors will be easy to maintain through a close relationship with their remains. When a pit is dug, the remains of those long deceased will be unearthed, just as when digging a grave, an older grave is exposed. The settlement in itself becomes a monument of the past.

If one and the same area is used as a settlement, a confrontation with the vestiges of past generations cannot be avoided. The relationship with the ancestors will become a frequent issue. A society can either try to avoid this confrontation by moving away (*Knutsson 1995*) or regard the connection to the ancestors as an important and desirable part of life. If a trust in the connection to the ancestral past exists, then the soil itself will be regarded as an important link between the living and the dead, a link that is directed towards the past and oriented towards the future (*Gosdon 1994.15*). The use of such soil might be a commemorative practice. The material culture within the soil represents an objectification of the past, yet it is also experienced subjectively (*Jones 2007.53*).

## Excavations at the Zvejnieki settlement and cemetery complex

During the period 1964–1977, settlement remains and more than three hundred graves were excavated at Zvejnieki in northern Latvia, under the direction of Francis Zagorskis (*2004*) (Fig. 1). Altogether, 317 graves were documented. They span the period from the 8th to the 3rd millennium cal BC, and are mostly contemporaneous with the settlement remains in the immediate vicinity (*Zagorska 2006*) (Fig. 2).

From 2005 to 2009, a new excavation was carried jointly between Latvian and Swedish archaeologists (*Larsson 2006; Nilsson Stutz* et al. *2008; 2013*). The graves were excavated in areas associated with a former farmhouse that had not been available for excavation during previous campaigns (Fig. 2). All the burials were found in the area to the east of the farmhouse. Several were more or less disturbed, as they had been placed in shallow graves and had later been affected by digging. However, two graves turned out to contain interred remains deep enough to be unaffected by later disturbances. The graves were between 0.7 and 0.8m deep and contained a very dark fill, typical of graves dated to the 7th and 6th millennium BC. The fill, mixed with soot and charcoal, bore a close resemblance to the occupation layer nearby. In addition, it included a considerable number of flint and bone finds similar to the settlement remains. However, there seemed to be a discrepancy between the date of the burial and some of the artefacts found in the fill.

Buried in one of the graves, No. 313, was a female dated to the mid-7th millennium BC (7525±60 BP, 6467–6249 cal BC, LuS 8220) (according to Oxcal v.4.1). However, the fill included a fragment of a slotted bone point that should date to the Preboreal or Early Boreal, a phase two millennia earlier (*Hartz* et al. *2010*). In graves excavated previously, discrepancies between the date of the burial and the date of bird as well as fish bones in the fill of the grave have been noted (*Zagorska 2006; Mannermaa 2008; Mannermaa* et al. *2007*).

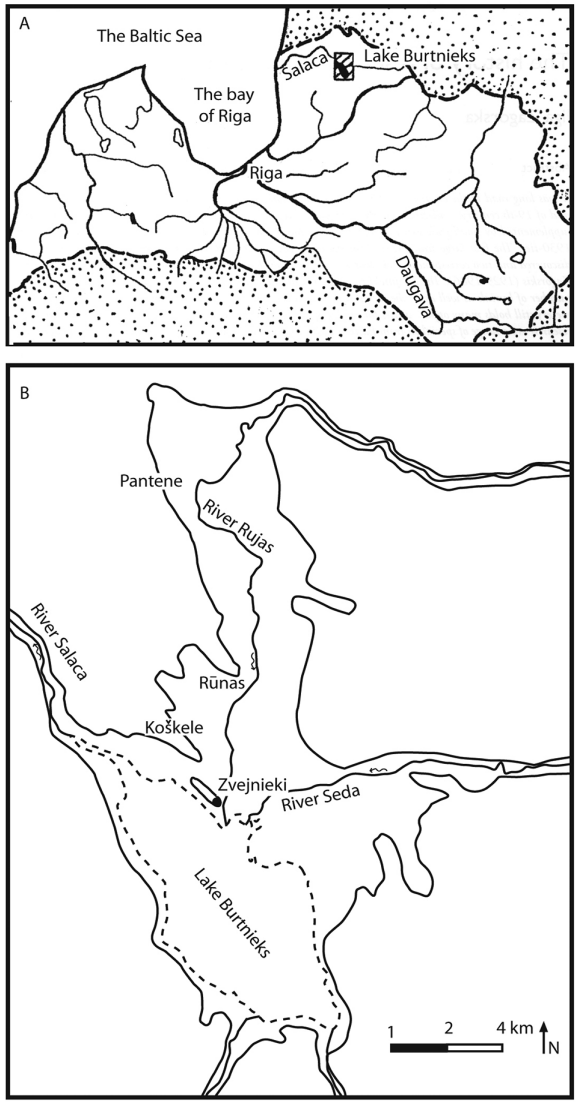



***Fig. 1. The location of the Zvejnieki site in Latvia (A) and the location of Lake Burtnieks (B). The solid line marks the extent of the lake when the site was in use, while the extent of the present lake is marked by a dotted line.***

The other deep grave contained a double burial, a male and a female, with a considerable number of grave goods (*Larsson 2009*) (Fig. 3). Most noticeable are the adornments of the female, with more than 120 amber pendants and two large amber rings, constituting the richest Stone Age amber grave in the Baltic region. This grave covered an area outside as well as inside the former farmhouse, now in ruins.

**Black soil**

The house had been rebuilt as late as the 1960s, but sited on the same foundation of stones as a much earlier farmhouse building, probably the first building on the site. As no cellar was dug, this provided a view of how the surface and soil might have looked before the area was farmed, the only opportunity for this kind of investigation within the entire site of Zvejnieki. No settlement remains were identified. However, a number of shallow graves were preserved as little as a couple of decimetres below the previous surface. These graves were even shallower than any previously excavated graves. This reinforced the interpretation that no farming had taken place in the area below the farmhouse during modern times. The fill, with a large number of artefacts (Fig. 4), could therefore not be regarded as soil from an existing occupation layer that the graves had cut through. However, finds from the fill, such as a couple of fragmented leister points of the Kunda type (Fig. 5), indicated that the fill held material that might be older than the graves.

The two interred in Burial 316–317 gave close $^{14}C$ values. Burial 316 was dated to 5285±55 BP, 4256–3979 cal BC (LuS 8217), and Burial 317 to 5105±50 BP, 3991–3781 cal BC (LuS 8216) (Fig. 6). Samples were also taken from a bone dagger made of a red dear ulna found close to the right arm of the male in the double grave. The main reason for taking this sample was to obtain a date from a terrestrial species of the same age as the humans in order to learn whether there was a freshwater reservoir effect, because a considerable intake of freshwater fish could have altered the apparent age of the humans (*Eriksson 2003; Meadows* et al. *2015*). The dagger was dated to 4865±60 BP, 3786–3521 cal BC (LuS 7852). However, the difference is rather small, and it seems that the reservoir effect was of no major importance in this case.

In order to obtain information about the age of the fill, a number of bones with and without traces of alteration were dated. The tip of a Kunda leister head was dated to 8275±55 BP, 7486–7090 cal BC (LuS 8738), a beaver vertebra was dated to 6320±60 BP, 5472–5081 cal BC (LuS 8222), a vertebra of wels yielded a date of 6630±55 BP, 5636–5482 cal BC (LuS 8223) and a wild boar incisor was dated to 5455±50 BP, 4447–4174 cal BC (LuS 8835). All the dates of bones in the fill are older or considerably older than the skeletons (Fig. 6).

This is an important indication that the fill was not simply taken from the occupation layer, but that soil from a settlement area abandoned a long time before was chosen as fill. This must have been a deliberate choice.

However, comparison with the settlement remains as regards radiometric dates cannot be accomplished, as only three radiocarbon dates are associated with the remains from the settlement, but from the settlement Zvejnieki II, and two later than the actual graves. However, burial 305, dated to 8270±70 BP, 7491–7111 cal BC, Ua-3634, held a leister of the Kunda type as the only grave gift and was found dug through an occupation layer, with similar artefacts surrounding the grave. Therefore, the oldest occupation layer is older than the grave. Other Latvian settlements with similar content are dated to the same phase (*Zagorska 2006*).

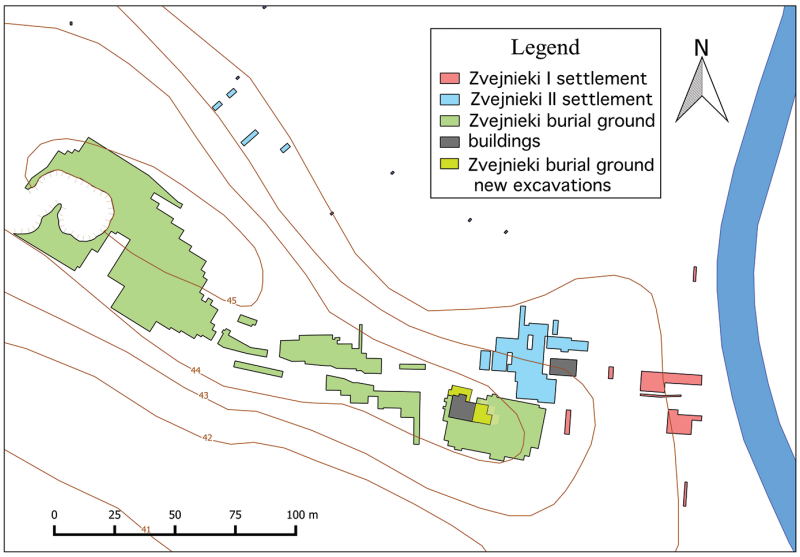



***Fig. 2. The Zvejnieki site with the location of the burial ground, the settlements, the farmhouse on the site and the gravel pit.***

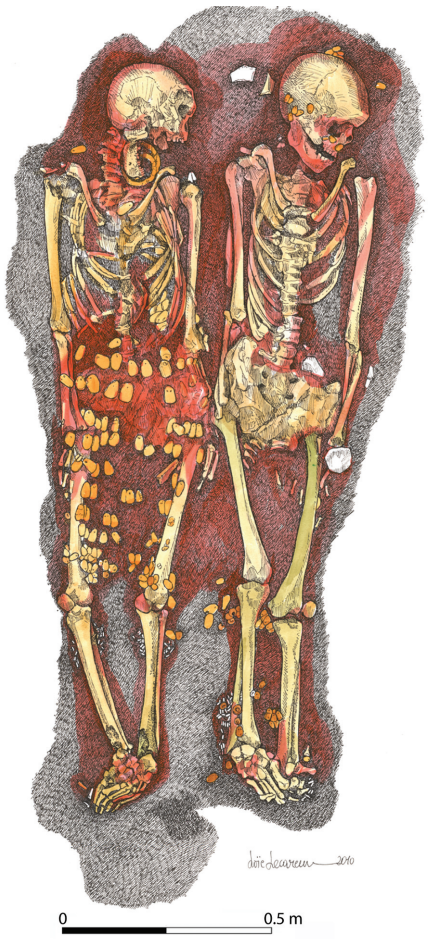



***Fig. 3. Double Burial 316–317 (drawing by Loïc Lecareux)***

According to the dates, which differ by as much as three thousand years, the soil must have been taken from different parts of the settlement area or a location that had been occupied during a considerable time. The dates do not seem to indicate that soil was taken from a contemporaneous settlement. We have to consider that little effort would have been required to bring soil from the occupation, as the settlement is located nearby. Considering the position of the settlement area and the relocation of the settlement during the millennia, it can be estimated that the soil had to be carried for a distance of between twenty and a hundred metres (Fig. 2).

Previously obtained radiocarbon dates for bone finds have turned out to be considerably earlier, as well as somewhat later, than the burial (*Zagorska 2006; Mannermaa 2008; Mannermaa* et al. *2007*). In graves from the 7th millennium (Burial 170), the 6th millennium (Burial 154) as well as the 5th millennium (Burial 164), the bird bones were between three and five millennia older than the burial remains (*Mannermaa* et al. *2007.Fig. 8*). A bone in Burial 165, dated to the 5th millennia, was just a few centuries older than the grave. These early bird bones are found in graves on the highest part of the gravel ridge and are of about the same age. They have been interpreted as having a natural depositional history, as there are no finds of that age in the settlement. According to a radiocarbon date 9415±80 BP, 9123–8921 cal BC (Ua-18201), as well as on the basis of artefact types, the settlement seems to start during the 9th millennium BC. However, only parts of the settlement area have been excavated, so even the early bones might originate from an occupation layer. Those cases where the bones are younger than the burial provide proof of later disturbance to the graves.

## Soil from the settlement

By removing soil from a settlement used in the distant past and using it in the fill of graves a connection between the present and past was established. There was evidently a need to connect the past with the present, as several other graves are filled with black soil (*Zagorski 2004*). This practice seems to be most common during the 5th and 6th millennia, but is already represented in the earliest burials in the cemetery. However, not all graves have a black fill, especially the ones older than the 6th millennium BC, so it was a custom more common in the later part of the period of use of the area as a burial site. It might be just a small number of persons within the community who were given this special favour during an early part of the period when the site was used as a cemetery. Some of the graves with the largest numbers of grave goods or with elaborate dress decoration are among those with a dark fill.

That not all graves include black soil in the fill is evident from a grave found not more than a couple of metres from the double grave. Burial 325 consisted of an adult and a child, of which the former was dated to 5230±50 BP, 4230–3961 cal BC (LuS 8833), almost contemporaneous with the double grave. Burial 325 was dug transversely into an older grave. Not a single artefact was found in the fill of this shallow grave. However, higher frequencies of the graves from the 6th and 5th millennium BC have a fill of black soil. An interesting change in the use of the cemetery might be related to the practice of filling with black soil. The majority of the earliest graves were found in the western, and highest, part of the gravel ridge. During the latter part of the Atlantic, the burials are located on the eastern slope of the ridge, and the eastern part of the ridge starts

to be the main focus for burials, almost all of which have grave fills of black soil. It seems that the inhabitants ceased burying their dead in the western area, where the ancestors had been buried, but the practice of including the soil of the ancestors' settlement was intensified.

**Graves into graves**

Another perspective related to the past in the past concerns the act of burial. In addition to tools and bones from wild animals, some more or less disarticulated human bones were found in the fill of the double grave (Fig. 6). The difference between the dates 6050±55 BP, 5206–4794 cal BC (LuS 8218) and 5830±60 BP, 4835–4541 cal BC (LuS 8219) indicates that the human bones in the fill originate from at least two different individuals, several hundred years older than the two burials in the grave. That graves were dug into older graves, partly destroying them, is apparent from the documentation of the excavations in the 1960s and 1970s (*Zagorski 2004*).

This habit became particularly obvious when the area below the farmhouse was opened up during the most recent excavation season. Several of the exposed graves had been partly destroyed by the digging of later graves. At least two graves had been affected by the digging of the double grave; it was possible to trace a finger bone from the fill to an adjacent grave (Burial 318).

It does not seem to have been of any special concern if an older grave was found in the course of digging a grave; digging continued anyway. No special practices were brought into action if an older grave was found. Skeletal parts that were found close to the edge of the grave might be pushed into the wall, as in the grave for the double burial. However, those found in the more central part of the grave were collected and later included in the fill.

We do not know how many people were buried at Zvejnieki. A total of 317 graves were recorded in the 1960s and 1970s, including some mass burials with as many as six individuals (*Zagorski 2004; Zagorska 2006*). We know that a number of graves had already been destroyed in the western part of the cemetery during the initial digging for gravel. Based on that knowledge, a calculation of about four hundred graves is most realistic. Already in the mid-19th century the site was well known for skeletal parts being brought to the surface by ploughing. That a considerable number of burials had been placed in shallow graves was well recorded during the excavation below the floor of the farmhouse. If ploughing had been carried out at the same depth as outside the house, then most of the documented graves would have been destroyed. This means that a considerable number of graves were lost during the farming of the fields around the farm. The most plausible number of graves originally located in the cemetery could be six hundred or even more. However, we have to consider the long duration of the cemetery. Even with as many as six hundred graves, the number of graves per generation corresponds to a small group of people, assuming that all were buried in the cemetery. The high number of interred children is an indication that most of the inhabitants were actually buried on the site (*Zarina 2006*).

It would seem strange if the people digging the grave were not aware that they might hit old graves. We do not know if any grave markers were used. No stone covering has been documented and no colouring from posts has been noticed. One indication that some graves were marked is evident from the double grave. In the uppermost part of the fill, an elongated stone, 0.3m in length, was found in an upright

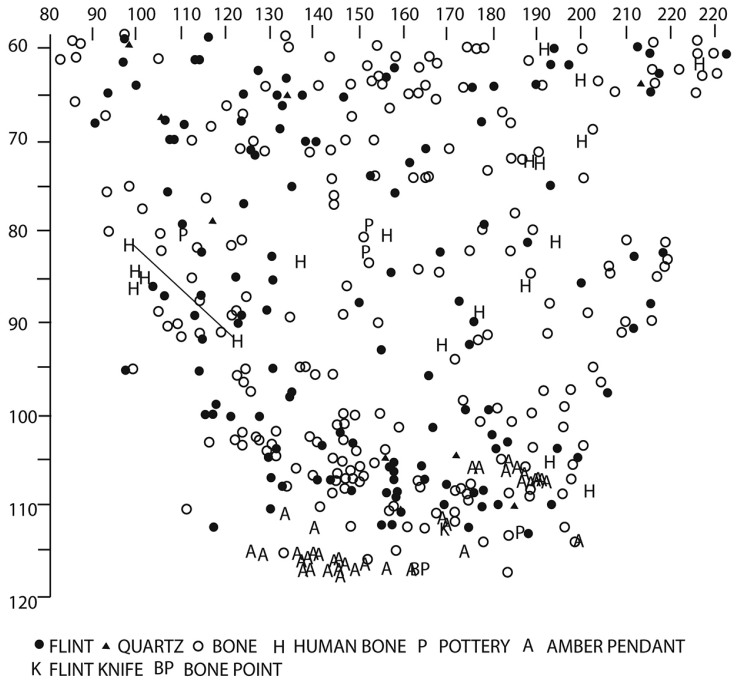



***Fig. 4. The fill of the double Burial 316–317 in a 20-cm-thick transverse section.***

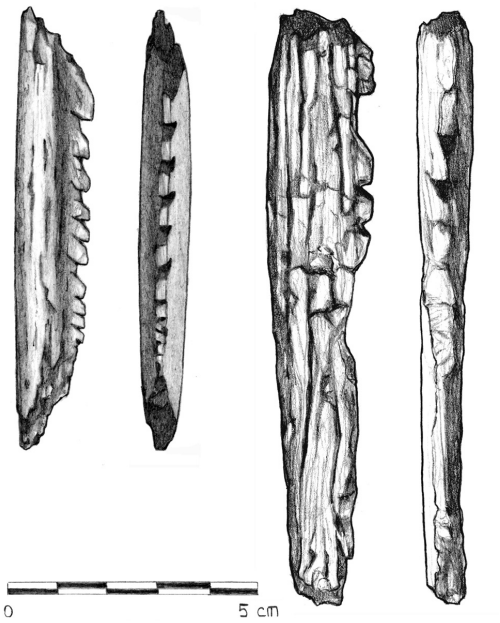



***Fig. 5. Fragments of leister points of the Kunda type found in the fill of the double Burial 316–317 (drawings by Loïc Lecareux)***

position. This stone might have been visible after the grave was refilled. On the other hand, the stone would have been ploughed away if the grave had been located outside the protected area of the farmhouse. This means that ploughing may have removed stones that marked graves.

Regardless of whether any grave markers existed, it did not bother the diggers if they hit an older grave; they cut through it. It might even be possible that digging a new grave into an older one had the same meaning as the fill: the new burial became linked to the earlier inhabitants of the site.

Like the soil of the ancestral occupation layer, the soil of the cemetery was mixed not only with the remains of everyday life, but also with the ancestors themselves. The skeletons were the durable substances associated with a cosmological sense of history (*Helms 1995*). However, the double grave was never affected by later grave-digging, perhaps due to the marking of the grave, which saved it from destruction. It could be that black soil – ancestral soil – in this area, which was reserved for the dead, might have had a special meaning that made further digging inappropriate. Furthermore, most graves with an occupation layer fill are deeper than the majority of graves within the cemetery.

Several graves in the cemetery at Zvejnieki include more than one individual. As many as six individuals were buried in one grave. Occasionally, a disease or accident might have taken a number of lives. In most cases, natural death was not often the cause of death of those interred at Zvejnieki. In several cases, the black soil seems to have been used as a marker for the deposition of further graves when individuals who died somewhat later were added to a grave. In these cases, the inhabitants still had a good memory of the first buried individual, who could have functioned as a guardian for deceased relatives. To place a recently deceased person close to an individual buried previously could have been considered a desirable action.

We have to be aware that the use of the settlement as well as the cemetery continued for several millennia, during which mortuary practices might have changed considerably with respect to the view of past inhabitants. However, during most of the time, a relationship between the dead and the living was established that brought the living into close connection with the ancestral remains, the remains of everyday life in old occupation layers as well as the remains of the inhabitants themselves.

## Grave fills of occupation layer in other hunter-gatherer societies

Concerning the graves at Zvejnieki from the 6th and 5th millennium, there seems to have been a tradition of using the fill as a marker of the connection between the past and present. Does something similar exist at other contemporaneous graves or cemeteries? One site to look into in more detail is Skateholm in southern Sweden, with more than eighty graves in three cemeteries dated to the Late Mesolithic (*Larsson 1993*). It was apparent in some graves that the fill had been arranged in sections of different colours. This was connected with a considerable variation in the character of artefacts in the fill (*Larsson 2016*). The graves with a high number of artefacts were also the darkest in colour. At the time of excavation, it was considered that soil from an existing occupation had penetrated during the digging of the grave. But in certain cases, the marked difference between different fills of the same grave indicates that soil from occupations was used intentionally. In one of the graves, the area closest to the wall of the grave consisted of light sand, with no artefacts, while the fill of the central part of the grave was dark, with a high number of artefacts. The preservation at Skateholm cannot be compared to the situation in Zvejnieki. Bones were found among the artefacts in the fill, but an insufficient organic component to be used for dating. However, based on

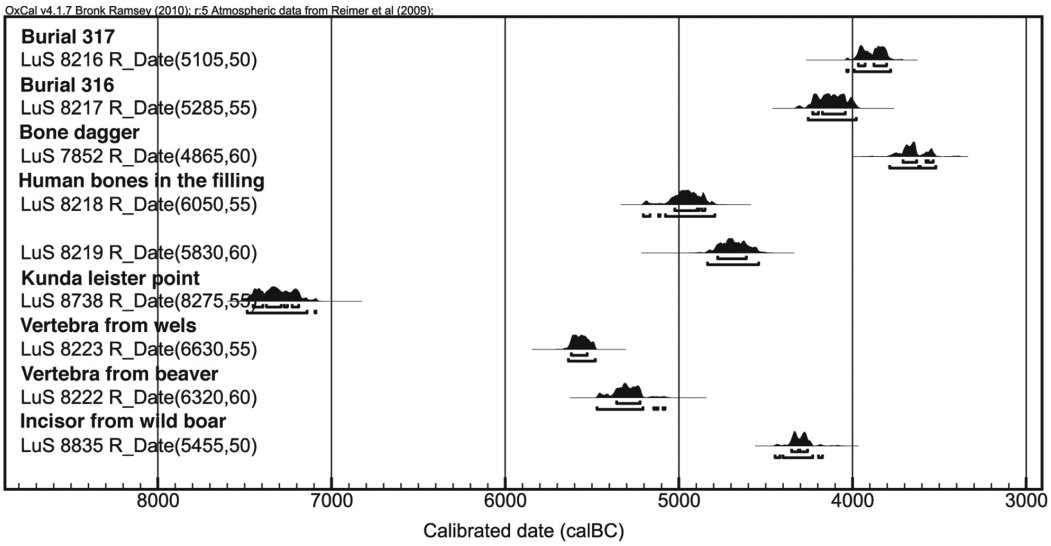



***Fig. 6. The dates of the burials, a bone dagger provided with the burial, the finds in the fill and human bones in the fill.***

some finds, there is a strong indication that earth was taken from another site and used as fill. Somewhat older sites from which soil could have been taken to be used as fill are known in the immediate neighbourhood, such as Skateholm II on a small island close to Skateholm I, and sites along the shoreline of the former lagoon.

## Handling soil from old occupation layers

In a general sense, the secondary use of occupation material might cause severe problems with the dating of layers and features. One example can serve to illustrate the problem. In the excavation of bog sites in the bog Rönneholms mosse in central Scania, the southernmost part of Sweden, several stages of settlement have been documented (*Larsson, Sjöström 2010*). During a recent excavation of the site Rönneholm 10, two layers were identified that belong to the Kongemose Culture of the Middle Mesolithic. However, the uppermost layer also included artefacts from the older Maglemose Culture. However, the microliths from the older part of the Mesolithic were all found in a sandy layer below a hearth (*Sjöström 2011*). The sandy layer was created in order to prevent the fire from burning into the peat below. As the surrounding area consists only of peat and gyttja layers, the sand must have been transported to the bog site from the firm shore. By accident or consciously, sand from an older settlement was brought in a vessel into the lake and laid down as a layer on which to build the fire.

The admixture of older occupation layer in a grave fill might make the use of charcoal, for example, as a sample for radiocarbon dating of the grave highly unreliable. The fill might be of a much earlier date than the burial. But when collagen is lacking in the bones of the burial, there are no other possibilities. A date based on the fill should then be regarded as a *terminus post quem*. Dating a grave from the tools found in the fill involves similar source critical problems that require very careful consideration.

The use of occupation soil might also have some consequences in the form of the alteration of stratigraphy. A grave such as some of those at Zvejnieki holds about one cubic metre of soil. It seems that soil was taken from different parts of the settlement. However, with several tens of graves, the disturbances to the original layers could have been considerable. When excavating occupation layers, such soil removals might be taken as evidence of much later interference. If not identified, the disturbances might cause severe problems concerning the interpretation of the stratigraphy.

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back to contents

# Depiction of hairstyle, reflection of identity? Some considerations concerning Neolithic depictions of hairstyles in the Anzabegovo – Vršnik and Velušina – Porodin cultural milieu

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ABSTRACT – *The phenomenon of Neolithic figurines and other anthropomorphic representations depicting humans with styled hair is an issue that has been generally overlooked in research. Their occurrence in Neolithic contexts all around Southeast Europe is fascinating in itself, and the same holds for the territory of the Anzabegovo – Vršnik and Velušina – Porodin cultural milieus, which is the case study presented in this article.*

KEY WORDS – *Neolithic; anthropomorphic figurines; depiction of hair; Republic of Macedonia*

## *Upodabljanje pričeske kot odsev identitete? Nekaj pomislekov o upodobitvah pričesk v neolitskem kulturnem okolju skupnosti Anzabegovo – Vršnik in Velušina – Porodin*

IZVLEČEK – *Fenomen neolitskih figurin in drugih antropomorfnih predstavitev, ki upodabljajo ljudi s pričeskami, je tema, ki je bila pri raziskavah na splošno spregledana. Njihova prisotnost v neolitskih kontekstih jugovzhodne Evrope je fascinantna že sama po sebi, kar velja tudi za skupnosti kulturnega okolja Anzabegovo-Vršnik in Velušina-Porodin, ki sta osrednji temi pričujočega teksta.*

KLJUČNE BESEDE – *neolitik; antropomorfne figurine; podobe pričesk; Republika Makedonija*

## Introduction

"*Her hairstyle must have been magnificent*" was my initial thought when I first saw the famous anthropomorphic representation with an outstanding depiction of styled hair from Tumba Madžari (Fig. 1). At that time, the visualisation of her hair had such a strong impact on me that it was not at all difficult to picture how she wore her hair almost eight thousand years ago. It was not this figurine that was travelling through my mind; it was a person with a real hairdo. Her long hair was knitted in a very artistic style. On both sides of her head, the long hair was neatly tied at the back, where strands of hair were braided in the form of a number of 'dragonfly' wings. A straight plait running from the top of the head covered the inner part of these extraordinary strands. To complete her appearance, short tiny locks of red painted hair adorned her face. It was a brief, but lovely moment, and I am convinced that many of the visitors shared my emotions by just looking at her.

Another extremely important and fortunate circumstance regarding my personal interest in representations of Neolithic hairstyles, however, is my involvement in archaeological excavations at the Govrlevo

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***Fig. 1. Cylinder from house model from Tumba Madžari, Skopje from the Archaeological museum of Macedonia (photo by Mateja Ravnik).***

site near Skopje conducted by Miloš Bilbija for many years now (*Bilbija 1985.36*). My participation in the excavation campaigns between 2004 and 2010 had a great influence on my views concerning this topic. The tiny fragments of figurine heads and other anthropomorphic representations discovered on a daily basis during the excavations exhibited such a great diversity in the way hair is depicted that it is possible that they are all unique.

The phenomenon of Neolithic figurines and other anthropomorphic representations depicting humans with hairstyles is an issue that has generally been overlooked in the history of research, but it is, I believe, very fascinating. In this article, I will explore some considerations concerning the depiction of hairstyles in Neolithic contexts. Although this theme has much broader theoretical connotations and could probably offer a much clearer insight if the whole Southeastern Europe were taken into consideration, I have limited myself to the territory of 'Anzabegovo – Vršnik' and the Velušina – Porodin cultural milieus, due to the aforementioned moments (Fig. 2).

Both cultural milieus represent the first Neolithic communities in a quite large territory (*Garašanin 1979a; 1979b; Sanev 2004; 2006; Tasić 2006; Zdravkovski 2006a; 2008*). Although they are both connected with the foundations of the Neolithic period in what is now the Republic of Macedonia, they reached their maximum cultural expression as well and territorial peak in the Middle Neolithic. Contexts ascribed to the Anzabegovo – Vršnik cultural milieu are mostly located in the Upper Vardar region including the Skopje region, Ovče pole, Polog and the valleys of the Bregalnica and Lakavica rivers, while contexts connected with Velušina – Porodin cultural milieu are generally found in the wider area of Pelagonija. According to the few $^{14}C$ dates available, the above-mentioned cultural expressions can be viewed as manifestations of the late 7$^{th}$ and 6$^{th}$ millennium BC.

But first, let us look at hair, its meaning and related practices in the recent past, as well as in today's societies.

## Hair, its meaning and related practices in the recent past

Hair is a biological polymer, and thus a part of the human body, but its appearance always has cultural implication as well. How hair is styled is culturally significant; short or long, loose or tied together, shaved or unattended, *etc*. In a way, hairstyle constantly reflects a society and its cultural sphere as well as relationships in it. Throughout history, people have cared about their appearance and tried to find ways to personalise their looks; however, all these personal attempts are also socially and cultu-

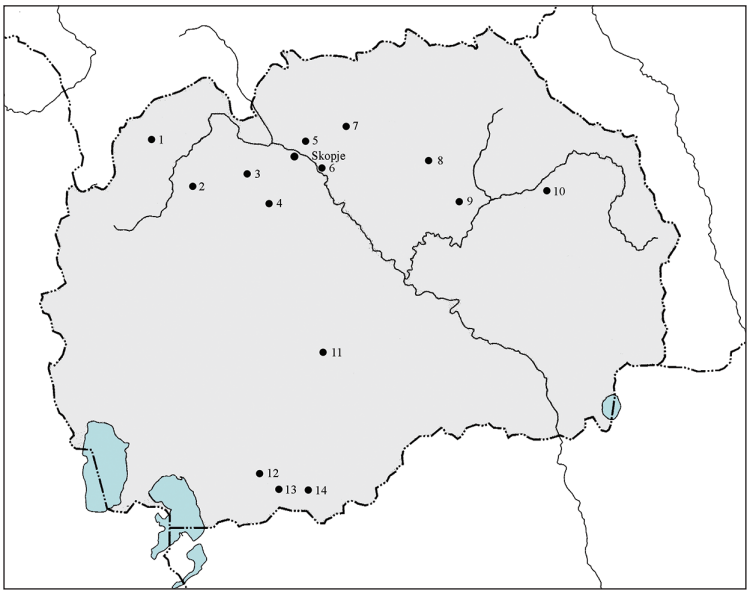



***Fig. 2. The region of Anzabegovo/Vršnik and Velušina/Porodin cultural milieu with Neolithic sites mentioned in the text: 1 Tumba Dolno Palčište; 2 Tumba Stenče; 3 Govrlevo; 4 Zelenikovo; 5 Tumba Madžari; 6 Tumba Čair; 7 Mrševci; 8 Rug Bair; 9 Anzabegovo – Barutnica; 10 Vršnik; 11 Gjumušica; 12 Tumba Optičari; 13 Veluška tumba; 14 Tumba Porodin (created by Aleš Ogorelec).***

rally predisposed. In a way, hair can be regarded as a key aspect of appearance, since it is permanently on view if not deliberately covered, removed or lost. Throughout history, people have been willing to groom, adorn and also remove their hair, and for this purpose also spend time, energy and money, as well to sometimes undergo lengthy and uncomfortable procedures (*Sherrow 2006.XXI*).

When going deeper into history and observing modern societies, we become aware of how important hair has always been and still is in all segments of a given society (*Olivelle 1998; Dikötter 1998; Ebersole 1998; Bryer 2000; Cheng 1998; Cox, Widdows 2005; Hiltebeitel 1998; Miller 1998*). In the correlation with the anthropological concept of the body as being three partite entities, the individual body, the social body and the body politic, B. Miller proposed that hair should be conceptualised in the same manner as "*individually experienced hair, socially symbolic hair and political hair"* (*Miller 1998.281*). These three concepts of hair can perhaps help us to look more systematically at some of practices related to hair that are known from history or in present-day societies that are closely connected with individual, social or political undertones. However, the practices discussed will be very limited, since there are so many throughout history and in the modern world that it is quite impossible to present them even in a slightly wider perspective.

According to the first written accounts on the history of Africa, hair had a special spiritual connotation in African cultures. Many saw the head as a centre of control, communication and identity in the body. Hair was regarded as a source of power that embodied the individual. Since it rests on the uppermost part of the body, hair itself was a means for communicating with divine spirits. Hair also has a strong social and sexual connotation. Most societies regard long, thick, neatly styled hair on young women as a sign of health, respectability, and fertility. On the other hand, unkempt hair could be a sign of illness, mourning or antisocial behaviour. Hair played an important role in many rituals and customs, especially in naming ceremonies or funerals. African hairstyles could reveal a person's age, birthplace, clan membership, socioeconomic and marital status, as well as occupation. For example, among the Masai, members of the group wore different hairstyles according to their position in society. Women and children were usually shaved; warriors wore long braids dyed with red clay, while community leaders wore the most elaborate hairstyles (*Sherrow 2006.12–15*).

For centuries in Japan, hairstyle has signified a person's marital status, social class, age, occupation and/or religious affiliation. During the Meiji period, for example, unmarried women wore butterfly hairstyles, while with the marriage hairstyle changed to a different type of bun (*Sherrow 2006.220*). A similar situation has been documented in China, where hairstyles may have reflected a person's social class, age, gender, religion, occupation and the customs in their communities. In both cases, unattended and neglected hair was a sign of illness or grief. The significance of women's hair in Japanese culture is also clearly manifested through the well-known proverb "*Hair is women's life*" (*Sherrow 2006.220*).

A variety of hairstyle traditions occurred in ancient societies in pre-Columbian America; among the Aztecs, for example, hairstyle indicated age and social status (*Sherrow 2006.238*). Native Americans in North America thought that their hair had a special spiritual significance. They also believed that if their hair came into the possession of enemies, the enemies would have power over them. Various hairstyles were adopted by the different Native American tribes. Also interesting is the case of Hopi women, who braided their hair into a single plait after marriage. Before marriage but after reaching the age when they were ready for marriage, young women wore a distinctive, whorled 'squash blossom' hairstyle resembling butterfly wings on each side of the head. This hairstyle was worn in a coming-of-age ceremony for young Hopi girls, and sometimes they are still worn today (*Sherrow 2006.288*).

Hairstyles of men and women's hairstyles have often differed greatly throughout history, and the styles of both have varied with changing fashions. Usually, some styles have been considered as 'feminine' and others as 'masculine'; however, women's hair has been worn longer than men's during almost all periods and in all cultures. In some eras and in some cultures, women's hair was bound or covered, especially after marriage. The roots of this practice are closely connected with early Judeo-Christian attitudes to women's hair (*Sherrow 2006.XXII*), which influenced at large women's hairstyles in European society, particularly during the Middle Ages. The changing habits of hair styling due to marriage are also known in the Balkans; there are some interesting instances from around Gaćište from the first half of the 20th century, when according to photographic archives, the premarital hairstyles of young girls were extremely elaborate compared to those of married women (*Jurković 2008.24*).

It is known that in many instances religion or other religious practices do have a direct influence on hairstyles. For example, the hair and beard of Sikh men may never be cut. An adult Sikh man is recognised by his long hair and beard. The symbolism of this treatment of hair practice lies within the historical context between 15th and 18th Century A.D. in Northern India. Coming from the background of devotional religion, early Sikh gurus deliberately drew the contrast between Sikh bodily symbols and those of traditional Hindu renouncer with his shaven head and others (*Olivelle 1998.36–37*). In fact, the shaving of heads as well as the whole body is also a practice encouraged by some religious beliefs, such as in Hindu, as already stated, and among Buddhist priests and nuns (*Sherrow 2006.220*), *etc*. However, in some strict religions, such as among the Amish group or Islam, women are forbidden to uncover their hair (*Sherrow 2006.35, 326*).

Hair, or rather hairstyle, has also been decreed by the state, such as the Manchu government's 1644 decree on hairstyle. A decree proscribed the shaving of the men's forehead and braiding their hair into a queue. The Manchu rulers were almost certainly unique in the importance they attributed to the political significance of men's coiffure, and in their willingness to compel by force such a large a population to adopt an alien style. Many who did not follow the rules were, in fact, killed (*Cheng 1998.123–142*). According to Cheng, this case reveals how hair became a means of social control and a focus of cultural and politic conflict. In traditional, China, men's long and plaited hair epitomised the Confucian norm of filial piety, Han culturalism and magical power. During the Qing dynasty, the shaved forehead and queue style symbolised Manchu autocratic authority and its cultural dominance (*Cheng 1998.138*).

Equally important from the perspective of hairstyle practices is the removal of hair. This practice can be traced in the historical sources all the way to Ancient Egypt, where all members of the higher classes, male and female, shaved their heads and wore wigs (*Sherrow 2006.43*). Shaving of hair is also a usual practice among men in some tribes in Asia, while women in India and Africa may shave their head for a particular reason, such as in mourning, for example. Indian traditions advise that a widow shave her head, stop wearing jewellery and dress in plain white or dark clothing (*Sherrow 2006.43*). In this way, the widow is socially separated from society (*Olivelle 1998.20*). The practice of removing the hair from the whole female body is expected in some cultures at certain times, such as upon marriage. Some Orthodox Jewish women cut their hair upon marriage and then conceal it with a wig of false hair, called a 'sheitel' (*Sherrow 2006.326*). The removal of hair from the head in some cultures has indicated social status. For example, in a number of instances, slaves were shaved, thereby indicating their low status. Another case worth mentioning is when the removal of hair is intended to humiliate and subordinate person or as a punishment, which has a long history and persisted into the modern era. For example, after Second World War, French woman who had collaborated with Nazi soldiers were publicly humiliated when their heads were shaved by members of the community (*Sherrow 2006.XXV*). In many cultures, the same fate also befell adulterous women or women who committed a crime (*Sherrow 2006.220*). In Asia, there is also a documented practice of criminals being shaved, which forced them to live the life of beggars outside society (*Olivelle 1998.20*).

Hair also has many symbolic connotations in a range of different societies. One that has been quite widely accepted is connected with grass and fertility. An extremely important quality of hair is that it grows continuously. Besides nails, hair is the only part of the natural body with this characteristic. Because of this the hair on the human head is in many cultures compared to grass. Both grow again if they are cut, both testify to the 'fertility' of their hosts, and in a way they are visually quite similar. Because of these visual connotations, hair is in often symbolically closely related to fertility (*Olivelle 1998.36–37*).

Another, very famous, example of hair symbolism is found in the story of Samson and Delilah, in which healthy hair is a symbol of strength. Hair symbolism can also be seen in many other cases, and sometimes the significance of hair in different cultures can be viewed and expressed in completely opposing ways. No single or unique meaning can be found in this vast range of ways in which hair is treated. It is in the very nature of the dialectic character of cultural products that the same fact or act may have different meanings for different individuals or groups (*Olivelle 1998.31*).

## Neolithic anthropomorphic representations

The occurrence of figurines and other anthropomorphic representations depicting humans with hairstyles in Neolithic contexts throughout South-east Europe is fascinating in itself, and the same holds for the territory of the Anzabegovo – Vršnik and Ve-

lušina – Porodin cultural milieus (Fig. 2). They give us a very good study basis from which to begin our research; however, let us look first at some general data.

Figurines as well as other anthropomorphic representations, whole or fragmented, are quite numerous in Neolithic contexts in the study area (*Sanev 2004; 2006; Koliштrkoska Nasteva 2005; Zdravkovski 2006a; 2006b; 2008; Mitrevski 2003; Naumov 2006; 2007; 2008; 2009*). According to Naumov, 274 published specimens have been published (*Naumov 2009.47–58, Fig. 6.1*), and many are still not published[1]. The figurines and other anthropomorphic representations vary greatly in form and representational technique on the one hand and great homogeneity on the other, as we shall see in the following section. There are three basic typological groups, with a variety of subgroups (*Sanev 2006.172*), based on the typological character and artistic concept of the objects' shape: anthropomorphic figurines, anthropomorphic dishes and anthropomorphic altars.

All these anthropomorphic figurines are miniature representations of the human body, male, female, and also ones with no indication of gender. They depict various body positions, standing, sitting or reclining. Most of them are made of fired clay with a very fine-grained composition; only a few are made from marble and quartz (*Sanev 2006.173*). In general, female are more frequent than male representations. Sanev managed figurines into several subgroups based on body shape. Female figurines can be divided into several different types: pear-like statuettes, statuettes with elongated necks, sitting miniature statuettes, two-part sitting statuettes, kneeling statuettes, standing statuettes and pillar statuettes. Anthropomorphic male statuettes occur only in two basic types: sitting and standing (*Sanev 2006. 174–181*). Figurines are usually discovered settlement areas, either on house floors together with pottery and other artefacts, or in the close vicinity of the so-called 'house domain', but they do not appear in other types of archaeological context.

Anthropomorphic dishes are very few in number; however, they also display some important characteristics concerning depictions of the human body (*Naumov 2009.59–72*). These dishes can be found in the Anzabegovo – Vršnik cultural milieu and thus constitute yet another aspect of body representation.

The next group of anthropomorphic representations according to Sanev are anthropomorphic altars. This group of items gives the Middle Neolithic Anzabegovo – Vršnik cultural milieu a kind of individual and unique quality. It is a kind of hybrid form of two elements: the so-called 'house model' in the lower part of the sculpture and a highly structured representation of human body in the upper segment. The 'house model' is a kind of rectangular form, in some cases perforated on all four sides. These perforations can be different shapes: oval, rectangular, circular *etc*. Small circular perforations can also be found on the upper corners of the 'house model'. In most cases, representations of the human body in these anthropomorphic altars are formally very homogeneous from the artistic point of view. The trunk can be depicted in very realistically, with breasts, abdomen and symmetrically outstretched arms, or with no particular insignia. The head is frequently in the form of a long cylinder, and circular, oval or rectangular in cross-section. The face is depicted very schematically, usually with highly accentuated arches above the eyes. The eyes are frequently portrayed only with an incised line, although they are sometimes depicted more elaborately. The mouth is represented only rarely. Most were discovered at Tumba Madžari, and also at some other sites in the Skopje region: at Govrlevo, Sredselo in Mrševci, Zelenikovo, Tumba Čair and outside the region of Dolno Palčište, Anzabegovo and Rug Bair (*Koliштrkoska Nasteva 2005; Sanev 2006; Zdravkovski 2008*). This type of anthropomorphic representation has many different names and descriptions in publications, such as the already mentioned 'anthropomorphic altars' (*Sanev 2006.182*), then 'altar with an image of the Great Mother' (*Koliштrkoska Nasteva 2005. 60*), anthropomorphic model of the house with chimney depicting a woman down the waist (*Koliштrkoska Nasteva 2005.61*), 'The Great Mother' (*Zdravkovski 2008.192; Koliштrkoska Nasteva 2005.62*), 'The Great Mother of God' (*Sanev 2008.188*), 'models of figurine/houses' (*Naumov 2009.47–58*), *etc*.

On the basis of typological classification and account of artistic-aesthetic differences, Sanev divided these sculptures into two basic groups. The first group consists of those depicting people with outstretched arms, placed on house models with decorated openings on the sides. The second group comprises altars with human images without arms, placed on house models (*Sanev 2006.188*). Another division based on the wall finishing of the house models was

1 Any statistical interpretation of current data would therefore not give us a referential overview.

also proposed: altars with a human image on a house model with carved walls and altars with a depiction of a human image on a closed-walled building (*Sanev 2006.188–189*).

Models of figurine-houses are usually found in settlements areas, whole or fragmented; according to the published data, they can be found in almost every studied 'house' assemblage. The abundance of these finds in settlement contexts and especially in 'house assemblages' led Sanev to the assumption that their presence in the house reflects the desire and obligation of each household to have one, which was provided while the house was being built (*Sanev 2006.190*). In any case, the most widespread interpretations of anthropomorphic altars are associated directly with cults and religion, since most authors see in these sculptures depictions of the 'Great Mother of the Gods' (*Kolištrkoska Nasteva 2005; Sanev 2006, Zdravkovski 2008*). The representation of the 'female principal', as Sanev puts it, was intended to approximate as closely as possible the narrative look of an actual woman of that time, and it included artistic effects linked to everyday life. According to Sanev, this is why some examples were made with elegant coiffure, adorned with bracelets, necklaces and other decorative details (*Sanev 2006.187*). Naumov's recent view is perhaps somewhat different, but very promising; by exploring several different aspects of figurine/houses, he concluded that these objects should be viewed as a matrix of a universal concept which is concentrated mostly around female regeneration and motherhood (*Naumov 2009.47–58*).

All three basic groups of anthropomorphic representations are indicative of Middle Neolithic contexts in the Skopje Valley and Pelagonia. In each group, the depiction of hairstyles can be observed in all the individual cases, as we shall see further on. In order to properly explore some issues of primary concern here, it is necessary to first explore some views on figurines in general.

Figurines are perhaps the most intriguing works of visual art found in Neolithic contexts thought-out the Balkan area, and they certainly receive a great deal of attention from the general as well as the specialist public. They are perhaps the most frequently exhibited artefacts in the exhibitions, many large-scale publications have been devoted to different aspects of the figurines and other anthropomorphic representations and there are quite a lot of catalogue-like publications, in which overviews of archaeological finds are presented in detail as well. And what is probably most important, they encourage researchers to constantly try to answer at least some of the questions concerning their production, use, function, meaning, role in society, *etc*. Since there are so many questions, there are also many different understandings and interpretations.

Authors provide us with several diverse views and interpretations concerning the above-mentioned aspects. Some authors see figurines as religious, ritual or some sort of cult devices; some connect them directly with an idea of a pantheon of gods and goddesses, with Maria Gimbutas being the actual promoter of this view (*Gimbutas 1982; 1989; 1999*). Other authors view them as the representations of everyday life; some see them as children's toys, *etc*. Views also differ on who made them, *i.e.* whether by men, women, priests, potters *etc*. Various accounts on the subject have already been presented elsewhere in detail (*Bailey 2005; Sanev 2006; Hansen 2007*). However, for our purpose it is important to emphasise at least some of the latest views that in my opinion work well within our theme.

In 2005, Douglass Bailey proposed, and later in 2008 developed, a rather new way of seeing Neolithic figurines, with some very instructive mechanisms, which enable us to observe and perhaps appreciate the figurines (*Bailey 2005; 2008.9–18*). In his opinion, figurines stimulate people (modern and Neolithic) to think and above all to make assumptions about themselves and other people. The process of miniaturisation and abstraction are to achieve such stimulation. In a way, all figurines are miniature representations of the human body. And with the practice of miniaturisation, the decision about which features to represent and which to omit comes as well. Reduction in size is always accompanied by a reduction in the number of features represented (*Bailey 2008.10*). Bailey also argues that, as a consequence of representational absence, when people make, look and handle miniature representations and otherwise engage with the miniature world, they gain access to other worlds and alternative realities, as shown in a number of examples (*Bailey 2005; 2008.10*).

In Bailey's view, we should comprehend figurines as philosophies, as entities that make people question who they are, what they look like, how they are similar to some but different from others (*Bailey 2005. 197–204; 2008.10*); and to tackle all these questions, he proposed looking at Neolithic figurines in terms

of the concept of stereotypes and the process of stereotyping (*Bailey 2008.10*). In the simplest terms, he sees stereotypes as conventional, formulaic and oversimplified conceptions or images which propose a set of fixed, unvarying ways to understand the whole world around us. At the broader level of social psychology, stereotypes are seen as inherent to human nature and society. They are understood as a critical apparatus with which people make sense of the world around them and of their relations with others whom they encounter, interact with and are dependent on (*Bailey 2008.11*). Stereotypes work within people's conceptions of what is normal or natural. They are part of the ways in which communities create and sustain a shared sense of the proper limits of what is accepted as legitimate and proper. Stereotypes also allow the construction of social groups by maintaining and reproducing norms and conventions of behaviour, identity and value, so they enable people to experience the world in a particular, perhaps more efficient, manner. Through their own mechanisms stereotypes can be regarded as fictions and illusions, since they do not record reality, but create a record of constructed perceptions within existing relations of powers and orders.

**Overview of elements depicting hairstyle**

Let us look more systematically at depictions of hairstyles, bearing all the foregoing in mind. The cylinder depicting the head of the so-called 'Great Mother' from house 6 in Tumba Madžari (Fig. 1; *Zdravkovski 2008.176*), described at the beginning, is not the only depiction of coiffure found in the Republic of Macedonia, of course. There are quite a few of them, and they appear in all three basic groups of anthropomorphic representations; however, in our opinion, the most of depictions of hair can be seen on various figurines or statuettes and on so-called 'anthropomorphic altars' (Figs. 3 and 4).

***Depiction of hairstyles on figurines*** [2]

If we look closely at figurines, we can see that various hairstyles are depicted in some variety, with very expressive although in a way stylised precision. The depictions were executed with diverse techniques. The choice of representation technique most likely depended on the maker's wish to represent a particular hairstyle. For portraying a couple or more buns (Fig. 3.1–4), as seen on the figurines from Anzabegovo (*Gimbutas 1976.Fig. 144*), Porodin (*Kolištrkoska Nasteva 2005.21, 27*), or Tumba Optičari (*Kolištrkoska Nasteva 2005.20*), the application technique has been used; sometimes with combinations of incisions to draw closer attention to the final appearance. Hair-buns are usually depicted with rather small, circular appliqués. They appear in pairs and sometimes in larger number (Fig. 3.3). It may seem striking that this kind of hairstyle depictions, apart from the figurine from Anzabegovo, are very similar to anthropomorphic representations that are culturally connected with the Velušina – Porodin cultural milieu. It is also important to mention that this kind of depiction can also be found on anthropomorphic vessels (*Sanev 2006.181, Fig. 21*).

Another interesting depiction of hairstyle was found in Gjumušica near Prilep (*Kolištrkoska Nasteva 2005.46*). Depictions of long almost loose worn hair, tied together at the back just at their end, are depicted very exact precision in incisions technique (Fig. 3.6). However, not only long, but also short haircuts have been depicted in some cases, as for example on figurines from Tumba Čair, Tumba Stenče, and Tumba Madžari. All three examples show a very short, flat hair, with some indications of a side or central parting (Fig. 3.7–9). The depictions are completed with incisions; however, the widths and densities of incisions vary considerably in all three cases, such that they create completely different final appearances.

Another interesting depiction of hairstyle is seen on a figurine from Anzabegovo (Fig. 3.5). It, too, was achieved with incisions representing short, probably slightly curly hair. A completely different hairstyle is seen on another figurine, from Tumba Madžari, most likely depicting short but extremely curly hair (Fig. 3.10). In this case the hairstyle is achieved with the application technique; however, it is rather badly preserved. Interestingly, depictions of hair in the so-called anthropomorphic altars use this technique more frequently, or at least the examples are more numerous, as we shall see below.

***Depiction of hairstyles on anthropomorphic altars***

The other group of anthropomorphic representations in which hairstyles are depicted with great precision are so-called 'anthropomorphic altars' or 'models of figurine-houses', as already mentioned. Most of these objects were discovered at well-known Neolithic sites

2 In this present overview of depictions of hair on figurines, some specimens from Rug Bair (*Hansen 2007.Taf. 151:2; Taf. 152:1, 2*) were not considered relevant, since such depictions are somewhat unusual and could easily be viewed as some form of headgear.

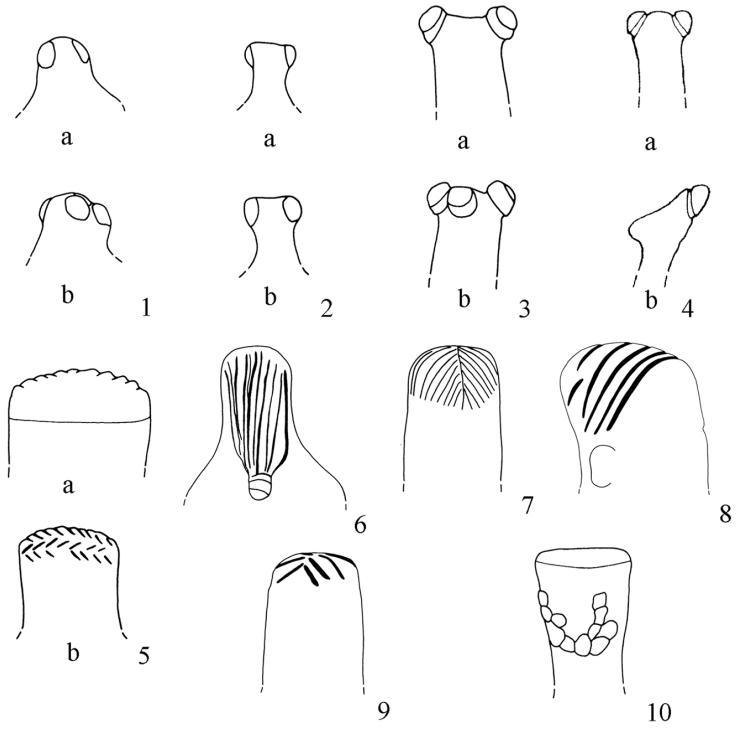



***Fig. 3. Selection of different hairstyles depicted on anthropomorphic figurines (a – front view, b – back or side view): 1 Tumba Optičari (after* Kolištrkoska Nastaseva 2005.20*); 2 Veluška Tumba, Porodin (*Kolištrkoska Nasteva 2005.21*); 3 Tumba Porodin (*Kolištrkoska Nasteva 2005.27*); 4 Anzabegovo (*Gimbutas 1976.Fig. 144*); 5 Anzabegovo – Barutnica (*Korošec, Korošec 1973.T. XI: 11*); 6 Gjumušica, Prilep (after* Kolištrkoska Nasteva 2005.46*); 7 Tumba Čair, Skopje (*Stojanova Kanzurova, Zdravkovski 2008.150–151*); 8 Tumba Stenče, Polog (*Stojanova Kanzurova, Zdravkovski 2008.154–155*); 9 Tumba Madžari, Skopje (*Stojanova Kanzurova, Zdravkovski 2008.152–153*); 10 Tumba Madžari, Skopje (*Kolištrkoska Nasteva 2005.26*) (drawings by Janja Tratnik Šumi compiled from selected publications).***

in the Skopje region of Tumba Madžari; some specimens were found at other sites. Apart from the remarkable depiction of hairstyle from house 6 from Tumba Madžari already described (Figs. 1 and 4.1; *Sanev 2006.Fig. 28*), some others are equally expressive and therefore important.

Several different ornamental techniques were used to complete the depiction of hair. Various incisions of different thickness and density were to portray flat or wavy hair (Fig. 4.2, 3, 5, 10, 11); however, the shape of the depiction is perhaps also enormously instructive when establishing the final outcome of the appearance. A cylinder from Tumba Madžari (chance find; *Sanev 2006.Fig. 27*) features a representation of swept-back hair achieved with wide incised lines extending from the top of the head towards the neck (Fig. 4.2). It is possible that some kind of bun was at the back of the head, but this was not preserved.

The hairstyle one a huge anthropomorphic head, also from Tumba Madžari (*Kolištrkoska Nasteva 2005. 57*) is very similar; however, some elements make this example unique. The incisions are quite wide and are complemented with small inside stitches, so that the final result looks like some kind of furrowed incision; the shape of the hairstyle, on the other hand, also differs somewhat. Some of the incisions on each side of the head were completed with a circular shape, so that it looks like some kind of coiled plait.

The hairstyle on the anthropomorphic representation from Govrlevo (Fig. 4.5) is also interesting, although it survived only in fragments. It looks as if light curly hair worn loose is depicted on the back of the head. A comparable or at least somewhat similar example is a specimen from Dolno Palčišče which has zigzag incisions portraying light curly hair of unknown length (Fig. 4.11). Another anthropomorphic representations with depiction of hairstyle was found at Tumba Madžari in quadrant 2, that was made with the incision technique (Fig. 4.10; *Sanev 2006.Fig. 26*). It has deep incisions forming a triangle running from the top of the head towards the neck which were made quite skilfully, showing probably smooth, loose hair combed towards the back of the head. Resembling an example already mentioned is another specimen found in house 5 at Tumba Madžari (Fig. 4.9; *Sanev 2006.184*). At first sight, it seems to have a great resemblance to the previous example, but a detailed examination of the item shows that the technique as well as the form depicted are not the same. Furthermore, it is more likely that another type of hairstyle was depicted in this case, showing a highly structured form of several plaits extending from the top and sides of the head towards the neck, where they are joined together in a triangle.

Extremely curly hair, almost like an 'Afro' look is generally shown with an additional triangular layer of clay running from the top of the head towards the neck, accompanied with numerous fingertips im-

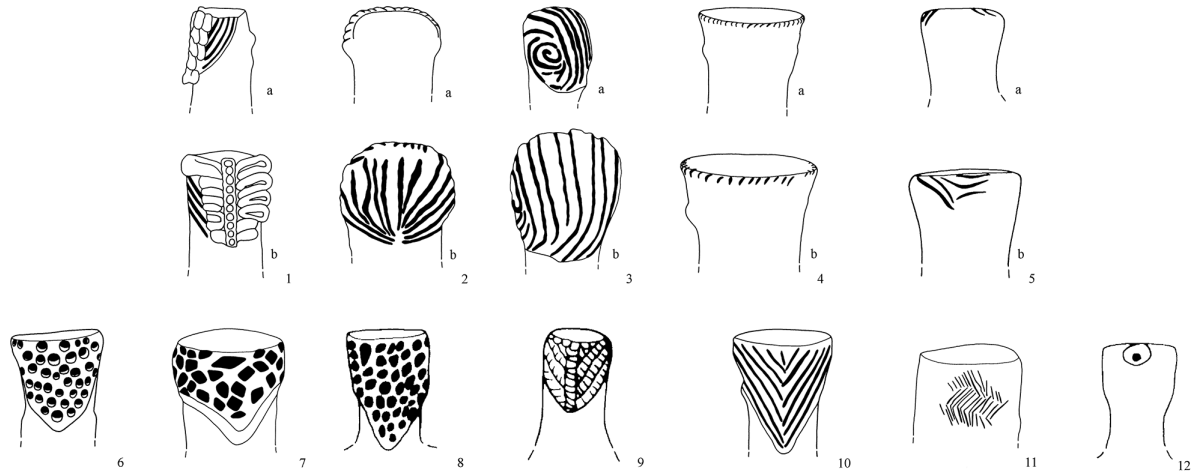


***Fig. 4. Selection of different hairstyles depicted on anthropomorphic altars (a – front or side view, b – back view): 1 Tumba Madžari, Skopje (*Koištrkoska Nasteva 2005.54*); 2 Tumba Madžari, Skopje (*Koištrkoska Nasteva 2005.56*); 3 Tumba Madžari, Skopje (*Koištrkoska Nasteva 2005.57*); 4 Tumba Porodin (*Koištrkoska Nasteva 2005.70*); 5 Govrlevo (*Koištrkoska Nasteva 2005.62*); 6 Tumba Madžari, Skopje (*Koištrkoska Nasteva 2005.55*); 7 Tumba Čair, Skopje (*Koištrkoska Nasteva 2005.69*); 8 Tumba Madžari, Skopje (*Koištrkoska Nasteva 2005.58*); 9 Tumba Madžari, Skopje (*Koištrkoska Nasteva 2005.60*); 10 Tumba Madžari, Skopje (*Koištrkoska Nasteva 2005.65*); 11 Tumba Dolno Palčište (*Koištrkoska Nasteva 2005.69*); 12 Tumba Porodin (*Koištrkoska Nasteva 2005.59*) (drawings by Janja Tratnik Šumi compiled from selected publications).***

pressions (Fig. 4.6–8; *Sanev 2006.Fig. 22–25*). This type of depiction is known from Tumba Madžari and Tumba Čair. A similar result was also achieved with a simple application technique, whereby numerous, smaller and crowded circular appliqués were attached to the head, as seen on some fragments of a cylinder from Govrlevo.

Two other depictions of hair deserve our attention. They are both connected with finds that culturally belong to the Velušina – Porodin cultural milieu. In one instance, the hair has been rendered with small incisions all around the head (Fig. 4.4; *Porodin; Koištrkoska Nasteva 2005.70*). In this, we can see perhaps a representation of very short flat hair, although this is a rather daring interpretation. In other case, a small application has been made at the back of the head, probably depicting a small bun (Fig. 4.12; *Porodin; Koištrkoska Nasteva 2005.59*).

As we can see, this detailed review of how hair is depicted on anthropomorphic representations has provided some illustrative and instructive observations.

Firstly, the variety of hairstyle depictions in Neolithic contexts in the Anzabegovo – Vršnik and Velušina – Porodin cultural milieus is immense, as the ornamental techniques used.

Secondly, hair is depicted on all three basic groups of anthropomorphic representations: on figurines or statuettes, on anthropomorphic vessels and on so-called anthropomorphic altars or models of figurine–houses. However, it is important to note that depictions of hairstyle on anthropomorphic vessels are indeed rare.

Thirdly, some distinctions in hairstyle depiction are noticeable in relation to different groups of anthropomorphic representations. The diversity of hairstyle depictions is much more striking and expressive on anthropomorphic altars than on figurines. Also, the variety of techniques used to depict hair is much more complex within the first group then the other. Furthermore, the quality overtone in execution of depictions is noticeable as well, also in favour of anthropomorphic altars. Differences can also be observed in the stylistic approach to depicting hair. On figurines, hair is usually only schematically portrayed, while hair is actually more realistic represented on models of figurine-houses.

Fourthly, taking into consideration all depictions of hair, it is possible to see that although hair is shown in many different styles, some depiction have similarities; this is true of the form of the hairstyle depicted as well as the execution of it. In these cases, it may well be suggested that they actually represent hair styled exactly the same way.

Fifthly, there seems to be some sort of variation in depictions of hair between the Anzabegovo – Vršnik

and Velušina – Porodin cultural milieus, although perhaps it is somewhat premature to be certain of this. However, there is some evidence that may make a good starting case. The hair depicted in the Velušina – Porodin cultural milieu seems to be limited to a small number of styles, in most cases involving different hair buns (Figs. 3.1–3 and 4.12), while in the Anzabegovo – Vršnik cultural milieu, where depictions of hairstyle are seen in multiple variations and ways, representing a rather diverse repertoire of different styles, hair buns representations are actually limited to one case only (Fig. 3.4).

If some of the representations are of actual hair styles, they can also point to intangible social activities going on in society which influenced the creation of at least some of these hairstyles. If it was real, the magnificent hairstyle fromTumba Madžari described above at the beginning was so multifaceted that it would definitely have required more than one person to be fashion it. We can suppose it very likely that in such cases these activities involved some kind of social bonding within the group.

**Conclusion**

The depiction of hair in Neolithic contexts in Southeast Europe is an exceptionally interesting theme, although it has perhaps not been discussed sufficiently. The theme is instructive and at the same time has great potential. Of course, it is in a way closely related to our understanding of anthropomorphic representations as such. Being aware of the broad array of questions that these items pose, our intention was not to answer them, but to open another chapter in this debate.

In his book about figurines, Douglas Bailey made what we believe to be an extremely important observation: "*Neolithic figurines have at least two kinds of meanings. On the one hand they can be explained in terms of the particularities of their use or function, the reason for which they were made... On the other hand, there is a second meaning and it is this, which may prove to be the more significant for understanding the social realities of living in the Neolithic Balkans. This second meaning works at deeper level and has nothing to do with the intention of person who modelled, decorated or fired a figurine. It does not have anything to do with the ceremony(s)/game(s)/prayer(s) in which that figurine was used. It does not even have anything to do with whether or not that figurine was found in a pit, a building an oven, a burial or in the desk drawer of and antiques' collector. This second meaning is the position of the figurine as unintentional, but potent, manifestation of the body in the Neolithic communities*" (*Bailey 2005. 198–199*).

The existing assemblage of figurines and other anthropomorphic representations from Neolithic contexts is in fact the biggest set of images associated with the human body known to us from the period. Even if it is true that understanding them through a concept of stereotypes and mechanisms of stereotyping remind us constantly that these representations are not representations of reality, but rather someone's perception of it, they are a most excellent legacy of what it meant to be human in this era.

Throughout the article, I have tried to look at depictions of hair in Neolithic contexts from two different cultural milieus (Anzabegovo/Vršnik and Velušina/Porodin) from various perspectives, showing the archaeological data and their broader contexts within the anthropomorphic representations. The debate went further, touching the broad sphere of hair as such and its meaning within different societies and different cultural practices in order to obtain some insights into how the politics of hair works in different cultural milieus. In a way, this was very informative and helped us grasp at least some potential reasons why it would be so important for someone to portray hair with such accuracy and care. The best answer by far is because hair mattered, and because hairstyle must have played a very important role within the societies that produced these anthropomorphic representations. Although seeing them through the perceptions and manufacturing abilities of someone else, they give us an enormous insight into the ways and practices of the society and its views of the world as well as the body.

As we saw through our overview of how hair is treated in different cultures and societies, hair styling or lack of it, always had and still has a very expressive and indicative value; this was even more the case in the past, thanks to globalisation. According to written sources and extensive ethnographic data, hair style in different societies can indicate age, marital status, social status, rank, position in society, even occupation, *etc*. But how can these illustrations work if we also take into consideration the abovementioned archaeological evidence? Barbara Miller proposed that hair should be conceptualised as *individually experienced hair, socially symbolic hair and political hair* (*Miller 1998.281*). Is it possible to in-

terpret our archaeological evidence through her understanding of the conceptualisation of hair. Can we assume that all the anthropomorphic representations depicting hair described herein actually reflect an individual's perception of an individual body, and hence represented an individual's coiffure, or are they depictions of Miller's other two types, socially symbolic or political hair?

Let us look first at the concept of the individual. The indications are contradictory. Above all, all the anthropomorphic representations considered here are in a way unique in form and execution, which supports the idea that these are individualised representations. However, on closer inspection, it becomes obvious that in all the examples the most central quality of personal identity of each human being is absent or depicted in extremely stylised manner almost careless, as Naumov pointed out (*Naumov 2009*). The faces of figurines are usually very schematic, with only a few incisions indicating the eyes and nose; in many instances, the face is completely absent. On the other hand, the faces on the models of figurine–houses are usually more elaborate; however, they do have some sort of standardised form of representation, such as in the eyes or eye arches, nose and sometimes mouth. From the choreographic point of view, they seem to have 'motionless' faces; they do not express any gesture or personal trait for that matter. Although there are some differences in facial depictions between figurines and models of figurine–houses, the fact remains that the faces in both cases do not articulate any elements of individual or personal identity. Hair depictions in our opinion support this idea, since there are some instances where hair is portrayed in almost identical mode, so that we can easily suppose that the depiction of the hair was intended to be universal rather than individualised. All these facts speak in favour of second and the third concept considered at the beginning; depictions of hair as a symbolic social marker and as political hair. There is some important evidence concerning the depiction of hair to support both of these concepts. When looking at the variety of hairstyles depicted on the figurines, which on some occasions assemble into some sort of fashion groups representing different modes of hairstyle, and taking into consideration also the fact that individual faces obviously did not matter, then these observations hold a quite a firm case in favour of socially symbolic depiction of hair. This observation may equally support the idea that the identity of some inner group expressed through hairstyle depictions, being this group of respective elderly women, young women before an initiation ceremony or something different. In addition, there has been also some evidence, which have already been brought up. It seems very likely that the Anzabegovo/Vršnik and Velušina/Porodin cultural milieus, both representing Middle Neolithic material traditions, which also differ in the other aspects of material and visual culture (*Naumov 2009*), preferred different hairstyles, at least as far as depictions of hair are concerned. In this case, one may also draw conclusions on the third conceptual entity, political hair.

In conclusion, I would like to address one other point concerning depictions of hairstyle or its absence. According to written sources and ethnographic data, the intentional removal of hair is a very common practice in many different cultures and societies. In a way, the removal of the hair is equally as important and illustrative as styling hair. From the archaeological point of view within our studied area, anthropomorphic representations that do not depict hair in any form at all are quite frequent (up to one fifth). Do such examples show the intentional removal of hair or something else?

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back to contents

# A new Pre-Pottery Neolithic site in Southeastern Turkey: Ayanlar Höyük (Gre Hut)

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ABSTRACT – *Ayanlar Höyük (Gre Hut), located 30km west of Şanlıurfa, was discovered during surface surveys conducted in 2013. Ayanlar Höyük dated to the Pre-Pottery Neolithic Period, is a large-scale mound like Göbekli Tepe and Karahan Tepe, covering an overall surface area of 14 hectares. It was learned recently that three artefacts dated to the Pre-Pottery Neolithic period which are held by Şanlıurfa Museum were brought from Ayanlar Höyük. The artefacts in Şanlıurfa Museum and the finds recovered from Ayanlar Höyük during a surface survey have been identified as having characteristics similar to those from Körtik Tepe, Göbekli Tepe, Nevali Çori and Karahan Tepe. Consequently, Ayanlar Höyük should be dated between the early Pre-Pottery Neolithic Period B (EPPNB) and the mid-Pre-Pottery Neolithic Period B (MPPNB).*

KEY WORDS – *Göbekli Tepe; Karahan Tepe; animal sculpture; decorative stone vessel; Pre-Pottery Neolithic Period*

## *Novo najdišče predkeramičnega neolitika na jugovzhodu Turčije: Ayanlar Höyük (Gre Hut)*

IZVLEČEK – *Najdišče Ayanlar Höyük (Gre Hut), ki je bilo odkrito med terenskimi pregledi leta 2013, se nahaja ok. 30km zahodno od Şanlıurfe. Ayanlar Höyük je veliko večslojno (tell) naselje, podobno najdiščema Göbekli Tepe in Karahan Tepe,ki se razteza na skupni površini 14 hektarjev in jo datiramo v obdobje predkeramičnega neolitika. Nedavno je bilo ugotovljeno, da so bili trije predmeti, ki datirajo v čas predkeramičnega neolitika in se zdaj nahajajo v muzeju v Şanlıurfi, dejansko izvirajo iz najdišča Ayanlar Höyük. Ti predmeti kot tudi najdbe, ki smo jih pridobili pri našem terenskem pregledu, imajo podobne značilnosti kot najdbe iz najdišč Körtik Tepe, Göbekli Tepe, Nevali Çori in Karahan Tepe. Na podlagi teh zbirov sklepamo, da lahko Ayanlar Höyük datiramo v čas med zgodnjim predkeramičnim neolitikom B (EPPNB) in srednjim predkeramičnim neolitikom B (MPPNB).*

KLJUČNE BESEDE – *Göbekli Tepe; Karahan Tepe; živalske skulpture; okrašene kamnite posode; predkeramični neolitik*

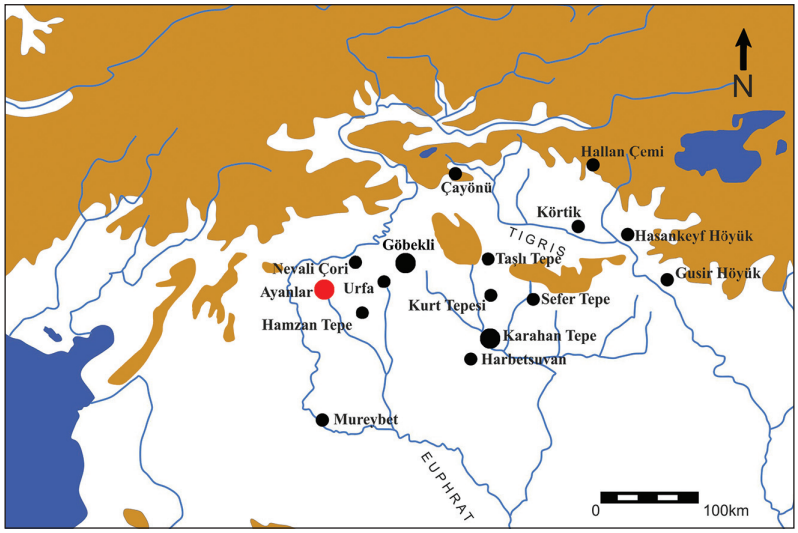
## Introduction

Ayanlar Höyük[1] was first discovered during surface surveys conducted in 2013 (*Güler, Çelik 2015.83–84, Res. 11–13; Çelik 2014a.19; 2014b.318*). Ayanlar Höyük is the largest mound from Neolithic period known in the region and is located west of Şanlıurfa (Map 1). As a result of the research conducted in the south-eastern part of Ayanlar Höyük, 6 settlements with characteristics that can be dated to the Neolithic Period were determined at distances ranging from 2 to 7km (*Çelik 2014a.19; 2014b.317–318;*

1 Ayanlar Höyük is called as 'Gre Hut' by the local community.


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*2015a.446–447; 2015b.356–357; Güler, Çelik 2015.82–83*).[2] These are mostly small-scale settlements. It is estimated that the mound of Ayanlar – the eastern, western and northern sections of which have yet to be investigated – was a big centre in its region. During the studies conducted in the region in 2015, it was understood that the three artefacts (*Ercan, Çelik 2013.Res. 1–3, Fig. 1–2*) brought to the Şanlıurfa Museum in 2013 and dated to the Pre-Pottery Neolithic Period were unearthed from Ayanlar Höyük[3]. Ayanlar Höyük is the third largest mound dated to the Pre-Pottery Neolithic Period after the previously known Göbeklitepe and Karahan Tepe in the region. With the discovery of Ayanlar Höyük, which stands out with its area of approx. 14ha (*Güler, Çelik 2015.Fig. 13; Çelik 2015a.447; 2014b.318; 2014a. 19; 2015b.357*)[4], the number of large-scale settlements dating to the Pre-Pottery Neolithic Period of the region now stands at three. This discovery demonstrates once again that multiple large-scale settlements existed in the region during the Neolithic Period.




***Map 1. Ayanlar Höyük and other Neolithic centres located in the region (created by O. Aras).***

## Location

The settlement is located partially underneath the northern part of Ayanlar Mahallesi, which is located within the boundaries of Karaköprü county, about 30km west of Şanlıurfa (*Çelik 2015a.447*)[5] by the motorway route (Fig. 1). The settlement was first discovered during a surface survey conducted in 2013 (*Güler, Çelik 2015.83–84; Çelik 2015a. 447–448; 2014a.19*).

Ayanlar Höyük's lies 733 metres a.s.l.. The mound is 250 x 300m and presents a broad and shallow structure which contains six small hillocks (Fig. 2). One of these hillocks contains a small burial ground thought to be in use recently and during the Byzantine period (*Çelik 2015a.448*). The mound is covered with cultivated soil approx. 10m above the bedrock. Pistachio orchards cover the land over the mound, as arable land is scarce in the region. A north-south road cuts through the centre of the mound, and an asphalt road runs on the southern part of the mound (Fig. 2).

The geological structure of the region comprises entirely calcareous stratigraphy. However, there is a high plateau 2km east of the mound with massive outcrops of basalt (*Güler, Çelik 2015.84; Çelik 2015b.357*). This region is in the form of a basalt-covered plateau known as Mt. Kaşmer, with an elevation of approx. 910 metres a.s.l. Flintstone deposits are not encountered in the vicinity of the settlement site. Therefore, it is thought that the inhabitants obtained their flint from another region.

Slightly inclined calcareous plateaus extend to the south, west and north of Ayanlar Höyük. An investigation of the geographical location of the mound shows that the surrounding area has generally

2 Five Neolithic settlements were identified in the previous publications. Thereafter, one more Neolithic settlement is added to such settlements based on the analyses on the finds, increasing the total number of Neolithic settlements to six.

3 No settlement from the Neolithic period has been found at İnlice village, the site where three artefacts are thought to have been discovered during surveys carried out in 2015. Interviews with İnlice villagers revealed that villagers were employed at Ayanlar village and that such artefacts might have been brought to the village from there (private interview with Mehmet Kaçmaz, 14.01.2015).

4 In previous publications, the surface area of the settlement was estimated at 17ha by including the pool groups carved into the bedrock around the mound. In the other publications, however, such pool groups are not included, and only the area of soil covering land on the mound is calculated.

5 Inadvertently specified as 27km in one of the publications on Ayanlar Höyük.

turned into barren and rocky terrain due to soil erosion, with very scarce arable land. In addition, it is also reasonable to mention that the Ayanlar site was founded close to water springs. As a matter of fact, the existence of a cave carved some 30m into the bedrock during early or middle Byzantine period to obtain water has been discovered in a valley south of the settlement (*Çelik 2014b.318, Res. 14*). This valley is also the origin of a stream bed through which seasonal rainwater flows down to the Harran Plain (Map 1).

Thus far, only the south-eastern section of Ayanlar Höyük has been investigated. Approx. seven sites were identified in this area (*Çelik 2015a.446–447; 2014b.317–318*)[6]; six are dated to the Neolithic period. Four settlements – Hasan Sırtı (*Çelik 2015b.35, Pl. 4.i–l*), Ömer Altundağ Tarlası (*Çelik 2015b.357, Pl. 4.e–h*), Çillo Mevkii 1 (*Çelik 2015a.446; 2015b. 356, Pl. 3.a–k*) and Çillo Mevkii 2 (*Çelik 2015a.446; 2015b.356, Pl. 3.l–t*) – are characterised as hillside settlements. The remaining two settlements, Domuzcurnu Tepesi (*Çelik 2015a.447, Fig. 17*) and Nebi Tarlası (*Çelik 2015a.447*), on the other hand, were founded on slightly higher hills. Out of these six Neolithic settlements, only Domuzcurnu Tepesi is reliably dated to the Pre-Pottery Neolithic period (*Çelik 2015b.356, Pl. 3.u–z*). Although several finds from the Pre-Pottery Neolithic were recovered from other settlements, such sites tend to present the characteristics of the Pottery Neolithic.

A similar fact concerning the Neolithic sites located south of Ayanlar Höyük also applies to Sefer Tepe and the surrounding area (*Güler* et al. *2013.297, Map. 1*). This suggests that Ayanlar Höyük might also be a site that should be characterised as a large-scale centre like Sefer Tepe (*Atakuman 2014.9, 26; Benz, Bauer 2014.15, 18*).

Ayanlar Höyük is another settlement founded on bedrock, just like the Pre-Pottery Neolithic sites in the region, such as Karahan Tepe, Nevali Çori, Göbekli Tepe, Şanlıurfa-Yeni Mahalle, Harbetsuvan Tepesi, Kurt Tepesi, Taşlı Tepe, Sefer Tepe and Hamzan Tepe (*Çelik 2014a.22*). The settlement is half a day's walk to several Pre-Pottery Neolithic sites in the region. The settlement is some 45km from Göbekli Tepe, 25km from Nevali Çori, 30km from Şanlıurfa-Yeni Mahalle and 35km from Hamzan Tepe (Map 1).

## Ayanlar Höyük finds

The surface surveys conducted in Ayanlar Höyük led to the identification of two periods, the Pre-Pottery Neolithic period and Byzantine period. The early and middle Byzantine period is rather confined to a small area below and around the village (Fig. 2.6). The ceramic finds from this period tend to be concentrated around the village. Headstones and a village cemetery dating to the early Byzantine period were discovered on hill 1 of the mound (Fig. 2.1). Flint and obsidian tools, top and bottom grindstones, pestles and stone axes were discovered in all other areas of the mound.

## Architectural finds

A harvested stone from Pre-Pottery Neolithic period was discovered in the village cemetery on hill 1 of Ayanlar Höyük (Figs. 2.1 and 3). Stones similar to this one were also discovered at Göbekli Tepe (*Schmidt 2010.Fig. 21*) and Karahan Tepe (Fig. 4). This is a shaped stone that could be used as a window or door. This stone is believed to be a porthole observed inside cult buildings (*Schmidt 2010.250*).

A harvested stone cube used in the village was also identified (Fig. 5). In terms of dimensions, this cube is similar to the cubes from the Göbekli Tepe Layer II, which are thought to have been used mainly in feasting ceremonies (*Dietrich* et al. *2012.687, Fig. 11*).

## Small finds

Most of the small finds recovered from Ayanlar Höyük consists of flint cores, chips, blades and debitage (Fig. 6.a–i). No Neolithic ceramics were found. A very small number of obsidian finds was recovered from the settlement in the form of chips and debitage. Moreover, Byblos- and Nemrik-type arrowheads, a stone chisel, end-scraper and hammer were discovered amongst the flint finds (Fig. 6.j–n). If we consider the flint tools as a whole, we observe types of tools peculiar to the Pre-Pottery Neolithic period from topological aspect. In particular, Byblos-type and Nemrik-type flint arrowheads were also found in the region at Göbekli Tepe (*Beile-Bohn* et al. *1998. Abb. 23.3; Schmidt 1988. Fig. 8; 2001.52, Fig. 10/3, 11/5*), Şanlıurfa-Yeni Mahalle (*Çelik 2000.Fig. 5.1; 2007.Fig. 20/6; 2011a.Fig. 20*), Hamzan Tepe (*Çelik*

6 The studies conducted at the Yoğunburç Oççik Mevkii site, which had previously been dated to the Neolithic, revealed that the ceramics are actually from the Chalcolithic and Byzantine periods.

*2010.Fig. 9.5,7,10,17,18*) and Karahan Tepe (*Çelik 2011b. Fig. 18 type I–1*).

The other stone finds recovered from the site are top and bottom grindstones (Fig. 7), pestles (Fig. 6. r–u), a hatchet made of pebble (Fig. 6o), stone dishes (Figs. 8 and 6.p), a decorated stone vessel fragment (Fig. 9.a–b), a stone cube (Fig. 8) and a piece of a sculpture thought to be the head of a leopard (Fig. 10.a–d).

A decorated stone vessel (Fig. 9.a–b), (*Ercan, Çelik 2013.Pic. 1a–d, Çiz. 1a–d*) and a stone dish (Fig. 8), (*Ercan, Çelik 2013.Pic 2, Çiz. 2*) discovered at Ayanlar Höyük and currently on display at Şanlıurfa Museum of Archeology present great similarities with the finds recovered from Körtik Tepe site (*Özkaya, San 2007.21–36*). Moreover, a fragment of a sculpture of dimensions thought to be a leopard on display at the same museum was also recovered from Ayanlar Höyük (Fig. 10.a–d). All the aforementioned artefacts were considered to be recovered from İnlice (Kurtharabesi) village, located approx. 10km south of Ayanlar Höyük. However, the surface survey carried out at this village revealed no signs of settlement. It was later ascertained that such finds had been transported to İnlice village from Ayanlar Höyük by a villager.[7]

Groups of hollows carved into the bedrock were encountered on the rocky terrain located south of the mound (Fig. 11). Similar groups, thought to be a technique employed for constructing pools, are recognised and known in the region from Göbekli Tepe (*Schmidt 2007.Fig. 5*), Karahan Tepe (*Çelik 2011b.Fig. 5; 2015.Fig. 27*) and Hamzan Tepe (*Güler, Çelik 2015.Res. 15; Çelik 2015.Fig. 23*). Another interesting find discovered in the graveyard on Ayanlar Höyük is a stone fragment considered to be an entrance gate or window to cult areas, maybe a porthole (Fig. 3). A similar find was also recovered from the surface of Karahan Tepe (Fig. 4). Moreover, identical finds were also encountered at Göbekli Tepe (*Schmidt 2010.250– 252, Fig. 21, 23–24*). Such stone finds were usually recovered from settlements where cult buildings are present (*Schmidt 2010. 250, Fig. 23*). Thus far, no 'T'-shaped pillars have been discovered at Ayanlar Höyük; however, the discovery of pillar pedestals at the settlement increases the probability of finding 'T'-shaped pillars here. Another artefact that supports this fact is the sculpture fragment thought to depict the head of a leopard (*Ercan, Çelik 2013.21, 35–36, Pic. 3a–d*). This fragment is very similar to finds recovered from Göbekli Tepe (*Schmidt 2007.Fig. 23*) and Nevali Çori (*Hauptmann 2007.Fig. 20*). Moreover, such sculptures are generally found in cult buildings (*Schmidt 2010. 251, Fig. 23*).

## Conclusion

The stream that flows from the basin area of Mount Kaşmer, located east of Ayanlar Höyük, featuring a basaltic structure is known as Karakoyun Stream (*Çelik 2007.15, Fig. 3; 2011a.139, Fig. 3*)[8]. In the Neolithic, this stream, the course of which was altered in the Byzantine period, flowed just upstream from the Şanlıurfa-Yeni Mahalle (Balıklıgöl Höyüğü) settlement (*Çelik 2007.165–178; 2011a. 139–164*). Therefore, the valley through which the Karakoyun Stream flows probably acted as a linking route between Şanlıurfa-Yeni Mahalle Höyük and Ayanlar Höyük.

The three artefacts (*Ercan, Çelik 2013.13–24*) identified as from Ayanlar Höyük before being delivered to Şanlıurfa Museum are important, as such artefacts demonstrate the possibility for the presence of cult buildings at this settlement. In particular, the sculpture fragment depicting the head of a lion/leopard among such artefacts greatly resembles the alto relievo lion located in Building C at Göbekli Tepe (*Schmidt 2011.48, Fig. 28*). Furthermore, the sculpture also has characteristics similar to those of the lion reliefs in the Lion Building (*Schmidt 1998.30–31, Abb. 9–10*).

The recovery of the decorated stone vessel from Ayanlar Höyük, which is currently on display at Şanlıurfa Museum, is also important because this is an indication that the burial traditions practiced at Ayanlar Höyük had characteristics similar to those at Körtik Tepe. In addition, although only four or five decorated stone vessel fragments have been recovered from the excavations at Göbekli Tepe, an almost intact stone vessel was recovered from Ayanlar Höyük. The presence of all these finds suggests that Ayanlar Höyük might be a large-scale settlement that will yield substantial finds.

So far, the finds recovered from Ayanlar Höyük indicate that the settlement has characteristics iden-

7 Private interview with Abdulkadir Kaçmaz on 16.01.2015, who delivered 3 artefacts to Şanlıurfa Museum.
8 This stream is also called as the Skirtos or Daişan stream.

tical with Layer II of Göbekli Tepe. However, taking into consideration the 10m of cultivated soil covering the settlement, it is highly possible that similar finds from Layer III of Göbekli Tepe will be found. In conclusion, the abundance and high-quality of the finds from Ayanlar Höyük resembling the finds from Göbekli Tepe and Karahan Tepe indicates that this settlement was an extensive Neolithic centre. Moreover, the surface area of the settlement, some 14ha, and the presence of small hills thereon, as at Göbekli Tepe and Karahan Tepe, shows that Ayanlar Höyük was an extensive settlement during the Neolithic period, like Göbekli Tepe and Karahan Tepe. Ayanlar Höyük should be dated between the early Pre-Pottery Neolithic B period (EPPNB) and mid-Pre-Pottery Neolithic period (MPPNB) in the light of the finds recovered there.

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***Fig. 1. View of Ayanlar Höyük from the North (photo by B. Çelik).***

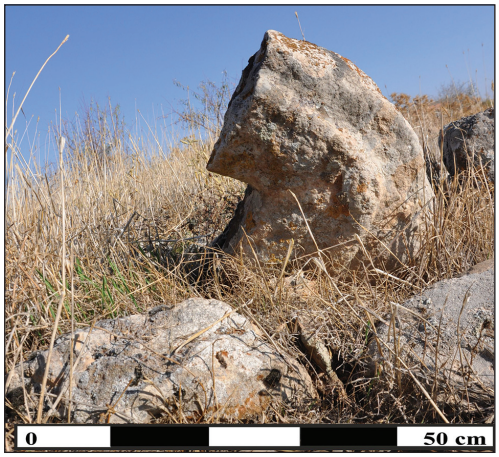



***Fig. 3. A porthole stone fragment from Ayanlar Höyük (photo by B. Çelik).***

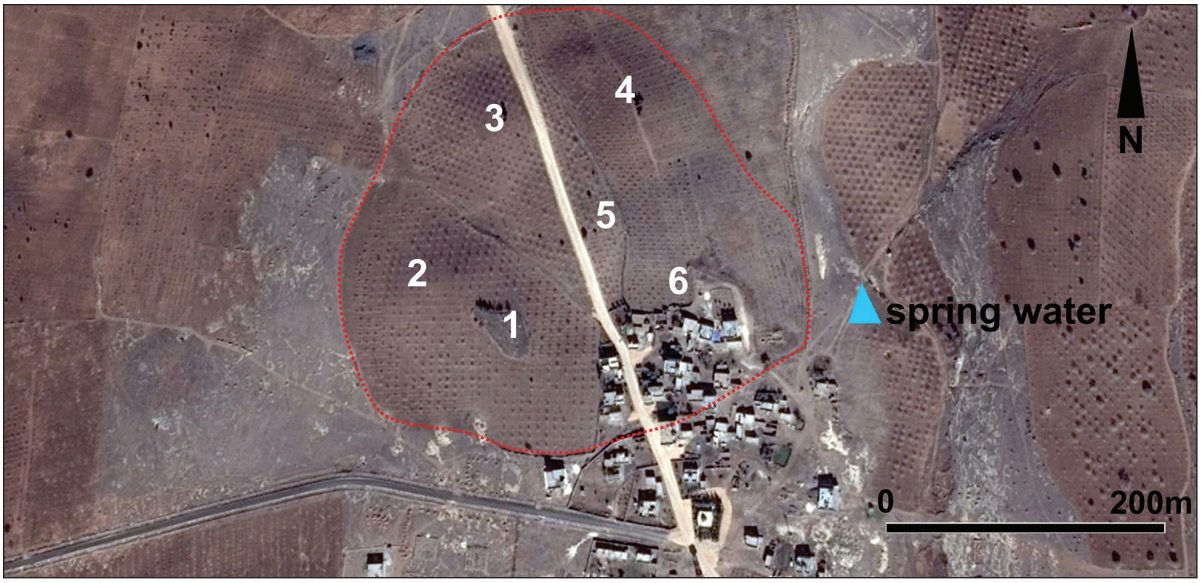



***Fig. 2. Ayanlar Höyük and the hillocks located on it (created by O. Aras).***




*Fig. 4. A porthole stone fragment from Karahan Tepe (photo by B. Çelik).*

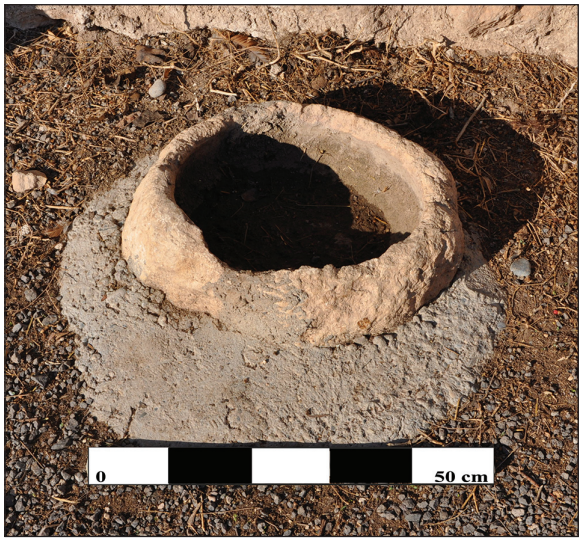



*Fig. 5. Stone cube from Ayanlar Höyük (photo by B. Çelik).*




*Fig. 6. Ayanlar Höyük small finds (photo by B. Çelik).*




*Fig. 7. Top and bottom grindstones from Ayanlar Höyük (photo by B. Çelik).*




*Fig. 8. Stone dish from Ayanlar Höyük (photo and drawing by B. Çelik).*

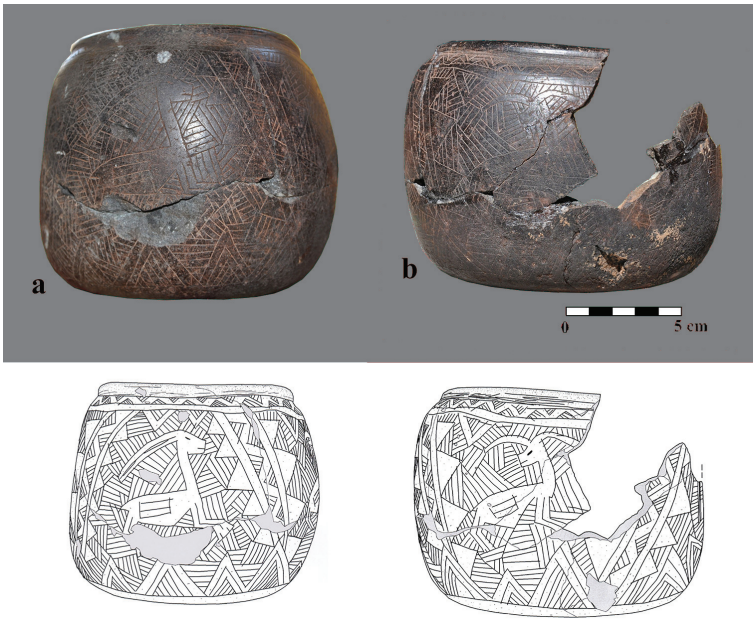



*Fig. 9.a–b. Decorated stone vessel from Ayanlar Höyük (photo and drawing by B. Çelik).*

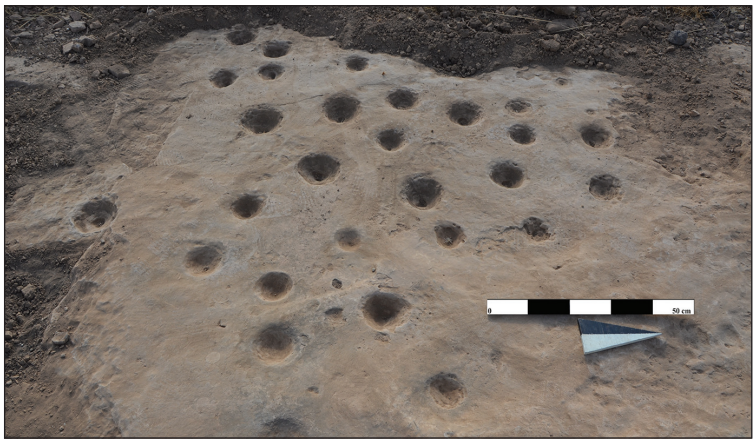


*Fig. 11. Groups of hollows carved into the bedrock at Ayanlar Höyük (photo by B. Çelik).*

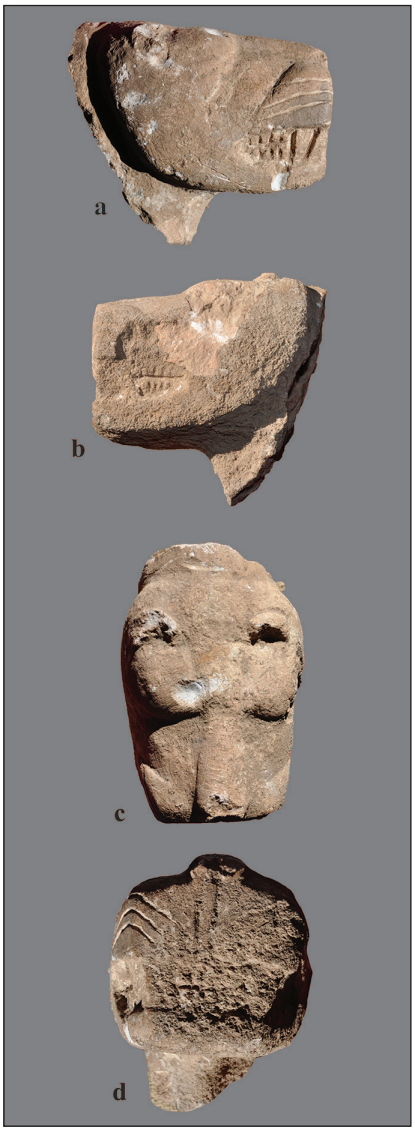



*Fig. 10.a–d. Fragment of sculpture depicting the head of a leopard from Ayanlar Höyük (photo by B. Çelik).*

# An examination of the worked bone and antler assemblage at Uğurlu (Gökçeada, Turkey)

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ABSTRACT – *Worked bone and antler tools were regularly used by prehistoric societies in northwest and western Anatolia to create and maintain everyday items. Uğurlu, one of the most important prehistoric sites in the north east Aegean, shows extensive evidence of bone and antler tool manufacture. This article examines the Uğurlu osseous assemblage from its inception during the Early Neolithic (6800 cal BC) to the middle Chalcolithic (4300 cal BC). A typology is established which labels the 534 items uncovered thus far, supported by contextual information. A comparison with other bone tool assemblages in the region is also presented, highlighting group similarities and type differences. The results show that few bone tools were found in the Early Neolithic Phase VI (6800–6600 cal BC), while pointed tools dominate Phase V (6600–5900 cal BC). The established Neolithic Phase IV (5900–5600 cal BC) witnesses a dramatic growth in the number of bone tools produced, which is steadily adapted with the advent of the Chalcolithic Phase III (5500–4900 cal BC). During this transition between the Neolithic and Chalcolithic, certain tool types decline in number and manufacturing style changes. In the middle Chalcolithic Phase II (4500–4300 cal BC), bone objects seem to be crudely made, possibly reflecting the emergence of local traditions.*

KEY WORDS – *Neolithic-Chalcolithic; bone tools; northwest Anatolia; typology*

## *Pregled zbirov obdelanih kosti in rogov na najdišču Uğurlu (Gökçeada, Turčija)*

IZVLEČEK – *Prazgodovinske skupnosti v severozahodni in zahodni Anatoliji so za izdelavo in popravilo vsakdanjih predmetov redno uporabljale obdelana koščena in rožena orodja. Na najdišču Uğurlu, enem najbolj pomembnih prazgodovinskih lokacij na severovzhodu Egejskega prostora, so odkrili številne dokaze o izdelavi koščenih in roženih orodij. V članku preiskujemo koščeni zbir iz Uğurla od nastanka najdišča v času zgodnjega neolitika (6800 pr. n. št.) do srednjega halkolitika (4300 pr. n. št.). Na podlagi zbira 534 tovrstnih predmetov, ki so bili do sedaj odkriti na najdišču, smo izdelali tipologijo, ki je podprta s podatki o kontekstih. Podatke smo nato primerjali z drugimi kostnimi zbiri v regiji, ki kažejo tako na podobnosti kot na razlike v tipologiji. Rezultati kažejo, da so v času zgodnje neolitske faze VI (6800–6600 pr. n. št.) uporabljali malo koščenih orodij, medtem ko v fazi V (6600–5900 pr.n.št.) prevladujejo konice. V obdobju uveljavljenega neolitika v fazi IV (5900–5600 pr.n.št.) se je število obdelanih koščenih orodij dramatično povečalo, ki se postopoma prilagodi v začetku halkolitika v fazi III (5500–4900 pr. n. št.). Prisotnost določenih tipov orodij se zmanjša v času prehoda med neolitikom in halkolitikom, spremeni pa se tudi stil izdelave. V času srednjega halkolitika v fazi II (4500–4300 pr. n. št.) so koščena orodja grobo izdelana, kar morda kaže na pojav lokalnih tradicij pri izdelavi.*

KLJUČNE BESEDE – *neolitik-halkolitik; koščena orodja; severozahodna Anatolija; tipologija*


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## Introduction

Animal bone was an important raw material source at Uğurlu, as its durability and manageability was utilised to create strong and versatile items. The systematic study of worked bone tools had its inception in the mid-20th century. Focus on typologies quickly expanded into other related areas, including use-wear analysis and experimental replication studies (for early concepts of bone tool typologies, see *Camps-Fabrer 1966.82–135; Schibler 1980*; for use-wear analysis, see *Semenov 1964; LeMoine 1997*; for replication studies, see *D'Errico* et al. *1984; Goodarzi-Tabrizi 1999*). In recent years, significant scientific advances have been made regarding the study of bone tools, expanding the knowledge base for this discipline (*Bradfield 2015.3–14; Spangenberg* et al. *2014.11–25; Griffitts 2011.52–66; Choyke 2007. 641–665; Legrand, Sidéra 2007.67–80*). In Anatolia and the Balkans, prehistoric bone tool studies now largely integrate typological analysis with an emphasis on scientific and theoretical procedure (*Russell 2005.339–369; Dekker 2014; Vitezović 2011.117–136; Zidarov 2008.57–62*).

Specialised publications of bone tools from Neolithic northwest Anatolia are lacking, with many site reports incorporating this material group with other small finds. A number of sites (Aşağı Pınar and Barcın Höyük in particular) (*Erdalkıran 2017.235 vd; Azeri 2015; Dekker 2014*) have specialists currently working on their worked bone material, while in-depth analysis from non-worked bone experts is included in the reports from Yeşilova, Yenikapı, Hoca Ceşme, Fikirtepe, and Pendik (*Derin 2012.182; Kızıltan, Polat 2013.123; Özdoğan 2001.33–34; 2013. 174–182*). Furthermore, the prehistoric sites of Yarimburgaz Cave, Toptepe, Aktopraklık, Ege Gübre, and Ulucak contain limited amounts of worked bone information in their published reports (*Özdoğan 2001.8–11, 64–66; Karul, Avcı 2011.1–15; Sağlamtimur 2012.197–225; Çevik 2012.143–158; Çilingiroğlu* et al. *2004.50*). However, there are some examples of detailed worked bone investigation, such as Marinelli's report on the Ilıpınar bone and antler assemblage (*Marinelli 1995.122–143*).

Excavators at Neolithic sites in modern-day Greece and Bulgaria pay close attention to worked osseous material. Rosalie Christidou and Michel Séfériadés examined the Neolithic assemblages at Limenaria and Dikili Tash to emphasise aspects of bone exploitation in the region (*Christidou 2005.91–104; Séfériadés 1992.99–112*. The term Neolithic used for sites in Greece corresponds with the Anatolian Chalcolithic period). Peter Höglinger's (*1997.157–196*) detailed report on the 272 stratified bone objects discovered at Karanovo is a notable addition to Bulgarian worked bone tool studies. Site reports from Yabalkovo and Kovačevo also contain further information for this region (*Leshtakov* et al. *2007.185–234; Sidéra 2013.173–178; Lichardus Itten* et al. *2006. 83–94*).

Positioned in the north Aegean off the northwest coast of Anatolia, Uğurlu, on the island of Gökçeada, is one of the earliest sites with evidence of farming and animal husbandry in the Aegean. Stratigraphic excavations have clarified the spatial extent of the settlement from the pre-pottery Neolithic occupation (*c.* 6800 cal BC) and brought to light evidence of the earliest examples of pottery production (*c.* 6600/6500 cal BC). A clear, yet gradual transition from the Neolithic to the Chalcolithic period is also observable (*c.* 5500 cal BC). Bone and antler tools were frequently created and used by this community to support their burgeoning lifestyle. This paper explores the bone tool assemblage with a focus on a typological and contextual analysis of the material. The subsequent discussion will provide an initial assessment of these tools and their position within the wider region.

## The Uğurlu excavation

Uğurlu is located on the western part of Gökçeada (Fig. 1). The site is a low mound covering an area of approx. 250 x 200m on a gentle slope at the eastern foot of Mount Isa (Doğanlı). The main Uğurlu-Dereköy road cuts through the site. So far, during the eight years of excavation, six main cultural phases, designated as I–VI (counting from top to bottom), and at least 15 layers of occupation have been revealed. The earliest Phase VI dates to the pre-pottery Neolithic period, *c.* 6800–6600 cal BC. Phase V is marked by the first pottery Neolithic, *c.* 6600/6500–5900 cal BC. During Phase IV, around 5900/5800 cal BC, the settlement expanded, and the islanders may have formed their own culture and identity. Around 5500 cal BC, major changes occurred at Uğurlu. These variations occurred in all aspects of cultural life, as indicated by modifications in settlement pattern, spatial organisation, the plan of buildings, art, and pottery production. The spatial organisation of settlements and building plans were further modified around 4500–4300 cal BC (*Erdoğu 2014.157–178; 2016.89–94*).

## Worked bone and antler assemblage

### *Methodology*

A ten-stage procedure was designed to collect information. After recording contextual information, the raw material (bone, antler, or tooth) of the object was recorded. The tool was then placed within a group, type, and if needed, sub-type. The object was measured (including maximum length, width, and thickness) and described. In this regard, each object was divided into a base, shaft, and tip and described individually. Surface condition, colour, and modification (in the form of striation direction) were then recorded. Striations were identified with the naked eye, a x3 magnification eye-piece, and in some cases, a USB microscope with x200 zoom. This microscope has a dual axis x50 and x200 lens with a manual focal range of 10mm onwards. The taxonomy and element were also recorded, limited to broad categories of small, medium, and large animal bones that were either long, short, flat, or irregular. All items were photographed and illustrated, with data recorded in a searchable database.

### *Typology*

In total, 534 worked antler and bone items have been recorded thus far (Tab. 1). From these, 455 have been typed, while the remaining 79 have been classified as undefined. Objects identified as undefined are either too fragmented to classify or have no formal shape. Some are waste from manufacture. In order to create a more distinct picture of the assemblage, any data using percentages relates to the 455 typed objects only.

The typology is first separated into four groups: 'pointed tools', 'cutting tools', 'polishing tools', and 'other'.

The most prominent type in the pointed tool group are points (Fig. 2). This type is used to describe any worked object with a pointed tip, excluding needles or pins. They were employed for a variety of tasks relating to perforation. The creation of everyday items such as clothes and shoes would have required the use of points to create stitching holes. Points were also required in ceramic decoration and textile manufacture to manipulate the visual form of an item. The decision to label this type 'point' rather than 'awl' is based on the unique functional characteristics of awls. Awls have a specific morphological function, and thus labelling all points as awls is misleading. Due to the large quantity of points (n = 191, 42% of the overall assemblage) eight sub-types have been defined, divided by morphology, raw material selection, and additional decoration (Tab. 2).

Type A points are most common, with 115 examples, and are characterised by a break on the shaft with a pointed proximal and no epiphysis or base. Type B consists of a longitudinally split bone with an intact distal end, while type C are split lengthwise, with the base or distal end split in half. Type D points have a rounded and smoothed distal epiphysis, and type E are identified by an angled proximal caused by abrasion on one lateral. Type F points are defined by decorations or additions made to the object's surface. Two motifs are apparent: one is a zigzag pattern seen on two examples, while another has a double-'v' incision (Fig. 3). Type G has a flattened and wide shaft that narrows into a small rounded tip, and what I describe as an awl, while type H comprises pointed objects made on other elements beside metapodial or tibia bones. Due to the variety of type H bone elements, mean length, width, and thickness varies greatly (the largest being a 88.42mm tool crafted from a femur and the smallest being a 39.78mm tool constructed from an incisor). Types A through G are mainly made on medium sized animal long bones, mostly metapodial bones of sheep and goats. Parallels exist between regional and inter-regional point types (Tab. 3).

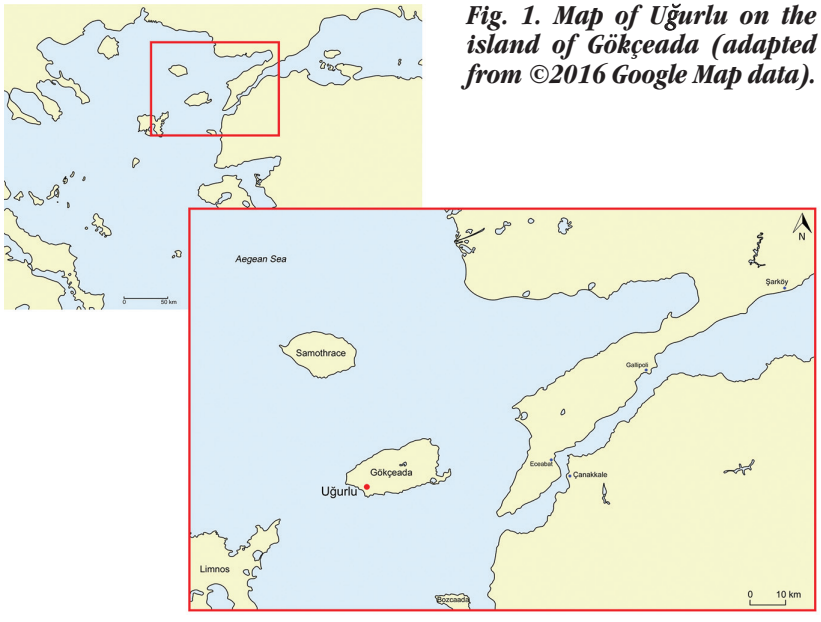



***Fig. 1. Map of Uğurlu on the island of Gökçeada (adapted from ©2016 Google Map data).***

| Group | Type | Sub-type | Number | Total |
|---|---|---|---|---|
| Pointed tools | point | Type A | 115 | |
| | | Type B | 11 | |
| | | Type C | 12 | |
| | | Type D | 27 | |
| | | Type E | 13 | |
| | | Type F | 3 | |
| | | Type G | 5 | |
| | | Type H | 5 | 191 |
| | rounded point | Type A (bone) | 17 | |
| | | Type B (antler) | 14 | 31 |
| | bi-point | | 2 | 2 |
| | hook | | 6 | 6 |
| | needle | Type A (notched) | 20 | |
| | | Type B (perforated) | 3 | 23 |
| | pin | Type A (pin) | 43 | |
| | | Type B (pin-point) | 4 | 47 |
| Cutting tools | chisel | | 4 | 4 |
| | gouge | | 8 | 8 |
| | pick | | 1 | 1 |
| | puncher | | 1 | 1 |
| Polishing tools | smoother | Type A | 83 | |
| | | Type B | 8 | 91 |
| | spatula | Type A | 23 | |
| | | Type B | 7 | 30 |
| Other | component/ composite elements | Type A – handle | 4 | |
| | | Type B – shaft | 6 | 10 |
| | perforated object | | 2 | 2 |
| | preform | | 4 | 4 |
| | utensil | Type A – spoon | 2 | |
| | | Type B – spatula-spoon | 2 | 4 |
| Total | | | 455 | 455 |
| Undefined | | | 79 | 79 |
| Total | | | 534 | 534 |

***Tab. 1. Uğurlu worked bone and antler typology.***

There are five other types in the pointed tool group (Fig. 4). Rounded points are distinguished from points by having rounded and blunt tips. They are divided according to their raw material, with type A made from bone, while type B are made from antler.

Only two bi-points are recorded, and are described as having both a pointed tip and base. This tool is associated with textile production or fishing related activities. Regarding fishing, three fish hooks are present. They vary in size and form, with breakage normally occurring on the bend, where the greatest amount of force is exerted. Two decorated headed bone hooks are also noteworthy. They were possibly used for securing clothing.

Needles are well represented and defined by a pointed tip either incised on the distal lateral (type A) or perforated at the base (type B). Of particular importance was the discovery of a large number of type A needles in trench P5, unit B91, discovered inside a pit and dated to 5600 cal BC. Considering their apparent deliberate placement, and no obvious parallels in the wider region, these objects may have had significant cultural value for the inhabitants of Uğurlu (Fig. 5).

The final type in the pointed tools group is pins. They are the second most frequent pointed tool and are circular, with a slender shaft and pointed tip. The majority fit into this form (type A); however, some (type B) have a non-circular shaft, but are slender and thin. Based on striation direction, these tools are related to perforation activities.

The second tool group are cutting tools, which comprises four types (Fig. 6). The tools in this group are associated with activities that require cutting, scraping or striking. There are 14 cutting tools in total, making this the smallest group (3% of the overall collection). Chisels are defined by a bevelled tip and compact shaft, with no set base profile. Use-wear analysis from Çatalhöyük suggests these types of tools were used for woodworking activities (*Giffitts 2011.52–66*). Gouges have a hollowed shaft, varied degrees of base modification and a modified tip. Tips were most commonly strengthened by burning until blackened. This reinforces the bone cortex, making it easier to use on hard materials. A pick and a punch, both made from antler, were also found. The pick may have been used for digging, while the punch was used by striking the base with another tool, transferring the energy to the tip to exert force. After continual use, the base and tip are left damaged, exposing the spongy bone.

There are only two types in the polishing tool group; however, it is the second most frequent group (n = 123, 27% of the overall assemblage). These tools are associated with the removal of excess material dur-



***Fig. 2. Uğurlu points. Left to right: type A (CC21B26x1); type B (P5B148x4); type C (DD20B4x1); type D (P6B7x9); type E (P5B106xz2); type F (BB20-21B9x1); type G (QP6B6x4); type H (BB20-21B59x7) (designed by J. W. Paul).***

ing hide preparation and pottery moulding (Fig. 7). The first of these are smoothers. Smoothers are also referred to in the Turkish literature as mablak. Some authors label morphologically similar items as chisels or gouges. They are characterised by a long curved shaft, either open (type A) or flat (type B), with a bevelled tip and base worked to varying degrees. Type A smoothers outnumber type B and are made from long bones, including metapodial, radius, and tibia bones, of medium- and large-sized animals. Striations usually appear on the second aspect of these objects, running horizontally and diagonally.

The second type in this group is spatulas. A spatula has a flat, broad shaft with elongated ends and is made exclusively on rib bones split lengthwise. Type A and B are differentiated by tip morphology: type A is rounded, while type B is pointed. Their primary purpose was pottery moulding. Closely linked with pottery production, experimental studies show that they are extremely useful in regularising the shape of ceramics and removing excess material (*Mărgărit 2017.206*).

Items in the 'other' tool group are not functionally associated with pointing, cutting, or polishing activities. This includes artefacts that appear not to be tools but, rather, to be worked bone and antler objects that may fulfil a variety of other functions, including use in ritual settings or as items with purely aesthetic value. There are 20 items in this group, divided into five types and four sub-types (Fig. 8).

Component/composite elements are separated into handles (type A) and shafts (type B). Handles in this context refers to handles for spoons, where the bowl has been broken off, while shafts are made exclusively from deer antler and hollowed out at one end to hold a sharp stone object. Shafts acted as handles to protect the user's hands, resulting in the ability to exert greater force.

Two perforated objects are included in this group. The first was made of deer antler and was perforated in the middle of the shaft, while the other is rectilinear, with a rounded and smoothed base. I suggest the latter perforated object may have functioned as a toggle used to hold a garment together, as it is similar in appearance to modern examples.

Four preforms are also recorded. A preform is any object displaying early signs of manufacture, but never made into a complete type. It is important to record them, as they can highlight procedural steps taken in constructing certain types. For example, one object is a needle preform which has the beginning of a perforation on one aspect and a dimpled impression on the other. Much of this object is rough, suggesting drilling was an initial step in the manufacturing process.



***Fig. 3. Point type F: P5B87x5, P6B41x2, BB20-21B9x1 (designed by B. Erdoğu and J. W. Paul).***

| Sub-type | Phase | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | VI | V | V–IV | IV | IV–III | III | II | surface | unknown | |
| A | 1 | 4 | 5 | 37 | 5 | 42 | 8 | 5 | 8 | 115 |
| B | – | 1 | 1 | 6 | 1 | 2 | – | – | – | 11 |
| C | – | 2 | 1 | 4 | 1 | 3 | – | – | 1 | 12 |
| D | – | 4 | – | 7 | – | 10 | 1 | 2 | 3 | 27 |
| E | – | – | – | 5 | – | 4 | 3 | – | 1 | 13 |
| F | – | – | 1 | 2 | – | – | – | – | – | 3 |
| G | – | – | 1 | 2 | 1 | – | 1 | – | – | 5 |
| H | – | – | 2 | – | 1 | 2 | – | – | – | 5 |
| Total | 1 | 11 | 11 | 63 | 9 | 63 | 13 | 7 | 13 | 191 |

| Sub-type | Mean max. length (mm) | Standard Deviation | Mean max. width (mm) | Standard Deviation | Mean max. thickness (mm) | Standard Deviation |
|---|---|---|---|---|---|---|
| A | 45.8 | 15.3 | 8.0 | 3.1 | 2.5 | 0.9 |
| B | 59.4 | 18.9 | 12.0 | 3.2 | 2.7 | 1.6 |
| C | 60.7 | 14.4 | 12.3 | 3.5 | 2.9 | 1.7 |
| D | 60.9 | 19.2 | 8.6 | 3.2 | 2.9 | 0.8 |
| E | 50.2 | 18.2 | 8.5 | 2.5 | 2.8 | 1.1 |
| F | 44.5 | 0.6 | 6.8 | 0.4 | 2.1 | 0.6 |
| G | 35.0 | 10.0 | 8.9 | 0.2 | 2.0 | 0.9 |
| H | – | – | – | – | – | – |

***Tab. 2. Uğurlu points sub-type contextual distribution, measurements, and parallel types.***

Utensils complete this group. Type A are described as spoons, with a rounded and bowled-shaped tip and handle, or broken shaft where the handle would have been. These items are associated with dairying activities, scraping, or ritual/symbolic settings. When slanting occurs on the bowl, as with sample DD20-B8x1, repeated scraping actions are implied. Type B are labelled spatula-spoons. Like type A, they have a concave head and handle, but the shaft is elongated and the head is wider.

The remaining 79 objects are labelled 'undefined' (Fig. 9). Some items in this group have clearly been modified, but their function remains unknown. Modifications involve notches, cut marks, and striation patterns. In addition, some objects are tools, but their function remains unknown. For example, three objects all share the same morphology and are manufactured on large animal long bones. It has been suggested that they may have acted as fishing rods. Another object from Phase II, *c.* 4300 cal BC is shaped much the same as a pipe, but there is no hollow connection between the stem and bowl. It may have been used as a digging instrument. There is also a collection of smoothed objects that are too small to be formally identified.

### *Context*

Important contextual levels relating to the worked bone and antler collection will be outlined in the following section. Not limited to the worked osseous



***Fig. 4. Uğurlu pointed tools. Left to right: rounded point type A (BB22B10x2); rounded point type B (P6ppx2); bi-point (P6B33x5); fish hook (BB20-21B59x6); needle type A (O5B18x1); needle type B (O5B36x3); pin type A (P6B25x3); pin type B (P6B30x6) (designed by J. W. Paul).***

| Sub-type | Regional Parallels | Inter-Regional Parallels |
|---|---|---|
| A | Ulucak Höyük point type A | Tóth's type 1/7–1/9; Camps-Fabrer point type IV; Makri type 1.1b |
| B | Ulucak Höyük point type B<br>Ilıpınar awl type A | Camps-Fabrer type II; Schibler's type 1/1; Choyke no. 1;<br>Payne type 2, type 3; Dikili Tash type IIIB, VIIA; Cave of Cyclops type B;<br>Karanovo point/awl type A |
| C | Ulucak Höyük point type C<br>Ilıpınar awl type B | Camps-Fabrer type III; Schibler type 1/2; Chomko type II;<br>Dikili Tash type IVB, VIIA; Karanovo point/awl type B |
| D | Ulucak Höyük point type D<br>Ilıpınar awl type B | Camps-Fabrer Type V |
| E | Ulucak Höyük point type E | Dikili Tash type VIIB; Karanovo type C |
| G | Ulucak Höyük point type G | Camps-Fabrer type IVa |
| H | Ilıpınar awl type C | Karanovo awl type C; Camps-Fabrer type I |

***Tab. 3. Regional and inter-regional parallels for point sub-types.***

material, this investigation will take into account relationality with other items in the overall material record. This section is divided into chronological phases, beginning with the earliest, to highlight developmental change in the assemblage.

### *Phase VI (Pre-Pottery Neolithic 6800–6600 cal BC)*

The earliest occupation at Uğurlu is represented in two deep trenches in the eastern part of the settlement, namely BB20-21 and CC21. Five bone tools have been recovered so far, comprising three spatulas, one spatula-spoon, and one type A point.

### *Phase V (Early Neolithic 6600–5900 cal BC)*

The worked bone objects in Phase V can be described as skilfully constructed, extensively used, and deposited largely intact. Twenty-three objects have been recorded so far and are confined to the eastern side of the site in trenches BB20-21 and BB22. The majority of these items are pointed tools, with points (n = 11) common. Sub-typed points range from A–D, with type A (n = 4) and type D (n = 4) predominating. Overall, points were modified to a great extent, as shown by finer measurements, surface condition, and overall preservation. Only one object is made from antler, while the rest are made from bone. The early inhabitants of the site had limited access to this material and, considering the distance to the mainland, access to deer, and therefore antler, would have been restricted, with sheep and goat favoured on the island for size and adaptability. Unit B58 in trench BB20-21 contained the most bone tools (three points, a smoother, and an undefined

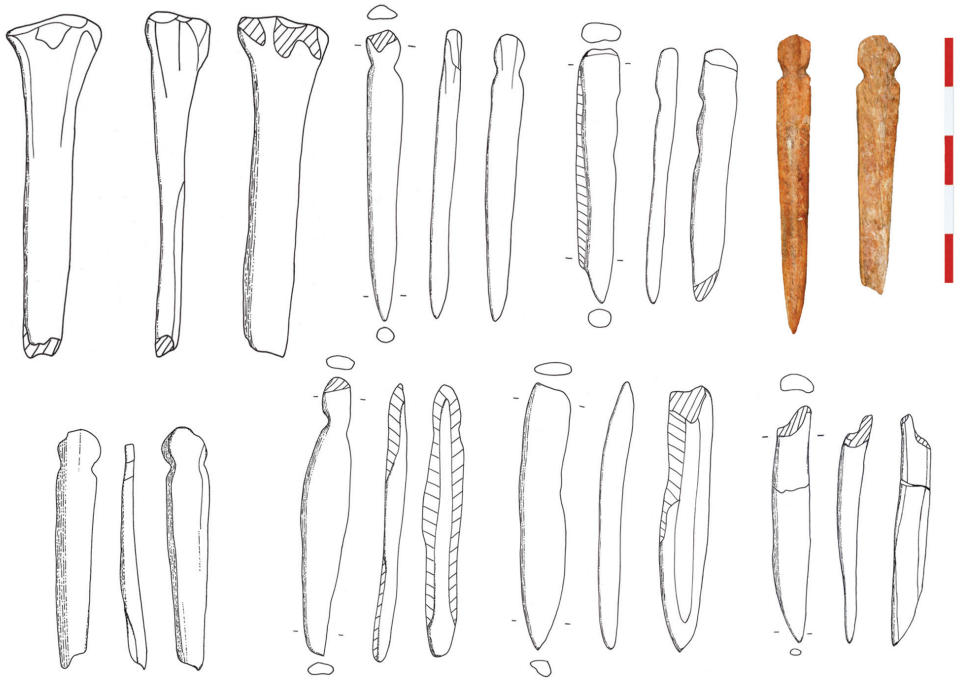


***Fig. 5. Worked bone assemblage in 'box-like pit' from trench P5, unit B91: P5B91x2, x3, x6, x9, x10, x13, x14 (designed by B. Erdoğu, N. Yücel and J. W. Paul).***

item) with worked sea shell and stone also recorded. The proximity of these items with stone and sea shell objects suggests an early connection between material groups. Relatively low numbers of finds in this period may be a result of two major factors. The first is access to raw material during an initial settlement process, and the second is the constricted excavation area. The shift from the Early Neolithic Phase V into the established Neolithic Phase IV (5900 cal BC) again sees pointed objects dominate, with points the most frequently recorded (n = 11), while polishing tools are also well represented (smoothers n = 3; spatulas n = 4). Only one object was not undefined, reflecting a general trend in the assemblage towards formality of types.

***Phase IV (Late Neolithic 5900–5600 cal BC)***

Phase IV at Uğurlu saw an expansion of material culture and architectural remains spread towards the western part of the site. Trenches O5, O6, P5, and P6 all contained vast amounts of worked bone material, more than was found on the eastern part of the site. 161 tools in this phase make it the second largest. Again pointed tools dominate, with points the item recorded most often (n = 63). A definite trend is now emerging, with type A points comprising the majority (n = 37). The zigzag motif carries into this period, as seen on one object. Another motif also appears at this time, a double 'v'-shaped incision on the middle of the shaft of one item, discovered in a fill level with four other worked bone objects. This complete object dates to Phase IV level 1, 5900–5800 cal. BC. These incisions seem to have served no functional purpose; rather, they have been added for purely artistic effect. Additional time is required when incising an object for purely decorative reasons, accounting for the relatively low number of decorated points in the overall assemblage (n = 3). After this period, no further decorated points are found in the assemblage. Thus, Phase IV represents a peak in the production of decorated pointed objects.

Pins (n = 18) are numerous in the Neolithic, with their slender shafts displaying high levels of polish. Needles (n = 12) are also well represented and their numbers peak during this phase. Cutting tools also reach their peak during Phase IV, with chisels (n = 3) and gouges (n = 3) represented, while polishing tools also becoming more frequent, with smoothers (n = 29) the second most frequent type. Spoons and spatula-spoons reach their highest numbers during this period. Flatter and wider spatula-spoons are larger in size, while object DD20B8x1 (Fig. 10) shares characteristics with similar regional examples.

Large amounts of worked bone and antler material from this period are spread across a variety of contexts. Only a few worked bone objects from the Late Neolithic originate from known contexts. On the eastern side, sixteen artefacts were discovered on floor unit B24 in trench BB20-21, 11 of which were worked bone. The remaining objects included two polished stone axes and one bead.

Besides floor levels, worked bone was also found in pits during the Neolithic. Unit B91 in trench P5 is a pit which contained 14 bone tool objects enclosed with yellow-coloured plaster. Many of the tools inside were type A needles. Interpreted as idols (*Erdoğu 2014.159*), these symbolically charged objects can be seen to represent an anthropomorphic form, with their notched bases representing a head, possibly inserted into clay figurines.

Fill deposits in trench P5 (units B14, B108, B104) also contained numerous bone tools alongside other objects, including worked sea shell, worked stone, and figurines. In all instances, breakage is an appropriate reason for the discard of these items. The transition from Neolithic to Chalcolithic (5500 cal BC) was moderate when observing the distribution



***Fig. 6. Uğurlu cutting tools. Left to right: gouge (P5B98x7); chisel (CC21 B19x4); punch (P6ppx3) (designed by J. W. Paul).***

of bone tool types, although in some cases, initial shifts in type frequencies become fully recognisable during the subsequent phase.

***Phase III (Early Chalcolithic 5500–4900 cal BC)***

The Chalcolithic period at Uğurlu is defined by maximum settlement growth and a variation in material culture. The worked bone reflects broad patterns of change, with new tool types favoured. It would be wrong to suggest that the quality of these items declined. Instead, a clear move towards homogeneity in some tool types of tools is noticeable, indicating shifts in manufacturing practice. A total of 176 worked bone objects from this period have been found, with pointed tools predominating (n = 63). The demise of types F and G, coupled with the inflated prevalence of type A points (n = 42), shows a move towards regularity in the point type. Additionally, pin and needle distribution all favour one sub-type of the other (type A pin: n = 20, type B pin: n = 0; type A needle: n = 6, type B needle: n = 0). Type A needles decline in frequency (n = 6), an interesting observation given their potential symbolic meaning. Perhaps their production became so regularised they were manufactured on materials easier to procure (but degradable), such as wood. Cutting tools are relatively uncommon, consistent with previous periods, while the number of smoothers remains the same (n = 23); however, they also become more homogenised, with only one type B recorded. The three component/composite elements are all type B shafts made from deer antler, while type B rounded points (made from deer antler) also increase during this period (n = 5). The more frequent use of this material might be linked to enhanced access to deer. Spoons and spoon handles also decline in number, with only one example recorded. This object, a small circular spoon head, with a missing long thin handle, is reminiscent of the spoons at Pendik and Kovačevo. Only one perforated object was found from this period. This item has one complete hole and one fragmented hole drilled from both sides, and possibly functioned as a toggle.

Floor levels offer the best contextual evidence. Trench V18 yielded four floor levels containing worked bone and antler material. Unit B12 contained two worked bone items and a piece of worked stone, while unit B11 yielded one worked bone pointed tool and one worked stone example. Interestingly, only one worked stone object was found in each of the two units, a trend with floor levels found in this trench.

Fill contexts contain the most worked bone material in trenches on both sides of the site. Trench DD-19-20, unit B2, is located inside Building 3 and included two type A pins, one stone chisel, and one worked sea shell. The pins are parallel in size, form, and colouration. They are well worn, with notches and scrapes covering their surfaces, and were uncovered next to one another. Unit B4 in trench BB22 produced some interesting results, with four spatulas found together: two type A and two type B. These objects, used for shaping the interior and exterior of pottery, were found within a dense concentration of animal bones. With only one type of bone object – worked bone spatulas – uncovered in this unit, it is safe to assume the area was associated with ceramic production. In the west, trenches P5 and P6 also contain numerous worked bone examples from fill contexts, especially unit B60 in trench P5. This has been labelled a pit, with a vast amount (n = 18) of bone tools damaged by burning. For example, one expertly crafted type A needle with two layers of notching at the base appears blackened because of burning.



***Fig. 7. Uğurlu polishing tools. Left to right: smoother type A (P6B-40x1); smoother type B (P5B137x6); spatula type A (P5B22x1); spatula type B (P5B148x2) (photo by J. W. Paul).***

Due to the symbolic nature of type A needles, the destruction of such a finely crafted object suggests it was unintentional. However, its placement within a pit may suggest that this object was in fact intentionally burnt. Perhaps this may have been a part of the ritual surrounding them, which explains their absence in the material record past the Neolithic period.

Overall, the worked bone assemblage of Phase III marks a period of adaptation. There is maximisation of homogenous forms, increase in the use items made from antler (Phase V: n = 1; Phase IV: n = 3; Phase III: n = 14), and a reduction and sometimes exclusion of certain tool types (type F and G points, type B needles and spoon handles are all absent during the Chalcolithic). During this phase, raw material was readily available and construction techniques followed known patterns. Most of the developments beginning in Phase III continue into Phase II.

### *Phase II (Middle Chalcolithic 4500–4300 cal BC)*

Fifty-three worked bone and antler objects were recovered from this phase. Although pointed tools remain the most recorded group (n = 21), polishing tools are a close second (n = 15). Points dominate (n = 13) and are defined by their homogeneity, with the majority type A (n = 8). Needles occur in relatively smaller numbers during this period (n = 3), with the inclusion of one type B needle, with a perforated base, and two type A needles. The two type A needles appear rudimentary when compared to their earlier counterparts, although they retain their slender shaft and appearance. No cutting tools were found during Phase II. This may reflect the use of other tool groups to replace these larger and more robust bone tools. 14 smoothers are disproportionately divided between type A (n = 13) and type B (n = 1) and are seen as crude variations on previous forms, with some displaying unworked distal epiphyses, while others have had their bases removed entirely. Undefined objects dramatically increase in this phase, 28% of the overall Phase II collection, with higher occurrences revealing a noticeable amendment to tool construction methodology. This is not to say skill levels dropped without exception. O11B-7x1 (Fig. 11) shows evidence of perforation on one aspect, made by a drill-like instrument. The second aspect has been indented for use as a guide. When considered together with the type B needle, it becomes clear expert craftspeople were still operating on bone and antler, just not to the same degree as in previous phases.

Almost all Phase II material comes from the western side of the site (in trenches O11, OP11, P5, and P6), with only two objects from the eastern side (trenches BB14 and BB15). Unit B4 in trench OP11 is associated with Building 1, a rectangular building 7 x 9m, and included two worked bone objects, with a pestle, spindle whorl, and worked sea-shell on its floor. Spindle whorls, an object used for textile manufacture that has not occurred frequently up to this point, are also found with worked bone items in trenches P6 (unit B2) and P5 (unit B2). Their increased presence could indicate an on-site shift in textile manufacture. Regularity in tool form also seems apparent. For instance, unit B2 in trench P6 contained three large, open-shafted smoothers, all with a slanted tip and similar use-wear characteristics from striation patterns.



***Fig. 8. Uğurlu other tools. Left to right: component/Composite elements type A- handle (BB20-21B29x2); component/composite elements type B- shaft (P6B5x6); perforated object (P5B68x1); preform (O11B7x1); utensil type A- spoon (DD20B8x1); utensil type B- spatula-spoon (CC21B26x2) (designed by J. W. Paul).***

Phase II worked bone was influenced particularly by the preced-

ing Chalcolithic Phase III period. Most of the type tendencies from the Neolithic had by now changed, with the exception of pointed tools. There was also a reduction in quality, but construction skill for certain objects remained consistent. By the conclusion of Phase II, worked bone tools at Uğurlu were being associated with a wider variety of objects than ever before.

## Discussion

### *Uğurlu worked bone and antler: a local perspective*

The worked bone and antler at Uğurlu can be described as an adaptable assemblage, adjusted to suit the needs of a society which sourced, modified, and used their tools to create essential items for daily use (Tab. 4). These tools were not created and used in isolation, but were rather connected to the larger material collection. Much of the raw material used to create these tools came from medium-sized animal bones (n = 116), which included sheep and goats. Access to animals was the first step in the manufacturing sequence at Uğurlu. A select number of animals would have been chosen for the initial journey, with small- and medium-sized ones (sheep, goat, and pigs) favoured due to limited space on seafarts (*Camps 1986.23; Broodbank, Strasser 1991. 240–241; Simmons 2014.77*). Animal selection had a direct influence on bone tool manufacturing, as the choice of animal would have been initially restricted. This is reflected in the assemblage, with tools made from large animal bones barely noticeable in the earliest periods (Phase V: n = 1) and steadily growing as time passed (Phase IV: n = 12). Animals were not slaughtered specifically for the production of tools; rather, they were butchered only when every available resource was depleted, including breeding with other animals to increase the size of the herd and extracting any meat or marrow. Due to size regulation, 70% of tools produced during the Neolithic from a known origin came from medium-sized animals such as sheep and goat. Fish hooks are also recorded in this early assemblage. Fish hooks and other fishing-related items such as nets would have been of great use on an island site, as fish and other molluscs could have supplemented a rather restricted diet (*Powell 1996.104–105*). As a result, the emergence of bone fish hooks around 6500 cal BC reflects an early adaptation of material culture not entirely land-based.

Moving into the Late Neolithic period (5900–5600 cal BC) at the site, Phase IV sees an increase in polishing tools. Moreover, decorated points (type F) are manufactured for the first time. Decorated points make a relatively short appearance in the cultural record, and then completely disappear by the end of Phase IV. These incisions were probably purely decorative. The introduction of artistic embellishments on functional tools thus shows a shift towards increased time allotment and greater manufacturing skill. Two clothing bone hooks also contain markings. One decorated with anthropomorphised features might be interpreted as a figurine, while the other contains a bird motif, which suggests some sort of symbolic importance.

Phase IV also witnessed a dramatic growth in the number of bone tools produced. With each object created, the operational chain is altered to provide optimal effectiveness for the user. For instance, the awl-shaped points (type G) give the user greater room to manoeuvre when boring holes through dried animal hide. Consequently, the array of point types reflects an expansion of tool preparation, linked with greater accessibility of raw material or increased skill. Needles are not found in Phase V, but increase in frequency during Phase IV (Phase IV: n = 12). They then decline drastically in number during the Chalcolithic (Phase III: n = 6; Phase II: n = 3). Given their shape, these needles may have been inserted into figurines found in contextually comparable locations, to represent a human form. Perhaps

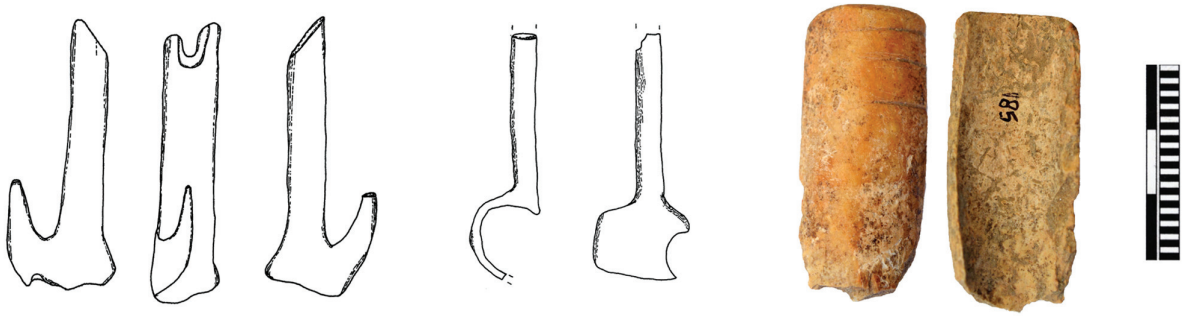


***Fig. 9. Undefined tools. Left to right: Q6B10x2; OP11B8x10; P5B50xz3 (designed by B. Erdoğu and J. W. Paul).***



*Fig. 10. DD20B8x1 (photo by J. W. Paul).*

these needles also played a symbolic role, contributing to the notion that Gökçeada may have been a 'sacred landscape.' It is conceivable that the island was prominent during prehistory due to its visible position from the mainland and anthropomorphised natural features (*Erdoğu 2003.7–22*). These needles may have substituted the religious/social identity of the island (*Erdoğu 2003.19*). Supporting this claim is the fact that these needles were found inside yellow plastered storage pits. Objects found inside, or associated with, plaster pits are common across Anatolia during the Neolithic, protecting the items housed inside (*Perlès 2005.275*). However, plaster pits also seem to serve a ritual or religious function, with plaster used at prehistoric Anatolian sites in conjunction with ritual activity, particularly during moments of transition (*Balter 2001.2278–2281; Hodder 2005. 10–11; Cessford, Near 2005.179*). The apparent short-lived popularity of needle production may have been the result of raw material choice, as other materials, such as wood, may have been favoured during later phases.

Although spatula-spoons are found in Phase VI, relatively complete examples of spoon heads or handles are first seen in Phase V and IV. Spoons are common on mainland Anatolia and Thrace, with finely worked objects frequently found (*Lichardus-Itten* et al. *2006.88–89; Özdoğan 2013.182–187*). Spoons may be linked with an original toolkit transported onto the island by mainland farming groups. These objects do not appear in the assemblage during the Chalcolithic, perhaps replaced again by raw material alternatives such as wood.

New procedures in the manufacturing sequence, seen in Phase IV, meant bone tools could be used with more force. Techniques such as the controlled burning of medium-sized animal bone tips during the final stage of manufacture solidified the tool's working end. This type of manufacturing sequence can be found on a number of items labelled gouges and chisels. Significant amounts of large animal long bones were also used to create gouges and chisels during the Neolithic (Phase V: n = 0; Phase IV: n = 6), resulting in two outcomes. First, bone tools made from large animal bones indicate an increased availability of large animals, or at least improved access to them. Second, the apparent willingness to try different manufacture methods suggests stability. If resources are scarce, or tools are needed for immediate use, time and experimentation give way to expediency and functionality. For example, tools deliberately burnt in a controlled setting emphasise a community relatively abundant in resources, with little time constraints to maintain production on an immediate basis.

From Phase IV onwards, greater numbers of unclassified objects began to emerge at Uğurlu (Phase IV = 9.9%; Phase III = 15.3%; Phase II = 28.3%). This may have been a direct result of experimentation, as different manufacturing methods were used to enhance tool capability. Underscoring this was the development of raw material not previously used at Uğurlu to make bone tools. As well as the increased use of large animal bones, deer antler was used in greater quantities (Phase V: n = 1; Phase IV: n = 7; Phase III: n = 11). Bone tool production steadily changed and adapted from the Neolithic to the Chalcolithic. There was no abrupt change in types or groups. Rather,



*Fig. 11. O11B7x1 (photo by J. W. Paul).*

| Group | Type | Phase | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VI | V | V–IV | IV | IV–III | III | II | surface | unknown | Total |
| Pointed tools | point | 1 | 11 | 11 | 63 | 9 | 63 | 13 | 7 | 13 | 191 |
| | rounded point | – | 3 | – | 4 | 4 | 12 | 3 | 2 | 3 | 31 |
| | bi-point | – | 1 | – | 1 | – | – | – | – | – | 2 |
| | fish hook | – | – | 1 | 2 | – | 2 | – | – | 1 | 6 |
| | needle | – | – | – | 12 | – | 6 | 3 | 1 | 1 | 23 |
| | pin | – | 1 | – | 18 | 6 | 20 | 2 | – | – | 47 |
| Cutting tools | chisel | – | – | – | 3 | – | 1 | – | – | – | 4 |
| | gouge | – | – | 1 | 3 | – | 3 | – | 1 | – | 8 |
| | pick | – | – | – | – | – | 1 | – | – | – | 1 |
| | puncher | – | – | – | – | – | – | – | – | 1 | 1 |
| Polishing Tools | smoother | – | 1 | 3 | 29 | 6 | 23 | 14 | 6 | 9 | 91 |
| | spatula | 4 | 1 | 4 | 6 | 1 | 12 | 1 | 1 | – | 30 |
| Other | component/composite elements | – | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 10 |
| | perforated object | – | – | – | – | – | 1 | – | – | 1 | 2 |
| | preform | – | – | 1 | – | 1 | 1 | 1 | – | – | 4 |
| | utensil | – | – | – | 3 | – | 1 | – | – | – | 4 |
| | undefined | – | 4 | 1 | 16 | 6 | 27 | 15 | 5 | 5 | 79 |
| **Total** | | **5** | **23** | **23** | **161** | **34** | **176** | **53** | **24** | **35** | **534** |

***Tab. 4. Uğurlu worked bone and antler contextual distribution.***

certain production characteristics that began around 5500 cal BC continued during the Chalcolithic Phase III period.

Many of the pointed tools recorded in Phase IV carry over to Phase III, including points, rounded points, needles, and pins. Despite this, regularity and production contrasts with their Neolithic counterparts, as sub-types seem to be favoured. Most of the Chalcolithic Phase III points (67%) are broken at the shaft (type A), with round-based versions (type D) also well represented (16%). There is no evidence of decorated (type F) or awl-shaped (type G) points during the Chalcolithic Phase III or II. An apparent maximisation of broken points may reflect an overall expanded manufacturing output, as many of these tools are found in pits and pit levels, rather than floor levels. Increased numbers of disposed items might correlate with amplified production and use, as tools were discarded in greater numbers. Rounded points made from bone and antler expand exponentially when compared to previous phases (Phase IV: 2.7%; Phase III: 8.1%). During Phase IV, spatulas are scarce in the overall record and evenly distributed across two sub-types (type A: n = 3; type B: n = 3). In contrast, during Phase III, they double in number, and almost completely conform to type A (type A: n = 10; type B: n = 2). Greater frequency of spatulas during Phase III (8.1%) when compared to Phase IV (4.1%) may also be linked to expanded pottery production, as these tools were primarily used to smooth ceramics during the moulding stage.

Choice of raw material also develops during the Chalcolithic. For instance, antler production, which seems to begin at the end of the Neolithic Phase IV (6000/5900 cal BC), grows in subsequent phases. This material was used to create rounded points (type B), shafts, and a pick. Not every tool type grew in frequency, however. Most notably, needles (Phase IV: 8.3%; Phase III: 4%) and utensils (Phase IV: 2.1%; Phase III: 0.7%) reduce in volume when compared to Phase IV. Type A needles, possibly associated with ritual activity during the Neolithic, were still used, but halved in number (Phase IV: n = 12; Phase III: n = 6).

When compared to previous phases, Phase II bone objects seem to be crudely made. A foremost sense of functionality over any visual appeal pervades the collection. Unclassified material is much larger when compared to earlier phases, with a ratio of almost 2:1 in terms of classified to unclassified material. In comparison, Phase III is roughly 5:1, while Phase IV is even higher. The number of smoothers also dramatically rises in Phase II (36.8% of the typed assemblage). In fact, they outnumber points (34.2%), a tool type consistently favoured throughout the site's history. They are smaller (mean length of 68.6mm; SD 20.4) when compared to Phase III smoothers (mean length of 79.1mm; SD 32.1). The adaption of textile manufacture during this phase, coupled with the increase of spindle whorls, might explain the lower frequency of points. Additionally, other material types, such as copper, may have been used, although limited evidence has been discovered to support this claim.

The modification of tool types, and the context in which they were discarded, provides insight into shifting site processes. For example, the constant reliance of pointed tools highlights confidence in the sourcing of certain raw material, including sheep and goat metapodial bones. Likewise, the disappearance of spoons after the Neolithic indicates a shift perhaps to a more localised toolkit. Needles, with their distinctive bases, coupled with a different ceramic technique, also emphasises a shift towards a localised material culture. Thus, an overall initial impression of the Uğurlu worked bone material is stability at a tool group level, while variation and adaptions occur at a tool type level.

### *Uğurlu worked bone and antler: a regional perspective*

The spread of Neolithisation to the corners of Anatolia is seen as a complex issue not easily solved by a simplistic model of migration (*Colledge* et al. *2004.35; Tomkins 2004.56; Özdoğan 2011.415–430; Budja 2013.47; Düring 2013.75–100; Lichter 2002.161–169; Pinhasi* et al. *2005.2220–2228; Thissen 1999.29–39*). In this regard, a web of interconnected strategies should be determined on an individual basis, with an emphasis on certain 'push' and 'pull' factors (*Anthony 1990.895; 1997.22*).

Despite Uğurlu's distance from the mainland (approx. 12km during prehistory), common regional material was evident at the site. Certain ceramic types at Uğurlu, such as Impresso ware, were common on the Anatolian west coast (*Özdoğan 2010.886*). Additionally, white-on-red painted ware, found in Phase IV at Uğurlu, was widespread north of the island, originating from Karanovo (*Erdoğu 2014.160; Marinova 2007.93*). Obsidian from Melos is also evident at Uğurlu, and was widespread in the region, with examples seen to the west and east (*Erdoğu 2014.161; Sampson 1998.20; Takaoğlu 2013.36; Miliç 2014*).

The extensive use of worked bone is also evident in this region, with certain common tool groups common to both Uğurlu and contemporary sites. Pointed tools were the predominant tool group at most sites in the region, with points (or awls, as they are also labelled) the most common type. Points were the most common type at Ulucak, Ilıpınar, Barcın Höyük, Dikili Tash, and Makri all have a predominance of points in their assemblages (*Marinelli 1995.124; Dekker 2014.64–65; Gerritsen* et al. *2013.93–112; Séfériadés 1992.102–104; Stratouli 1998.36–40*). The most common sub-type seems to be the Uğurlu type B point, with morphologically similar sub-types evident at Ulucak (type B), Illıpınar (type A), Dikili Tash (type IIIB), the Cave of Cyclops (type B), and Karanovo (type A). The large amount of pointed tools found across the region is the result of several factors, including the relatively simple set of manufacturing steps needed to produce points, a wide selection of raw material to draw upon during construction, and the ease of breakage. Smoothers at Uğurlu also find regional parallels, for example at Ilıpınar, Dikili Tash, and Karanovo, although they are often labelled as chisels (*Marinelli 1995.126; Séfériadés 1992.100–101; Höglinger 1997.161*).

However, when investigating regionally comparative worked bone assemblages, certain characteristic tool types become evident. For Uğurlu, this is the type A needle, not seen in collections across the region, except for a wooden parallel at Yenikapı (*Kızıltan, Polat 2013.123*). For sites in Anatolia, Ulucak Höyük is characterised by its increased production and use of larger animal bones, while Ilıpınar has a well-represented collection of spoons, toys, and figurines (*Marinelli 1995.121–143*). Barcin Höyük, Pendik, Fikirtepe, Hoca Çeşme, and Aşağı Pınar all have high-quality bone spoons in their assemblages. These are well made, richly decorated items. Northwest of the island, Dikili Tash is reliant on deer antler as a raw material source, more so than any other in the region. The assemblage at Makri is defined by the absence of items such as spoons, fish hooks, pendants, and spatulas (*Stratouli 1998.36–40*). Karanovo, emerging from the Anatolian tradition, contains a large section of well-crafted spoons, also common to the Thrace area (*Höglinger 1997.157–159*). Sites in the region, therefore, have certain unique worked bone tool types that are not always widespread or shared between sites. As a result, not all types seen at Uğurlu are shared with other sites.

Overall, the Uğurlu assemblage can therefore be seen as one that shares common regional tool groups, while also displaying localised tool types (for example, type A needles). Regarding the Neolithisation of the island, a land-based agricultural society relied on domestic animals, grains, and a toolkit largely made up of types consistent with other mainland cultures. As time passed, however, certain localised traditions took effect, most evident in the change of ceramics. This is also reflected in the worked bone assemblage, for instance with the decrease in bone spoons, highlighting shifting manufacturing practices. Although Uğurlu borrows various elements from the Anatolian tradition, bone spoons (and the associated handles)

are rare and were produced only during the Neolithic (Phase V: n = 2; Phase IV: n = 4). The decrease in the number of utensils in Chalcolithic Phase III at Uğurlu does reflect larger trends north and west of the island. The lack of spoons is synonymous with sites located in modern Greece during the same period (*Perlès 2005.278*). Sites in Anatolia (particularly Thrace) had a continual use and manufacture of bone spoons during this time, which makes the lack of widespread transfer to the Aegean prominent in the material record.

Thus, it is clear that the worked bone and antler collection at Uğurlu was entirely consistent with nearby sites, its dynamic assemblage working within a global tradition that, like other sites investigated, had its own distinctive local traditions.

## Conclusion

When Uğurlu was first settled in the 7th millennium cal BC, bone tool production was already underway, as it was an essential component of the prehistoric toolkit. Throughout the Neolithic and Chalcolithic, as the site grew, so too did bone tool manufacture, incorporating a wider variety of animal bone and antler during subsequent phases. The worked bone assemblage did not exist in isolation, but was rather one element assisting and enhancing the Neolithic way of life. As a result, these bone objects were used to sew animal hide into shoes and bags, mould clay into pots for cooking and storage, secure fish to a line, and conceivably assist in ritual performance.

Future studies regarding the Uğurlu worked bone collection will focus on further use-wear analysis to support functional assignment. Further investigation of analogous tool types with those found at Uğurlu, such as type A needles and decorated points, would also be worthwhile as part of a larger comparative analysis including sites to the north and east.

In sum, stability defines the Uğurlu worked bone assemblage, with their production, use, and discard remaining constant over roughly 2000 years. This collection played an extremely important supportive role in the establishment and maintenance of a community located at a geographic and cultural crossroads.

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back to contents

# The earliest villages in Iron Age Iberia (800–400 BC): a view from Cerro de San Vicente (Salamanca, Spain)

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ABSTRACT – *The onset of the Iron Age underwent manifold disruptions. The emergence of long-lasting nucleated villages in Iberia* c. *900/800 BC best encapsulates such profound changes. This paper draws on the results of excavations over the last few decades at a fortified tell-like settlement in central Iberia: Cerro de San Vicente (Spain). The article focuses on formation dynamics in earth architecture to understand the role of cultural choices in the genesis of these sites. The occurrence of sophisticated lifestyles and novel cultural expressions in this village (avant-garde devices such as a drain pipe, unprecedented building techniques, exotic imports and alien practices) suggests the plausible role of inter-regional migration in their adoption. The appraisal of intra-site spatial arrangements sheds fresh light upon the diachronic social trajectories of these agrarian communities, from a seemingly egalitarian organisation to an increasingly ranked one.*

KEY WORDS – *household archaeology; earth architecture; archaeological excavation; Early Iron Age; Iberian peninsula*

## *Najstarejše železnodobne vasi na Iberskem polotoku (800–400 pr.n.št.): pogled iz najdišča Cerro de San Vicente (Salamanca, Španija)*

IZVLEČEK – *Za začetek železne dobe so značilne številne prekinitve. Pojav dolgotrajnih centralnih vasi na Iberskem polotoku v času ok. 900/800 pr.n.št. najbolje predstavlja te korenite spremembe. Osrednjo temo članka črpamo iz rezultatov izkopavanj preteklih desetletij iz utrjene naselbine tipa* tell *v osrednjem delu Iberskega polotoka: Cerro de San Vicente (Španija). Za boljše razumevanje pomembnosti kulturnih izbir pri nastanku takšnih najdišč se v članku osredotočamo na dinamike oblikovanja arhitekture iz blatnih opek. Pojav naprednejših načinov bivanja in nove kulturne oblike (avantgardne naprave, kot so odtoki, edinstvene tehnike gradnje, eksotični importi in tuje navade) na tem najdišču nakazujejo, da so imele pri sprejemanju teh novosti verjetno pomembno vlogo medregionalne migracije. Ocena organizacije prostora znotraj najdišča pa kaže na diahronične družbene trajektorije teh poljedelskih skupnosti od navidezno egalitarne organizacije do vedno večje razslojenosti družbe.*

KLJUČNE BESEDE – *arheologija hišnih gospodarstev; arhitektura iz blatnih opek; arheološka izkopavanja; zgodnja železna doba; Iberski polotok*


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## Introduction

Iberia in the early first millennium BC was home to a variety of socio-political developments. However, research has traditionally focused on the historical trajectories of the Atlantic and Mediterranean areas under the direct impact of Phoenician colonisation and their immediate hinterland (*Celestino, López Ruiz 2016*). This emphasis has developed at the expense of further processes in inland and northern peninsular regions, within the so-called Indo-European-speaking peoples of 'Celtic' Iberia (*Almagro-Gorbea 1995; 2014*). As a result, knowledge of the period is portrayed by some scholars as rather unbalanced (*Moore, Armada 2011.23*). This paper concentrates on the inner tablelands of central Iberia, far from the widely-researched coastal settings colonised by Phoenicians. In so doing, our work explores what new insights minority archaeologies can contribute to the characterisation of mainstream narratives on the Iron Age in Western Europe (*Ruiz Zapatero 2011*).

The early centuries of the first millennium BC in Iberia coincided with the later Bronze Age and the earlier Iron Age. The perception of the onset of the European Iron Age in terms of continuity or change depends heavily on chrono-cultural schemes, the scope and scale of analyses, and the kind of evidence they draw upon (*Kristiansen 1998; Haselgrove, Pope 2007; Moore, Armada 2011*). However, across Iberia, this period is mainly envisaged in terms of historical disruption. Several key phenomena occurred at this juncture, with variable regional and temporal currency: a) significant and steady demographic growth; b) abrupt shifts in lifestyles (*e.g.*, the co-residence of neighbours in nucleated settlements) and ritual practices (*e.g.*, the spread of cremation burial); c) a fluid transference and adoption of outsider know-how and technology (*e.g.*, unprecedented earth-building techniques), imports (*e.g.*, iron or wheel-thrown pottery), exogenous domestic animals (*e.g.*, donkey, hen) and probably also people; and d) heterogeneous yet concomitant socio-political dynamics towards ranked organisations. These phenomena sharply contrast with previous millennia, when transcendental changes are far less apparent (*Ruiz-Gálvez 1994; Fernández-Posse 1998; Álvarez-Sanchís 2000; Ruiz Zapatero 2009; Romero Carnicero* et al. *2008; Torres Rodríguez 2013*).

Among the aforementioned novelties, a crucial archaeological indicator epitomises the idiosyncrasy of the Iron Age in most Iberian regions: the founding of permanent sedentary villages (*Almagro-Gorbea 1995; Parcero 2003; González Ruibal 2006–2007; Romero Carnicero* et al. *2008; Delibes de Castro, Romero Carnicero, 2011; González García* et al. *2011; Álvarez-Sanchís, Ruiz-Zapatero 2014*). Understanding the emergence of these aggregated settlements is thus of paramount importance; however, current narratives are flawed by premises and long-held uncritical assumptions that permeate the literature. Thus, rural communities beyond the Mediterranean world are regarded as rather isolated and stagnant, transposing the much later ethnocentric Graeco-Roman descriptions. The feasible interregional movement of people is dismissed by most Iberian scholars, who embrace a dogmatic autochthonism. Finally, a misunderstanding of the formation processes of the archaeological record leads to interpreting prehistoric remains (dwellings and necropolises) as the unproblematic and reliable reflection of prehistoric social life.

To furnish a more cogent account of social dynamics in Early Iron Age (henceforth EIA) Iberia (*c.* 800–400 BC), it is crucial to critically reconsider inherent limitations in the available sources, expose misguided stands, and raise new questions and fresh lines of enquiry. This article is intended to contribute to this endeavour by reappraising old archaeological evidence with new eyes, and by identifying prospective research avenues. The paper stems from an ongoing research project focused on a remarkably well-preserved EIA hillfort in central Iberia: Cerro de San Vicente (Salamanca, Spain). Over the last decades this site has been subject to successive excavations, mostly within a preventive archaeology framework. The results were summarised in an outreach guide for the general public (*Macarro, Alario 2012*), but detailed information has remained unpublished, despite the relevance of some of the findings. A monograph with detailed documentation is to be published in 2018. For the time being, this article presents some outstanding discoveries at this site and discusses their contribution to scholarly debates on the emergence of nucleated settlements in Iron Age Iberia. This will help to pinpoint recent issues that will be tackled by forthcoming excavations at the site.

## The site of Cerro de San Vicente (Salamanca, Spain)

### *Location*

Cerro de San Vicente is a hilly relief in the city of Salamanca (Spain) by the Tormes River, a tributary stream of the Duero River and within the buffer

zone inscribed in the UNESCO World Heritage List. The EIA occupations are located on an elongated and flat-topped sandstone plateau, situated at 805m a.s.l. (Fig. 1–2). This hilltop settlement is delimited by three slopes: the north-western and southern are the steepest, namely the vertical cliff to the south, where the Tormes flows some 30m below (Fig. 2). To the east, a smooth hillside – nowadays terraced – exends down to the La Palma thalweg, a ravine-like area drained in modern times, yet providing fresh water and suitable soils for horticulture back in later prehistory. To the northeast, a more easily passable plain was fortified with a rampart enclosing an area of 1.6ha. Outside the wall, further EIA remains have also been documented in this sector, so that the village covered an area over at least 2.5ha (*Macarro, Alario 2012*). The inhabitants of this village probably sought a place that was easily defended, located by the major river in this region and not far from the sedimentary lowlands, and at a strategic crossroads within long-distance exchange routes. Indeed, at this section of the Tormes River there was an important natural ford, subsequently crossed by the Roman road called Iter ab Emerita Asturicam (*Roldán Hervás 2007*), which has a Roman bridge 400m away from Cerro de San Vicente. Importantly, this Roman road, and the later modern drove-way materialises a much older south-north pathway which connected Western Iberia with other regions since at least the third millennium BC (*Galán Domingo, Ruiz-Gálvez 2001*).

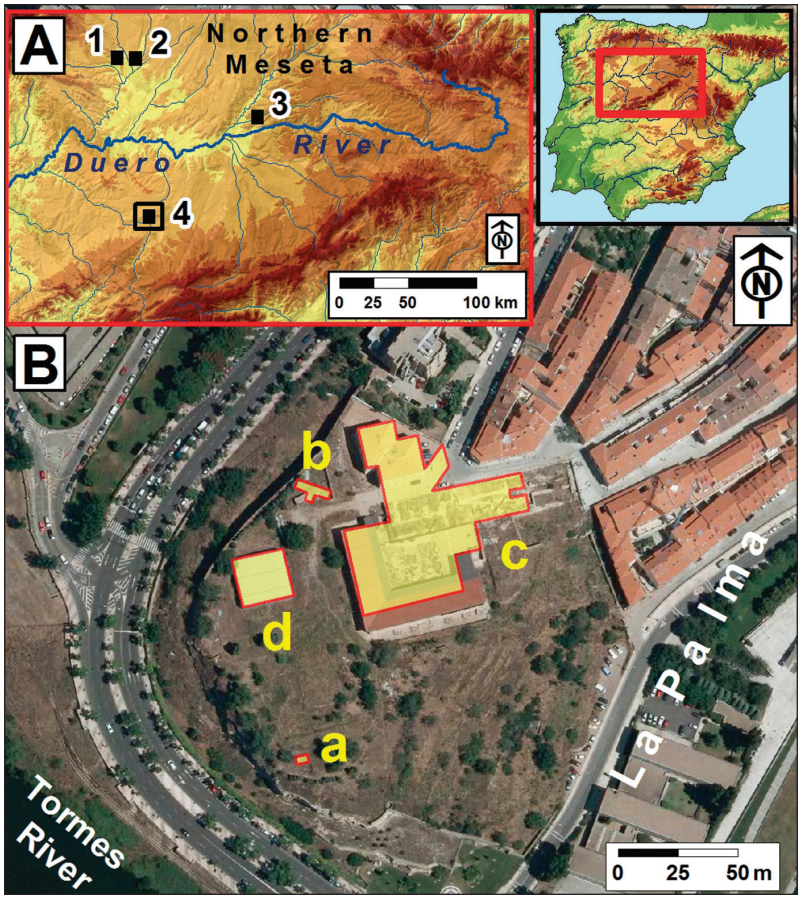



***Fig. 1. Location of Cerro de San Vicente site in the Iberian peninsula. A Sites mentioned in text: 1 Los Cuestos de la Estación; 2 La Corona/ El Pesadero; 3 Soto de Medinilla; 4 Cerro de San Vicente. B Excavated sectors with EIA remains (in yellow): a test-pit in 1990; b trench in 1992; c excavations in the cloister and surroundings (1994–2007); d open-area excavations in 2006.***

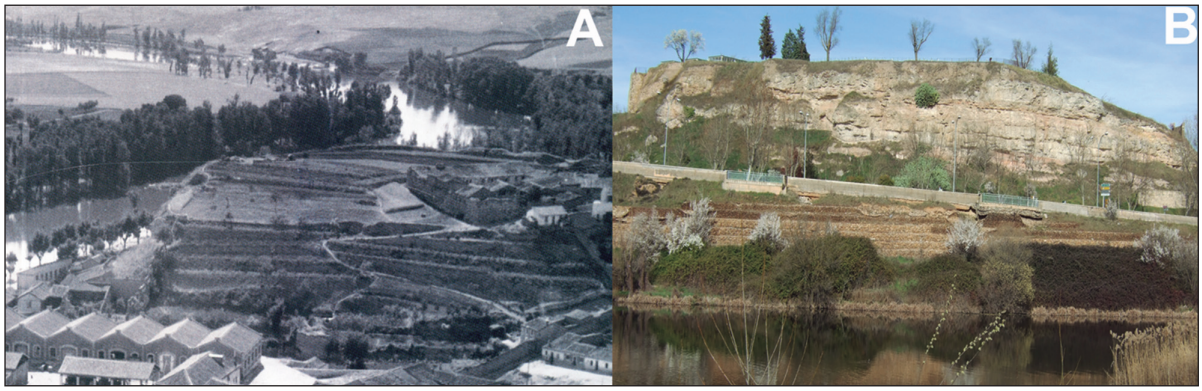



***Fig. 2. A Cerro de San Vicente in the early twentieth century from the east, with the La Palma thalweg in the foreground, and the Tormes River in the background (photograph from the Gombau Archive, Council of Salamanca). B Present-day view from the south, with the Tormes in the foreground. Note the prehistoric mound protruding over the hill.***

After abandoning the EIA village, the summit was occupied by later Iron Age groups responsible for sparse disturbance of the uppermost levels. Fortunately, the subsequent urban expansion of Salamanca avoided the hillock – therefore preserving it from the deep subsoil truncation typical of Roman and medieval occupations – and it was neither cultivated nor scavenged to retrieve dark earth or bones for manuring. The place was only home to the high medieval and modern monastery of San Vicente and some contemporary buildings, which – except the foundation trenches – had a limited impact on the deepest prehistoric sediments (*Benet Jordana 2001; Macarro, Alario 2012*). EIA occupation was first identified by Prof. Maluquer de Motes (*1951*), and the settlement has been subject to modern excavations since 1990, which have until now unearthed about 30% of the site plan (Fig. 1B). In 1990, a 15m$^2$ test pit was dug close to the southern edge of the summit, leading to the first stratigraphic assessment. Between 1992 and 2007, successive large-scale excavations (some 1000m$^2$) were conducted in the northeastern plain, focused on the medieval and modern remains of San Vicente monastery, yielding partially truncated EIA houses and some smaller structures. Farther north, outside the monastic complex, excavations in 1994–1996 and 2003 documented the prehistoric rampart (*Macarro, Alario 2012*). In 2006, a total of 500m$^2$ was uncovered in an open area, yielding five houses and 13 smaller ancillary structures dated to the later phases (Figs. 1B–3).

### *Intra-site anatomy and biography of an EIA village*

Archaeological campaigns at Cerro de San Vicente have uncovered a thick and well-preserved prehistoric stratification up to 3–4m in height. As occurs at other contemporary sites (*Romero Carnicero* et al. *2008; Blanco García 2017*), these sediments shape tell-like anthropogenic accumulations – an artificial mound covering the summit of the sandstone hill (Fig. 2). Such a sequence seems the cumulative result of occupation, refurbishment, ruination and abandonment episodes. These can be grouped into diverse phases – numbers depend on the excavated sector – composed of manifold layers and structures recorded as stratigraphic units (henceforth SU). Despite some unsolved uncertainties and mismatches between conventional chronology and radiocarbon estimates, an overall diachronic trajectory of the settlement can be presented, with four major phases (Tab. 1). Fieldwork has reached the deepest layers, especially in the test-pit excavated in 1990 and the medieval cloister excavated in 2001–2002. The earliest dwellings (phase I) were wooden huts, oval or circular in shape and covered with daub. These foundational layers yielded the first handmade painted wares and the earliest Soto-style vessels, a long-lasting pottery tradition characteristic of the EIA in the region (*Romero Carnicero* et al. *2008*). The architecture and material culture from these oldest levels are accord with findings from the contemporary sites of Soto de Medinilla (*Delibes de Castro* et al. *1995*) and Los Cuestos de la Estación (*Esparza Arroyo* et al. *2016*) (Fig. 1A). There is more information on the latest, more extensively excavated phase III. Thus, an open-area excavation in 2006 uncovered such uppermost architectural structures, most of them now on public display (Fig. 3).

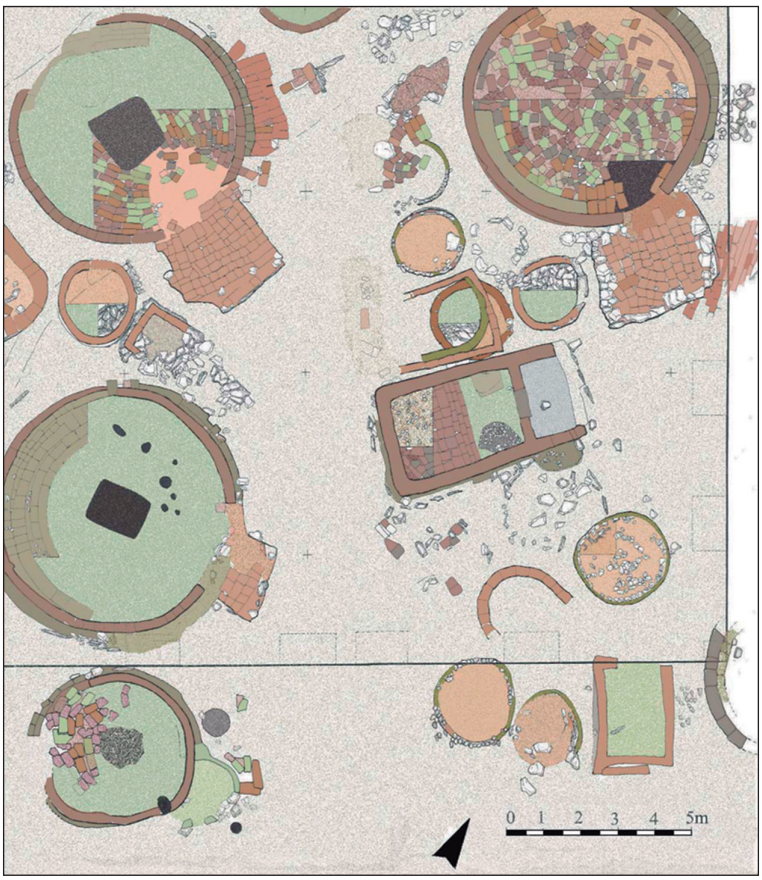



***Fig. 3. Open-area excavations in 2006.***

Eight radiocarbon assays are available from the site, which targeted

| Phase | Conventional chonological framework | Architecture | Material culture |
|---|---|---|---|
| Phase IV | Late Iron Age (400–50 BC) | Poorly preserved domestic remains on site. Some pits and quare stone and mud houses. | Wheel-thrown pottery, especially painted Celtiberian ware. Plenty of bronze and iron utensils. |
| Phase III | Early Iron Age (650 BC–400 BC) | Heyday of the village. Thickly packed and abundantly documented dwellings: mud-brick roundhouses with porches within stone-fenced domestic compounds featuring sewers. | Hand-made painted ware, late Soto-style (aka 'Soto Pleno') ware, early combed vessels, earliest wheel-thrown imported vessels, Orientalising bronze and glass items. |
| Phase II | Onset of the Early Iron Age (800-650 BC) | Mud-brick round and square houses. Settlement layout poorly known on site. | Hand-made painted ware, plenty of Soto-style ware. |
| Phase I | Late Bronze-Early Iron Age transition (*c.* 1000–850 BC) | Scattered post-built wattle-and-daub round huts. Only isolated and partial cases documented on site. | Earliest hand-made painted ware, earliest Soto-style (aka 'Soto Formativo') ware, bronze and early iron items (imported?). |

***Tab. 1. Outline of key phases, associated architecture and material culture from Cerro de San Vicente.***

both outdoor middens and indoor house fillings (Tab. 2). Some limitations are apparent. Thus, all samples are on long-lived charcoal remains and no AMS dates are available, only conventional radiocarbon estimates. The absence of taxonomic and taphonomic assessment impedes a fine-grained contextual evaluation, and thus, erratic anthracological residues redeposited in a younger layer or affected by the 'old wood' problem cannot be ruled out (*e.g.*, Beta-77445). The calibrated data[1] (Tab. 2) show the impact of the aforementioned pitfalls coupled with the effect of the plain area in the calibration curve *c.* 800–400 cal BC or 'Hallstatt plateau' (*Hamilton* et al. *2015*), since all these estimates fall within this time lapse. The foundation remains ill-defined; Beta-77447 was retrieved from the bottom (phase I, SU 61) of a thick midden, but its wide standard deviation makes it unhelpful (Tab. 2). However, the internal coherence of radiometric dates and typology allow us to posit an early foundation, most likely by 850 cal BC (Tab. 2). Radiocarbon estimates from the latest layers (top zone of the sequence) from open-area excavations in 2006 suggest dates much older than those based on typological criteria alone, as often occurs (*Hamilton* et al. *2015*). Thus, the occurrence of typical late Soto-style ware, early combed-impressed vessels, imported wheel-thrown vessels and bronze fibulae, and the general village layout, suggest a sixth century BC date (Tab. 1). However, an ashy layer covering the most recent floor of a long-lived roundhouse from this phase III yielded burnt remains (CSIC-2072) actually dated to the eighth century BC with 83% probability (Tab. 2). The drainage pipe found in 1990 is among the oldest sewerage systems in the northern half of Iberia, yet its date is slippery: the previous phase III is badly-dated (Beta-77445) and the assay associated with phase IV (Beta-78721, *c.* 370–20 cal BC) is too recent and broad. Typology allows us to conclude that by 450 BC the whole population had deserted this village and moved to the nearby hills; only sporadic activities are traceable (Tab. 1). There they founded a large Late Iron Age hillfort that eventually became the Roman city of Salmantica (*Benet Jordana 2001; Macarro, Alario 2012*). Such relocation correlates with a marked and widespread social and political reorganisation after the mid-first millennium BC: previous scattered communities were driven by phenomena of aggregation (sinecism) that led to the foundation of larger oppida (*Almagro-Gorbea 1995; 2014; Fernández-Posse 1998; Romero Carnicero* et al. *2008; Torres Rodríguez 2013; Blanco García 2017*). In sum, based on typological comparisons and radiocarbon dating, its biography spanned at least four centuries of uninterrupted occupation, which amount to some 16–18 generations. Obtaining accurate and reliable radiometric estimates of key milestones within this village's biography will be a priority in future fieldwork.

Extant material evidence for domestic activities is retrieved from two kinds of multi-layer accumulations informing diverse temporalities, like prehistoric tells elsewhere (*e.g., Kienlin 2015; Shillito 2017*): a) open-air spaces, including lanes and refuse heaps (middens) where waste was routinely piled. Middens contain microstratified organic-rich ashy lenses with abundant domestic residues (ceramics, faunal bones,

1 Dates calibrated using Oxcal 4.2 with the IntCal13 curve (*Reimer* et al. *2013*) and expressed at 2-sigma range.

| Lab. code | Material | Context | Age BP | $\delta^{13}C$ ‰ | Age cal BC (2σ) |
|---|---|---|---|---|---|
| Beta-78721 | Charcoal | 1990. Outdoor midden, top zone (phase IV, SU 16). | 2150 ± 60 | –25 | 370–20 |
| Beta-77445 | Charcoal | 1990. Outdoor midden, medium zone (phase III, SU 30). | 2450 ± 70 | –25 | 700–380 |
| Beta-77447 | Charcoal | 1990. Outdoor midden, bottom zone (phase I, SU 61). | 2320 ± 80 | –25 | 750–680 (82.6%), 540–180 (12.8%) |
| CSIC-2072 | Charcoal | 2006. Roundhouse 1, indoor conflagration layer (phase IIIa, SU 140b). | 2583 ± 30 | –25.5 ± 0.2 | 820–740 (82.6%), 690–660 (8.6%), 640–590 (4.2%) |
| CSIC-2126 | Charcoal | 2006. Roundhouse 5, indoor collapsed fill (phase III, SU 521b). | 2541 ± 39 | –25.0 ± 0.2 | 810–530 |
| Ua-34086 | Charcoal | 2006. Outdoor midden by roundhouse 4, intermediate zone (phase III, SU 419). | 2535 ± 40 | –25 | 800–520 |
| Beta-98135 | Charcoal | 1994-96, medieval cloister. Outdoor midden layer (phase III, SU 87). | 2430 ± 50 | –25 | 760–400 |
| Beta-98136 | Charcoal | 1994-96. Outdoor layer over collapsed EIA rampart (phase II, SU 73). | 2290 ± 80 | –25 | 750–90 |

***Tab. 2. Radiocarbon dates from Cerro de San Vicente.***

botanical macro-remains, *etc.*) in secondary position, providing information on the everyday; and b) dwellings and ancillary buildings (workshops, granaries) in primary position, filled with indoor coarser strata composed of abundant rubble and architectural debris plus domestic residues that illustrate occasional episodes of construction, refurbishment or abandonment.

The overall layout for phase III (Tab. 1) is one of thickly-packed houses with ancillary smaller buildings, enclosed to the north by a stone-and-earth wall (Fig. 4). Such edifices are solid, built with standardised materials, and exhibit regular shapes and sizes. The bulk of edifices adopt circular plans (Fig. 5A), the prevailing architectural choice in the region (*Romero Carnicero* et al. *2008.661–664; Ruiz Zapatero 2009.234–236; Blanco García 2017*). Rectangular buildings also occur from phase II, and account for 25% of known edifices (Fig. 5B). Constructions can be divided into two groups: a) the largest ones are either roundhouses (13–50m$^2$) or rectilinear quarters (11–25m$^2$) and exhibit the diagnostic features of dwellings: central fireplaces, sometimes decorated, with traces of sooting and a continuous bench opposite the door by the internal part of the wall (Fig. 6D); and b) smaller (< 7m$^2$) circular or rectangular structures without hearths or benches, assumed to be barns – a round one yielded barley – ovens, workshops, kitchens or warehouses (*Romero Carnicero* et al. *2008; Álvarez-Sanchís, Ruiz Zapatero 2014*). The circular houses in the late phases commonly have entrance halls, antechambers or porches tiled with mud-bricks, and some also feature perimeter sidewalks (Fig. 5A). Excavations through successive construction phases have shown that builders always orientated house entrances in strictly the same direction – commonly to the south-east – and that central fireplaces accurately overlaid previous ones.

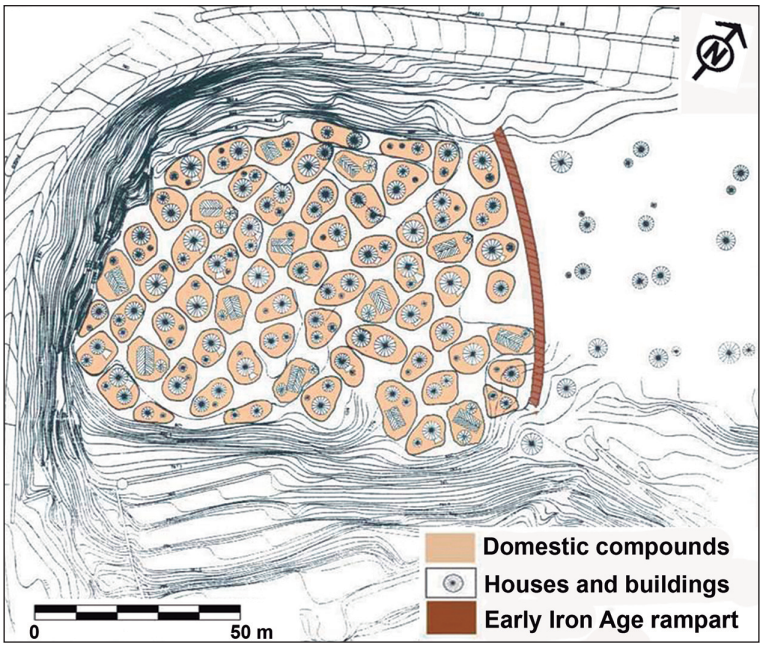



***Fig. 4. Hypothetical image of the EIA prehistoric village of Cerro de San Vicente, based on archaeological investigations.***

In most cases, only the foundations of such edifices are *in situ*. In the case of dwellings, walls are 20–35cm wide and up to 40cm high, with exceptionally well-preserved walls up to 80cm high (Fig. 6A). The builders used clay extensively, both for structural elements and to coat surfaces. Raw earth was commonly used in daub-and-wattle constructions, as in previous millennia. However, around 800 BC, novel materials appeared: sun-dried adobes of various formats, including parallelepiped and slightly arched ones suitable for roundhouse walls (Fig. 6A-B). Some rectilinear walls were built with solid earth mixed with straw (Fig. 6C). Iberian archaeologists often describe such walls rather vaguely as tapial or rammed earth, yet their building technique is ill-defined: they could be actual rammed earth, also named pisé de terre – mud filled and compacted using wooden formwork (*Jaquin* et al. *2008*), or kneaded mud, also known as bauge or façonnage direct (*Belarte 2002.40–41*). In any case, these earth building techniques and know-how were unprecedented in inner Iberia prior to *c.* 850 BC (*Álvarez-Sanchís 2000; Romero Carnicero* et al. *2008*). All of the inner surfaces of the houses were plastered with clay, from floors to walls including hearths, and these mud coatings are often hardened by fire (Fig. 6D). The floors were carefully prepared with a succession of layers to guarantee perfect waterproofing and smooth and hard soil surfaces. These involved slate slabs covered with gravel and an outer coating made of crushed sandstone mixed with sand and water (Fig. 6E) – an effective technique deploying local materials that was still in use in medieval times. On occasions, the bench and lowest walls exhibit brightly coloured plasters. These are predominantly monochrome geometric motifs (*e.g.*, triangles in red or white), and also polychrome designs in red, yellow and black (Fig. 6F). The superimposition of plasterwork coats indicates the periodic renewal and refurbishment of the house. Indeed, phase IV of roundhouse 6 (from the 1990 test-pit) featured 17 soil micro- layers within a thick mud coating 13cm thick.

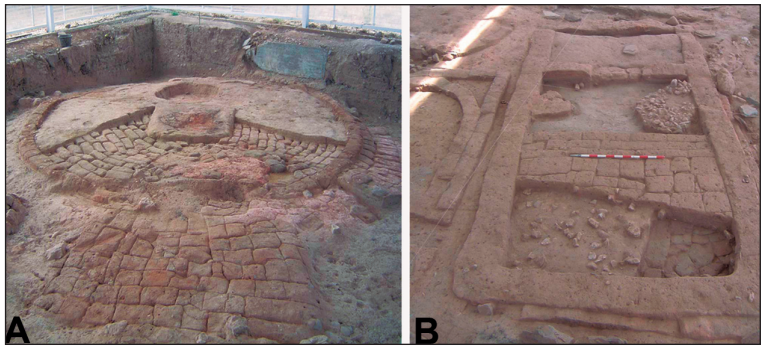



***Fig. 5. Mud-brick architecture from the open-area excavations in 2006. A Roundhouse with tiled porch or antechamber; B rectangular building with internal divisions.***

The houses yielded no internal divisions. The only exception is a rectangular building divided into three rooms by a mud-brick partition and a raised floor, which may suggest functions other than residence (Fig. 5B). The roofing of these buildings remains a matter of speculation, since no clearly collapsed roofs have been identified. The presence of some central postholes and frequent lumps of daub featuring trunk imprints suggest thatched roofs, likely supported by a wooden structure and a central post.

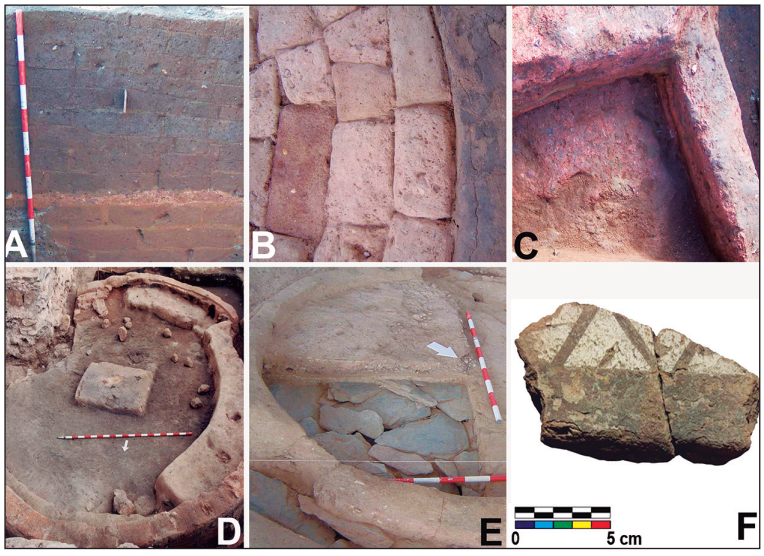



***Fig. 6. Unprecedented EIA earth building materials. A wall made of rectangular mud bricks; B curved mud bricks; C rectilinear solid earth walls; D mud-plastered house, including a hearth and bench; E sectioned floor of a small round building showing superimposed layers; F black and white painted wall coating.***

As for formation dynamics, no equipment akin to 'de facto refuse' was clearly left behind inside the mentioned buildings (*Schiffer 1987; LaMotta, Schiffer 1999*). The widely and uncritically accepted 'Pompeii premise' was not in operation here, and this realisation prevents us from making any direct interpretations in utilitarian or social terms (*LaMotta, Schiffer 1999*). In actual

fact, the demise of houses probably involved certain formalities (*Webley 2007*). Thus, dwellings and subsidiary structures seem to have been carefully cleared prior to their final abandonment. In addition, walls were dismantled, and house interiors infilled with carefully cached mud-bricks lying on their wider sides (Figs. 5, 7B). These strata of adobes were subsequently used as foundations for the succeeding house floor. Some houses were also burnt (Fig. 7), most probably on purpose, since the fire was really intense, *i.e.* fuelled to keep it burning; combustion only affected particular buildings and not their surroundings; and houses were devoid of any belongings or furnishings, *i.e.* they had been emptied in advance (*cf. Stevanović 1997*). The interment of individual children below house floors was also a widespread and long-lasting practice by Iron Age peoples in Iberia (*Romero Carnicero* et al. *2008; Sánchez Alonso 2015*). This site has hitherto yielded only one such burial. In 2002, excavations of a roundhouse in the cloister revealed a neonate with articulated bones; this corpse was deposited within a small hole beneath the soil and lacked any burial furnishings.

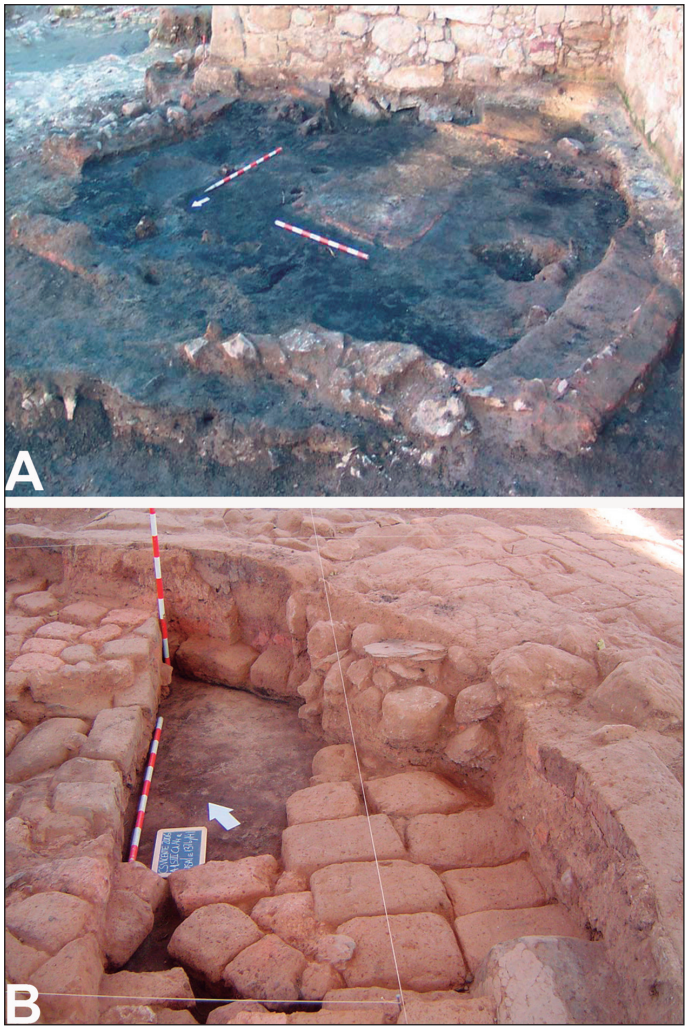



***Fig. 7. Forms of house abandonment. A rectangular burnt building devoid of items (partially overlaid by medieval walls); B burnt roundhouse infilled with several layers of cached mud-bricks (sooting apparent on the floor, under the adobes).***

The later phases of this village were internally arranged in domestic neighbourhoods or aggregates of buildings, each one probably used at the same time by a single household. Excavations in 1990 (Fig. 1B) unearthed parts of two roundhouses enclosed by a linear structure of large sandstone boulders, the probable foundation of a wooden fence that demarcated this compound from the adjacent one (Fig. 8). The courtyard around these houses was tiled with mud brick, which overlaid a slate drain pipe featuring two parallel walls covered by slate capstones (Fig. 8). Similar EIA sewer channels from southwest Iberia have been published (*e.g., Rodríguez Díaz 2004*), but this is the oldest and northernmost example known to date. These interspersed and fenced domestic clusters were connected by winding lanes (Fig. 4). Since the location of open-air spaces was reproduced through time, and constructions were rebuilt on the same spots, the earliest layouts and functional arrangements persisted for centuries.

Finally, it is worth mentioning the rampart in the north-eastern plain area (Figs. 4, 9). Despite its extensive destruction by medieval and modern buildings, some 35m of this massive enclosure were detected in four rescue excavations (1994–1996, 2003). The preserved remains are 3m wide and up to 1.5m in height, and originally some 90m long. Its foundation was made with large slate slabs and sandstone boulders overlaid by earthen rubble framed by two mud walls, a rampart-building method documented in other EIA villages (*e.g., Misiego* et al. *2013*).

## Material culture and village lifestyles

The accumulation of archaeological remains at Cerro de San Vicente was heavily mediated by cultural precepts regulating how to dispose of refuse and how to abandon and rebuild living quarters. Everyday waste was routinely piled in open-air heaps in

the surroundings of buildings. Indoor infills and mostly outdoor middens have produced abundant archaeological and bioarchaeological items. Yet these are redeposited residues in secondary position, *i.e.* items discarded out of their original 'systemic' context (*LaMotta, Schiffer 1999*). Bearing in mind such intricacies, the multi-stratified nature of these accumulations, coupled with typological comparisons and radiocarbon-dating, allow a diachronic overview of domestic equipment and everyday chores.

Excavations have retrieved a wide and rich array of archaeological materials. These people lived on integrated and complex agropastoral practices, based predominantly on wheat (*Triticum aestivum/durum*) combined with other minority cereals (*Triticum dicoccum* and *Hordeum vulgare*) and legumes (*Vicia faba*), suggesting a low-fallow agriculture system (*Romero Carnicero, Cubero Corpas 1999; Romero Carnicero* et al. *2008.664–668*). Palynological analyses at the site indicate a dense and stable riparian forest, whereas the progressive clearance of arboreal taxa and the expansion of shrub and grassland (*Gramineae*) point to the extension of agro-pastoral activities during the later occupation phases. Specialists at the Autonomous University of Madrid conducted zooarchaeological studies on the assemblage of bones retrieved from the open-area excavations in 2006 (*Macarro, Alario 2012.79–82*). Their assessment illuminated consumption patterns at this settlement during phase III (conventionally dated to the 7th–6th centuries BC): 80% are domestic animals, mostly adult sheep (*Ovis aries*), followed by pigs (*Sus* sp.), and cows (*Bos taurus*) used as draught animals, according to pathologies also attested in Soto de Medinilla (*Romero Carnicero, Cubero Corpas 1999.179*). The earliest hen bones have also been documented here.

Pottery comprises the most abundant archaeological material. The initial stages yield only hand-made pottery in the early Soto style (Tab. 1). Both coarse wares for storage and cooking and tableware feature prominently at Cerro de San Vicente. From the onset of the Iron Age *c*. 900/800 BC, fine wares for consuming foodstuffs were made to very high standards. Thus, EIA drinking vessels display homogeneous paste colours and extremely thin walls with intensely burnished smooth surfaces. These observations suggest the likely use of moulds, and perfect control of firing conditions within a sophisticated craftsmanship framework, which likely involved a certain degree of specialisation and technological innovation. Furthermore, these pottery repertoires indicate new ways of preparing and consuming food that are alien to this region, yet comparable to southern regions (*Arnáiz, Fuente 2016*).

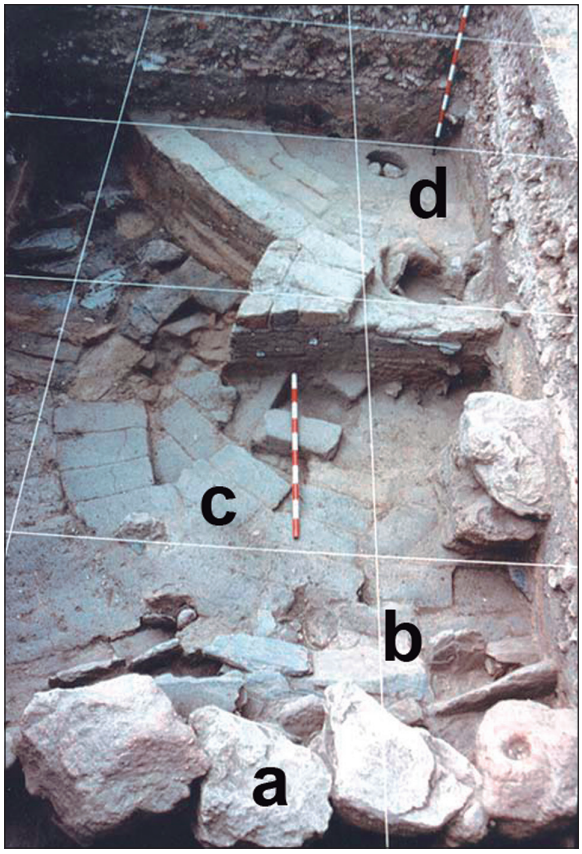



***Fig. 8. Test-pit in 1990 showing a fence of boulders demarcating a compound (a), a drain pipe of slate slabs (b), an adobe-paved outdoor courtyard (c), and part of a roundhouse with multiple (17) soil layers (d).***

The pottery has little decoration: sporadic geometric incisions and impressions in the upper part of vessels, and fingernail impressions on rims. This has made it difficult to construct accurate typological seriation (*Romero Carnicero* et al. *2008; Ruiz Zapatero 2009; Blanco García 2017*), although several formal traits make it possible to trace the circulation of know-how and perhaps also potters. Thus, some types (biconical urns) indicate links to north-eastern Iberia and the Urnfield tradition, whereas the ubiquitous small carinated vessels clearly suggest southern Iberian and Levantine Iberian connections. Likewise, painted fine vessels in an Orientalising style (Fig. 10), allegedly originating in the Iberian southwest or 'Tartessian' area (*Torres Ortiz 2002; Celestino, López Ruiz 2016*), are index fossils of the EIA in central Iberia (*Romero Carnicero* et al. *2008*). Bowls, cups and small pots exhibit geometric designs in diverse bichrome or polychrome combinations



***Fig. 9. The stone foundation of the village's earthen wall during rescue excavations in 1994–96 in the eastern sector.***

to obtain eye-catching contrasting motifs (Fig. 10). Such coloured decorations were added after the firing stage of vessels. The upper phases also produced hand-made pottery in a later style, with abundant combed-impressed motifs, some of them also reproduced in the hand-made ceramics (Fig. 10). An outstanding discovery is a hollow hand-made terracotta object with intensely polished surfaces. It was found during the 2006 open-area excavation, lying upside-down within the indoor collapsed filling (SU 517, phase II) of a rectangular adobe building. It vaguely resembles a bird-like shape, with a central vertical hole, a thin nozzle at one end (fragmented), and a thicker protuberance at the other end (also broken), and has four broken feet protruding at its base (Fig. 11). This is a unique item, with no clear parallels, or perhaps was a zoomorphic drinking vessel, a musical instrument – an idiophone (a rattle?) rather than an aerophone[2] – or even a perfume sprayer.

The inhabitants of Cerro de San Vicente used flint knapping, but tin-bronze metallurgy is well attested, and this site has produced fragments of crucibles and abundant copper-based smelting by-products. Marks of metal knives are apparent on bones consumed at this village. Several imports are known at this site, such as simple and leaf-shaped double-spring fibulae (brooches), amorphous iron items and glass beads. The earliest wheel-thrown wares appeared in the 6th century BC; they feature pale light-brown pastes and some red painted lines; they probably originated in the Iberian southeast. The concentration of these exotic items in western Iberia suggests their probable diffusion from Atlantic and Mediterranean settings (*Romero Carnicero* et al. *2008; Delibes de Castro, Romero Carnicero 2011; Arnáiz, Fuente 2016*).

## Discussion

Village lifestyles spread across all Iberia from roughly similar dates (*c.* 900/800 BC) and adapted manifold socio-economic regional processes, ranging from egalitarian to increasingly statified organisations. In the long run, these ways of organising social life became extremely successful and resilient. Contrary to

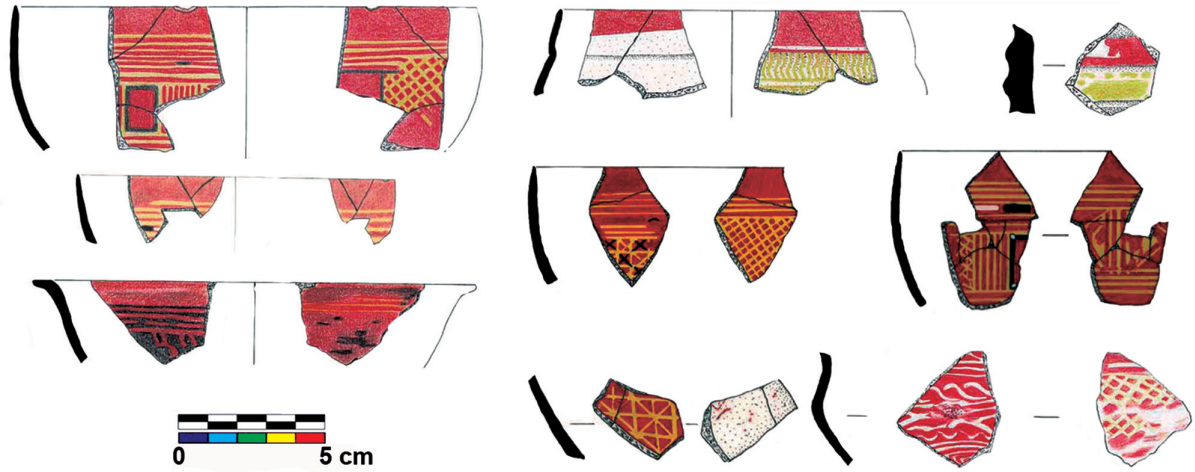



***Fig. 10. Painted hand-made tableware in the Orientalising style.***

2 It is not a lamp, as initially thought, since is very different from contemporary wheel-thrown pinched nozzle lamps and has no sooting marks. It resembles an ocarina, but lacks stops (holes for playing it) and the narrow and uneven chamber would resonate very poorly.

previous attempts at permanent settlement in later prehistory, especially during the second millennium BC, this date marked a point of no return in the ways of settling the Iberian landscapes.

Village-dwelling communities in central and northern Iberia accommodated diverse kinds of societies at different times. The available information suggests self-sufficient, small-scale agrarian groups composed of corporate kinship social units. The definitive sedentary nature of their customs is deduced from the massive character of their household archaeology, and from reliable palaeo-economic records. A communal ethos is apparent in the usual fortification of settlements with ditches or ramparts (*e.g., González-Ruibal 2006–07.194; González García* et al. *2011*) and also in the homogeneity and regularity of modular architecture and building materials (*Romero Carnicero* et al. *2008.676*). The absence of obvious social inequalities can be inferred from the comparable sizes of houses and overall similarities in their domestic inventories. Such features are in keeping with a peasant-like, undivided and roughly egalitarian social system (*Esparza Arroyo 1995; 2011; Romero Carnicero* et al. *2008; Ruiz Zapatero 2009; González García* et al. *2011; Álvarez-Sanchís, Ruiz-Zapatero 2014*). Nevertheless, a minute diachronic assessment of Cerro de San Vicente provides some valuable insights into the idiosyncratic materiality of these early villages in central Iberia. It also highlights some overlooked factors that might have contributed to these archaeological outcomes.

Excavations at this village have shed important light on the technological level and sophistication of its inhabitants. Domestic architecture exhibits an array of novel building techniques, especially adobe and ill-defined solid earthen walls. The advantages of such construction innovations are manifold: they guarantee long durability and fewer maintenance requirements than wattle-and-daub using widely available local materials; they facilitate thermoregulation, provide optimal hygiene and excellent insulation from weather and noise. These villages also succeeded in meeting basic needs and providing food for growing numbers of people. Contrary to millennial lifestyles, from 800 BC some nucleated habitats were very populous, and likely resulted from the aggregation of hitherto self-sufficient and scattered homesteads (*Delibes de Castro, Romero Carnicero 2011; Ruiz Zapatero 2009; Álvarez-Sanchís, Ruiz-Zapatero 2014; Blanco García 2017*). Thus, based on excavations and the available enclosed space (Fig. 4), Cerro de San Vicente was hypothetically home to about 60 small roundhouses, and if occupied by nuclear families of four members, this amounts to a minimum of 250 residents, a figure in accord with calculations for similar contemporary sites (*González-Ruibal 2006/2007; Romero Carnicero* et al. *2008*). It is difficult to account for such numbers if the interregional movement of populations – a taboo concept for some scholars – is ruled out, inasmuch as Late Bronze Age landscapes in the region were really thinly populated (*Esparza Arroyo 1995.137–139; Álvarez-Sanchís 2000.71–72; Romero Carnicero* et al. *2008.652–657*).



***Fig. 11. Unique terracotta zoomorphic object of unknown function. Scale in cm.***

A contentious yet barely discussed issue in current Iron Age narratives is the very materiality of some sites as vertical accumulations up to 8m high, comparable in many aspects to prehistoric tells from temperate Europe (*Kienlin 2015*). Iberian archaeological literature tacitly accepts that they are the unproblematic result of definitively sedentary lifestyles in relatively large agglomerations (by local standards). However, worldwide ethno-historical evidence shows that the nucleation of sedentary peoples does not necessarily entail thick and rich stratifications. Moreover, as occurred in other European cases, such as the Late Neolithic and Early/Middle Bronze Age tells in the Carpathian basin (*Kienlin 2015*), large multi-layer hilltop sites were rare occurrences in prehistoric landscapes dominated by small inconspicuous lowland sites. First-hand fieldwork at Cerro de San Vicente allows us to claim that its bulky and massive sediments resulted from specific cultur-

al choices rather than being natural by-products of fully sedentary agglomerations. The formation dynamics of this village are mainly associated with customary ways of managing waste from daily chores and with particular ways of refurbishing and rebuilding houses, and these social practices led to the particular nature of these sites.

A long-held and deeply entrenched prejudice in European scholarship – hardly ever mentioned, with some exceptions (*Webley 2007*) – prompts archaeologists to presume that most Iron Age houses are akin to Pompeii-like scenarios, *i.e.* fortunate snapshots of everyday life ('systemic contexts') frozen at a discrete past instant (*Schiffer 1987; LaMotta, Schiffer 1999*). However, the foregoing review of the houses excavated so far at Cerro de San Vicente allows us to contest such a claim. The bulk of the house floors were unfurnished prior to abandonment, as was commonly the case everywhere (*LaMotta, Schiffer 1999*). Some buildings may have been partially ruined, yet even on these occasions, the trapped indoor items are not in accord with suddenly collapsed constructions. At this site, deserting a house most probably involved a pre-planned procedure and some cultural formality. Thus, some houses were deliberately set on fire, a cultural custom archaeologically traceable among other later European prehistoric tell communities (*Stevanović 1997*). In addition, some materials were indisputably placed after abandoning a house and before preparing the new home. Examples include: the zoomorphic terracotta item abandoned within a four-corner structure (Fig. 11), four suckling pigs deposited over the floor of a roundhouse, and caches of mud bricks filling empty roundhouses – some of them after burning (Fig. 7). Further deliberate under-floor deposits were probably connected with the cyclical rebuilding of houses, such as the interment of a neonate (*Sánchez Alonso 2015*).

These observations must be fully considered if we are to make reliable inferences about prehistoric social life. This is especially so when interpreting the contents of domestic buildings, since they will rarely be 'de facto refuse' or actual Pompeii-like scenarios of everyday activities (*LaMotta, Schiffer 1999*). At Cerro de San Vicente, both outdoor middens and indoor accumulations are deeply stratified, and post-abandonment truncation is negligible, so that their multi-layer matrices allow fine-grained sequencing of materials. Moreover, contextual and stratigraphic associations are traceable between specific houses, annexed buildings and middens within fenced compounds. These types of spatial, temporal and contextual associations are invaluable for assessing such archaeological assemblages. In short, there is scope for addressing functional and social readings from this household archaeology, provided that we do so critically and with certain reservations.

A good starting point for a measured social characterisation of these communities is to assess the role of the domestic realm. Houses are pivotal in many societies (*Joyce, Gillespie 2000*), and acknowledging their relevance does not directly lead to envisaging any specific type of society. Yet we wonder whether there is room for illuminating the social mechanisms at work in these prehistoric groups from the seminal house society model (*Joyce, Gillespie 2000; González-Ruibal 2006*). We shall refer here to house societies in the sensible and restrictive sense posited by González-Ruibal (*2006.145*), drawing strictly on Levi-Strauss' original proposal. Within such a sociological framework, houses are basic and self-perpetuating corporate social units composed of co-resident household members who shared shelter, sustenance (land, cattle and equipment, *i.e.* 'economic capital') and immaterial wealth (rights and alliances, *i.e.* 'social and symbolic capital') and compete with each other to keep, enlarge and pass on their heritage undivided (*Joyce, Gillespie 2000; González-Ruibal 2006; González-Ruibal, Ruiz-Gálvez 2016*).

The foregoing review reveals that EIA houses matched several archaeological indicators considered by González-Ruibal and Ruiz-Gálvez (*2016.387–388*) as diagnostic traits of house societies: a) imperishable and massive building materials, with decorated walls and fireplaces that highlight the material investment in the domestic quarters; b) the potent symbolism of houses, suggested by the subsoil burial of children, the planned conflagration and closure of roundhouses with cached adobes, or the presence of likely cultic structures; c) the additive materiality of the dwellings, involving respect for, and incorporation of, successive accretions (foundations, soils, plaster coatings), which underscore their monumental appeal as a reservoir of architectural biographies and a deep concern with genealogical roots; and d) the perseverance of the earliest layouts for centuries, involving the persistent rebuilding of structures and the location of middens in the same spots, or the coincident orientation of house entrances and the superimposition of hearths, all indicating a strong corporate identity outlasting the lifespan of individuals through generations, as true memorials. All these commonalities at least allow us to desig-

nate these communities as 'house-centric societies' (*Gillespie 2007.27–29; González-Ruibal, Ruiz-Gálvez 2016.390*). One major drawback remains to the applicability of the house society model to the EIA communities in central Iberia: their egalitarian and communal ethos, since they allegedly lacked strong internal inequality and competition among households.

Nonetheless, local forms of sociality within such villages were far from static and homogeneous. Indeed, diachronic approaches to their societal organisation (*Romero Carnicero* et al. *2008; Torres Rodríguez 2013; Álvarez-Sanchís, Ruiz-Zapatero 2014*) indicate that some accrued increasingly internal disparity and struggle towards heterarchy, in spite of mechanisms against this trend (*González García* et al. *2011*). Despite the narrow stratigraphic test pits often available (*Ruiz Zapatero 2009*), a great deal of the excavated villages yielded houses and smaller buildings arranged in no apparent order (*Romero Carnicero* et al. *2008; Blanco García 2017.662*). However, the later phases at Cerro de San Vicente show neighbourhoods bounded by fences (Figs. 4, 8), as was also documented in open-area excavations at other villages (*Macarro, Alario 2012.51–53; Misiego* et al. *2013*). Furthermore, the last occupation at the village of Soto de Medinilla (*Delibes de Castro* et al. *1995*) features large storage jars in some houses, as well as porches, regarded as a device for displaying the wealth of some neighbours (*Romero Carnicero, Cubero Corpas 1999.183–184; Romero Carnicero* et al. *2008*). These clusters and the very occurrence of storage vessels within certain domestic compounds tally well with the presence of houses displaying higher investments in architecture and exhibiting their wealth. Such observations open the door to envisaging them as 'great houses' within increasingly competitive and heterarchical organisations (*González Ruibal, Ruiz-Gálvez 2016. 387, 397*).

## Conclusions

The excavations at Cerro de San Vicente offer a paradigmatic example of how our knowledge of later prehistoric European societies is still too patchy and how highly detailed fieldwork at selected sites can challenge scholarly ideas. A re-examination of diverse misguided claims may help more reliable and fruitful lines of inquiry to be considered. This has specifically been the case with approaches to tell-like settlements in central Iberia (*e.g., Romero Carnicero* et al. *2008; Blanco García 2017*). The multi-layer village addressed here seems to be the unintended effect of many people disposing of their waste next to their houses, coupled with their preference for rebuilding houses on the same spot (*cf. Kienlin 2015*). The additive accumulation of building foundations, hearths, mortar walls and soils was an iterative social practice that continued for centuries. These facts accord with a conscious attempt at perpetuating these accumulations and underpin the intention probably held by its inhabitants to continue the settlement indefinitely (*Stevanović 1997; Gillespie 2000.12–14*).

In social terms, a fresh reading of the evidence can also be posited: among the studied prehistoric communities some became akin to the house society model (*Gillespie 2000.27–29; González Ruibal 2006*). As a general interpretive framework for the region, the accumulation of an agricultural surplus might have been facilitated by complex high-return agricultural systems and technological innovations (*Ruiz-Gálvez 1994*). These factors have been identified and discussed elsewhere (*e.g., Fernández-Posse 1998; Romero Carnicero* et al. *2008; Delibes de Castro, Romero Carnicero 2011*) and are also apparent at Cerro de San Vicente, despite the incomplete publication of the respective evidence (*Macarro, Alario 2012*). Therefore, such agrarian accumulation was probably in operation in the Duero basin by the mid-first millennium BC. Over time, the domestic realm embodied the success of particular 'great houses', and provided the legitimisation for claiming prerogatives over other contending houses within local communities (*Stevanović 1997.387–388*). Social relations were progressively based on the transmission of land property rights by inheritance, and this led to an obsession with genealogical lines and social memory (*Ruiz-Gálvez 1994; González Ruibal, Ruiz-Gálvez 2016*). Prehistoric multi-layered sites are rich and promising test cases for this kind of account, yet research should also pay adequate attention to the smaller and numerous ill-defined farmsteads in their surroundings to avoid further biased accounts (*Ruiz-Zapatero 2011.95*).

The location of Cerro de San Vicente in central Iberia, far from the more permeable coastal settings entailed neither rusticity nor isolation in the material expressions of its inhabitants. This statement accords with previous claims about the existence of a sumptuous and cosmopolitan culture among some inner Iberian EIA local communities (*Romero Carnicero* et al. *2008.678*). The excavations revealed technology, such as one of the oldest sewer pipes known in

northern Iberia or building techniques that endured up to modern times. The earliest villages in the EIA central Iberia are characterised by avant-garde earth building techniques, exotic domestic animals and novel technologies capable of sustaining growing populations, a renovated material culture and contrasting ways of consuming food and enacting rituals (*Álvarez-Sanchís 2000; Torres Ortiz 2002*). These novelties taken together make more sense if exchange, connectivity and demic movement between Atlantic and Mediterranean Iberian areas where Phoenicians were established are fully taken into account. The means of dispersal and adoption of such innovations and the biological contribution of southern immigrant people will be hot topics in the near future. Illuminating such multifaceted aspects will require clearly formulated questions and science-based enquiry to start disentangling the onset of the Iron Age in Iberia from fresh perspectives.

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back to contents

# I remember. Differences between the Neanderthal and modern human mind

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ABSTRACT – *Modern humans remember things they experience as personal events. An important reason for this personal perception of time is episodic memory, which enables mental time travel. This type of memory could not have been fully evolved in Neanderthals and they might not have imagined their personal past and future. Thus, their archaeological record does not contain durable objects which would be preserved from one generation to another. Their burials also do not include convincing grave goods that indicate a belief that personal time continues after death.*

KEY WORDS – *episodic memory; Neanderthals; modern humans; body ornamentation; Palaeolithic burials*

## *Spominjam se. Razlike v mišljenju neandertalca in modernega človeka*

IZVLEČEK – *Moderni ljudje se spomnimo stvari, ki smo jih doživeli, kot osebne dogodke. Pomemben razlog za takšno osebno percepcijo časa je epizodični spomin, ki nam omogoča mentalno potovanje skozi čas. Neandertalci morda niso imeli popolnoma razvite te vrste spomina ter si niso zamišljali svoje osebne preteklosti in prihodnosti. Zato v njihovem arheološkem zapisu ni zaslediti trajnih predmetov, ki bi se ohranjali iz generacije v generacijo. Tudi njihovi pokopi nimajo prepričljivih grobnih pridatkov, ki bi kazali na prepričanje, da se osebni čas nadaljuje tudi po smrti.*

KLJUČNE BESEDE – *epizodični spomin; neandertalci; moderni ljudje; krašenje telesa; palaeolitski pokopi*

## Introduction

Neanderthals were similar to us in many ways, which is why the question arises as what it is that separates us from them. What was it that led modern humans to the point where we still exist and are extremely technologically successful, while Neanderthals became extinct? Are we more intelligent and more resourceful, or is it only that we think differently? It is often suggested that developed symbolic thinking separates modern humans from other, extinct human species. Symbolic thinking is indicated in the Palaeolithic archaeological record by the occurrence of artefacts such as jewellery and 'Palaeolithic art', which have no direct practical value. The symbolic way of thinking and vivid imagination might have enabled the emergence of different beliefs and rituals connected to them. Given that in captivity some species of apes can to a certain extent learn to communicate with symbols (*Savage-Rumbaugh 1986*), it would be unusual if Neanderthals, who were significantly more intelligent, had not mastered this skill. How is it, then, that the archaeological record of Neanderthals has so few traces of behaviour which goes beyond everyday activities?

One of the answers could be that Neanderthals did not have a fully developed episodic memory, which enables modern humans to experience the flow of time and, because of this, remember their person-


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al past and plan their personal future. Hence, we create durable objects that can survive their makers and we have a language which enables us to discuss our or others' experiences.

**Memory and language**

People have short-term and long-term memory. Short-term memory stores information only for as long as it is important to perform a certain task. It is connected to another type of memory, working memory. While short-term memory holds information, working memory holds information and manipulates it. Long-term memory, on the other hand, enables us to remember information for several hours, days or even years. It is divided into procedural and declarative memory. Procedural memory contains knowledge of how to perform certain tasks, from motor to cognitive skills. Declarative memory stores information about things and events. It is further subdivided into semantic and episodic memory (*Šešok 2006; Wynn, Coolidge 2012.40*).

Semantic memory is a complex system of mental operations, which people share with some animals, *e.g.*, birds and mammals. It refers to knowledge about the world, but without an autobiographical context (Fig. 1). It stores general knowledge about facts, objects, events, and relations between them. It enables us to realise that something has happened, but does not allow us to actually remember the event (*Tulving 2005*).

Episodic memory is a part of declarative memory, due to which we remember past events as personal experiences connected to an actual time and place, and not only as information that something once happened. We understand that things happen to us, and therefore try to direct the flow of events so that they will benefit us in the future. Since it provides autobiographical information about our personal past, episodic memory offers the basis for creating our personal identity. It is because of this type of memory that we have the capacity for mental time travel. The mental reconstruction of the past and the construction of future events are responsible for the human concept of time and the understanding of the continuity between the past and the future. We are even able to imagine what happened before our birth and what will happen after our death. Episodic memory probably completely developed only with the modern humans, and it separates us from animals and other human species (*Suddendorf, Corballis 1997; 2007; Tulving 2005*). The archaeological evidence suggests that even in modern humans, it might had not have fully evolved until the Late Palaeolithic, when durable ornaments, art and burials with grave goods started to appear.

Mental travel into the future should be distinguished from prediction. This distinction is comparable to the difference between episodic and semantic memory. Prediction can be instinctive and exists without personal mental stimulation or imagining of future events. Since episodic memory is not necessary for the functioning of any other type of memory or learning system, organisms that do not have it can function fully and learn about the world around them (*Suddendorf, Corballis 1997; Tulving 2005*).

We can also access the past by other cognitive systems, but without autonoetic consciousness (*Tulving 2005.14*). Thus, it is possible for people who have lost their episodic memory through injury to know facts from their personal past, but not remember when and how they happened. Their semantic memory also makes it possible for them to use language quite normally (*Klein* et al. *2009.300*). Nevertheless, language gained importance and complexity when people started sharing their personal experiences with others. A large part of human conversation consists of joint reliving of past events. Shared memories are the basis for a large and complex social network which extends beyond family relations and is typical of our species (*Suddendorf, Corballis 1997.137*).

It is possible that sharing memories of collectively experienced adventures was the basis for the deve-



***Fig. 1. Where is the bone? Semantic memory enables the dog to be aware that the bone is buried at a precise place in space, but does not allow it to realise that it buried the bone.***

lopment of complex language. Such language enabled the joint recollection of the past and planning of the future, which connected members of a community. From the verbal recollection of important events, storytelling eventually developed. The most successful summaries of important events could have become 'learning aids' for the audience. Such stories were told and learned from for several generations. To the stories, which recollected the important moments in an individual's and community's life, gestures, facial expressions, colour, various objects and sound were added, which led to the development of dance and play. A sort of simple theatre was created in which actors relived, at first, probably their own and later also others' actions.

It is difficult to determine precisely when complex language evolved. The archaeological record does not preserve direct evidence about the use of language, so its presence can only be deduced indirectly. Anatomical characteristics indicating the development of vocal organs of our ancestors are sometimes preserved. However, well-developed organs such as the hyoid bone do not necessarily mean that extinct human species had speech and language, even if their organs are morphologically similar to those of modern humans (*Fitch 2000.262–263; D'Anastasio* et al. *2013.3* with citations). To determine when complex language occurred, studies of the FOXP2 gene are also important. This gene probably played a certain role in the inclusion of vocalisation in the mirror neuron system, which enabled the development of language as an intentional system that can be acquired (*Corballis 2011.70–71*). The FOXP2 gene does also exist in other species of mammals, but after the split between apes and man, the substitution of two amino acids occurred on this gene. It was probably these two mutations that enabled the development of language. Some researchers have suggested that this happened in the last 200 ky and coincided with the occurrence of modern humans (*Enard* et al. *2002*). Others believe that Neanderthals had a FOXP2 gene similar to that of modern humans and that both mutations on it occurred earlier, at the time of their common ancestor (*Krause* et al. *2007*). Yet another group is convinced that language could be even older (*Dunbar 2004. 125*).

Regardless of when they developed, the languages of gesture and speech afforded direct communication between group members who were in the same place at the same time. But the archaeological record of Late Palaeolithic modern humans reveals their need for external memory systems which enable an indirect and lasting transfer of information. The system of communication which was not bound to a certain moment, but was lasting and presented a sort of external memory, is today known as 'Palaeolithic art'. When Palaeolithic people created images, they succeeded in bridging time and space with visual messages, some of which have survived till today. However, the need for a lasting record of knowledge did not appear until episodic memory and recognition of the flow of time had evolved. For ancestral human species, probably also including early anatomically modern humans, who might have lived mostly in the present, the transfer of knowledge to external objects as durable information carriers was unnecessary and probably also inconceivable.

Episodic memory is reflected in finds of durable objects which were not limited to only one generation, but circulated for a long time. Among such objects, jewelry is especially interesting, since it could be linked to self-awareness and the transfer of identity from the person who wore it to the object with which they adorned themselves. If it is made from durable materials, it can also be preserved for future generations.

The treatment of the deceased in the Late Palaeolithic also reflects the appearance of episodic memory, since for the first time there are attempts to preserve the identity and personal story of the deceased among their descendants. This is evident in the archaeological record from the occurrence of human relics, for example pierced human teeth (*White 2003.Fig. 41*) or skulls used as vessels (*Bello* et al. *2015*), and from ritual burials with grave goods, such as the rich burials from Sungir in Russia (*White 2003.141–145; Formicola, Buzhilova 2004.189*) and Arene Candide in Italy (*Pettitt* et al. *2003.15; Giacobini 2007.26*).

Is therefore episodic memory one of the characteristics separating us from the Neanderthals, with whom we were similar enough, on the one hand, to interbreed with (*Green* et al. *2010*), while on the other hand, the archaeological record of both species reveals significant differences? Neanderthals could have used jewellery (*Zilhão* et al. *2010; Peresani* et al. *2013*), buried their dead (*Rendu* et al. *2014*), and perhaps even created rock art (*Pike* et al. *2012; Rodriguez-Vidal* et al. *2014*), but these expressions of behaviour not directed solely towards survival, cannot be compared to the number, recognisability, and

quality of similar finds occurring in Pleistocene Europe after the arrival of modern humans. Because such finds reflect capacity for mental time travel, it seems that this ability truly developed only in the Late Palaeolithic with modern humans, while Neanderthals might have perceived the flow of time differently.

## Neanderthals

Material remains from Neanderthal sites indicate that they were an intelligent, skilful, and practical human species. They mastered the advanced Levallois technique of stone tool production, which required planning of flaking. The stone tool knappers who used this technique were capable of critical observation of their own progress in the core reduction and adjusted new flakes according to past actions (*Coolidge, Wynn 2009.189*). Complex stone tools are primarily a reflection of procedural memory, but do not convey much about the evolution of episodic memory. Nevertheless, it is possible that the production of tools, which required the recollection of past experience and the planning of future actions, was one of the foundations for the development of episodic memory.

At least some Neanderthal tools were hafted on bone or wood, which is proven by the discovery of birch-bark pitch at the German site of Königsaue. Such pitch needs to be heated at the appropriate temperature prior to use, so Neanderthals had to experiment to find the right temperature. This indicates their well-developed technical thinking (*Koller* et al. *2001; Grünberg 2002; Kozowyk* et al. *2017*). They could also have used fibres for hafting stone tools (*Hardy B.* et al. *2013*), which means that they might have been able to combine three materials to obtain a useful tool or weapon.

They were good at observing their surroundings and used characteristics of the landscape, such as river valleys, moors or steep rocks in their hunting strategies. The approx. 120 ky-old spear from the German site of Lehringen, which is made of yew wood, confirms the fact that they were successful hunters who also made wooden weapons (*Villa, Lenoir 2009.70* with references). The use of wood in the manufacturing of weapons is confirmed by the Slovenian find of a wooden spearhead from the Late Mousterian (*Gaspari* et al. *2012*). From another Slovenian site, Divje babe I, osseous artefacts are known (*Turk M., Košir 2016*), showing that Neanderthals were also able to process bone and even made specialised tools out of it (*Soressi* et al. *2013*). Some believe that they also used throwing weapons (*Hardy B.* et al. *2013*), which enabled them to increase the distance between themselves and their prey.

Analyses of Neanderthal bones from several European sites have revealed that they were mostly carnivores (*Richards* et al. *2000; Bocherens* et al. *2001*). They were active and capable hunters, comparable to other predators of the time. Their diet was based on the meat of large herbivores; they even consumed mammoth meat (*Wißing* et al. *2016*). Their preference were animals with plenty of fat, such as bovides, which is why they preyed more frequently on healthy, strong animals (*Bocherens* et al. *2001*). There is little doubt that they were opportunistic scavengers, while the broken and smashed bones of hunted animals at their sites indicate that they also consumed high calorie bone marrow.

Where this was enabled by natural resources, the Neanderthal diet included plants, mushrooms and small mammals, reptiles, and sea animals (*Stringer* et al. *2008; Henry* et al. *2010; Hardy K.* et al. *2012; Hardy B.* et al. *2013*). Finds of charred plant remains and studies of starch grains in dental calculus confirmed that at least in some areas Neanderthals ate plants and sometimes processed them thermally (*Lev* et al. *2005; Henry* et al. *2010; Hardy K.* et al. *2012*). Thermally processed food is easier to digest and more efficient than raw food (*Wrangham 2009.37–39*), which must have been known to the Neanderthals, and so at least occasionally they roasted their food. It has been suggested that they used fire in ways quite similar to modern humans (*Roebroeks, Villa 2011*).

In addition to fire, the cold climate required them to wear clothes to protect themselves. Comparisons with present-day hunters and gatherers who live in various climatic environments have revealed that it was necessary for Neanderthals to protect themselves from the cold if they wanted to survive. For those living in warmer areas, it was enough to protect about a quarter of the body, while those who lived in the coldest territories had to cover up 70% to 80% of their body surface (*Wales 2012*).

The indices of Neanderthal clothing are only indirect, since clothes were made of impermanent materials and vanished. At two French Mousterian sites Pech-de-l'Azé I and Abri Peyrony, four bone fragments with polished areas and rounded tips were found. They are very similar to the tools used in the Upper

Palaeolithic to process hide. Analyses of use-wear traces of the artefact from Pech-de-l'Azé I showed that it was indeed used for processing hide (*Soressi* et al. *2013*). If these tools were used for processing hides, we can fairly certainly say that the hides were used to make clothes and possibly covers which would protect them from cold while they slept. Since Neanderthal sites do not reveal any appropriate needles, their clothes were probably not tailored or sewn to fit the body. Their clothing was simple; the processed hide was wrapped around the body and if necessary tightened with plant or sinew straps (*Wales 2012*). They might have even made a mental leap and started using fur as a camouflage, which enabled hunters to approach their prey unnoticed. However, more convincing evidence of such behaviour is known from Upper Palaeolithic modern humans, who depicted mixed beings with human and animal characteristics which could be a representation of a hunting disguise (*Demouche* et al. *1996; Hodgson, Helvenston 2006*). It is possible that, eventually, therianthropes were ascribed symbolic meaning and might represent not only disguised hunters, but spiritual beings (Fig. 2).

Neanderthals' practical skills and their thorough knowledge of the environment in which they lived are also indicated by the use of stalagmites to construct structures in the Bruniquel Cave (*Jaubert* et al. *2016*) or to manufacture pigment containers in the Cioarei Cave (*Cârciumaru* et al. *2012*). Pieces of ochre and cut off and hollowed stalagmite tips were found in the Mousterian layers of this cave. Stalagmite tips served as containers in which ochre was stored and crushed into a pigment. Pigments are relatively frequent at Mousterian sites (*Roebroeks* et al. *2012.1889; Neruda 2016.251*), but it is still not known how the Neanderthals used them. Finds of pigments do not necessarily indicate symbolic behaviour, since they can be used for solely practical purposes (*Petru 2008.12–13* with references).

We can only speculate as to when and how the practical use of pigments turned into symbolic behaviour. It is also impossible to determine when people started using pigments for body decoration. Since some Upper Palaeolithic statuettes representing females have bodies or parts of them painted red, we can assume that such behaviour started at least at that time. Considering the early presence of pigment in the archaeological record (*Barham 2002*), this practice could have been present even earlier. At first, the painting of the body was perhaps a form of visual display, the purpose of which was, similarly to animal display, to intimidate rivals and attract partners for reproduction (*Kuhn, Stiner 2007.42*). Decoration with bird feathers, supposedly known to Neanderthals and which, according to some researchers (*Peresani* et al. *2011*), indicates their symbolic thinking, could have had a similar purpose.

## 'Art' and ornaments

Neanderthals were certainly resourceful and had a developed technical intelligence which helped them survive in difficult conditions. A few finds also indicate occasional flashes which transcend solely practical activities. However, such finds are rare and some of them give reason for caution regarding their interpretation. Most were made by late Neanderthals – the geometrical pattern on the wall in Gorham's Cave, for example – which was supposedly engraved by Neanderthals sometime before 39 ky (*Rodriguez-Vidal* et al. *2014*). The red disc originating from El Castillo Cave in Spain, was also made around that time, since it is slightly over 41 ky old, but it is not quite clear who painted it, modern humans or Neanderthals (*Pike* et al. *2012*).



***Fig. 2. An engraving of a human being with the head of a jackal. Wadi Metkhandoush, Libya, Mesolithic or younger.***

Marine shells, approx. 50 ky old, with traces of red pigment, found in two Spanish caves Aviones and Antón also date to the late phases of Neanderthal existence (*Zilhão* et al. *2010*). In Aviones Cave, the mollusc shells from Mousterian layers were mostly of edible species, which Neanderthals wrapped in algae to keep alive during transportation from the coast to the cave. This reconfirms the practicality and resourcefulness of Neanderthals, who obviously knew very well how to preserve such food. But the shells with red pigment at the site are of inedible species and were probably collected for their shells after the animal had died. Some have a hole which was not drilled artificially, but is of natural origin. Perforated shells are supposed to be jewellery, while the unperforated ones might have been used as pigment containers (*Zilhão* et al. *2010.1026*).

A fossil marine shell painted with ochre was also found in a Mousterian layer at the Italian site of Grotta Fumane (*Peresani* et al. *2013*). Several perforated shells, supposedly jewellery, were found in the younger layers of this site. Therefore, it could be assumed that the only painted shell came to the Mousterian from younger layers. Nevertheless, the authors of the article believe this not very likely. They also reject the possibility of its practical use, and suggest that it was worn by Neanderthals as a pendant (*Peresani* et al. *2013.11*).

Finds from Qafzeh Cave in the Middle East indicate the possibility that also early anatomically modern humans used shells as pigment containers (*Vanhaeren* et al. *2006.1785*). Umbo-perforated shells are frequently not so damaged (*Zilhão* et al. *2010.Fig. 1*) that they could not still be used as containers. The holes could have even been used for attaching the shell to a string and suspended. This, however, does not mean it was considered a piece of jewellery. Hanging it on a string could have had a practical significance – to transport the shell more easily or temporarily put it aside. It is not impossible that the practical use of shells led to the idea of decorating the body with jewellery. Shell containers attached to strings and hung on the clothes or body could in time have acquired a new meaning and become jewellery. However, to perceive an object as jewellery, a cognitive leap of the extensive population was probably necessary, not only a few rare flashes. Such a leap can be proven only when jewellery becomes an important part of life and is found frequently and over extensive areas. This happened approx. 40 ky ago, at the beginning of the Upper Palaeolithic, when jewellery started to appear in Asia (*Kuhn* et al. *2001; Langley, O'Connor 2016*) and Europe (*Kuhn* et al. *2001; White 2003.132–133*), as well as in Africa (*d'Errico* et al. *2012*) and a bit later in Australia (*Balme, Morse 2006*). Most jewellery was also artificially perforated as well (*Kuhn* et al. *2001.7643–7645*). All the holes in the marine shells which were interpreted by researchers as Neanderthal pendants occurred naturally (*Romandini* et al. *2014.2*). With intentionally perforated shells, we can assume with great probability that people considered them special objects, since they put knowledge and effort into making the holes. If the holes are of natural origin, the probability of shells being jewellery significantly decreases.

The frequent presence of jewellery in the archaeological record does not necessarily reflect the moment when this activity started, but it does mean that the use of jewellery became part of material culture, which was arguably transmitted from generation to generation (*Bouzouggar* et al. *2007.9964*). It also points to a new perception of time, which does not stop with an individual's death, but is transcended through objects to descendants. When, due to the development of episodic memory, people started thinking about a future that endure beyond the time of their lives, the need arose to deposit knowledge and beliefs in lasting objects for use by several generations.

Eagle talons found at some Neanderthal sites have also caught the attention of researchers (*Romandini* et al. *2014; Radovčić* et al. *2015*), because some of them might have intentionally made notches and polish on their surface. In the number of talons, Krapina stands out, since eight were found there. With their age of approx. 130 ky the finds from Krapina are also much older than the rest, the age of which spans between 50 ky and 48 ky BP. It has been suggested (*Radovčić* et al. *2015*) that the talons might have had a symbolic meaning and that Neanderthals wore them as jewellery. However, they could also have been practically useful objects. This possibility is mentioned by Matteo Romandini *et al.* (*2014.8*), even though they prefer the notion of them being jewellery.

It has transpired that some of the artefacts which supposedly reflect the Neanderthal's symbolic thinking were erroneously interpreted. Detailed research of engraved stones appearing at some Mousterian sites revealed that the engravings are connected to the production and use of the stones. As such, they do not indicate 'artistic', symbolic Neanderthal be-

haviour, as was originally believed, but are indicators of their practical nature (*Peresani* et al. *2014*).

An artificial scratch on the nummulite fossil from the Mousterian layers at the Hungarian site Tata is probably also not the work of a Neanderthal (*Steguweit 2003*). At the same Hungarian site, in the 100 ky old layers, a piece of mammoth tusk was found on which traces of red pigment are preserved, while its edges are polished from long-term use. Marshack suggested, that it could be a ritual item (*Marshack 1990.468, Fig. 17.11*). However, the fragment could have been used for purely practical purposes, *e.g.*, in processing hides, since it resembles the above-mentioned Mousterian items for processing hides from the French sites at Pech-de-l'Azé I and Abri Peyrony.

Another controversial find is the Neanderthal flute from the Slovenian site of Divje babe. Opinions differ as to whether the holes in the flute were made intentionally or are of natural origin (*Turk I.* et al. *2003; 2005; d'Errico* et al. *1998; Chase, Nowell 1998*). Considering the convincing evidence, it is probable that the majority of holes were made by a Neanderthal (*Turk I.* et al. *2003; 2005*). Why the bone was perforated and what was its purpose is impossible to determine. The suggestion that Neanderthals used it as a flute, is impossible to prove. It is true that it can be played, but this is something attempted in modern times. If people today are resourceful and feel drawn to music, they can play on objects which appear to have no connection to music. The Neanderthals perception of music remains a mystery. They would probably have used the flute differently from the way we use it today. They might have whistled for purely practical reasons, to frighten off dangerous animals, or just the opposite, to attract prey. Or they might have used it for the same reasons present-day Maasai warriors use animal horns, to call for help when in danger.

Judging from the finds, through most of their existence Neanderthals did not make artefacts reflecting intensive symbolic thinking. Their stone, bone and wooden tools and weapons were practical objects of a technically skilled human species which was very capable and well adapted, but almost exclusively oriented towards day-to-day survival.

**Social behaviour**

It has been suggested that the Neanderthal brain was organised differently from that of modern humans. They might have had a better developed visual cortex for processing visual information, but less neural tissue in other brain areas, including those which are connected to social cognition (*Pearce* et al. *2013*). Considering the size of the sleeping space and activity around hearths at the rock-shelter of Abric Romani, it has been assumed that the Neanderthal group visiting the cave consisted of only 8 to 10 people (*Vallverdú 2010.143*), so it seems that Neanderthals lived in small, local groups (*Coolidge, Wynn 2009.199*). Only upon exceptional events, such as a hunt for larger animals, did they form larger groups of 20 to 40 individuals (*Wynn, Coolidge 2012.75–78*).

The smallness and the geographical dispersal of Neanderthal groups might have caused technological and social stagnation (*Bocquet-Appel, Degioanni 2013*) and limited genetic diversity (*Lalueza-Fox* et al. *2011.250*). Mating between relatives was more common than it is in modern humans (*Castellano* et al. *2014*). This indicates that Neanderthals lived in closed groups and rarely associated with foreigners of their own or other human species. Despite their wariness, they still had to find mating partners outside their natal groups. Genetic research of Neanderthal bones from the Spanish cave of El Sidrón indicates that it was women who more often moved to another group to find a suitable mate (*Lalueza-Fox* et al. *2011*). As a consequence of their enclosure in the natal group, they occasionally mated within the group. The genome of a Neanderthal female from Altay revealed that her parents were closely related and that reproduction between close relatives was quite frequent among the Neanderthals of this area (*Prüfer* et al. *2014*). So it is probable that, at least in this area, groups of Neanderthals avoided each other, rather than socialised.

Life in small isolated groups did not require intensive symbolic behaviour, so a lot of time and effort needs to be invested into finding evidence of Neanderthal symbolic thinking, while the Upper Palaeolithic 'art' of modern humans is recognised as something familiar to us, even though we may not understand what it means. Since Neanderthals spent most of their time in direct contact, they were able to show each other things in a straightforward way, and thus symbols were not needed. Judging from the finds, Upper Palaeolithic modern humans behaved differently. In the Aurignacian, the number of inhabitants in Europe significantly increased, which enabled the development of complex societies with well-developed exchange networks and social connections (*Mellars, French 2011*). Groups of modern humans

frequently socialised and thus developed symbols which made their communication easier. Episodic memory and the advanced language associated with it enabled members of the community to share concepts and beliefs, while joint memories and plans made it easier for them to form complex groups. As a reflection of an evolved capacity for mental time travel, graves with various grave goods started to appear in the Late Palaeolithic.

**Burials**

Archeologists have differing views of the topic of Palaeolithic burials. This is especially true of Middle Palaeolithic burials; but even for some Upper Palaeolithic ones, it is not completely clear whether they are indeed burials or whether the skeletons were well preserved by chance.

Many of the Neanderthal burials were discovered at the beginning of the previous century, when important sites were poorly excavated. Excavation records are frequently inadequate, so it is difficult to reconstruct the circumstances of the finds. Such is the case with the famous burial of an adult Neanderthal at the French site of La Chapelle-aux-Saints. It was discovered in 1908, but due to the lack of excavation records, even a hundred years later there are still doubts as to whether this really was a burial. Since crucial data are incomplete, interpretations of the find are completely contrary. Some are certain that this was a burial (*Rendu* et al. *2014*), while others claim there is no evidence for this (*Dibble* et al. *2015*). The skeleton was found in a shallow pit, but it is not clear whether it is of natural or anthropogenic origin. Since the skeleton was well preserved, it was assumed that it had been buried immediately after death and was thus protected from decay. The cave served as a dwelling for Neanderthals; numerous stone tools and animal bones indicate long-term occupation of the site (*Rendu* et al. *2014.4*). Artefacts and animal bones were also found alongside the skeleton in the pit. However, they are almost certainly not grave goods, but garbage that was thrown or fell into the pit. The skeleton was not deposited outside the occupation area, but was part of the living context, which is a common characteristic of Neanderthal burials (*Pettitt 2011.137* with references).

A child's skeleton from the French site of Roc de Marsal, was also considered as an example of intentional, possibly even ritual burial. However Dennis Sandgathe *et al.* (*2011*) demonstrated that the skeleton might have been preserved as a result of natural processes. They suggested that the body was not covered, which means that skeletons can be relatively well preserved even if the body is not buried immediately after death (*Sandgathe* et al. *2011.252*). The good preservation of skeletons was one of the main arguments of those who argued for the existence of intentional Neanderthal burials. It was suggested that the human remains could be well preserved only if the body had been quickly buried and thus protected from predators. Yet the remains from the Roc de Marsal indicate that skeletons can also be well preserved by completely natural processes.

In the archaeological record of Europe, the Middle East and other areas of western Asia, fewer than 100 eventual Neanderthal burials are known. For this reason, it is not possible to state that Neanderthals generally buried their dead, since these were extremely rare events (*Pettitt 2011.97–98*). They might have perceived death differently from modern humans. This is indicated by the fact that, even if they buried their dead, they did not invest much effort in the process of burial, since their goal was just the short-term protection of the body (*Wynn, Coolidge 2012. 111*). Their burials also do not reveal any convincing example of grave goods. All objects found in the vicinity of Neanderthal skeletons and also most of those in the graves of early anatomically modern humans can be explained in a different, simpler way, which indicates that they probably considered objects solely as useful items (*Pettitt 2002.18*) and did not assign additional symbolic meaning to them. With the development of episodic memory, some objects probably became a part of an individual's personal story and acquired emotional charge, because they were seen as an extension of their owner and thus in a way imbued with the person who possessed them. For this reason, they were added to the body as an inseparable part of the deceased when their owner died. Such a perception of objects probably appeared in the Gravettian, less than 30 ky ago, when the first indisputable burials with grave goods started to appear. They are rare events, since in Eurasia fewer than five preserved Upper Palaeolithic burials are documented per millennium (*Riel-Salvatore, Gravel-Miguel 2013.304*). Still, it seems that more complex funerary practices developed at the time. The dead probably lived on in the memory of the living. Thus, the past started to influence the future through the present. Ancestor worship developed, which is still present in some places even today (Fig. 3).

## Conclusion

Neanderthals were resourceful and intelligent, which enabled them to survive the climatic and environmental changes of their time; but they vanished after modern humans arrived on their territory. Was this a coincidence, or did our species have a small, but fatal advantage in relation to them? Episodic memory, which is important feature of the modern human mind, might have been one such advantage. The most obvious reflection of episodic memory in Palaeolithic archaeological contexts are finds of lasting ornaments and ritual burials. Both are rare and poorly proven in the Mousterian, and thus the subject of conflicting interpretations. One of the possibilities is that Neanderthals did not have the need for such objects or behaviour, because their episodic memory was less evolved than ours and the flow of the time from past to the future was not so important to them as it is for us. They certainly planned the future and remembered past experiences to some extent, but their perception of future and past might have been to a great extent dependent on semantic rather than episodic memory.

While people remained incapable of mental time travel, they might have decorated themselves only in moments of social display, and then they discarded the ornamentation. Lasting ornaments made of resistant materials become frequent only with modern humans in the Upper Palaeolithic, whereas before that they were quite rare. The same is true for other forms of 'art', which started to appear more frequently in Europe at the beginning of the Upper Palaeolithic with arrival of modern man. Since Neanderthals' perception of personal past and future was probably different from ours, they did not record what happened to them and had no need for 'external memory' through which to transfer and preserve information. Therefore, the finds which could be perceived as such transmitters are rare in their archaeological record.

Neanderthals might in some cases have buried their dead, but there is no convincing evidence that they performed any kind of ritual during the process. Ritual burials with grave goods appear only in the Gravettian, and probably point to a new perception of the flow of time, which does not end with death. The deceased became ancestors and the past started to strongly influence the present. To satisfy the dead and ensure their help, people made sure that the passage between the worlds was as smooth as possible. Hence they added food and favorite objects of the deceased to the grave.



***Fig. 3. In some places, people still keep skulls of ancestors, which physically revive the memory of the dead members of society (from* Buschan 1922/1923.Fig. 36*).***

An absence of expressions of so-called symbolic behaviour does not mean that Neanderthals were less capable then modern humans; they were simply different. Their behaviour should thus not be reduced to the sphere of modern human behaviour (*Romandini* et al. *2014*), but they should be granted their own identity, ways of thinking and acting, which enabled them to be successful and efficient in their world.

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back to contents

# Book review

**Dragoş Gheorghiu and George Nash (eds.)**
**Place as Material Culture: Objects, Geographies and the Construction of Time**.
xvi + 324 pages, 107 figures, 13 tables. 2013. Newcastle upon Tyne: Cambridge Scholars Publishing;
ISBN (10) 1-4438-4261-3; ISBN (13) 978-1- 4438-4261-7 hardback.

The purpose of this volume is to explore the complexity of the past by analysing the relationships between place, territory, the material value of objects and landscapes, and time and ritual, concepts applied within archaeological investigation. It presents the archaeology of place as a series of interconnecting and interactive relationships, and it is clear that things and places do not emerge without some form of agency, usually through the concept of material manipulation, coupled with elaboration, innovation and time; depending on the raw material used and the process of manipulation and its relationship with the environment, materiality gains value.

But how do we as modern humans work within the complexity of place, materiality, time, and ritual?

The need to describe places, albeit in an empiricist and banal way, is traditional in archaeological discourse. Discourse is sometimes followed by a more fruitful and interpretive account. However, these accounts tend to ignore human emotion, which is bound up in place, as for example in the ritualised and symbolic meanings that place holds. This book explores the significance of geography, place and the materiality that place holds, and challenges many of the traditional norms that have hitherto trivialised landscape archaeology. It is divided into fifteen thought-provoking and crafted chapters and will be an ideal companion to anyone involved in social sciences: (1) Introduction: Place, materiality, time and ritual: towards a relational archaeology by Dragoş Gheorghiu and George Nash, (2) Prehistoric place: Studies in material culture, time and space by Ezra B. W. Zubrow, (3) A Place in time: temporal dimensions of the human experience in a material world by Roberta Robin Dods, (4) Space and time as cultural artefacts: Blackpool as Heterotopy and Heterochrony by Paul Bouissac, (5) Hunter-gatherer territories in the European Upper Palaeolithic by François Djindjian, (6) Experience and perception of memorable places: lithic scatters and mapping the British Neolithic by Clive Jonathon Bond, (7) The importance of acoustics and illumination when creating a chronotope: reflections about two Middle Neolithic palisades from Southern Sweden by Raimond Thörn, (8) Concepts of space, place and time in the Late Neolithic Carpathian Basin: the geometry of Rondels of the Lengyel complex by Emilia Pásztor and Judit P. Barna, (9) Space and place as artefact: on the life and death of Tell Settlements of the South Eastern Europe Chalcolithic by Dragoş Gheorghiu, (10) The mountains during the Bronze Age in Southern and Central Italy: spaces becoming places by Cristiana Ruggini and Valentina Copat, (11) Art for those visiting the underworld: an appraisal of the Later Prehistoric Menhir of Robin Hood's Stone, Allerton, Liverpool by George Nash, (12) Materiality of place, performative time and mortuary space as locality in the Early Iron Age of Southwest Germany by James A. Johnson and Seth A. Schneider, (13) The power and the glory: hillforts, ironworking and the monumental landscape in the Early Iron Age of Central and South Eastern Slovenia by Philip Mason, (14) How natural are natural places? Challenging stereotypes in the interpretation of landscape in Iron Age Veneto, Italy by Sarah de Nardi and, finally, (15) Relationship between people, space and places during the Iron Age: exploitation of coastal space and resources through the island settlements in Western France by Anna Baudry and Marie-Yvane Daire.

At best, we can argue that place is very much a social construct, the physical boundaries being arbitrary and formed from history, conformity and consensus. Cultural boundaries ritualise a place by different acts of separation materialised in the form of symbolic and ritual limits, generating a rite of passage and ownership; as a result, a place becomes a ritualised fragment of a whole, establishing a series of places (or points) within a place.

Cultural places are structured in a fractal way, their smallest material element being the object, followed by object assemblages (representing the various levels of occupation within, say, a site) and, finally, the material culture that defines the form, function and personality of a territory or region, sometimes


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referred to as a tradition. Objects with clear intentionality of design and style can be considered rhetorical, the indexes of places. The structure which gives identity to a place is sometimes known as the genius loci, *i.e.* an animistic and sacred symbol. "*For natural places, their genius loci shall be investigated in the materiality of geomorphs, not only as human interventions in nature, but natural interventions with people*" suggested editors in an introductory chapter. Sometimes, part of the material and at other times the whole place is re-used (or recycled) through a process of monumentalisation, and this ideological practice creates the premises for social competition.

Concluding this perceptual voyage through meaningful places, one could suggest that there is a need to rethink the interpretation or understanding of natural places as simply marked by an 'absence'of something, in this case structures. Also, sacred objects and offerings have to be interpreted and understood in their landscape and place-specific context, as they may reflect, though not representing, significant or magical features of the landscape that could be a focus of cult and ritual per se; there can be no 'interpretation from afar'.

For this reason, the book is an attempt to place emphasis on the idea that, in itself, time is a means of measuring the materiality of the world, and also that a material place is an indissoluble mix of material and time. A place seen as a chrono-material relationship in a determined location of the territory is a chronotope; therefore, the spatial-temporal experience of a place implies a heterotopic and a heterochronic experientiality. Although the temporal dimensions of the human experience are complex, two kinds of time in the material archaeological record of a place can be discerned: linear time (since making an object or walking through a landscape involves a sequential experience of time) and circular or cyclical time.

If the 'ephemerality' of place troubles and puzzles us, it is because we have not been trained to appreciate a place that was meaningful to people for a variety of reasons, but not monumentalised, not 'marked out' by permanent structures. Natural places and small-scale votive and ritual deposits deserve the same attention as monumental sites, insofar as people interacted with them in meaningful ways, and made them 'special'. Navigation and approach to a special place can feel sequential even without the guidance of monuments, walls, or humanly defined pathways, and the bodily engagement with land forms can convey a distinct narrative element to place: going through places, feeling the land change in one's muscles, experiencing place with all the senses, body and soul.

One 'material' way to build group identity is to relate objects with time, since 'objects anchor time'. The materialisation of the past through objects and, consequently, the manipulation of memories through materials are very visible in monuments. A relationship between the living and the dead through social 'technologies of remembrance' is possible with the use of material monuments. This material support of collective memory can produce 'memorable places'. Such continuity in time of a specific place becomes a problem of rituality and generates ritual time.

The relationship of the materiality of natural places with their phenomenological experience through ritual and performance, more than through rational thinking, offers to the archaeology of place a novel insight into the relationship between 'humans and nature'. People connect space or territory with place not only visually and kinaesthetically, but also through other sensory modalities: haptic (touch), acoustic and oldfactory. These perceptions of a place, defined as a heterotopy, are quantifiable qualities of the built environment and represent the relationship of being with place.

The book, presents a series of essays that illustrate the philosophical and physical construction of place, and there are no apologies for the disparate approaches of the authors: the over-riding theme is place and the agencies that construct, govern and manipulate it. What is made clear is that bounded places are constructed in a variety of ways, sometimes via the use of objects, sometimes using natural points, and sometimes through the rhetoric of language, the latter "*creating a fluidity in the consequence and novelty of place*" suggested editors. The consequence and novelty of place are certainly bound up with how places (and objects within them) become ritualised. This process is usually the result of history through time; the longer the history, the more power it gains.

A conclusion to consider is that a relational nature of place necessitates different strategies in terms of approach, such as the determination of coordinates and position, temporality, materiality and of the relationships with the natural context.

A place could represent a temporal relationship between present and past, between living people and their ancestors, becoming an image of memory. A place could be made visible when using material markers with ritual and aesthetic value, which transform themselves into monuments when they relate time and material to a specific spot.

In this book it is, demonstrated that place, materiality, time and ritual are in many ways difficult to disconnect and are autonomous in their own right, since they form a sort of syncretism, an identitary syncretism which explains the topophily of human beings and the existence of genius loci. Ironically, in a preference for place and landscape understanding, what has failed to be delivered is a precise methodology for understanding the interrelatedness of artefacts and place. Studies have remained centred on broad scale analysis in most cases, without directly using artefact data.

However, these life histories or biographies should not be considered separate from the physical and social setting of place. The biography of a place is nothing without a biography of the artefact recovered from that place.

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back to contents