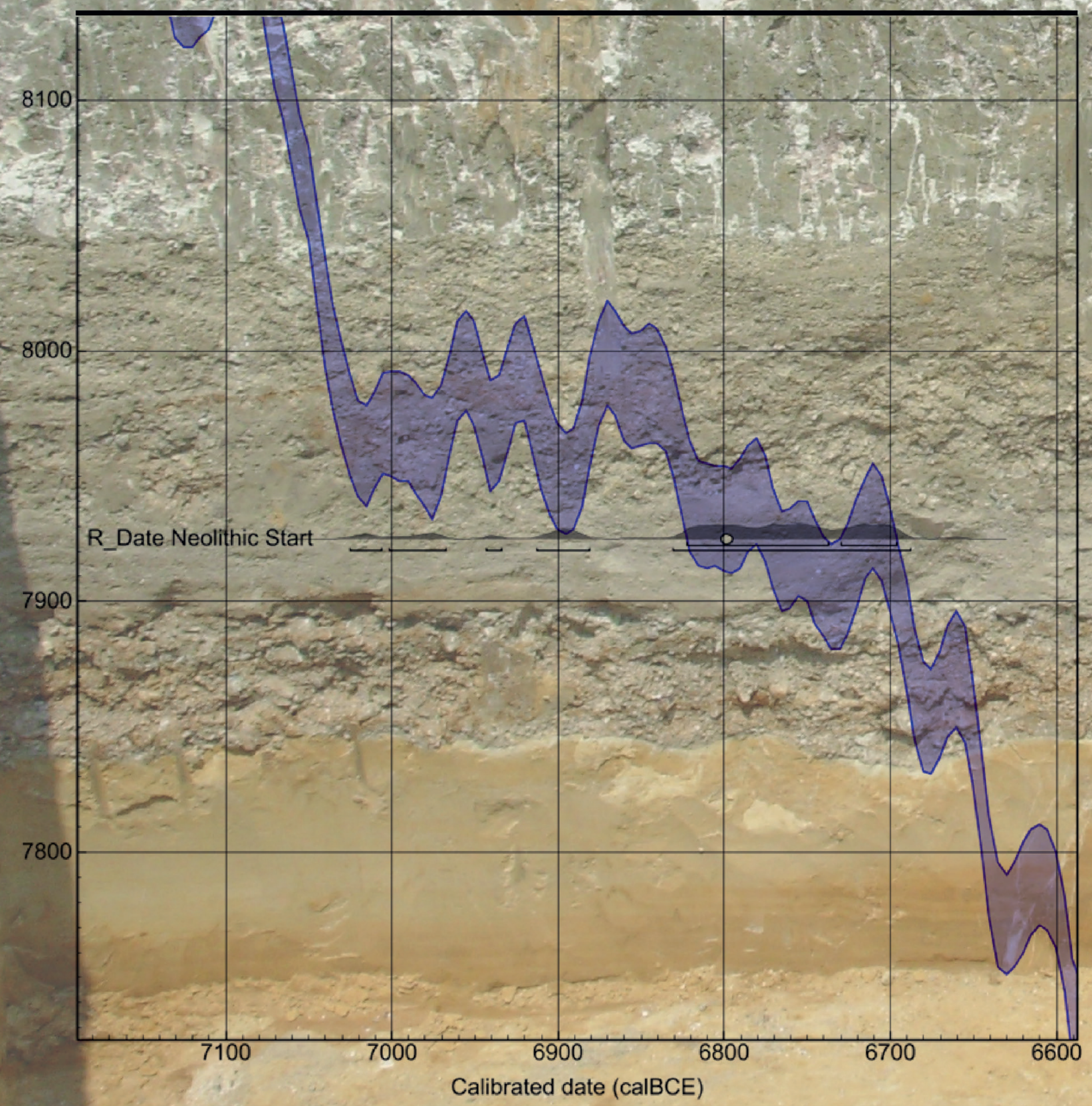

RELATIVELY ABSOLUTE

Relative and Absolute Chronologies in the Neolithic of Southeast Europe

Edited by Miroslav Marić, Jelena Bulatović and Nemanja Marković

Beograd
2023

RELATIVELY ABSOLUTE
Relative and Absolute Chronologies in the Neolithic of Southeast Europe

ISBN 978-86-7179-122-9

RELATIVELY ABSOLUTE

Relative and Absolute Chronologies in the Neolithic of Southeast Europe

Edited by Miroslav Marić, Jelena Bulatović and Nemanja Marković

INSTITUTE FOR BALKAN STUDIES
SERBIAN ACADEMY OF SCIENCES AND ARTS

SPECIAL EDITIONS 156

RELATIVELY ABSOLUTE

Relative and Absolute Chronologies in the Neolithic of Southeast Europe

Edited by
Miroslav Marić
Jelena Bulatović
Nemanja Marković

Editor in chief
Vojislav G. Pavlović
Director of the Institute for Balkan Studies SASA

Belgrade
2023.

Publisher

INSTITUTE FOR BALKAN STUDIES,
SERBIAN ACADEMY OF SCIENCES AND ARTS

Knez Mihailova 35
11000 Belgrade, Serbia
email: balkinst@bi.sanu.ac.rs
www.balkaninstitut.com

Editors:

Miroslav Marić, Institute for Balkan Studies, Serbian Academy of Sciences and Arts, Belgrade, Serbia,
Jelena Bulatović, Department of Historical Studies, University of Gothenburg, Gothenburg, Sweden;
Nemanja Marković, Institute of Archaeology, Belgrade, Serbia.

Editorial board:

Alasdair Whittle, Haskel Greenfield, Nenad Tasić,
Zoi Tsirtsoni, Žarko Tankosić, Miroslav Marić.

Reviewers:

Blagoje Govedarica, Institut für Ur- und Frühgeschichte, Freie Universität Berlin, Germany.
Benjamin W. Roberts, Department of Archaeology, University of Durham, UK.
Miljana Radivojević, Institute of Archaeology, University College London, UK.

Design and Print:

Birograf, Zemun

ISBN 978-86-7179-122-9

The volume was funded by the Science Fund of the Republic of Serbia PROMIS grant #6062361, project Regional Absolute Chronologies Of the Late Neolithic in Serbia (RACOLNS).

Contents

Introduction

It is probably best assumed that the passage of time has been an important part of human reality for as long as humanity has existed. The notion of time, although likely not understood and measured by early hominids as it is today, was a self-evident fact of the cycles of life that each of us undertakes, from the moment of birth to the day of death. It became even more important to understand and measure when humans first attempted to understand their environment, to put it under their control. Perhaps at first, it was enough to realise when it was a period of cold or hot weather, a time of bounty and scarcity but as the complexity of human livelihood began to emerge with the onset of the Neolithic, the concept of time must have started to matter even more. Time, an intangible concept that cannot be rewound, renewed or traded, is an intricate part of daily lives governing our actions and cycles. The realisation that we can measure and organise it in the order of the occurrence of events to establish its flow was as important to the humans of the past as much as the concept of growing your own food resources and living in organised societies settled in specific environments. Certain authors (Aveni 1989) argue that the perception of time is inborn to living beings, evidenced through behaviours regulated by circadian cycles, but the measurement of time is surely a cultural product. Mankind, most likely even before the time of the Homo Sapiens, must have been aware of the biological time, evidenced in the individual phases of life that each living being goes through from birth to death. But the motion beyond that realisation, one that would cause the development of the concept of physical time; the time that exists as an external, measurable entity, must have demanded more than the inborn quality.

The measurement of time must have started very early in human prehistory, but the perishable character of material evidence from the human past partially prohibits us from discovering the point when it occurred. Additionally, even if material evidence is to be found, would we be able to, from our perspective, understand its character of timekeeping with certainty? If we were to argue the measurement of time came about in the Palaeolithic, then the material evidence is very limited due to, ironically, the sheer amount of time that has passed since. Perhaps then, it is possible to proxy search for other probable indicators of the existence of time as a concept among the current hunter-gatherer tribes that still occupy secluded parts of Earth today, avoiding contact with contemporary human societies of the 21st century? Certain studies (Sinha et al. 2011) have indicated that hunter-gatherer tribes in Amazon lack the linguistic structure that relates time and space or even lack words for time or terms associated with measuring time, like month or year. This, however, does not prevent them from talking about events and their sequence of occurrence, but it illustrates that, for them, the concept of time does not exist independently of events. Is it then prudent to assume that the Palaeolithic hunter-gatherers must have had the notion of seasonal cycles, possibly to keep track of which food sources to look for when, but surely not had them organised in calendars, rather as a series of interconnected and overlapping events related to certain natural phenomena (e.g. climatic cycles)? Would it be far-fetched to suspect that these Palaeolithic societies did not count the cycles of time but rather related them to events easily identifiable and transferable by the collective memory? This concept seems logical from the aspect of the short time scale that the hunter-gatherers were living on, based on recurring seasonal changes. It would also imply that their time was highly dependent on narratives passed down from generation to generation.

If no evidence of quantitative timekeeping can be found in the Paleolithic, can it then be identified in the Neolithic? Sedentary life and plant cultivation go hand in hand with the concept of longer annual or perennial cycles based on prolonged planning, food production, and harvesting management. While hunter-gatherers were influenced by individual seasons of climatic changes, Neolithic farmers would need to rely on at least annual cycles to know the adequate periods for sowing, cultivation and harvesting. It is safe to assume that these annual cycles would have already been known from the repetitive cyclical motions playing out above our heads – the astronomical cycles of constellations and the Sun and the Moon. The nature of these measurements is still unclear in the Neolithic period, as a key ingredient, writing, was still missing, depriving us of material evidence. Undoubtedly, the astronomical cycles have had an important role in the development of time measurement and the emergence of codified calendars, the basis for the earliest known systems of time measurement that would appear in the later periods.

Thus, moving to the earliest material evidence for timekeeping records may be pertinent, which originates in the Sumerian and Dynastic Egyptian periods (Greengus 1987; Polcaro 2013) from about 2200 BCE. However, it should be assumed that there would have been even older records since the writing system predates these earliest chronological records by almost a millennium. The Sumerian calendars were lunisolar, based on 12 lunar months, subdivided into seasons and organised around natural cycles like day (the regular rising and setting of the Sun), lunar month (the transition of the Moon through its cycle of phases) and solar cycle (the change rising and setting positions of the Sun throughout its annual cycle), while the Egyptian was solar based. The historical stage for chronology was thus set, driven by the need of emerging complex societies to record their time for posterity. Another side effect of the timekeeping was the creation of dynastic histories, the first relative chronological system known, albeit envisaged as a justification for the immense power vested in rulers rather than as a recording of the passage of time. Thus, a twofold split in chronology appeared, with shorter scaled civil time recording short-term astronomical cycles and regulating civil life, while historical time dealt solely with larger time scales that spanned periods from the current rulers back to the mythical, often divine, ancestors. The historical time was often referred to as sacred time, which must always be cyclical time as its existence made the present time (Eliade 1959). These cyclic events in which sacred times recreated the rituals originating from past sacred events from the long-gone periods often resulted in the creation of great years, truly long cycles which would often span multi millennia that were to repeat themselves over and over again.

The development of the concept of time did not end there. The cyclic time of the Bronze Age middle eastern societies began to be replaced by the notion of linear time, irreversible and not traced back to prior events in the Early Iron Age. This notion is deeply connected with the appearance of Judaism and monotheistic concepts of the Universe, which has its creation, lasting period and ending point (Goldberg 2000). Ancient Greek philosophers also tried to grasp the nature of time and the concept of chronology, introducing infinite time into the matter. The Sophist philosopher Antiphon claimed that time is not a reality, but a concept or a measure (Dunn 1996), while Parmenides saw it as an illusion because change is impossible and illusory (Hoy 1994). Somewhat later, Plato, in his Timaeus, stated that the time was created by the Creator and identified it with the period of motion of the heavenly bodies, of which he specially commented on the so-called Great Year, a complete cycle of the equinoxes around the ecliptic; effectively the return of the planets and the "fixed stars" to their original relative positions, a process that takes about 25,800 years (Plato 2001). This notion, derived from ancient astronomical observations of the movement of stars and constellations in the night sky, contributed further to the notion of linear time that early Christian authors will additionally advance in their attempts to synchronise and record the timeline of early Christianity.

In his Confessiones, St. Augustine noted that the world was neither timeless and eternal nor created at a certain point in the time series, but that the world and time were created together and also stated, "There are three times; a present of things past, a present of things present, and a present of things future" (Augustine 1992, XI:26). For Augustine, time is God's creature and God is the beginning and the end. This position reflects Neo-Platonism with an added splash of Aristotelian time as a linear stream, flowing from a beginning towards an end. This idea of linear time would not change much in the Early Medieval period. However, the theological view of time considers time to be of the material world only and that time ceases to exist in the immaterial after-world when they give way to eternity. Thus, time is an imperfect reflection of the heavenly life that awaits the worthy in this transitory world. Life on this Earth is time-bound and limited, while heavenly life is timeless and everlasting.

On the opposite end of the spectrum, in the Mediaeval period, earthly time is still a flow of moments, measured in terms of cyclical movements of the celestial bodies and the rhythm of nature (Polcaro 2013, 5). Timekeeping became very important, especially when serving religious needs, like Epiphany, Christmas, Annunciation and others. These calculatory problems occupied early Christianity, and many computations were made in attempts to fix the dates of these major events until finally, a Benedictine monk Bede Venerabilis published his study De temporum ratione in 725 AD. With the advent of the developed and Late Medieval period and the resurrection of town life that sprang around fortified castles of nobility, a new concept of time started to appear, centred primarily on acquiring economic and social wealth and prestige. The prohibition of usury, which forbade Christians from making money out of money loans and credits with interest, started giving way to money lending, which required exact determination of the lending period dependent on the universal measurement of time. By the late 14th century, even time itself became viewed as a commodity that could be parcelled out and measured on an even scale. The invention of mechanical devices for time measurements – mechanical clocks enabled this organisation of daily life by the clock. In the Renaissance, the concept of time as a precious good became an everyday topic for intellectual elites like Michel de Montaigne or Giordano Bruno (Ashcroft 2018).

The rise of science in the Modern period, starting from the late 15th century, brought about changes in paradigms in many aspects of life, often breaking away from well-established traditions. The concept of time was not left unchanged either in this process. Examining the material or physical world led scientists like Galileo to state that an objective reality exists with its intrinsic properties, independent and distinct from the individual perceiving it (Galilei 2017). Galileo, one of the greatest minds of his period, considered time and motion to be two of these properties. However, another, perhaps the best-known scientist of the period, Isaac Newton, was credited with the introduction of absolute time alongside concepts like absolute space and absolute motion. In his Philosophiae Naturalis Principia Mathematica, Newton states: "Absolute, true, and mathematical time, of itself, and from its own nature, flows equably without relation to anything external, and by another name is called duration: relative, apparent, and common time, is some sensible and external (whether accurate or unequable) measure of duration by the means of motion, which is commonly used instead of true time; such as an hour, a day, a month, a year" (Newton 1687).

However, Newton's view of the time was not the only one in existence and was furthermore soundly opposed by another prominent intellectual figure of the period, Gottfried Leibniz, who considered that space and time are for him purely relative "an order of coexistence, as time is an order of successions. For space denotes, in terms of possibility, an order of things that exist at the same time, considered as existing together, without entering into their particular manners of existing" (Leibniz's third letter to Clarke – February 25, 1716).

These views on space and time gave birth to the absolute concept of time (Newton) and a relational one (Leibniz) based on different logical priorities of space and time concerning objects and material processes. The key question and difference lie in the dilemma of whether the existence of space and time allows the existence of objects or does the existence of objects creates space and time. Despite all advancement over the century, it is just these views that, to this day, govern, more or less, the Western concept of time, which also lies at the heart of the archaeological notion of time.

In its earliest periods, modern archaeology heavily relied on the concept of relative chronologies, particularly when dealing with recorded histories of human societies being studied. It is of no surprise because no way of establishing absolute age existed in that period. The interest in the ancient Middle East and Graeco-Roman periods heavily relied on epigraphic sources listing periods, rulers and important events. However, the oldest known archaeological chronology developed was the one of a Danish archaeologist C.J. Thomsen, curator of the National Museum of Denmark, who divided the prehistoric period into the Stone, Bronze, and Iron ages (the scheme was published in 1836 in his book Ledetraad til nordisk Oldkyndighed). By the end of the 19th century and the beginning of the 20th, relative chronologies were an everyday item in the archaeological kit (e.g., Petrie 1899; Reinecke 1899, 1902), helping establish the relative age of finds and sites throughout the world.

Relative chronology remained a principal archaeological tool for chronological placement of material cultures until the mid-20th century when Willard Libby proposed an innovative method applicable to organic materials which enabled absolute dating of finds based on the measure of decay of carbon-14, an unstable isotope of carbon. This method brought back the absolute time scale to archaeology in a revolutionary manner, making possible more precise historical and prehistoric chronologies across the periods. Libby, a professor of chemistry at the University of Chicago, realised that carbon-14, an isotope abundant in the atmosphere, is embedded into the organic living matter during its life cycle through respiration, food and liquid consumption and that its accumulation ceases with the death of the organic. He proposed that if one could establish the amount of carbon-14 in an object, one could estimate that object's age using the half-life of the unstable carbon-14 isotope, i.e., the rate of decay of the original isotope quantity to half of the starting value. For this method to work, Libby assumed that the concentration of carbon-14 has been constant for thousands of years and that the isotope moves readily through the atmosphere, biosphere, oceans and other bodies of water in a known process as the carbon cycle. The first factor was later proven to be generally true, but for the second, Libby had to calculate a ratio of carbon-14 atoms per every carbon atom on Earth, which appeared to be one carbon 14 atom per every 1012 carbon atoms. Following this, he calculated the mixing of carbons across different reservoirs resulting in a prediction of carbon-14 distribution across features of the carbon cycle. Further research by Libby and others established its half-life as 5,568 years (later revised to 5,730 ± 40 years), providing another essential factor in Libby's concept. In 1949 Libby and Arnold published their results (Libby and Arnold 1949), proving the success of the method and paving the way for its introduction into the world of archaeological chronologies.

Libby's discovery helped resolve multiple issues in the sphere of anthropology and archaeology, including the notion that civilisation originated in Europe and diffused outwards into the rest of the world. By dating man-made artefacts from Europe, the Americas, Asia, Africa and Oceania, archaeologists could establish that civilisations developed in multiple independent sites across the globe. Spending less time trying to determine artefact ages, archaeologists could now ask more searching questions about the evolution of human societies and behaviour in prehistory.

Radiocarbon dating in Southeast Europe made its maiden steps in the 1960s and continued in the early 1970s, with first data published from sites like Starčevo, Karanovo, Sesklo, Vinča and others (Kohl and Quitta 1966; Lawn 1973; Nandris 1968; Vogel and Waterbolk 1963) illustrating the importance of Southeast Europe as a prominent corridor for the introduction of the Neolithic way of life into Europe. Since then, the amount of radiocarbon measurements has increased immensely, creating new insight into the dynamics of the emergence and development of the Neolithization of Europe. Old schematics of parallel relative chronologies of material cultures in the region became infused with absolute dates from many sites in the region, creating a detailed narrative of events that would shape the identity of Europe's earliest farmers spanning over two thousand years.

To this great narrative of the Neolithic period and its chronology, we contribute and dedicate our volume in the hope that new generations of researchers will find it useful for research and the creation of new questions and topics that still exist out there and are waiting to be explored and placed in the ever-growing mosaic of knowledge that archaeologists build in an attempt to understand our past and origins better.

The Editors

References

Ashcroft, R. E. 2018. “Time in the Works of Michel de Montaigne (1533–1592) and Giordano Bruno (1548–1600)”. Unpublished PhD Thesis. University of Durham, Durham.

Augustine, S. 1992. “Confessiones”. Oxford: Oxford University Press.

Aveni, A. 1989. “Empires of Time: Calendars, Clocks, and Cultures”. New York: Basic Books.

Dunn, F. M. 1996. “Antiphon on Time (B9 D-K)”. The American Journal of Philology 117, 65–69.

Eliade, M. 1959. “The Sacred and the Profane: The Nature of Religion”. Orlando, London: Harvest Book Harcourt Inc.

Galilei, G. 2017. “Il Saggiatore”. CreateSpace Independent Publishing Platform.

Goldberg, S. A. 2000. “Accounts and Counts of Jewish Time”. Bulletin du Centre de recherche français à Jérusalem 7, 92–108.

Greengus, S. 1987. “The Akkadian Calendar at Sippar”. JAOS 107, 209–229.

Hoy, R. C. 1994. “Parmenides’ Complete Rejection of Time”. The Journal of Philosophy 91, 573–598.

Kohl, G. and H. Quitta. 1996. “Berlin Radiocarbon Measurements II”. Radiocarbon 8, 27–45.

Lawn, B. 1973. “University of Pennsylvania Radiocarbon Date XV”. Radiocarbon 15, 367–381.

Libby, W. F. and J. R. Arnold. 1949. “Age Determination by Radiocarbon Content: Checks with Samples of Known Age”. Science 110, 678–680.

Nandris, J. 1968. “Lepenski Vir”. Science Journal 1, 64–70.

Newton, I. 1687. “Philosophiae Naturalis Principia Mathematica”. London.

Petrie, W. M. F. 1899. “Sequences in prehistoric remains”. Journal of the Royal Anthropological Institute of Great Britain and Ireland 29, 295–301.

Plato. 2001. “Timaeus”. The Focus Philosophical Library edition. Newburyport: Focus Publishing.

Polcaro, V. F. 2013. “The concept of time, from Palaeolithic to Newtonian physics”. The European Physical Journal Conferences 58, 1–8.

Reinecke, P. 1902. “Zur Chronologie der 2. Halfte des Bronzealters in Sud- und Norddeutschland”. Korrespondenzblatt der deutschen Gesellschaft für Anthropologie, Ethnologie und Urgeschichte, 17–32.

Reinecke, P. 1899. “Studien zur Chronologie des Ungarlandischen Bronzealters. I. Teil. Prähistorisches aus Ungarn und den Nachbarländern. Budapest: Beiblatt der Ethnologischen Mitteilungen aus Ungarn 1.

Sinha C., Sinha, V. D. S., Zinken, J. and W. Sampaio. 2011. “When Time is not Space: Evidence from Amazonian language and culture”. Language and Cognition 3, 137–169.

Vogel, J. C. and H. T. Waterbolk. 1963. “Groningen radiocarbon dates IV”. Radiocarbon 5, 163–202.

1.

‘As if all Time were theirs’: reflections on the path towards precise narratives for the Neolithic and Copper Age of southeast Europe

Alasdair Whittle

In his 1928 poem, ‘Proud Songsters’, the English writer Thomas Hardy envisaged birds in spring singing ‘as if all Time were theirs’. We can hardly make the same claim in archaeology yet, but the attempt to control time and, in doing so, to construct as precise chronologies as possible for the Neolithic and Copper Age of southeast Europe – and, of course, elsewhere as well – is certainly underway, and the potential rewards are great. At stake is a robust, explicit and quantifiable basis for writing interpretive narratives of sequences of human action, with people centre-stage in detailed and diverse local, regional and wider histories. The current effort to interrogate the archaeological record for chronological order and wider meaning is not in itself new since previous versions go back, of course, at least a century (e.g. Childe 1929; cf. Lucas 2021); indeed, the most effective strategy at present is arguably one that combines existing and proven strengths in the knowledge of the material and understanding of the detail for local and regional sequences with the best available forms of modelling of radiocarbon results (Bánffy et al. 2018).

What follows in this brief paper, based on personal involvement in efforts to build chronological precision over the last twenty and more years, focuses particularly on the various dating programmes for southeast and central Europe within the project, *The Times of Their Lives* (ToTL), from 2012–17. I will also refer to other significant dating and modelling projects within the same sort of area, though without any attempt at comprehensive coverage or completeness, given the length of this paper. This is combined with critical reflection on the strengths and weaknesses of what ToTL managed to achieve, with reference to what I see as research priorities for the study of the Neolithic and Copper Age across this area. I hope that this can contribute to setting the agenda for ongoing and future research.

The modelling process

I am not a mathematician, a statistician or an archaeological scientist. It is others who have set out the robust basis for Bayesian chronological modelling (from a much longer list, Buck et al. 1996; Buck and Meson 2015; Bayliss and Bronk Ramsey 2004; Bayliss 2009; 2015; Bayliss et al. 2007; 2011; 2016; 2020; Bronk Ramsey 2009), which seems to me, as a non-specialist archaeologist interested in precise chronologies and the implications those hold for the kinds of narratives we can attempt, to be the currently best available and still improving method. Repeated simulations (e.g. Bayliss et al. 2007, Figures 4–8; 2011, Figures 2.6–2.12) convince me that the method works and that without formal modelling to counteract the statistical scatter of radiocarbon dates, informal date estimates will regularly perceive any given phenomenon as starting earlier, lasting longer and ending later than was the case in reality (Bayliss et al. 2007, 9).

Given that the method does work, we should set as ambitious agendas as possible and be engaged in building chronologies everywhere on a century-by-century basis, with further precision wherever possible down to the scales of generations and decades (Bayliss and Whittle 2019). The most recent authoritative synthesis of the Neolithic and Copper for southeast Europe (though excluding Greece), by John Chapman, notes a number of relevant Bayesian modelling projects (Chapman 2020, 20, and table 11.1) but mostly operates with a generalised phase scheme which lumps several centuries together (thus, Phase 2 from 6300–5300 cal BC, Phase 3 from 5300–47/4500 cal BC, and so on: Chapman 2020, 21, table 1.1). This is completely understandable on a pragmatic basis and given the scope of the very wide-ranging synthesis and its many sub-themes, but also frustrating in that it reduces the sense of the desirability and urgency of moving towards chronological precision and the rewards which that can bring.

In my experience, ranging from initial studies of selected long barrows in southern Britain (Bayliss and Whittle 2007) to the wider investigation of causewayed enclosures in southern Britain and Ireland together with the broader early Neolithic context (Whittle et al. 2011) and then to the range of enquiries generated by ToTL (Whittle 2018), it is the explicit repeatability of the modelling process (Bayliss et al. 2011, Figure 2.20; 2016, Figure 3) which has been of key importance. New information is regularly added, and assumptions change; more dates accumulate. All models should probably be regarded as provisional and open to further questioning. For long barrows, information is newly available from aDNA analysis of inter-generational relationships, which should serve as further, constraining priors in renewed modelling, for example of the chronology of the Hazleton long barrow in the Cotswolds of southern England (Meadows et al. 2007; Fowler et al. 2021; cf. Massy et al. 2022). We should look forward to that kind of analysis in southeast and central Europe mortuary contexts, when and if radiocarbon dating and modelling can be combined with aDNA investigations. For enclosures, a decade of the accumulation of further dates and the appearance of the latest calibration curve (Reimer et al. 2020) have already led to fresh modelling and significant new insights (Bayliss et al. 2020; Whittle et al. 2022) and broader update of *Gathering Time* for England and Wales is also underway. We should anticipate parallel upgrades and model improvements for southeast and central Europe as a whole, noting previous criticism of the simplicity and weakness of some early models (Bayliss 2015).

Though I repeat that the technicalities are best treated by the relevant expert modellers, three developments in particular in the modelling process have caught my non-specialist eye. The hierarchy of desirable samples has already been well set out (Bayliss et al. 2007; 2011; 2016), but in exploiting existing and new archives of datable material, we need to make the most of what is available. Therefore, charcoal outlier analysis (Dee and Bronk Ramsey 2014) seems a particularly welcome addition to the modelling arsenal. The ability to accurately date lipids in pottery (Casanova et al. 2020) must surely have revolutionary implications for contexts and sequences where otherwise desirable sample categories are absent, and the application of this to southeast and central Europe is eagerly to be anticipated. Thirdly, the ongoing and future refinement of single-year tree-ring calibration data (Reimer et al. 2020) promises to add significant further precision to date estimates at some point down the line. In these various ways, although only briefly sketched here, there can be every hope that modelling can be further refined as research progresses, as long as the discipline can maintain a conscious and collective drive for improvement. In that light, I find it curious to see 'looking for points of origin', 'identifying events' and 'focusing attention on actions' in a list of supposedly 'old style' archaeological stories (Lucas and Olivier 2022, 62, Table 3.2).

My own experience of dating and modelling projects has been a privileged one, with good funding and plentiful dates as a result, and an expert modeller as a colleague. That is not the case everywhere or for everyone, and it is obviously a challenging situation when only certain sites have been well dated, sitting in broader contexts that lack the same precision. It is also challenging when the quantity and quality of dates as a whole for a given phenomenon leave much to be desired. In our experience within ToTL, that applied especially to the corpus of dates available for the study of the spread of the LBK from the southern fringes of central Europe westwards (Jakucs et al. 2016), but those available for both the Vinča and the Lengyel cultures as a whole are also far from perfect (Whittle et al. 2016; Regenye et al. 2020). The response should not be, however, to despair; we need to take the long view. If enough sites come to be dated with suitable samples, even if small in quantity, the long-term result should be much-improved datasets. One encouraging example within our recent ToTL experience was how even a handful of dates for the Balaton-Lasinja context at Veszprém-Jutasi út in north-west Hungary could contribute significantly not just to the technicalities of Copper Age chronology but also to broader understanding of settlement and household changes at the end of the Neolithic and subsequently (Regenye et al. 2022).

As field projects continue, more opportunities will present themselves for obtaining more dates and selecting optimum samples. It is also important not to neglect the archives. Everything possible should be done to protect documentation and old records as well as finds, and they should be exploited to the full in the drive to increase the number of dates. Archives going back to the 1920s were crucial in our dating project on the early Neolithic enclosures of southern Britain (Whittle et al. 2011), and the even older archive for Vinča-Belo Brdo was a vital element in the multi-stranded approach to dating that key tell (Tasić et al. 2015; 2016a; 2016b). There are surely many more examples of usable archives across the settlement record of southeast Europe.

Finally, it has been my experience to have worked over the last twenty years and more in teams, which have combined varied strengths in modelling, on the one hand, and understanding of specific and wider archaeological contexts, on the other. In an era of increasing use of 'big data' and the temptation to use summing on the back of large, often uncritically gathered databases, this more focused and I would argue, more critical and robust approach offers the best way ahead, demanding though it is in terms of time and expertise.

Some key problems in the study of the Neolithic and Copper Age of southeast and central Europe

As I see things, the Bayesian chronological approach offers an interrogative approach; more precise date estimates gain significance in relation to a growing number of new research questions. In a short paper like this, I make no claim to be setting out a comprehensive list of key problems for the study of the Neolithic and Copper Age of southeast and central Europe, but I do want to use examples from ToTL and other dating projects to underscore what more precise chronologies can contribute to our understanding of three central themes: the spread of initial settlement, the development of settlements, and the nature of cultural behaviour. These case studies should also serve to highlight what could be done better in the future.

The spread [and close up] of initial Neolithic settlement

We are still far from a good understanding of the timing and tempo of the initial spread of the Neolithic in southeast and central Europe, even though its outlines are becoming clearer (for recent syntheses, see Shennan 2018; Chapman 2020). The need for a better grasp of the chronology becomes all the more pressing as the aDNA revolution continues to feed important new insights into colonisation and acculturation processes (Reich 2018, and references; Vander Linden and Silva 2021; Kristiansen 2022; Whittle et al. 2023). So far, dating coverage region by region has been patchy; some areas are better served than others, for example, Serbia and eastern Hungary (Whittle et al. 2002), while some regions, such as Macedonia and northern Greece (Naumov, this volume; Reingruber, this volume), are still in the process of accumulating sufficient datasets. Some individual sites have been well dated, and their results formally modelled, for example, Ecsegfalva 23 on the Great Hungarian Plain (Bronk Ramsey et al. 2007; see also, for other studies, Porčić et al. 2021; Borić 2016), but it is my impression that these are still relatively few and far between. Wider modelling has had a more mixed history. There have been some informal exercises, for example, for the northwards spread of the Körös culture on the Great Hungarian Plain (Domboróczki 2010, Figure 11), following on from earlier informal estimates for the spread of the Starčevo and Körös cultures (Whittle et al. 2002; Bronk Ramsey et al. 2007; cf. Oross and Siklósi 2012). There certainly have been other explicit models for estimating population expansion rates and numbers respectively, which use summed probability distributions (Silva and Vander Linden 2017; Vander Linden and Silva 2021; Porčić et al. 2020; 2021; Blagojević et al. 2021). One of these is based on a larger and wider database and seeks trends within clusters of dates (Silva and Vander Linden 2017; Vander Linden and Silva 2021), while the other is a more concentrated effort focused on the central Balkans (Porčić et al. 2020). Neither uses formally modelled date estimates in a Bayesian framework, and it is hard to see the detail with which radiocarbon results are treated within the respective databases. Nonetheless, both exercises produce interesting suggestions of pulses during the spread rather than a steady expansion rate. Therefore, we have come a long way from the very general, eyeballed 'wave of advance' model, based on very scanty numbers of dates, offered long ago (Ammerman and Cavalli-Sforza 1984). However, the standard weaknesses of the summing approach presumably also apply (e.g. Contreras and Meadows 2014; Crema 2022); it is admitted that summed probability distributions 'offer a unique, if blurry, window' (Vander Linden and Silva 2021, 8). It seems to me that the next desirable step would be the application of formal modelling in a Bayesian framework to wider processes of colonisation in southeast Europe, including Greece.

The ToTL project did not engage with these issues in southeast Europe. We did, however, have the opportunity to examine the spread of the earliest LBK from the southern fringes of central Europe westwards (Jakucs et al. 2016). Although this takes us into parts of Europe largely beyond the scope of this volume, I think this study has relevant implications. First, as already noted, despite a century or more of research on the LBK and some seven decades of radiocarbon dating, the quantity and quality of the available radiocarbon dataset for the earliest LBK leave much to be desired. Once again, individual sites stand out as well-lit beacons, such as Brunn in eastern Austria (Stadler and Kotova 2019), but are surrounded by others with far less detail and precision. There is no need to rehearse the detailed results of the formal modelling of what is available here, but two points can be made. Modelled results differed regarding timing and tempo from conventional expectations of the chronology of the LBK. After the initial Formative phase, probably in the 56th and 55th centuries cal BC, represented only by the sites of Pityerdomb and Brunn (Jakucs et al. 2016; see also Bánffy and Whittle 2022), the main phase of earliest LBK expansion probably only began in the 54th century cal BC, potentially spreading very rapidly (Jakucs et al. 2016). That has implications not only for the nature of subsequent LBK development since it compresses the sequence but also by comparison for the possibility of variations in the rates of spread in southeast Europe, hinted at already in the studies by Silva and Vander Linden (2017, Figure 2; cf. Vander Linden and Silva 2021) and by Porčić et al. (2020). Our LBK exercise was not, however, the last word, and we are now engaged in a renewed study of the spread of the earliest LBK, using more dates, IntCal20 and charcoal outlier analysis, as well as improved spatial nuance: another example of the opportunity to repeat and refine models.

Tells and flat settlements

In many ways, it can be argued that studies of the chronology of tells, particularly among the range of forms of settlement in the Neolithic and Copper Age of southeast Europe, are in a healthy state. A scatter of sites have been dated and modelled, including Polgár-Csőszhalom in Hungary (Raczky et al. 2015), Okolište in Bosnia (Hofmann 2013) and Pietrele in Romania (Reingruber 2015). ToTL was able to add detailed and comprehensive models for Vinča-Belo-Brdo, Serbia, and Uivar, Romania (Tasić et al. 2015; 2016a; 2016b; Draşovean et al. 2017; Bayliss et al. 2020). Those ToTL models now set out explicit, quantified and probabilistic estimates for the starts and endings of these two tells, for the rates of accumulation of deposits, and the duration of sequences of burnt and unburnt houses. Cumulatively, one could claim that these results begin to match the standards set by the modelling for Çatalhöyük in Turkey (Bayliss et al. 2014). The multi-stranded approach to dating the history of the Belo Brdo tell and the very closely recorded sequence at Uivar could be seen as the basis for particularly fruitful results, while the modelling at Csőszhalom managed to combine detailed investigation of both tell and accompanying flat settlement. From these exercises, we know far more than previously about the overall accumulation rates of tell deposits and the histories of houses within them.

It is also worth noting what could still be improved. Plenty of the samples used for Belo-Brdo, Uivar, Csőszhalom, Okolište and Pietrele were sub-optimal, often out of necessity and the lack of alternatives. Single-context recording was not consistently available, notably in the older excavations. Lipid dating of pottery could potentially play a key role in refining individual house histories by filling gaps in samples for dating the construction, use and decay or destruction of buildings. In some instances, the number of dates could be increased. Perhaps at both Csőszhalom and Okolište, for example, more samples could have been dated, at the former to cover every step of the tell deposits and at the latter with a bigger range of kinds of samples.

On a wider scale, what is needed now are many more comparable studies, which will obviously take time – and money. It is often the case in research that new projects tend to be physically distanced from comparable activity for the sake of novelty and distinctiveness. But what opportunities must there now be, in the long-term, to exploit neighbouring tells and flat settlements in many micro-regions across southeast Europe and including Greece to achieve detailed histories that embrace not just preeminent individual tells but whole communities across broader landscapes. Without that kind of wider perspective, ultimately, models for the initial appearance of tells, their relative successes in terms of duration and achieved height, and the circumstances in which they declined, will remain hopelessly generalised. At the moment, we appear to have a broad pattern in the northern part of the Balkans at least, of endings of tells and other settlements from *c*. 4700 cal BC to around and after *c*. 4500 cal BC (Tasić et al. 2016a; 2016b; Draşovean et al. 2017; cf. Link 2006; Borić 2015). The great tell at Vinča-Belo Brdo appears to be among the latest, if not the latest, to be abandoned within the orbit of the Vinča culture, the circumstances including repeated burnings (Tasić et al. 2015). The favourite hypothesis to explain the demise of tells has probably been the rise of the autonomous household, but this idea, attractive though it is in many ways, seems to float above the evidence and ignore any complexities to do with the interaction between households and neighbourhoods, communities and regions. What we will need will be detailed site histories unfolding at generational or, even better, decadal scales, covering not just individual places but whole regions. If this seems hopelessly ambitious and over-optimistic, think of the already numerous areas where numbers of sites, including tells, have been excavated, at least partially, and could begin to provide the material for a denser mesh of investigation.

The same challenge ultimately applies to the study of flat settlements. Given the lack of depth of deposits, it should be easier to investigate such sites in the first place, but the same token may restrict sample availability. The ToTL study of the development of the great settlement at Alsónyék-Bátaszék in southern Transdanubia, Hungary, provides a case in point (Bánffy et al. 2016; Oross et al. 2016a; 2016b; 2016c; Osztás et al. 2016). The successive Starčevo, LBK and Sopot occupations were dated using a pragmatic range of samples, but for the vast Lengyel occupation, it was graves which were targeted; relatively few samples were available from the features of excavated houses, and the study of accompanying pit complexes had not yet been completed (Osztás et al. 2016). It will be interesting to see in due course whether, following further post-excavation analyses, it will be possible to extend the dating of Alsónyék to these other contexts (which will be challenging, especially including the analysis of the typically large and intercutting pit complexes) and whether that will change the current picture of rapid growth and slow decline at Lengyel Alsónyék (Bánffy et al. 2016). In other cases within ToTL, it was possible to achieve good dating coverage and modelling of flat settlements, at Szederkény-Kukorica-dűlő and Versend-Gilencsa (Jakucs et al. 2016; 2018) and other successful exercises with flat settlements elsewhere, for example at Balatonszárszó-Kis-erdei-dűlő, western Hungary (Oross et al. 2020; Oross et al. this volume), and Vráble, Slovakia (Meadows et al. 2019; Furholt et al. 2020a; 2020b), should also be noted. The availability of suitable samples in good contexts is again a recurrent challenge, as at Versend (Jakucs et al. 2018). But it is through submitting enough samples and formally modelling the results, in combination with a good understanding of diagnostic associated material culture, that further insights can be obtained into key issues such as settlement and house duration, on the one hand, and cultural hybridity and diversity, on the other. If more sites can be dated and modelled in these ways, we have the opportunity to move from very general models of households to a sense of specific variation, individual contexts and local and regional histories.

For both tells and flat settlements, it is enhanced chronological precision which will enable fresh insights into specific situations and contexts. Short durations for early houses in tell sequences might suggest deliberate endings (principally by fire) to create places of renown (Tasić et al. 2016b, 30–2, Figures 16–17; Draşovean et al. 2017, 651). The apparent brevity of occupation at the flat site of Versend, by way of contrast, suggested the possibility of tension and conflict among the longhouses of the settlement (Jakucs et al. 2018), and something similar has been suggested for Vráble (Furholt et al. 2020a). It is worth thinking about the possible contrasts with the situation in many tells, where a different collective ethos could have prevailed, with individual houses and presumably households subsumed in wider neighbourhoods and communities, and perhaps with conflicts operating between rather than within sites. And greater chronological precision opened up the opportunity to attempt quantified population estimates for Lengyel Alsónyék (Osztás et al. 2016; Bánffy et al. 2016*)*. There are, of course, plenty of variables in such an exercise, but this effort seems to me to be much more focused and much more robust than the use of summed radiocarbon dates as population proxy.

Cultural worlds

The richness and diversity of the material culture of the Neolithic and Copper Age of southeast and central Europe have long been recognised (back to Childe 1929 and beyond); this encompasses but goes beyond pottery (Chapman 2020). Heroic efforts were made in earlier decades of research to sort the correct sequences. That having largely been achieved, have things tended to fossilise into rather static cultural blocks? More could surely still be done to refine pottery and other typologies, and more seriations would be welcome (Schier 1996; 2000; Diaconescu 2014; Diaconescu et al. 2020). So I would argue that although material culture may appear to be a familiar (some might say too familiar) element of traditional approaches, often within a rather unthinking culture-history model, it, in fact, presents the opportunity for dynamic new questions of agency and identity, at multiple scales: from the household to regional and even wider networks.

Within ToTL, we were able to take a first, closer look at cultural behaviour at two scales. On the one hand, we could offer spatially wide-ranging reviews of the chronological development of the Vinča and Transdanubian Lengyel cultures, respectively (Whittle et al. 2016; Regenye et al. 2020). These worked, it can be claimed, because it was possible to combine the modelling of associated radiocarbon dates with robustly established material culture studies based on typology and seriation. This was not bad, as a start, but more could be done. As ever, more dates on suitable samples from good contexts would give a more robust framework, and more sensitive and targeted typologies and seriations could presumably add considerable regional nuance, long argued for (for example, Chapman 1981; Schier 1995). There seems to me enormous scope still to extend such approaches, for example, to both earlier and later phases of the sequence, including to the Starčevo-Körös-Criş nexus of the later seventh into the earlier sixth millennia cal BC, and to post-Lengyel (Regenye et al. 2022) and post-Vinča (Borić 2015) horizons of the later fifth millennium cal BC and subsequently. There is presumably much scope too for similar detailed modelling of Tisza/Herpály development in eastern Hungary in the earlier part of the fifth millennium cal BC, moving out from the studies of individual sites such as Csőszhalom. Ultimately, there is also surely great scope for uniting Balkan and Greek sequences, which as a generalisation, have tended to operate as separate spheres (see Tsirtsoni, this volume, and references).

On the other hand, we modelled individual contexts in considerable detail, from the top of Vinča-Belo Brdo and through successive contexts at Uivar, to the flat settlements of Szederkény and Versend. The implications of the results for the tell situations will be enhanced when further studies are published of the associated household material inventories, while in contrast, the exercises at Szederkény and Versend showed impressive cultural diversity and hybridity, household by household and varying across parts of the settlements (Jakucs et al. 2016; 2018). Once again, perhaps we need to take the long view since it will take both time and money to build up detailed models for histories of neighbouring households, with equally detailed inventories of their material contents.

Ultimately, the challenge will be to combine these and other scales. For example, will we be able to look closely at individual contexts in the emergence and spread, say, of the first Vinča communities, or to document in detail the comparative character of individual households across the late period of Vinča decline in the 47th and 46th centuries cal BC? What was the detailed material response of individuals, households and neighbourhoods in the rapidly shifting circumstance of the rise and fall of Lengyel Alsónyék, as seen in mortuary and domestic practice? How did not just the forms of pottery but the colours, textures and other qualities of all forms of material culture (Chapman 2020, 57–63) serve to mediate social relations in difficult and changing times?

Answers to these and many other such difficult questions currently elude us, but perhaps we can claim that enough has been done by way of preliminary study to suggest how such challenges might be met in the future, if the discipline commits itself to a sustained and collective effort at building robust and precise chronologies. Could all time one day be ours?

Acknowledgements

I am grateful to all the many colleagues with whom we cooperated through the course of *The Times of Their Lives*. I am particularly indebted to Alex Bayliss for her construction of hundreds of models. ToTL was funded by an Advanced Investigator Grant (295412; 2012–17) from the European Research Council, co-led by myself and Alex Bayliss. Thanks are due to Eszter Bánffy, Bisserka Gaydarska and Krisztián Oross for critical reading of an earlier draft of this paper and to Miroslav Marić for his encouragement.

References

Ammerman, A. J. and Cavalli-Sforza, L.L. 1984. "*The Neolithic transition and the genetics of populations in Europe"*. Princeton: Princeton University Press.

Bánffy, E., A. Bayliss, A. Denaire, B. Gaydarska, D. Hofmann, P.D. Lefranc, J. Jakucs, M. Marić, K. Oross, N. Tasić and A. Whittle. 2018. "Seeking the Holy Grail: robust chronologies from archaeology and radiocarbon dating combined". *Documenta Praehistorica* 45, 120–36.

Bánffy, E., A. Osztás, K. Oross, I. Zalai-Gaál, T. Marton, É.Á. Nyerges, K. Köhler, A. Bayliss, D. Hamilton and A. Whittle 2016. "The Alsónyék story: towards the history of a persistent place". *Bericht der Römisch-Germanischen Kommission* 94, 283–318.

Banffy, E. and A. Whittle. 2022. "Szentgyörgyvölgy-Pityerdomb and the formative phase of the LBK revisited". In *Wissensschichten: Festschrift für Wolfram Schier zu seinem 65. Geburtstag*, eds. E. Kaiser, M. Meyer, S. Scharl und S. Suhrbier, 145–61. Rahden: Marie Leidorf.

Bayliss, A. 2009. "Rolling out revolution: using radiocarbon dating in archaeology". *Radiocarbon* 51, 123–47.

Bayliss, A. 2015. "Quality in Bayesian chronological models in archaeology". *World Archaeology* 47, 677–700.

Bayliss, A., N. Beavan, D. Hamilton, K. Köhler, É.Á. Nyerges, C. Bronk Ramsey, E. Dunbar, M. Fecher, T. Goslar, B. Kromer, P. Reimer, E. Bánffy, T. Marton, K. Oross, A. Osztás, I. Zalai-Gaál and A. Whittle. 2016. "Peopling the past: creating a site biography in the Hungarian Neolithic". *Bericht der Römisch-Germanischen Kommission* 94, 23–91.

Bayliss, A. and C. Bronk Ramsey. 2004. "Pragmatic Bayesians: a decade integrating radiocarbon dates into chronological models". In "*Tools for constructing chronologies: tools for crossing disciplinary boundaries",* eds. C.E. Buck and A.R. Millard, 25–41. London: Springer.

Bayliss, A., C. Bronk Ramsey, J. van der Plicht and A. Whittle. 2007. "Bradshaw and Bayes: towards a timetable for the Neolithic". *Cambridge Archaeological Journal* 17(1), supplement, 1–28.

Bayliss, A., S. Farid. And T. Higham. 2014. "Time will tell: practising Bayesian chronological modeling on the East Mound". In "*Çatalhöyük excavations: the 2000–2008 seasons"*, ed. I. Hodder, 53–90. Los Angeles: Cotsen Institute of Archaeology.

Bayliss, A., B. Gaydarska, A. Whittle, F. Draşovean and W. Schier. 2020. "Chapter 6. Scientific dating and chronological modelling". In "*Uivar "Gomila": a prehistoric tell settlement in the Romanian Banat. Vol. I: site, architecture, stratigraphy and dating"*, eds. F. Draşovean and W. Schier, 491–548. Rahden/Westf.: Verlag Marie Leidorf.

Bayliss, A., P. Marshall, M. W. Dee, M. Friedrich, T. J. Heaton and L. Wacker. 2020. "IntCal20 tree rings: an archaeological SWOT analysis". *Radiocarbon* 62, 1045–78.

Bayliss, A., J. van der Plicht, C. Bronk Ramsey, G. McCormac, F. Healy and A. Whittle. 2011. "Towards generational time-scales: the quantitative interpretation of archaeological chronologies". In *Gathering time: dating the early Neolithic enclosures of southern Britain and Ireland*, eds. A. Whittle, F. Healy and A. Bayliss, 17–59. Oxford: Oxbow Books.

Bayliss, A. and A. Whittle, eds. 2007. "*Histories of the dead: building chronologies for five southern British long barrows". Cambridge Archaeological Journal* 17.1, supplement.

Bayliss, A. and A. Whittle. 2015. "Uncertain on principle: combining lines of archaeological evidence to create chronologies". In *Material evidence: learning from archaeological practice*, eds. R. Chapman and A. Wylie, 213–42. Abingdon: Routledge.

Bayliss, A. and A. Whittle. 2019. "What kind of history in prehistory?" In *Time and history in prehistory*, eds. S. Souvatzi, A. Baysal and E.L. Baysal, 123–46. Abingdon: Routledge.

Blagojević, T., M. Porčić, J. Pendić and S. Stefanović. 2021. "The Neolithic Demographic Transition in the central Balkans: population dynamics reconstruction based on new radiocarbon evidence". *Philosophical Transactions of the Royal Society* B, doi.org/10.1098/rstb.2019.0712.

Borić, D. 2015. "The end of the Vinča world: modelling the Late Neolithic to Copper Age transition and the notion of archaeological culture". In *Neolithic and Copper Age between the Carpathians and the Aegean Sea: chronologies and technologies from the 6th to the 4th millennium BCE*, eds. S. Hansen, P. Raczky, A. Anders and A. Reingruber 157–217. Bonn: Habelt.

Borić, D. 2016. "*Deathways at Lepenski Vir: patterns in mortuary practice"*. Belgrade: Serbian Archaeological Society.

Bronk Ramsey, C. 2009. "Bayesian analysis of radiocarbon dates". *Radiocarbon* 51, 337–60.

Bronk Ramsey, C., T. Higham, A. Whittle and L. Bartosiewicz. 2007. "Radiocarbon chronology". In *The early Neolithic on the Great Hungarian Plain: investigations of the Körös culture site of Ecsegfalva 23, County Békés*, ed. A. Whittle, 173–88. Budapest: Institute of Archaeology, Hungarian Academy of Sciences.

Buck, C. E., W.G. Cavanagh and C. D. Litton. 1996. "*Bayesian approach to interpreting archaeological data"*. Chichester: Wiley.

Buck, C. E. and B. Meson. 2015. "On being a *good* Bayesian". *World Archaeology* 47, 567–84.

Casanova, E., T. D. J. Knowles, A. Bayliss, J. Dunne, M. Z. Barański, A. Denaire, P. Lefranc, S. di Lernia, M. Roffet-Salque, J. Smyth, A. Barclay, T. Gillard, E. Claßen, B. Coles, M. Ilett, C. Jeunesse, M. Krueger, A. Marciniak, S. Minnitt, R. Rotunno, P. van de Velde, I. van Wijk, J. Cotton, J., A. Daykin and R. P. Evershed. 2020. "Accurate compound-specific ^{14}C dating of archaeological pottery vessels". *Nature* doi.org/10.1038/s41586-020-2178-z.

Chapman, J. 1981. "*The Vinča culture of southeast Europe: studies in chronology, economy and society"*. Oxford: British Archaeological Reports.

Chapman, J. 2020. "*Forging identities in the prehistory of old Europe: dividuals, individuals and communities, 7000–3000 BC"*. Leiden: Sidestone Press.

Childe, V. G. 1929. "*The Danube in prehistory"*. Oxford: Clarendon Press.

Contreras, D. A. and J. Meadows. 2014. "Summed radiocarbon calibrations as a population proxy: a critical evaluation using a realistic simulation approach". *Journal of Archaeological Science* 52, 591–608.

Crema, E. R. 2022. "Statistical inference of prehistoric demography from frequency distributions of radiocarbon dates: a review and a guide for the perplexed". *Journal of Archaeological Method and Theory* (2022), doi: 10.1007/s10816-022-09559-5.

Dee, M. and C. Bronk Ramsey. 2014. "High-precision Bayesian modelling of samples susceptible to inbuilt age". *Radiocarbon* 56, 83–9.

Diaconescu, D. 2014. "Remarks on the chronology of the Lengyel culture in the western half of the Carpathian Basin based on the analysis of funerary assemblages". *Praehistorische Zeitschrift* 89, 12–39.

Diaconescu, D., F. M. Niţu and C. I. Suciu. 2020. "The early Vinča culture in Transylvania: considerations regarding its chronological position using correspondence analysis". *Quaternary Archaeology* 560–1, 65–77.

Domboróczki, L. 2010. "Report on the excavation at Tiszaszőlős-Domaháza-puszta and a new model for the spread of the Körös culture". In *Neolithisation of the Carpathian Basin: northernmost distribution of the Starčevo/Körös culture*, eds. J.K. Kozłowski and P. Raczky, 137–76. Kraków and Budapest: Polish Academy of Arts and Sciences, and Institute of Archaeological Sciences of the Eötvös Loránd University.

Draşovean, F., W. Schier, A. Bayliss, B. Gaydarska and A. Whittle. 2017. "The lives of houses: duration, context and history at Neolithic Uivar". *European Journal of Archaeology* 20, 636–62.

Fowler, C., I. Olalde, V. Cummings, I. Armit, L. Büster, S. Cuthbert, N. Rohland, O. Cheronet, R. Pinhasi and D. Reich. 2021. "A high-resolution picture of kinship practices in an early Neolithic tomb". *Nature*. https://doi.org/10.1038/s41586-021-04241-4.

Furholt, M., N. Müller-Scheeßel, M. Wunderlich, I. Cheben and J. Müller. 2020a. "Communality and discord in an early Neolithic settlement agglomeration: the LBK site of Vráble, southwest Slovakia". *Cambridge Archaeological Journal* 30, 469–89.

Furholt, M., I. Cheben, J. Müller, A. Bistákova, M. Wunderlich and N. Müller-Scheeßel. 2020b. "*Archaeology in the Žitava valley 1: the LBK and Želiezovce settlement of Vráble*". Leiden: Sidestone Press.

Hofmann, R. 2013. "*Okolište 2 — Spätneolithische Keramik und Siedlungsentwicklung in Zentralbosnien*". Bonn: Habelt.

Jakucs, J., E. Bánffy, K. Oross, V. Voicsek, C. Bronk Ramsey, E. Dunbar, B. Kromer, A. Bayliss, D. Hofmann, P. Marshall, P. and A. Whittle. 2016. "Between the Vinča and *Linearbandkeramik* worlds: the diversity of practices and identities in the 54th–53rd centuries cal BC in south-west Hungary and beyond". *Journal of World Prehistory* 29, 267–336.

Jakucs, J., K. Oross, E. Bánffy, V. Voicsek, E. Dunbar, P. Reimer, A. Bayliss, P. Marshall and A. Whittle. 2018. "Rows with the neighbours: the short lives of long houses at the Neolithic site of Versend-Gilencsa". *Antiquity* 92, 91–117.

Kristiansen, K. 2022. "*Archaeology and the genetic revolution in European prehistory"*. Cambridge: Cambridge University Press.

Link, T. 2006. "*Das Ende der neolithischen Tellsiedlungen. Ein kulturgeschichtliches Phänomen des 5. Jahrtausends v. Chr. im Karpatenbecken"*. Bonn: Habelt.

Lucas, G. 2021. "*Making time: the archaeology of time revisited"*. Abingdon: Routledge.

Lucas, G. and L. Olivier. 2022. "*Conversations about time"*. Abingdon: Routledge.

Massy, K., R. Friedrich, A. Mittnik and P. W. Stockhammer. 2022. "Pedigree-based Bayesian modelling of radiocarbon dates". *PLoS One*, doi.org/10.1371/journal.pone.0270374.

Meadows, J., A. Barclay and A. Bayliss. 2007. "A short passage of time: the dating of the Hazleton long cairn revisited". *Cambridge Archaeological Journal* 17.1, supplement, 45–64.

Meadows, J., N. Müller-Scheeßel, I. Cheben, H. Agerskov Rose and M. Furholt. 2019. "Temporal dynamics of *Linearbandkeramik* houses and settlements, and their implications for detecting the environmental impact of early farming". *The Holocene* 24(10), 1653–70.

Oross, K., E. Bánffy, A. Osztás, T. Marton, É. Á. Nyerges, K. Köhler, A. Szécsényi-Nagy, K. W. Alt, C. Bronk Ramsey, T. Goslar, K. Kromer and D. Hamilton. 2016a. "The early days of Neolithic Alsónyék: the Starčevo occupation". *Bericht der Römisch-Germanischen Kommission* 94, 93–121.

Oross, K., L. J. E. Cramp, G. Gortva, J. Jakucs, K. Lyublyanovics, T. Marton, G. Serlegi, B. Vágvölgyi and A. Whittle. 2020. "'It's still the same old story': the current southern Transdanubian approach to the Neolithisation process of central Europe". *Quaternary International* doi.org/10.1016/j.quaint.2020.05.049.

Oross, K., A. Osztás, T. Marton, É.Á. Nyerges, K. Köhler, Z. Gallina, K. Somogyi, E. Bánffy, C. Bronk Ramsey, T. Goslar and D. Hamilton. 2016b. "Longhouse times: dating the Alsónyék LBK settlement". *Bericht der Römisch-Germanischen Kommission* 94, 123–49.

Oross, K., A. Osztás, T. Marton, K. Köhler, J. G. Ódor, A. Szécsényi-Nagy, E. Bánffy, K. W. Alt, C. Bronk Ramsey, B. Kromer, A. Bayliss, D. Hamilton and A. Whittle. 2016c. "Midlife changes: the Sopot burial ground at Alsónyék". *Bericht der Römisch-Germanischen Kommission* 94, 151–78.

Oross, K. and Z. Siklósi. 2012. "Relative and absolute chronology of the Early Neolithic in the Great Hungarian Plain". In *The first Neolithic sites in central/southeast European transect. Volume III. The Körös culture in eastern Hungary*, eds. A. Anders and Z. Siklósi, 129–59. Oxford: British Archaeological Reports.

Osztás, A., I. Zalai-Gaál, E. Bánffy, T. Marton, É. Á. Nyerges, K. Köhler, K. Somogyi, Z. Gallina, C. Bronk Ramsey, E. Dunbar, B. Kromer, A. Bayliss, D. Hamilton, P. Marshall and A. Whittle. 2016. "Coalescent community at Alsónyék: the timings and duration of Lengyel burials and settlement". *Bericht der Römisch-Germanischen Kommission* 94, 179–282.

Porčić, M., T. Blagojević, J. Pendić and S. Stefanović. 2020. "The timing and tempo of the Neolithic expansion across the central Balkans in the light of the new radiocarbon evidence". *Journal of Archaeological Science: Reports* 33, doi.org/10.1016/j.jasrep.2020.102528.

Porčić, M., M. Nikolić, J. Pendić, K. Penezić and T. Blagojević. 2021. "Expansion of the Neolithic in southeastern Europe: wave of advance fuelled by high fertility and scalar stress". *Archaeological and Anthropological Sciences*, doi.org/10.1007/s12520-021-01324-1.

Raczky, P., A. Anders, K. Sebők, P. Csippán and Z. Tóth. 2015. "The times of Polgár-Csőszhalom: chronologies of human activities in a Late Neolithic settlement in northeastern Hungary". In *Neolithic and Copper Age between the Carpathians and the Aegean Sea: chronologies and technologies from the 6th to the 4th millennium BCE*, eds. S. Hansen, P. Raczky, A. Anders and A. Reingruber, 21–48. Bonn: Habelt.

Regenye, J., E. Bánffy, P. Demján, J. Ebert , A. Osztás, C. Bronk Ramsey, E. Dunbar, R. Friedrich, A. Bayliss, N. Beavan, B. Gaydarska and A. Whittle. 2020. "Narratives for Lengyel funerary practice". *Bericht der Römisch-Germanischen Kommission* 97, 5–80.

Regenye, J., E. Bánffy, K Oross, E. Dunbar, R. Friedrich, A. Bayliss, N. Beavan, B. Gaydarska and A. Whittle. 2022. "Some Balaton-Lasinja graves from Veszprém-Jutasi út and an outline chronology for the earlier Copper Age in western Hungary". *Documenta Praehistorica* 49, doi 10.4312/dp.49.4

Reich, D. 2018. "*Who we are and how we got here: ancient DNA and the new science of the human past"*. Oxford: Oxford University Press.

Reimer, P. J., W. E. N. Austin, E. Bard, A. Bayliss, P. Blackwell, C. Bronk Ramsey, M. Butzin, H. Cheng, R. L. Edwards, M. Friedrich, P. M. Grootes, T. P. Guilderson, I. Hajdas, T. J. Heaton, A. G. Hogg, K. A. Hughen, B. Kromer, S. W. Manning, R. Muscheler, J. G. Palmer, C. Pearson, J. van der Plicht, R. W. Reimer, D. A. Richards, E. M. Scott, J. R. Southon, C. S. M. Turney, L. Wacker, F. Adolphi, U. Büntgen, M. Capano, S. Fahrni, A. Fogtmann-Schultz, R. Friedrich, S. Kudsk, F. Miyake, J. Olsen, F. Reinig, M. Sakamoto, A. Sookdeo and S. Talamo. 2020. "The IntCal20 Northern Hemispheric radiocarbon calibration curve (0–55 kcal BP)". *Radiocarbon* 62(4) doi: 10.1017/RDC.2020.41.

Reingruber, A. 2015. "Absolute and relative chronologies in the Lower Danube area during the 5th millennium BC". In *Neolithic and Copper Age between the Carpathians and the Aegean Sea: chronologies and technologies from the 6th to the 4th millennium BCE*, eds. S. Hansen, P. Raczky, A. Anders and A. Reingruber, 301–24. Bonn: Habelt.

Schier, W. 1996. "The relative and absolute chronology of Vinča: new evidence from the type site". In *The Vinča culture, its role and connections*, ed. F. Draşovean, 141–62. Timişoara: The Museum of Banat.

Schier, W. 2000. "Measuring change: the Neolithic pottery sequence of Vinča-Belo Brdo". *Documenta Praehistorica* 27, 187–97.

Shennan, S. 2018. "*The first farmers of Europe: an evolutionary perspective"*. Cambridge: Cambridge University Press.

Silva, F. and M. Vander Linden. 2017. "Amplitude of travelling front as inferred from ^{14}C predicts levels of genetic admixture among European early farmers". *Scientific Reports* 7:11985, doi10.1038/s41598-017-12318.

Stadler, P. and N. Kotova. 2019. "*Early Neolithic settlement Brunn am Gebirge, Wolfholz, Site 2 in Lower Austria and the origin of the western Linear Pottery culture (LPC). Volume 1"*. Langenweissenbach and Wien: Beier and Beran.

Tasić, N., M. Marić, K. Penezić, D. Filipović, K. Borojević, D. Borić, P. Reimer, N. Russell, A. Bayliss, A. Barclay, B, Gaydarska and A. Whittle. 2015. "The end of the affair: formal chronological modelling for the top of the Neolithic tell of Vinča-Belo Brdo". *Antiquity* 89, 1064–82.

Tasić, N., M. Marić, C. Bronk Ramsey, B. Kromer, A. Barclay, A. Bayliss, N. Beavan, B. Gaydarska and A. Whittle. 2016a. "Vinča-Belo Brdo, Serbia: the times of a tell". *Germania* 93, 1–75.

Tasić, N., M. Marić, D. Filipović, K. Penezić, E. Dunbar, P. Reimer, A. Barclay, A. Bayliss, B. Gaydarska and A. Whittle. 2016b. "Interwoven strands for refining the chronology of the Neolithic tell of Vinča-Belo Brdo", Serbia. *Radiocarbon* 58, 795–831.

Vander Linden, M. and F. Silva. 2021. "Dispersals as demographic processes: testing and describing the spread of the Neolithic in the Balkans". *Philosophical Transactions of The Royal Society B* 376: 20200231, doi.org/10.1098/rstb.2020.0231.

Whittle, A. 2018. "*The times of their lives: hunting history in the archaeology of Neolithic Europe"*. Oxford: Oxbow Books.

Whittle, A., L. Bartosiewicz, D. Borić, D., P. Pettitt and M. Richards. 2002. "In the beginning: new radiocarbon dates for the Early Neolithic in northern Serbia and southeast Hungary". *Antaeus* 25, 63–117.

Whittle, A., A. Bayliss, A. Barclay, B. Gaydarska, E. Bánffy, D. Borić, F. Draşovean, J. Jakucs, M. Marić, D. Orton, N. Tasić, W. Schier and M. Vander Linden. 2016. "A Vinča potscape: formal chronological models for Neolithic cultural development in southeast Europe". *Documenta Praehistorica* 43, 1–60.

Whittle, A., A. Bayliss and F. Healy. 2022. "A decade on: revised timings for causewayed enclosures in southern Britain". In *Marking place: new perspectives on Early Neolithic enclosures*, ed. J. Last, 203–22. Oxford: Oxbow Books.

Whittle, A., F. Healy and A. Bayliss. 2011. "*Gathering time: dating the Early Neolithic enclosures of southern Britain and Ireland*". Oxford: Oxbow Books.

Whittle, A., J. Pollard and S. Greaney, eds. 2023. *Ancient DNA and the European Neolithic: relations and descent*. Oxford: Oxbow Books.

2.

The impressed pottery of the Aegean Neolithic

Agathe Reingruber, Lily Bonga, and Laurens Thissen

Abstract: This chapter presents data on impressed decorated vessels from the Neolithic of the circum-Aegean, focusing on the north-western Aegean, where they are most common. Included are mainly those sites that have been reliably radiocarbon dated, where the contexts of impressed sherds were well-documented and their frequency indicated. Our intention is to show where and when the highest concentrations of impressed sherds with the greatest variety of styles occurred. By revealing the origin of this specific category of finds, we conclude that the transfer of e.g., ceramic styles in the Aegean region was not uni- but multidirectional, which ultimately challenges the ex oriente lux model.

Keywords: Circum-Aegean Neolithic, Thessaly, Macedonia, Chronology, Pottery, Impressed decoration, Neolithic transfer

Introduction

The treatments and decorations of vessel surfaces have been, for decades, if not centuries, the only reliable method for relative chronological appraisals of pottery inventories of the layers and sites from which they derived. Morphological or technological features were regarded as secondary and not emphasised. Relying primarily on qualitative information, cross-regional comparisons resulted in broad chronological schemes. At first, the mere occurrence of a particular style, be it paint or decoration in the negative (e.g., impressions) or positive (e.g., knobs and bands), was taken as a conclusive hint for a certain chronological setting.

In Greece, with the publication by Chr. Tsountas in 1908, such styles were determined and sorted according to their putative appearance in layers of two main sites, Sesklo and Dimini, in the coastal area of Thessaly. Including also information from other sites in more northerly Thessaly, Tsountas differentiated between three main pottery categories with chronological components: A (earlier Neolithic), B (later Neolithic) and Γ/C (Chalcolithic/Bronze Age). By adding a number and – if necessary – additionally a small letter, a system was created that has been in use for almost a century. Category A (covering in today's terminology the Early <u>and</u> Middle Neolithic) is represented by three subcategories: A1 monochrome and undecorated, A2 impressed and incised, and A3 painted pottery. Although the A2-pottery had been prominently discussed and presented in photos by Tsountas (1908: 168, Plates 13–14), the exact provenance of these sherds (apart from some general remarks related to the sites of Argissa and Mesiani Magoula) cannot be traced back. No distinction was made between the great variety of impressed decoration, be it with a finger or a single-pointed or multi-pointed instrument, and no emphasis was placed on their combination with red and/or white paint.

Little attention was given to such sherds also by A. J. B Wace and M. S. Thompson 1912; although they adapted the Tsountas system and considerably enlarged the painted variants by adding more categories (A4–A6), they comprised A2 as both impressed and incised decorations and did not define the impressed pottery as a style of its own. Yet, they asserted that A2-pottery occurs merely in Northern Thessaly (1912: 14).

D. Theocharis also did not make a clear distinction between the decorative styles in the negative. Only a short mention was made related to the 'impressed/incised' decoration (Theocharis 1973: 308, endnote 37), which occurred together with early painted decoration in a second stage of the Early Neolithic (EN), after the monochrome horizon, according to his observations.

In 1971, J. Milojčić-v. Zumbusch published the pottery from Otzaki Magoula, excavated under the direction of her husband, V. Milojčić. She supported and advanced his views on the appearance of decorative styles and worked herself with the materials pre-sorted and recorded statistically by team members. F. Schachermeyr, K. Grundmann, and H. Hauptmann were in different seasons in charge of the first documentation of pottery inventories, creating lists with sherds counted according to varieties.

Therefore, even if rudimentary, Milojčić-von Zumbusch was able to present some quantifications related to the frequency of decorated specimens among the undecorated bulk of sherds. Also, most of the decorated sherds were discussed according to their contexts. The previously observed pottery variants were then connected to (for that time) well-observed stratigraphies.

Building upon the results from Sesklo, Otzaki, Argissa and other sites, a sequence of surface treatments and decorations was set up. According to Theocharis and Milojčić, the oldest pottery was not decorated but monochrome (A1). Whether such a purely monochromatic phase existed cannot be confirmed, but doubts about its Thessalian-wide occurrence must be acknowledged. In the subsequent stage (the EN II), red paint on buff came into common use (A3). The impressed decorations (A2) appeared either simultaneously with the painted style in the EN II (acc. to Theocharis) or only in a later stage, the EN III (acc. to Milojčić). Additionally, it was observed that the decorations in the positive (knobs, pellets, stripes) and negative (impressions, incisions) were sometimes combined with red and/or white paint. All these styles continued to be in use also during the Middle Neolithic (MN), which made a precise chronological assertion of especially surface materials problematic.

Differences in the interpretations of Milojčić and Theocharis may have to do with the fact that their observations were founded on sites some 50 km apart; Theocharis at first based his descriptions on sites in the south of Thessaly, near the coast (Sesklo) and the hills (Achilleion) with little impressed pottery. Later on, he was surprised by the abundance of impressed pottery at the northerly site of Nessonis II (Theocharis 1962: 81 and Plate X). Milojčić, on the other hand, explored sites near the Pinios river (Argissa, Otzaki) with a high number of impressed decorated sherds. At these two sites, such sherds occurred only after paint was already in use and not together with it. Consequently, in northern Thessaly, impressed decoration served to create a separate phase, the EN III (Milojčić-von Zumbusch 1971: 147–48). As it later turned out, impressed decoration played only a minor role in the coastal area and southern Thessaly, and there the later EN was seen as a continuum (EN II–III) and was not split into separate phases. Therefore, in Eastern Thessaly, a regionalisation of styles must be considered. This is the case also with Western Thessaly, where impressions were abundant and appeared together with painted decoration.

The topic of this contribution will be how the different impressed styles, initially characterised for Thessalian sites, can be compared with impressed styles from the circum-Aegean region.

Aims and methods

In our study, we included sites where both the frequency of impressed decoration was mentioned in well-documented contexts, and ^{14}C data were obtained from these contexts. Our intention is to show where and when the highest concentrations of impressed sherds with the greatest varieties of styles occurred.

Although impressed decorated sherds have been used in a qualitative rather than quantitative approach as markers for population movements in coastal areas of the Mediterranean (e.g., Çilingiroğlu 2016; Zilhão 2001), impressed vessels hardly occur at Mediterranean coastal sites of southern Anatolia and are absent from the southern Aegean (the Peloponnese and the island of Crete). This kind of decoration is rare at the Eastern Aegean coastal sites, like painted decoration. We, therefore, emphasise the independence of this type of decoration from the Near East and Anatolia and bring a completely different region into focus: Macedonia.

A word on terminology: misunderstandings deriving from the history of research

Milojčić and Milojčić-von Zumbusch were the first to describe the impressed variants of decorated sherds in detail. They saw the Aegean, and Thessaly along with it, as a link between the East and the West but were not able to identify the source of the impressed pottery styles. A rather vague northern or eastern influence seemed possible to them but not connected to immigration (Milojčić-von Zumbusch 1971: 150). A different conjecture was expressed in 1976 by Milojčić's congenial 'sparring partner,' F. Schachermeyr: either impressed decoration was owed to the 'intrusion of foreign elements from the neighbouring northwest' or immigrants from Syria brought it into the Adriatic region, and from there it spread towards the Balkans and into continental Greece (Schachermeyr 1976: 46). J. Müller showed that this second possibility could not be verified as the pottery products differ strongly between Syria and the Adriatic region. He also argued against using the Adriatic terminology for Aegean decorative styles (Müller 1994: 220, 267–68). Milojčić had, namely, 'borrowed' the terminology used in the Western Mediterranean and spoke of *Cardial* and *Impresso* decoration. In contrast to the Western Mediterranean, the Aegean decoration was never executed with the serrated edge of a *Cardium edule* shell but with different kinds of tools. Milojčić-von Zumbusch herself was aware of this misconception and suggested the terms 'Rädchenverzierung' (cog wheel ornament) or 'Kammzier' (comb ornament: Milojčić-von Zumbusch 1971: 78) alternatively. Since the term '*Rädchenverzierung*' is used for Roman *terra sigilata* and, moreover, the principle of rotation had very probably not yet been implemented in the Neolithic toolkit, we will speak here of comb-impressions. Furthermore, the term *Impresso* points to a strong relation between the Aegean and the Adriatic region that is neither evident in the specificity of the ceramic assemblage (e.g., morphology, paste, decoration) nor exemplified with other artefact types. Notably, in the Western Mediterranean, apart from Apulia, painted decoration is missing. Given these differences, we prefer to use terms like fingernail and tool impressions instead of *Impresso*.

Another necessary terminological clarification is related to barbotine decoration (see also Bonga 2019: 160–161). The term barbotine is used for decoration with clay added intentionally on the surface of the dried pot and then treated with a tool or fingers to produce an organised appearance (e.g., in the Körös culture of Hungary). This kind of decoration has not been confirmed for the Neolithic pottery of the Aegean. Therefore, even if clay has been pushed aside with a tool or a nail when decorating the still-soft body, resulting in an uneven surface, the decoration is still that of the impressed kind (confusingly called fingernail-barbotine by Milojčić-von Zumbusch 1971: 146).

In addition to the decoration itself, the designations used for the pottery cultures producing such decorations also vary. Sites with impressed decoration were first discovered in Thessaly and only later on in Western and Central-West Macedonia. Milojčić dated the oldest examples of impressed sherds in the Aegean to the EN III phase, named Presesklo (*Vorsesklo*) and '*ältere Magulitzakultur*' by Milojčić-von Zumbusch (1971: 146). This name was lent from the eponymous site of Magoulitsa in Western Thessaly (Milojčić-von Zumbusch 1971: 148; Papadopoulou 1958: 39–49) with an 'older Magoulitsa phase' characterised by 'fingernail-barbotine' and a younger phase with '*cardium* decoration' (Milojčić-von Zumbusch 1971: 146, Taf. XX,1–9 and Taf. XXV.9–12).

A close examination of this material in June 1999 in Volos showed that the material did not contain specifically impressed sherds, but many Red-on-white painted and scraped examples, clearly datable to the MN. In conclusion, it was formulated that it is rather overstated to create a culture based on a few selected sherds extracted from the bulk of the materials (Reingruber 2008: 305), especially because the impressed decoration cannot be narrowed down exclusively to the final phase of the EN and the few decades around 6000 cal BC as it also appears in the MN. The absolute dates from Otzaki and Achilleion confirm this. Impressed decoration may indeed have occurred already in the EN II ('Protosesklo', after 6300 cal BC – see below) and definitely was in use until the end of the MN (up to 5600 cal BC). A too strict understanding of this style has led to some confusion – for example, a very strict interpretation of the radiocarbon dates from Nea Nikomedeia (Reingruber 2008: 394–95) and also a temporal limitation of impressed sherds from surface materials into a single phase: that of the EN III (Gallis 1992).

The evidence from Eastern Thessaly in the NW Aegean

As we do not dispose of enough information regarding decorated pottery from closed or ongoing projects in the Western Thessalian sites of Ag. Anna Tirnavou, Prodromos I–III, Theopetra or Sykeon (Chourmouziades 1971; Krahtopoulou et al. 2020; Kyparissi-Apostolika 2000; Chatziangelakis and Vouzaxakis 2022), we will focus instead on Eastern Thessaly (Figure 1).

Figure 1. *Map of the Aegean with a selection of Neolithic sites mentioned in the text*

Otzaki Magoula

Although excavated 60 years ago, the stratigraphic situation in Otzaki reveals better than any other site the first appearance of impressed decoration on pottery and demonstrates its longevity. The first documented sherds of this kind appeared in the 'Transitional layer' and are thus missing from the very beginning of the site's existence (in the 'Deep layer' of the EN II). Once there, they continued to be produced in the following layers in Area III (Table 1) and found throughout all the layers in Area II (of the MN), their quantity increasing over time (Reingruber 2008: Tab. 4.8). Their first appearance in the 'Transitional layer' with only three examples should not be over-emphasised, although this information may gain some more weight when adding the observation from the site of Nessonis I, where Theocharis documented two sherds with fingernail impressions in a level of the EN II (Theocharis 1962: 77, Figure 3). But within the 'Middle layer' in Otzaki (of the so-called '*ältere Magulitzakultur*'), this type of decoration is firmly used in pottery production (Figure 2.14–19). And it thrived in the 'Upper layer' (of the '*jüngere Magulitzakultur*'), Milojčić-von Zumbusch (1971: 147) describing the transition as fluent (Figure 2.7–13).

This 'Upper layer' was originally attributed to the EN III, but the re-evaluation of the stratigraphy and the radiocarbon dates (with results between 6000–5800 cal BC) showed that it is of early MN date and, therefore, coeval with the lowest levels in Area II (Reingruber 2008: 275). This means that the first impressed decorated vessels were indeed produced in Otzaki before 6000 cal BC (in the 'Middle layer' of the EN III at the latest) and that this style was adapted and transformed also in other northern Thessalian sites before and after 6000 cal BC (Reingruber et al. 2017: 34–53). What was previously called 'Presesklo' or 'Vorsesklo' (Milojčić-von Zumbusch 1971: 75), therefore, straddles the smooth EN–MN transition (Reingruber et al. 2017: 42).

Layers in Area III (bottom-up) (trench with EN deposits)	Levels	Sherds with impressed decoration (n)	% from layer	% from total
'Upper Layer' ('*Obere Schicht*')	3c–2	114 (out of 2395)	4.76	1.28
'Middle layer' ('*Mittlere Schicht*')	7b–4	25 (out of 1710)	1.46	0.28
'Transitional layer' ('*Übergangsschicht*')	9a–7c	3 (out of 2564)	0.12	0.03
'Deep Layer' ('*Tiefe Schicht*')	10e–9b+house AB17 and pit B18–19	0 (out of 2213)	0	0
TOTAL		***142 (out of 8882)***		***1.6***

Table 1. *Frequency of impressed decoration from Otzaki, Area III (after Milojčić-von Zumbusch 1971, Vol. I: 79–80 and Vol. II: Beilage 1; counted are the impressed categories VIIIa–VIIIe)*

Impressions on sherds of the 'Transitional' and 'Middle layer' in Otzaki are executed with fingernails or single-ended blunt and broad tools or are finger-pinched. They appear on mostly thick-walled, uncoated surfaces and from all that is known, this kind of decoration covered the whole surface of the vessel, leaving rim and base zones undecorated (Figure 2.14–15 – similar to an example from the Theopetra cave: Kyparissi-Apostolika 2000: Figure 14.12,1–4 and Figure 14.19,1–3).

Decorations made with a comb-like instrument are more abundant in the 'Upper layer' in Area III and the lowest levels 16 to 14 of Area II (Milojčić-von Zumbusch 1971: Taf. P; Mottier 1981: Typentafel D; compare Figure 2.5–9). Area II, directly north of Area III, contains MN deposits exclusively. In this period (the early MN), according to Mottier (1981: 26), the fingernail ornamentation disappears, and also the instrumental ornamentation recedes.

The pottery from Area II was not presented on a statistical basis. However, from the typological tables (Mottier 1981: Typentafel D), we can surmise that instead of complete coverage of the vessel surface with unsorted impressions, well-organised single rows of horizontal impressions made with a multi-toothed comb or a single-ended sharp instrument prevail. According to a rather general remark given in Milojčić-von Zumbusch 1971: 150 in the lowest levels (16 and 15), sherds with simple tool decorations were outnumbered by those with comb decoration (75 against 180). From levels 14–10, comb-decorations prevailed with a total of 130 sherds. They do not cover the whole vessel but are arranged in parallel horizontal rows accentuating only parts of it; the fields in between, or even the impressions themselves, can be painted in red colour (Figure 2.1–2; also compare Gallis 1992: 43, Figure 4 with a complete example from Sarandaporo). More often than not, they appear on deep but rather narrow open shapes standing on a low vertical ring base or a concave bottom (Figure 2.6,9; also compare Figure 3.6). In the upper levels of Area II, with levels 13–2, impressed designs are not only coated or combined with red paint but white paint is also added, like in the complete example from Soufli Magoula (Theocharis 1962: 77, Figure 3): This fusion of the two decorative styles (impressed decoration with the Red-on-white painted style) occurred on open bowls with straight walls and either flat or concave bottoms in Area II in Otzaki in an advanced stage of the MN, probably only after 5800 cal BC (Mottier 1981: Typentafel D, Nos. 4, 5, 9 and Nos. 22, 23, 26, 30). That impressed decoration appeared on exclusively domestic vessel shapes was already observed by Milojčić-von Zumbusch (1971: 148).

Argissa Magoula

In Argissa, a total of 6524 sherds were recorded during two excavation seasons, 1956/58 (Reingruber 2008: 159). With 154 sherds (2.4% of the total), the impressed decorations outnumber 107 painted ones (Reingruber 2008: 199, 209). Thirty-three sherds are decorated with impressions by a comb-like instrument; on 17, red paint or a red slip was added next to or above the impressions. Yet, due to the many pits and ditches cutting through the EN and MN levels, only 19 sherds were attributed to safe contexts in levels 24 and 23; further six sherds were observed in square C12, levels 27–25 (of the EN II), in the direct proximity of a pit and may be contaminations (catalogue in Reingruber 2008: 686–702). Unlike the case in Otzaki, no clear chronological distinction can therefore be made between finger-, tool- and comb-impressions, but, like in Otzaki, the combination of impressions with paint is younger (only met in level 23 of the MN: Reingruber 2008: 211, Taf. 26, 29). Impressed surfaces are usually of a darker hue and less burnished;

shapes cannot be firmly reconstructed, but beaded rims and slightly elongated lips fit into the general repertoire (Reingruber 2008: Taf. 26.15 and Taf. XXIX.12,14,28 Compare also Otzaki, Area III, 'Upper layer': Milojčić-von Zumbusch 1971: Taf. XX.4–7,11). Outstanding yet is a concave base of the early MN comparable to Figure 2.9 (Reingruber 2008: Taf. 29.26) – it often recurs in the material from Elateia 1 where it appears exclusively with comb-impressed ornaments (Figure 3.6). In Argissa, the ornaments in the negative also confirm the continuity from EN to MN.

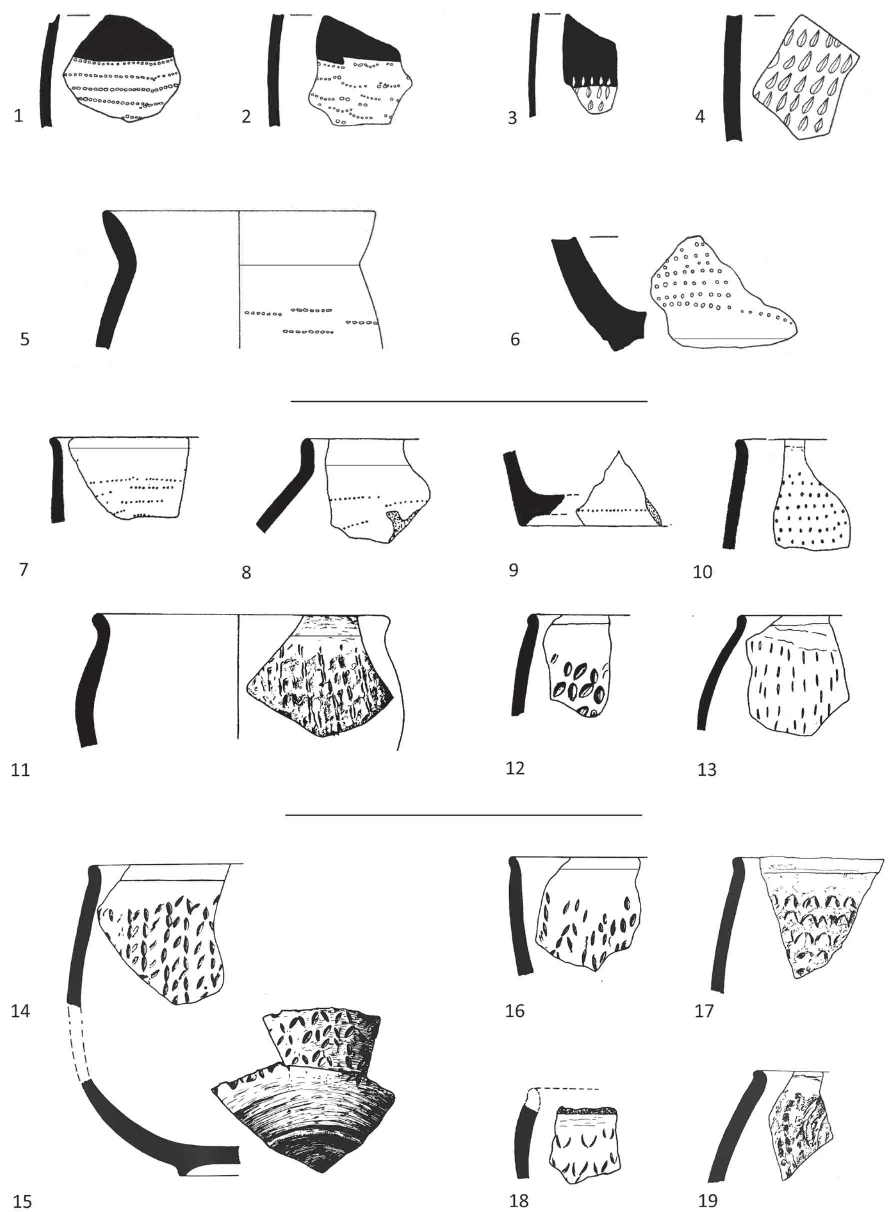

Figure 2. *Impressed sherds from Otzaki Magoula. 1–6: Area II, level 16a (after Mottier 1981: Taf. 5); 7–13: Area III, 'Upper layer'; 14–19: Area III, 'Middle layer' (after Milojčić-v. Zumbusch 1971: Taf. XXV, XXIV and XX; scale 1:3)..*

Elateia 1

New evidence from Thessaly derives from the basins of Sykourio and Elateia. Flat sites of the EN–MN were recently discovered and intensively surveyed there. One of these sites, Elateia 1, is radiocarbon dated to 6000–5800 cal BC (Reingruber et al. 2021: 184–201). 635 decorated sherds represent 5.6% of the total sherd bulk, with 11,337 pieces. There is an apparent preference for impressed decoration in 442 examples, over just 95 painted sherds. On four fragments, both styles are combined, resulting in the 'fusion style' of impressed with painted decoration (Figure 3.2). This small number confirms that Elateia 1 was abandoned before this style unfolded itself at a later stage of the MN, after 5800 cal BC. Also, the combination of the impressed styles at play favours a relative chronological position at the beginning of the MN and not earlier or later since only a few impressions were executed with the fingernail (26 examples, most probably the thumb, and in 25 other cases rather a broad implement may have been used: Figure 3.1). The majority has been ornamented with the help of a tool – in this case, we can differentiate between single-ended (252 pieces) or multi-toothed, comb-like tools (139 cases). In Elateia 1, comb-like instruments can have up to nine teeth. On some sherds, rows of dots were imitated with a single-ended, pointed instrument (similar to Figure 2.10).

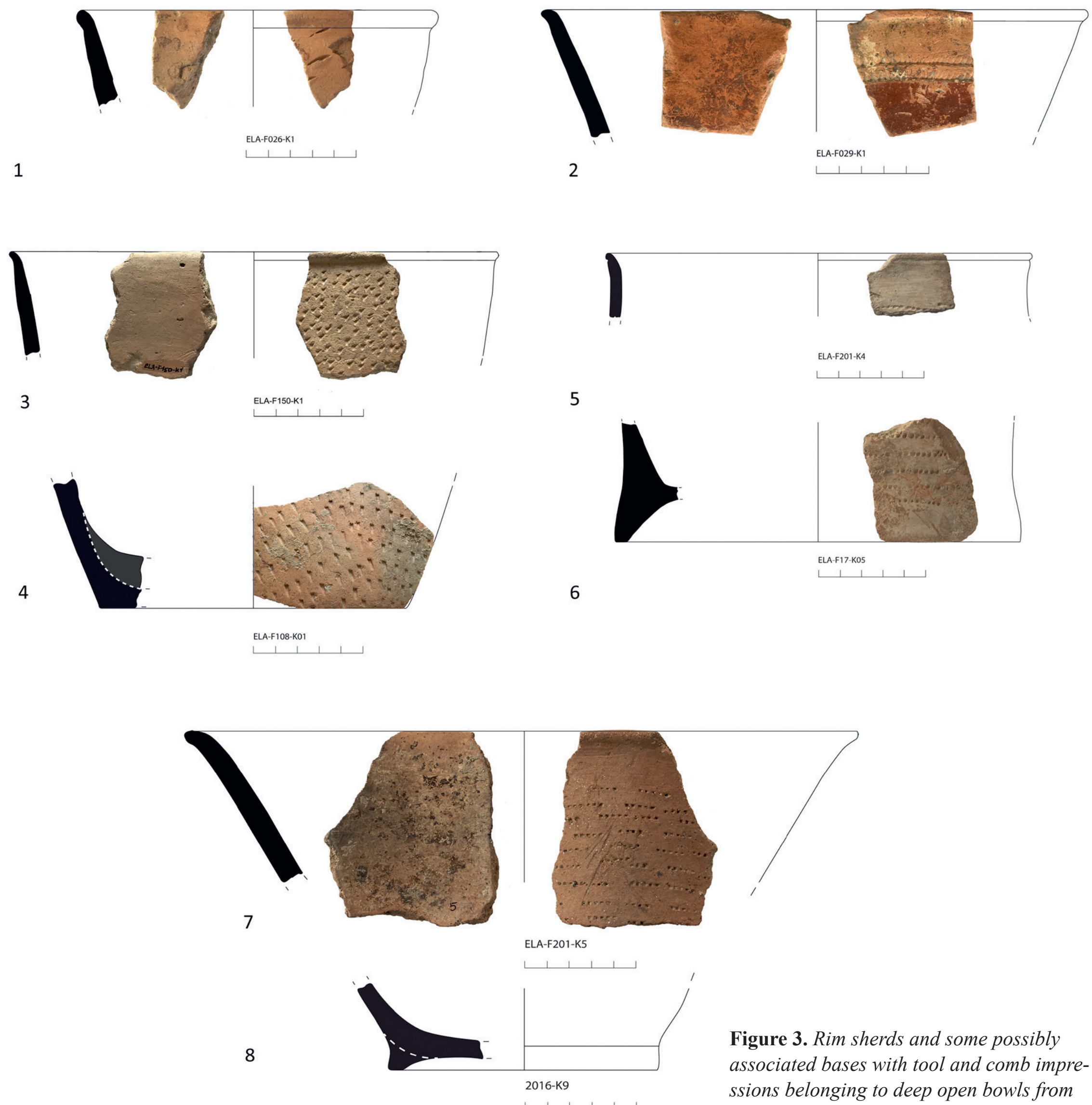

Figure 3. *Rim sherds and some possibly associated bases with tool and comb impressions belonging to deep open bowls from Elateia 1 (6000–5800 cal BC)*

In 48 cases, the vessel shape is known: impressed decorations were applied on mostly open, straight-walled or slightly concave shapes with a flat or raised base (Figure 3). A very specific kind of base that occurred with only single pieces in the materials of Otzaki and Argissa, but with 25 examples at Elateia 1, is almost exclusively related to impressions with a comb (Figure 3.6). It is chronologically very sensitive, occurring in the late EN/early MN (Milojčić-v. Zumbusch 1971: 53, Taf. 15.24–25, Taf. XXV.12; Mottier 1981. Typentafel D.4,22). Yet the other base, the flat variant, to which a straight body and a slightly concave rim belong (Figure 3.3–3.4), continued into the later MN together with the fused impressed-painted decoration. Combining a specific decoration with a certain shape is, therefore, not random but repetitive and results in standard vessels.

Achilleion

At Achilleion, only 62 out of *c.* 115,000 sherds have an 'unpainted decoration' with which a decoration in the negative is meant: incised, slashed, impressed or excised (Winn and Shimabuku 1989: 75 and 92, Tab. 5.5). Only 29 of these are of the impressed style: 15 have fingernail impressions, eight are punctuated/stabbed, and six are pinched. Being so few, they were considered to be imported. With only 18 pieces deriving from a secure context (Winn and Shimabuku 1989: 162 Tab. B.15), a conclusive chronological sorting is rather daring. According to Table B15 and the plates (Winn and Shimabuku 1989: 162 and Figure 5.67–69), only one example of a pinched impression occurred in Phase IIb. All other sherds with finger pinches and nail impressions were found in the ditch of Phase IVa-late/IVb and were only tentatively dated to phases IIb/IIIa. Impressions with a comb and by fingernail prevail in IIIb and IVa. Judging by this scant evidence, also in Achilleion, impressions made by tool or fingernail occur before dots in horizontal lines. Additionally, the general assignment to Achilleion phases IIb–IVa would confirm that at this site also, the impressed decoration a) does not belong to the basal occupation and b) straddles the EN–MN transition to continue deep into the MN.

According to ^{14}C dates, Phase IIb (with finger impressions) can be dated to 6210–6070, whereas Phases IIIb and IVa (with comb-impressions) to 6070–5800 cal BC (Reingruber and Thissen 2017: http://www.14sea.org/3_IIc.html#site3).

Sesklo A

The farther south we move in Thessaly, the less impressed sherds occur; this observation is true not only for Achilleion but also for Sesklo. Impressed sherds are absent from area Sesklo C of the EN I–II (Wijnen 1981: 37): either for chronological reasons (Sesklo C was used for different purposes than Sesklo A, not as living but as a working area), for technical reasons (trenches were too small, sherds were too few), or for chronological reasons (impressed pottery appeared indeed only after the EN II stage). The pottery from the main site, Sesklo A, is still unpublished, but from personal expertise, carried out in the summer of 2000 in the storehouse of the site, we can confirm that impressed decoration was rare (Reingruber 2008: 249–50). One sherd shows comb-impressions in parallel horizontal lines, and two others of this kind are additionally combined with paint. Thus, they are of an MN appearance. Additionally, in the Neolithic exhibition of the Athanasakio Archaeological Museum of Volos, a copy of the *c.* 4m-high profile from Sesklo A, the magoula, is on display. On its side are arranged representative sherds: next to the EN II level are two thick-walled sherds with impressions of fingernails or fingertips. Even if they may not have appeared in the same context with blacktopped and early painted sherds, this early kind of impressed decoration was also identified in Sesklo.

Eastern Thessaly in the context of Central and Southern Greece

We can conclude that in Thessaly, other than often corroborated, impressed decoration is not confined to the final stage of the EN but straddles the EN–MN transition and continues well into the MN, as confirmed by Otzaki, Achilleion and Elateia 1. In the beginning, nail impressions and pinches appeared on characteristic incurving deep bowls with bead rims and low ring bases, known since EN I (Figure 2.14–15). But after c. 6000 BC, the overwhelming majority of the impressions were done with an instrument on mostly open, slightly concave shapes with very distinctive bases that form a continuous, flat surface with the body of the vessel (Figure 3.6). Rim diameters at Otzaki vary between 18–24cm, and base diameters from 8–10cm. In Elateia 1, 11 rims measured 6–24cm, and 14 bases measured 10–20cm. These bowls had no handles.

The importance of the Thessalian impressed pottery is reflected by its longevity. It is a dynamic ornament, subject to transformations both regarding the ornaments and the shapes on which it appeared. It is adjusted to changes over the centuries, occurring first in unorganised impressions on plain convex vessels or horizontal rows and later mainly in rows, sometimes together with a red slip or accompanied by red-coloured broad bands. In the later MN, it is fused with the Red-on-white painted style, applied on open shapes with flat, concave bases (Reingruber 2008: Fototafel 4/3; Reingruber et al. 2021: Figure 8.11). Impressed decoration in Thessaly is not a short episode or a mere trend but part of the standard and, as such, more than fashion.

Farther south of Sesklo, no impressed sherds were found in Tsangli, Pyrassos and Tsani (Milojčić-von Zumbusch 1971: 147–48). The exceptional occurrence of impressed sherds in the Phthiotis completes this picture. In the area around Domokos (Dimaki 1994: 91–102), at the magoules of Spathakia, Vardhali and Koutroulou, impressed decoration still occurs in small numbers, but south of the Spercheios valley, e.g., in Elateia-Drachmani (French 1972: 4; Reingruber 2008: 325), it is only sporadic. Farther south, in the Argolid and Crete, there is no impressed decoration at all.

Western Central Macedonia

Nea Nikomedeia

Other than in Thessaly, the EN sites from Macedonia (west of Thessaloniki) contained decorated sherds from their earliest levels onwards. Similar to Western Thessaly, no monochrome horizon is identifiable, while painted and impressed sherds occurred together. Impressions were obtained using single fingertips and fingernails, pressing the clay between two fingers (resulting in pinches) or using different tools, but without comb-like instruments (Yiouni 1996: Figure 5.55). In Nea Nikomedeia, from a total of *c.* 140,000 sherds, 5600 are decorated (4%). Of those, 88% are painted, 9% are impressed, and 3% have applied decoration (Yiouni 1996: 81–82, and 89). From the total collection, the impressed decorated sherds amount to only 0.4% (*c.* 500 pieces), the painted ones to 3.6%.

The overall impression offered by the sherds decorated with either fingernails or tools from Nea Nikomedeia is that of a well-organised display of ornaments (Figure 4). Given the small size of sherds, a distinction between full coverage of the body and only single parallel vertical or horizontal lines (erratic or organised) is sometimes hard to make. As the site was abandoned around 5900 cal BC, it is no surprise that no comb-impressions occur here. The inventory from Nea Nikomedeia certainly predates that of Otzaki, Area II and Elateia 1. Compared to Thessaly, there are also differences in the shapes: bead-rim bowls do not occur in Nea Nikomedeia; instead, impressions are carried out on rather thin-walled simple bowls (either slightly closed or slightly opened), leaving a 2–4 cm wide zone along the rim free of decoration. 13% have an additional slip applied over the impressed decoration.

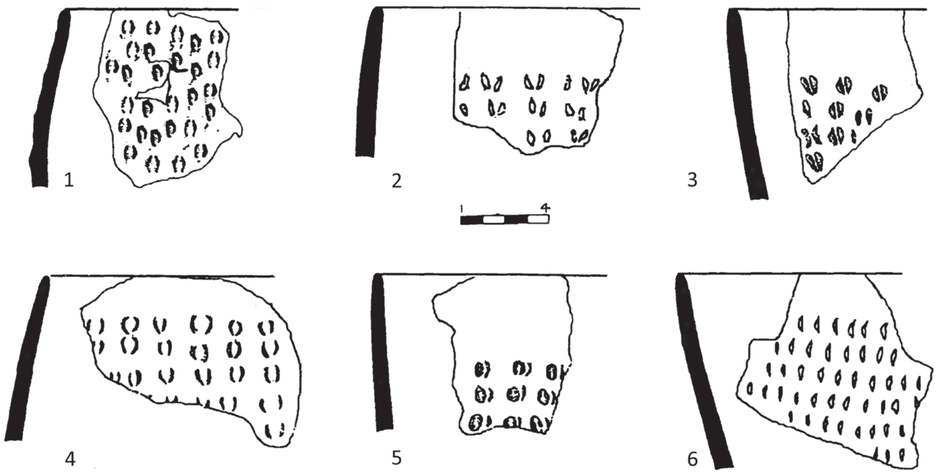

Figure 4. *Nea Nikomedeia: well-displayed ornaments on thin-walled vessels of deep, slightly closed or opened bowls (after Yiouni 1996: Figure 5.55)*

A precise chronological evaluation of the site is complex despite a whole sequence of 14C dates. According to the authors, the site was not inhabited longer than a maximum of 50–150 years, over three generations only (Yiouni 1996: 185). This contrasts the wide temporal frame given by the radiocarbon dates of at least 500 years according to the median values. As there is no information given to the stratigraphical context of the dates, several interpretations are feasible:

– In a first attempt, the radiocarbon dates were interpreted in view of both the Thessalian sequence and the one from Northern Macedonia (Amzabegovo) and thought to cover rather the end of the 7th millennium around 6150 cal BC, ending before 6060 cal BC (Reingruber 2008: 395–96; Thissen 2000: 194). This was in line with the information given that the site covered only a short period during the EN without any evidence of the MN (Pyke 1996: 48; Yiouni 1996: 104).

– In a second attempt, the separation into three datable clusters was followed up, with the oldest dates (the combined date OxA-1605+OxA-4282, the date OxA-3876 and the date OxA-3874) falling between 6350 and 6250 BC, a group of five dates is covering the 62nd century BC, and the youngest combined date (OxA-1603+OxA-4280) results shortly after 6000 cal BC (Reingruber and Thissen 2017: http://www.14sea.org/3_IId.html#site1). This date, with a median value at 5900 cal BC, would indicate a continuation of the habitation into the early MN. Yet, this view contradicts the results of Pyke and Yiouni in 1996.

Recently, Igor Yanovich has interpreted the sequence as falling anywhere into the timeframe of 6300 and 6050 BCE at 95% HPD, concluding that the site may well be coeval with the EN II in Thessaly (Yanovich 2021: 17, Table 1).

If, therefore, a longer duration of the site is feasible, we can conclude that the impressed decoration appeared earlier in western Central Macedonia than in Thessaly. And there is indeed new evidence for this conclusion.

Revenia-Korinos

Ongoing projects in the Pieria, the south-western part of Central Macedonia, have expanded our knowledge not only on the organisation of space within settlements but also on pottery production, as well as the duration and combination of decorative styles (e.g., Urem-Kotsou et al. 2014; 2017). In addition, reliable radiocarbon data have provided new insights for interpreting the Neolithic way of life distribution and subsequent transregional contacts.

From Revenia, 29 new radiocarbon data were obtained on different materials, 11 on long-lived oak, seven on cattle bones, and only one on a short-lived seed (Maniatis and Adaktylou 2021). Bones of omnivores like humans (nine) and pigs (one) may have been subdued to the reservoir effect, and their results need to be treated with care. Regardless of the phase to which the dates were assigned, most of the 29 results correspond to a steep portion within the calibration curve, but both at the beginning of the sequence (around 6600–6500 cal BC) and at its end (at 6200–6000 cal BC) there is a flat part in the curve that makes some of the dates look older, on the one hand, and, on the other, look younger than what they, in fact, may have been. Judging by the position of the dates on the curve, one can assume that they cover the period 6500–6200 cal BC (Figure 5.1). The four dates making the sequence look older, in addition to their disadvantageous position on the curve, were determined on fish-eating species pig (DEM-2820) and human (DEM-2826), on charcoal of long-lived oak (DEM-2751), and only one on a cattle bone (DEM-2825), but here there is no indication of collagen content.

We will not discuss the dates in detail here but point at the probability that the EN-habitation in Revenia may have lasted over several generations, somewhere between 6500 and 6200 cal BC. This spans the EN I and the EN II in a Thessalian chronological framework.

As an example, we will point out the situation in ‘habitation pit 11’ that was used in the second stage as a burial place. According to Papaioannou (2011: Tables 5.4–5.8), layers 2–5 yielded impressed sherds, yet always in small amounts (Table 2). They were indeed present from the lowest level 5 onwards, but their number almost doubled in level 2.

Layers in habitation pit 11 (bottom-up)	Sherds with impressed decoration (n)	% from layer	% from total
2	98 (out of 6593)	1.48	0.81
3	12 (out of 1426)	0.84	0.09
4	15 (out of 1571)	0.95	0.12
5	18 (out of 2269)	0.79	0.15
TOTAL	***143 (out of 12,134)***		***1.18***

Table 2. *Frequency of impressed decoration from Revenia-Korinos (after Papaioannou 2011, tables 5.4–5.8)*

From the ‘deepest level of the pit’ (Maniatis and Adaktylou 2021: 1045) derives a charcoal sample determined as *Quercus* sp. (DEM-2745/MAMS-20227: 7404±27 BP; 6370–6230 cal BC 1σ). Given the possibility of the old-wood effect, we can use it here only as a *Terminus post quem* (*TPQ*). Also, the dates on human bones from this pit, with results between 6400 and 6300 cal BC (Maniatis and Adaktylou 2021: 1033, Table 1), susceptible to the reservoir effect and belonging to the second stage of the pit’s usage, are challenging to connect to the impressed pottery from within the pit as presented in Papaioannou 2011. From another feature, pit 7, two dates on charcoal and a third date on cattle bone yielded results between 6390–6230 cal BC (Maniatis and Adaktylou 2021: 1032, Table 1). The pit also produced small amounts of impressed pottery below 0.5% (Papaioannou 2011: Tables 5.1–5.3).

Therefore, it is relatively safe to assume that impressed decoration was in use before 6230 cal BC in Revenia. This reinforces the view that an earlier start of the Nea Nikomedeia sequence should be envisaged, possibly even at 6300 cal BC. We conclude that at Revenia and at Nea Nikomedeia, impressed decoration predates the Thessalian variant by at least a century.

Paliambela-Kolindrou

At Paliambela-Kolindrou, impressed decorations seem to date even 200–300 years earlier than those of the Thessalian ‘Magoulitsa culture’. From the eleven dates obtained mainly on animal bone (Maniatis 2014: 208, Figure 3), the three oldest (Figure 7, Paliambela) gave results between 6530–6450 cal BC (according to their medians). They all derive from pit 630, which was assigned to EN 1 (Maniatis 2014: 207–08). This pit was approx. 1.7 x 1.07m in size and contained 1.32kg pottery, consisting of 187 sherds, six of which were decorated with finger and nail pinching (3.2%) (Papadakou 2011: 90–91). Based on a remark given by Urem-Kotsou et al. 2014: 507 of those sherds derived from the upper layer of the pits’ deposit.

Since the backfill of the pit consisted of uneven layers between c. 61 and 62m above sea level (Papadakou 2011: 90), the depth of the three radiocarbon samples is also given with larger intervals. They were collected at different heights (Maniatis et al. 2015: 151), but only DEM-2458, the youngest of the three dates, is derived from the upper part at 61.90/61.76m asl. Therefore, it may be connected to the impressed sherds and offer a starting point for this kind of pottery in Paliambela at c. 6450 cal BC.

Western Macedonia

In Western Macedonia, in the hilly areas on both sides of the river Aliakmon and its tributaries, at the sites of Paliambela-Roditis and Varemenoi-Goulon decorated sherds are generally fewer than in the Pieria (Urem-Kotsou et al. 2017, Tab. 1 and Figure 8). If at all quantifiably, the impressed decorated ones do not exceed 0.4% of the total bulk of materials, similar to the quantity observed in Nea Nikomedeia. At Mavranei-Panagia farther west, in the area of Grevena (Wilkie and Savina 1997: 203, Figure 2), only a few such sherds were reported. New insights are expected from the Grevena Archaeological Project started in 2021 (a collaboration between the Ephorate of Antiquities of Grevena and the Landscape Archaeology Research Group at the Catalan Institute of Classical Archaeology). Even in Servia V, closest to Thessaly, Ridley and Wardle (1979: 193, 207) mentioned only a few sherds with nail impressions that were also not quantifiable. As this latter site is dated to post-5800 BC, there may be a temporal reason at play as this kind of decoration is of earlier periods. More reliable data, though, have been obtained on the large-scale excavation at Mavropigi-Fillotsairi.

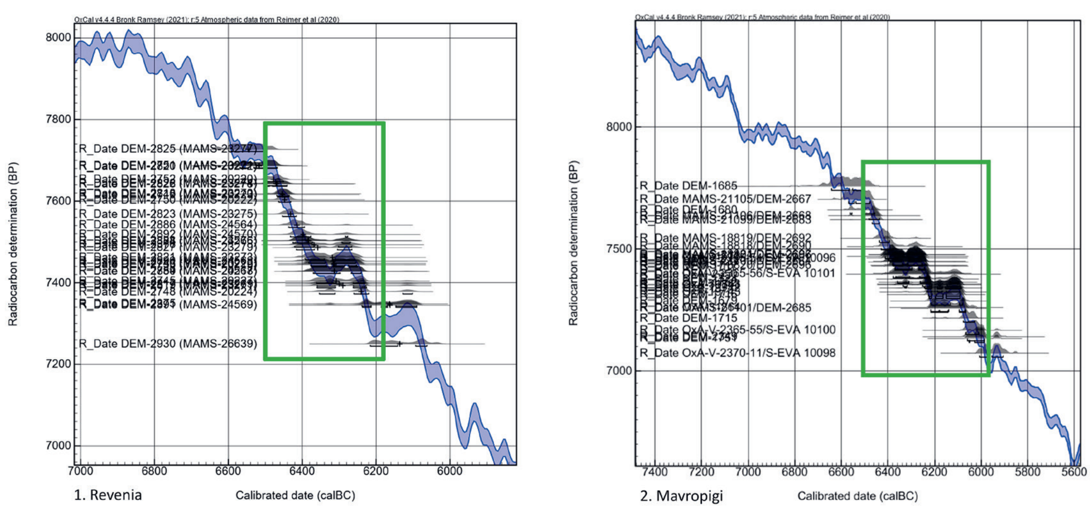

Figure 5. *Radiocarbon dates from Revenia (1) and Mavropigi (2), plotted on the calibration curve. The green squares outline the most probable duration of the total settlement periods.*

Mavropigi-Fillotsairi

As discussed elsewhere (Bonga 2020; Starnini 2018), the 32 radiocarbon dates from this site cover the whole duration of the EN (Figure 5.2). Our aim is not to present a detailed analysis of the individual phases but to point out the most probable start of impressed decorations at the site. As with Revenia, the two oldest dates in the sequence fall within a flat portion of the curve and were obtained on charcoal (of unknown species). One of them (DEM-2667) shows a very low δ13C value of -30.8‰ (compared to the expected -25.00‰) and must be treated with care. Especially so when considering that the only date obtained on short-lived material for Phase I (MAMS-21100/DEM-2684) is at 6380–6260 cal BC. Besides, Phase I was excavated only in the 'C*entral Orygma'* (όρυγμα=pit), producing merely a few sherds (Table 3), some joining with fragments from Phase II (Bonga 2019: 162). Therefore, even if Phase I may not have started as early as 6600 cal BC, as suggested before (Karamitrou-Mentessidi et al. 2013; Karamitrou-Mentessidi 2014: 245; Maniatis 2014: 207; Starnini 2018: Tab. 1), and Phase II only after 6400 cal BC, we can assert that both styles of decoration (painted and impressed) were in use very early on, definitely so within Phase II. The best sequence is that from the '*Central Orygma*', with radiocarbon dates from Phases I–II and with impressed sherds from Phases II–III (Bonga 2019: 163 and Figure 4). But note that all seven radiocarbon samples from here have been obtained on charcoal. Therefore, like in Revenia, the oldest date, DEM-1723 at 6380–6250 cal BC can be taken only as *TPQ* for Phase II (Bonga 2017: Figures 6–7).

In Mavropigi, a variety of different decorations in the negative has been documented (Bonga 2017: Figure 7; 2019: Figure 4; 2020: Figs. 16–18): Besides fingernails and finger pinches, blunt or sharp tools were also used to decorate the vessels, but no comb-like tools. Like at the other Macedonian sites, also in Mavropigi, habitation did not continue into the 6th millennium BC, and this may be why no multi-toothed decorations (comparable to the MN in Thessaly) were applied.

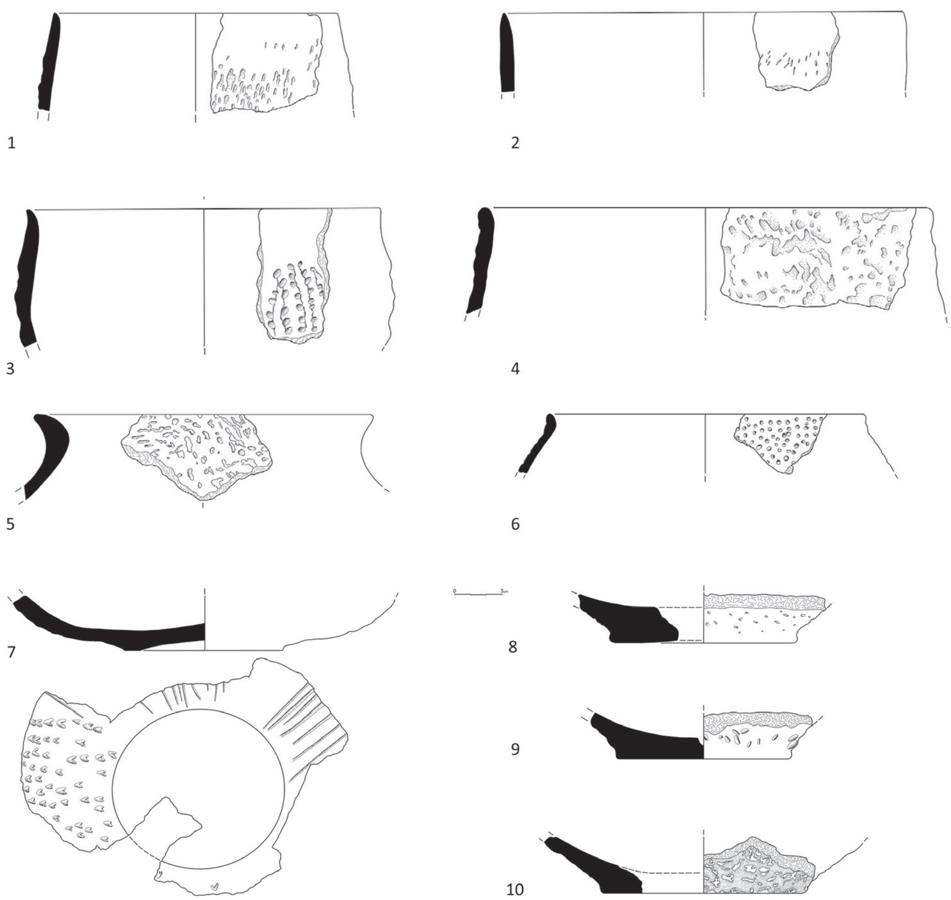

Figure 6. *Mavropigi-Fillotsairi: Sherds of various vessel shapes, with impressions covering most of the vessel body (Bonga 2020: Figures 17–18)*

The thickness of the Mavropigi sherds and the design of the ornaments convey a coarser and less careful impression (Figure 6) when compared to Nea Nikomedeia, where the impressions are neater and clearer. There also seems to be a distinction between the full coverage of vessel bodies in Mavropigi as opposed to single parallel lines (erratic or organised) in Nea Nikomedeia.

When comparing shapes, several types of vessels are represented at Mavropigi, unlike in Nea Nikomedeia, where only deep bowls with simple rounded lips are depicted. Additionally, pronounced lips of open or closed variants and necked vessels are represented (Figure 6.1–6). Comparisons with the Thessalian repertoire show similarities in rim shapes but differences in the bases, as these are in Mavropigi, usually flat and rather thick-walled due to reinforcement (Figure 6.7–10).

Apart from being visually different, the quantities from Mavropigi-Fillotsairi seem larger than those from Revenia, Paliambela-Kolindrou and Nea Nikomedeia. This is the case when looking separately at the sherds from the 'Central Orygma' (compare Table 3) and when calculating the total number of sherds from the site (Table 4).

The radiocarbon dates may suggest an anteriority of the Mavropigi and Paliambela examples (Figure 7) as compared to those from Nea Nikomedeia (or also Otzaki in Thessaly) we can potentially trace a chronological development, with changes in style and quality.

Phases of the Central Orygma (bottom-up)	Sherds with impressed decoration (n)	% from layer	% from total
Phase IIIb	266 (out of 6398)	4.16	0.99
Phase IIIa	124 (out of 2395)	5.17	0.46
Phase II	1204 (out of 17,987)	6.69	4.48
Phase I	0 (out of 76)	0	0
TOTAL	***1594 (out of 26,856)***		***5.93***

Table 3. *Frequency of impressed decoration from the 'Central Orygma' at Mavropigi-Fillotsairi*

Discussion

The new evidence from Mavropigi-Fillotsairi, Revenia-Korinos and Paliambela-Kolindrou has changed our perception of the relative chronological appraisals of pottery styles as previously developed for Thessaly. In this contribution, we rely on results from preliminary reports that may be adjusted in the final publications. Yet, the contextualisation of impressed sherds within early levels at all three sites can be regarded as secured. The exact dating of these levels needs more detailed appreciation. For the time being, we can use the results obtained on charcoal from the '*Central Orygma*' in Mavropigi and from 'habitation pit 11' in Revenia at 6380 and 6370 cal BC, respectively, only as *TPQ*s. Yet, the result on a bone of unknown species from Paliambela, with a median value at 6450 cal BC, could confirm a very early start of impressed pottery in the Pieria and Western Macedonia (Figure 7, Paliambela). At these sites, impressed decorations appear to date 100–300 years earlier than the 'older Magoulitsa culture' in Thessaly, thus making the Macedonian sites carrying the oldest impressed pottery in Greece.

In Central Macedonia east of the Axios River, impressed vessels were (to our present knowledge) not produced: in the Langadas Basin, 20km northeast of Thessaloniki, impressed decoration is absent, e.g., in Lete I, dated to the first half of the 6th millennium BC (Dimoula et al. 2014:498). Also, in Thrace, both in Makri to the west of the river Evros/Meriç/Marica and in Hoca Çeşme to the east of the river, no quantifiable amounts of impressed decoration have been reported, apart from a few such sherds in Makri Phase A dated to 5800/5700 cal BC (Efstratiou et al. 1998: 31). From Uğurlu on the island of Gökçeada (Imbros), few such sherds appeared in phase IV, post-6000 cal BC (Erdoğu 2013: Figure 37). The scarcity of impressed decoration from the northeastern sites of the Aegean coast is striking and not comparable to the abundance of impressed sherds in Western Macedonia. It appears that impressed decoration did not spread along the coastal sites towards the east.

In the Eastern Aegean, the Izmir region between Ege Gübre in the north and Çukuriçi Höyük in the south is well-researched, with new and significant results obtained in the last two decades. Pending publications of excavated materials from Çukuriçi Höyük, we rely here on the information given from the tellsite of Ulucak and additionally from the two flat sites of Dedecik-Heybelitepe and Ege Gübre.

As asserted by all authors, decoration (be it painted or impressed) is not an outstanding characteristic of these inventories and is usually given as few, rare or even very rare (Çilingiroğlu 2016: 81, Herling et al. 2008: 21; Sağlamtimur 2012: 200).

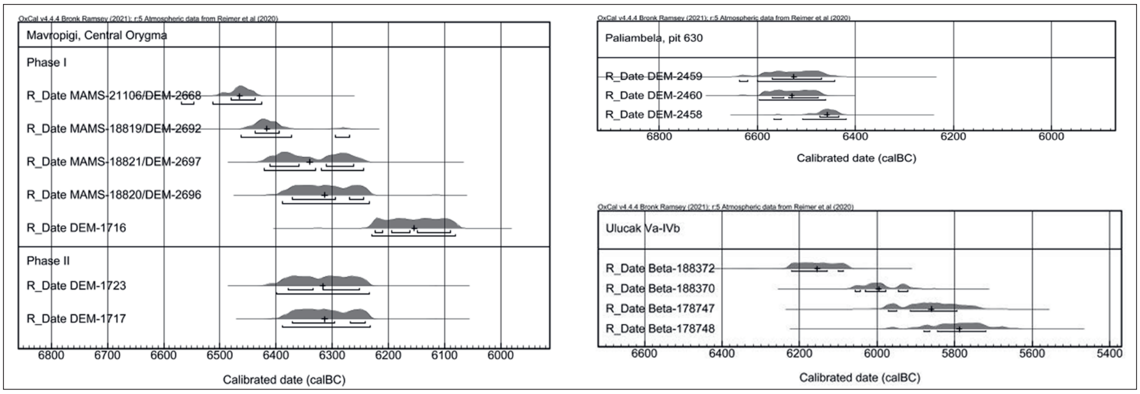

Figure 7. *Calibrated radiocarbon dates from levels with impressed sherds from Mavropigi ('Central Orygma'), Paliambela-Kolindrou (Pit 630 of the EN 1) and Ulucak Va–IVb (more information on individual dates at www.14SEA.org)*

In Ulucak, impressed decorations occurred from Phase Va onwards, dated to around 6100/6000 cal BC, but probably rather postdating 6000 cal BC (Çilingiroğlu 2016: 82), since the outlier Beta-188372 (Figure 7, Ulucak) fits well well to the dates from Phase Vb. All dates have been obtained on charcoal and can thus be used only as *TPQ*s. Impressions were used up to the end of the Neolithic occupation (Chalcolithic in Anatolian terminology) in Phase IVa at 5800/5700 cal BC. Therefore, Ulucak (like all the other sites in the region) was abandoned after *c*. 5800 cal BC, at the end of the first phase of the MN (in Aegean terminology). This may explain why the decorative styles of the later MN phases in the Western Aegean are not represented in the Eastern Aegean.

The high percentage of 2–8% impressed sherds in Ulucak, as given in the table 'Percentage of impressed pieces' by Çilingiroğlu (2009, vol. II), is not comparable with the sites discussed above, as it is related to only the diagnostic pieces (e.g., Çilingiroğlu 2009: 95, 102, 126) and not to the total inventory. The total of 102 impressed sherds outnumber the 16 painted examples by far, the latter of the Red-on-cream or Cream-on-red style, comparable to the MN-painted decoration in the Western Aegean. Virtually all the impressed body sherds are covered with impressions of fingernails or broad tools, thus comparable with the older Thessalian and Macedonian variants. As rims and bases are exceptional, the shapes decorated with impressions are difficult to reconstruct, but two restorable vessels with raised bases are of the closed type with knobs attached under the rim (Çilingiroğlu 2009: Pl. 29.1 and Pl. 35.2).

Less than 1% of impressed sherds from the flat site Ege Gübre are decorated all over with fingernails and more seldom with tool impressions; most of them are covered with a red slip (Sağlamtimur 2012: Figure 19–20). The excavator of Ege Gübre equated the duration with phase IV at Ulucak, which is confirmed by the eleven ^{14}C dates (Sağlamtimur 2012: 202) that cover, apart from two outliers owed to a flat portion in the calibration curve, the period 6040–5820 cal BC. This site is thus of the early MN in Aegean terminology.

In Dedecik-Heybelitepe, a few vessels of the lower layer A (coeval with Ulucak V–IV) were decorated with finger pinches or impressions, accounting for less than 1%. Judging by the two body sherds depicted, the impressions covered broad surfaces of the vessel, not organised in specific patterns (Herling et al. 2008: 21 and Figure 4, 7–8). As in the case of Ulucak and Ege Gübre, this decoration is rather comparable with the older variant of impressed styles in Thessaly and Macedonia. At Dedecik, it had been proven for the first time that the obsidian used for chipped stone tools derived from the Aegean island of Melos and with diminishing quantities from Anatolian sources (Herling et al. 2008: 29). Thus, trans-Aegean networks in both directions, East–West as well as West–East, must be considered. In addition to tools, decorated pots may also have reached the East Aegean coast from the west.

Comparisons with impressed decorations from SW-Anatolia can be made only in a very general and superficial way. Apart from this, also the examples from the Lake District (e.g., from Höyücek KAD and

Höyücek West, Hacılar I und Kuruçay 7) post-date 6000 cal BC (Reingruber 2008: 455-456 and Tab. 5.6). Connections with areas even farther east are difficult to assess: Neither in Mersin-Yumuktepe nor in Tell Sabi Abyad are the shapes comparable to those in the Aegean (Müller 1994: 267), nor are surface colour and paste. One should not exclude the possibility of convergent phenomena, especially from such distant areas like the Jazira in eastern Syria and Argissa in Thessaly.

Furthermore, a distinction should be made between the styles themselves with:

– Full coverage of the body as is the case in Macedonia and Thessaly on the older variant (long) before 6000 cal BC but occurring throughout the Eastern Aegean sites only around and after 6000 cal BC;
– Single parallel lines, be they erratic or organised, as is the case within the younger variant of the NW Aegean before and after 6000 cal BC, but not observed in the Eastern Aegean.
– A combination with red and/or white paint resulting in the 'fusion style': this youngest variant, dated to after *c*. 5800 cal BC, is observed mainly in Thessaly.

Table 4 summarises our present state of knowledge: the oldest sites with impressed decoration are those from Western Macedonia, followed by the Thessalian sites. Given the proximity between the two regions, this is not surprising. The two oldest sites, Paliambela-Kolindrou and Mavropigi-Fillotsairi, also gave the highest possible numbers of impressed sherds, with more than 3% of the total assemblage. In Thessaly, only the northernmost site, Elateia 1, provided such high figures; however, this site is younger, and the sherds derive from a systematic survey, not excavations. The southernmost Thessalian sites have the least impressed materials (Achilleion and Sesklo): the farther away from Central Macedonia, the lower the frequencies. They are lowest in the Eastern Aegean, where impressed sherds occur very late.

If the radiocarbon dates and the statistics are correct, a transfer of the impressed decoration can be inferred from the NW coast to the eastern coast of the Aegean, from the area where it derives from a longer tradition to an area where it was in use for a short period and with statistically irrelevant number of pots (Figure 8). It appears in the east more as a fashion, without clear standards in shape and style. Where impressions are common in Macedonia and Thessaly, they occur on characteristic vessel shapes, surfaces, and categories and constitute a standard.

Site	Period or phase	Total assemblage	Impressed decoration	%	Earliest possible appearance
Paliambela, Pit 630	EN 1	187	6	3.2%	after 6450 BC
Mavropigi	EN	67,971	2506	3.7%	6380–6250 BC
Revenia, Pit 11	EN-MN	12,134	143	1.2	6370–6230 BC
Nea Nikomedeia	EN	140,000	503	0.4%	6350–6250 BC
Argissa	EN–MN	6,524	154	2.4%	before 6000 BC
Otzaki, Area III	EN II–MN I	8,882	142	1.6%	before 6000 BC
Achilleion IIb–IVa	EN–MN	115,000	64	0.1%	6210 BC
Elateia 1 (survey)	MN I	11,337	442	3.9%	6000 BC
Ulucak Va-IVa, Ege Gübre IV-III, Dedecik-Heybelitepe	LN/EC in Anatolian or EN/MN in Aegean terminology		'rare'	-1%	around and after 6000 BC

Table 4. *Relative proportions of impressed pottery in the total amount of sherds from Macedonian and Thessalian sites compared to East Aegean sites, termed there Late Neolithic (LN) and Early Chalcolithic (EC)*

Profiting from the knowledge of how far east the obsidian networks expanded in the Aegean, it may not be a surprise that other materials (among those that have survived the millennia) were exchanged Aegean-wide not in only one direction but in multiple directions. And this may now also hold true for specific decoration styles on pottery.

However, not all regions were involved in this exchange, for impressed decoration does not appear in the southern Aegean (Argolid, Attica, Crete and Caria). It is difficult to give a conclusive explanation at this stage of research. However, one has to consider the cultural aspect with regionalisation of the circum-Aegean area (Reingruber 2022) and also the chronological aspect with sites that were either abandoned (e.g., in the Eastern Aegean) or not yet founded (e.g., Argolis and Crete) before certain decorative styles emerged and began to spread.

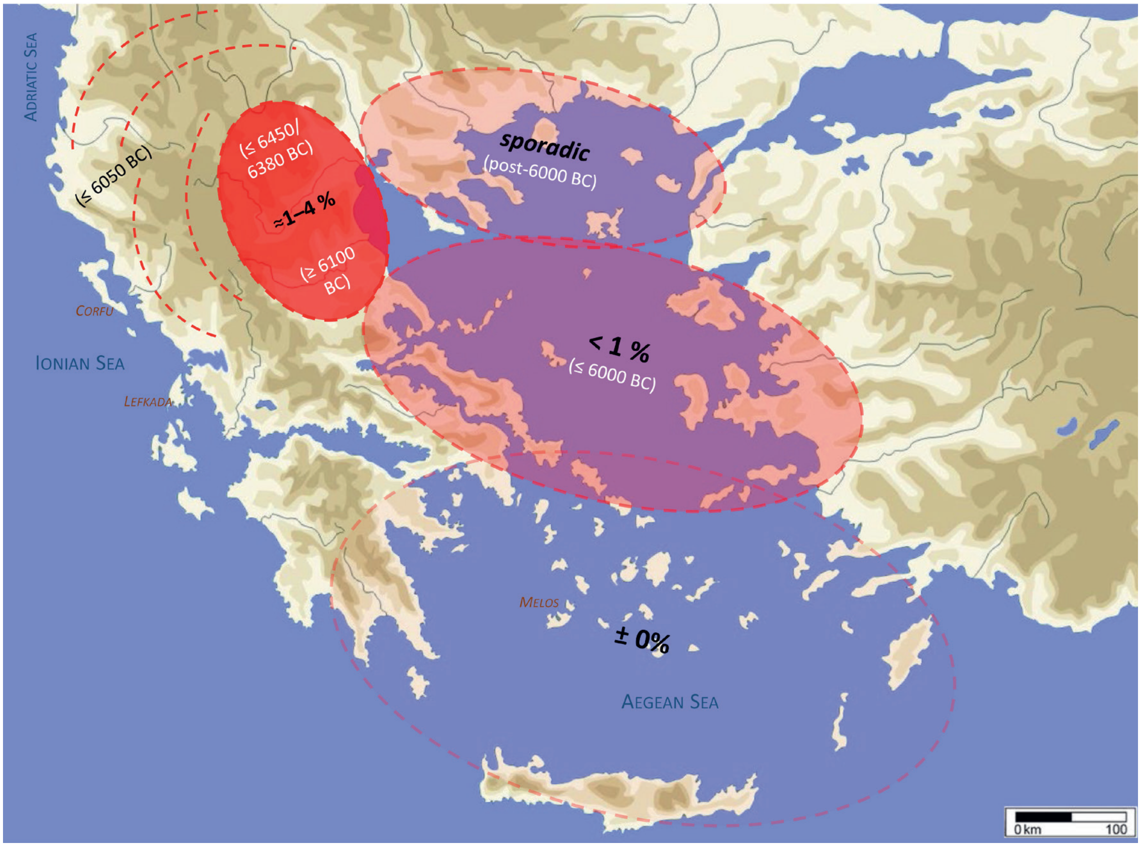

Figure 8. *Frequency of impressed decorated sherds per circum-Aegean area and per time (before, around, and after 6000 cal BC).*

On the other hand, as was suggested elsewhere (Bonga 2017: 378–79, 382–84; 2020: 51 and footnotes 132, 135–36), based on ceramic types (including impressed decoration), small finds, and lithics, Mavropigi-Fillotsairi had close relationships with communities in the Korça Basin of southeastern Albania, only *c.* 60 km apart as the crow flies. In addition, the still insufficiently researched regions such as Epirus (e.g., Episkopi: Vasileiou 2016) or the Ionian islands (e.g., Sidari on Corfu: Sordinas 1969; Choirospilia on Lefkada: Velde 1912: 857 and Figure 9), with finger-pinched and impressed sherds in their early assemblages, were more related to mainland Greece, Albania and the southwest Balkans than to Dalmatia (Tsonos 2018: 493-494). Besides, the appearance of *Impresso* in the southern Adriatic is much later in date than the impressions documented in Greece (Bonga 2019). Not to mention the huge chronological S–N-gradient of several hundreds of years between 6000/5900 BC in the southern part and 5500/5400 BC in the northern part of the Adriatic Basin (Kačar 2021: 800 and Figures 2 and 5).

Considering this, the second option expressed by Kačar (2021: 809) seems rather probable: that the Neolithic disseminated into the Adriatic not via the Ionian Sea but from the hinterland, from Greek Macedonia via Albania. We propose that the first fingernail and tool-impressed pots were made in a region located in the present-day border triangle of Greece, Albania, and North Macedonia. From there, the idea of decorating vessels in this way was gradually adopted by potters on many other sites in a far wider area and as late as 6050 cal BC (and even later) on settlements in the Ionian and Adriatic region (Figure 8).

Conclusions

Other than the *Impresso* and *Impressa* pottery of the Western Mediterranean, the impressed decoration in the Aegean is not a coastal phenomenon. It is completely absent from the southern Aegean, in little quantities occurring in the central part of the Aegean (on the height of Izmir–Lamia) and comparatively abundant in the NW Aegean. Therefore, it cannot serve as an indicator for a maritime 'coastal expansion' (Özdoğan 2022: 414), although a possible 'connectivity' (Çilingiroğlu 2016: 75) can be inferred between certain Aegean coastal areas but not for the overall Mediterranean.

The causes and mechanisms for this phenomenon and its distribution are poorly understood for the time being, and without further research into the social importance of fashions, symbolic meanings, and functional and/or aesthetic aspects, they remain speculative. Future studies must also consider other artefact groups to reveal and understand nuanced technological and social interactions. Yet, the first step is now taken: more precise descriptions of the impressions themselves, quantitative evaluations combined with new absolute data have shown that different from what was previously thought, the impressed decoration is not most numerous and ancient in Thessaly but in Western Macedonia.

Two different styles were observed, not necessarily reflecting a regional but rather a chronological difference: in Mavropigi finger pinches, fingernail impressions or impressions executed with a blunt tool over the whole surface of the pot convey a rather rough appearance, whereas, in Nea Nikomedeia, the impressions are organised in horizontal or vertical rows. In Thessaly, both variants are known from Otzaki Area III (especially the organised one), but in Area II (of the MN), comb-impressions appear that can be accompanied by red paint. Interestingly, this kind of decoration has not been observed elsewhere – judging by the published materials, it is rare in Western Macedonia (Bonga 2020: Figure 19b) and completely missing from Central Macedonia, certainly so at sites that were abandoned before 6000 cal BC, confirming that it is of later appearance.

In North Macedonia, the usage of impressed decorated vessels seems to coincide with the emerging Neolithic way of life (for a re-evaluation of the old data, compare Naumov, this volume). In the Ionian and Adriatic areas, finger-pinched impressions are among the earliest Neolithic finds, post-dating 6050 BC. At this time, many of the Greek Macedonian sites excavated so far were abandoned; others were founded only at later stages of the MN or even in the early LN (e.g., Dispilio, Avgi, or Kremastas: Sofronidou and Dimitriadis 2014; Stratouli and Kloukinas 2020; Toufexis 1994; Tsigka 2018: 55): they provided later variants of the negative decoration, together with barbotine-arcading. This may be why impressed decoration continued to thrive during the earlier MN only in Thessaly, where it was adapted and transformed into new variants (comb-impressions organised in horizontal, parallel lines) and eventually (after 5800 BC) fused with the painted decoration.

In Thessaly, an immediate relation between impressed ware and the Neolithisation process is not given as it occurs only in a later stage of the EN. There, painted decoration is older and is rendered in red paint on buff surfaces, later on, a white slip. Interestingly, the white-painted variant of the Macedonian style that spread all over the Balkans has not been applied to Thessalian pots (with few exceptions). In Thessaly, two spheres of influence must be acknowledged: one based on painted and one on impressed decoration. In SE-Thessaly (Sesklo, Achilleion), painting occurred first and dominated during the EN and MN; in NE-Thessaly (Otzaki, Argissa, Elateia 1), impressed decoration outweighed the painted variant but without replacing it. On the contrary, the two styles fused into a new variant that appeared only after 5800 BC, applied on their own shapes with flat bases and flaring rims.

Given the long tradition of impressed decoration in Western Macedonia since at least 6350 BC, its subsequent appearance in Thessaly (after 6200 BC) and later appearance in the Eastern Aegean (after *c.* 6000 cal BC), we conclude that this kind of decoration is of NW Aegean tradition from where it spread in larger parts of the Aegean (and eventually also into the Ionian and Adriatic areas). The contacts between the western and eastern coastal areas of the Aegean were thus not only one-way, from East to West, but in several directions, including West to East, as had already been shown by the spread of the Melian obsidian in the Aegean, before and during the Neolithic period (Reingruber 2018: Figures 2–3).

The attempts mentioned above to trace the impressed pottery back to either the Near East or the Adriatic region must be considered outdated, in the truest sense of the word: the impressed decoration of the NW Aegean is older than that from which it was thought to derive. Its origin is not to be sought in distant regions but can instead be considered a genuine element of the NW Aegean pottery production (Figure 8).

Acknowledgements

The authors would like to thank Miroslav Marić for including their joint paper in the proceedings of the Belgrade conference and the two anonymous reviewers for their constructive critique. A. Reingruber feels indebted to the directress of the Ephorate of Antiquities in Volos in 1999–2000, Vasso Adrymi-Sismani, for allowing a close examination of the materials from Sesklo A and – with the additional support of Vasso Rondiri and Litsa Skafida – of the materials from Magoulitsa. Special thanks are due to the Ephorate of Antiquities in Larissa, in particular Giorgos Toufexis, for the joint study of (not only) the Nessonis I–II materials and the generous support he always provides. L. Bonga thanks Georgia Karamitrou-Mentessidi and Nikos Efstratiou for their continued support.

References

Bonga, L. 2017. "Thoughts on the Preliminary Study of Early Neolithic Decorated Pottery from the Central Origma at Mavropigi-Filotsairi". In *Communities, Landscapes and Interaction in Neolithic Greece*. Proceedings of the International Conference, Rethymno, Crete, 29–30 May 2015, eds. A. Sarris, E. Kalogiropoulou, T. Kalayci, and L. Karimali, 371–384. Michigan: Ann Arbor.

Bonga, L. 2019. "Early Ceramic Styles and Technologies in the Aegean and the Balkans. Retrospect and Prospects". *Documenta Praehistorica* 46, 158–72. DOI:10.4312/dp.46.10

Bonga, L. 2020. "Pioneering Potters: Early Neolithic Ceramics from Mavropigi-Fillotsairi, Western Macedonia". *Athens University Review of Archaeology* 3, 9–62. http://epub.lib.uoa.gr/index.php/aura/article/view/2170

Chatziangelakis, L. and K. Vouzaxakis. 2022. "Ο προϊστορικός οικισμός στον Συκεώνα Καρδίτσας. Ανασκόπηση και ανασύνθεση δεδομένων (The prehistoric settlement in Sykeona Karditsa. Data review and reconstruction)". In *7th Archaeological Meeting of Thessaly and Central Greece* (AETHSE) 2018–2021.

Chourmouziades, G. 1971. "Η διακεκοσμημένη κεραμεική της αρχαιοτέρας νεολιθικής περιόδου εις την Θεσσαλίαν (The decorated pottery of the earliest Neolithic period in Thessaly)". *Archaiologike Ephemeris* 110, 165–187.

Çilingiroğlu, Ç. 2009. "*Central-West Anatolia at the end of 7th and beginning of 6th millennium BCE in the light of pottery from Ulucak (Izmir)*". Unpublished PhD Dissertation, vol. 1 and 2, Department of Prehistory, University of Tübingen. https://publikationen.uni-tuebingen.de/xmlui/bitstream/handle/10900/46490/pdf/Diss_Cilingiroglu_1.pdf?sequence=1&isAllowed=y

Çilingiroğlu, Ç. 2016. "Impressed Pottery as a proxy for connectivity in the Neolithic Aegean and Eastern Mediterranean". In *Of Odysseys and Oddities: Scales and modes of interaction between Aegean societies and their neighbours*, ed. B.P.C. Molloy, 75–96. Sheffield: Sheffield Studies in Aegean Archaeology.

Dimaki, S. 1994. "Προϊστορικοί οικισμοί στη Βόρεια Φθιώτιδα (Prehistoric settlements in North Phthiotida)". In *La Thessalie. Quinze annees de recherches archeologiques, 1975–1990*. Actes du colloque international Lyon, 17–22 Avril 1990, ed. R. Misdrahi-Kapon, 91–102. Athens: Ministere Grec De La Culture.

Dimoula, A., A. Pentedeka and K. Filis. 2014. "Lete I. The pottery of a neolithic site in central Macedonia 100 years after". In A *Century of Research in Prehistoric Macedonia: 1912–2012*. International Conference Proceedings, eds. E. Stefani, N. Merousis, A. Dimoula, 491–503. Thessaloniki: Archaeological Museum of Thessaloniki.

Efstratiou, N., M. P. Fumanal, C. Ferrer, D. Urem Kostos, A. Curci, A. Tagliacozzo, G. Stratouli, S. M. Valamoti, M. Ntinou, E Badal, M. Madella and K. Skourtopoulou. 1998. "Excavations at the Neolithic settlement of Makri*,* Thrace*,* Greece (1988–1996) – A preliminary report". *Saguntum* 31, 11–62.

Erdoğu, B. 2013. "Uğurlu. A Neolithic Settlement in the Aegean Island of Gökçeada". In *The Neolithic in Turkey, vol. 5: New excavations and New Research*, eds. M. Özdoğan, N. Başgelen and P. Kuniholm, 1–33. Istanbul: Archaeology and Art publications 2013.

French, D. H. 1972. "*Notes on Prehistoric Pottery Groups from Central Greece"*. Athens: Self-published.

Gallis, K. 1992. "*Άτλας προϊσορικών οικισμών της ανατολική Θεσσαλική πεδιάς* (Atlas of prehistoric settlements of the eastern Thessalian plain)". Society of Thessalian Historical Studies: Larisa.

Herling, L., K. Kasper, C. Lichter and R. Meriç. 2008. "Im Westen nichts Neues? Ergebnisse der Grabungen 2003 und 2004 in Dedecik-Heybelitepe". *Istanbuler Mitteilungen* 58, 13–65.

Kačar, S. 2021. The Neolithisation of the Adriatic: Contrasting Regional Patterns and Interactions Along and Across the Shores." Open Archaeology 7: 798–814. DOI.org/10.1515/opar-2020-0166

Karamitrou-Mentessidi, G., N. Efstratiou, J.K. Kozłowski, M. Kaczanowska, Y. Maniatis, A. Curci, S. Michalopoulou, A. Papathanasiou and S.M. Valamoti. 2013. "New evidence on the beginning of farming in Greece: the Early Neolithic settlement of Mavropigi in western Macedonia (Greece)". *Antiquity Project Gallery* 87(336): http://www.antiquity.ac.uk/projgall/mentessidi336/

Karamitrou-Mentessidi, G. 2014. "About prehistoric sites in western Macedonia: prefectures of Kozani and Grevena". In *A Century of Research in Prehistoric Macedonia: 1912–2012.* International Conference Proceedings, eds. E. Stefani, N. Merousis, A. Dimoula, 233–250. Thessaloniki: Archaeological Museum of Thessaloniki.

Krahtopoulou, A., C. Frederick, H.A. Orengo, A. Dimoula, N. Saridaki, S. Kyrillidou and A. Garcia-Molsosa. 2020. "Re-discovering the Neolithic landscapes of western Thessaly, central Greece". In *Current approaches to tells in the prehistoric old World*, eds. A. Blanco-González and T. L. Kienlin, 25–40. Oxford: Oxbow Books.

Kyparissi-Apostolika, N. 2000. "Η Νεολιθική Εποχή στην σπήλαιο της Θεόπετρας (The Neolithic Age in the cave of Theopetra)". In *Σπήλαιο Θεόπετρας. Δώδεκα χρόνια ανασκαφών και έρευνας 1987–1998, Πρακτικά Διευθνούς Συνεδρίου.* Theopetra Cave: Twelve Years of Excavation and Research 1987–1998, Proceedings of the International Conference, ed. N. Kyparissi- Apostolika, 181–234. Athens: The Greek Ministry of Culture and the Institute for Aegean Prehistory.

Maniatis, G. 2014. "Radiocarbon dating of the major cultural changes in prehistoric Macedonia: recent developments". In *A Century of Research in Prehistoric Macedonia: 1912–2012*. International Conference Proceedings, eds. E. Stefani, N. Merousis and A. Dimoula, 205–222. Thessaloniki: Archaeological Museum of Thessaloniki.

Maniatis, Y., K. Kotsakis, and P. Halstead. 2015. "Παλιάμπελα Κολινδρού. Νέες χρονολογίες της αρχαιότερης νεολιθικής στη Μακεδονία (Paliambela-Kolindrou: New dates of the earliest Neolithic in Macedonia)". *To Archaiologiko Ergo sti Makedonia kai Thraki (AEMTH)* 25 (2011), 149–156.

Maniatis, G. and F. Adaktylou. 2021. "Revenia-Korinos: one of the earliest Neolithic settlements in North Greece as evidenced by radiocarbon dating". *Radiocarbon* 63(3), 1025–1051. DOI:10.1017/RDC.2021.26

Milojčić-von Zumbusch, J. and V. Milojčić 1971. "*Die deutschen Ausgrabungen auf der Otzaki-Magula in Thessalien I: Das frühe Neolithikum*". Beiträge zur ur- und frühgeschichtlichen Archäologie des Mittelmeer-Kulturraumes 10–11. Bonn: Rudolf Habelt.

Mottier, Y. 1981. "*Die deutschen Ausgrabungen auf der Otzaki Magula in Thessalien II: Das mittlere Neolithikum*". Beiträge zur ur- und frühgeschichtlichen Archäologie des Mittelmeer-Kulturraumes 22. Bonn: Rudolf Habelt.

Müller, J. 1994. "*Das ostadriatische Frühneolithikum: die Impresso-Kultur und die Neolithisierung des Adriaraumes*". Prähistorische Archäologie in Südosteuropa 9. Berlin: Spiess.

Özdoğan, M. 2022. "An Annotation of Afterthoughts on the Times of Change". In *6000 BC: Transformation and Change in the Near East and Europe*. Proceedings of the Berlin Conference, November 2011, eds. P. F. Biehl and E. Rosenstock, 405–16. Cambridge and New York: Cambridge University Press.

Papadakou, T. 2011. "*Η Κεραμεική της Αρχαιότερης Νεολιθικής από τη Θέση Παλιάμπελα Κολίνδρου (The Early Neolithic Pottery from the site of Paliambela Kolindrou)*". Unpublished M.A. Thesis, Department of Archaeology, Aristotle University of Thessaloniki. https://ikee.lib.auth.gr/record/127307/files/GRI-2011-7316.pdf

Papadopoulou, M. 1958. "Μαγουλίτσα, νεολιθικός συνοικισμός παρά την Καρδίτσαν (Magulitsa, a Neolithic settlement outside of Karditsa)". *Thessalika* A, 39–49.

Papaioannou, A. 2011. "*Η κεραμική από τους Λάκκους 7 και 11 της πρώϊμης νεολιθικής θέσης Ρεβενίων Κορινού (*The pottery from Pits 7 and 11 of the early Neolithic site of Revenia Korinos)". Unpublished M.A. Thesis, Department of Archaeology, Aristotle University of Thessaloniki. http://ikee.lib.auth.gr/record/127308/files/GRI-2011-7317.pdf

Pyke, G. 1996. "Structures and Architecture". In *Nea Nikomedeia I. The Excavation of an Early Neolithic Village in Northern Greece 1961–1964*, eds. R. J. Rodden, G. Pyke, P. Yiouni, and K.A. Wardle, 39–54. Oxford and Northampton: Alden Press Limited.

Reingruber, A. 2008. "*Die Argissa Magula: Das frühe und das beginnende mittlere Neolithikum im Lichte transägäischer Beziehungen. Die deutschen Ausgrabungen auf der Argissa Magula II*". Beiträge zur ur- und frühgeschichtlichen Archäologie des Mittelmeer-Kulturraumes 35. Bonn: Rudolf Habelt.

Reingruber, A. 2018. "Geographical mobility and social motility in the Aegean before and after 6600 BC". *Praehistorische Zeitschrift* 93(1): 1–24. https://doi.org/10.1515/pz-2018-0005

Reingruber, A. 2022. "Regional Styles and Supra-regional Networks in the Aegean Before and Around 6000 cal BC". In *6000 BC: Transformation and Change in the Near East and Europe*. Proceedings of the Berlin Conference, November 2011, eds. P. F. Biehl and E. Rosenstock, 247–60. Cambridge and New York: Cambridge University Press. DOI: https://doi.org/10.1017/9781107337640.018

Reingruber, A and L. Thissen. 2017. "Analysis, Region II – The Aegean, Subregion IIc – Western Aegean: 1. Northern Central Greece". In *The 14SEA Project: A ^{14}C database for Southeast Europe and Anatolia (10,000–3000 cal BC)*, eds. A. Reingruber and L. Thissen. http://www.14SEA.org.

Reingruber, A., G. Toufexis, N. Kyparissi-Apostolika, M. Anetakis, Y. Maniatis and Y. Facorellis. 2017. "Neolithic Thessaly: Radiocarbon dated periods and phases". *Documenta Praehistorica* 44, 34–53.

Reingruber, A., G. Toufexis and Y. Maniatis. 2021. "Elateia 1 in northeastern Thessaly 8000 years ago: relative and absolute chronology of a flat extended settlement". *Documenta Praehistorica* 48: 184–201.

Ridley, C. and K. A. Wardle. 1979. "Rescue Excavations at Servia 1971–73: A Preliminary Report". In *Rescue Excavations at Servia 1971-1973: A Preliminary Report*, eds. M. Wijnen, C. Ridley, K. A. Wardle, R. N. L. Hubbard, J. P. N Watson, and R. E. Jones, 185–226. Athens: The Annual of the British School at Athens 74.

Sağlamtimur, H. 2012. "The Neolithic Settlement of Ege Gübre", In *The Neolithic in Turkey. New excavations and new research. Vol. 4 – Western Turkey*, eds. M. Özdoğan, N. Başgelen and P. Kuniholm, 197–225. Istanbul: Archaeology and Art Publications.

Schachermeyr, F. 1976. "*Die Ägäische Frühzeit I*". Wien: Verlag der Österreichische Akademie der Wissenschaften.

Sofronidou M. and S. Dimitriadis. 2014. "Συνέχειες και ασυνέχειες στην κεραμική των πρώιμων φάσεων του νεολιθικού Δισπηλιού" (Continuities and discontinuities in the pottery of the early phases of Neolithic Dispilio). In *A Century of Research in Prehistoric Macedonia: 1912–2012*. International Conference Proceedings, eds. E. Stefani, N. Merousis and A. Dimoula, 537–548. Thessaloniki: Archaeological Museum of Thessaloniki.

Sordinas, A. 1969. "Investigations of the Prehistory of Corfu during 1964–66." *Balkan Studies* 10(2), 393–424.

Starnini, E. 2018. "The Figurines from the Early Neolithic Settlement of Mavropigi (Western Greek Macedonia) and their Significance in the Neolithization Process of Greece". *Eurasian Prehistory* 14(1–2), 55–152.

Stratouli, G. and D. Kloukinas 2020. "Transformations of Settlement Space at Neolithic Avgi, NW Greece". In *Making Spaces into Places*, eds. N.N. Tasić, D. Urem-Kotsou and M. Burić, 43–52. BAR International Series 3001. Oxford: BAR Publishing.

Theocharis, D. R. 1962. "Από τη νεολιθική Θεσσαλία (From Neolithic Thessaly)". *Θεσσαλικά* Δ΄ (*Thessalika* 4), 63–83.

Theocharis, D. R. 1973. "*Neolithic Greece"*. Athens: National Bank of Greece.

Thissen, L. 2000. "A Chronological Framework for the Neolithisation of the Southern Balkans". In Karanovo Band III, eds. St. Hiller and V. Nikolov, 193–212. Beiträge zum Neolithikum in Südosteuropa. Österreichisch-bulgarische Ausgrabungen und Forschungen in Karanovo. Internationales Symposium 1997. Vienna: Phoibos Verlag.

Toufexis, G. 1994. "Ανασκαφή στο νεολιθικό οικισμό Κρεμαστός του Νομού Γρεβενών" (Excavation in the Neolithic settlement of Kremastos in the Prefecture of Grevena). *To Archaiologiko Ergo sti Makedonia kai Thraki (AEMTH)* 8, 17–26.

Tsigka, M. 2018. "*Incised and impressed pottery during the Neolithic period in Western Macedonia*". A thesis submitted for the degree of Master of Arts (MA) in the Classical Archaeology and the Ancient History of Macedonia, International University of Thessaloniki, School of Humanities. https://repository.ihu.edu.gr/xmlui/bitstream/handle/11544/29388/Dissertation.pdf?sequence=1

Tsonos, A. 2018. "Η Λευκάδα και οι σχέσεις της με τα Βαλκάνια κατά τη Νεολιθική Εποχή και την Εποχή του Χαλκού" (Lefkada and its relations with the Balkans during the Neolithic Age and the Bronze Age). In *Το Αρχαιολογικό Έργο στην Αιτωλοακαρνανία και στη Λευκάδα από τους προϊστορικούς έως τους ρωμαϊκούς χρόνους* (The Archaeological Project in Aetoloakarnania and Lefkada from the Prehistoric to the Romans times), eds. O. Vikatos, V. Staikou and F. Sarantis, 493-507 Proceedings of the 2nd International Archaeological and Historical Conference. Messolonghi: Ephorate of Antiquities of Aetoloakarnania and Lefkada.

Tsountas, C. 1908. "*Αἱ προϊστορικαί ακρπόλεις Διμηνίου καί Σέσκλου"* (The prehistoric citadels of Dimini and Sesklo). Athens: Sakellarios.

Urem-Kotsou, D., A. Papaioannou, T. Papadokou, N. Saridaki and Z. Intze. 2014. "Pottery and stylistic boundaries. Early and middle neolithic pottery in Macedonia". In *A Century of Research in Prehistoric Macedonia: 1912–2012.*, eds. E. Stefani, N. Merousis and A. Dimoula, 505–517. International Conference Proceedings. Thessaloniki: Archaeological Museum of Thessaloniki.

Urem-Kotsou, D., A. Dimoula, G. Elezi, T. Papadakou, A. Papiaonnou, N. Saridaki, I. Siamidou, T. Silva, E. Tzemopoulou and K. Kotsakis. 2017. "Patterns in Contemporaneous Ceramic Traditions: Interregional Relations between Thessaly and Macedonia during the Early and Middle Neolithic". In "*Communities, Landscapes and Interaction in Neolithic Greece*", eds. A. Sarris, E. Kalogiropoulou, T. Kalayci and L. Karimali, 324-338. Proceedings from the International Conference, Institute for Mediterranean Studies, Rethymno, Crete, 29–30 May 2015: 324–338. Michigan: Ann Arbor.

Vasileiou, E. 2016. "Episkopi (Ioannina, Greece): a Neolithic extended settlement in central Epirus". *Antiquity Project Gallery* 90(350): https://www.antiquity.ac.uk/projgall/vasileiou350

Velde, G. 1912. "Anthropologische Untersuchungen und Grabung in einer Höhle der jüngeren Steinzeit auf Levkas" (mit einem Vorwort von W. Dörpfeld). *Zeitschrift für Ethnologie*, 44(5), 845–864.

Wace, A. J. B. and M. S. Thompson. 1912. "*Prehistoric Thessaly*". Cambridge: University Press.

Wijnen, M. 1981. "*The Early Neolithic I Settlement at Sesklo: An Early Farming Community in Thessaly, Greece*". Analecta Praehistoric Leinesia 14. Leiden: Leiden University Press.

Wilkie, N. and M. Savina. 1997. "The Earliest Farmers in Macedonia". *Antiquity* 71: 201–207.

Winn, S. and D. Shimabuku. 1989. "Pottery". In *Achilleion. A Neolithic Settlement in Thessaly, Greece, 6400–5600 BC*, eds. M. Gimbutas, S. Winn and D. Shimabuku, 75–164. Los Angeles: Institute of Archaeology, University of California.

Yanovich, I. 2021. "Including Explicit Priors on Phase Duration in Bayesian 14C Dating. Re-evaluating the Dates for Basal Knossos and for Nea Nikomedeia (Early Aegean Neolithic)". *Documenta Praehistorica* 48, 2–23.

Yiouni, P. 1996. "The Early Neolithic Pottery: Technology. Analysis and Comparison with other Neolithic Ceramic Materials". In "*Nea Nikomedeia I. The Excavation of an Early Neolithic Village in Northern Greece 1961–1964*", eds. R. J. Rodden, G. Pyke, P. Yiouni, and K. A. Wardle, 55–193. Oxford and Northampton: Alden Press Limited.

Zilhão, J. 2001. "Radiocarbon evidence for maritime pioneer colonisation at the origins of farming in west Mediterranean Europe". *Proceedings of the National Academy of Sciences of the United States of America* 98(24): 14180–14185.

3.

Calibrated chronology of the Neolithic tells in Pelagonia

Goce Naumov

Abstract The article gives a revised, and updated chronological overview of the Pelagonian Neolithic tell sites. The dates mainly originate from older measurements of the second half of the twentieth century but have not, thus far, been systematically put into proper context using modern statistical methods. The paper presents a combination of contexts retrieved during original archaeological excavations of the 1970s with documented contexts to produce a detailed chronology of the Neolithic tell settlements in Pelagonia.

Keywords: Balkans, Macedonia, Pelagonia, Neolithic, Tells, ^{14}C Chronology, Bayesian modelling

Laboratory dating of archaeological sites has been a regular practice in world science for approximately seven decades. Establishing radiocarbon analyses and their advancement through applying AMS analyses led to a revolutionary determination of the time frames for past settlements. Although relative chronology and analogies in the material culture remain the primary method in excavations and chronological references, laboratory results have made it possible to move much more precisely through various stages of the past, primarily through those belonging to prehistory. Due to the frequent processing of samples of charcoal, wood, seeds, bones and other organic materials, the beginnings of the Neolithic were established in diverse regions, including the Balkans. Such data from Neolithic settlements in Greece, Bulgaria, Albania, Serbia and Romania established the formation of the first agricultural villages in the second half of the seventh millennium BC. (Reingruber and Thissen 2005; Reingruber and Thissen 2009; Reingruber et al. 2023). The same was done for the Neolithic in Macedonia, mostly through the data obtained from the analyses of samples from Amzabegovo (Bien and Pandolfi 1972; Gimbutas 1976; Linick 1977). Unfortunately, since these analyses (performed in the 1970s) to date, little has been done for dating the Neolithic sites in Macedonia accurately.

Only a few settlements, and mostly in the last ten years, have been dated using the radiocarbon method, while AMS analyses have rarely been applied. The only dating of ceramic finds through thermoluminescence has been done on the material from Amzabegovo, but unfortunately, it remains the only such example (Gimbutas 1976). The situation with the laboratory dating of the Neolithic sites in Pelagonia is the same, with one exception for this region, which will be given more attention in this paper. Namely, for eight prehistoric sites from this region, C^{14} analyses were made in the 1970s (and one in the following decade); however, these data were not used in Macedonian archeology at all. Until 2009, no Macedonian archaeologist used these data, although they were published approximately forty years ago (Srdoć et al. 1977; Valastro et al. 1977). They were indirectly mentioned only in a few works that made a general overview of the Neolithic sites in the Balkans (Nikolova 1998; Thissen 2000; Whittle et al. 2005), and recently they started to be used in Macedonian archeology as well (Fidanoski 2009a; Fidanoski 2019; Naumov 2009; Naumov 2015; Naumov 2016a). However, in none of the general reviews of the Neolithic in Macedonia were these data used, although the results of the analyses were already available (Garašanin 1979; Mitrevski 2003; Mitrevski 2006; Mitrevski 2013; Sanev 1994; Sanev 1995; Zdravkovski 2006). Despite that, the entire chronology of the Neolithic in Macedonia was based on the dates from Amzabegovo, including that relating to Pelagonia, even though there were laboratory analyses that suggested a different chronological framework.

The dating of the prehistoric sites in Pelagonia was carried out more than five decades ago, long before the advancement of chronological analyses and interpretations with the help of calibration, Bayesian statistical modelling and the AMS method. These radiocarbon analyses from Pelagonia seem outdated today, as current chronologies are primarily based on samples obtained from the latest excavations. Considering that after the eighties of the last century, only a few analyses have been made for the sites in Pelagonia, it is necessary to use the results of this laboratory research, at least until the next chronological data based on samples from the new excavations. Until then, this information will be used to determine the time frame of the Pelagonian Neolithic, and they can complement the chronological picture of the Neolithic in Macedonia. For those reasons, a review will be made of the radiocarbon analyses of several sites from Pelagonia, whose dates were recently calibrated and published on several occasions (Naumov and Tomaž 2015; Naumov 2016a; Naumov et al. 2021a; Naumov et al. 2023).

The Neolithic in Pelagonia

Pelagonia is the largest valley in the Republic of Macedonia, which is located in its southwestern part (**Fig. 1**). Its alluvial plain, formed by a Neogene lake, is surrounded by several high mountains that create a closed and relatively isolated entity (Dumurdjanov et al. 2004; Mirčovski et al. 2015; Trifunovski 1997). Frequent rainfall and fertile soil near most wetlands allowed constant access to raw materials, which ensured a stable livelihood for many generations (Puteska et al. 2015). Such conditions and environment did not differ much from those in the Neolithic, which enabled the rapid inhabitation of a large number of agricultural communities at the end of the seventh millennium BC. The high density of Neolithic settlements established on tells and the multitude of finds on their surface attracted the interest of many archaeologists. These sites were investigated in several stages by applying different methods while providing initial insights into the emergence and development of the Neolithic in this region.

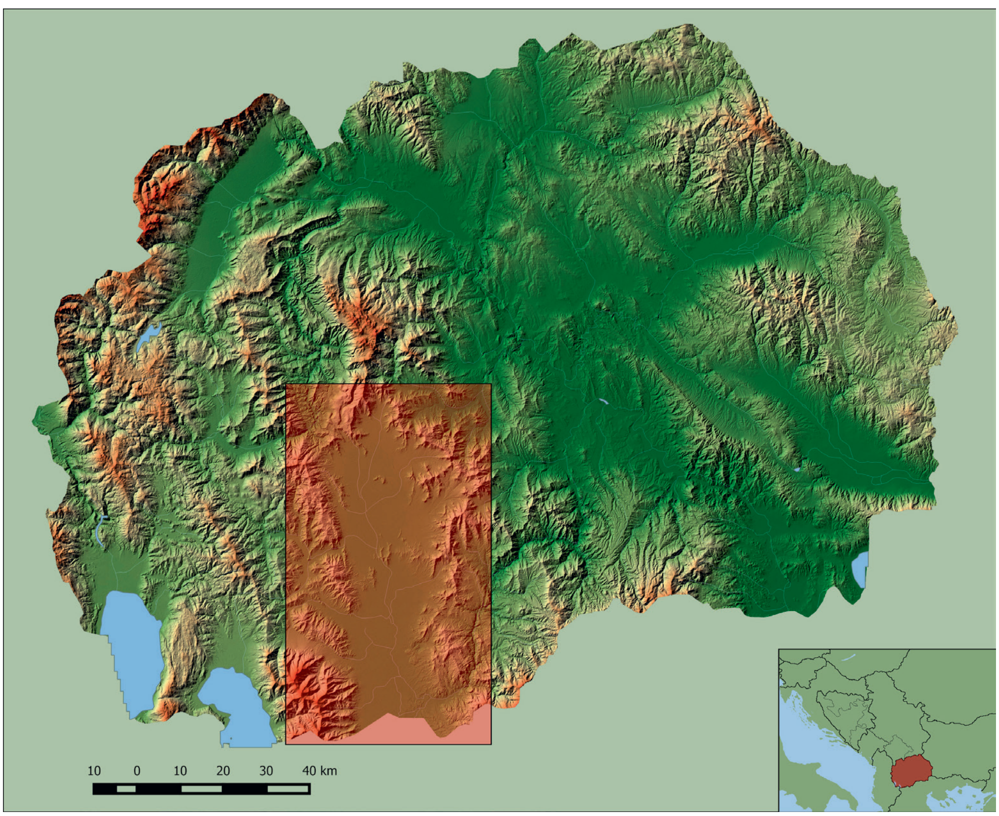

Figure 1. *Map of the Republic of Macedonia with an indication of Pelagonia in red*

The most significant upsurge of archaeological research on the tells in Pelagonia was at the same time when the aforementioned chronological analyses were performed, that is, in the seventies of the last century. At that time, Dragica Simoska, Blagoja Kitanoski, Voislav Sanev and Jovan Todorović excavated a dozen tells, although the previous research of Miodrag Grbić and Josip Korošec, who have a part in the study of this region, should not be neglected either (Grbić et al. 1960; Kitanoski 1977; Kitanoski et al. 1980; Simoska and Sanev 1975; Simoska and Sanev 1976; Simoska and Sanev 1977; Simoska et al. 1979). These excavations were preceded by the research of Walter Heurtley and Vladimir Fewkes, which, despite being before World War II and of a smaller scale, still provided an initial picture of the layout of the prehistoric tells in Pelagonia (Fewkes 1934; Heurtley 1939). After the archaeological boom about sixty years ago, research in this region was suddenly absent until a few years ago. Meanwhile, only a small part of the tells was sporadically investigated, mainly in the Prilep part of Pelagonia (Kitanoski et al. 1983; Kitanoski et al. 1987; Simoska and Kuzman 1990; Temelkoski and Mitkoski 2006; Temelkoski and Mitkoski 2008). However, in the last decade, the intensity of research in this region has increased, through the application of multidisciplinary research, such as geomagnetic scanning of settlements, GIS mapping of sites, excavations of tells, archaeobotanical, archaeozoological, geoarchaeological, lipid and use-wear analyses, as well as the calibration of chronological dates (Naumov et al. 2013; Naumov and Tomaž 2015; Naumov 2016a; Naumov et al. 2017a; Naumov et al. 2018; Naumov et al. 2021a; Naumov et al. 2020; Naumov et al. 2023).

Although modest in scope, archaeological research in the last six decades has provided elementary knowledge about the Neolithic in Pelagonia. Thanks to the clear features of the pottery, the sites from this region were determined within the so-called cultural group Velušina-Porodin (Garašanin 1979; Sanev 1994). Although from today's perspective, the cultural definition of the sites is debatable, especially since similar elements are present in the Ohrid and Korča regions (Naumov 2016b), this traditional approach of cultural-historical archeology enabled the specificity of the Pelagonian Neolithic to be highlighted in the 1970s. The characteristic white-painted vessels and anthropomorphic house models (Figure 2) contribute to this to a great extent, which also represents one of the most complex symbolic forms in the Balkan Neolithic through which the local identities of the agricultural communities of this plain are manifested (Chausidis 2010; Naumov 2010; Naumov 2013; Temelkoski and Mitkoski 2005). Also, the density of settlements in Pelagonia is unusual, considering that more than half of the Neolithic sites in Macedonia are located in this region (Naumov and Stojkoski 2015; Naumov 2016a; Naumov et al. 2017a; Simoska and Sanev 1976). And the rest of the archaeological material – such as figurines, altars, stamps and tools – demonstrate the specific features of the societies in Pelagonia, although they are similar to those of the surrounding regions.

A precise chronological framework in Pelagonia has still not been written. Its temporal determination was usually attributed to the Amzabegovo-Vršnik cultural group, i.e., in the time between the seventh and fifth millennium BC (Sanev 1995). Even the division of Neolithic phases was done in the same way, even though in Pelagonia, there are no clear demarcations between the Early and Middle Neolithic. Ceramic material has mostly been used as a chronological reference in the determination of phases, although there are no stable indicators for such archaeological and probably artificial determination of phases in the Neolithic (Naumov et al. 2020). As a result, vessels were used as an indicator of relative chronology, with the help of the chronological sequence of the Neolithic sites and those of other prehistoric periods.

This would be wholly justified in the absence of exact chronological data, but the published results of radiocarbon analyses of the Pelagonian sites were available and should have been used in Macedonian archaeology much earlier. For those reasons, instead of a more thorough consideration of the material culture from Pelagonia, this paper will provide a complete overview of the results of the C^{14} analyses and their calibration. Even though these dates might be outdated for their more systematic inclusion in the chronology of the Balkan Neolithic, their elaboration is still necessary because, at the moment, they provide the only exact information about the time determination of the Neolithic in Pelagonia.

Figure 2. *Neolithic vessels, figurines and models from the sites of Tumba and Veluška Tumba at Porodin:*

1. h – 48 cm (Fidanoski 2009, T. 66, 7); 2. w – 23 cm (Fidanoski 2009, T. 66, 5); 3. h – 17 cm (Fidanoski 2009, T. 67, 3); 4. h – 7 cm (Kolištrkoska Nasteva 2005, Figure 7); 5. h – 12 cm (Kolištrkoska Nasteva 2005, Figure 26); 6. h – 6 cm (Kolištrkoska Nasteva 2005, Figure 5); 7. no scale (Vasileva 2005, 40); 8. h – 25 cm (Kolištrkoska Nasteva 2005, Figure 43); 9. no scale (Vasileva 2005, 40).

The Chronology of the Neolithic Tells

As stated above, in Macedonian archaeology, the time of establishment and function of the Pelagonian Neolithic sites is based solely on relative chronology. This is usually done in relation to other sites from Macedonia, but seldom to those in neighbouring regions from Greece and Albania, except for analogies at the level of material culture (Benac 1989; Garašanin 1979; Sanev 1994). According to initial knowledge, it is considered that the Neolithic in Pelagonian flatlands began a little later due to frequent floods and groundwater emergence, although several uncertain dates suggest much earlier processes of the Neolithisation (Kitanoski et al. 1980; Naumov 2009; Naumov 2015). The results from the surrounding regions in Greece and Albania indicate that the earliest agricultural communities formed their first settlements in the second half of the seventh millennium BC, which is also confirmed by several dates in Pelagonia (Allen et al. 2014; Bunguri 2014; Naumov and Tomaž 2015; Naumov 2016a; Naumov et al. 2023; Reingruber and Thissen 2009; Reingruber et al. 2023). These dates from the sites in Pelagonia lead to a more precise determination of the entire time span of the Neolithic, which is why they deserve a more detailed elaboration on this occasion.

Interestingly, almost all the dates obtained for Pelagonia come from the 1970s, concurrently with the flourishing of archaeological research in this region. The heads of the research, Dragica Simoska and Voislav Sanev, in the spirit of the scientific enthusiasm of the time, sent samples from several sites to laboratories in Zagreb (Croatia) and Austin (Texas, USA). The results of the analyses were then published, giving the first radiocarbon dates for Pelagonia (Srdoć et al. 1977; Valastro et al. 1977). Later in the 1980s, results were also obtained from the site at Markovi Kuli in Prilep, investigated and dated by a Polish team (Pazdur 1990). Unfortunately, after these studies, no other analyses were made for sites in Pelagonia except those from current research (Naumov et al. 2018; Naumov et al. 2021a; Naumov et al. 2023). During these analyses in the 1970s and 1980s, samples from eight sites were processed, of which six were dated to the Neolithic. These sites will be elaborated in detail to determine the possible chronological frame for the Neolithic tells in Pelagonia, while the dates from current research will be mentioned in the concluding remarks as they are under Bayesian modelling now and will be published as a detailed chronological sequence elsewhere.

During the calibration of the chronological data from the 1970s, the dates published in the journal Radiocarbon (the editions 19/2 and 19/3 issued in 1977) were used. The samples from Topolčani and Mogila were analysed in the laboratory of the ‘Ruđer Bošković Institute, while those from Veluška Tumba and Tumba near Porodin and Golema Tumba near Trn were processed at the University of Texas at Austin (Srdoć et al. 1977; Valastro et al. 1977). In the papers where the results of the analyses are published, the introductory part explains the process of processing the samples and how the obtained chronological values were reached. How compatible these procedures are with today’s approach to processing charcoal, and seed samples remains to be discussed. However, besides those from the current research, these were the only analyses that have been made on samples from Pelagonia, which is why they are taken into account in this review of the chronology of Neolithic sites in this area. The chronological values obtained from these analyses were recently calibrated by the author of this paper in OxCal v4.2.4 software and the IntCal 13 supplement for determining the atmospheric curve, produced by the Oxford Radiocarbon Accelerator Unit (Bronk Ramsey 2009; Reimer et al. 2013). The results of the calibration of the samples from the sites near Topolčani, Mogila, Porodin, Trn and Markovi Kuli are elaborated below, as well as their chronological layout within the Neolithic phases. Also, the dates from recent dating of Vrbjanska Čuka, Vlaho, and Veluška Tumba will be mentioned regarding dates from the 1970s, although some of them were already calibrated and published or will be included in forthcoming publications.

Topolčani

The Neolithic settlement of Čuka is located near the village of Topolčani, that is, in the upper half of the Pelagonian plain (Figure 3). It was researched on several occasions under Blagoja Kitanoski and in collaboration with Dragica Simoska and Jovan Todorovic (Kitanoski 1977; Kitanoski et al. 1983). The settlement contains the common elements for the Neolithic communities in Pelagonia, including the typical Early Neolithic vessels, anthropomorphic house models, ‘altars’, figurines, sanding balls, etc. The dates obtained during the analyses of the charcoal samples complement the knowledge and coincide with the archaeological material found. Two samples were sent for analysis, i.e., Z-494 from layers 15–16 in probe

I and Z-495 I from layer 22 in the same probe (Srdoć et al. 1977). Although the second sample stratigraphically belongs to a lower, i.e., probably older layer, its chronological value is 7010±190 BP, while that of the sample from the upper layer is 7680±160 BP. There are several explanations for this situation. The younger sample from layer 22 could belong to a pit that is younger than layers 15–16, or the measurement of the layers was done in reverse, that is, from the oldest with the lowest numerical value to the youngest with the highest number, which was a rare archaeological practice in Macedonia.

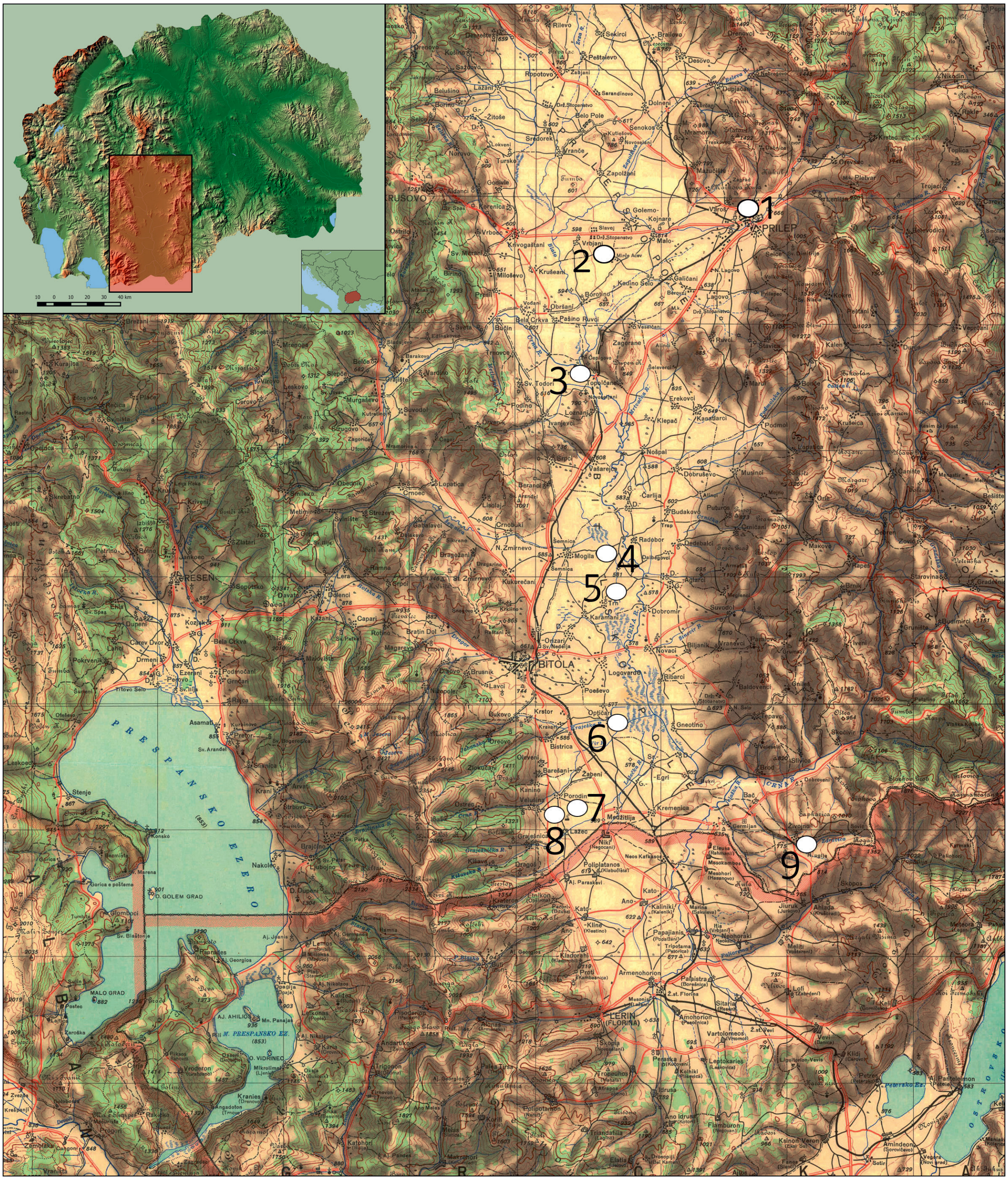

Figure 3. *Map of Pelagonia with the sites involved in the calibration of the radiocarbon dates: 1. Markovi Kuli – Prilep; 2. Vrbjanska Čuka – Slavej; 3. Čuka – Topolčani; 4. Tumba Sredselo – Mogila; 5. Golema Tumba – Trn; 6. Tumba – Optičari; 7. Tumba – Porodin; 8. Veluška Tumba – Porodin; 9. Vlaho – Živojno.*

In any case, the analysed samples give very different dates, and the question is, do the layers belong to such different time periods? Namely, the calibration of these chronological values showed that the time of sample Z-494 (7680±160 BP) can be related to the period between 6862 and 6236 cal BC with 87.7% probability of accuracy, while that of sample Z-495 (7010±190 BP) ranges between 6253 and 5558 cal BC with 95.1% probability (Figure 4a). This means the approximate years related to these samples are around 6500 BC for Z-494 and 5950 BC for Z-495 (Figure 4b). In the context of the chronology of Neolithic settlements, the latter date seems far more likely. However, the first and much earlier date goes beyond the established norms for the beginnings of the Neolithic in this part of the Balkans, although such dates have been indicated for several sites in Greece, Albania and Macedonia, which will be discussed below (Allen et al. 2014; Andoni et al. 2017; Bonga 2020; Naumov et al. 2023; Reingruber 2011; Reingruber et al. 2023). Such a date can be the result of several factors or refer to a few conditions: 1) unstable processing of the sample in the laboratory; 2) the sample may belong to organic material that is older than the time when it was used in the settlement; 3) the sample was actually used in the time indicated by the calibrated data of the radiocarbon analyses.

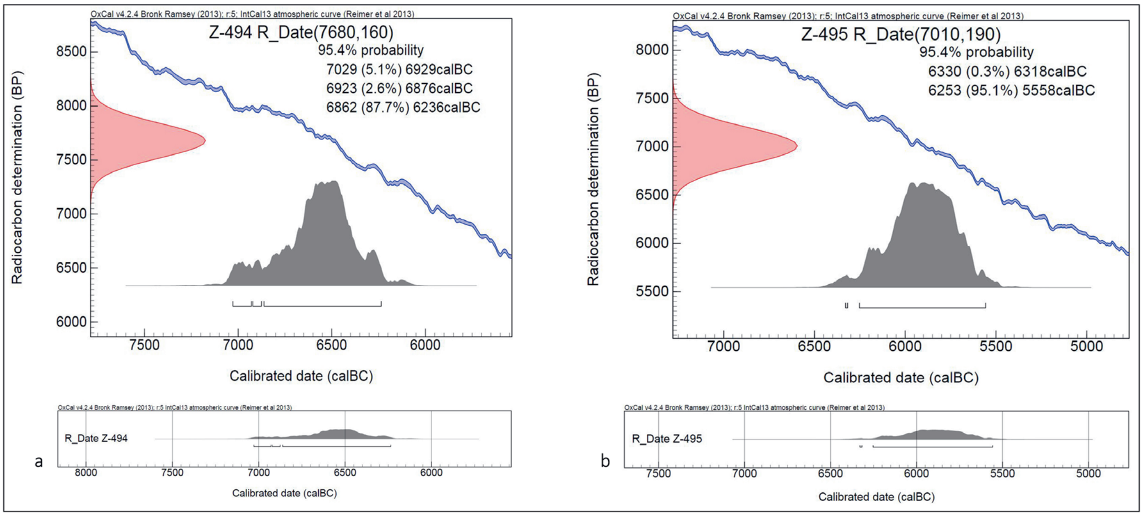

Figure 4. *Calibrated dates from Čuka – Topolčani*

These deviations from the expected time frames are not uncommon in radiocarbon analyses and are usually taken with caution. But even if this date is correct, there are hypotheses for an earlier establishment of the first agricultural communities in the Balkans, which several archaeologists have already seriously begun to consider (Perlés 2001). In that case, the settlement near Topolčani would be one of those rare ones that were created within the first waves of Neolithisation. But to prove or disapprove that, new analyses of more samples from the lowest layers of the tell are necessary. Until then, this early date will only be indicative of a probability that needs to be further investigated through future archaeological research and laboratory analysis.

Mogila

The tells at Mogila are located in the very middle of the Pelagonian plain (Figure 3). It is a complex of several tells concentrated in the village of Mogila itself but also outside it. The density of tells initially led archaeologists to register a more significant number of such settlements (Simoska and Sanev 1976); however, if the construction of village streets and public buildings is taken into account, then it is probably a matter of modern artificial division of a larger tell that had a central character if compared to the rest (Naumov et al. 2013). The excavation of these tells, carried out in several archaeological campaigns from the 1970s to 2014, was concentrated on the central settlement, i.e., in the middle of the village (Naumov and Tomaž 2015; Simoska et al. 1979; Simoska 1988). Different archaeological teams have excavated the central and peripheral parts of the tell, but the stratigraphic layout and results are almost identical. The usual elements for the Early Neolithic in Pelagonia were also found at this site, and they largely coincide with those of the other sites, although some stand out for their specificity.

From this site, 3 charcoal samples from three different horizons were analysed: Z-496 from layer 11 in horizon I, Z-497 from layers 14–25 in horizon II and Z-498 from layer 28 in horizon III (Srdoć et al. 1977). The chronological value of the second sample Z-497 is 1480±80 BP, and it deviates significantly from the other dates. However, its calibration and dating in the VI century AD and belonging to the II horizon is not surprising because the excavations confirmed archaeological material from this period and numerous intrusions of Medieval pits into the Neolithic layers (Naumov and Tomaž 2015; Simoska et al. 1979).

Unlike those in Topolčani, the other two dates coincide entirely with the Neolithic chronology in Pelagonia, but their presence in the layers corresponds to the stratigraphic layout of the site. The chronological value of the third date (Z-498) is 7010±190 BP; it refers to material originating from the period between 6253 and 5558 cal BC with 95.1% probability (Figure 5a). Its chronological setting would be around 5900 BC, which is closely related to one of the dates in Topolčani. Comparing these dates from Mogila and Topolčani, it can be noted that they have an identical chronological value of 7010±190 BP (Srdoć et al. 1977). Here the question arises whether the identical values of these dates are correct or result from an error: repeating the numbers for different samples (Z-495 and Z-498). Such a question is difficult to answer without having access to the archived documentation of the laboratory analyses, so these two dates remain to be used with a certain amount of reserve.

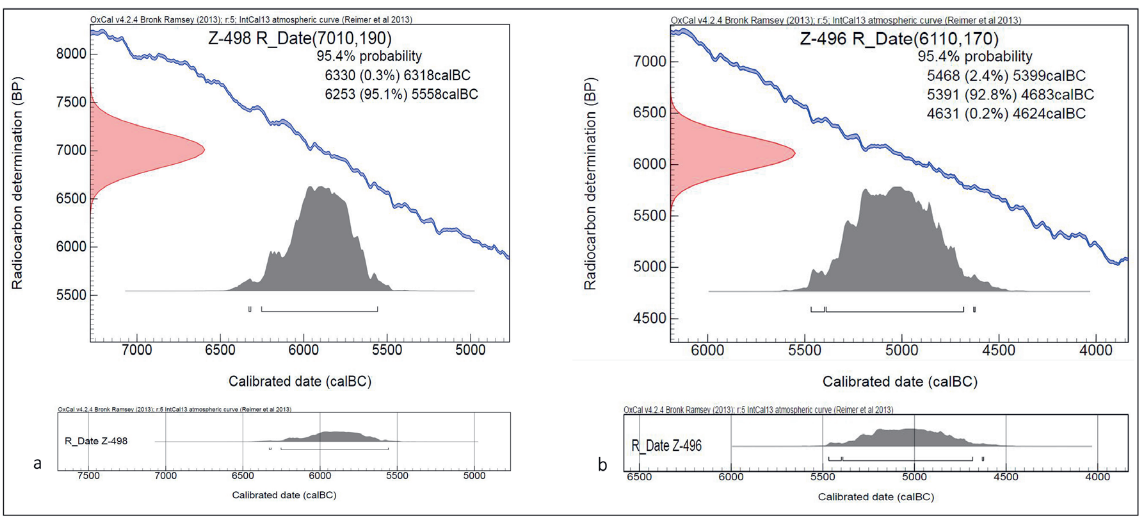

Figure 5. *Calibrated dates from Tumba Sredselo – Mogila*

The second date from Mogila (Z-496) is much younger but still belongs to the Neolithic. Its chronological value is 6110±170 BP, while the calibration specifies the dating in the period between 5391 and 4683 cal BC with a probability of 92.8% (Figure 5b). Although the time span for this date is quite broad, it can still be considered that the analysed sample belongs to the period around 5000 BC. Therefore, this sample can be dated to the Late Neolithic period, a time which, according to the material culture of this site, deviates from the usual characteristics for this period in Pelagonia (Benac 1979; Sanev 1995). This problem will be thoroughly discussed below, although it should be emphasised that this situation may refer to an inadequate sample or to the need for a more precise redefinition of the Late Neolithic in this region (Naumov 2016b).

Porodin

At the village of Porodin, three tells were investigated: Tumba, Veluška Tumba and Tumba Bara (Grbić et al. 1960; Simoska and Sanev 1975; Sanev and Simoska 1983). Due to their specificity, they were defined as eponymous sites, hence the naming of the cultural group 'Velušina-Porodin' (Garašanin 1979; Simoska and Sanev 1976). In Macedonian archaeology, this cultural group remained synonymous with the Neolithic in Pelagonia, although its features are clearly present in the Ohrid region as well, an area with which Pelagonia was in intense contact throughout the Neolithic (Naumov 2016b; Naumov 2020). Tumba and Veluška Tumba are the two sites that were dated in the 1970s, although recent dating was made that will be considered in the discussion and concluding remarks of the paper.

Veluška Tumba

This tell is positioned about half a kilometre south of the village of Porodin (Figure 3). It may be one of the most explored sites in Pelagonia, but, unfortunately, the least publicised until recent research (Naumov et al. 2017b; Naumov et al. 2020; Naumov 2022). Although it has been explored in more than 10 campaigns in different decades from the 1970s to 2013, only a few reports have been published (Simoska 1986; Simoska and Sanev 1975; Simoska and Sanev 1983; Stojanova Kanzurova 2017). Considering its common features within the material culture (white-painted vessels, anthropomorphic house models, 'altars', figurines, etc.), this tell was considered the oldest and used as a reference. Consequently, all other Neolithic sites in Pelagonia were related to it through relative chronology. However, 1970s laboratory analyses of samples from this site currently demonstrate that it is slightly younger than those at Topolčani and Mogila, although the recent dating of the site indicates quite early dates as well.

In 1972, three samples from this site were submitted to the University of Texas at Austin: charcoal, burnt wood and seeds (Valastro et al. 1977). Given the good contexts from which the samples were taken and their chronological closeness, these can be considered to be some of the best reference dates for Pelagonia. Thus, the burnt wood sample (Tx-1785) was taken from a building in phase IV, which is considered to have belonged to the earliest settlement of the site. The chronological value for the date of this sample is 6950±120 BP, while after calibration with 95.4% probability, it is calculated that the sample originates from a period between 6034 and 5635 cal BC, that is, from around 5850 BC (Figure 6a). The second sample (Tx-1786) is of wheat grains and is very similar in time to the previous one, although it belongs to a building from Phase II. The time determined during the laboratory analysis is 6890±140 BP, which, with the calibration, is defined in a range from 6032 to 5553 cal BC. Therefore, it can be considered that these grains were deposited as food raw material around 5730 BC (Figure 6b). The third sample (Tx-1809) has a very similar date to the previous one and belongs to charcoal in a post hole from a Phase II building. Its chronological value is 6900±90 BP, which through calibration with 89.2% probability, has been established that it can be dated between 5928 and 5641 cal BC, i.e., around 5750 BC (Figure 6c).

The chronological closeness of these dates, the different stratigraphy and the defined contexts from which they are taken create a solid chronological sequence. According to the calibrated dates, it can be considered that this settlement in these phases was active for at least 150 years (that is, from 5850 to 5700 BC). The youngest layers of the tell (phase/horizon I), damaged by modern agricultural activities, were not taken into account here, which is why no samples were taken for radiocarbon analysis. The laboratory analysis report also indicates a time span of 250 years for the life of this site, possibly including its final stages (Valastro et al. 1977). However, the dating of seed samples from the recent excavations of the earliest levels of Veluška Tumba indicate the establishment of this site at least at the very end of 7th millennium BC. In that context, considering all dates from this settlement, it can be proposed that it was inhabited for several hundred years, while its precise and updated chronological sequence will be available after the finalisation of the Bayesian modelling and publication of these dates.

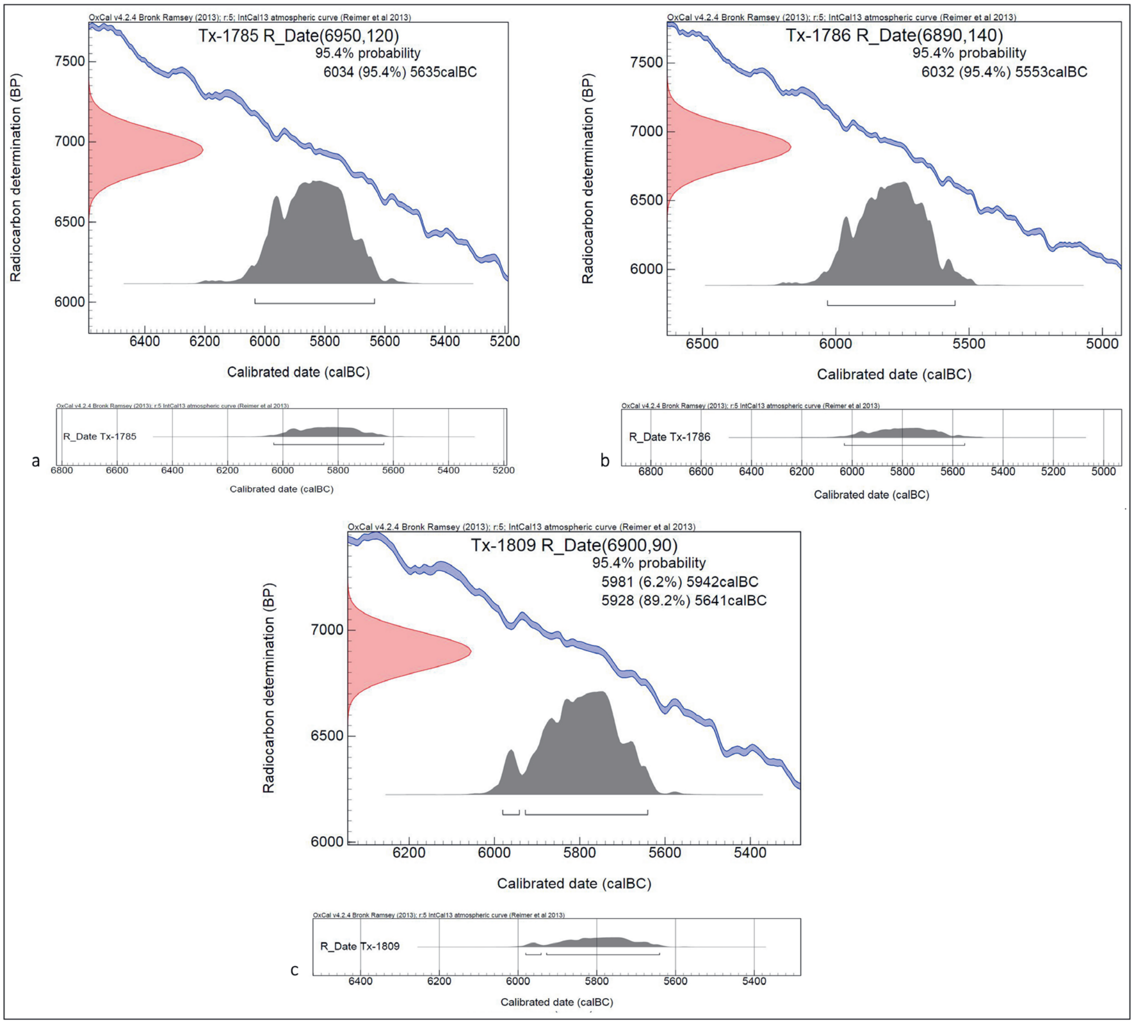

Figure 6. *Calibrated dates from Veluška Tumba – Porodin*

Tumba Porodin

The Neolithic settlement of Tumba is positioned approximately 1 km east of the village of Porodin (Figure 3). It was investigated only in two campaigns in 1953 and 1954, which also represent one of the first systematic excavations of Neolithic sites in Macedonia, after those of Grgur Tumba near Bitola (Grbić et al. 1960). This tell also stands out for its characteristic elements of material culture, which is why it is not by chance that it gets the status of the eponymous site of the so-called Velušina-Porodin cultural group. Even though it was excavated a long time ago, wheat grain samples were preserved, which were later delivered to the University of Texas at Austin, where they were processed for radiocarbon analysis (Valastro et al. 1977). The analyses demonstrate that the chronological value of the sample (Tx-1787) is 6760±60 BP, which after calibration with 95.4% probability, points to the period between 5877 and 5486 cal BC, so it could be expected that these grains could be in use around 5650 BC (Figure 7a). Although it is not indicated which horizon or layer the sample came from, the analysis report states that the material is similar to phase/horizon I and II from Veluška Tumba. This is also confirmed by the calibrated dates, which are about 100 years apart.

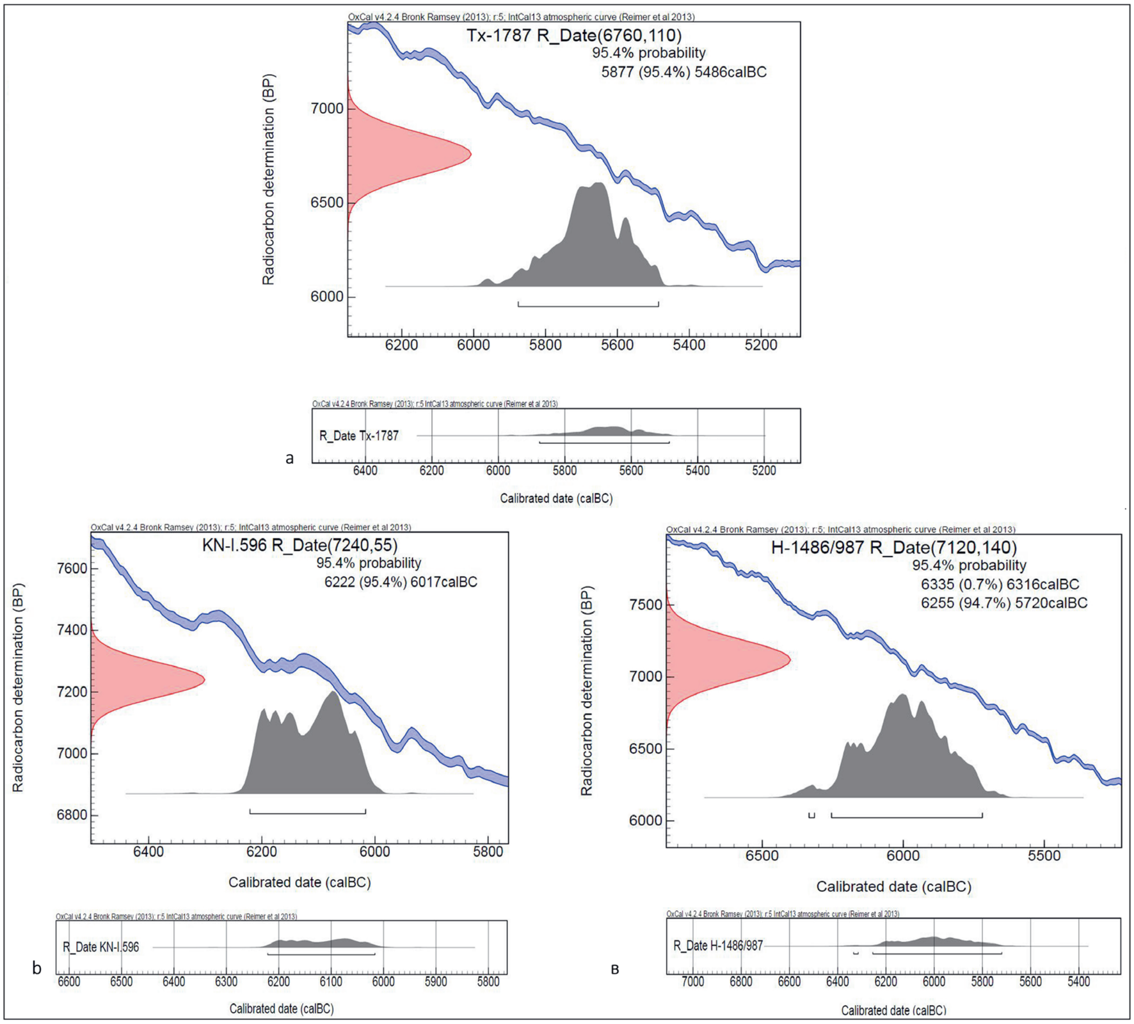

Figure 7. *Calibrated dates from Tumba – Porodin*

In the archaeological publications, there are two more samples from this site, for which the reports from radiocarbon analyses cannot be found at the moment (Nikolova 1998; Quitta and Kohl 1969). Although these dates should be considered with great reserve, they will only be briefly illustrated on this occasion without corresponding calibration graphs. In the first case, sample KN-I.596 is mentioned, for which there is no information about the type of material nor reference to where the analysis results are mentioned (Figure 7b). Its chronological value is 7240±55 BP, while the calibration with 95.4% probability points to a period between 6222 and 6017 cal BC, around 6070 BC. Such a date is relatively older than the others from the 1970s related to the tell at Porodin, but it is almost identical to the new dates from Veluška Tumba. Considering the vicinity and similarity of material culture between these two tells, this untraced date from Porodin could be considered, although new sampling and dating of the site would be necessary to test its accuracy.

The same applies to the other sample from this locality (H-1486/987). Both its origin and material are unknown, except for the name of the site and the chronological value, i.e., 7120±140 BP. The 94.7% calibration confirms a 6255 to 5720 cal BC time span, which places this sample around 6000 BC (Figure 7a). However, without further verification of the sources and calibration reports of these samples, they cannot be used in a thorough interpretation of the Pelagonian Neolithic chronology.

Markovi Kuli

In the archaeological community, the site of Markovi Kuli near Prilep is known as a Medieval town located in the northeastern part of Pelagonia (Figure 3). However, research by a Polish team in the second half of the 1980s confirmed the presence of a prehistoric settlement in the bedrock, which researchers initially dated to the Late Neolithic and Bronze Age (Cnotliwi 1990). Some of the finds confirm this dating because they have characteristic elements like those of the so-called Trn cultural group, but also indicate features common to Early and Middle Neolithic (Benac 1989; Naumov 2016b; Naumov and Mitkoski 2018). However, radiocarbon analyses demonstrate that this site can be dated to the so-called Middle Neolithic, although, as mentioned above, this phase concerning terminology is questionable.

Five samples from this site were submitted to the Silesian University of Technology in Gliwice, three of which date to the Middle Ages and one to the Iron Age (Pazdur 1990). The oldest sample (animal bone) originates from the cultural layer associated with the dwelling in the rock shelter. Its chronological value is 6680±110 BP, and the calibration with 93.9% probability points to the calendar period between 5808 and 5465 cal BC, approximately around 5600 BC (Figure 8). Given the date in relation to the archaeological material, several possible explanations can be suggested: 1) the bone sample may belong to an animal that lived hundreds of years earlier in the bedrock (died or was eaten); 2) inappropriate processing of the sample in the laboratory; 3) correct date for the Middle Neolithic, but insufficiently correct processing of the archaeological material and its attribution to the Late Neolithic. The last possibility is very likely, given that the archaeological team that worked on this site had never before studied a Neolithic settlement in Macedonia, and at the same time, their research on Markovi Kuli was mainly focused on the Medieval period.

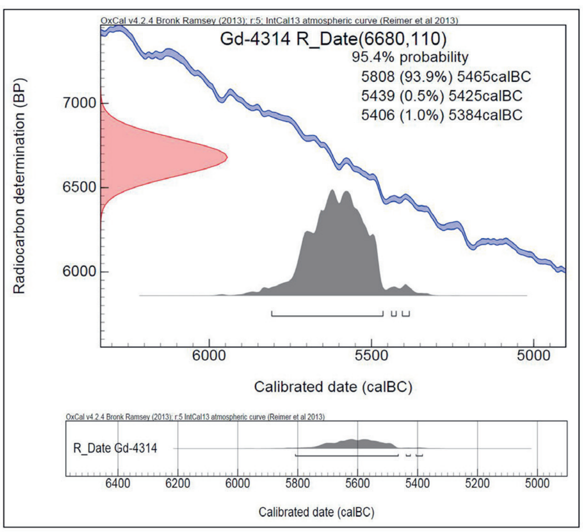

Figure 8. *Calibrated dates from Markovi Kuli – Prilep*

The modestly published material from the Neolithic settlement in the rock shelter has apparent Late Neolithic features, although forms have been discovered that correspond entirely to the shape of Middle Neolithic vessels, and even those that can be identified with the Early Neolithic in Pelagonia (Cnotliwi 1990, T.41–T.45; Naumov and Mitkoski 2018). However, regardless of the interpretations of the archaeological material, the calibrated date corresponds to the Neolithic chronology in this region and should be taken into account. According to the provided information and the small number of finds, the site could be determined as a livestock pen or a shelter that was used for a short time in the Middle Neolithic, then to be used again in the Iron Age and the Middle Ages.

Trn

There are several tells near the village of Trn, positioned in the central part of Pelagonia (Figure 3). Two of them, Golema Tumba and Mala Tumba, were investigated in 1973, bringing new knowledge about the later phases of the Neolithic in this region (Simoska and Sanev 1977). Namely, the findings indicated features that were not typical for this region, and therefore the site was established as an eponym for the so-called Trn cultural group, first attributed to the Middle and then to the Late Neolithic in Pelagonia (Benac 1979; Sanev 1994). Black polished vessels with white encrusted patterns stand out as the most representative reference of this cultural group. They were initially considered elements belonging to the Adriatic Neolithic (Benac 1989), but after much new research in the Balkans and beyond, new routes to the source of this ‘culture’ have been proposed, leading all the way to Western Turkey and Central Anatolia (Naumov 2016b). Considering the specific features and the new data, it can be quite justifiably pointed out that these settlements were active in the Late Neolithic. This is confirmed by the dates obtained for one of the excavated tells.

In 1973 three samples from the Golema Tumba site were submitted to the University of Texas at Austin, although it is not indicated what material they were from (Valastro et al. 1977). The youngest sample (Tx-1788) comes from a building in the last phase of the settlement, i.e., Horizon I. The chronological value is 5640±90 BP, whose calibration with 95.4% probability points to the period between 4691 and 4336 cal BC, around 4500 BC (Figure 9a). The next sample (Tx-1789) is from the same building and has a very similar chronological value (5670±90 BP) and a calibrated year between 4707 and 4351 cal BC, that is, around 4500 BC (Figure 9b). Given that these samples belong to the same archaeological context, this dating is entirely expected and well-founded, so it can be used as a reference for determining the age of the object and the phase in which it was used. The third sample (Tx-1790) is slightly older than the previous ones and comes from a building in the first stages of settlement, that is, from Horizon II. Its chronological value is 5950±90 BP, and the calibrated time span is from 5061 to 4597 cal BC, which with 95.4% probability, determines the period around 4800 BC (Figure 9c). If it is considered that the samples come from the earliest and the latest layers of the tell, then it can be suggested that it was actively used for a period of 200 to 300 years. However, the recent revision of transitional Neolithic - Chalcolithic chronology in the Balkans should be referenced as the Trn dates from the middle of the 5th millennium could belong to Early Chalcolithic (Bulatović et al. 2018; Naumov et al. 2019).

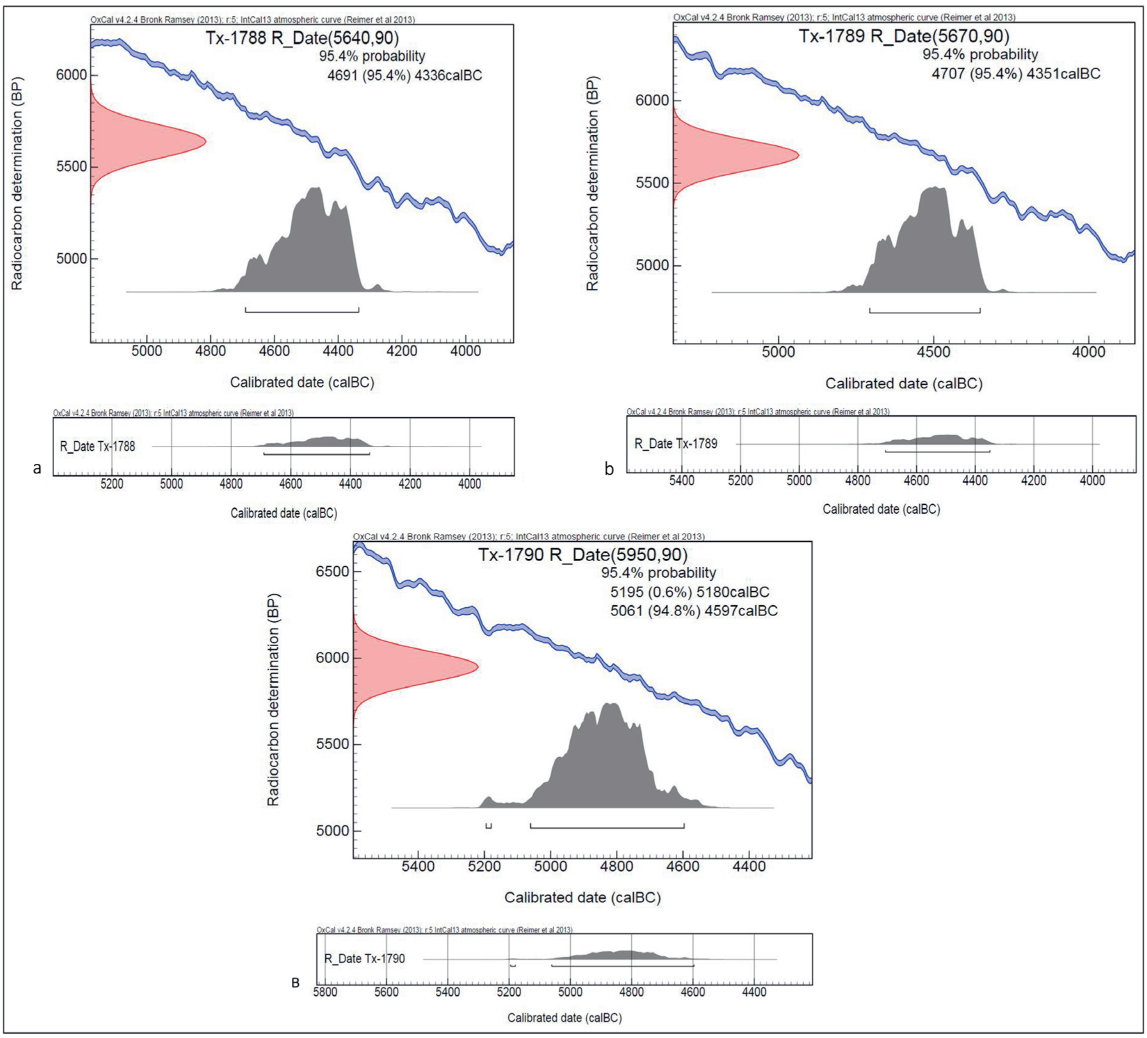

Figure 9. *Calibrated dates from Golema Tumba – Trn*

Presentation of the results of chronological analyses of this site will complete the review of the dated sites in Pelagonia, although there are data on two others (Crnobuki and Karamani) whose dating refers to the Chalcolithic and the Bronze Age (Srdoč et al. 1977). The above-mentioned calibrated dates for one of the tells at Trn could be attributed to the Early Chalcolithic, while the earlier date, apparent features, and similarities with pottery from other synchronous sites could be regarded as Late Neolithic. Indeed, it should not be excluded that the settlement could have been inhabited in the Chalcolithic in its final stages, as suggested by several finds. It must be taken into account that the artificial delimitation of the archaeological periods (in this case, the Late Neolithic and Early Eneolithic) does not always imply a rapid process and a sudden change in the material culture. Sometimes these changes took place over several decades or centuries, so a good synchronisation between archaeological findings and C^{14} analyses can indicate how this transformation process took place. Hence, it is necessary to summarise the dates mentioned above from all presented sites through a final review in the context of Neolithisation in the Balkans and to elaborate on how it was manifested and modified over time through the material culture on the tells where it was produced and used.

Optičari

The site named 'Tumba' refers to a big tell approximately 1 km east of the village of Optičari (Figure 3). It was excavated at the end of the 1980s for a short period, but the research gave solid information on the impressive material culture produced in this Neolithic settlement (Simoska and Kuzman 1990). The white painted patterns on pottery, massive anthropomorphic house models and the bodily features on figurines have an apparent relationship with those of Veluška Tumba. Thus, the sites' chronology could also be associated, i.e., the beginning of the 6th millennium BC. Although seeds from Tumba Optičari were unearthed, they were never sent for radiocarbon analysis to make absolute dating of this tell. Therefore, in the recent initiative to date the Pelagonian tells a sample from Optičari was sent to the University of Bern that provided the first accurate chronological determination of this Neolithic settlement.

The radiocarbon analysis of chickpea seed (from a vessel with unclear context full of cereals) determined that the sample BE-5280 dates to 7019 BP, with a standard deviation of ± 22 years. The calibration of the date with 95.4% probability gives a time span between 5983 and 5846 cal BC, while the highest peaks point to 5900 and 5970 cal BC as the most probable years (Figure 10). It is not clear whether the sample comes from a vessel in the earliest levels or from some later phase, so it cannot be proposed whether it is related to the beginning of the life on the tell or afterwards. At any rate, the apparent relationship of date and material culture with those of Veluška Tumba indicates the possible synchronous existence of these tells approximately 8.5 km apart.

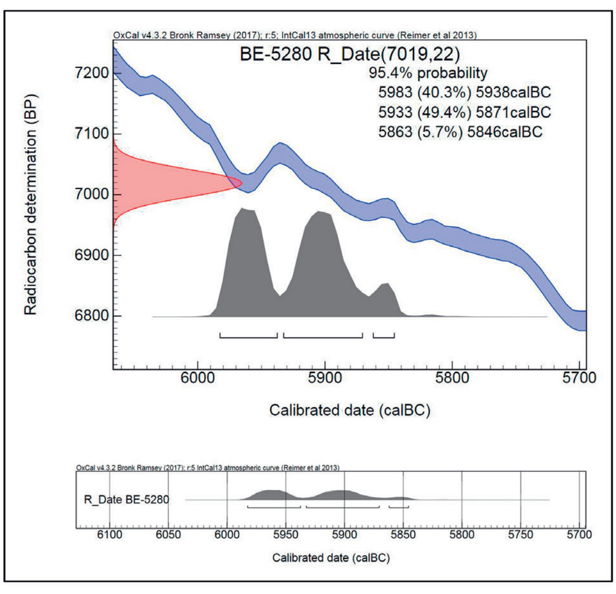

Figure 10. *Calibrated dates from Tumba – Optičari*

Vrbjanska Čuka

Vrbjanska Čuka is one of the most thoroughly studied Neolithic tells in Pelagonia. The initial excavation of this tell, located roughly a kilometre south of the village of Slavej (Figure 3), started in 1979 and ceased in 1989 (Kitanoski 1989; Mitkoski 2005). Since 2016 there has been intensive and continuous multidisciplinary research on this tell that provided a more comprehensive understanding of the first farmers in Pelagonia (Antolin et al. 2020; Mazzucco et al. 2022; Naumov et al. 2016; Naumov et al. 2021a; Stojanovski et al. 2020). A variety of results gave an impressive knowledge of the spatial organisation of the settlement surrounded by a ditch, as well as of the economic and social complexity of clay structures, food, pottery, tools and figural representations. The chronological frame of the site was also one of the major research directions, and therefore, several types of samples from Vrbjanska Čuka were sent to various laboratories for radiocarbon dating to obtain an accurate chronology of the site (Naumov et al. 2018; Naumov et al. 2021a; Stojanovski et al. 2020).

Consequently, a set of dates was provided that gives the initial chronological framework of the settlement between 6000 and 5700 BC, i.e., the end of the Early Neolithic in Balkan chronology (Figure 11). For the first group of dates from Vrbjanska Čuka, nine samples were sent to the National Centre of Accelerators at the University of Seville, Laboratory for the Analysis of Radiocarbon with AMS at the University of Bern and the Organic Geochemistry Unit/BRAMS at the University of Bristol. The majority of samples were cereal and pea remains sampled from the floor in Building 2 (Horizon I), considered one of the earliest Neolithic contexts, but there were a few from the uppermost Neolithic layers (seeds and lipids from pottery), as well as from the final stages of the tell (human teeth and seeds). The dates and laboratory values will not be elaborated here as they are published elsewhere. They indicate the establishment of the settlement during the end of the Early Neolithic (i.e., the 60th century BC) and its abandonment approximately 300 years later, i.e., in the same period as many other tells in Pelagonia.

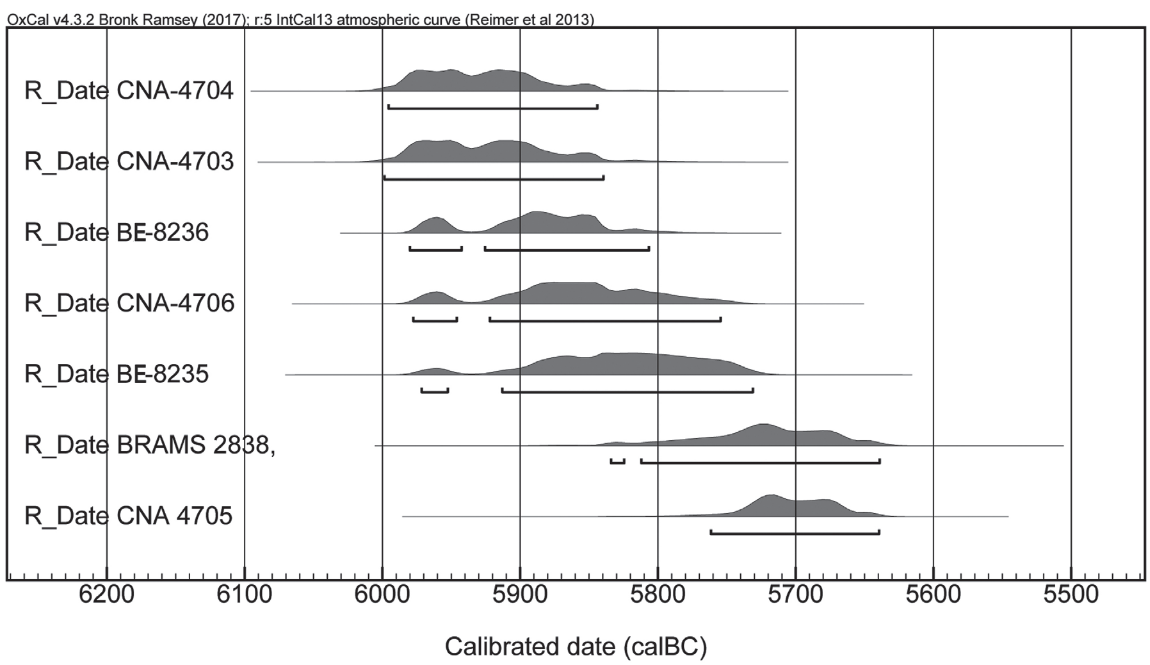

Figure 11. *Calibrated dates from Vrbjanska Čuka – Slavej*

Vlaho

Vlaho is an Early Neolithic settlement that differs from the others included in this chronological overview of Pelagonian tells, mostly due to its position and character. It is not established like others in the flatlands of Pelagonia but on the slopes of mountain Nidje that encompass this valley (Figure 3). The site was surveyed in the 1970s, and besides detecting material from the early stages of the Neolithic, it was not excavated systematically (Simoska and Sanev 1976). Considering its specific character, a project for multidisciplinary research at Vlaho was established in 2020 that started with prospection and was followed by excavation, geomagnetic scanning, and geoarchaeological survey, as well as with archaeobotanical, archaeozoological, and radiocarbon analysis (Naumov et al. 2021b; Naumov et al. 2023). The research provided remarkable results on chronology, spatial organisation, material culture, diet, and the environment by demonstrating a system of ditches, daub buildings, white-painted pottery, human representations, and common Neolithic food resources between 6400 and 6000 BC.

The seed samples were dated at the University of Seville and the Electro-Technical University in Zurich. Three dates from the earliest, middle, and latest phases will be presented on this occasion. The dating of samples is related to 7460 BP, 7371 BP, and 7151 BP with a standard deviation of +/- 36 years (Figure 12). Their calibration indicates 6410 to 6240 cal BC (with a median date around 6320 BC), 6370 to 6080 cal BC (median pointing to 6230 BC), and 6072 to 5930 cal BC (with a median date around 6020 BC). These are, so far, the earliest reliable dates for Pelagonia that significantly contribute to understanding the Neolithic beginnings in the Balkans and elaborate the models of inhabitation of this valley by the first farming communities in the 64thcentury BC. The dates demonstrate that communities inhabiting Vlaho were residing on mountain slopes for approximately 300 years, i.e., before the major wave of tells establishment in the flatlands around 6000 BC.

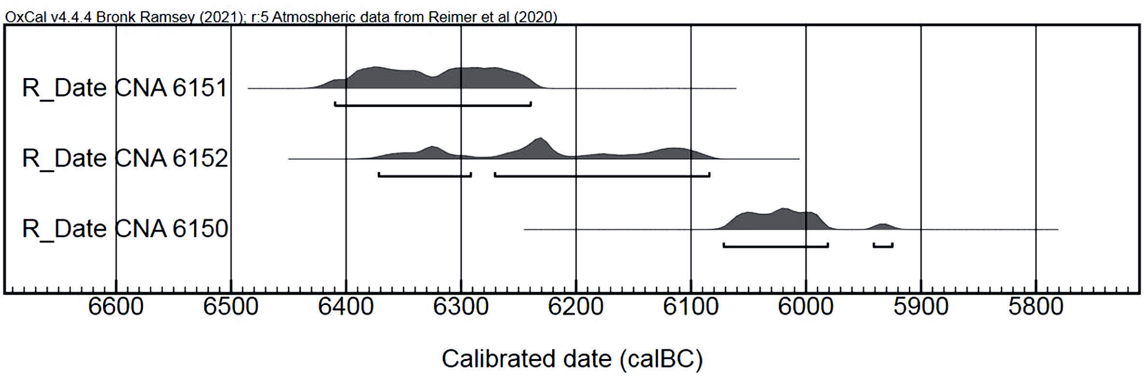

Figure 12. *Calibrated dates from Vlaho – Živojno*

Chronology in context

A review of dates from the Pelagonian tells provides a baseline for the Early to Late Neolithic timeline, even though the data is relatively outdated. In any case, they will be used to make a current chronological framework for this region, at least until the next set of thorough sampling and dating of the tells, when new results are obtained that can confirm or reject the current state. According to the available dates from radiocarbon analysis, the Neolithic in Pelagonia took place from the second half of the 7th and the beginning of the 6th millennium BC to the middle of the 5th millennium BC. Several dates suggest the time of settlement of the first farmers in this region, while others – indicate the transformation from the Neolithic to Chalcolithic societies.

For now, one of the dates in Topolčani is the earliest for Pelagonia, although its accuracy is debatable. The calibration indicates a period between 6862 and 6236 (c. 6500 BC), which is a relatively early date compared to others in the surrounding regions of Greece, Albania and Bulgaria. Since it does not come from a sequence of dates but from a single sample, such a date cannot be fully taken into account, as it probably belongs to material from a time much older than when the tell was used. However, some scientists do not reject such dates, despite their possible irrelevance. Namely, Catherine Perlès, in her interpretation of the beginnings of the Neolithic in Greece, points out that there may be several waves of inhabitation in the Balkan Peninsula, much earlier than those when the agricultural settlements were thoroughly established (Perlès 2001). She refers to these first settlers from the Middle East as 'pioneers' who aimed to explore the territory of the Balkans and find new resources for establishing a stable life. She points to several sites in Greece that can function as pioneer camps, later developed into settlements. In this regard, the new dating of the Vlaho site on the mountain slopes of Pelagonia may indicate the 64th century BC as a period of the first inhabitation of this region (Naumov et al. 2023). As identical dates came from cereals and were analysed in two different laboratories, they can be considered accurate and a future reference for the beginning of the Neolithic in Pelagonia.

In that context, several other dates from Greece and Albania that support Perlès thesis should be mentioned. New research at the Mavropigi site near Kozani, approximately 40 kilometres south of Pelagonia, confirmed its dating around 6500/6400 BC, considering as well the discussion on its temporal range (Bonga 2020; Karamitrou Mentessidi et al. 2013; Reingruber et al. 2023). In addition, several dates from Albania point to the beginnings of the Neolithic in this part of the Balkans, that is, around the middle of the 7th millennium BC. In his analysis of the process of Neolithisation in Albania, Adem Bunguri suggests three waves, the oldest of which was detected at Vluša and placed in relation to the settlement at Sidari, on the island of Corfu in Greece, dated between 6610 and 6420 (Bunguri 2014). However, it was only in the third wave of Neolithisation, which is also younger, that he established the connections of several sites in Albania (Vashtemi, Podgori and Sovjan) with those of Pelagonia. In contrast, the most recent excavations of the Neolithic settlement at Vashtemi reconfirmed an early settlement date of this area between 6470 and 6370 AD. BC (Allen et al. 2013). The issue with this date is that it does not come from an archaeological layer but from samples extracted through coring for geoarcheological purposes since samples dated between 9240 and 8790 BC were also extracted from the same place with an identical method.

The other results, based on samples from the archaeological layers in the settlements near Podgori, Pogradec and Konispol, point to their formation around 6000 BC, which is very close to most of the dates obtained from the sites in Pelagonia (Allen et al. 2013, Tab. I). Some archaeologists also propose that the beginning of the Neolithic in the geographical area of Macedonia took place in the period after 6200 BC, while the one in Thessaly can be expected around 6500 BC. Agatha Reingruber and Laurence Thiessen point out that the sites in Thessaloniki Plain (Nea Nikomedeia and Giannitsa) are dated after 6230 BC (Reingruber 2011; Reingruber and Thissen 2009). Thissen states in his doctoral thesis that Pelagonia enters the process of Neolithisation only later, that is, after the first waves that take place in the Ovče Pole and Bregalnica regions (Thissen 2000). It somewhat coincides with the dating of the sites in the Korça and Prespa regions of Albania but also with most of those subjected to radiocarbon analysis in Pelagonia. However, the recent dates obtained from the Vlaho site in Pelagonia demonstrate earlier inhabitation of Pelagonia in 64th century BC, as well as the revised dating of the Early Neolithic in Greece in 65th century BC, that in some way changes the perspectives on the advance of the Neolithisation in the geographical region of Macedonia (Naumov et al. 2023; Reingruber et al. 2023).

Furthermore, there is the second date from Topolčani, which is set in the period between 6253 and 5558, that is, c. 5950 BC (Figure 13). This is followed by a date from Mogila, identical to that from Topolčani, further highlighting its accuracy. Then a date from Tumba Optičari (c. 5970/5900 cal BC) and the three dates in a row from Veluška Tumba near Porodin follow (c. 5850 BC, c. 5750 BC, and c. 5730 BC), that is, the periods between 6034 and 5635, 5928 and 5641, as well as between 6032 and 5553 BC. Here the new unpublished dates from Veluška Tumba should also be considered as they are a bit earlier and set at the very end of the 7th millennium. The dates from the other site near Porodin, Tumba, come next (c. 5650 BC, i.e., the period between 5877 and 5486 BC). Also, the date provided from a recent analysis of Porodin seed should be considered as it points to the period of c. 5750 BC. The dates from two tells not far from each other in the vicinity of Porodin are noteworthy due to their close timeline. Namely, Veluška Tumba is 400 meters south of the village, while Tumba is approximately 1 km east of the village, so they are about 900 meters apart. If the dates are correct, then these tells were established one after the other or functioned simultaneously (if the dubious KN-I.596 date is accepted). This appearance of groups of tells with a similar chronology is relatively common in Pelagonia, as confirmed by the densely distributed sites at Mogila, Trn, Optičari, Ribarci, etc. (Simoska and Sanev 1976). This issue has been discussed on several occasions, and several possible explanations have been proposed for the dense arrangement of tells, a feature precisely determined through prospection and GIS mapping in Pelagonia (Naumov and Stojkoski 2015; Naumov and Tomaž 2015; Naumov et al. 2013; Naumov et al. 2017a).

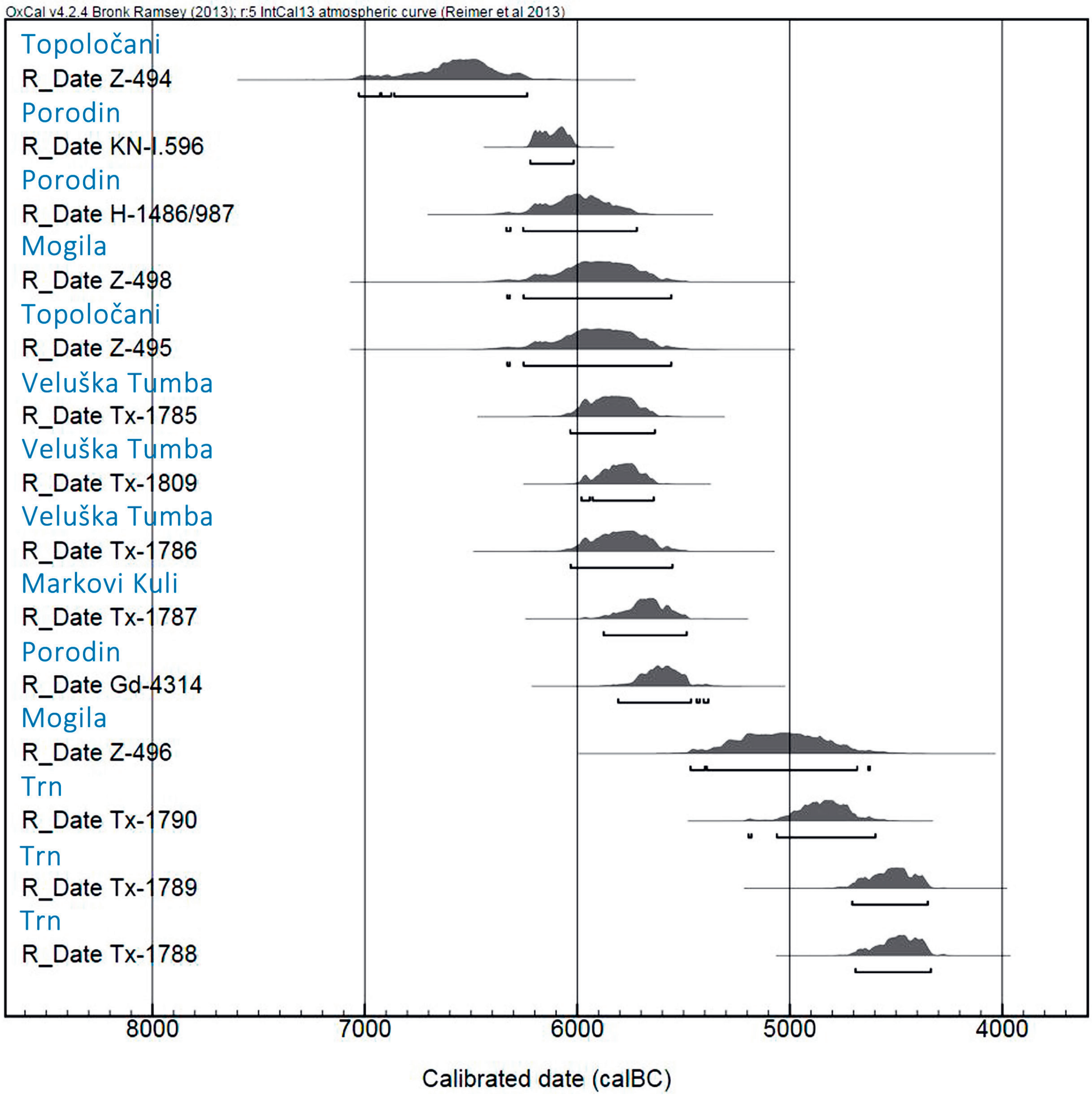

Figure 13. *Chronological sequence of the calibrated dates for the Neolithic tells in Pelagonia*

Synchronic to these tells at Porodin, and particularly Veluška Tumba, is Vrbjanska Čuka, approximately 40 km north of them. The Early Neolithic settlement was established around 6000 BC and lasted approximately 250–300 years (Naumov et al. 2021a). Also, the date from the rock shelter at Markovi Kuli near Prilep (c. 5600 years, i.e., the period between 5808- and 5465-years BC) is chronologically close now represents the northernmost dated site in Pelagonia (Figure 13). After a few centuries of a chronological gap, the second date from Mogila, which roughly refers to the period around 5000, i.e., between 5391 and 4883 BC, indicates a new timeline related to the Late Neolithic. However, the archaeological material found from these phases does not have the features common to the Late Neolithic in this region, mainly the pottery of the Trn cultural group. Therefore, it can be noted that the Neolithic in Mogila in the period around 5000 BC differs significantly from that of the tell in Trn, which is located 4 km southeast of it. It is somewhat understandable since the dates from the tell at Trn are slightly younger. They belong to the Late Neolithic in the context of Macedonian chronology (c. 4800 and c. 4500), although the second one should be regarded as Early Chalcolithic due to temporal relationship with sites from the Ohrid region, Serbia and Bulgaria (Boyadzhiev 2015; Bulatović 2018; Naumov et al. 2019). If the Late Neolithic dates and the archaeological material from Mogila and Trn are taken into account, then it is quite clear that this phase is not unified as previously interpreted. In different stages of its duration, the material culture also changed, starting with simpler forms with fine clay and black polished vessels to pottery decorated with white encrustation and coarse fabric.

This discussion of the Late Neolithic dates from Mogila and Trn enables a relative systematisation of the presented dates within the Neolithic phases. Although the dates whose processing was done 40 years ago are problematic, they could still be used within archaeological studies' framework. The Neolithic in Macedonia is conditionally divided into three phases based on the studies and dating of the Neolithic settlement near Amzabegovo (Gimbutas 1976; Korošec and Korošec 1973; Sanev 2009). In all other regions, cultural groups and sites are correlated to it, although it is more about artificial attribution through material culture than a periodisation based on chronological analyses. In that sense, the sites in Pelagonia are defined through the Veluška-Porodin group, initially treated as Early Neolithic, later divided into two phases identical to those of the Amzabegovo-Vršnik group (Garašanin 1979; Sanev 1995).

Consequently, the archaeological phases are chronologically divided into Early Neolithic (6100-5800 BC), Middle Neolithic (5800-5200 BC) and Late Neolithic (5200-4500 BC). Although this division is exceptionally generalised, it is still used as a reference in Macedonian archaeology and will be applied as such in this case as well. In that case, the sites from Pelagonia dated between 6000 and 5800 BC (Topolčani, Mogila and Veluška Tumba) would be attributed to the Early Neolithic, those from the period between 5750 and 5600 BC (Tumba near Porodin and Markovi Kuli) would belong to the Middle Neolithic, while the tells dated from 5000 to 4500 BC (Trn and a horizon in Mogila) would be defined as Late Neolithic. Of course, such a division is apparently artificial, especially considering there is no clear demarcation between the Early and Middle Neolithic in Pelagonia (Naumov et al. 2021a). However, considering this traditional chronological outline, some networks with dated sites out of Pelagonia could be determined merely based on similarities in the material culture.

The network that Pelagonian societies built was mainly concentrated towards the southwest, i.e., the Ohrid and Korça regions, and not so much towards the north, east, and south, although there are similarities between the house models with the Amyndeon area in Greece and some painted patterns in Mavropigi (Bonga 2020, Fig. 24; Chrysostomou et al. 2015, Fig. 6). The connections between the settlements of the Pelagonian Plain and the Ohrid Basin are very dynamic and vivid, likewise in the Early Neolithic and Late Neolithic (Naumov 2016b). Despite the massive geographical barriers (high mountains), these two regions interacted intensively and even established a common identity manifested through vessels, anthropomorphic house models, stamps, etc.

The relations between Pelagonia and Ohrid regions could be more thoroughly elaborated with the dates from the sites around the lake, which are rarely made and even more rarely published. The eventual radiocarbon analysis of samples from the Early Neolithic settlement Dolno Trnovo in the periphery of the city of Ohrid could establish the possibility of synchronous production of white-painted pottery and anthropomorphic house models that have apparent similarities (Kuzman 2017; Naumov 2016b). However, the dates of piles from the Ohridati pile-dwelling bring some new perspectives (Westphal et al. 2010), as this site also shares common elements of Pelagonian material culture. The calibrated dates refer to c. 5800 and c. 5500 BC, which coincides with the dating of the Neolithic tells in Pelagonia (Figure 13). These results indicate earlier Neolithic phases in this pile-dwelling, although mainly the Late Neolithic and Chalcolithic material has been published. If these exact data are concerned, as well as the similarities between painted pottery and anthropomorphic house models from the Pelagonia and Ohrid regions, then it is apparent that the Neolithic communities from these geographical areas maintained constant communication since the Early Neolithic. This networking continued even in Chalcolithic, as the dating of Ploča pile-dwelling indicates, which is furthermore supported by the pottery identical to the Chalcolithic cultural group Šuplevec-Bakarno Gumno (Naumov et al. 2019).

Conclusion

A review of the results obtained from the analyses of samples taken in the 1970s from several tells in Pelagonia demonstrates that they can be used to construct a chronological outline of the Neolithic in this region. Even though these dates may seem obsolete, and their deviations are +/- 100 years, they still give some initial perspective on the beginnings and end of the Neolithic in Pelagonia. Moreover, the latest dating provided through the analyses of samples from recent excavations point to the same chronological values so that dates from the 1970s can be accepted, at least until the next substantial series of radiocarbon examinations of sites from this region.

Most dates confirm the beginning of the Neolithic among tells around 6000 BC, unless one takes the questionable date from Topolčani, which range throughout the second half of the 7th millennium BC. Although the earliest dates of tells refer to the very beginning of the 6th millennium BC, it does not mean that they are the earliest dates for the Neolithic settlements in Pelagonia. Namely, the tells of the alluvial soil could be a development stage of the Neolithisation process when the local population had already established the potential of the natural resources in the Pelagonian plain. It should not be excluded that earlier settlements were established on the surrounding hills where natural processes and frequent changes in water levels in the plain were continuously observed. Such a site is the Neolithic settlement Vlaho near Živojno, which is much higher on the mountain slopes outside the plain and has characteristic Early Neolithic painted ceramics, figurines, anthropomorphic models of houses and altars (Simoska and Sanev 1976). Recent excavations of the site and dating of samples from the foundation levels confirm its inhabitation in the 64th century BC, and it is, so far, the earliest exact date from Pelagonia (Naumov et al. 2021b; Naumov et al. 2023). This further supports the idea that the Neolithisation of Pelagonia was initially performed on the higher points, i.e., mountain slopes, and only a few centuries later expanded downwards with the creation of tells in the flatlands.

Nevertheless, from the modest number of analyses, it can be seen that there was continuous habitation in Pelagonia from the first half of the 7th millennium BC until the middle of the 5th millennium. This social dynamism was interrupted (or there are currently no data on it) in the second half of the 6th millennium BC, a period that any analysed sample has not confirmed. Only one sample from Mogila and another from recent research in Veluška Tumba are dated around 5000 BC, while between 4800 and 4500 BC, a series of dates from Trn imply living in the final stages of the Neolithic and the beginning of the Chalcolithic. Considering the apparent differences between the material from Trn and the other (Early Neolithic) settlements in Pelagonia, it can be proposed that this chronological hiatus of approximately a half millennium contributed to the initiation of new social processes that were manifested through the material culture of several Late Neolithic settlements in this basin. The question remains open, whether an entirely new population settled the tells in the Late Neolithic or the descendants of initial inhabitants returned that were possibly displaced due to some climatic factors? Anatolian elements had already been suggested in the Late Neolithic of the Balkans, and they were confirmed for Pelagonia and the Ohrid region, which also suggests possible ingression or interaction with communities from Asia Minor (Naumov 2016b; Nikolov 1998; Özdoğan 2011).

This means that a new population can be expected in Pelagonia, given the time hiatus between the Early Neolithic and Late Neolithic settlements in this region. A question arises as to what happened to the Early Neolithic communities if there are no chronological records of settlements in the Pelagonian plain during the second half of the 6th millennium BC. Did they settle the higher areas of the valley (for which there are no confirmations so far) or were directed to the Ohrid and Polog region around 5600 BC, as there are chronological and archaeological analogies? In any case, future radiocarbon and dendrochronological analyses will answer these questions more precisely than relative archaeological analogies. This pertains to the beginning of the Neolithic in Pelagonia and the other phases of this period when it is possible to ascertain the simultaneous existence of several neighbouring settlements established on tells. Further chronological dating, Bayesian modelling, GIS modelling and XRF analyses may provide a thorough insight into the chronology of tells, their position in the area, and the networks between the communities that inhabited them. Studies on these communities' social and symbolic processes can also be applied, which could follow more complex processes evidenced by the Neolithic material culture and architecture in Pelagonia.

Acknowledgement

This paper is a translated and updated version of the article written originally in the Macedonian language: Naumov, G. 2016. Kalibrirana hronologija na neolitskite tumbi vo Pelagonija. In Fidanoski, Lj. and G. Naumov, G. (eds.) *Neolit vo Makedonija: novi soznanija i perspektivi*: 67–96. Skopje: Centar za istražuvanje na predistorijata.

I am grateful to Miroslav Marić for his invitation to attend the 'Relative Absolute' conference and to present this revised chronological overview.

References

Allen, S.E., I. Gjipali, P. Karkanas, A. Gardeisen, G. Piquès, R. Ruka, G. Tsartsidou, and E. Ruzi. 2014. New Light on the Early Neolithic Period in Albania, The Southern Albania Neolithic Archaeological Project (SANAP), 2006-2013. In *Proceedings of the International Congress of Albanian Archaeological Studies*, eds. Perzhita, L., I. Gjipali, G. Hoxha and B. Muka, 107-119. Tirana, Center for Albanian Studies: Institute of Archaeology.

Andoni, E., E. Hasa and I. Gjipali.2017. „Neolithic settlements on the Western bank of Lake Ohrid, Pogradec and Lin 3". In *Proceedings of the international conference 'New archaeological discoveries in the Albanian region,* ed. M. Korkuti, 123-139. Tirana: Institute of Archaeology.

Antolín, F., A. Sabanov, G. Naumov and F. Soteras. 2020. „Crop choice, gathered plants and household activities during the beginnings of farming in Pelagonia valley (North Macedonia)". *Antiquity* 94 (376) (Project Gallery), 1-8.

Benac, A. 1979. „Prelazna zona". In *Praistorija Jugoslavenskih Zemalja* II, Neolitsko doba, ed. A. Benac, 363-472. Sarajevo: Akademija nauke i umetnosti Bosne i Hercegovine.

Benac, A. 1989. „Neki problemi odnosa Makedonije i Zapadnog Balkana u neolitskom dobu". *Macedoniae Acta Archaeologica* 10, 9 – 24.

Bien, B. S. And L. J. Pandolfi. 1972. „La Jolla Natural Radiocarbon Measurements VI". *Radiocarbon* 14 (2), 368-379.

Bonga, L. 2020. "Pioneering Potters, Early Neolithic Ceramics from Mavropigi-Fillotsairi, Western Macedonia". *Athens University Review of Archaeology (AURA)* 3, 9-62.

Boyadzhiev, Y. 2015. „Tell Yunatsite, Development and Absolute Chronology of the Settlements from the Beginning of the Chalcolithic to the Early Bronze Age". In *Neolithic and Copper Age between the Carpathians and the Aegean Sea*, eds. Hansen, S., P. Raczky, A. Anders, A. Reingruber, 381-394. Bonn: Rudolf Habelt.

Bronk Ramsey, C., M. Scott, and H. van der Plicht. 2013. „Calibration for archaeological and environmental terrestrial samples in time range 26-50 ka Cal BC". *Radiocarbon* 55, 2021- 2027.

Bulatović, A., M. Vander Linden and M. Gori. 2018. "New AMS Dates as Contribution to the Absolute Chronology of the Early Eneolithic in the Central Balkans". *Starinar* 68, 19-32.

Bunguri, A. 2014. "Different models for the Neolithization of Albania". *Documenta Praehistorica* 41, 79-94.

Chausidis, N. 2010. "Neolithic Ceramic Figurines in the Shape of a Woman - House from the Republic of Macedonia". In *Anthropomorphic and Zoomorphic miniature figures in Eurasia, Africa and Meso-America, morphology, materiality, technology, function and context*, eds. Gheorghiu, D. And A. Cyphers, A. 25 - 35. BAR International Series. Oxford: Archaeopress.

Chrysostomou, P., J. Jagoulis and A. Mäder. 2015. "The 'Culture of Four Lakes', Prehistoric lakeside settlements (6^{th} – 2^{nd} millennium BC) in the Amindeon Basin, Western Macedonia, Greece". *Archäeologie Scweiz* 38 (3), 24-32.

Cnotlivi, E. 1990. „Praistoriskoto karpesto zivealiste na padinite na Markovi Kuli". In *Tvrdinata Markovi Kuli, izvestai od rabotata na misijata 1984-1988*, ed. L. Krzizanovski, 62-69. Warsawa: Pracovnie Konservacji Zabitkov.

Dumurdzanov, N., T. Serafimovski, and B.C. Burchfiel. 2004. "*Evolution of Neogene- Pleistocene Basins of Macedonia. Digital Map and Chart Series 1 (Accompanying notes)"*. Boulder, Geological Society of America.

Fewkes, V. 1934. „Archaeological reconnaissance in Yugoslavia". *Bulletin of the American School of the Prehistoric Research* 1, 29-62.

Fidanoski, Lj. 2009a. „Periodization and Chronology of the Neolithic Cultures". In *Neolithic Communities in the Republic of Macedonia*, eds. G. Naumov, Lj. Fidanoski, I. Tolevski and A. Ivkovska, 31–34. Skopje: Dante.

Fidanovski, Lj. 2009b. „Pottery Production“. In *Neolithic Communities in the Republic of Macedonia*, eds. G. Naumov, Lj. Fidanoski, I. Tolevski and A. Ivkovska, 65 - 80. Skopje: Dante.

Fidanoski, Lj. 2012. „*Cerje-Govrlevo and Miloš Bilbija“*. Skopje: Museum of Skopje.

Fidanoski, Lj. 2019. „The Beginning of the End, the Story of the Neolithisation of North Macedonia”. *Eurasian Prehistory* 15/1–2, 163–212.

Garašanin, M. 1979. „Centralnobalkanska zona“. In *Praistorija Jugoslavenskih Zemalja* II- Neolitsko doba, ed. A. Benac, 79-212. Sarajevo: Akademija nauke i umetnosti Bosne i Hercegovine.

Gimbutas, M. 1976. „*Anza, Neolithic Macedonia, As reflected by Excavation at Anza, Southeast Yugoslavia“*. Los Angeles: The Regents of the University of California.

Grbić, M., P. Mačkić, Š. Nadj, D. Simoska and B. Stalio 1960. „*Porodin, kasno-neolitsko naselje na Tumbi kod Bitolja“*. Bitolj: Narodni muzej Bitolj i Beograd: Arheološki institut.

Heurtley, W. A. 1939. „*Prehistoric Macedonia, An archaeological reconnaissance of Greek Macedonia (West of the Struma) in the Neolithic, Bronze and Early Iron Ages*.“ Cambridge: Cambridge University Press.

Karamitrou-Mentessidi, G., N. Efstratiou, J. K. Kozłowski, M. Kaczanowska, Y. Maniatis, A. Curci, S. Michalopoulou, A. Papathanasiou, and S. M. Valamoti. 2013. „New evidence on the beginning of farming in Greece, the Early Neolithic settlement of Mavropigi in western Macedonia (Greece)”. *Antiquity* Project Gallery 87(336), http://www.antiquity.ac.uk/projgall/mentessidi336/.

Kitanoski, B. 1977. “Neolitska naselba Čuka kaj selo Topolčani”. *Macedonia Acta Archaeologica* 3, 27-42.

Kitanoski, B. 1989. „Vrbjanska Čuka“. *Arheološki Pregled* 28, 47 - 48. Ljubljana Kitanoski, B., D. Simoska and J. Todorović. 1980. „Naselbata Pešterica i problemot na raniot neolit vo Pelagonija“. *Macedoniae Acta Archaeologica* 6, 9 - 20.

Kitanoski, B., D. Simoska and J. Todorović. 1983. „Novi arheološki istražuvanja na naselbta Čuka vo Topolčani kaj Prilep“. *Macedonia Acta Archaeologica* 6, 9-20.

Kitanoski, B., D. Simoska and J. Todorović. 1987. „Radin Dol, neolitska naselba kaj Prilep“. *Macedonia Acta Archaeologica* 7-8, 7 -29.

Kolištrkovska – Nasteva, I. 2005. „*Praistoriskite dami od Makedonija“*. Skopje: Muzej na Makedonija.

Korošec, P. and J. Korošec 1973. „*Predistoriska naselba Barutnica*“. Prilep: Arheološko društvo na Makedonija.

Kuzman, P. 2017. „From Zlastrana to Penelopa, Neolithic sites in the Ohrid region (II)“. In *Neolithic in Macedonia, Challenges for New Discoveries*, eds. Fidanoski, Lj. And G. Naumov, 83-112. Skopje: Center for Prehistoric Research.

Linick, T. W. 1977. La Jolla Natural Radiocarbon Measurements VII. *Radiocarbon* 19 (1),19-48.

Chausidis, N. 2010. „Neolithic Ceramic Figurines in the Shape of a Woman - House from the Republic of Macedonia“.

Mazzucco, N., A. Sabanov, F. Antolín, G. Naumov, G., Lj. Fidanoski and J. Gibaja. 2022. “The spread of agriculture in south-eastern Europe, New data from North Macedonia“. *Antiquity* 96 (385), 15-33.

Mitkoski, A. 2005. „Vrbjanska Čuka kaj seloto Slavej, Prilepsko“. *Zbornik na Muzejot na Makedonija* 2, 33 – 46.

Mirčovski, V., B. Boev, Z. Efremoski, A. Šorša and Đ. Dimov. 2015. „Hydrochemical Data for Ground Waters in the Bitola’s Part of Pelagonia Valley, Republic of Macedonia”. *Geologica Macedonica* 29, 15-24.

Mitrevski, D. 2003. „Prehistory in Republic of Macedonia – FYROM“. In *Recent Research in the Prehistory of the Balkans*, ed. D. V. Gramenos, 13-72. Thessaloniki: Archaeological Institute of Northern Greece.

Mitrevski, D. 2006. „Some Problems Regarding Macedonian Prehistory - 30 Years Later“. In *Homage to Milutin Garašanin*, eds. N. Tasić, N. And C. Grozdanov, 17-26. Belgrade: Serbian Academy of Sciences and Arts, Macedonian Academy of Sciences and Arts.

Mitrevski, D. 2013. „Praistorija vo Republika Makedonija“. In *Makedonija, mileniumski kulturno-istoriski fakti*, eds. P. Kuzman, E. Dimitrova and J. Donev, 83-266. Skopje: Media Print and Univerzitet Evro-Balkan.

Naumov, G. 2009. „The process of Neolithization“. In *Neolithic Communities in the Republic of Macedonia*, eds. G. Naumov, Lj. Fidanoski, I. Tolevski and A. Ivkovska, 17 - 27. Skopje: Dante.

Naumov, G. 2010. “Symmetry analysis of Neolithic painted pottery from Republic of Macedonia“. In *Data Management and Mathematical Methods in Archaeology. Archaeologia e Calcolatori* 21, ed. T. Biro – Katalin, 255 – 274. Roma: Dipartimento Patrimonio Culturale.

Naumov, G. 2013. „Embodied houses, social and symbolic agency of Neolithic architecture in the Republic of Macedonia“. In *Tracking the Neolithic house in Europe - sedentism, architecture and practice*, eds. D. Hoffman and J. Smyth, 65 – 94. New York: Springer.

Naumov, G. 2015. “Early Neolithic Communities in the Republic of Macedonia”. *Archeologické Rozhledy* LXVII (2015/3), 331-355.

Naumov, G. 2016a. „Tell Communities and Wetlands in the Neolithic Pelagonia, Republic of Macedonia”. *Documenta Praehistorica* 43, 327-342.

Naumov, G. 2016b. „Between Wetlands and Lakes, the network of Neolithic communities in Pelagonia and Lake Ohrid, Republic of Macedonia“. In *Southeast Europe and Anatolia in prehistory, essays in honor of Vassil Nikolov on his 65th anniversary,* eds. K. Bačvarov and P. Gleser, 175-189. Bonn, Rudolf Habelt Publishing House.

Naumov, G. 2020. “Neolithic wetland and lakeside settlements in the Balkans”. In *Settling Waterscapes in Europe, The Archaeology of of Neolithic-Bronze Age Pile-Dwellings,* eds. A. Hafner, E. Dolbunova, A. Mazurkievich, E. Pranckenaite, and M. Hinz, *111-136.* Bern and Heidelberg: Propylaeum.

Naumov, G. 2022. “Recent Fieldwork at the Neolithic site of Veluška Tumba in Pelagoni a.“ *Studia Praehistorica* 16, 33-64.

Naumov, G. and S. Stojkoski. 2015. „Novi predistoriski tumbi vo Pelagonija“. *Zbornik na NU Zavod i muzej – Bitola* 16, 169-185.

Naumov, G. and A. Tomaž. 2015. „Arheološki iskopuvanja na neolitskiot lokalitet „Školska Tumba“ vo Mogila“. *Patrimonium* 13, 67-95.

Naumov, G. and A. Mitkoski. 2018. „Predistorijata na Markovi Kuli kaj Prilep“. *Balcanoslavica* 47 (2), 35-67.

Naumov, G., M. Trzeciecki, M. Chwiej, M. Przybyła, M. Bugaj, P. Szczepanik and M. Podsiadło. 2014. „Arheološko, topografsko i geofizičko istražuvanje na neolitski tumbi vo Pelagonija“. *Patrimonium* 12, 345 – 372.

Naumov, G., A. Mitkoski, A. Murgoski, J. Beneš, M. Przybila, Đ. Milevski, V. Komarkova, M. Vychronova, M. and I. Stoimanovski. 2016. „Istražuvanje na Vrbjanska Čuka kaj Slavej – 2016“. *Patrimonium* 14, 13-42.

Naumov, G., A. Mitkoski, A. Murgoski and Gj. Milevski. 2017a. „Reconnaissance of Prehistoric Sites in North Pelagonia“. *Patrimonioum* 15, 11-36.

Naumov, G., J. Jon and O. Chvojka. 2017b. “Geophysical scanning of prehistoric tells in Central Pelagonia”. In *Neolithic in Macedonia II, step forward in the study of the first farming societies*, eds. Lj. Fidanoski and G. Naumov, 161-180. Skopje.

Naumov, G., A. Mitkoski, K. TalevskI, A. Murgoski, J. Beneš, I. Živaljević, J. Pendić, D. Stojanoski, F. J. Gibaja, N. Mazzucco, A. Hafner, S. Szidat, V. Dimitrijević, S. Stefanović, K. Budilova, M. Vychronova, T. Majerovičova and J. Bumerl. 2018. „Research on the Vrbjanska Čuka site in 2017“. *Balcanoslavica* 47(1), 253–285.

Naumov, G., A. Hafner, B. Taneski, A. Ballmer, J. Reich, M. Hostettler, M. Bolliger, J. Francuz, A. Maczkowski, A. Boogard, F. Antolin, M. Charles, W. Tinner, C. Morales del Molino, and A. Lotter. 2019. „Research in 2019 at the site of Ploča-Mićcov Grad near Gradište (Lake Ohrid)”. *Patrimonium* 12, 11–46.

Naumov, G., Mitkoski, A., Talevski, H., Anvari, J., Przybila, M., Stojanovski, D., Antolín, F., Sabanov, A., Živaljević, I., Dimitrijević, V., Gibaja, J., Mazzucco, N., Milevski, G., Dumurđanov, N., Pendić, J., Blažeska, Z., Stefanović, S. 2021a. „Early Neolithic tell of Vrbjanska Čuka in Pelagonia". *Praehistorische Zeitschrift* 96 (2): 345-381.

Naumov, G., J. Gulevska, K. Penezić, F. Antolin, A. Mitkoski, A. Sabanov and R. Soteras. 2020. „Multidisciplinarno istražuvanje na Veluška Tumba vo 2019 godina". In *Neolithic in Macedonia, in honor of Dragica Simoska*, eds. Lj. Fidanoski and G. Naumov, 29-61. Skopje: Center for Prehistoric Research.

Naumov, G., J. Gulevska, F. Antolin, A. Sabanov, R. Soteras, R. and A. Fidanoska. 2021b. „Multidisciplinary Research of the Neolithic Settlement Vlaho at Živojno in Pelagonia". *Patrimonium* 19, 11-28.

Naumov, G., M. Przybyła, J. F. Gibaja, K. Penezić, K., F. Antolín, A. Sabanov and A. Fidanoska. 2023. „An Early Neolithic enclosure at the site of Vlaho, Pelagonia". *Antiquity (Project Gallery)*, 1-8.

Nikolova, L. 1998. „Neolithic sequence, the upper Stryama valley in western Thrace (with an appendix radiocarbon dating of the Balkan Neolithic)". *Documenta Praehistorica* XXV, 99-131.

Nikolov, V. 1998. "The Circumpontic cultural zone during 6th millennium BC". *Documenta Praehistorica* 25, 81-89.

Özdoğan, M. 2011. "Archaeological Evidence on Westward Expansion of Farming Communities from Eastern Anatolia to the Aegean and the Balkans". *Current Anthropology* 52 (2), S415-S430.

Pazdur M. 1990. „Datiranje na organskite primeroci od arheološko-konzervatorskite istražuvanja so radiokarbonovata metoda C-14". In *Tvrdinata Markovi Kuli, izveštai od rabotata na misijata 1984-1988*, ed. L. Krzyzanowski, 70-75. Warsawa: Pracovnie Konservacji Zabitkov.

Perlés, C. 2001. „*The Early Neolithic in Greece, The first farming communities in Europe"*. Cambridge, Cambridge University Press.

Puteska, A., B. Dimovska, R. Šajn and T. Stafilov. 2015. "Distribution of chemical elements in soil samples from the Pelagonia region, Republic of Macedonia". *Geologia Croatica* 68/3, 261-272.

Quitta, H. and G. Kohl. 1969. „Neue Radiocarbondaten zum Neolithikum und zur frühen Bronzezeit Südosteuropas und der Sowjetunion". *Zeitschrift für Archäologie* 3, 223-255.

Reimer, P. J., E. Bard, A. Bayliss, J. W. Beck, P. G. Blackwell, C. Bronk Ramsey, P. M. Grootes, T. P. Guilderson, H. Haflidason, I. Hajdas, C. Hattè, T. J. Heaton, D. L. Hoffmann, A. G. Hogg, K. A. Hughen, K. F. Kaiser, B. Kromer, S. W. Manning, M. Niu, R. W. Reimer, D. A. Richards,

E. M. Scott, J. R. Southon, R. A. Staff, C. S. M. Turney and J. van der Plicht. 2013. „IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0-50,000 Years cal BP". *Radiocarbon, 55* (4), 1869-1887.

Reingruber, A. 2011. "Early Neolithic settlement patterns and exchange networks in the Aegean". *Documenta Praehistorica* 38, 291-305

Reingruber, A. And L. Thissen. 2005. „*Aegean Catchment (E. Greece, S. Balkans and W. Turkey) 10 000 - 5 500 cal BC* (*on line* 2005*)"*. http,//www.canew.org/data.html

Reingruber, A. And L. Thissen. 2009. „Depending on ^{14}C Data, Chronological Frameworks in the Neolithic and Chalcolithic of Southeast Europe". *Radiocarbon* 51 (2), 751-770.

Reingruber, A., L. Thissen and L. Bonga, L. 2023. "The impressed pottery of the Aegean Neolithic". In *Relative absolute. Chronologies of the Neolithic period in Southeast Europe*, eds. M. Marić, J. Bulatović and N. Marković, ___Belgrade, Balkanološki institut SANU.

Sanev, V. 1995. „Neolitot i neolitskite kulturi vo Makedonija". In *Civilizacii na počvata na Makedonija*: *prilozi za istražuvanjeto na istorijata na kulturata na počvata na Makedonija*, eds. G. Stardelov, M. Matevski and C. Grozdanov, 21 – 46. Skopje: Makedonska akademija na naukite i umetnostite.

Sanev, V. ed. 2009. „*Anzabegovo, naselba od raniot i sredniot neolit vo Makedonija"*. Štip: Nacionalna ustanova za zaštita na spomenicite na kulturata i muzej – Štip.

Sanev, V. and D. Simoska. 1983. "*Neolitskite naselbi Veluška Tumba i Golema Tumba kaj selo Trn vo razvitokot na prvite zemjodelski zaednici vo Centralna Pelagonija* – unpublished report". Bitola: Zavod za zaštita na spomenicite na kulturata.

Simoska, D. 1986. „Veluška Tumba, neolitska naselba“. *Arheološki Pregled* 26, 48.

Simoska, D. 1983. „*Preliminaren izveštaj za 1987 godina od arheološkite iskopuvanja na lokalitetot Tumba v Sredselo (Tumba 1) selo Mogila*. Unpublished report. Bitola: Zavod za zaštita na spomenicite na kulturata.

Simoska, D. and P. Kuzman. 1990. „Tumba Optičari“. *Arheološki Pregled* 1988, 63 - 66. Simoska, D. and V. Sanev. 1975. „Neolitska naselba Veluśka tumba kaj Bitola”. *Macedoniae Acta Archaeologica* 1, 25 – 85.

Simoska, D. and V. Sanev. 1976. „*Praistorija vo Centralna Pelagonija“*. Bitola: Naroden Muzej.

Simoska D. and V. Sanev. 1977. „Neolitska naselba na Mala Tumba kaj selo Trn, Bitola“. *Macedonia Acta Archaeologica* 3, 215–237.

Simoska D., B. Kitanoski and J. Todorović. 1979. „Neolitska naselba vo selo Mogila kaj Bitola“. *Macedonia Acta Archaeologica* 5, 9–30.

Srdoč, D., A. Sliepčević, B. Obelić, N. Horvatinčić and R. Bošković. 1977. „Radiocarbon measurements IV”. *Radiocarbon* 19 (3), 465-475.

Stojanova Kanzurova, E. 2017. „Chronological and cultural character of Veluška Tumba, Bitola, Village of Porodin, in the Early and Middle Neolithic of Velušina-Porodin group“. In *Acta Musei Tiberiopolitani* 2, eds. Z. Rujak, V. Sekulov, V. And D. Cvetanov, 45-53. Strumica: NU Zavod za zaštita na spomenicite na kulturata, Muzej Strumica.

Stojanovski, D., I. Živaljević, V. Dimitrijević, J. Dunne, R. C. Evershed, M. Balasse, A. Dowle, J. Hendy, R. Fischer, C. Speller, J. Jovanović, E. Casanova, T. Knowles, L. Balj, G. Naumov, A. Putica, A. Starović and S. Stefanović. 2020. „Living off the land, Terrestrial based diet and dairying in the farming communities of the Neolithic Balkans“. *PLOS One* 15(8), 1-18.

Temelkoski, D. and A. Mitkoski. 2005. „Sadova keramika od Vrbjanska Čuka“. *Macedoniae Acta Archaeologica* 16, 29 – 53.

Temelkoski, D. and A. Mitkoski. 2006. „Praistoriska naselba Mogila Senokos“. *Macedonia Acta Archaeologica* 17, 55 – 88.

Temelkoski, D. and A. Mitkoski. 2008. „Docnoneolitska naselba na lokalitetot Kutline kaj selo Rakle“. *Macedoniae Acta Archaeologica* 18, 93-108.

Thissen, L. C. 2000. „*Early Village Communities in Anatolia and the Balkans 6500 - 5500 cal BC, Studies in chronology and culture contact“*. PhD dissertation. Leiden. Universiteit Leiden.

Trifunovski, J. 1998. „*Bitoljsko-prilepska kotlina, antropogeografska proučavanja“*. Beograd: Srpska akademija nauka i umetnosti.

Valastro, S., J. E. Mott Davis and A. G. Varela.1977. University of Texas at Austin, Radiocarbon dates 11. *Radiocarbon* 19 (2), 280-325.

Vasileva, M. 2005. “*Kade e našeto minato. Voved kon praistorijata na Pelagonija”*. Bitola: Visoi.

Westphal, T., W, Tegel, K. U. Heußner, P. Lera and K. F. Rittershofer. 2011. „Erste dendrochronologische Datierungen historicher Hölzer in Albanien“. *Archeologische Anzeiger* 2, 75-95.

Whittle, A., L. Bartosiewicz, D. Borić, P. Pettit and M. Richards. 2005. „New Radiocarbon Dates for the Early Neolithic in Northern Serbia and South-East Hungary, Some Omission and Corrections“. *Antaeus* 28, 347-355.

Zdravkovski, D. 2006. „New Aspects of the Anzabegovo-Vršnik Cultural Group“. In *Homage to Milutin Garašanin*, eds. N. Tasić and C. Grozdanov, 99-110. Belgrade: Serbian Academy of Sciences and Arts, Macedonian Academy of Sciences and Arts.

4.

New radiocarbon dates from the Early /Middle neolithic site Cerje-Govrlevo

Ljubo Fidanoski

Abstract The image of the Macedonian Neolithic as an essential part of the Anatolian and Southeast European cultural bridge, in recent times, has been significantly diminished due to various factors. Unfortunately, this was inevitable for many reasons, of which the most important were/are: the deficiency of extensive explorations, the absence of international collaborations within the past research, the insufficient level of interdisciplinary studies, the partial publications of material, etc. However, in the last 20 years, archaeological and interdisciplinary explorations have occurred on a few Neolithic sites in North Macedonia, such as in Cerje-Govrlevo, Vrbjanska Čuka and Veluška Tumba. This study presents new radiocarbon dates from Cerje-Govrlevo, thus enriching the Neolithic chronology and, most importantly, challenging our ideas and conclusions about the first farming communities in North Macedonia.

Keywords: Macedonian Neolithic, Radiocarbon dates, Neolithic Chronology, Neolithization; Balkans Early Neolithic.

The Site

The site of Cerje-Govrlevo is located on a flattened terrace on the southern slope of Vodno Mountain (Figure 1), at the south border of the Skopje Plain, at an altitude of 500 m above sea level (Fidanoski and Tomaž 2010). The site was excavated in the 1980s (Trench I) and the early 2000s (Trench II). It was occupied in the Early and Middle Neolithic (c. 6000–5500 cal BC). Settlement continuity at Cerje-Govrlevo is demonstrated by documented house remains, built one above another by successive generations of inhabitants. The material culture of Cerje-Govrlevo was attributed to the main Neolithic culture group in North Macedonia (its eastern and northern parts), known as Amzabegovo-Vršnik, but it also exhibits clear similarities with Velušina-Porodin culture, located in the south-western part of North Macedonia (Pelagonia).

The Stratigraphy

The site stratigraphy is very complicated and depends on the geomorphological configuration of the terrain itself, as well as the post-depositional factors due to the long-lasting successive use of the settlement area (Fidanoski 2011; Fidanoski and Tomaž 2010; Fidanoski 2012; Fidanoski 2015; Fidanoski 2017a). Namely, during the excavations, it became clear that the thickness and position of different layers vary considerably in a very small area (Figure 2).

Figure 1. *Panorama of the site (Fidanoski 2017a: Fig. 1, 14).*

Figure 2. *Southern cross-section: the alluvial layer (bottom right) and the ditch (below) (Fidanoski 2017a: Fig. 14, 30).*

In the north-western corner of the trench, sterile geological deposits were exposed only 0.4 m under the present-day surface, while in the opposite corner (the southeastern), the sterile layer was detected at a depth of more than 4.5 m (Figure 3). In this small distance (about 12 m), the slope was fairly steep in this part of the site (Figure 4). Accordingly, the house remains indicate that they were constructed on the slope itself, although, according to the archaeological evidence, the house foundations were flattened.

Figure 3. *Western cross-section: the ditch (below) (Fidanoski 2017a: Fig. 6, 22).*

During excavations in Trench II (excavated area of around 130 square meters) – where the new archaeological excavations were carried out (after 2000) – the remains of three different houses were discovered (Figure 5). They were constructed on a solid clay basis to be level in an attempt to compensate for the hillslope visible in the trench. Nevertheless, geomorphological processes have been dynamic over time and even today, and the sloping of layers in a northwest-southeast direction was documented in the trench. This gradient was clearly visible on the trench cross-section and also noticed by the inclination of all discovered archaeological phenomena and settlement structures (pits, houses, layers, etc.). Geomorphological condi-

Figure 4. *Southern and part of the eastern cross-section: the alluvial layer (bottom part of the eastern cross-section and its massive inclination caused by the loose deposit of the ditch) and the ditch (below) (unpublished photo by A. Ogorelec).*

tions thus influenced the formation of the thickest layers in the southern and eastern parts of the trench, where the terrain inclination is maximal. A massive dark brown alluvial layer consisting of very compact and refined soil devoid of anthropogenic material was documented at the very eastern part of the trench. Its depth was 1.5 m thick at the eastern cross-section of the trench, at the same time having an almost ideally flat surface and filling (compensating for) the slope towards the western part of the trench – the layer was utterly absent in the central part of the trench. Furthermore, this layer served as a natural flat foundation used for some of the structures described below.

Figure 5. *Consecutive houses built one above another (Fidanoski 2012: Fig. 28, 176).*

The excavated section of the settlement revealed well-defined architectural remains. In total, the remains of six houses were discovered, three in Trench I from the 1980s and three in Trench II. In both cases, the houses were built one above the other. A prolonged continuity of the settlement from Early and Middle Neolithic was easily visible (and Late Neolithic material was also documented). Houses were constructed on very compact soil, had clay floors built on wooden beams, the walls had wooden frames coated with clay, and they probably had a gabled roof. Discovered houses' inventories always included: an oven, grindstones, ceramic vessels, weights, and sometimes ceramic items that could be interpreted as art and different tools.

One relatively well-preserved house was excavated in Trench II, and in the vicinity of the house, three ovens were discovered (two smaller ellipsoid-shaped ovens and one big calotte oven) – referred to as an oven complex or workshop (Figure 6). It is assumed that a possible workshop existed in this settlement area. Due to several rows of postholes near the calotte oven, we assume that the area was covered with light wooden construction. In addition to the architectural remains of the houses, in Trench II, numerous pits (with little archaeological material) were found in their immediate vicinity, probably used for different activities and purposes associated with everyday life in these houses.

Figure 6. *The foundation of the ovens' complex built near the house (on the right side) and over the ditch (5930–5900 cal BC median) (Fidanoski 2017a: Fig. 9, 25).*

Only one burial from the Neolithic period was discovered in Trench II. It was a burial of a young man in a flexed position, whose lower part was completely destroyed during the construction of the earliest house. In addition, in the immediate vicinity of the mentioned house and above the oven complex, a partial inhumation of a human mandible was unearthed within one completely preserved ceramic bowl – referred to as a ritual deposit (Figure 7).

Figure 7. *The ritual deposit dug out within the ovens' complex (5930 cal BC median) (Fidanoski 2011: Fig. 9, 70).*

Beneath the mentioned archaeological contexts in Trench II, a ditch was documented, thus being the evidence of the earliest occupation of Cerje-Govrlevo, at least in this completely excavated trench (Figure 4). Today, the occurrence of ditches is a relatively common feature found at Balkan Early Neolithic sites. In cross-section, the ditch resembles the Latin letter 'V', and it runs in the east-west direction (with a slight swerve towards the southeast) in the length of more than 10 m (the entire length of Trench II) (Figure 3). It has an average depth of around 1 m and a width between 1.5 and 2 m (Figures 5, 6). This feature fits well with the site's stratigraphy and adds more evidence to the inclination of almost all layers in the north-west-southeast direction. Lastly, shallow circular pits (probably imprints of wooden posts) were discovered only on the northern side of the ditch (Figure 4).

The Dates

The complexity of Cerje-Govrlevo's stratigraphy and chronology was further emphasised by new radiocarbon dates (provided by the BIRTH project). Unfortunately, due to a lack of appropriate archaeological material, the earliest feature of Cerje-Govrlevo – the ditch – was not dated. However, the most important archaeological contexts constructed above it were dated, providing new insight into the cultural deposits and further broadening their interpretation.

Figure 8. *The foundation of the house (built on the thick alluvial layer and dug out empty pits 5930–5850 cal BC median) (Fidanoski 2019: Fig. 22, 64).*

Figure 9. *The foundation layer of the house (created above the alluvial layer and the pits, 5930–5850 cal BC median) (unpublished photo by A. Ogorelec).*

Contrary to the variable thickness of deposits and the natural geomorphological inclination towards the southeast, a very short chronological sequence exists according to the new radiocarbon dates. In short, above the ditch and its immediate vicinity, seven contexts were dated: a) the house foundation and house deposit (Figure 8, Figure 9); b) the oven complex (Figure 6); c) the ritual deposit (Figure 7) and d-g) deposit layers above the ditch (Figure 10, Figure 11, Figure 12). They all fell in the range of 5950–5850 cal BC median, or between 6000 and 5750 cal BC with 95.4% probability. What is striking is that the excavation stratigraphy documentation suggests that the oven complex/workshop, the ritual deposit, and the house are unlikely to have been built simultaneously. However, the radiocarbon dates (especially in their median values) suggest that they were almost synchronously made and used. Furthermore, nearly every context is clearly separated by various layers in between. For example, underneath the house layers dated 5920-5850 median cal BC (95% prob.), there is a very thick, almost sterile, possibly alluvial, layer (Figure 4, Figure 13). This layer which was 1.5 m thick at the eastern cross-section, was almost completely flat, thus covering the eastern part of the trench and the ditch. This alluvial layer may probably result from a sudden flood or a similar massive water-accumulated deposit that covered this part of the site (within the trench) in a short amount of time. The geomorphological inclination of the hill onto which the settlement was constructed is best seen by this layer which is completely absent in the western part of the trench and the ditch. Above this layer, the earliest date provided is around 5950 cal BC median (Figure 12). The oven complex and ritual deposit were dated around 5930 and 5900 cal BC median in the western part of the trench. It should be noted again that at this part of the trench, and within these archaeological contexts, the alluvial layer was completely absent (due to the terrain slope). Furthermore, the oven complex and ritual deposit were not established at the same time (the former being earlier), and as seen by the stratigraphy in this part of the trench, these contexts were not built at the same time as the house (which also was founded onto the alluvial layer). Finally, the oven complex was dug into the sterile soil, and the ritual deposit was dug into a layer above it.

Figures 10 and 11. *A thick layer above the ditch maybe in association with the house (created above the alluvial layer, 5910 cal BC median) (unpublished photo by A. Ogorelec).*

Figure 12. *A thick layer above the ditch and below the house foundation (created above the alluvial layer, 5950 cal BC median) (unpublished photo by A. Ogorelec).*

Figure 13. *The eastern cross-section, the thick alluvial layer is registered at the bottom and its massive inclination caused by the loose deposit of the ditch (Fidanoski 2017a: Fig. 11, 26).*

In conclusion, due to the geomorphological sloping towards the southeastern and eastern sides of the trench, excluding the earliest anthropological presence (the undated ditch), the earliest documented layer (devoid of archaeological material) is the alluvial deposit. Its spread towards the western side of the trench was limited at the central part by a massive opposing slope of the hill itself. In a way, it can be stated that the Neolithic community in Cerje-Govrlevo constructed many of their most important architectural structures directly on the most dynamic and active stratigraphical and geomorphological areas, at least within this trench (Figure 14, Figure 15, Figure 16). Due to these factors, some of the contexts mentioned above were built onto the alluvial layer (the house), while the majority of them were built on the sterile soil of the slope where this alluvial layer is completely absent (the oven complex, ritual deposit, and other layers). Also, towards the western part of the trench, it becomes obvious that almost all layers exhibit their spatial limit and depth rapidly due to the massive terrain inclination. Nevertheless, one can possibly conclude that the narrow chronological sequence does not corroborate the massive deposits and the dynamic stratigraphical activities, especially in addition to the geomorphological processes of the terrain itself.

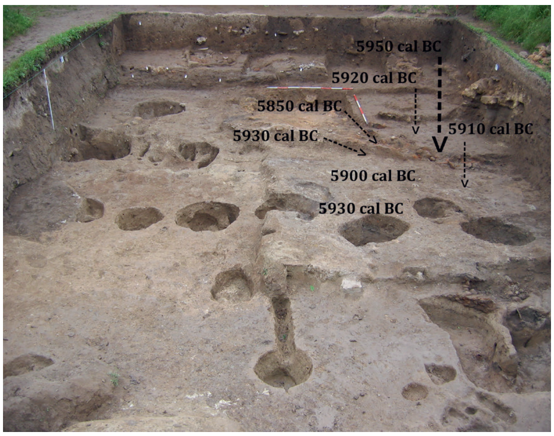

Figure 14. *The situation in the trench at the first excavation campaign with new methodology applied (the dates only provisionally shown in relation to the contexts) (Fidanoski and Tomaž 2010; Fig. 5, 67).*

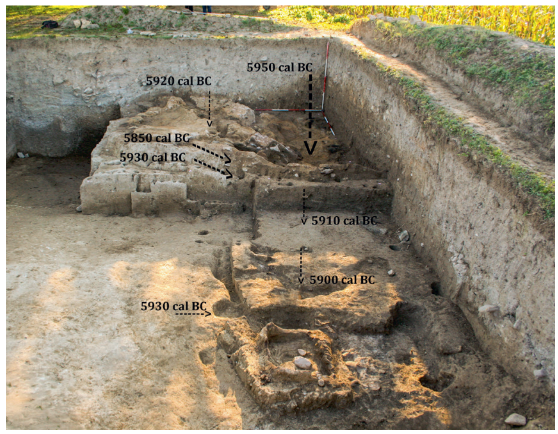

Figure 15. *The situation in the trench after a few excavation campaigns with the new methodology applied (the dates only provisionally shown in relation to the contexts) (unpublished photo by A. Ogorelec).*

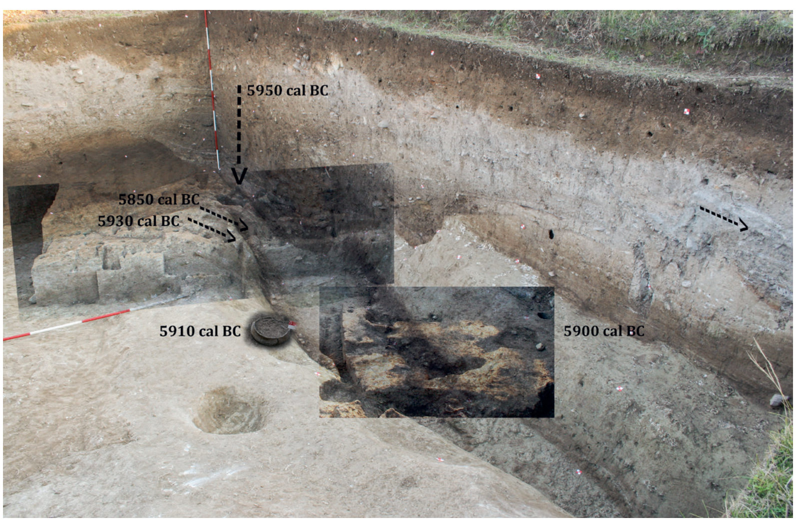

Figure 16. *The situation in the trench after the exhaustion of archaeological layers and contexts, with digital insertions of the dated contexts (the dates only provisionally shown in relation to the contexts) (unpublished photo by A. Ogorelec).*

To summarise, interpreting these seven contexts using the median date values places them in the period between 5950 and 5850 cal BC, and if one interprets the more comprehensive probability range – the time span between 6000 and 5750 cal BC (Figure 17). Before these dated contexts, the Neolithic newcomers at Cerje-Govrlevo dug out the earliest (still undated) feature of the site – the ditch. It was dug out near a very steep slope (maybe a small hill), spreading southeast. This first structure in the analysed part of the settlement (documented in this trench only) was later partially filled in with a thick alluvial deposit accumulated from the eastern side (the deposit never reached the western part of the ditch and the trench due to the steep slope of the terrain). The earliest dated context of the site (5950 median cal BC) is a layer above the ditch, above the thick alluvial layer, and beneath the earliest house. The layers beneath the earliest house were dated between 5920 and 5850 cal BC). Several contexts (the oven complex, ritual deposit, and some layers) were built between 5930 and 5900 cal BC, dug into sterile soil and not the alluvial layer (which is absent in this part of the trench). The already published dates were provided from contexts above and later than those – in later times dating to an interval between 5850 and 5500 cal BC.

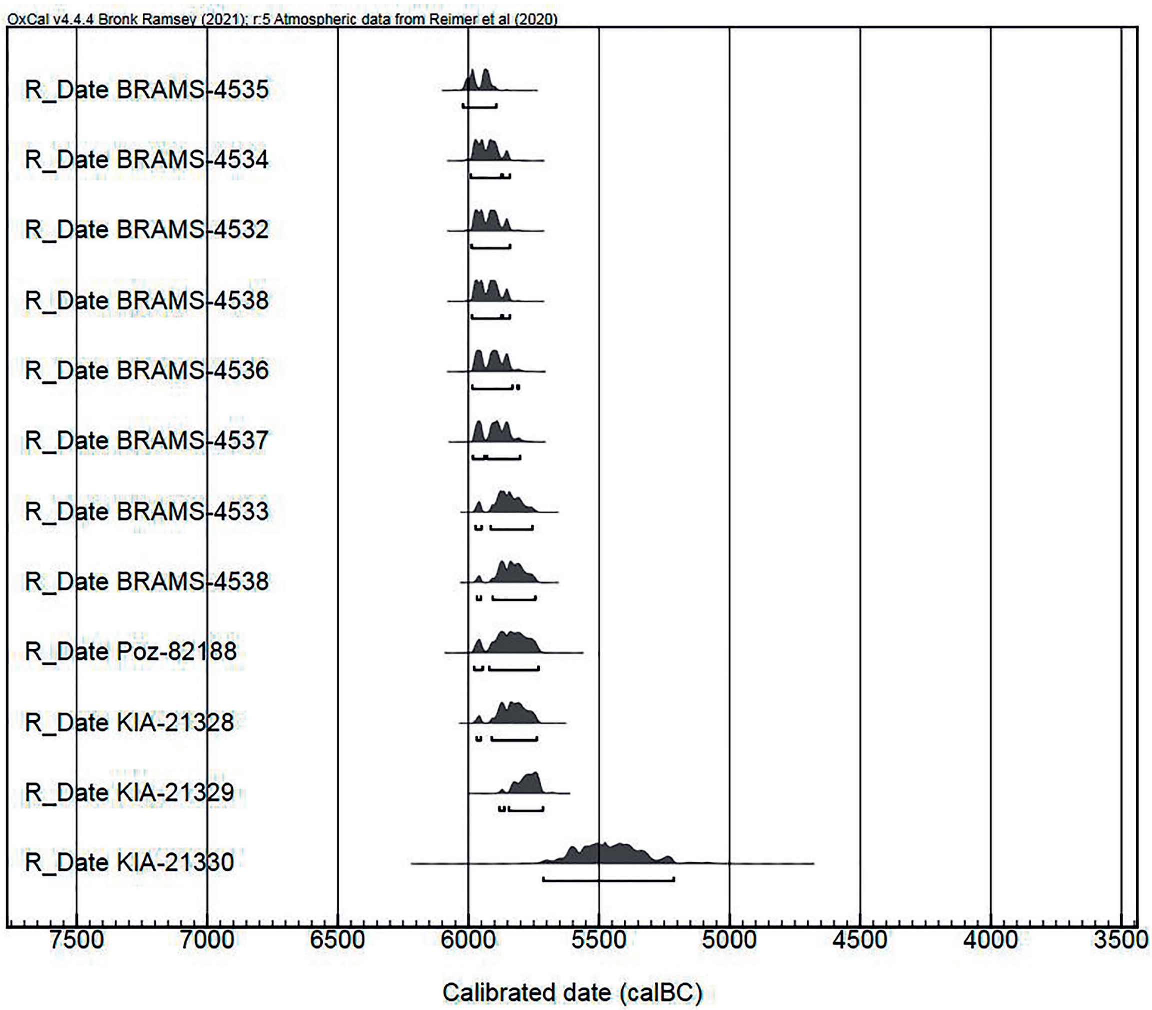

Figure 17. *Cerje Govrlevo radiocarbon dating sequence*

The narrow range of these new seven dates and the large quantity of cultural and geomorphological deposits may be explained as follows: a) the dates should be interpreted by their broader chronological values, thus allowing the massive deposits and deposition of many time-consuming structures as the house, the oven complex, the ritual deposit, etc. (in the context of the obvious complex stratigraphy and geomorphology) or b) the deposition of layers and contexts happened in very rapid processes and in a relatively short time. It is possible that the thick alluvial layer accumulated in a very short time interval, primarily if it represents the remains of a massive flood (the layer also filled the complete eastern part of the ditch). However, other built structures could have been more time-consuming to construct, use period and disposal. Thus, the correlation between the stratigraphy, geomorphology, and anthropogenic factors suggests a broader chronological interpretation of these new radiocarbon dates concentrated in a small part of the trench. Finally, it is possible that the inhabitants of Cerje-Govrlevo constructed their structures in very short periods and used and disposed of them in short periods – if one interprets only the dates' median values. Again, given the mentioned natural and anthropogenic factors, the first possibility is more plausible.

Discussion

Given the short history of archaeological excavations at Cerje-Govrlevo and the limited research area of around 250 square meters in total (Trench I with around 120 square meters and no radiocarbon dates and Trench II with 130 square meters and twelve dates), the site has yielded large quantities of typical Early/Middle Neolithic material culture: pottery, ceramic anthropomorphic house models, figurines, ritual tables, tools made of stone, bone, antler, as well as a large amount of animal remains (Fidanoski 2017b; Fidanoski 2018a; Fidanoski 2019a; Fidanoski 2020). The architectural remains found in Cerje-Govrlevo are common in the North Macedonian Neolithic, although some are rarely found in other sites (the oven complex, ditch, etc.). In general, the material culture from this site is represented by very diverse objects made using the same technologies and shapes that span more than two or three, or even several centuries – as seen by the older and the new dates and correlated with the relative chronology and site's stratigraphy (Figure 18).

In the context of Macedonian Neolithic, this site is one of the better-explored ones, and with these new dates as well as the older ones (twelve in total), is second best in the absolute dated site – only after the best-dated site in the country (Amzabegovo) (Gimbutas 1976; Naumov 2009; Fidanoski 2018b). However, bearing in mind the complex stratigraphy of Cerje-Govrlevo, the number of radiocarbon dates is still unsatisfactory, especially in the context of the earliest structure of the site (the ditch) – which is still undated due to the scarce archaeological remains. Furthermore, given the accumulation of deposits in the southeastern part of the trench – on the opposite side of the slope (or the hill) and next to the ditch – it is very possible that with future research, earlier dates (pre 6000 cal BC) should be expected. Nonetheless, even with these dates and the stratigraphy, in the correlation between the contexts above the ditch, the ditch itself was most probably dug out before 6000/5950 cal BC. In that context, Cerje-Govrlevo was settled not much later than (or even maybe at the same time as) the earliest sites in North Macedonia (Amzabegovo and Veluška Tumba) and slightly earlier or synchronous with Vrbjanska Čuka (Naumov 2016; Naumov et al. 2018).

Given this, the relatively early dates from Cerje-Govrlevo chart a new chronological map in this part of the country, although these earliest sites appear to be very scattered in a fairly wide area. On the other hand, this should not come as a surprise given the lack of absolute dating of almost all explored sites in each region in North Macedonia. For now, these earliest three sites in North Macedonia (6100/6000 cal BC) are situated in very different micro-regions, and the distance between them is more than 100 km. Of the three, Cerje-Govrlevo is the most northern site, and unlike the others, its surrounding area is comprised of mountainous terrain rich in pastures, water and woodlands. Amzabegovo is situated more than 100 km southeast in a hilly region rich in agricultural areas and pastures. Veluška Tumba, unlike the previous two sites, which are open terrace settlements, is a mound established in marshy lands of the vast Pelagonia Plain, more than 100 km further to the southwest. In addition, there are many more Early Neolithic sites in the immediate vicinity of this site. In fact, this plain is most probably the most densely settled region in the Balkans during the Neolithic. This is a completely different situation compared to Amzabegovo and especially Cerje-Govrlevo, which are void of same-period sites in their immediate vicinity. Unfortunately, there aren't any relevant zooarchaeological analyses of the animal remains, except Amzabegovo, but according to the preliminary investigations on the material from Cerje-Govrlevo, it is expected that the role and the structure of animal husbandry are very similar (if not the same) with Amzabegovo (in the early phases).

Figure 18. *Cerje Govrlevo examples of site assemblage*

Finally, the material culture found in Amzabegovo and in Veluška Tumba shows specific visual differences, especially in pottery, that set the two regions apart. The pottery found at Cerje-Govrlevo shows similarities with both cultures, thus being one of the rare 'culturally intermediate' sites (for example, as Vrbjanska Čuka) between those large cultures (Fidanoski 2017c).

The problem of 'later dates' of the Macedonian Neolithic today is more evident in the broader geographical context of the Balkan Neolithic, where many new dates emerge, thus constantly shifting the chronological frameworks within smaller/larger regions in this important area of Europe (Fidanoski 2019b). Actually, if there weren't the newest dates from the Early Neolithic in Serbia, the problem would not have existed, since on more than a few sites, the earliest dates are between 6250 and 6150 cal BC (which matches well with the period of 8.2 cal BP event). These early dates derived from sites much more to the north in the Balkans allow a different interpretative approach to Neolithization to be undertaken (Porčić et al. 2020). This new chronological discrepancy among southern and northern Early Neolithic sites in the Balkans needs a more thorough elaboration of the human dispersals in the broader Mediterranean area, which should be a part of a more elaborated study. In that context, given the well-known absolute chronology of the Macedonian and Bulgarian Early Neolithic sites, in addition to the relatively new Serbian dates and the dates published in this paper, one can offer (at least) three possibilities: a) there are pre 6250 cal BC sites in North Macedonia and Bulgaria but are still not found; b) there are already such early sites excavated, but still not dated and c) there are no such early sites in this part of the Balkans. If we agree that the most probable continental paths of Neolithic dispersals in the Balkans from south to north is the land of modern-day North Macedonia and Bulgaria, then pre-6250 cal BC sites should have been found already. The large territory from Greece to Serbia should have been settled, at least partially first, to enable the Early Neolithic settlers to move further north. The 'jumping territories' endeavour by the early Mediterranean Neolithic settlers, i.e., passing large territories without a trace (even with seasonal campsites) with such diverse natural environments, is almost impossible. The gap of one or two centuries between the earliest Serbian sites in comparison with the earliest Macedonian and Bulgarian sites (within the period of the 8.2 cal BP event) is, most probably, a result of an absence of many early sites and a small number of absolute dates. However, the state of research on Neolithic sites in North Macedonia and Bulgaria is very different, thus further burdening the interpretation of the Neolithization processes. For example, in North Macedonia, many sites have been excavated, but with small-scale excavation campaigns, in small excavation areas and almost always lacking even a few absolute dates (Fidanoski 2018b). On the contrary, the situation in Bulgaria is almost completely different – many sites have been excavated and have had large parts of them explored (some of them even more than half of their occupation space), but also lack large numbers of absolute dates (with few exceptions). Given this, it is safe to assume that such early sites exist in some regions both in North Macedonia, Bulgaria, Kosovo and Albania, but their number is probably very limited. These rare sites might have been already explored but are still undated with large sequences, many of them are likely not known to us, but hopefully, they will be registered soon.

Concluding Remarks

Given the general narratives of the older explorations of the North Macedonian Neolithic, framed within the larger narrative of the Balkan-Anatolian Neolithic complex, many of the important elements (site structure, regional dispersals, chronology, material culture, economy, etc.) were challenged by new studies in the recent years. These new studies and research on the North Macedonian Neolithic sites are still ongoing. For instance, we know today that early sites are established at higher elevations – in hilly micro-regions- unlike the older interpretations claiming that the Early Neolithic sites were located only in plains. There is at least one Middle Neolithic pile-dwelling site in Ohrid Lake, (few) sites with subterranean dwellings; many of the decoration techniques and pottery shapes proved to be much more resistant to time and thus are invalid for relative chronology than when it was first suggested, and so on.

Due to many political and social factors, the research of the North Macedonian Neolithic was, and still is, late (with very few exceptions) in many fields of exploration (interdisciplinary input, methodology, theoretical approaches, etc.). Such is the example of Cerje-Govrlevo, a site explored in short periods over many archaeological excavation campaigns (in the 1980s and in the first decade of the 21st century) in a very limited area (around 250 square meters in total). But one should know that this site is one of the best-explored Neolithic sites in North Macedonia. As such, the site has yielded a vast amount of archaeological material from the Early and Middle (and also Late) Neolithic. Many house remains were found, some of which had well-preserved inventories, an immense quantity of pottery decorated with all known techniques and a variety of shapes, large numbers of anthropomorphic house models, stone and bone tools, and substantial quantities of animal remains. Moreover, changes in the architecture and even in pottery production were never established in the proposed Early to Middle Neolithic shift, suggesting that such a change is just a subjective interpretation derived from the older generalised narratives about the Balkan Neolithic rather than a real fact.

Until the employment of more modern excavation methodology and documentation (in the last four excavation campaigns), the site was referred to as a typical (Early, Middle and Late) Neolithic settlement – with typical architecture and material culture. Without absolute dates and only based on relative chronology, the interpretation of archaeological material, architecture, and stratigraphy in many studies suggested that Cerje-Govrlevo is a site comprising all Neolithic phases, more importantly, a site with permanent continuity (as many famous Balkan sites, such as Amzabegovo, Karanovo, Starčevo, etc.) for more than half a millennium. In the large narratives about the Early Neolithic sites, especially their creation, duration and demise, Cerje-Govrlevo fit very well and was never challenged. However, this very general image of dozens of Early and Middle Neolithic sites with numerous cultural layers, deposits and archaeological material has been altered in recent years.

The image of Cerje-Govrlevo as a typical Early and Middle Neolithic site is in the process of such an alteration. This new approach to the site's dynamics is primarily based on two most important elements: a) the introduction of modern excavation techniques and documentation and b) the availability of absolute dates. As already mentioned, the results of these elements provide a completely new image of the site concerning chronology and stratigraphy. The site's stratigraphy and geomorphology were much better understood based on new excavations and research, and the absolute dates provided the missing time intervals within the stratigraphy. However, the result of these new studies poses further questions, especially given the median values of the chronological sequence and the site's stratigraphy. Either the Neolithic inhabitants created, used, and disposed of their structures in very short periods, or the dates of the contexts should be interpreted in their broader values. Both scenarios are possible, and in any case, at least they provide entirely new insight into the site, especially its dynamics in time and space.

Acknowledgements

The dating of Bristol AMS (BRAMS) radiocarbon dates was conducted by ERC BIRTH project *Births, mothers and babies: prehistoric fertility in the Balkans between 10000 and 5000 BC* (funded by European Research Council, Grant Agreement N°640557). Regarding absolute dates and the many debates about the Neolithic, especially for calibrating the dates, I owe special gratitude to Goce Naumov.

References

Fidanoski, Lj. 2011. "Археолошки истражувања на неолитската населба Церје-Говрлево во 2004 година". Macedoniae acta archaeologica 20, 53–76.

Fidanoski, Lj. 2012. Cerje-Govrlevo and Miloš Bilbija. Skopje: Museum of the city of Skopje.

Fidanoski, Lj. 2015. "Home Sweet Home: Neolithic Architectural Remnants from Cerje-Govrlevo, Republic of Macedonia". Analele Banatului XXIII: 11–44.

Fidanoski, Lj. 2017a. "Layers". In Skopje before 8 Millennia 1: The Earliest Builders from Cerje-Govrlevo, ed. Lj. Fidanoski, 13–36. Skopje: Museum of the city of Skopje.

Fidanoski, Lj. 2017b. "Skopje before 8 Millennia 1: The Earliest Builders from Cerje-Govrlevo". Skopje: Museum of the city of Skopje.

Fidanoski, Lj. 2017c. "Cerje-Govrlevo: A Neolithic Settlement at the Crossroad between the Amzabegovo-Vršnik and Velušina-Porodin Cultures". In Dragiša Zdravkovski In Memoriam. Cultural Manifestations during the Neolithic Period on the Territory of the Republic of Macedonia and neighbouring Regions, ed. E. Stojanova Kanzurova, 29–68. Skopje: Archaeological Museum of Macedonia.

Fidanoski, Lj. 2018a. "Skopje before 8 Millennia 2: The First Potters from Cerje-Govrlevo". Skopje: Museum of the city of Skopje.

Fidanoski, Lj. 2018b. "Again About the Macedonian Neolithic". In Neolithic in Macedonia: Challenges for New Discoveris, eds. Lj. Fidanoski and G. Naumov, 113–136. Skopje: Center for Prehistoric Research.

Fidanoski, Lj. 2019. "Археолошки истражувања на неолитската населба Церје-Говрлево во 2008 и 2009 година". Macedoniae acta archaeologica 20, 55–70.

Fidanoski, Lj. 2019a. "Skopje before 8 Millennia 3: Among Deities and Men of Cerje-Govrlevo". Skopje: Museum of the city of Skopje.

Fidanoski, Lj. 2019b. "The Beginning of the End: The Story of the Neolithisation of North Macedonia". Eurasian Prehistory 15 (1–2), 163–212.

Fidanoski, Lj. 2020. "Skopje before 8 Millennia 4: Craftsmen and Agropastoralists of Cerje-Govrlevo". Skopje: Museum of the city of Skopje.

Fidanoski, Lj. and A. Tomaž. 2010. "Under the Field of Wheat: Archaeological Research at the Neolithic Site at Cerje-Govrlevo". Macedonian Heritage, Homage to Miloš Bilbija Year XIV, No. 36–37, 61–72.

Gimbutas, M. 1976. "Chronology". In Anza, Neolithic Macedonia, as reflected by Excavation at Anza, Southeast Yugoslavia, ed. M. Gimbutas, 29–77. Los Angeles: The Regents of the University of California.

Naumov, G. 2009. "Processes of Neolithization". In Neolithic Communities in the Republic of Macedonia, eds. G. Naumov, Lj. Fidanoski, I. Tolevski and A. Ivkovska, 19–27. Dante: Skopje.

Naumov, G. 2016. "Калибрирана хронологија на неолитските тумби во Пелагонија." In "Неолитот во Македонија, нови сознанија и перспективи", eds. Lj. Fidanoski and G. Naumov, 67–96. Skopje: Center for Prehistoric Research.

Naumov, G., A. Mitkoski, H. Talevski, A. Murgoski, N. Dumurdjanov, J. Beneš, S. Zidat, V. Dimitrievikj, S. Stefanovikj, K. Budilova, M. Vihronova, T. Majerovičova and J. Bumerl. 2018. "Истражување на локалитетот Врбјанска Чука во 2017 година". Balcanoslavica 47, 253–285.

Porčić, M., Blagojević, T., Pendić, J. and S. Stefanović. 2020. "The Timing and Tempo of the Neolithic Expansion Across the Central Balkans in the Light of the New Radiocarbon Evidence". Journal of Archaeological Science 33: 1–12. https://doi.org/10.1016/j.jasrep.2020.102528.

Tolevski, I. 2017. "Architectural Characteristics of the Neolithic Houses from the Archaeological Site Cerje near the Village Govrlevo". In Skopje before 8 Millennia 1: The Earliest Builders from Cerje-Govrlevo, ed. Lj. Fidanoski, 37–60. Skopje: Museum of the city of Skopje.

Naumov, G., A. Mitkoski, H. Talevski, A. Murgoski, N. Dumurdjanov, J. Beneš, S. Zidat, V. Dimitrievikj, S. Stefanovikj, K. Budilova, M. Vihronova, T. Majerovičova and J. Bumerl. 2018. "Истражување на локалитетот Врбјанска Чука во 2017 година". Balcanoslavica 47, 253–285.

5.

Chronology, economy, and technology of the Late Neolithic site of Jablanica (central Serbia)

Selena Vitezović, Nemanja Marković,
Jelena Bulatović, Velibor Katić, and Miroslav Marić

Abstract Various socio-economic changes, including the introduction of metallurgy, mark the long duration of the Vinča culture. For detailed studies of the transformations of the Vinča societies, analyses of subsistence and economy must also be placed on the chronological line. The small-sized excavations carried out in 2018 at the Late Neolithic site of Jablanica (*c.* 5000–4700 BC) in central Serbia provided a faunal assemblage that enabled analyses of animal exploitation patterns, bone technology and also provided the samples for radiocarbon dating. The faunal remains show the predominance of domestic species, especially cattle. The site also yielded approximately 90 artefacts produced from bone and antler, including finished objects, preforms and manufacturing debris. Predominant raw materials were bones, mainly long bones, metapodials and ribs, followed by red deer antlers. Also, one artefact from *Spondylus* shell was found. Awls were the most frequent techno-type, and the typological repertoire also included other pointed tools, scrapers and other tools. Several preforms (mainly awls) and manufacture debris provided evidence of a working area or workshop within the settlement. Absolute dates showed that the beginning of the Late Neolithic occupation at the site of Jablanica could be equated with the relative depths of 4.5 meters at the type site of Vinča – Belo Brdo, or the late Vinča Pločnik I (Vinča C) period, while the radiocarbon dates associated with the end of the Late Neolithic occupation of the site can be correlated to layers between 4.0 and 3.5 meters at the type site of Vinča, i.e., the Vinča Pločnik IIa.

Keywords: Late Neolithic, Vinča culture, faunal analyses, bone technology, radiocarbon dates

Introduction

The 5th millennium BC in the central Balkan area is marked by the Vinča culture complex phenomenon, widespread in present-day Serbia and parts of Croatia, Romania, Montenegro, and Bosnia and Herzegovina (Garašanin 1979). Over this long period, diverse socio-economic changes occurred, including the introduction of copper metallurgy and related changes in the economy and technology. Temporal changes within the Vinča culture were mainly studied from the viewpoint of the modifications in the material culture, particularly stylistic ones, while the transformations in economy and technology were less explored. Studies of subsistence, economy and technology from individual sites must be accompanied by detailed studies of absolute chronology for a broader, comprehensive approach to socio-economic changes that took place in the 5th millennium BC. The faunal assemblage from the site of Jablanica enabled comparative, comprehensive studies of subsistence patterns, bone technology, and absolute dates.

Archaeological background

The archaeological site of Jablanica is situated in the village of Međulužje, near Mladenovac, approximately 50 km from Belgrade. The prehistoric settlement was located on a trapezoid-shaped plateau on the western bank of the Jablanica stream, and its estimated area is over 50 ha (Figure 1a). It was first discovered in 1899, and the first excavations were carried out already in 1900 by Miloje M. Vasić. These results were published in 1901 and 1902 (Reinach 1901; Wassits 1902). The excavations covered the surface of 64 m^2 and revealed a large prehistoric settlement of the Vinča culture complex. These research activities represent, in fact, the first systematic archaeological excavations of some prehistoric settlements in Serbia with up-to-date archaeological standards.

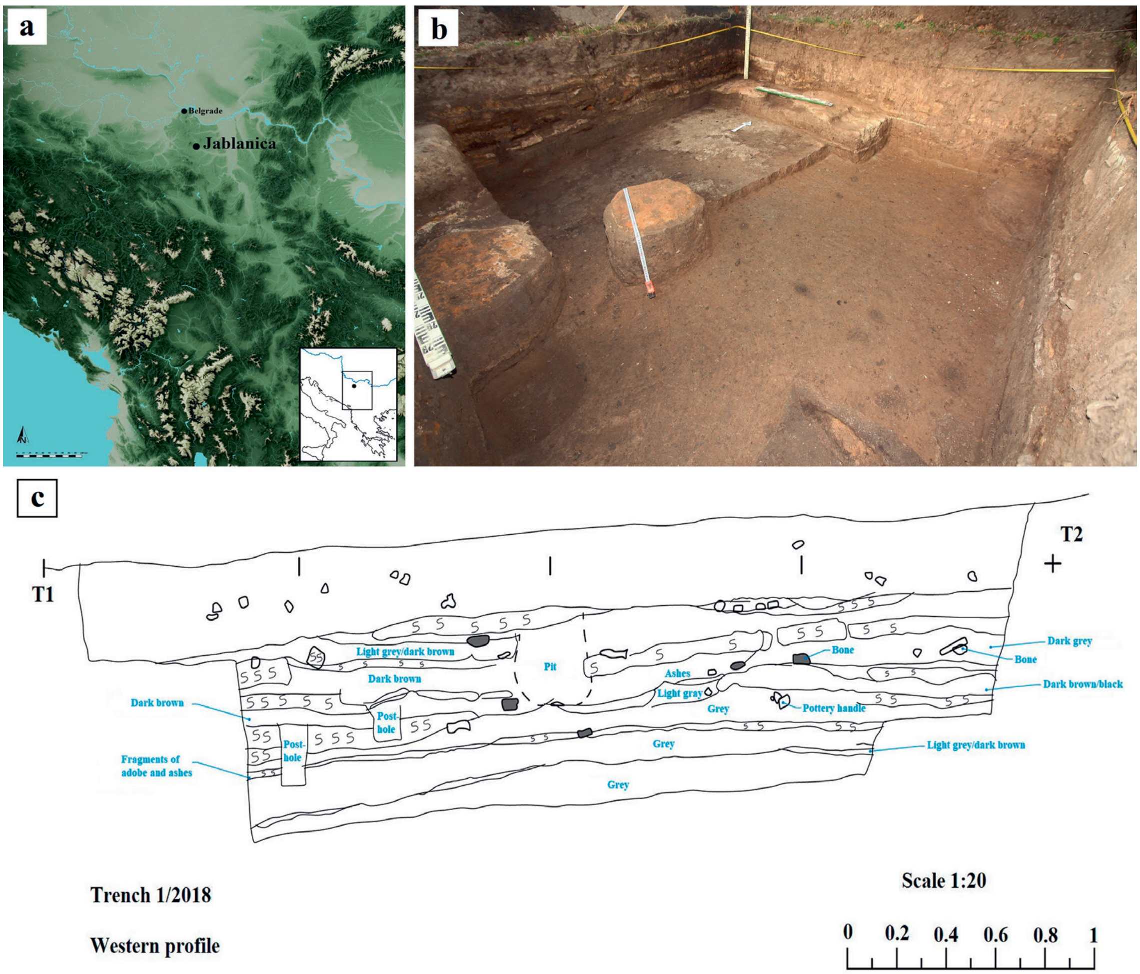

Figure 1. *Jablanica: a. position of the Late Neolithic site; b. Trench 1, view from the south-eastern corner; c. western profile of Trench 1*

The research was carried out again in 1996 by the Institute for heritage protection of the city of Belgrade, encompassing one trench with dimensions of 4 x 4 m. To the north from the central part of the site, divided by the valley of a small seasonal stream, another site was discovered, labelled Jablanica II. It was registered in 1986 during an archaeological field survey performed by the Museum of Mladenovac (part of the Belgrade City Museum) (Katić 1989, 2003). This part of the prehistoric settlement was located on a small river terrace, covering an area of approximately 0.60 ha. The Međulug plateau is situated above it and to the northwest, while there is a slight depression on the eastern side, probably created by water. Small-scale rescue excavations were carried out in 2018 by the Museum of Mladenovac. One trench, 4 x 4 m, located in the central part of the terrace, was excavated with the primary goal of defining the vertical stratigraphy of the site and determining the degree of damage caused by agricultural works (Figure 1b). The excavation methodology did not include sieving, and the excavation spits were grouped into habitation horizons.

The cultural layer from the trench from 2018 was 1.10 m thick, and the stratigraphic sequence consisted of five habitation horizons. The earliest habitation horizon comprises a part of the floor from grey clay and a horseshoe-shaped hearth outside the house. Several post holes were noted, usually grouped, thus suggesting the presence of some above-ground structures, such as shelters above the hearths. Post holes were also discovered in the later phases, but it was impossible to connect them with the reinforcement elements of the walls of any structure. Structures from the third and the fourth habitation horizons are placed right on top of each other, as suggested by the findings of large amounts of clay mass and ashes. Two circular structures were noted: red, burnt soil and a hole in the centre. Agricultural works partly destroyed the final habitation horizon, and only the northern part of a larger structure was noted, with preserved width of up to 1.5 m (Figure 1c).

These excavations revealed a large Vinča culture settlement with rich portable findings – ceramic vessels, anthropomorphic and zoomorphic figurines, altars, ground and chipped stone tools, as well as the faunal remains and the bone objects.

Radiocarbon dating

Samples from Trench 1 were selected for radiocarbon dating, carried out as part of the project "*Regional Absolute Chronologies of the Late Neolithic in Serbia"*, funded by the Science Fund of the Republic of Serbia.

The chosen trench, albeit relatively small and located towards the outskirts of the Late Neolithic settlement on the site, yielded an abundance of ceramic finds and animal remains, making it a perfect candidate for estimating a chronological sequence of the site in this part. It was also the only trench on the site to be excavated with careful methodology and good documentation. While the stratigraphy of the site overall may be thicker and consist of long-lasting evidence of occupation in other parts, the fact that the only other excavations on the site were undertaken over a hundred years ago (Vassits 1902) prevents us from radiocarbon dating this collection as we lack documentation and organic material for samples.

In total, 10 bone samples were sent for AMS dating at the Debrecen HEKAL MICADAS type Accelerator Mass Spectrometer. The samples were pre-treated by ultrasonification in distilled water, treated with the ABA method (Molnar et al., 2013), followed by gelatinisation and ultra-filtration (Brown et al., 1988), and then freeze-dried and combusted. Finally, they were graphitised and dated by Accelerator Mass Spectrometry (Kromer et al., 2013). The samples chosen were solely animal bones, as no short-lived macrobotanical samples were available to choose from, as no wet or dry sieving was implemented during excavations. The Bayesian modelling was undertaken in OxCal v4.4 program (Bronk Ramsey, 2010, 1995), and the models described are defined by OxCal CQL2 keywords and the brackets seen on the left edge of model figures. Calibrated radiocarbon dates are given in grey outlines, with posterior density estimates created by Bayesian modelling in solid dark grey.

The model was constructed using Bayesian statistics, which provide a probabilistic method for estimating absolute dates of past events. Bayes' theorem in archaeology enables archaeologists to analyse collected data from the field in the context of prior beliefs (or existing archaeological knowledge and experience) to create new understanding through the incorporation of existing knowledge and new data to create posterior beliefs that become future prior beliefs and inform new data and its interpretation in cyclic repeats. Simplified, this means that radiocarbon dates are definite specific information on a certain problem (chronology) and substantially affect the output of the chronological model. Then, informative beliefs, such as stratigraphic evidence collected by an archaeologist during excavations, provide the relationship between two (or more) radiocarbon samples obtained from the examined site. Informative beliefs can also be different, like the seriation of certain artefact categories of similar. Short-lived organic samples are preferred to provide age proximity between radiocarbon samples, thus narrowing the posterior likelihoods of individual samples. In our example, relative stratigraphy of the trench, devised by its excavator, was used to provide informative beliefs.

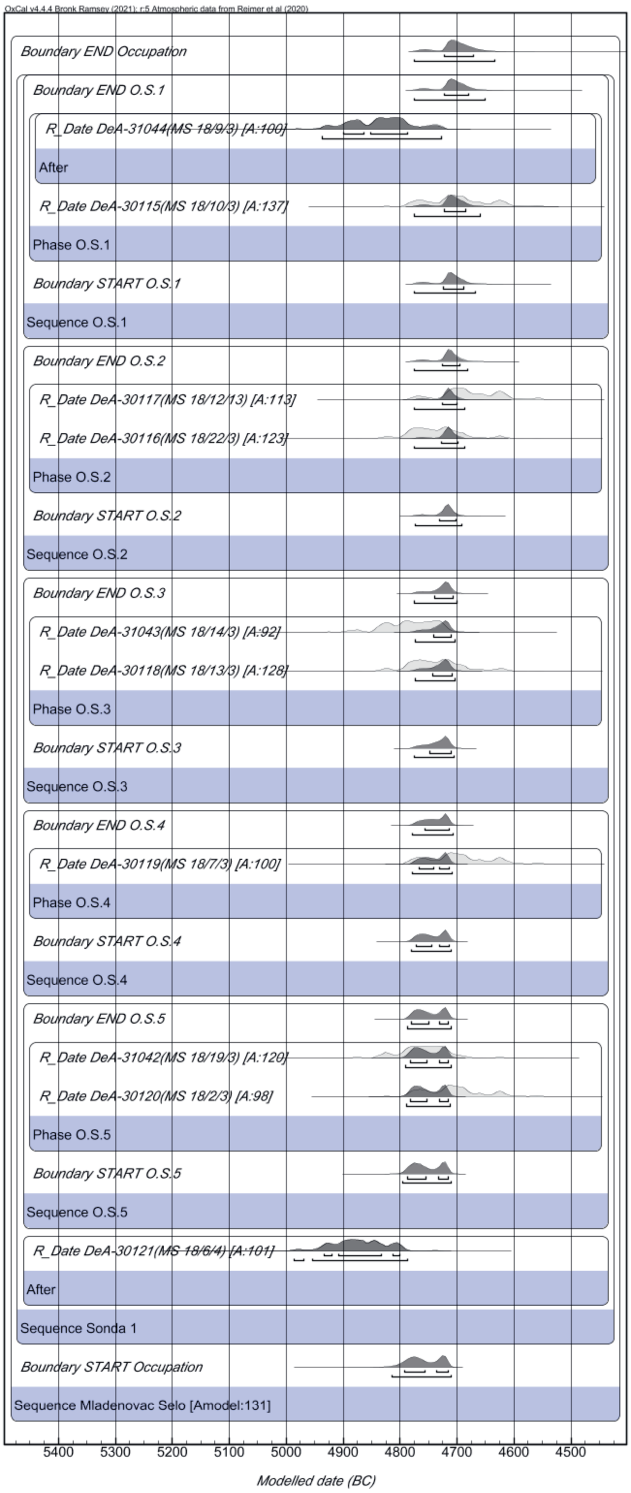

Figure 2. *Bayesian chronological model of Jablanica Trench 1*

Using the stratigraphic sequence of Trench 1 in Jablanica recorded during the excavations in 2018, the constructed Bayesian chronological model presented us with a very strong agreement (Amodel: 131), with only two samples (DeA-30121 and DeA-31044) displaying a strong indication of being residual bone (Figure 2). Modelled start of the occupation of the part of the settlement in Trench 1 (Figure 3) can be dated as 4815–4711 cal BC (95% prob.), possibly 4793–4756 cal BC (43.3% prob.) or 4737–4717 cal BC (25% prob.). The chronological sequence of events unfolding in the trench appears to have been very short. The oldest phase, spit 5 appears to last anywhere between 0 and 25 years (95% prob.), possibly just between 0 and 9 years (68% prob.). Similar can be said for other spits as well, since they all appear to cover archaeological accumulations that mainly lasted between 0 and 25–30 years (95% prob.), possibly 0–8 or 9 years (68% prob.). The end of the Late Neolithic occupation in the trench can be estimated to 4776–4634 cal BC (95.4% prob.), possibly 4723–4671 cal BC (68% prob.), which indicates a short occupation span of 0 to 177 years (95.4% prob.), possibly just between 0 and 71 years (68% prob.), which is indeed a short timeframe for the Late Neolithic occupation, comparable to three generation spans (Figure 4, 5). To summarise, the beginning of the Late Neolithic occupation in Trench 1 at the site of Jablanica can be equated with the relative depths of 4.5 meters at the type site of Belo Brdo or the late Vinča Pločnik I (Vinča C) period, while the radiocarbon dates associated with the end of the Late Neolithic occupation of the site can be correlated to layers between 4.0 and 3.5 meters at the type site of Vinča (Tasić et al. 2015: Tab. 5), i.e., the Vinča Pločnik IIa (Vinča D1) period (Tasić et al. 2015: Tab. 8).

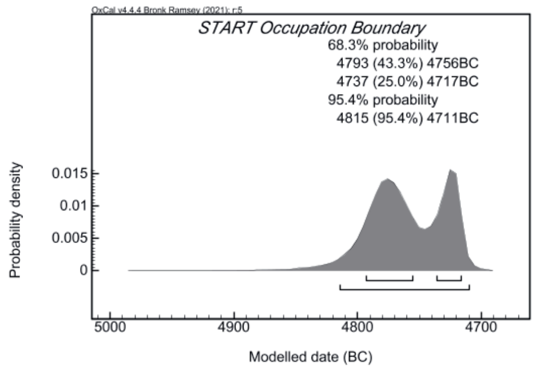

Figure 3. *Modelled Late Neolithic Start of occupation of Jablanica, derived from Bayesian model from Figure 1*

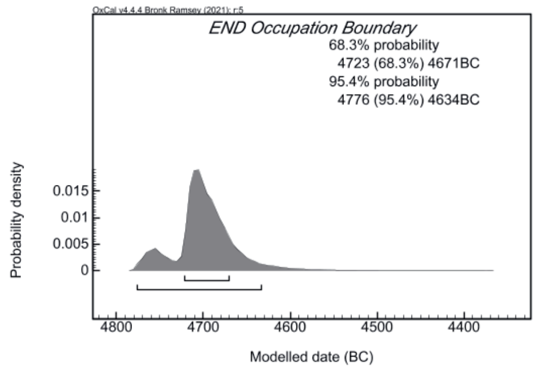

Figure 4. *Modelled Late Neolithic End of occupation of Jablanica, derived from Bayesian model from Figure 1*

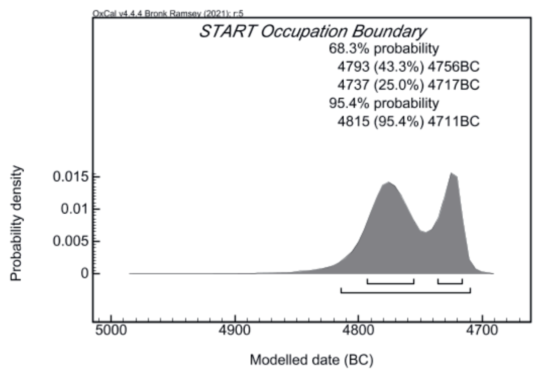

Figure 5. *Modelled span of the duration of the Late Neolithic settlement of Jablanica, based on data from Trench 1*

Faunal assemblage

The animal remains from Trench 1 found during archaeological excavations at the site of Jablanica in the 2018 campaign were hand-recovered from five Late Neolithic habitation horizons. Taxonomic determination was carried out using the comparative collection of the Laboratory for Bioarchaeology at the Faculty of Philosophy in Belgrade. Also, guides of morphological criteria and comparative anatomy were used (Boessneck et al. 1964; Boessneck 1969; Schmid 1972; Payne 1985; Prummel and Frisch 1986; Prummel 1988; Helmer and Rocheteau 1994; Halstead et al. 2002; Zeder and Lapham 2010; Zeder and Pilaar 2010). The distinction between wild and domestic pig species was derived from the correlation of metric data. The metric analysis was carried out following the metric standards of Driesch 1976. Quantification was performed according to the number of identified specimens (NISP).

The Jablanica faunal assemblage consists of the remains of mammals, birds, amphibians, fish, and molluscs (Table 1). The assemblage comprises 4,146 specimens. Out of the total number of specimens, 739 (19%) could be identified to a species or to a genus level. The relative distribution of domestic animal remains (83%) outnumbers the wild (17%). The most frequent domestic species was cattle (54.5%), followed by a domestic pig (17%) and caprines (9.5%). The dog remains were represented by 2%. The most frequently hunted species was a red deer (7%), followed by a hare (4%), roe deer (3%) and wild boar (2.5%).

Common name	Latin name	NISP	% NISP
Domestic cattle	*Bos taurus*	402	54.5
Domestic pig	*Sus domesticus*	128	17
Wild boar	*Sus scrofa*	19	2.5
Pig (indet.)	*Sus* sp.	2	0.5
Sheep or goat	*Ovis/Capra*	70	9.5
Dog	*Canis familiaris*	16	2
Red deer	*Cervus elaphus*	51	7
Roe deer	*Capreolus capreolus*	20	3
Hare	*Lepus europaeus*	31	4
Total identified		**739**	**100**
Large mammals		2946	
Medium mammals		398	
Small mammals		4	
Micromammals		1	
Birds	Aves	10	
Amphibians	Amphibia	1	
Fish	Pisces	1	
Snails	Gastropoda	14	
Bivalves	Bivalvia	32	
Total unidentified		3407	
TOTAL		4146	

Table 1. *Distribution of taxa at Jablanica, as Number of Identified Specimens (NISP)*

Anatomical region	Element	Cattle	Pig	Caprines	Red deer	Roe deer
Head	Cornus	3			18	2
	Cranium	9	11			
	Praemaxilla	1	2	1		
	Maxilla	5	7	1	1	
	Mandibula	30	23	9	2	1
	Dentes	33	10	3	2	
	Hyoid	1		1		
	Head total:	**82**	**53**	**15**	**23**	**3**
Axial	Vertebrae	9	2			
	Pelvis	14	3	3	1	
	Axial total	**23**	**5**	**3**	**1**	**0**
Upper limb parts	Scapula	6	9	4		
	Humerus	22	8	2	2	3
	Femur	10	4	1		
	Upper limbs parts total:	**38**	**21**	**10**	**2**	**3**
Lower limb parts	Radius	18	6	8	2	2
	Ulna	6	8	3	1	1
	Tibia	18	15	11	1	1
	Fibula		1			
	Carpalia	16			1	
	Tarsalia	58	2	2	6	
	Metapodium	46	9	17	10	10
	Sesamoideum	14				
	Lower limbs parts total	**176**	**41**	**41**	**21**	**14**
Phalanx	**Phalanx I-III**	**82**	**8**	**4**	**4**	**0**
	TOTAL:	**401**	**128**	**70**	**51**	**20**

Table 2. *Distribution of skeletal elements of the main domesticated and wild species*

The distribution of skeletal elements of cattle, pigs, caprines, red deer, and roe deer are provided in Table 2. The animal remains are grouped into five anatomical regions: head, axial, upper limb parts, lower limb parts, and phalanges. Skeletal elements of analysed species from all anatomical regions are present in the faunal assemblage, although their frequency varies from species to species. In the case of almost all species, the most frequent skeletal elements are from the lower parts of the limbs – metapodials, followed by head and upper limb parts, except for cattle. In the case of cattle, after the elements of the lower parts of the limbs, elements of the head and phalanges are equally represented. In the case of red deer, over 78% of head elements are antlers. Considering that they are fragments of beams and tines, it is difficult to distinguish whether the antlers originate from hunted animals or part of them are shed antlers collected in the surrounding area of the settlement. Rib fragments are also represented in the assemblage. Out of the total number of large mammal remains, ribs comprise 2%, while only three specimens (0.5%) originate from medium size mammals. Based on the distribution of skeletal elements, i.e. presence of bones from all anatomical regions, it can be concluded that whole domestic and wild animals were brought to the Jablanica settlement and further processed for food and raw materials.

Although the animal remains from the Late Neolithic Jablanica are well-preserved without pronounced weathering marks, they are highly fragmented. Whole skeletal elements constitute 3% of the total faunal assemblage. Butchery marks were revealed on the bones of cattle, pigs, and caprines and comprised 1% of the specimens in total. Traces of burning were found on 25.5% of animal remains. Most burnt specimens are carbonised or calcined, indicating the post-consumption treatment, such as managing midden areas. Gnawing marks are found on 4.5% of the specimens, indicating that dogs or even pigs had occasional access to animal bones. Taphonomic characteristics of the faunal assemblage from Jablanica, particularly the high percentage of carbonised and calcined specimens, indicate the possible existence of the organisation and management of midden areas in the settlement (Table 3).

Modifications	n	% n
Butchery	42	1
Gnawing	187	4.5
Burning	1057	25.5
Worked bones	90	2.2

Table 3. *Distribution of bone modifications in total faunal assemblage (n = 4146)*

In total, 90 (2.2%) animal remains had manufacturing and use-wear traces.

Animal husbandry in large communally oriented settlements from the first half of the fifth millennium BC in the central part of present-day Serbia, i.e., in the vicinity of Jablanica, was based on breeding large herds of cattle – e.g., Vinča – Belo Brdo (Bulatović 2018), Grabovac – Đurića Vinogradi (Bulatović and Spasić 2019), Stubline (Gillis et al. 2020), Selevac (Legge 1990), and Drenovac (Dimitrijević 2020). The relative distribution of different mammal species indicates that the most important economic species in the Late Neolithic settlement of Jablanica was domestic cattle. In light of that, the Jablanica settlement fits into the regional economic pattern. In some other large Late Vinča settlements, where animal husbandry was mainly based on herding domestic cattle, hunting played a less significant role in the economy (e.g., Pločnik) (Bulatović and Orton 2021). With 17% of the Jablanica faunal assemblage and species diversity, the hunting activity in this Late Neolithic settlement corresponds to the regional trend.

Bone tool assemblage

The bone tool assemblage consists of 90 artefacts. Some of them were recognised during excavations, while most were singled out during the faunal analysis. Artefacts were analysed from the technological viewpoint, meaning that the raw material selection, manufacturing techniques, morphology and use-wear traces were considered. Artefacts were analysed with low magnification (up to 20x), and the use-wear traces are poorly preserved in general since most artefacts had surfaces damaged by weathering, erosion, and carbonate crusts, and also, numerous items were carbonised from exposure to fire. The interpretation of the manufacturing and use-wear traces follow published criteria (Campana 1989; Christidou 1999; 2001; Christidou and Legrand 2005; Legrand and Sidéra 2006; Legrand 2007; 2008; Newcomer 1974; Patou-Mathis ed. 2002; Peltier 1986; Ramseyer ed. 2004; Sidéra 2005: Semenov 1976), while the typological classification is based on the morphology of the working end and possible function, the one already developed for the prehistoric assemblages in South-eastern Europe (Vitezović 2007; 2011; 2016) (see also Vitezović 2016 and references therein for details on the methodological procedures).

Raw materials used were predominantly bones, mainly metapodial bones and ribs. Also, several astragali were found, as well as one phalanx. Bones were from both large and medium-sized ruminants – cattle, red deer and sheep/goats. Red deer antlers were used to a lesser extent, and it was impossible to determine whether they were collected or obtained from hunted animals. Just one artefact from *Spondylus* shell was discovered. Artefacts from teeth were not noted.

Figure 6. *Complete and fragmented awls produced from small ruminant metapodial bones*

Pointed tools. Tools with a pointed end were the most frequent, particularly medium-sized pointed tools – awls. Two subtypes were noted, awls produced from long bones and awls made from ribs. Awls from long bones were all made from longitudinally split metapodial bones from small ruminants (Figure 6). Bones were split along their natural sulcus by grooving and cutting with a chipped stone tool and finalised by burnishing with an abrasive stone tool (for a detailed reconstruction of this technique, see Sidéra 2005). Two completely preserved awls have segments of proximal epiphysis preserved at the base, and several fragmented awls with the distal epiphysis are preserved. These awls were generally intensively used, often heavily fragmented, and when visible, use-wear traces consist of polished, shiny surfaces resulting from contact with soft, organic materials (Christidou and Legrand 2005; Legrand 2007; 2008; Peltier 1986). Awls produced by using the same technique (grooving, splitting, burnishing) from the same raw material and with the same morphological traits are among the most common tool types in other Vinča culture bone assemblages – they are encountered, among others, at Vinča – Belo Brdo (Bačkalov 1979; Srejović, Jovanović 1959: 182), Selevac (Russell 1990: 524), Drenovac (Vitezović 2007), Pločnik (Vitezović 2021a: 43–51, Figure 17, 18, 19; 2021b), etc. They are common on other Late Neolithic sites in Europe as well – e.g., in Greece (Stratouli 1998: taf. 25/1), in Hungary (Tóth 2013: 329–331), in Switzerland (Deshler-Erb et al. 2002: 342, abb. 507/1, 2, 4, 6), etc.

Awls made from ribs were produced from longitudinally split ribs, also finalised by burnishing with an abrasive stone. Only two are somewhat better preserved, while the majority are heavily fragmented – only the tips are preserved (Figure 7). They were also intensively used, and use-wear traces consist of polished, shiny surfaces, and smoothed, abraded spongy tissue on the inner side. A significant ratio of completely worn and broken tools suggests they were already disposed of, i.e., that the excavated area encompassed a rubbish pit.

Figure 7. *Awls made from ribs – fragments of distal segments*

Rib awls were also a widespread techno-type in the Vinča culture, known from, among others, Vinča – Belo Brdo (Bačkalov 1979; Srejović, Jovanović 1959: 182), Selevac (Russell 1990: 524), Drenovac (Vitezović 2007: 138–140), Pločnik (Vitezović 2021a: 51–54; Figure 25, 26, 27), and many more.

Several heavy points were found. They are mainly fragmented, but three of them are completely preserved. Two are produced from metapodial bones, one from red deer and the other from cattle (Figure 8). They were made using the same technique as awls – bones were longitudinally split by grooving with a chipped stone tool and finalised by burnishing and polishing. The point from the red deer bone has the distal epiphysis preserved as the base, while the point from cattle bone has the proximal epiphysis. Their distal ends are thicker, more massive points used for working on more resilient materials, such as wood, etc. Similar heavy points may be found at other Vinča culture sites – for example, Pločnik (Vitezović 2021a: 54–57, Figure 28).

Figure 8. *Heavy points produced from large ruminant metapodial bones*

One complete and one fragmented heavy point were made from unsplit ribs; ribs were divided into segments by transversal cutting and sawing, and then the side edges were cut with a chipped stone tool and burnished. Thus obtained blanks, with both bone plates of the ribs preserved, were further modified by burnishing into massive pointed tools. In order to obtain finer tools, such as awls, ribs were usually split longitudinally into two halves (two bone plates) and then shaped by burnishing – as frequently noted on this and other Vinča culture sites (e.g., Vitezović 2007; 2021a; see also Christidou 1999; 2001 for the reconstruction of this technique), but in this case, the artisan decided to make tools that are thicker and more resilient.

Fine pointed tools – needles – are not frequent; one almost complete small pointed tool made from a segment from a split rib was found, and also, few of the fragmented items were most likely needles.

Figure 9. *Fragmented tool from red deer antler, probably large cutting tool*

Figure 10. *Spatula-chisel made from rib*

Cutting tools. Two fragmented antler tools were probably axes or adzes. Only the basal part is preserved for the first one, a segment from the beam just below the crown (Figure 9). Traces of crown tines being removed may be noted, and a broken perforation is produced by cutting with a chipped stone tool. The other artefact is also a beam with crown tines removed, and the distal part is missing, but perhaps it was modified into a cutting edge. Similar axes/adzes are also known from other Vinča culture settlements, including Vinča – Belo Brdo (Srejović, Jovanović 1959).

Burnishing tools. Two scrapers made from ribs were found; they were made from unsplit segments of ribs and have a rounded working edge, worn from use. Also, one complete tool was found, a spatula-chisel made from the rib (Figure 10). The rib was split, and the tool was made from one bone plate. The tool has an irregular triangular shape; the basal end is small, while the distal end is wider. The working edge is slightly rounded, almost straight, sharp and worn from use. The spongy tissue is intensively worn, while the upper surface shows strong polish from use. Diverse types and subtypes of burnishing tools made from ribs are also frequent at other Vinča culture sites – for example, Selevac (Russell 1990: 532), or Pločnik (Vitezović 2021a: 61–63; Figure 39), to mention just a few.

Percussion tools. Three antler tines were modified into small percussion tools (Figure 11). They have traces of cutting at the basal part – the antler was thinned by the gradual removal of pieces of cortex by a chipped stone tool, and when the spongy tissue was reached, it was carefully cut through. The natural tip of the tine was also modified by cutting small pieces of the antler (whittling) to produce a small circular or elliptical working surface. The traces of use are not well preserved, but it may be noted that the distal ends are heavily worn, with lines and shallow grooves from use. They were probably used on different materials – for woodworking, food preparation, etc. On one of them, there are possible traces of being used as a retouching tool – dense, grouped short, deep grooves and incisions (see Patou-Mathis ed. 2002). Small punching tools made from antlers are also known, among others, at Drenovac (Vitezović 2007: 152).

Objects of special use. One fragmented large long bone, without preserved traces of manufacture but with intensive traces of use on its outer surface (intensive polish, worn surfaces, dense lines and striations), may have been some sort of a handle.

Five astragali with traces of use were noted, two with broken perforations. The use-wear traces are located on condyli – they are flattened and worn, and also some smoothing on the lower part may be observed on some of them. Perforations, R=5 mm, made by drilling, were positioned in the upper part. The function of these items is still a matter of debate (see Vitezović 2021a: 73–77 for an extensive overview), but their traces of use suggest they were most likely used on soft, organic materials, such as leather, hide, plant fibres, and the existence of perforation may point to their use as loom weights.

Several rib segments were also noted without preserved traces of manufacture but with intensive traces of use. Use-wear consists of worn surfaces, intensively polished, and irregular lines and striations. They were most likely used as some sort of supporter or working surfaces. Similar items were noted on other Vinča culture sites, such as Drenovac (Vitezović 2007), and for those found at Selevac, an interpretation as thong stretchers was offered (Russell 1990: 533). The examples from Jablanica were probably used for different purposes (for different raw materials), including possible thong stretchers.

Ornaments. Only one ornament was found, a fragmented bracelet from *Spondylus* shell (Figure 12). Ornaments made from marine molluscs were noted in other Vinča culture settlements – they were most frequent at the eponymous site of Vinča – Belo Brdo (Dimitrijević and Tripković 2002; 2006), but were also noted, for example, at Selevac (Russell 1990), Vitkovo (Vitezović 2013), Pločnik (Vitezović 2021a; 2021b), and many more (see also Vitezović, Antonović 2020). This find from Jablanica contributes to the map of their distribution and the reconstruction of trade routes.

Incomplete items. Besides several artefacts that are too fragmented to be identified typologically, three fragments of metapodial bones with just traces of manufacture were also noted. These bones were split longitudinally, and traces of a groove produced by a chipped stone tool are clearly visible. Traces of later stages of manufacture (namely, burnishing) and use-wear traces are missing, showing that these items are manufacture debris – and, as these are proximal fragments of metapodial bones, they were most likely discarded and only the distal portions were used for tool production.

Figure 11. *Small punching tool from red deer antler tine*

Figure 12. *Fragmented Spondylus bracelet*

Concluding remarks

The site of Jablanica was a large Vinča culture settlement, which flourished between 5000 and 4700 BC. The excavations at one trench in 2018 revealed five habitation horizons, and the radiocarbon dates enabled detailed information regarding the duration and their absolute dates. The beginning of the occupation by the Vinča culture communities can be equated with the relative depths of 4.5 meters at the type site of Belo Brdo or the late Vinča Pločnik I (Vinča C) period, while the radiocarbon dates associated with the end of the Late Neolithic occupation of the site can be correlated to layers between 4.0 and 3.5 meters at the site of Vinča – Belo Brdo.

The subsistence was based on domestic animals, and the most important economic species was domestic cattle, while hunting red deer, hare, roe deer, and wild boar played a minor role. Bones from domestic animals and occasional bones from wild species were also used to produce everyday tools, mainly pointed and burnishing tools, used for processing organic materials, such as leather, hide, plant fibres, and to a lesser extent, for woodworking. Antlers were not frequent, and it cannot be determined whether they were collected from hunted animals. Manufacturing techniques are those frequently used at other Vinča culture settlements, and the typological repertoire includes tools frequently encountered at other sites – awls from metapodial bones, awls from ribs, burnishing tools from ribs, used astragali, etc. The relatively limited repertoire (for example, small amounts of cutting and burnishing tools and the absence of large percussion tools) is due to the limited excavated area. The single find of an ornament from a mollusc shell shows that the communities at Jablanica also participated in supraregional trade and exchange networks.

Acknowledgements

This research is a part of the PROMIS project Regional Absolute Chronology of the Late Neolithic in Serbia – RACOLNS, No. 6062361, funded by the Science Fund of the Republic of Serbia.

References

Bačkalov, A. 1979. "Predmeti od kosti i roga u predneolitu i neolitu Srbije". Beograd: Savez arheoloških društava Jugoslavije.

Boessneck, J. 1969. "Osteological differences between sheep (Ovis aries Linn.) and goat (Capra hircus Linn.)". In D. Brotwell, and E. Higgs (eds.), *Science in Archaeology*: 331–358. London: Thames and Hudson.

Boessneck, J., H. Müller, and M. Teichert 1964. "Osteologische Unterscheidungsmerkmale zwischen Schaf (*Ovis aries* Linné) und Ziege (*Capra hircus* Linné)". *Kühn-Archiv* 78: 1–29.

Bronk Ramsey, C., 1995. "Radiocarbon calibration and analysis of stratigraphy: the OxCal program". *Radiocarbon* 37, 425–430.

Bronk Ramsey, C., 2010. OxCal v4.2b4 (c14.arch.ox.ac.uk/oxcal).

Brown, T., Nelson, D., Vogel, J., Southon, J. 1988. "Improved collagen extraction by modified Longing method". *Radiocarbon* 30, 171–177.

Bulatović, J. 2018. "*Arheozoološki aspekti društvenih i kulturnih promena na centralnom Balkanu u petom milenijumu pre nove ere"*. Unpublished Ph.D. thesis, University of Belgrade, Serbia.

Bulatović, J. and D. Orton. 2021. "Animal remains from Pločnik". In M. Radivojević, B. Roberts, M. Marić, J. Kuzmanović-Cvetković, and T. Rehren (eds.), *The Rise of Metallurgy in Eurasia: The Archaeology of Early Metallurgy and Society in the Central Balkans: Evolution, Organisation and Consumption of Early Metal in the Balkans*: 422–432. Oxford: Archaeopress.

Bulatović, J. and M. Spasić. 2019. "Životinjski ostaci sa neolitskog nalazišta Grabovac – Đurića vinogradi". *Zbornik narodnog muzeja* 24 (1): 63–84.

Campana, D. 1989. "Natufian and Protoneolithic Bone Tools. The Manufacture and Use of Bone Implements in the Zagros and the Levant". Oxford: BAR International Series 494.

Christidou, R. 1999. "Outils en os néolithiques du Nord de la Grèce: étude technologique". Unpublished PhD thesis. Paris: Université de Paris I-Nanterre.

Christidou, R., 2001. "Study of Bone Tools at Three Late/Final Neolithic Sites from Northern Greece". In Choyke A., Bartosiewicz L. (eds.): Crafting Bone: Skeletal Technologies through Time and Space – Proceedings of the 2nd meeting of the (ICAZ) Worked Bone Research Group Budapest, 31 August – 5 September 1999. Oxford: British Archaeological Reports International Series 937, Archaeopress, 41–47.

Christidou, R., Legrand, A. 2005. "Hide working and bone tools: experimentation design and applications". In Luik, A. Choyke, C. Batey and L. Lougas (eds.), From Hooves to Horns, from Mollusc to Mammoth – Manufacture and Use of Bone Artefacts from Prehistoric Times to the Present. Proceedings of the 4th Meeting of the ICAZ Worked Bone Research Group at Tallinn, 26th–31st of August 2003. Muinasaja teadus 15. Tallinn: 385–396.

Deschler-Erb, S., Marti-Grädel, E., Schibler, J., 2002. "Die Knochen-, Zahn- und Geweihartefakte". In De-Capitani, A., Deschler-Erb, S., Leuzinger, U., Marti-Grädel, E., Schibler, J., Die jungsteinzeitliche Seeufersiedlung Arbon, Bleiche 3: Funde. Frauenfeld:Departement für Erziehung und Kultur des Kantons Thurgau, Archäologie im Thurgau 11, 277–366.

Dimitrijević, I. 2020. "*Ekonomski i društveni značaj životinja u vinčanskim naseljima u Pomoravlju*". Unpublished Ph.D. thesis, University of Belgrade, Serbia.

Dimitrijević, V.; Tripković, B. 2002. "New Spondylus findings at Vinča–Belo Brdo 1998–2001 campaigns and the regional approach to problem". In Starinar, n. s. LII, 48–62.

Dimitrijević, V.; Tripković, B. 2006. "Spondylus and Glycymeris bracelets: trade reflections at Neolithic Vinča–Belo Brdo", in Documenta praehistorica, XXXIII, p. 237–252.

Driesch von den, A. 1976. "*Guide to the Measurements of Animal Bones from Archaeological Sites*". Cambridge: Peabody Museum Press.

Garašanin, M. 1979. "Centralno-balkanska zona". In A. Benac, (ed.), Praistrija jugoslavenskih zemalja II – Neolitsko doba. Akademija nauka i umjetnosti BiH – Centar za balkanološka istraživanja, Sarajevo: 79–212.

Gillis, R. E., J. Bulatović, K. Penezić, M. Spasić, N.N. Tasić and C.A. Makarewicz. 2020. "Herding and hunting at Vinča-Belo Brdo and Stubline during the Late Neolithic, a stable isotopic perspective". In N. Marković and J. Bulatović (eds.), *Animal Husbandry and Hunting in the Central and Western Balkans Through Time*: 19–39. Oxford: Archaeopress.

Halstead, P., P. Collins and V. Isaakidou 2002. "Sorting sheep from goats: morphological distinctions between the mandibles and mandibular teeth of adult Ovis and Capra". *Journal of Archaeological Science* 29: 545–553.

Helmer, D. and M. Rocheteau 1994. "*Atlas du Squelette Appendiculaire des Principaux Genres Holocenes de Petits Rumiant du Nord de la Méditerranée et du Proche-Orient (Capra, Ovis, Rupicapra, Capreolus, Gazella)*". Juan-les-Pins: APDCA.

Katić, V. 1989. "Rezultati rekognosciranja teritorije Mladenovca". *Glasnik srpskog arheološkog društva* 5: 156–163.

Katić, V. 2003. "Stogodišnjica publikovanja Jablanice kod Mladenovca". In D. Stojković (ed.) *Huk duše, knjiga 2*: 142–145. Mladenovac: Biblioteka Despot Stefan Lazarević.

Kromer, B., Lindauer S., Synal H., Wacker, L. 2013. "MAMS – a new AMS facility at the Curt-Engelhorn-Centre for Archaeometry, Mannheim, Germany". *Nuclear Instruments and Methods in Physics Research* 294 (B), 11–13.

Legge, A. 1990. "Animals, Economy end Environment". In Tringham, R., Krstić. D. (eds.), *Selevac: A Neolithic Village in Yugoslavia:* 215–242. Monumenta archaeologica 15. Los Angeles: Institute of Archaeology, University of California.

Legrand A. 2007. "Fabrication et utilisation de l'outillage en matières osseuses du Néolithique de Chypre: Khirokitia et Cap Andreas-Kastros". Oxford: BAR International Series 1678. Archaeopress.

Legrand, A., 2008. "Neolithic bone needles and vegetal fibres working: experimentation and use-wear analysis". In Longo, L., Skakun N. (eds.), "Prehistoric Technology" 40 Years Later: Functional Studies and the Russian legacy. BAR International Series 1783, Oxford, pp. 445–450.

Legrand A., Sidéra I. 2006. "Tracéologie fonctionnelle des matières osseuses: une méthode". Bulletin de la Société préhistorique française 103/2: 291–304.

Molnar, M., Janovics, R., Major I., Orsovszki, J., Gönczi, R., Veres, M., Leonard, A., Castle, S., Lange, T., Wacker, L., Hajdas, I., Jull, A. 2013. "Status report of the new AMS 14C sample preparation lab of the Hertelendi laboratory of environmental studies (Debrecen, Hungary)". *Radiocarbon* 55 (2–3), 665–676.

Newcomer, M., 1974. "Study and replication of bone tools from Ksar Akil (Lebanon)". World Archaeology 6 (2), 138–153.

Payne, S. 1985. "Morphological distinctions between mandibular teeth of young sheep, Ovis, and goats, Capra". *Journal of Archaeological Science* 12: 139–147.

Patou-Mathis, M. (ed.) 2002. "Retouchoirs, compresseurs, percuteurs… Os à impressions et éraillures". Fiches de la Commission de nomenclature sur l'industrie de l'os préhistorique. Cahier X. Paris: CNRS.

Peltier, A. 1986. "Étude expérimentale des surfaces osseuses façonnées et utilisées". Bulletin de la Société Préhistorique Française 83/1: 5–7.

Prummel, W. 1998. "Distinguishing Features of Postcranial Skeletal Elements of Cattle, Bos primigenius f. taurus, and Red Deer, Cervus elaphus". *Schriften aus der Archäologisch- Zoologischen Arbeitsgruppe Schleswig-Kiel* 12: 5–51.

Prummel, W. and H.-J. Frisch 1986. "A guide for the distinction of species, sex and body side in bones of sheep and goats". *Journal of Archaeological Science* 13: 567–577.

Ramseyer, D. (ed.), 2004. "Matières et techniques". Fiches de la Commission de nomenclature sur l'industrie de l'os préhistorique. Cahier XI. Paris: CNRS.

Reinach, S. 1901. "La Station Néolithique de Jalanica (Serbie)". In M. M. Boule-Verneau (ed.) *Matériaux pour l'histoire de l'homme, Revue d'anthropologie, Revue d'ethnographie réunis- L'anthropologie*: 527–533. Paris: Libraires de l'Académie de médecine.

Russell, N., 1990. “The bone tools”. In Tringham, R., Krstić, D. (Eds.), Selevac: A Neolithic village in Yugoslavia. University of California Press, Los Angeles, pp. 521–548.

Schmid, E. 1972. “*Atlas of Animal Bones. For Prehistorians, Archaeologists and Quaternary Geologists*”. New York: Elsevier.

Semenov, S. A. 1976. “Prehistoric technology. An experimental study of the oldest tools and artefacts from traces of manufacture and wear”. Barnes and Noble. Wiltshire.

Sidéra, I. 2005. “Technical data, typological data: a comparison”. In H. Luik, A. Choyke, C. Batey, and L. Lougas (eds.), From Hooves to Horns, from Mollusc to Mammoth – Manufacture and Use of Bone Artefacts from Prehistoric Times to the Present. Proceedings of the 4th Meeting of the ICAZ Worked Bone Research Group at Tallinn, 26th–31st of August 2003. Muinasaja teadus 15. Tallinn: 81–90.

Stratouli, G. 1998. “*Knochenartefakte aus dem Neolithikum und Chalkolithikum Nordgriechenlands*”. Bonn: Rudolf Habelt.

Srejović, D., and Jovanović, B. 1959: “Oruđe i oružje od kosti i nakit iz Vinče”. *Starinar n. s.* IX–X: 181–190.

Tasić, N. N., Marić, M., Bronk Ramsey, C., Kromer, B., Barclay, A.J., Bayliss, A., Beavan, N., Gaydarska, B., Whittle, A., 2015. “Vinča-Belo Brdo, Serbia: the times of a tell”. Germania 93, 1–75.

Tóth, Zs., 2013. “Csont- és agancseszközök komplex vizsgálata a késő-neolitikus AszódPapi földek lelőhelyén”. Ph.D. Dissertation, Eötvös Loránd University, Budapest.

Vassits, M. 1902. “Die neolithische station Jablanica bei Medjulužje in Serbien”. *Archiv für Anthropologie 27, Heft 4*: 517–582.

Vitezović, S., 2007. “Koštana industrija u neolitu srednjeg Pomoravlja”. Mphil thesis, Faculty of Philosophy, University of Belgrade.

Vitezović, S. 2011. “Koštana industrija u starijem i srednjem neolitu centralnog Balkana”. PhD thesis. Faculty of Philosophy, University of Belgrade.

Vitezović, S. 2013. “Personal ornaments in the Vinča culture: the case study of Vitkovo and Stragari”. In I. V. Ferencz, N. Cătălin Rişcuţa, and O. Tutilă Bărbat (eds.), Archaeological small finds and their significance: Proceedings of the symposion: Costume as an identity expression (Costume as an identity expression. Simpozion internaţional). Editura Mega Cluj–Napoca, Deva: 9–20.

Vitezović, S. 2016. “Metodologija proučavanja praistorijskih koštanih industrija”. Srpsko arheološko društvo. Beograd.

Vitezović, S. 2021a. “Praistorijski lokalitet Pločnik kod Prokuplja: koštana industrija (istraživanja 1996–2011)”. Arheološki institut, Beograd.

Vitezović, S. 2021b. “The bone industry at Pločnik”. In Radivojević, M., Roberts, B. W., Kuzmanović-Cvetković, J., Marić, M., Šljivar, D., Rehren, T. (eds.), The Rise of Metallurgy in Eurasia: The Archaeology of Early Metallurgy and Society in the Central Balkans. Archaeopress, Oxford, pp. 393–396.

Vitezović, S. and Antonović, D. 2020. “Jewellery from osseous and lithic raw materials in the Vinča culture”. In Beauty and the eye of the beholder. Personal adornments across the millennia, edited by Monica Mărgărit and Adina Boroneanț, 87–100. Târgovişte: Cetatea de Scaun.

Wassits, M. 1902. “Die neolithische Station Jablanica bei Međulužje in Serbien”. *Archiv für Anthropologie* 27(4): 517–582.

Zeder, M. and H. Lapham 2010. “Assessing the reliability of criteria used to identify postcranial bones in sheep, Ovis, and goats, Capra”. *Journal of Archaeological Science* 37: 2887–2905.

Zeder, M. and S. Pilaar 2010. “Assessing the reliability of criteria used to identify mandibles and mandibular teeth in sheep, Ovis, and goats, Capra”. *Journal of Archaeological Science* 37: 225–242.

6.

Late Neolithic chronology in the contact zone between the south edge of the Carpathian Mountains and the Pannonian plain – the case study of the Vršac region

Miroslav Marić, Jelena Bulatović,
Nemanja Marković, and Ivana Pantović

Abstract The Late Neolithic period in Southeast Serbian Banat is marked by a host of Vinča culture sites located between the Danube and the Vršac mountains, the south end of the Carpathian mountain range in this area. It is a predominantly flat landscape enclosed by extensive former marshes of Mali and Veliki Rit in the northwest, Vršac mountains in the northeast, and Deliblato sands and River Nera in the southwest and the southeast. Over 40 late Neolithic sites are known throughout the area, most from surveys, but some also excavated. Between 2020 and 2022, as part of the *Regional Absolute Chronologies of the Late Neolithic in Serbia* project, funded by the *Science Fund of the Republic of Serbia*, At and Potporanj sites were radiocarbon dated to produce detailed, Bayesian statistical model-based chronologies that could be used as a local chronological reference for future researchers of the Late Neolithic in the region. In this chapter, we present unified chronological data attributable to the beginning and ending phases of the Neolithic in this region.

Keywords: Serbian Banat, Late Neolithic, Vinča culture, Radiocarbon dating, Bayesian modelling, At, Potporanj

Introduction

The geographic region of Banat occupies the southeast edge of the Pannonian plain and the Southwest brinks of the Carpathian mountain range (Figure 1) and is divided today between three countries, Hungary, Serbia and Romania, the latter possessing almost two-thirds of the region in its western portion. Historically, the region was part of the Habsburg monarchy (1716–1867) and the Austro-Hungarian Empire (1867–1716) after being reclaimed from the Ottoman Empire (1552–1716) who conquered it in 1552 after a series of wars with the Hungarian Kingdom. In 1920, after the treaty of Trianon in 1920, it was divided between the three countries that enclose its territory today. In this chapter, we will focus on a smaller region of Banat, particularly the Southeast portion of the Serbian Banat area, roughly centred between the Danube east of Belgrade and the border between Serbia and Romania in the northeast.

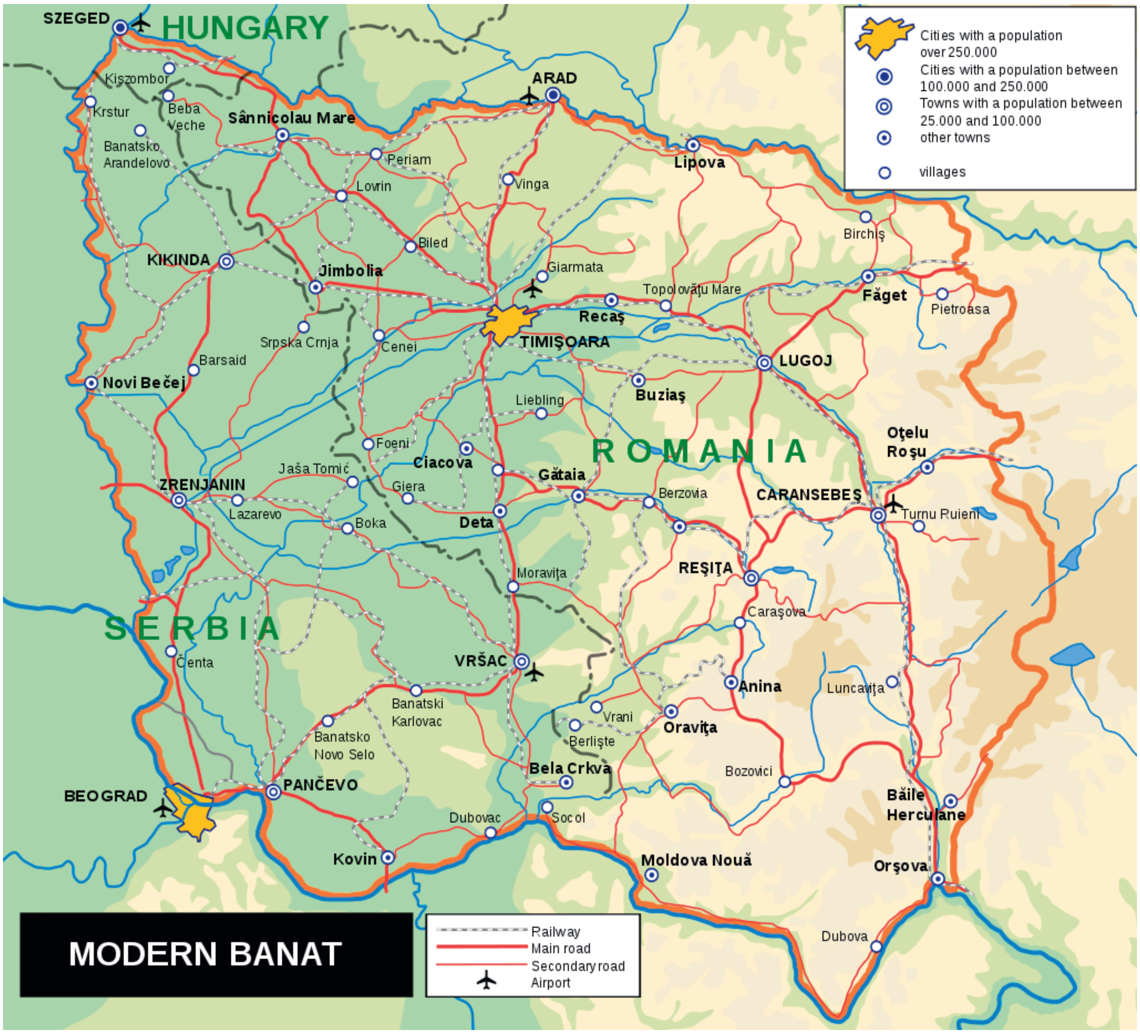

Figure 1. *Banat Geographic Region*

This region of predominantly flat landscape is nestled between several major geological formations. In the southwest, it borders the Deliblato Sands (Figure 2), once part of a vast desert that was formed during the recession phase of the Pannonian Sea (Butorac et al. 2002), while in the northeast, it abuts the south-west slopes of the Carpathian mountain range known as Vršac mountains. This formation, with its highest peak (Gudurički Vrh) at 641 meters above sea level, is composed predominantly of old rock formations like crystalline schists in the form of gneisses, while younger formations of mostly Pliocene sediments can be found in its lower northern and southern areas (Zeremski 1985). The number of water springs is relatively large, with the north side dominated mostly by stream valleys formed only between Gudurički Vrh and Donji Veršišor, opposed to larger branching streams of Mesić, Guzajna and Sočica on the southern, milder slopped side of the range. Underneath the northern slopes of Vršac mountains is one of the two major geomorphological features located in the immediate vicinity of each other; Mali Rit (Small marsh), approximately elliptical, 11 kilometres long and 2.2 kilometres at its widest (Figure 2), oriented southwest to northeast on its longer axis. The southeast side of Mali Rit is formed of mountainous rock of an older period intermixed with loess, whilst the opposing side consists of the loess plateau extending from At to the village of Vatin. The bottom of Mali Rit comprises older and younger marsh and lake sediments. Its formation started towards the end of the last Ice Age and was complete by about 8000 years BCE, after which the deposition of marsh-lake sediments started leading to the formation of the marsh/lake that finished by about 5500 BCE (Bugarski et al. 1995, p. 30).

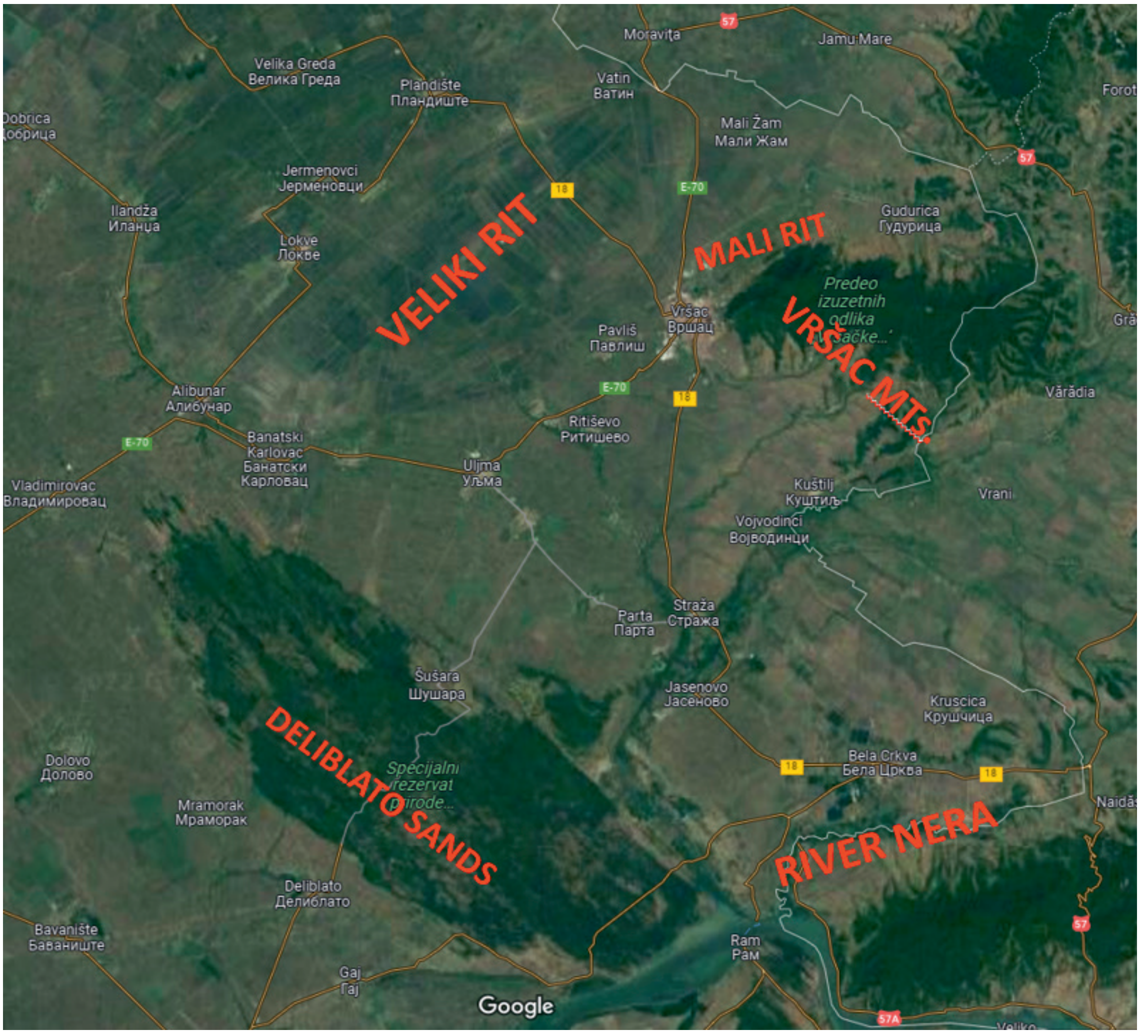

Figure 2. *Southeast Serbian Banat Region*

Next to Mali Rit, on the west side, is the At-Vatin loess plateau, a sort of division barrier beyond which is another, an even larger geomorphological feature of the area, the so-called Veliki Rit or the Alibunar depression (Figure 2). This feature, 30 kilometres long and close to 11 kilometres wide at its widest (between Pavliš and Barice villages), has most of its bottom at between 75 and 76 meters above sea level, with occasional spots at 78 meters. The depression results from the Epeirogenic movement, but its genesis is long and starts at the Würm II-III interglacial period lasting well into the Boreal (Zeremski 1967, pp. 150–151). The shaping of this feature was profoundly affected by the 8.2Kya event that resulted in the deposition of significant marsh/lake sediments at its bottom, a consequence of a moister climate that lasted for several hundred years, between 6300/6200 to 5800/5500 BCE (Burroughs 2005, p. 178). The endorheic character of the depression particularly assisted in the formation of a marshland/lake landscape that pertained until the vast reclamation works started in the late 18th century, which, over the last two centuries, were crowned by the finalisation of the Danube-Tisza-Danube canal system in 1977, which finally changed the direction of water accumulation and led to the draining of excess surface water towards the Karaš River valley.

Tucked between the Deliblato sands, Veliki Rit, and Vršac Mountains, the south Banat loess flat extends towards the southeast to the valley of the Nera River and encompasses the valley of the Karaš River (Figure 2). A geological survey of the area identified three loess horizons formed during the Würm I-III glaciation periods, with horizons of fossil soil in-between, formed during Würm I–II and II–III interstadials (Zeremski 1972).

Human occupation of the area presented in the chapter is evidenced already in the Palaeolithic period, primarily through chance finds of the Aurignacian period (Mihailović et al. 2011), but also through limited excavations on certain sites, like At (Chu et al. 2016; Radovanović 1986). However, large-scale systematic research on the Palaeolithic period is yet to be conducted. So far, there has been no evidence of Mesolithic occupation in the presented region, but it could be possible in the area, though without proper systematic research, the sites still elude detection.

In contrast to the previous periods, the Neolithic is better known, primarily due to a long-term archaeological survey of the region, started in the late 19th century by the first archaeologist in the area, Felix Milleker. In his carrier, spanning over five decades, Milleker identified some of the sites as early as 1883, one year after he started working in the Vršac city museum, which itself was founded one year before. Over the last 140 years, more than 70 Neolithic sites have been registered in the area presented here, over 30 of which belong to the period of Late Neolithic (Prikić and Joanovič 1978). However, out of the known sites, a handful of them, like At, Potok Mesić, Potporanj, and Pavliš, have ever been excavated, the latter three during archaeological rescue work mainly. Other sites are known solely from surface collections of finds. The problem is further accentuated by scarce publication of the research results, mostly just in the form of short reports (Joanovič 1977, 1976; Milleker 1938; Rašajski 1976, 1962) with only several larger volumes (e.g. Joanovič 2003; Pantović 2014; Prikić and Joanovič 1978).

Figure 3. *Position of the presented region with respect to the important known sites of the Late Neolithic period*

The importance of the region presented in our chapter for the Late Neolithic period of the southern edge of the Pannonian plain is almost immediately apparent if we take into account its position with respect to the large complexes and centres of the Neolithic in the region (Figure 3). Located between some of the larger and best-known sites of the so-called Vinča culture, like the type site of Belo Brdo in the southwest, Újvár and Parţa in Romania to the north and Turdaş in the northeast and Belovode and Rudna Glava in the southeast, the region appears to be in the middle of a more extensive network that connects the core area of the Vinča culture to the south with the northern expansions in modern-day Romania. Unsurprisingly, the two excavated sites, At and Potporanj especially, are probably best known for the most considerable quantity of obsidian finds, followed by Belo Brdo itself (Chapman 1981, pp. 80–81). Obsidian, an easily traceable material, is a perfect medium to illustrate the existence of well-established, long-running networks that span vast distances and connect different societies of the same period (Tripković 2004). Limited modelling using GIS based on the characteristics of the landscape in the area and the positions of known sites with obsidian finds (Marić 2015: Figure 10) illustrate that the immediate vicinity of the modern town of Vršac may have been a natural funnel of trade routes from various directions, possibly indicating why a large quantity of Vinča period sites (over 25 in 20 km range around Vršac) are patterned in such manner. In such a network of closely positioned late Neolithic settlements, the site of At is of particular interest to us, being at the very heart of it, on a dominant loess plateau between the eastern edge of Veliki and the western edge of Mali Rit. Establishing a strict chronological framework for this region in the Late Neolithic period based on sets of radiocarbon dates is of great importance for future research.

Methodology

In 2020, a project titled *"Regional Absolute Chronologies of the Late Neolithic in Serbia"*, funded by the Science Fund of the Republic of Serbia, set about examining various regions of Serbia for adequate collections and sites of the Vinča culture that could be used to produce detailed chronological sequences combining newly produced radiocarbon dates coupled with the knowledge of relative chronologies within a Bayesian statistical framework. The project was inspired by earlier work on the Belo Brdo site in Vinča, which produced several new chronological strands of the excavations on the type site of the Vinča culture (e.g. Tasić et al. 2016a, 2016b; Whittle et al. 2016). Over the next two years of the project duration, multiple sites from several regions of Vinča culture distribution were analysed (Figure 4) with over 200 new radiocarbon dates made in the process, most out of secure contexts with well-known stratigraphic positions.

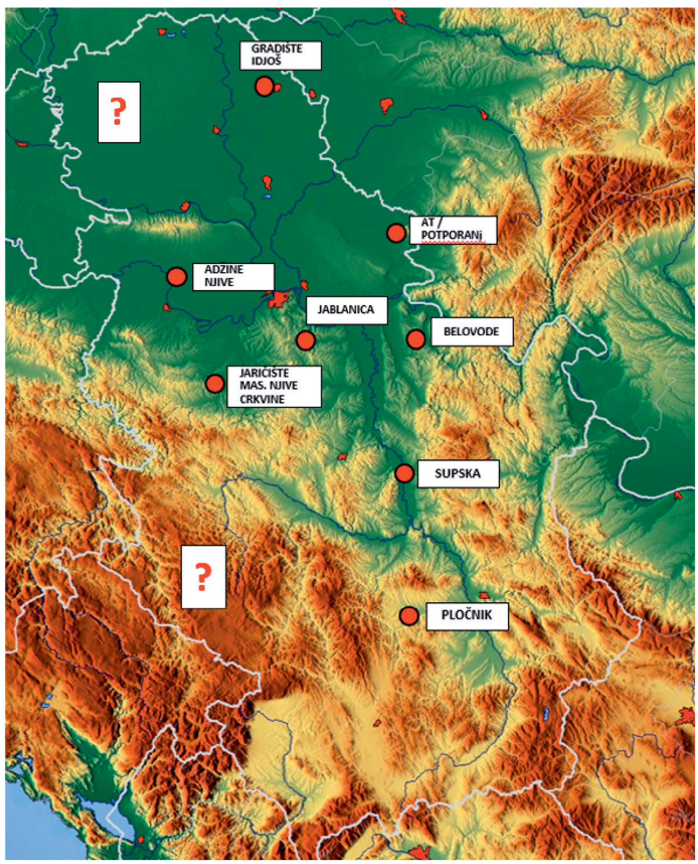

Figure 4. *Archaeological sites researched during the "Regional Absolute Chronologies of the Late Neolithic in Serbia" project*

These newly acquired dates were to be used within a Bayesian statistical framework to produce a strict chronological model of the analysed site. The field of Bayesian statistics provides archaeologists with an explicit probabilistic method that can be used to estimate absolute dates of individual events from the past. The method strength is the possibility to quantify uncertainties linked with these statistical estimates of radiocarbon measurements. It is not a novel statistical concept (Lindley 1991) and has been used in modern archaeology (Bayliss et al. 2007; Buck et al. 1996). Bayes' theorem in archaeological applications means that archaeologists analyse new data collected about a research problem (in this case, data is the standardised likelihoods of radiocarbon samples) in the context of existing archaeological experience and knowledge of the research problem (denoted as prior beliefs in Bayesian statistics). This concept then enables the creation of a new understanding of the research problem by incorporating existing knowledge and new data (to create posterior beliefs). These posterior beliefs then become future prior beliefs and inform the collection of new data and its interpretation in cyclic repeats of the procedure (Figure 5). In simplified terms, calibrated radiocarbon dates form the standardised likelihoods part of the model and are then reinterpreted regarding the prior archaeological beliefs (the knowledge), which can be informative and uninformative. The first represent specific and definite information on a problem that substantially affects the output of the model. In our example, the informative beliefs are usually evidence from stratigraphic sequences between two or more radiocarbon samples of an archaeological site being analysed. Without this, information sequences from artefact typologies or seriation can also be used. A key issue is that age proximity between the radiocarbon sample and the context which they date must exist; thus, short-lived samples such as charred grain or articulated bones are sought after. On the other hand, uninformative prior beliefs occur where there is little definite information about the research problem. However, these need also be included in the Bayesian model to avoid biasing it. This approach accounts for the fact that the radiocarbon dates being analysed in a model are related (Bayliss et al. 2007; Bronk Ramsey 2000). Uninformative prior beliefs may stem from the period of site use or the circulation period of a certain pot type indicative of a phase. This allows the model to assess how much calibrated radiocarbon dates reflect the real chronological time span of an archaeological activity dated and if they are, and to what degree, a product of statistical scatter.

$$\frac{P\,(\text{data} \mid \text{parameters})}{P\,(\text{data})} \times P\,(\text{parameters}) = P\,(\text{data} \mid \text{parameters})$$

⇓ ⇓ ⇓

Standardized likelihoods x Prior beliefs = Posterior belief

⇓ ⇓ ⇓

C14 dates x Arch. knowledge = A Solution

Figure 5. *Bayes' theorem in archaeological application*

To complement the radiocarbon analyses and available chronological sequences with another strand of data needed for a more precise Bayesian model, statistical analyses of pottery typology were undertaken on most chosen sites using a revised universal typology proposed by Garašanin and Stanković (1985) in order to enable direct cross-comparison of site assemblages chosen for the analyses. Multiple typologies of Vinča pottery were developed over several decades of research (e.g., Garašanin 1951; Jovanović 1994; Nikolić 2004; Vukmanović and Radojčić 1990), most strictly associated with specific sites they were designed for. The typology used during the project was created drawing from both the older ones but mostly from research done on a more recent project (Mirković-Marić et al. 2021a, 2021b). Ten principal categories of vessels were defined according to their assumed or proposed function, with further subdivisions within each category based on vessel morphology. The statistical analysis of vessels was then performed using Correspondence analysis (CA), as this method already showed good results on Vinča style pottery (Diaconescu et al. 2020; Schier 1996). The popularity of CA is increasing with the availability of personal computing in archaeological research and is most appropriately used in analysing tables that contain counted data, which number or frequency of pot types per archaeological context or site certainly is. The ability to represent both rows (contexts) and columns (pot types) of a data matrix as points in a single plot (Baxter

1994, p. 100). Superimposing the row and column data identifies possible clustering to reveal pattering of values (if there is one) that stand out from the calculated average data profile. Most commonly, CA is used to seriate data, i.e., to test if specific finds can identify the relative chronology of archaeological contexts or entire sites (Baxter 1994, p. 118) based on the presumption that row orders reflect the relative chronology of contexts and column data chronological evolution of material type on examination. When successful, CA will produce a *horseshoe* pattern in the plot, the so-called *Guttman effect* (Schier 1996, Figure 2). The data represented at the end of the horseshoe will have nothing in common, and the data in between will share a certain amount of similarities, indicating progressive development over time. The CA analysis was performed in the Factoshiny statistical package of the R code, a freeware statistical environment.

The AMS radiocarbon dates were made predominantly on animal bones, as in most archival assemblages used in the project no macrobotanical samples were available primarily as none were collected at the time of excavation, mainly because some of the chosen sites were excavated long before the collection of macrobotanical samples was introduced. Samples of animal bone, usually no more than 20 g in size, were then analysed in two separate laboratories, the BRAMS facility of the University of Bristol, UK and the HEKAL AMS laboratory in Debrecen, Hungary, where they were prepared in concordance with the procedures explained in Knowles et al. (2019) and Molnar et al. (2013). The direct comparison of measurements was made possible using replicate measurement data if shown to be statistically consistent (Ward and Wilson 1978). The Bayesian modelling was undertaken in the OxCal v4.4 program (Bronk Ramsey 2010, 1995), and the models described are defined by OxCal CQL2 keywords and the brackets seen on the left edge of model figures. Calibrated radiocarbon dates are given in grey outlines, with posterior density estimates created by Bayesian modelling in solid dark grey. Intrusive or residual samples are kept in the model and given in red colour.

Results and discussion

One major obstacle was detected early in the Southeast Serbian Banat region; the lack of excavated Late Neolithic sites with a complete chronological sequence of the Vinča culture. Although they must exist, the small number of excavated sites prevented us from identifying them in the landscape. To alleviate this issue, the team decided to use data from two sites, the early phase Kremenjak, found on the outskirts of the village of Potporanj, and the late phase At, located on the northern outskirts of Vršac.

Figure 6.
Location of the site of Potporanj

The site of Kremenjak near Potporanj was discovered by accident in 1882 when reclamation works began in the area. It was first surveyed by Felix Milleker, who undertook his single research campaign on the site in 1899. The site is located in the southeast part of the village of Potporanj (Figure 6), partially under the modern settlement. It was located on an elevated section of a flat diluvial terrace with no marking geomorphological features. On the eastern periphery of the village was a shallow valley of one of the source streams for the Boruga stream, later marked as a swamp on the maps. A similar valley of the Boruga tributary also existed in the past on the northern edge of Potporanj village. These streams were beneficial for the Vinča settlement, providing additional water sources in its immediate vicinity. In 1947, a scheduled construction of a large drainage channel led to the start of rescue archaeological excavations on the site, which were resumed in 1957 and 1958 (Brukner 1960). The excavations confirmed the existence of an early phase Vinča-Tordoš settlement with stratigraphy ranging between 2.5 and 3.4 meters. After the construction of the Dunav-Tisa-Dunav drainage canal system that destroyed significant parts of the settlement, further research was halted until 2011, when a new campaign, led by Ivana Pantović of the Vršac City Museum, started, aiming at establishing remaining site boundaries, habitation layers and procuring absolute dates. After an initial geophysical survey that indicated the existence of multiple archaeological features, including wattle and daub structures, pits, and even possible enclosure ditches, several trenches were opened to test the results on both sides of the drainage channel. The stratigraphy of the trenches was documented using single context recording, producing a detailed relative stratigraphic sequence for Bayesian modelling. However, even from the Milleker record, it was evident that the site was abandoned by the end of the early phase of the Vinča culture (Plates 1–2), a fact further confirmed in the analysis of the ceramic assemblage as well (Plates 1–3); another site was needed to produce data for the ending part of Vinča culture in the region.

This site proved to be At-Crvenka, located on the northern outskirts of Vršac (Figure 8). It is located on an elevated loess plateau that divides the Mali and Veliki Rit but is also near the conflux of Mesić stream into the Veliki Rit. The site was first known as Westrand (or West side) after a regulatory canal was dug from Središte towards Vršac, discovering archaeological layers. After 1910, Milleker started referring to it as At (a local toponym for the area) when similar finds were discovered further along the plateau. Certain areas of the site were excavated on multiple occasions by Rasto Rašajski and Šarolta Joanović from 1961 onwards as part of rescue archaeological work due to sand extraction in the area of the site. In 1984, an archaeological excavation was made in a successful attempt to identify Palaeolithic layers located underneath the Late Neolithic settlement (Radovanović 1986). Similar attempts were repeated in 2014 and 2015 (Chu et al. 2016), leading to the discovery of a Starčevo period multi-roomed pit dwelling. Finally, in 2021, the first geophysical survey was done in order to establish the boundaries of the site, and the condition of features, for the first time revealing a complex settlement with wattle and daub rectangular structures grouped in several areas, numerous pits and multiple enclosure ditches that separate the settlement into smaller segments. The material from the site is abundant and well-preserved (Plates 3–4).

Based on the results of excavations in Potporanj, although still not processed in full, the construction of a Bayesian chronological model relying on relative stratigraphic relationships between features recorded during the excavation in trenches 2 and 2a was undertaken. In total, 4 horizons were detected during the excavations. However, only horizons II to IV could be associated with the early Vinča period settlement. Sporadic finds of Starčevo/Körös pottery in the deeper layers suggest an earlier occupation of the site, together with a single radiocarbon sample POZ-70082 (7180,50), found out of context, which can be dated to 6218–6138 cal BC or 6097–5978 cal BC or 5946–5922 cal BC (95.4% prob.), or possibly 6073-5999 cal BC (68.3% prob.). For the construction of the model, there were 27 radiocarbon samples available. However, due to poor preservation of animal bones from the site, most likely associated with waterlogged terrain associated with the proximity of a former stream bed, a certain percentage of radiocarbon samples were made on charcoal or burned sediment (Table 1), which on several occasion proved to be intrusive or residual (5 samples in total). This left us with 22 radiocarbon samples that were identified as being usable for the construction of the model (Figure 7), which exhibited a good overall agreement (Amodel: 81).

The model indicates that the Vinča period habitation (horizon IV) on the site began about 5331–5207 cal BC or 5188–5122 cal BC (95.4% prob.), possibly 5289–5211 cal BC (68.3% prob.). The duration of this early phase on the site is also very interesting, as it may have lasted anywhere from 0–215 years (95.4% prob.) or 0–164 years (68.3% prob.). A similar effect was noted earlier for the Vinča A phase (Whittle et al. 2016, p. 28), indicating a long development of the ceramic typology typical for this period.

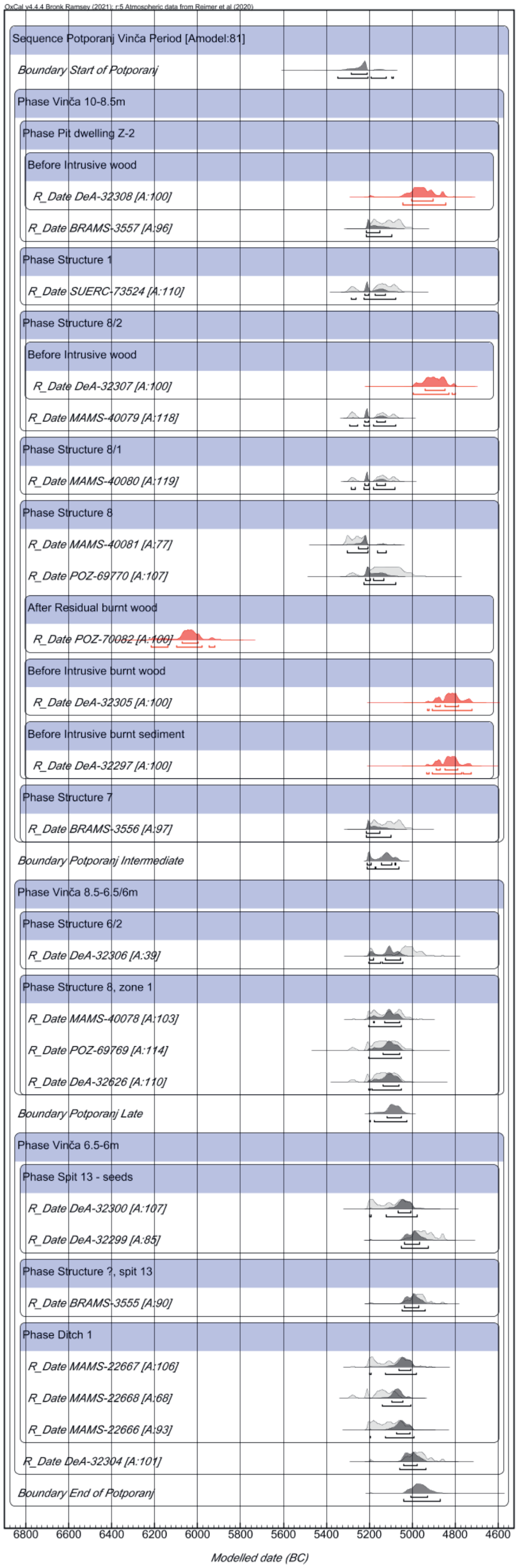

Figure 7.
Bayesian chronological model devised in Oxcal 4.4 for the site of Potporanj

Figure 8.
Location of the site of At

The middle phase of Potporanj in the Vinča period (horizon III) appears to start at 5211–5176 cal BC or 5170–5062 cal BC (95.4% prob.), possibly 5149–5094 cal BC or 5209–5192 cal BC (68.3% prob.). This horizon also appears to have lasted shorter than the previous, for 0–117 years (95.4% probability), possibly 0–57 years (68.3% prob.). Finally, the late phase of Potporanj (horizon II) starts about 5176–5025 cal BC (95.4% prob.), possibly 5115–5050 cal BC (68.3% prob.), and is again a longer phase, lasting anywhere from 0–246 years (95.4% prob.), possibly 53–184 years (68% prob.).

The end of the Late Neolithic occupation on Potporanj, at least in the trenches used for this analysis, can be modelled at 5198–5188 cal BC or 5040–4871 cal BC (95.4% prob.), possibly 5008–4927 cal BC (68.3% prob.). However, this may be somewhat different in other parts of the settlement, currently unexcavated. The Late Neolithic settlement on the site thus may have lasted close to 300 years in continuity, being abandoned at an exciting moment in the chronology of the Vinča period.

If we are to examine the relative chronological phasing of the site, it appears that the Late Neolithic settlement in Potporanj appeared towards the middle of the Vinča A phase, or the period corresponding to the 9-8.8 meters relative depths on the settlement of Belo Brdo (Tasić et al. 2016a). This horizon then proceeded well into the early Vinča B1 period (Whittle et al. 2016, Figure 2). However, since the site assemblage, including pottery finds, has not yet been fully analysed, it is impossible to distinguish this change without an in-depth statistical analysis. The start of horizon III, marked as the intermediary phase of Late Neolithic life in Potporanj (Figure 7: *Boundary Potporanj Intermediate*), coincides with the second half of the Vinča B1 period, and it also extends into the Vinča B2 phase. In Belo Brdo, the beginning of this horizon would fall between 7.5 and 7 meters of relative depth. The late phase of Potporanj, horizon II (Figure 7: *Boundary Potporanj Late*), starts near the end of the Vinča B2 phase and extends towards the transformative, Gradac phase, the beginning of the metallic period Vinča. These layers correspond to relative depths between 7 and 6.5 meters on the Belo Brdo site (Tasić et al. 2016a). Finally, the end of the Late Neolithic settlement on Potporanj could be modelled to the beginning stage of the Gradac phase, the period corresponding to layers between 6.5- and 6-meters relative depth in Belo Brdo, a phase in which the central Balkans Vinča becomes infused with copper metallurgy that, over the following centuries will gradually change its nature, best reflected in the material culture of the late phases.

It must be stated here that due to the lack of excavated sites in the region, in this chapter, we have no available dates for the so-called Vinča C phase, a period which most likely already starts with the Gradac phase and is one of the most prominent periods in the span of the Late Neolithic Vinča culture. This period is the time of expansion of Pannonian plain linear pottery traditions towards the core area of Vinča, already somewhat present towards the beginning of the Gradac phase in the site assemblages in the area (Plate 3: 10–14). This suggests that existing networks brought about changes in the material culture in the northern parts of the Vinča territories, likely due to influences shifting towards the north, away from the core area of the culture. We cannot, without a doubt, also exclude the possibility that Vinča C material exists on At. However, out of multiple excavated trenches, adequate sampling material (i.e., animal bones) was preserved only from trenches 4 and 5, thus preventing us from dating other excavated areas of the site using existing archival records in the City Museum of Vršac. Perhaps new research started in 2021 will produce new strands of data for future dating of different parts of the Late Neolithic settlement there.

If we turn our attention to the late period of Vinča culture in the southeast Serbian Banat, a more detailed paper about the methodology of work for the late phase modelling, based on the site of At is presented elsewhere (Marić et al., in preparation). In this chapter, we will discuss only the modelling results in relation to the chronology of the Late Neolithic in the presented area. The approach for the site of At was somewhat different. Using the most chronologically sensitive category of pottery assemblage, the bowls, it was possible to establish the existence of three specific pottery phases that encompassed several excavation layers, each through the application of Correspondence Analysis. Combining the results of the CA with 25 successful radiocarbon samples (Table 2) into a Bayesian chronological framework using OxCal (Figure 9), it was possible to construct a model that had a very strong agreement (Amodel: 275), which suggests that the Late Neolithic occupation in this area of the site of At started around 4737–4700 cal BC (95% probability; Start AT1; Figure 9), probably 4723–4710 cal BC (68.3% probability). The premiere phase of occupation did not last long, up to 24 years (95.4% probability), but likely just 8 (68.3% probability), which can be seen using the *Interval* command in OxCal.

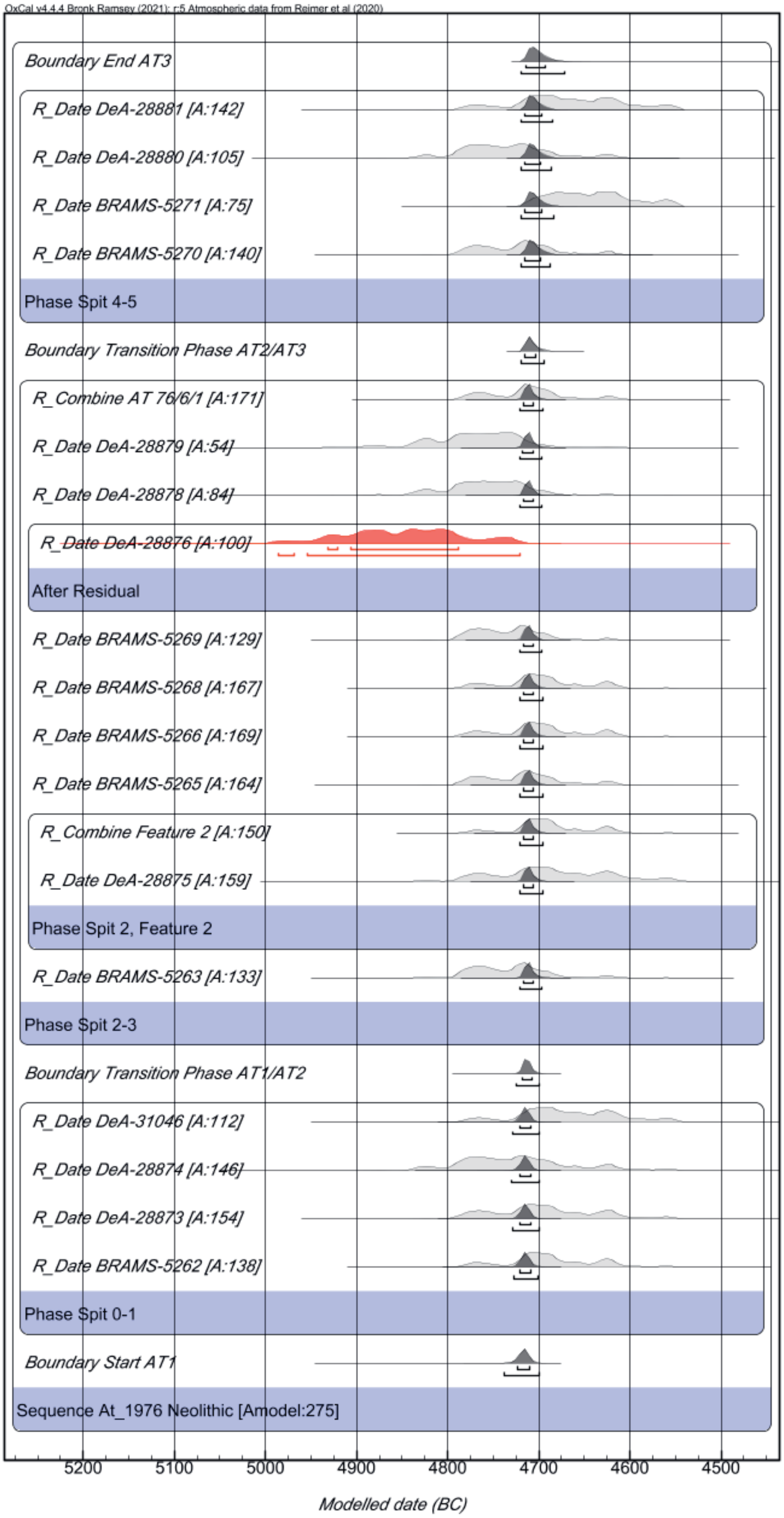

Figure 9.
Bayesian chronological model devised in Oxcal 4.4 for the site of At

The second phase of At occupation (*Transition phase AT1/AT2*; Figure 9) started at 4724–4701 cal BC (95.4% probability), possibly 4719–4708 cal BC (68.3%), and again lasted a relatively short period – at most 17 years (95.4% probability), possibly just 7 (68.3% probability). This puts it well within one generation's lifespan. The final phase of Late Neolithic occupation of At in trenches 4 and 5 (*Transition phase AT2/AT3*) began at around 4720–4695 cal BC (95.4% probability; Figure 9), possibly 4716–4704 cal BC (68.3% prob.), lasted up to 37 years (95.4% prob.), possibly just 11 (68.3% prob. Figure 9). According to the model, the end of late Neolithic occupation in the area of the site where trenches 4 and 5 were located is modelled at 4720–4673 cal BC (95.4% prob.; Figure 7), possibly 4715–4694 cal BC (68.3% prob.).

Comparing the absolute chronology of this part of the site from the aspect of relative chronological schemes, the Late Neolithic Vinča period use of space in trenches 4 and 5 at the Late Neolithic settlement on At coincides with the early Vinča D phase (Whittle et al. 2016, p. 31), a fact corroborated by finds of some specific late phase bowls, like the biconical bowls with inverted rims, a very typical form of the late Vinča period phases. These bowls, although existent in the assemblage, are not as dominant as they appear towards the end of the Vinča D phase on other sites when they become almost the only bowl type (Garašanin 1979, tbl. I/1, III/3, IV/4, VI/2; Mirković-Marić et al. 2021b). This occupation on At would correspond to layers between 4.0 and 3.5 meters relative depth on the Belo Brdo site in Vinča.

Conclusions

The Bayesian chronological modelling illustrated here is a powerful tool for deciphering and understanding chronological relations in prehistoric periods. Using a combination of techniques available to an archaeologist of today, it can create a robust chronological scale, with specific fixed points in absolute time, that can be a basis for detailed archaeological research in any area. However, the ending results can only be as good as the data they rely on, i.e., the excavated material, its recording at the time of the excavation and keen scrutiny of the processes that created the deposits excavated. Through this chapter, we hope that we have been able to demonstrate the potential of archival records, often created several decades ago, to produce new information using methods unavailable at the time of their creation. We must also stress that keeping larger volumes of raw data, i.e. the finds is by all means necessary, no matter how much it complicates the everyday activities of Institutions that store it. For example, when our project started in the autumn of 2020, we were unsure whether the state of preservation of the At archives was sufficient to achieve any results from it. Luckily, it has proven that our doubts were unfounded in the end, enabling us to present a meaningful chronological sequence for a significant period in the region. We were able to produce formally modelled estimates for almost the whole of the duration and timing of Late Neolithic in Serbian southeast Banat, a region linking the core area of the Vinča culture south of the Danube and its expanse into the Carpathian Mountains.

Having examined the newly created chronology of the site of Potporanj, we can argue that the expansion of the Vinča style material culture into the northeast regions started early, perhaps within just a generation or two after the forming of the Belo Brdo site, 70 kilometres to the south. Off course, this proposition should be taken *cum grano salis*, as Potporanj could be even earlier, but limited excavations done so far have prevented us from being entirely sure. We can see that the settlement evolution is a stable, steady growth that extends over multiple generations, further corroborated by the sheer thickness of the culture layers created by the prolonged life of the Late Neolithic settlement. The model also supports the notion of continuity of material culture as the phases extend for longer periods, a fact that will possibly be further examined in detail when the statistical and typological analysis of the finds is completed in the near future. Perhaps then, we will be able to distinguish further subphases that will illustrate better a gradual, subtle evolution of material culture, which could then enable us to construct even more precise, generational, or two-three generational chronological models with shorter subphasing spans and life cycles. The cessation of Late Neolithic life on Potporanj remains yet another exciting episode to investigate further, now especially in the light of its chronological position, towards the

Gradac transitional phase and the onset of the Vinča C phase, a period profoundly infused with transformative processes that include the invention of copper metallurgy, copper implements emergence, spread and consumption, but also the emergence of a host of new settlements throughout the region (Lazarovici et al. 2009; Ristić-Opačić 2005) and a distinct change in material culture.

The ending of the Vinča period in Serbian southeast Banat can be examined on the site of At. There, so far at least, the latest material of the Vinča period was discovered over several excavation seasons, especially during the 1970s. Examining the finds from two trenches with adequate dating material available closely, it was possible to establish three different ceramic phases. These, however, appear to date to a relatively short period, indicative of the beginning of the Vinča D phase rather than its ending period. A rather dynamic episode of events over a relatively short period occurred and marked the end of the Vinča occupation of the site. From the Bayesian modelling, it can be suggested that the ending phase of the Vinča settlement at At did not unfold to the full extent 70 kilometres further to the south, on the type site of Belo Brdo. Perhaps in the case of At, the ending of the typical Vinča style ceramics settlement is not the end of the occupation. Some authors (Draşovean 2015, 2014, 1997) suggested that the Foeni pottery-style communities dominated the Vinča D period in the Banat area. Indeed several fragments of what appear to be Foeni red painted ware with geometric decorations are known from the site of At (Plate 3: 15–16), but no secure context containing Foeni pottery has ever been excavated on the site, and we cannot thus corroborate the existence of a Foeni type pottery settlement here. The contemporaneity of late Vinča C and Foeni I, as suggested by Draşovean (2014, Figure 7b) using Bayesian chronological modelling, could indicate the origin of these pieces rather than establish the existence of a Foeni settlement on At, but further research may prove different. The extinction of the Vinča pottery style settlement on Uivar, another late Vinča period site in the relative vicinity (Draşovean 2014, pp. 146–147), clearly suggests a possibility that Vinča period settlements in Serbian Banat met a fiery end somewhat sooner than the Danubian settlements further south, possibly due to destructive force of incomers (Draşovean 2015, p. 133). However, more research is needed in the area to understand better the processes that occurred at the end of the Late Neolithic and the beginning of the Eneolithic in the Serbian southeast Banat. We hope that our work presented here will provide that necessary incentive to restart systematic research of the site of At, possibly the largest of all late period Vinča sites in the region of the town of Vršac in Serbian Southeast Banat.

Acknowledgements

The research presented in this paper was supported by the Science Fund of the Republic of Serbia, PROMIS grant #6062361, project RACOLNS.

Laboratory Nr.	Sample Ref.	Material	Stratigraphy	14C age (BP)	C:N
DeA-32303	POT 01/2013	Charred wood	Trench 2, spit 10	6028 ±39	
DeA-32304	POT 03/2013	Charred wood	Trench 2, spit 12, structure remains	6070 ±30	
DeA-32297	POT 06/2014	Sediment (macro charcoal not found)	Trench 2, spit 17, floor level	5952 ±28	
DeA-32298				6218 ±31	
DeA-32305	POT 07/2014	Charred wood	Trench 2, spit 17, floor level	5947 ±31	
DeA-32626	POT 01/2018	*Bos taurus,* maxilla	Trench 2a, spit 14, structure 8	6195 ±34	4.7
DeA-32306	POT 04/2018	Charred wood	Trench 2a, spit 16 under structure 6/2 (oven)	6106 ±30	
DeA-32307	POT 15/2018	Charred wood	Trench 2a, spit 17, structure 8/2	6010 ±30	
DeA-32299	POT 18/2018	*Cornus* mas stone	Trench 2a, spit 13	6042 ±29	-
DeA-32300	POT 18/2018			6139 ±31	
DeA-32308	POT 02/2019	Charred wood	Trench 2, structure 2/1	6057 ±33	
DeA-32309	POT 04/2019	Charred wood	Trench 2A, spit 19, post hole, bottom	6035 ±31	
MAMS-22666	POT 01/2012	Charred wood	Ditch 1 – crossection	6156 ±30	
MAMS 22668	POT 03/2012	Animal bone	Ditch 1	6211 ±25	
MAMS 22667	POT 02/2012	Charred wood	Ditch 1	6139 ±29	
BRAMS-3555	POT 03/2015	Charcoal	Trench 12, spit 13, Structure floor	6069 ±19	
MAMS-40078	POT 01/2018	Charcoal	Trench 2, spit 14, beneath house floor	6158 ±19	
Poz-69769			Trench 2, spit 14, beneath oven	6190 ±40	
BRAMS-3556	POT 03/2018	Charcoal	Trench 2a, Spit 17, Structure 7	6161 ±19	
MAMS-40081	POT 04/2018	Charcoal	Trench 2a, spit 17, structure 8, floor	6290 ±22	
Poz-70082			Trench 2a, spit 17, structure 8, floor	7180 ±50	
Poz-69770			Trench 2a, spit 17, structure 8, floor	6180 ±50	
MAMS-40080	POT 03/2018	Charcoal	Trench 2a, spit 17-1, structure 8, oven	6221 ±19	
MAMS-40079	POT 02/2018	Charcoal	Trench 2a, spit 17-4, structure 8, bottom	6227 ±20	
SUERC-73524		*Bos taurus*, bone	Trench 2, Structure 1, oven bottom, west area	6217 ±31	3.2
BRAMS-3557	POT 03/2019	Charcoal	Structure Z, 2/1	6163 ±19	

Table 1. *List of 14C samples used to create Bayesian chronology of Potporanj.*

Laboratory Nr.	Sample Ref.	Material	Stratigraphy	14C age (BP)	C:N
BRAMS-5261*	AT 76/2/1	*Cervus elaphus*, phalanx 1	Trench 4, spit 1	5828 (±27)	2.71
BRAMS-5262	AT76/9/2	*Bos taurus*, radius	Trench 4, spit 1	5829 (±27)	2.71
BRAMS-5263	AT 76/4/2	*Cervus elaphus*, metacarpal	Trench 4, spit 2	5857 (±27)	2.72
BRAMS-5264**	AT 76/11/2	*Bos taurus*, metatarsal	Trench 4, spit 2, Feat. 2	5836 (±27)	2.73
BRAMS-5265	AT 76/6/2	*Bos taurus*, metatarsal	Trench 4, spit 3	5847 (±27)	2.71
BRAMS-5266	AT 76/5/2	*Cervus elaphus*, metatarsal	Trench 4, spit 3	5834 (±27)	2.73
BRAMS-5267***	AT 76/6/1	*Cervus elaphus*, metatarsal	Trench 4, spit 3	5836 (±27)	2.73
BRAMS-5268	AT 76/8/3	*Bos taurus*, metacarpal	Trench 5, spit 3	5833 (±27)	2.72
BRAMS-5269	AT 76/8/4	*Bos primigenius*, metacarpal	Trench 5, spit 3	5858 (±27)	2.71
BRAMS-5270	AT 76/7/3	*Cervus elaphus*, metatarsal	Trench 5, spit 4	5849 (±27)	2.70
BRAMS-5271	AT 76/7/4	*Bos taurus*, metacarpal	Trench 5, spit 4	5792 (±26)	2.71
DeA-28873	AT 76/9/1	*Cervus elaphus*, radi+ulna	Trench 4, spit 1	5835 (±37)	3.5
DeA-28874	AT 76/3/1	*Cervus elaphus*, metatarsal	Trench 4, spit 1	5859 (±46)	3.7
DeA-28875	AT 76/11/1	*Bos taurus*, tibia	Trench 4, spit 2, Feat. 2	5830 (±41)	3.5
DeA-28876	AT 76/5/1	*Bos taurus*, metatarsal	Trench 4, spit 3	5965 (±49)	3.5
DeA-29963	AT 76/1/1	*Bos primigenius*, metacarpal	Trench 4	5814 (±64)	
DeA-28877	AT 76/1/3	*Bos taurus*, radius	Trench 4	5893 (±48)	3.4
DeA-28878	AT 76/8/1	*Cervus elaphus*, metacarpal	Trench 5, spit 3	5882 (±41)	3.2
DeA-28879	AT 76/8/2	*Bos taurus*, humerus	Trench 5, spit 3	5896 (±39)	3.0
DeA-28880	AT 76/7/1	*Cervus elaphus*, tibia	Trench 5, spit 4	5864 (±39)	3.3
DeA-28881	AT 76/7/2	*Bos primigenius*, metatarsal	Trench 5, spit 4	5815 (±41)	
DeA-31045*	AT 76/2/1	*Cervus elaphus*, phalanx 1	Trench 4, spit 1	5947 (±38)	3.2
DeA-31046	AT 76/10/1	*Bos taurus*, metatarsal	Trench 4, spit 1 (or 3)	5816 (±37)	3.3
DeA-31047**	AT 76/11/2	*Bos taurus*, metatarsal	Trench 4, spit 2, Feat. 2	5813 (±34)	3.3
DeA-31048***	AT 76/6/1	*Cervus elaphus*, metatarsal	Trench 4, spit 3	5857 (±37)	3.2

Table 2. *List of 14C samples taken for At site. Samples marked with *, ** and *** are replicate 14C samples.*

PLATE 1

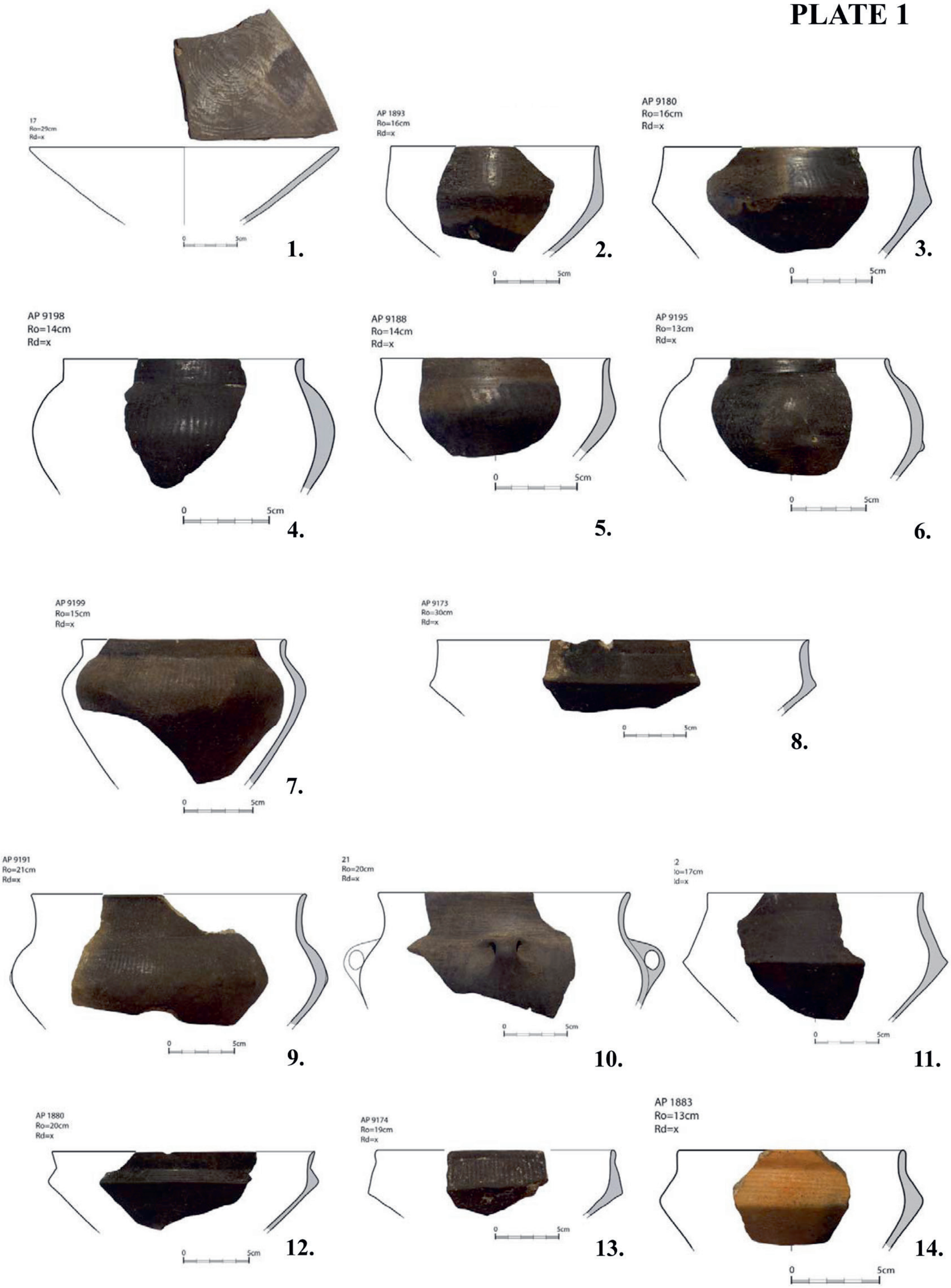

Plate 1. *Early period Vinča style pottery from the site of Potoranj*

PLATE 2

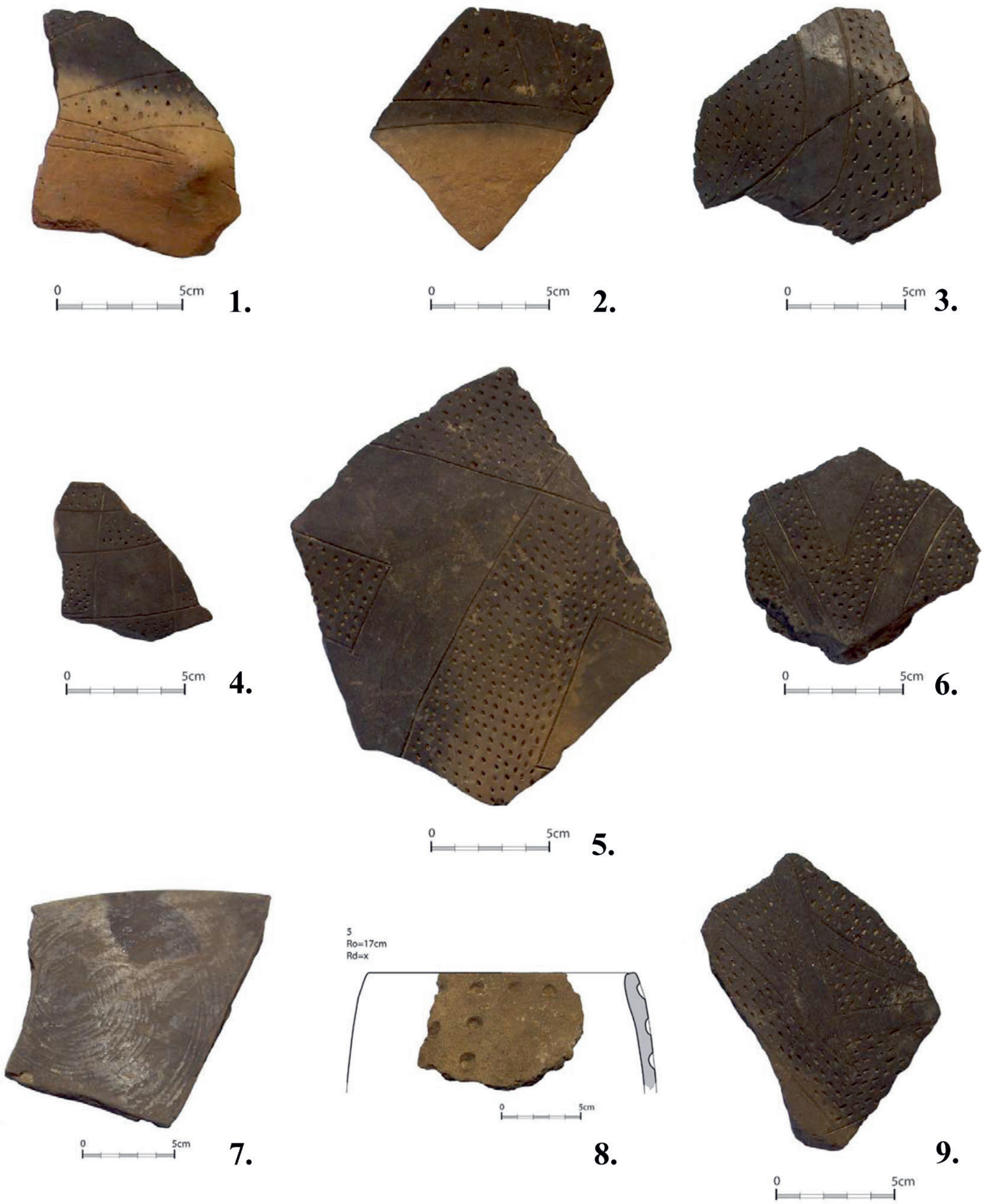

Plate 2. *Selection of typical early period Vinča style pottery decoration from Potporanj*

PLATE 3

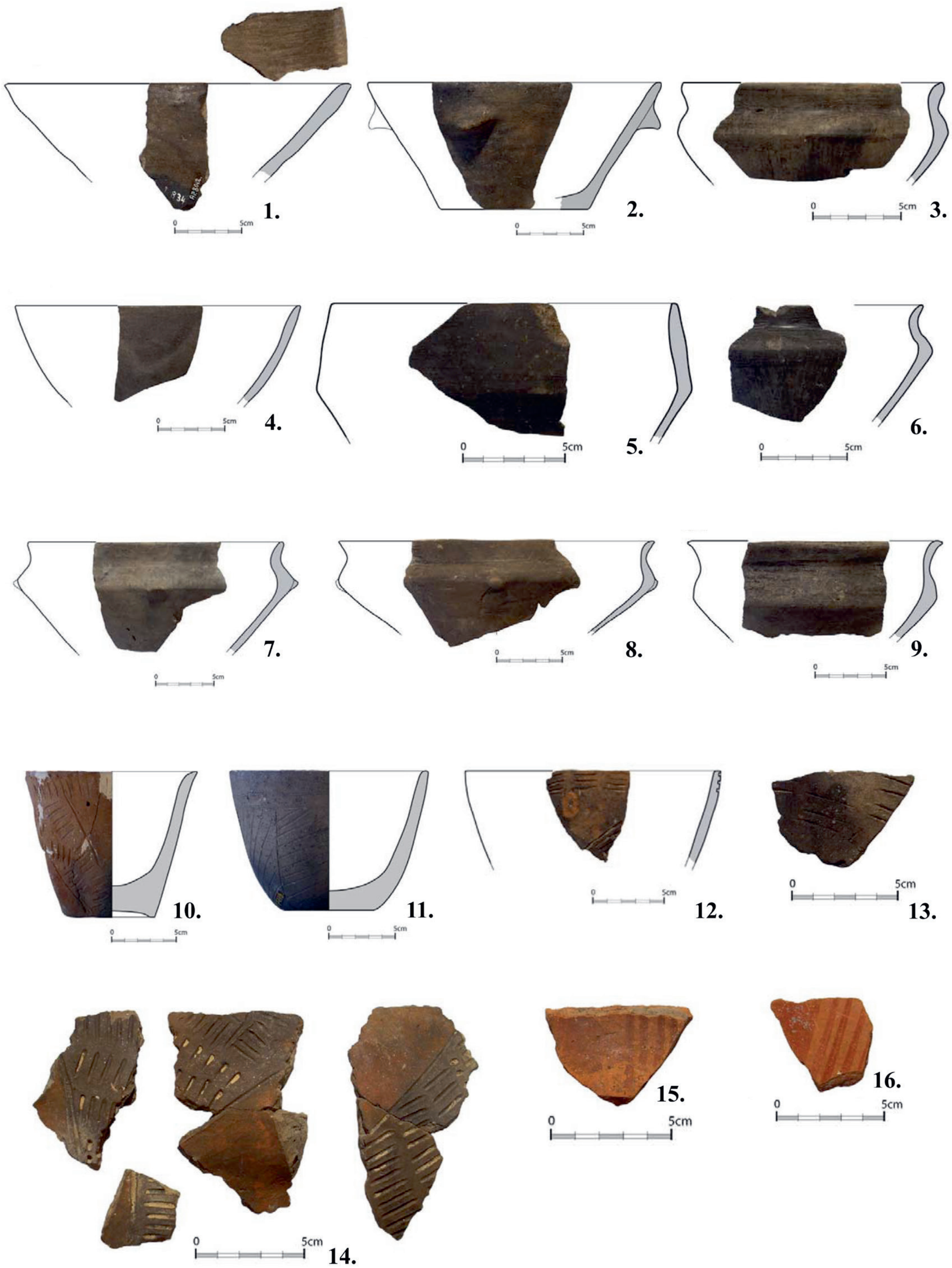

Plate 3. *Late period Vinča style pottery and non-local pottery from the site of At*

PLATE 4

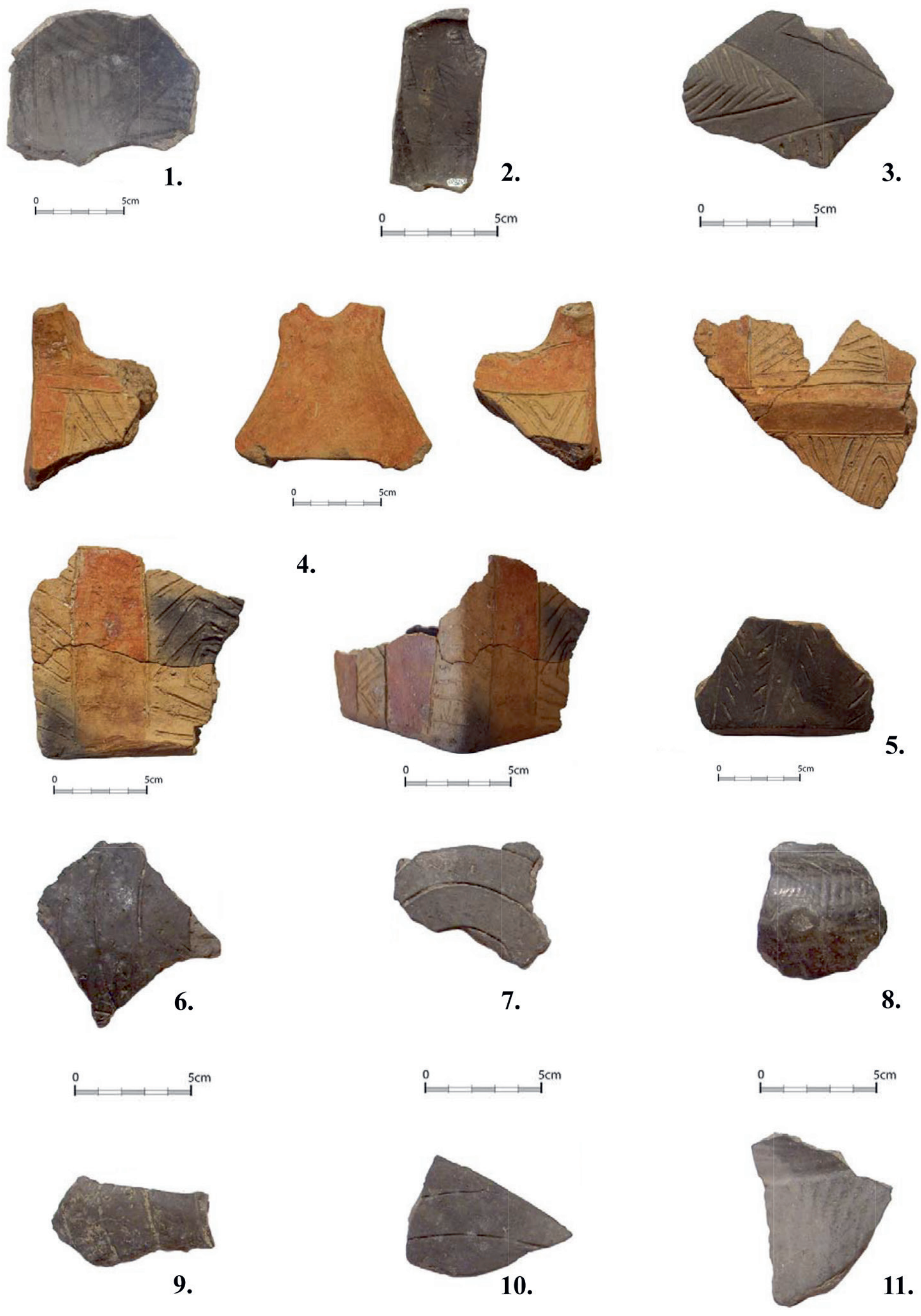

Plate 4. *Selection of typical Late Neolithic decorations of Vinča style and Linear pottery style from At*

References

Baxter, M.J. 1994. *"Exploratory Multivariate Analysis in Archaeology"*. Edinburgh: Edinburgh University Press.

Bayliss, A., C. Bronk Ramsey, C., J. van der Plicht and A. Whittle. 2007. "Bradshaw and Bayes: towards a timetable for the Neolithic". *Cambridge Archaeological Journal* 17, 1–28. https://doi.org/10.1017/S0959774307000145

Bronk Ramsey, C. 2010. "*OxCal* v4.2b4". http://c14.arch.ox.ac.uk/oxcal.

Bronk Ramsey, C. 2000. "Comment on 'The use of Bayesian statistics for 14C dates of chronologically ordered samples: a critical analysis". Radiocarbon 42, 199–202.

Bronk Ramsey, C., 1995. "Radiocarbon calibration and analysis of stratigraphy: the OxCal program". *Radiocarbon* 37, 425–430.

Brukner, O. 1960. "Potporanj - Kremenjak, Utrine. Neolitsko naselje". *Starinar* XI, 230.

Buck, C. E., W. G. Cavanagh, and C. D. Litton. 1996. "*Bayesian Approach to Interpreting Archaeological Data*. *Statistics in Practice*". Chichester: John Wiley & Sons.

Bugarski, D., N. Carić, S. Kicošev, P. Tomić, J. Romelić, J. Plavša, S. Ćurčić and G. Jovanović. 1995. "*Opština Vršac. Geografske monografije vojvođanskih opština"*. Novi Sad: Prirodno-matematički fakultet, Institut za geografiju.

Burroughs, W. J. 2005. "*Climate Change in Prehistory. The End of the Reign of Chaos"*. Cambridge: Cambridge University Press.

Butorac, B., V. Habijan-Mikeš, and V. Vider. 2002. "*Ostanak peščara u Vojvodini"*. Subotica: Grafoprodukt.

Chapman, J. 1981. "*Vinča Culture of Southeast Europe: Studies in Chronology, Economy and Society"*. British Archaeological Reports, BAR International Series 117, Oxford: Oxford University Press.

Chu, W., D. Mihailović, I. Pantović, C. Zeeden, T. Hauck, and F. Lehmkuhl. 2016. "Archaeological excavations at the site of At (Vršac, Serbia)". *Antiquity, Project Gallery* 352, 90.

Diaconescu, D., F. M. Niţu and I. S. Cosmin. 2020. "The early Vinča culture in Transylvania: Considerations regarding its chronological position using correspondence analysis". *Quaternary International* 560–561, 65–77. https://doi.org/10.1016/j.quaint.2020.05.019

Draşovean, F. 2015. "The Transition from the Neolithic to the Copper Age in Banat. Tradition and Innovation". In *AD FINEM IMPERII ROMANI. Studies in Honour of Coriolan H. Opreanu*, eds. S. Cociş, V. A. Lăzărescu, M. Gui, and D. A. Deac, 129–144. Cluj-Napoca: MEGA Publishing House.

Draşovean, F. 2014. "On the Late Neolithic and Early Eneolithic Relative and Absolute Chronology of the Eastern Carpathian Basin. A Bayesian Approach". In *The Neolithic and Eneolithic in Southeast Europe. New Approaches to Dating and Cultural Dynamics in the 6th to 4th Millenium BC*, eds. W. Schier, F. Draşovean, 129–172. Rahden: Verlag Marie Leidorf GmbH.

Draşovean, F. 1997. "Die Petreşti-Kultur im Banat". *Praehistorische Zeitschrift* 72, 54–80. https://doi.org/10.1515/prhz.1997.72.1.54

Garašanin, M. 1951. "*Hronologija vinčanske grupe*". Arheološki seminar. Ljubljana: Univerza v Ljubljani.

Garašanin, M., S. Stanković. 1985. "Razrada tipologije vinčanske grupe. Prilog jedinstvenoj arheološkoj dokumentaciji". *Glasnik Srpskog Arheološkog Društva* 2, 10–30.

Joanovič, Š. 2003. "*Tipološka analiza glačanog kamenog materijala iz Potpornja*". Vršac: Gradski muzej Vršac.

Joanovič, Š. 1977. "At, Vršac – neolitsko naselje i grob". *Arheološki pregled* 19, 18–20.

Joanovič, Š. 1976. "Banatska Subotica – Cerovica". *Arheološki pregled* 18, 46.

Jovanović, B. 1994. "Gradac Phase in the relative chronology of the late Vinča culture". *Starinar* 43–44, 1–12.

Knowles, T. D. J., P. S. Monaghan and R. P. Evershed. 2019. "Radiocarbon Sample Preparation Procedures and the First status Report from the Bristol Radiocarbon AMS (BRAMS) Facility". *Radiocarbon* 61, 1541–1550. https://doi.org/10.1017/RDC.2019.28

Lazarovici, G., C. M. Lazarovici and Z. Maxim. 2009. "The chronological and cultural place of the Vinča and Turdaş cultures in the context of European civilisations". In *The Danube Script in the Light of Turdaş and Tărtăria Discoveries,* eds. Z. Maxim, I. Marler and V. Crişan, 167–168. Cluj-Napoca: Muzeul Naţional de Istorie a Transilvaniei.

Lindley, D. V. 1991. "*Making Decisions"*. London: Wiley.

Marić, M. 2015. "Modelling Obsidian Trade Routes during Late Neolithic in the Southeast Banat Region of Vršac Using GIS". *Starinar* 65, 37–52.

Marić, M., N. Marković, J. Bulatović and I. Pantović. 2023. "Regional Absolute Chronologies of the Late Neolithic in Serbia. The case study of At near Vršac". In *Proceedings from the 8th and 9th Scientific Conference Methodology and Archaeometry*, ed. I. Miloglav, 75–91. Zagreb: Sveučilište u Zagrebu, Filozofski fakultet, Odjel za arheologiju.

Mihailović, D., B. Mihailović and M. Lopičić. 2011. "The Palaeolithic in Northern Serbia". In *The Prehistory of Banat. The Palaeolithic and Mesolithic*, eds. N. Tasić and F. Draşovean, 77–101. Bucharest: The Publishing House of the Romanian Academy pp. 77–101.

Milleker, F. 1938. "Vorgeschichte des Banats: Neolithikum". *Starinar* 13, 102–166.

Milutin Garašanin, 1979. "Centralnobalkanska zona". In *Praistorija Jugoslavenskih Zemalja, Tom II*, ed. Alojz Benac, 79–212. Sarajevo: ANUBiH.

Mirković-Marić, N., M. Savić and M. Rajičić. 2021a. "Pottery from Trench 18 at Belovode". In *The Rise of Metallurgy in Eurasia. Evolution, Organisation and Consumption of Early Metal in the Balkans,* eds. M. Radivojević, B. W. Roberts, M. Marić, J. Kuzmanović Cvetković, and T. Rehren, 152–169. Oxford: Archaeopress Publishing LTS.

Mirković-Marić, N., M. Savić and M. Rajičić. 2021b. "Pottery from Trench 24 at Pločnik". In *The Rise of Metallurgy in Eurasia. Evolution, Organisation and Consumption of Early Metal in the Balkans,* eds. M. Radivojević, B. W. Roberts, M. Marić, J. Kuzmanović Cvetković, and T. Rehren, 317–344. Oxford: Archaeopress Publishing LTS.

Molnar, M., R. Janovics, I. Major, J. Orsovszki, R. Gönczi, M. Veres, A. Leonard, S. M. Castle, T. Lange, L. Wacker, I. Hajdas and A. J. T. Jull. 2013. "Status report of the new AMS 14c sample preparation lab of the Hertelendi laboratory of environmental studies (Debrecen, Hungary)". *Radiocarbon* 55, 656–676.

Nikolić, D., 2004. "Keramičko posuđe". In *Grivac. Naselja protostarčevačke i vinčanske kulture*, ed. M. Bogdanović, 205–318. Kragujevac: Centar za naučna istraživanja Srpske akademije nauka i umetnosti i Univerziteta u Kragujevcu, Narodni muzej Kragujevac.

Pantović, I. 2014. "*Vinčanski amuleti – jugoistočni Banat"*. Gradski muzej Vršac, Vršac.

Prikić, M. and Š. Joanovič. 1978. "*Neolit južnog Banata sa pregledom neolitskih nalazišta*". Pančevo: Narodni muzej u Pančevu, Narodni muzej u Vršcu.

Radovanović, I. 1986. "Vršac-At, paleolitsko nalazište". *Arheološki pregled* 25, 11–12.

Rašajski, R. 1976. "At, Vršac – neolitsko naselje i nekropola bronzanog doba". *Arheološki pregled* 17, 14–16.

Rašajski, R. 1962. "Beluca, Pavliš, Vršac – višeslojno praistorijsko naselje". *Arheološki pregle*d 4, 26–28.

Schier, W. 1996. "The relative and absolute chronology of Vinča: new evidence from the type site". In *The Vinča Culture, Its Role and Cultural Connections,* ed. F. Draşovean, 141–162. Timişoara: National Museum.

Tasić, N. N., M. Marić, C. Bronk Ramsey, B. Kromer, A. J. Barclay, A. Bayliss, N. Beavan, B. Gaydarska and A. Whittle. 2016a. "Vinča-Belo Brdo, Serbia: the times of a tell". *Germania* 93, 1–75.

Tasić, N. N., M. Marić, D. Filipović, K. Penezić, E. Dunbar, P. Reimer, A. Barclay, A. Bayliss, B. Gaydarska, and A. Whittle. 2016b. "Interwoven Strands for Refining the Chronology of the Neolithic Tell of Vinča-Belo Brdo, Serbia". *Radiocarbon* 58, 795–831. https://doi.org/10.1017/RDC.2016.56

Tripković, B. 2004. "The Role of obsidian in the Neolithic: a symbolic expression of human domestication?" In *Actes Du XIVème Congrès UISPP, Université de Liège, Belgique, 2–8 Septembre 2001*, eds. I. Jadin, and A. Hauzeur, 181–189. Oxford: British Archaeological Reports.

Vukmanović, M. and N. Radojčić, N., 1990. "Quantative Analysis of Pottery". In *Selevac: A Neolithic Village in Yugoslavia.* Monumenta Archaeologica, eds. R. E. Tringham and D. Krstić, 289–321. Los Angeles: University of California Press.

Ward, G. K. and S. R. Wilson. 1978. "Procedures for Comparing and Combining Radiocarbon Age Determinations: A Critique". *Archaeometry* 20, 19–31. https://doi.org/doi.org/10.1111/j.1475-4754.1978.tb00208.

Whittle, A., A. Bayliss, A. Barclay, B. Gaydarksa, E. Bánffy, D. Boric, F. Draşovean, J. Jakucs, M. Marić, D. Orton, I. Pantović, W. Schier, N. Tasić, M. Vander Linden. 2016. "A Vinča potscape: formal chronological models for the use and development of Vinča ceramics in southeast Europe". *Documenta Praehistorica* 43, 1–60.

Zeremski, M. 1985. "*Geomorfologija Vršačkih planina*". Novi. Sad: Matica Srpska.

Zeremski, M. 1972. "Južnobanatska lesna zaravan (prilog regionalnoj geomorfologiji Vojvodine iz aspekta egzo i endodinamičkih procesa". *Zbornik Matice srpske za prirodne nauke* 43, 5–80.

Zeremski, M. 1967. "Alibunarska depresija – prilog genezi oblika sa posebnim osvrtom na njegovu paleomorfo-strukturu i savremena tektonska kretanja". *Zbornik Matice srpske za prirodne nauke* 32, 121–153.

Ristić-Opačić, J. 2005. "Topografsko-hronološke karakteristike naselja vinčanske kulture na teritoriji Srbije". *Glasnik Srpskog arheološkog društva* 21, 71–112.

7.

North Croatian Late Neolithic relative and absolute chronologies: current state of research

Katarina Botić

Abstract Relative chronology of the Late Neolithic in the Sava-Drava-Danube interfluve region (northern Croatia) was introduced in the 1960s and following decades when diversification of pottery styles was more closely studied and named as separate cultures. The most substantial contribution to building a micro-regional relative chronology based on the typology of pottery finds was that of S. Dimitrijević, with later attempts by Z. Marković to re-define relative chronology and add to the still scarce typology of already established pottery stiles. However, splitting up relative chronology into three or four stages of the same "culture" prevailed and is still in use.

Attempts to define the absolute chronology are still scarce. Although a fair number of radiocarbon dates have been published, especially in the last 20 years, the quality of samples, lack of sampling strategy, and problematic results received render most of them poorly usable. In addition, there have been no attempts to build a local chronology by combining Bayesian modelling of radiocarbon dates with full statistical seriation of finds from individual sites. This paper focuses on problems related to the past methodology, a new approach to building a more precise local chronology and discusses conclusions about the Late Neolithic micro-regional chronology of several recently published papers.

Keywords: Sava-Drava-Danube interfluve, Late Neolithic, history of research, radiocarbon dates, local chronology

Introduction

Late Neolithic relative chronology in the Sava-Drava-Danube interfluve region (northern Croatia) was established in the 1960s and following decades when diversification of pottery styles was more closely studied and named as separate cultures. The most substantial contribution to building a micro regional relative chronology, primarily based on the typology of pottery finds, was that of S. Dimitrijević, with later attempts by Z. Marković to re-define relative chronology and add to the still scarce typology of already established pottery stiles (Table 1). However, the division of relative chronology into three or four stages of the same "culture" prevailed, and is still primarily used.

Attempts to define absolute chronology are recent and still scarce. Although a fair number of radiocarbon dates have been published, especially in the last 20 years, the quality of samples, lack of sampling strategy, and problematic results received render most of them poorly usable. In addition, there have been no attempts to build a local chronology through combining Bayesian modelling of radiocarbon dates with full statistical seriation of finds from individual sites. This paper focuses on problems related to the past methodology of relative and absolute chronology, a new approach to building a more precise local chronology and discusses conclusions about the Late Neolithic micro regional chronology of several recently published papers.

S. Dimitrijević (1968; 1971; 1979)		
Older phase	I-A	Vinča B-1 **Klokočevik – Klinovac**
	I-B	Vinča B-2
Middle phase	II	Vinča C
Younger phase	III	Vinča D1/D2
Z. Marković (1994: 63)		
Older phase	I-A	Vinča B-1
	I-B	Vinča B-2
Middle phase	II	Vinča C
Younger phase	III	Vinča D
Transition phase (late Neolithic / early Eneolithic)	IV	end Vinča D-2 / Vinča D-3
S. Dimitrijević 1978; 1979 Brezovljani type of the Sopot culture		
Z. Marković 1984; 1985; 1994; 2012 Ražište type of the Sopot culture		

Table 1. *Relative chronology of the Sopot culture in relation to the Vinča culture, after S. Dimitrijević and Z. Marković.*

Regional settings

Although the Sava-Drava-Danube interfluve is considered as one micro geographical region, in the archaeological sense, it is split into three distinct zones: 1) eastern zone (Eastern Slavonia); 2) central zone (around Požega Valley); 3) western zone (Moslavina-Bilogora region) (Figure 1). Late Neolithic regional chronology, as it is perceived today, includes classical Sopot (defined by Dimitrijević as a by-product of late Starčevo and Vinča contacts; Dimitrijević 1968; 1979) in Eastern Slavonia and Western Syrmia, Ražište style in the central zone (defined by Z. Marković), so far documented on the sites in in its eastern part (Marković 1985; 1994; 2012; Marković and Botić 2014; 2016; Botić 2018; 2020a), and late Ražište and Brezovljani styles in the western zone. Ražište style appears along the classical Sopot style on some of the sites in the central zone, while other sites, as far as it is possible to discern from published data and partially reviewed material, contain exclusively classical Sopot style remains. It is still unclear what the precise chronological relation between these sites is, i.e. if some are older or contemporary. Western zone is the least well defined archaeological zone because radiocarbon dates are mostly missing; only two AMS dates were published for Gornji Brezovljani site (Figure 1: 26) (Botić 2020: 198), none exist for Korenovo sites, although typo-chronological and technological problems were discussed on several occasions (e.g. Težak-Gregl 1993; Spataro et al. 2021). Pottery-based chronology is not adequate to explain most probable parallel occurrence of Korenovo and Ražište styles as it is seen in the contexts of Baranya County (southern Hungary) sites and their correlation with earliest Vinča and early LBK in the wider region (cf. Jakucs 2020; for comparison between pottery-based chronology with that based on pottery and radiocarbon dates cf. Jakucs and Voicsek 2016; Jakucs et al. 2016).

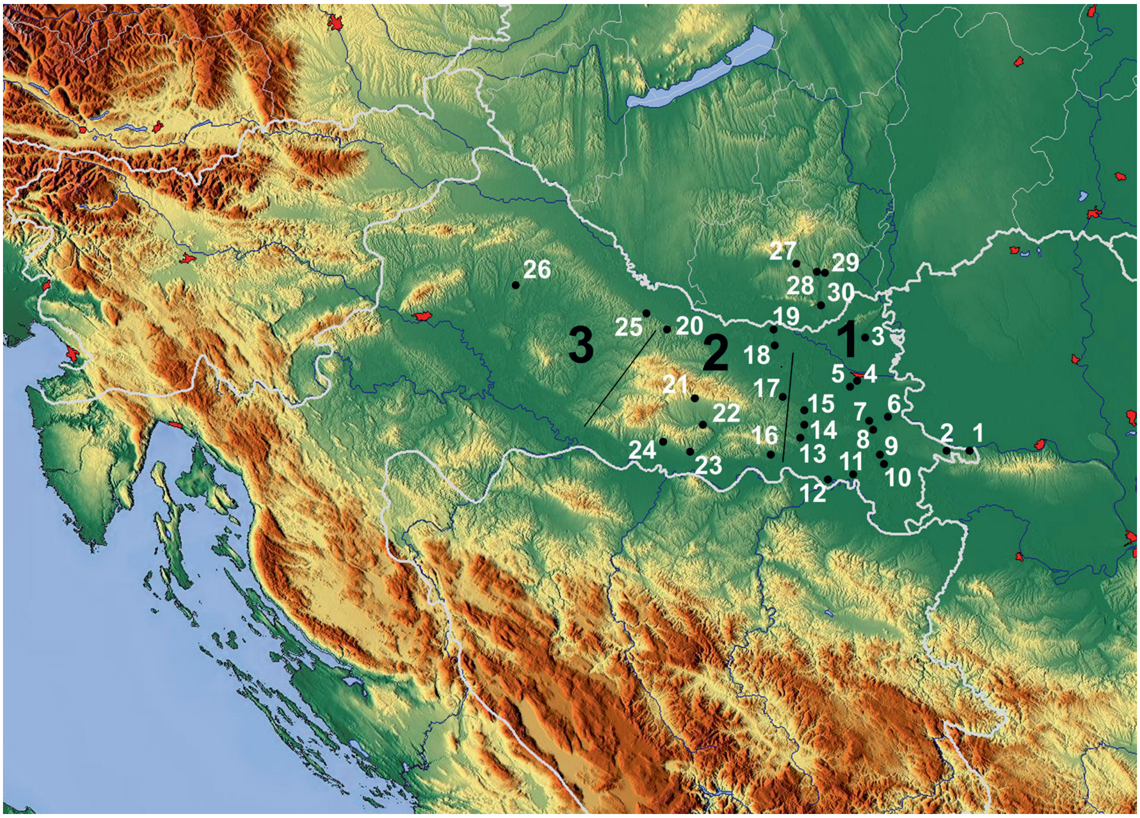

Figure 1. *Map of sites and zones (1 eastern; 2 central; 3 western):*

1 Ilok – Ađanski kraj / Krstbajer; 2 Bapska – Gradac; 3 Kneževi vinogradi – Osnovna škola (Elementary School); 4 Osijek – Hermanov vinograd; 5 Čepin – Ovčara / Tursko groblje; 6 Bršadin – Pašnjak pod selom; 7 Vinkovci – Zablaće; 8 Vinkovci – Sopot; 9 Privlaka; 10 Otok – Gradina / Mandekov vinograd; 11 Županja – Dubovo–Košno; 12 Kruševica – Njivice; 13 Novi Perkovci – Krčavina; 14 Ivandvor – šuma Gaj; 15 Gorjani – Kremenjača; 16 Klokočevik – Klinovac; 17 Podgorač – Ražište; 18 Golinci – Selište; 19 Donji Miholjac – Vrancari; 20 Pepelana; 21 Radovanci; 22 Vidovci – Glogovi; 23 Nova Gradiška – Slavča; 24 Nova Kapela – Ravnjaš; 25 Virovitica – Brekinja; 26 Gornji Brezovljani; 27 Szemely-Irtás; 28 Szederkény-Kukorica-dülö; 29 Versend-Gilencsa; 30 Villány-Villányvirágos

(physical map: https://maps-for-free.com/; *made by K. Botić)*

Late Neolithic micro regional relative chronology

Despite intensified archaeological excavations, especially in the last 15 years, there was almost no change in relative chronology. Sopot culture, defined by S. Dimitrijević (1968; 1979) based on several Eastern Slavonian sites and consequent relative chronology, was later disputed by Z. Marković (1994), mostly considering the latest regional and final phases of the Neolithic and the beginning of the Eneolithic (Table 1). At that time, Ražište and Brezovljani styles were defined as regional variants of the Sopot culture, later than its initial phase. New regional research, however, dates the coeval existence of the Vinča A, early LBK, Ražište and Korenovo styles at the Szederkény-Kukorica-dülö site near Pécs (Figure 1: 28), starting slightly after 5350 BC (Jakucs 2020), with probable contemporaneous occupation of Donji Miholjac – Vrancari and Podgorač – Ražište sites (Figure 1: 27) (Jakucs 2021) south of the Drava River (Botić 2018; 2020a) in the central zone. Moreover, some of the sites exhibit additional diversification of pottery styles, including sites south of the Drava River, or even a degree of 'hybridisation' such as at the Szemely-Irtás site (Figure 1: 27) (Jakucs 2021) in the later phase of the Ražište and Korenovo styles. Ražište pottery style appears among the surface finds at the Villány-Villányvirágos site (Figure 1: 30), the southernmost Baranya site at the moment (Horváth 2006: 321, Fig. 2). The initial Sopot I-A phase was identified by Dimitrijević on only one site:

Klokočevik – Klinovac (Figure 1: 16) (Dimitrijevič 1968: 1979: 268). However, this site is situated in the eastern part of the above mentioned central zone, i.e. out of the territory of the initial Vinča appearance and formation of the Sopot culture (Burić 2015). Dimitrijević published only a short description of layers in the two profiles of the excavated trenches and very sparse pottery finds (Dimitrijević 1968; 1971; 1979). Phases I-A and I-B he also saw at Otok – Gradina / Mandekov vinograd site (Figure 1: 10); although material was published only in drawings, it is apparent that there are differences between these two sites and that some of the shards from Klokočevik may very well be linked to the LBK decoration style (cf. Dimitrijević 1971: T. XI: 3, 6). For example, fragment no. 6 must have been very problematic for his chronology because it was omitted in 1979 (Dimitrijević 1979: T. XLV); fragment no. 3 was firstly dated to the I-A phase in 1971 and later to the I-B phase in 1979. There are several other examples. Material from Otok, on the other hand, has more common traces with the Vinča style (cf. Dimitrijević 1968; Burić 2009; 2011).

Dimitrijević considered the end of the Sopot culture (phase III) in the eastern zone parallel to Vinča D1/D2 phases while Marković (1994; 2012) added phase IV parallel to the Vinča D2/D3 phases. Milojčić's phase Vinča C–D (Milojčić 1943; 1949; Whittle et al. 2016) was not recognized (Table 1). In the past, methodology of field research consisted of spits defined by the depth of a spade which was problematic when excavations were carried out on multi-layered / tell sites; this is apparent in the publications where stratigraphy of the sites was discussed on profiles of the excavated trenches, only rarely the ground plans, and very small selection of finds. Methodology of field research in the last 20 years changed and is based on stratigraphic units permitting better control of the content of each archaeological feature. However, publication of archaeological features without or with small amount of selected finds is still very much in use.

New excavations carried out at the eponym Sopot tell site revealed the youngest constructions dated to the Sopot IV phase (Krznarić Škrivanko 2015: 378–379). After personally examining some of the finds from these features, we can confirm that they belong to the Sopot IV phase as described by Z. Marković (1994). We thank M. Krznarić Škrivanko and Vinkovci Town Museum for this opportunity. Excavations at Bršadin – Pašnjak pod selom site (Figure 1: 6) (Botić 2019; 2020b) documented a Late Neolithic settlement; some of the pottery finds exhibit more chronologically sensitive Vinča or Vinča like elements similar to those from the other sites, such as Bapska, Divostin, Vinča and Gomolava, in the layers dated to the phases from Vinča C to D1 (Botić 2020b). It is, however, difficult to discern what typical vessel forms of the Sopot "culture" are, although both elements of the phases Sopot III (after Dimitrijević) and Sopot IV (after Marković) are present. New excavations at Bapska – Gradac site (Figure 1: 2) documented pottery finds from the Sopot III / Vinča D phases (Burić 2011) which confirms earlier Dimitrijević's finds from this site (Dimitrijević 1968).

In the central and western zones, in the Drava River valley, Seče style appears at the same late period (late 5th millennium; Marković 1994; problems with pottery style-based chronology are also connected to this style and to this specific region, for more see "Marković 2012), while Brezovljani style most probably continues in the same region during most of the 5th millennium (see note 2). Lasinja pottery style already appears in some parts of the Sava-Drava-Danube interfluve at that time (e.g. Balen 2008; Marković 2012; Rajković 2018; Čataj 2018). Brezovljani style pottery appears in the central zone as well, eg. Nova Gradiška – Slavča, Pepelana (Figure 1: 20, 23) and other sites (Mihaljević 2013). Despite recent attempts to summarise the chronology of the Sava-Drava-Danube interfluve in the 6th and 5th millennium BC (Balen et al. 2014; 2018 etc.), it is clear that the state of published research is not adequate to resolve apparent problems.

Site	**Total dates**	AMS	Charcoal	Short lived sample
Virovitica – Brekinja	**2**		2	
Donji Miholjac – Vrancari	**4**	4	1	3
Podgorač – Ražište	**3**	3	1	2
Golinci – Selište	**1**	1	1	
Novi Perkovci – Krčavina	**2**		2	
TOTAL	**12**	**8**	**7**	**5**

Table 2. *Total number of radiocarbon dates for the Middle – Late Neolithic in the eastern part of the central zone (late Starčevo, LBK, early Vinča, Ražište styles).*

Site	**Total dates**	AMS	Charcoal	Short lived sample
Nova Gradiška – Slavča	**9**	4	9	
Radovanci	**1**	1		1
Nova Kapela – Ravnjaš	**4**	4	4	
Vidovci – Glogovi	**5**	5	5	
Pepelana	**1**		1	
Gornji Brezovljani	**2**	2	2	
TOTAL	**22**	**16**	**21**	**1**

Table 3. *Total number of radiocarbon dates for the Middle – Late Neolithic in the central and west zones (Korenovo – not dated, Sopot, Brezovljani styles).*

Site	**Total dates**	AMS	Charcoal	Short lived sample
Bapska – Gradac	**7**	5	2	5
Bršadin – Pašnjak pod selom	**11**	11		11
Čepin – Ovčara / Tursko groblje	**4**		4	
Županja – Dubovo–Košno	**6**		6	
Gorjani – Kremenjača	**4**	4	1	3
Ivandvor – šuma Gaj	**6**	6		3
Kneževi Vinogradi – Osnovna škola	**1**			1
Kruševica – Njivice	**1**		1?	
Osijek – Hermanov vinograd	**2**		1	1
Otok – Mandekov vinograd	**3**		1	2
Privlaka – Gradina	**2**		1	1
Vinkovci – Sopot	**26(29)***	9(12?)	22	4(7?)
Vinkovci – Zablaće	**4**	4		4
TOTAL	**77(80?)**	**39(42?)**	**38(39?)**	**35(38?)**

* Three dates published without the error (excluded from modeling)

Table 4. *Total number of radiocarbon dates for the Middle – Late Neolithic in the east zone (Sopot, Vinča styles). ? – data on AMS measurements and nature of samples not provided in the published material.*

Late Neolithic regional absolute chronology

A large number of radiocarbon dates primarily appeared in publications as a result of the large-scale rescue excavations, which intensified after 2005. We used 111 radiocarbon dates (Tables 2–4) for the period of micro-regional Late Neolithic collected from publications(for details about most of these dates, see Botić 2017: 223 etc., Supplement 2; Bršadin – Pašnjak pod selom, Botić 2020b; Gorjani – Kremenjača, Šošić Klindžić et al. 2019; Vinkovci – Zablaće, Krznarić Škrivanko 2020; very likely, a substantial number of radiocarbon dates are still waiting to be published) but there are disagreements about their context. Many of these dates were published without or with very scarce archaeological context other than features. Consequently, it is not always acceptable to attribute them to the Sopot culture/style. About 56% were AMS dated; short-lived samples were used for only 39 out of 63 AMS measurements (human or animal bones, seeds and non-charred plant macrofossils). In general, the poor sampling strategy was the main problem (Burić 2015), and it has continued until the present.

Another problem in building site-by-site or general micro-regional chronology is an uneven distribution of available radiocarbon dates throughout the three zones and among the sites: most of the radiocarbon dates are available for the eastern zone (East Slavona and Western Syrmia), while only a few dates are available for most of the sites in all three zones and very few sites were dated by ten or more radiocarbon dates. This is illustrated the best by simple sums of dates (Figures 2–4): the central zone is split between two graphs because its eastern part, for the moment, is mainly dated earlier (and it has specific chronological continuity, diverse from the other zones as can be seen in Figure 2; Table 2) than its southern/western part. However, only 12 dates, out of which 8 AMS are available for this zone (Figure 2), and only 7 (5 AMS) date the period between the earliest documented transition to the Middle Neolithic (from about 5400/5350 BC) to the mid-5th millennium(four dates from Donji Miholjac – Vrancari site and one from Podgorač – Ražište site (Table 2); the date from Golinci – Selište site is somewhat younger, as are the rest of the dates from the Podgorač – Ražište and Novi Perkovci – Krčavina sites).

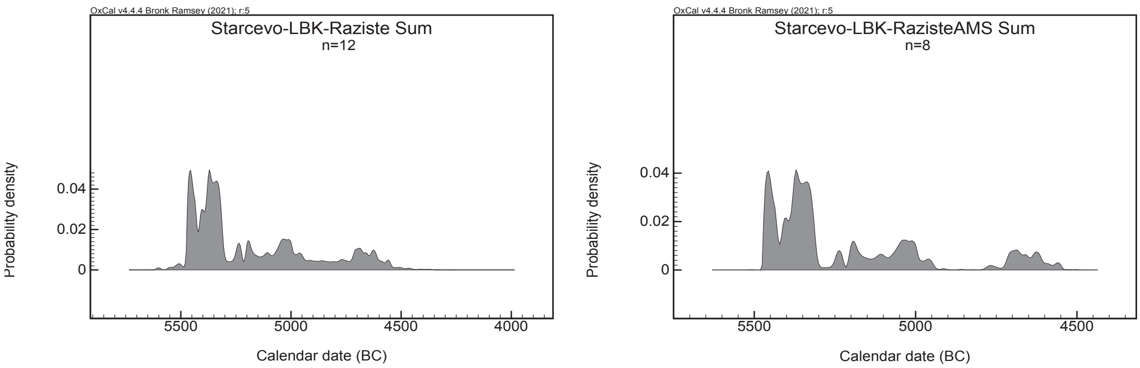

Figure 2. *Sums of radiocarbon dates for the Middle – Late Neolithic period in the eastern part of the central zone (left: all radiocarbon dates, right: AMS dates).*

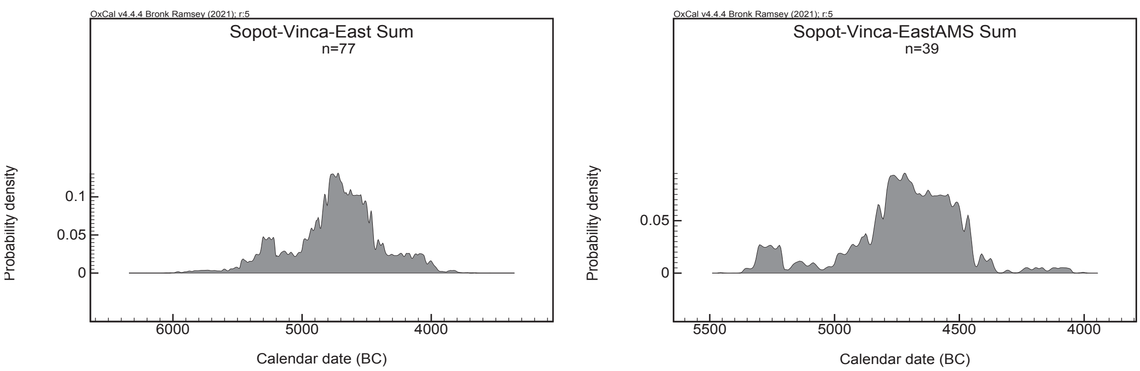

Figure 3. *Sums of radiocarbon dates for the Middle – Late Neolithic period in the east zone (left: all radiocarbon dates, right: AMS dates).*

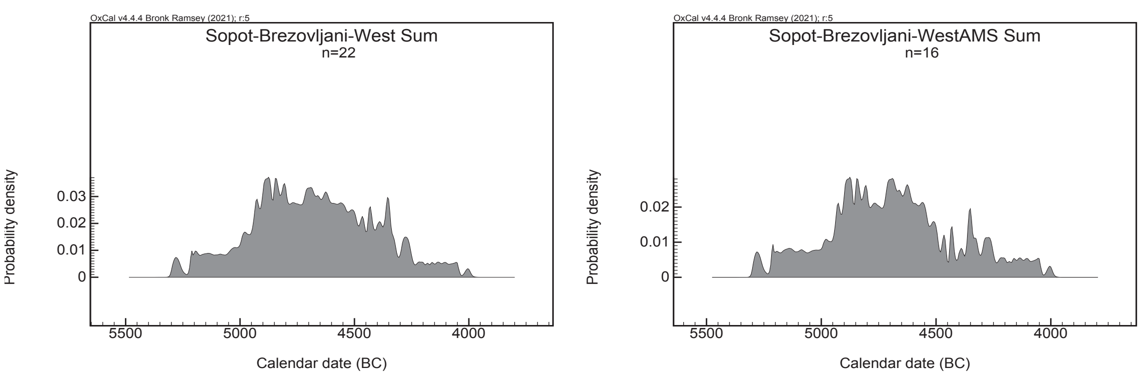

Figure 4. *Sums of radiocarbon dates for the Middle – Late Neolithic period in the central and west zones (left: all radiocarbon dates, right: AMS dates).*

In the eastern zone, the situation is more complicated. Most 77 dates (39 AMS) (Figure 3) date archaeological contexts after 5000 BC. However, several dates deviate from this average and are older (Table 5). Dates of the most recently excavated Vinkovci – Zablaće site (Figure 1: 7) come from contexts without any additional finds (Graves 1–3), or the context was not published (SU 69/70). The main settlement construction types are timber-framed longhouses without long pits and partly with narrow foundation channels along the longest sides (Krznarić Škrivanko 2020: 129, Fig. 2). Similar type of construction was discovered at Kruševica – Njivice site (Figure 1: 12) (Miklik-Lozuk 2014). This site was dated by a single radiocarbon date from the sample that was not collected from the timber-framed longhouses but from the large pit (Table 5). Except for four stone tools, no other context was provided for this site in general or for this radiocarbon date in particular. Such house constructions are different from those on tells, which are generally linked to the Vinča influence and appear in the eastern zone. However, house constructions of a similar type appear in the western LBK and later Lengyel traditions, and are present at settlements in the Baranya region, complemented by pottery styles and the rest of the assembly.

All six dates from Dubovo – Košno site (Figure 1: 11) are a more significant problem because the context which the samples came from is not known (it is impossible to verify the position and exact stratigraphic units) as detailed plan and/or description is missing (c.f. plan Marijan 2006: 44, Fig. 2). Sparse pottery finds published seem similar to Ražište style as defined for the area around Đakovo and not the classical Sopot style (Marijan 2006; Marković Botić 2008; Botić and Boras 2021). House constructions seem to follow the same timber framed pattern as the two previously mentioned sites (cf. Marijan 2006; 2007). More importantly, radiocarbon measurements were performed on charcoal samples, two of which were exposed to ground waters (Table 5). For the moment, Vinkovci – Zablaće and Kruševica – Njivice dates may still prove to be the missing link with the early Vinča B phase (Jakucs and Voicsek 2017) in the eastern zone, but we will have to wait for the detailed processing and publication of all the archaeological finds from these two sites. Dubovo – Košno dates have too high an error to be of further use (Table 5), and charcoal samples will have to be replaced by short-lived samples; new dates will have to be published with full details of the context if they will be further used for dating the beginning of the micro-regional Late Neolithic, especially the Sopot style in the Eastern Slavonia. One more date should be excluded from further dating of the Late Neolithic, from the Kneževi Vinogradi – Osnovna škola (Elementary School) site (Table 5). Not only is the error too high, but the human remains dated come from a mixed context (Šimić 2012: 212) and may well belong to the previous Early Neolithic Starčevo context.

Two dates from the eponym Sopot site (Figure 1: 8) also diverge from the rest. House SU 11 was dated to the Sopot III/IV phases by two radiocarbon dates and the context (Krznarić Škrivanko 2011; 2015; Botić 2017: 225), but sample Z-2826 yielded a much older date (Table 5). The second date has the same problem: house floor SU 183a is dated to the Sopot II phase by one AMS date (Beta 230033; Krznarić Škrivanko 2011: 214, Tab. 3; Botić 2017: 226) and the context, however, the sample Z-3868 yielded older result. Once again, results of radiocarbon measurements on charcoal samples exhibit too high errors for further use.

Two published dates for the central zone are older as well. One of the dates from Nova Gradiška – Slavča (Table 5), according to the principal investigator, dates the context (channel SU 37A) in the Brezovljani style (Mihaljević 2013: 78, 101, Fig. 16), while adjacent pit SU 37 was dated to the Sopot II/III phase (Z-3234) (cf. Mihaljević 2006: 33; 2013: 76–79, 101; transition phase Sopot II/III corresponds to the end of the Brezovljani style; after Dimitrijević 1979: 334). However, channel SU 37A is at least 400 y older according to this single date which may be the result of the sampling strategy. If the result of this radiocarbon measurement can be confirmed by short-lived samples in the future, this would be the oldest dated Brezovljani phase.

The second older date for the central zone is that from the Radovanci site (Figure 1: 21). At this site, archaeological material was collected after the illegal excavation of the house basement; pottery attributed to the Sopot style was reportedly found in the closed context with the skeleton (Balen and Potrebica 2006: 25) which was sampled for radiocarbon dating (Table 5). Published pottery finds have more in common with the Brezovljani style, i.e. material is closer to that which occurs west and north of this site (Gornji Brezovljani, Špišić Bukovica, Pepelana etc.) (Balen and Potrebica 2006: 24); it is also similar to that in the western Transdanubian Lengyel tradition (c.f. Barna 2017) although some elements of its decoration and technology of production may have some points in common with the Ražište style which appears on the sites geographically relatively close by somewhat earlier. It is quite clearly different from the classical Sopot pottery finds in the eastern zone. If the human remains dated come indeed from the same context as the pottery finds, this is the oldest dated Brezovljani context in the interfluve.

Site	Lab code	Material and context	14C age BP	Method	Literature
Dubovo – Košno	Z-3439	charcoal sample 221 (SU 318, sq. I/48); no other context	6870 ± 115		Obelić et al. 2011: 396
	Z-2973	charcoal sample 214 from pit-dwelling SU 148, sq. F-38, western part; no other context	6530 ± 100		Obelić et al. 2002: 620; 2004: 252, Tab. 1; Marijan 2001: 44, note 12; 2006: 48
	Z-3046	charcoal sample, SJU 308, sq. H-49d, PU 228; no other context	6380 ± 100		
	Z-2969	charcoal mixed with soil and exposed to the groundwater, PU 152, pit SU 160, sq. H-38; no other context	6270 ± 140		
	Z-3045	charcoal sample, SU 1804, sq. Z-43d, PU 339; no other context	6320 ± 100		Obelić et al. 2002: 620; 2004: 252, Tab. 1; Marijan 2001: 44, note 12; 2006: 48–49
	Z-2998	charcoal sample exposed to the groundwater from pit-dwelling SU 1144, sq. R-38/39; no other context	6220 ± 100		
Kneževi vinogradi – Osnovna škola (Elementary School)	Z-3386	human bone (femur); no direct finds, mixed Starčevo/Sopot context at the same depth in the rest of the pit	6350 ± 135		Obelić et al. 2011: 400; Šimić 2012: 212
Kruševica – Njivice	Z-3595	charcoal, sq. N24, SU 314, half pit-dwelling; no other context	6115 ± 60		Obelić et al. 2011: 400; Miklik-Lozuk 2014: 56
Nova Gradiška – Slavča	Beta 278784	charcoal, SU 37A, channel; pottery finds	6310 ± 40	AMS	Mihaljević 2013a: 78, 180, Tab. 31
Radovanci	OxA-23499	human bone; material collected, mixed context, Sopot pottery reported next to the skeleton	6229 ± 34	AMS	Perić 2012: 22; Balen and Potrebica 2006; Balen and Čataj 2014: 68
Vinkovci – Sopot	Z-2826	charcoal sample, fragment of a wooden construction / support of the house SU 11 wall, sq. I/6, depth 2.11 m	6340 ± 100		Obelić et al. 2002: 618; Krznarić Škrivanko 2011: 211, 220, Tab. 1
	Z-3868	charcoal sample, house floor SU 283a, sq. K/30/04	6295 ± 135		Krznarić Škrivanko 2011: 211, 220, Tab. 1
Vinkovci – Zablaće	DeA-11612	Grave 1, tooth (male 35–50 yr); Probe II, no other context	6299 ± 36	AMS	Krznarić Škrivanko 2020: Tab. 1
	DeA-11613	Grave 2, tooth (child 0–5 yr); Probe II, burial in the large wooden post hole, no other context	6310 ± 36	AMS	
	DeA-11614	Grave 3, tooth (female 35–50 yr); Probe II, no other context	6223 ± 33	AMS	
	DeA-23705	animal tooth; pit-dwelling SU 69/70, no other context	6248 ± 42	AMS	

Table 5 *Radiocarbon dates that deviate from most Late Neolihic results.*

Regarding the end of the micro-regional Late Neolithic, it was pointed out (Burić 2015; Botić 2016a) that it overlaps with the beginning of the Eneolithic, namely Lasinja culture at the end of the 5th millennium BC. Period between 4300 and 4000/3900 BC was dated on several sites: Otok – Mandekov Vinograd (Z-2762, charcoal, 5330 ± 120 BP; Z-2913, burned seeds of Triticum aestivum L., 5555 ± 120 BP – Obelić et al. 2002: 611; 2004: 252, Tab. 1), Osijek – Hermanov vinograd (Z-2830, charcoal, 5260 ± 120 BP – Šimić 2000: 228; Obelić et al. 2002: 610; 2004: 252, Tab. 1), Čepin – Ovčara/Tursko groblje (Z-3263, charcoal, 5500 ± 90 BP – Šimić 2004: 59; Obelić et al. 2011: 396), Nova Gradiška – Slavča (Beta 278786, AMS, charcoal, 5290 ± 40 BP; Beta 303974, AMS, charcoal, 5430 ± 40 BP – Mihaljević 2013: 180, Tab. 3), and Vinkovci – Sopot (Z-2754, charcoal, 5360 ± 130 BP; Z-2909, charcoal, 5220 ± 100 BP; Z-2911, charcoal, 5330 ± 90 BP; Z-2827, charcoal, 5380 ± 98 BP – Obelić et al. 2002: 617–618; 2004: 252, Tab. 1; Z-3866, charcoal, 5415 ± 195 BP; Beta 230030, AMS, charcoal, 5300 ± 40 BP – Krznarić Škrivanko 2011: 214–215, Tab. 3). Most of these dates have too high an error to be considered for modelling but several AMS dates confirm the occupation of these sites well into the micro-regional Eneolithic. There is a fair amount of radiocarbon dates for a somewhat older period (4500–4300 BC) as well.

The settlement at the Bršadin site was recently dated by 11 AMS dates (Botić 2020b), with the youngest contexts dated before 4600 BC (Figure 5). However, this site underwent severe alterations in unknown period(s);; there are indications of tell mound levelling. Consequently, the topmost structures were damaged and were not dated. It is possible that the occupation of this site continued into the second half of the 5th millennium. The foundation of explored part of this settlement occurred after 4900 BC (Figure 5) (Botić 2020b). Another very recently excavated Late Neolithic settlement, at Ilok – Ađanski Kraj/Krstbajer position (Figure 1: 1), exhibits late Viča D period elements in pottery assembly, very similar to Vinča eponym site (cf. Borić 2015: 167, Fig. 5; Tasić et al. 2016a: 14, Fig. 10; Whittle et al. 2016: 5, Fig. 3). Both of these settlements were most probably founded at the same time as the settlement at Bapska although Bršadin dates are for the moment partially older (Figures 5–6) and there are no dates yet for the Ilok site.

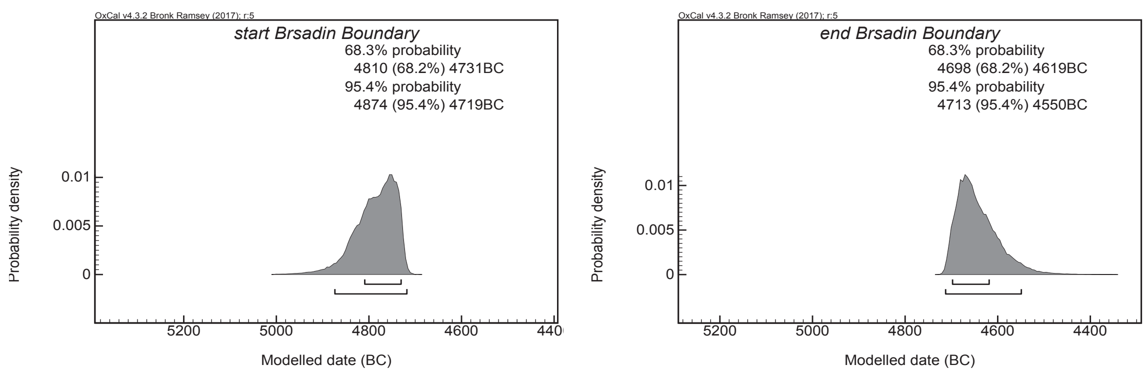

Figure 5. *Start and end boundary for the Bršadin – Pašnjak pod selom site (11 AMS dates).*

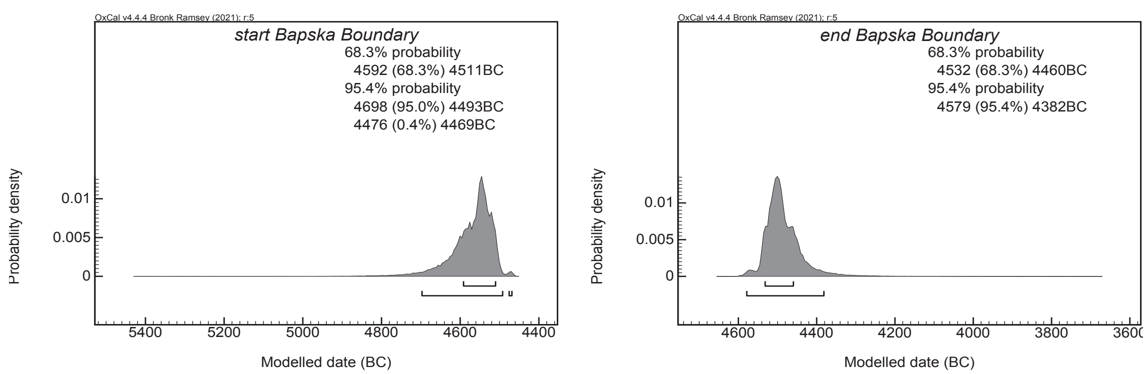

Figure 6. *Start and end boundary for the Bapska – Gradac site (5 AMS dates).*

Discussion

The complexity of the Middle and Late Neolithic in the Sava-Drava-Danube interfluve reflects a similar situation in adjacent regions north of the Drava River and in the Danube River basin. As already mentioned, sometime during the 54th century BC rapid changes seem to have occurred, which is reflected in appearance of diverse pottery styles and coexistence on various sites in the Sava-Drava-Danube interfluve central zone and in Baranya County (Jakucs et al. 2016). These styles (LBK, early Vinča, Ražište, and Korenovo) do not only differ in surface decoration, but the tempering, firing, surface treatment, and vessel forms have their own micro-regional or site-by-site variants; traditions transferred from the Early Neolithic Starčevo style vary as well.

At the same time, timber-framed longhouses appear both in the Drava and the Sava river valleys. From that time until the end of the Neolithic, micro-regional diversity continues. Classical Sopot style, as defined by S. Dimitrijević, occurs in the eastern zone. However, it is still not entirely clear when and where Vinča style appeared there, although newly excavated site Vinkovci – Zablaće may at least partially answer this question; radiocarbon dates point to the period of Vinča B (cf. Whittle et al. 2016) but older phase of the settlement can be expected as the child in the Grave 2 was buried in a hole left by a large wooden post, most probably the remain of a large longhouse (Krznarić Škrivanko 2020: 135, Fig. 8). Complex situation at this site is also demonstrated by the contents of one larger cylindrical pit with three whole vessels left at its bottom (Krznarić Škrivanko 2020: 133, Fig. 6). Description of these vessels was not published but we had the opportunity to examine them at the Vinkovci Town Museum; one of the vessels is biconical with incised arched motifs in the upper segment (similar to Ražište style), the other has a linear motif executed in double dashed lines, in a Stichbandkeramik tradition while the third was undecorated. Parallels for the Stichband decoration cannot be found in the close vicinity, only in the central Europe at the moment (see Zápotocká 2007: 203, Abb. 3, especially no. 13 as the closest parallel). Vinkovci – Zablaće vessel form suggests the early Stichbandkeramik phase. However, Zápotocká states that it only spreads in its 3rd phase. The exact position and orientation of this pit and its full context were not published. Both decorated vessels had dark, finely executed, unpolished surfaces. The third vessel was coarser. Earlier discovered Grave 3 from Vinkovci contained two early Vinča vessels (Burić and Težak-Gregl 2010); however, they do not match the early Vinča (Vinča A) vessels at Szederkény-Kukorica-dülö and other sites around it (cf. Jakucs et al. 2016; Jakucs and Voicsek 2016; Whittle et al. 2016). They match early Vinča assembly from Vinča – Belo Brdo site (Borić 2015; Tasić et al. 2016a), which is dated somewhat later than the Baranya County finds. They also point to the micro-regional classical Sopot development later on. The fact that these vessels were found in the same context as the late Starčevo pottery (Spiraloid B after Dimitrijević) is not surprising; as mentioned before, an amalgamation of pottery styles in the same contexts is quite common in that transition period from the Early to the Middle Neolithic. Unfortunately, this grave context was not radiocarbon dated.

The beginning of the Late Neolithic in the eastern zone with fully developed classical Sopot style can be dated to the period around 5000 BC and later. Already mentioned problems with uneven distribution of radiocarbon dates and lack of full contexts prevent the development of full chronology of this micro-region, but it can be observed that most of the dates span between 5000 and 4400 BC (Figure 7). Most dates diverging from that period, whether older or younger, should be re-examined or re-dated before considering them for further dating of the beginning or the end of the Late Neolithic. Regional absolute chronology based on these problematic dates was published by Obelić et al. in 2004. We advise taking the results from this study with caution.

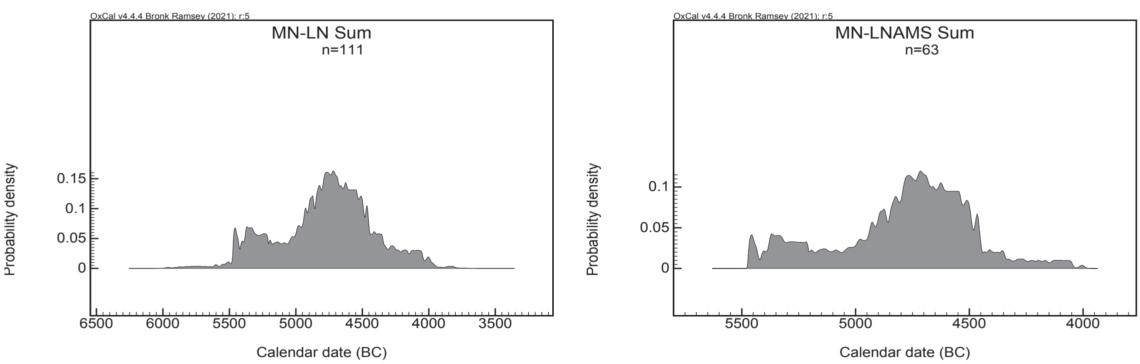

Figure 7. *Sums of radiocarbon dates for the Middle – Late Neolithic period in the Sava-Drava-Danube interfluve (northern Croatia) (left: all radiocarbon dates, right: AMS dates).*

Rašište style seems to first appear in the central zone (so far well attested in its northern and eastern part), followed by the Brezovljani style, while in the western zone, Brezovljani style succeeded the Korenovo style. This simplified relative chronology is not the best view on the problem: recent excavations around Nova Gradiška, Novska and Pakrac, i.e. central and western region border zone (namely its southern and south-western part), yielded mixed context finds (late Korenovo, Brezovljani, Ražište elements) that are primarily described as Sopot but may well represent a regional amalgamation of styles, as seen in the Drava River valley, and their transformation, especially from the 5000 BC onwards (e.g. Mihaljević 2010: 115; Nodilo 2013: 176; 2014: 60, 61, cat. nos. 154, 161–163; Ivanković 2013: 173; 2014: 58). Lack of radiocarbon dates and publication of pottery assembly for most of these contexts prevents building this micro-regional chronology for the moment.

Z. Marković determined Ražište as a variant of the Sopot culture in 1985; its relative chronology was linked to the Sopot I-B and later, after the excavations at Novi Perkovci – Krčavina site (Figure 1: 13), to the Sopot I phase (Marković 2012). After the new excavations and the first series of radiocarbon dates from Podgorač – Ražište, Golinci – Selište and Donji Miholjac – Vrancari sites (Botić 2021) south of the Drava River, and Szederkény-Kukorica-dülö, Szemely-Irtás and other sites north of the Drava River in the Baranya County, the chronology of Ražište style is quite different. North of the Drava River, this style appears along the early Vinča (A), early LBK and Korenovo styles, and it is predominant in the western part of the settlement in Szederkény-Kukorica-dülö, while in the eastern part of this settlement, with predominant Vinča (A) style, it appears along early Vinča, early LBK and Biňa-Bicske styles (Jakucs 2021: Fig. 16). The beginning of both eastern and western parts of this settlement was dated to the period following 5350 BC (Jakucs et al. 2016; Jakucs 2021). The end of both settlement parts at Szederkény is dated to the period predating 5150 BC. The continuity of Ražište style is dated at the Szemely-Irtás site into the 5th millennium BC (Vinča B2/C1 – Jakucs 2021: 138). The same situation is observed south of the Drava River, where the oldest dates and pottery finds appear almost at the same time as in Szederkény-Kukorica-dülö while the younger phase, after 5000 BC, is observed in the region around Đakovo and most probably further south. As mentioned before, sites with Ražište style appear around Đakovo along the sites where only classical Sopot-style material was reported and/or could be verified, which poses the question about their chronological relations. There are no Ražište style finds further east for the moment.

Such early dating of Ražište style, its decorative and technological elements, and its geographic distribution suggest its appearance as a local 'product' of the early LBK and early Vinča (A) contacts with limited Early Neolithic Starčevo technological traditions. Therefore, this style should not be considered a variant of the classical Sopot or even its earliest phase. Differences in vessel shapes, tempering, firing and surface treatment between these two styles are too great to be further considered tightly connected. Both, however, appear in the Late Neolithic (most of the 5th millennium BC) along several other styles and traditions which share some of the same elements, such as red-painted motifs, albeit with different intensity and technology. A recently published paper on Sopot chronology in the Sava-Drava-Danube interfluve by Šošić Klindžić et al. (2019) does not take into consideration this diversity of traditions between Ražište and classical Sopot styles. This paper should as well be taken with extreme caution when discussing the Late Neolithic chronology of the interfluve. The same problem occurs with some older papers (e.g. Sraka 2012). On the other hand, Transdanubian regional differences were already noted by Regenye in 2002; they are linked to the regional differences south of the Drava River, namely classical Sopot in eastern Slavonia and the Brezovljani style in the west. The map presented in this paper draws the separation line between these two Late Neolithic styles from Donji Miholjac in the Drava region, down the Požega Valley, to the area around Nova Gradiška. This is precisely where we see first the development of the Ražište style followed by the emergence of the Brezovljani style. Discussion about the Sopot variants in this paper should be disregarded. This paper also rightly connects the Brezovljani style with the Western Transdanubian Lengyel style, as they share most of the traits.

The Late Neolithic settlement foundation in the Danube River valley seems to have occurred at the beginning of the 5th millennium for a specific reason. Some indications that the environmental conditions may have played a role in this can be seen at the Bršadin site, where the settlement was founded on a very low Vuka River bank (tell Sopot was also founded on a low Bosut River bank at a very similar time, cf. Krznarić Škrivanko 2015). Radiocarbon sequence and most distinct finds were used to create the first preliminary composite chronology of the site (Botić 2020). The importance of building site-by-site chronologies before attempting to create a regional one and the methodology were described by Marić et al. (2021) and Diaconescu et al. (2020).

Other sites, such as Bapska – Gradac and Ilok – Ađanski Kraj/Krstbajer, appear in the Western Syrmia on elevated positions and are most probably contemporaneous with the Bršadin settlement. For the moment, Bršadin and Bapska sites are dated to Sopot III–IV/Vinča C–D/D periods (c. 4800–4500 BC). However, the difficulty in attributing finds to the Sopot or Vinča assembly is preventing us from drawing precise conclusions. Whittle et al. (2016) demonstrated difficulties in building and comparing regional chronologies of the Vinča culture. With some certainty, we can partially attribute some of the pottery finds from Bršadin to the short Milojčić's phase Vinča C–D and early Vinča D phase as described and dated by Borić (2015) and Tasić et al. (2016a; 2016b). Other pottery finds from the Ilok site can be similarly attributed, although some differences between these two sites exist.

Conclusions

The traditional approach to the Middle and Late Neolithic micro-regional chronology consisted of a short publication of the archaeological contexts with a list of radiocarbon dates. Despite a significant number of radiocarbon measurements performed in the last 20 years, there have been almost no attempts to build a site-by-site and, consequently, a local chronology through combining Bayesian modelling of radiocarbon dates with full statistical seriation of finds from individual sites. Although the beginning of the Neolithic in the Sava-Drava-Danube interfluve at the very beginning of the 6th millennium BC is fairly known (Botić 2016b), the transformation that occurred in the period following 5400 BC is only beginning to be understood, both south and north of the Drava River (Marković 1994; 2012; Horváth 2006; Jakucs and Voicsek 2016; 2017; Jakucs et al. 2016; 2018; Botić 2018; 2020a). This is a period of pottery styles diversification in the interfluve: early Vinča (A), early LBK and Ražište styles in the central zone (Podgorač – Ražište, Golinci – Selište, Donji Miholjac – Vrancari), and in the Baranya County (Szemely-Irtás, Szederkény-Kukorica-dülö, Versend-Gilencsa, Villány-Villányvirágos) where Korenovo elements appear in some of the same contexts; local LBK Korenovo style (Dimitrijević 1979; Težak-Gregl 1993) in the Moslavina-Bilogora region followed by Brezovljani style (Dimitrijević 1978; 1979), and classical Sopot style in the eastern zone with significant Vinča influence (Dimitrijević 1979; Burić 2011). The diversity between eastern and western zones is also seen in the house dimensions and structure; timber-framed longhouses appear in both the Drava and Sava River basins (Virovitica – Brekinja, Donji Miholjac – Vrancari, Kruševica – Njivice, Dubovo – Košno) with only one known site from the central area of the eastern zone (Vinkovci – Zablaće). In the eastern zone, on the other hand, tell settlements appear in the Late Neolithic with houses of smaller dimensions and very often with clay floors in wattle and daub house constructions. Flat settlements in the same zone follow the timber-framed longhouse model but are of smaller dimensions.

Regarding the absolute dating of these changes, over 100 radiocarbon dates have been collected from publications of the last 20 years. However, large majority were published without clear context or a full study. Not enough of these measurements were performed on short-lived samples. Further, there were attempts in the past to justify and date old typo-chronology periods (Obelić et al. 2004) or to use all available radiocarbon dates without taking into consideration micro-regional and temporal diversity, problems with samples and/or contexts listed here (Šošić Klindžić et al. 2019; Sraka 2012). At present, robust Middle and Late Neolithic chronology is still missing. However, there are indications about certain temporal occurrences, such as the beginning of the Middle Neolithic transformation in the Drava River valley, the appearance of the Late Neolithic along the Danube and the transformative period at the end of the 5th millennium BC. Building complete chronologies of several key sites and incorporating them into the micro-regional chronology would be a good start.

References

Balen, J. 2008. “Apsolutni datumi sa zaštitnih istraživanja na prostoru Slavonije kao prilog poznavanju kronologije srednjeg eneolitika”. Vjesnik arheološkog muzeja u Zagrebu XLI, 17–35.

Balen, J. and L. Čataj. 2014. “Sopotska kultura”. In Darovi zemlje. Neolitik između Save, Drave i Dunava, eds. J. Balen, T. Hršak and R. Šošić Klindžić, 59–73. Osijek: Arheološki muzej u Zagrebu, Filozofski fakultet Sveučilišta u Zagrebu, Muzej Slavonije Osijek.

Balen, J. and H. Potrebica. 2006. “Nalazište Radovanci u Požeškoj kotlini”. In Od Sopota do Lengyela. Prispevki o kamenodobnih in bakrenodobnih kulturah med Savo i Donavo, ed. A. Tomaž, 21–27. Koper: Založba Annales.

Balen, J., T. Hršak and R. Šošić Klindžić, eds. 2014. “Darovi zemlje. Neolitik između Save, Drave i Dunava”. Osijek: Arheološki muzej u Zagrebu, Filozofski fakultet Sveučilišta u Zagrebu, Muzej Slavonije Osijek.

Balen, J., I. Miloglav and D. Rajković, eds. 2018. “Povratak u prošlost. Bakreno doba u sjevernoj Hrvatskoj”. Zagreb: Archaeological Museum in Zagreb, Faculty of Humanities and Social Sciences of the University of Zagreb, Archaeological Museum Osijek.

Barna, J. P. 2017. “The Formation of the Lengyel Culture in South-Western Transdanubia”. Archaeolingua Series Maior 39. Budapest: Archaeolingua.

Botić, K. 2016a. “Climatic influences on appearance and development of Neolithic cultures in southern outskirts of Carpathian Basin”. Studia Quaternaria 33(1), 11–26. DOI: 10.1515/squa-2016-0002

Botić, K. 2016b. “Neolithisation of Sava-Drava-Danube interfluve at the end of the 6600–6000 BC period of Rapid Climate Change: a new solution to an old problem”. Documenta Praehistorica 43, 183–207. https://doi.org/10.4312/dp.43.9

Botić, K. 2017. “Neolitička naselja na prostoru sjeverne Hrvatske”. Unpublished PhD dissertation, Zagreb: University of Zagreb. http://darhiv.ffzg.unizg.hr/id/eprint/9572/

Botić, K. 2018. “Middle Neolithic absolute dating in North Croatia – New research”. Studia Universitatis Hereditati 6(1), 89–100.

Botić, K. 2019. “Bršadin, Pašnjak pod selom – rezultati arheoloških istraživanja 2018. godine”. Annales Instituti Archaeologici XV, 25–36.

Botić, K. 2020a. “Middle Neolithic transformation: Starčevo–LBK–Vinča meeting point and the emergence of Ražište style in Drava river valley”. Quaternary International 560–561, 197–207. https://doi.org/10.1016/j.quaint.2020.03.032

Botić, K. 2020b. “Kasnoneolitičko naselje Bršadin – Pašnjak pod selom, kronostratigrafski prikaz tri sezone arheoloških istraživanja”. Annales Instituti Archaeologici XVI, 54–70.

Botić, K. and J. Boras. 2021. “Novi Perkovci – Krčavina. Prapovijesno višeslojno arheološko nalazište”. Đakovo: Muzej Đakovštine.

Burić, M. 2009. “Vinčanska kultura i njezin utjecaj na neolitik istočne Hrvatske”. Unpublished PhD dissertation. Zagred: University of Zagreb.

Burić, M. 2011. “Gradac u Bapskoj – slika života istočne Hrvatske prije 7000 godina, Izdanje povodom obilježavanja stogodišnjice prvih arheoloških istraživanja u Bapskoj (1911.–2011.)”. Zagreb: Filozofski fakultet.

Burić, M. 2015. “Problems of the Late Neolithic Absolute Chronology in Eastern Croatia”. Archäologie in Eurasien 31, 143–156.

Burić, M. and T. Težak-Gregl. 2010. “Das Grab 3 in Vinkovci – Ein Beitrag zur relativen Chronologie der Starčevo und Vinča-Kultur”. In Panta Rhei. Studies in chronology and cultural development of South-Eastern and Central Europe in earlier prehistory presented to Juraj Pavúk on the occasion of his 75. Birthday, eds. J. Šuleková, P. Pavúk, P. Kalábková and B. Kovár, 59–65. Bratislava: Comenius University.

Čataj, L. 2018. “Lasinjska kultura”. In Povratak u prošlost. Bakreno doba u sjevernoj Hrvatskoj, eds. J. Balen, I. Miloglav and D. Rajković, 25–47. Zagreb: Archaeological Museum in Zagreb, Faculty of Humanities and Social Sciences of the University of Zagreb, Archaeological Museum Osijek. https://doi.org/10.17234/9789531758185-03

Diaconescu, D., Niţu, F. M. and C. I. Suciu. 2020. “The early Vinča culture in Transylvania: Considerations regarding its chronological position using correspondence analysis”. Quaternary International 560–561, 65–77. https://doi.org/10.1016/j.quaint.2020.05.019

Dimitrijević, S. 1968. “Sopotsko-lenđelska kultura”. Monographiae Archaeologicae 1. Zagreb: Arheološki institut Filozofskog fakulteta.

Dimitrijević, S. 1971. “Das Neolithikum in Syrmien, Slawonien und Nordwestkroatien – Einführung in den Stand der Forschung”. Archaeologia Iugoslavica X (1969), 39–76.

Dimitrijević, S. 1978. “Neolit u sjeverozapadnoj Hrvatskoj (pregled stanja istraživanja do 1975. godine)”. In Arheološka istraživanja u sjeverozapadnoj Hrvatskoj, Znanstveni skup Varaždin 22–25. X 1975, ed. Ž. Rapanić, 71–128. Zagreb: Hrvatsko arheološko društvo.

Dimitrijević, S. 1979. “Sjeverna zona”. In Praistorija jugoslavenskih zemalja. II: Neolitsko doba, ed. A. Benac, 229–360. Sarajevo: Centar za balkanološka ispitivanja Akademije nauka i umjetnosti Bosne i Hercegovine.

Horváth, F. 2006. “Comments on the connections between the Vinča complex and the Carpathian Basin”. In Homage to Milutin Garašanin, eds. N. Tasić and C. Grozdanov, 309–324. Belgrade: Serbian Academy of Sciences and Arts, Macedonian Academy of Sciences and Arts.

Ivanković, A. 2013. “Lokalitet: Kukunjevac – Brod (AN 25)”. Hrvatski arheološki godišnjak 9 (2012), 171–174.

Ivanković, A. 2014. “Kukunjevac – Brod”. In Darovi zemlje. Neolitik između Save, Drave i Dunava II. Kataloške jedinice, eds. J. Balen, T. Hršak and R. Šošić Klindžić, 57–58. Osijek: Arheološki muzej u Zagrebu, Filozofski fakultet Sveučilišta u Zagrebu, Muzej Slavonije Osijek.

Jakucs, J. and V. Voicsek. 2016. “The northernmost distribution of the early Vinča culture in the Danube valley: A preliminary study from Szederkény-Kukorica-dülö (Baranya County, southern Hungary)”. Antaeus 33 (2015), 13–54.

Jakucs, J. and V. Voicsek. 2017. “A Kr. e. 6. évezred második felének új kutatási eredményei Baranya megyében”. A Janus Pannonius Múzeum Évkönyve 54, 133–177.

Jakucs, J., E. Banffy, K. Oross, V. Voicsek, C. Bronk Ramsey, E. Dunbar, B. Kromer, A. Bayliss, D. Hofmann, P. Marshall and A. Whittle. 2016. “Between the Vinča and *linearbandkeramik* worlds: the diversity of practices and identities in the 54th–53rd centuries cal BC in southwest Hungary and beyond”. Journal of World Prehistory 29, 267–336. https://doi.org/10.1007/s10963-016-9096-x.

Jakucs, J., K. Oross, E. Banffy, V. Voicsek, E. Dunbar, P. Reimer, A. Bayliss, P. Marshall and A. Whittle. 2018. “Rows with the neighbours: the short lives of longhouses at the Neolithic site of Versend-Gilencsa”. Antiquity 92(361), 91–117. https://doi.org/10.15184/aqy.2017.218

Krznarić Škrivanko, M. 2011. “Radiokarbonski datumi uzoraka sa Sopota”. In Panonski prapovijesni osviti. Zbornik radova posvećen Korneliji Minichreiter uz 65. obljetnicu života, ed. M. Dizdar, 209–225. Zagreb: Institute of Archaeology.

Krznarić Škrivanko, M. 2015. “Rezultati Dimitrijevićevih istraživanja Sopota u svjetlu novih istraživanja”. Opvscula archaeologica 37–38 (2013–2014), 371–395.

Krznarić Škrivanko, M. 2020. “Vinkovci – Zablaće: novootkriveni lokalitet sopotske kulture na vinkovačkom području”. In Homo universalis, zbornik radova posvećen Zorku Markoviću povodom 65. obljetnice života, eds. M. Dizdar, K. Botić and H. Kalafatić, 127–139. Zagreb: Institut za arheologiju.

Marić, M., M. Radivojević, B. W. Roberts and D. C. Orton. 2021. “Relative and absolute chronology of Belovode and Pločnik”, In The Rise of Metallurgy in Eurasia. Evolution, Organisation and Consumption of Early Metal in the Balkans, eds. M. Radivojević, B.W. Roberts, M. Marić, J. Kuzmanović Cvetković and T. Rehren, 439–454. Oxford: Archaeopress Publishing Ltd.

Marijan, B. 2001. "Zaštitna istraživanja arheoloških lokaliteta uz južni trak autoceste Zagreb-Lipovac, dionica V. Kopanica-Županja, poddionica Babina Greda-Županja". Obavijesti Hrvatskog arheološkog društva XXXIII(2): 35–45.

Marijan, B. 2006. "Neolitičko naselje Dubovo-Košno kod Županje". In Od Sopota do Lengyela. Prispevki o kamenodobnih in bakrenodobnih kulturah med Savo i Donavo, ed. A. Tomaž, 43–51. Koper: Založba Annales.

Marijan, B. 2007. "Naseobinski elementi na neolitičkome lokalitetu Dubovo-Košno kod Županje". Archaeologia Adriatica I, 55–84.

Marković, Z. 1984. "Neka pitanja neolitika, eneolitika i brončanog doba našičkog kraja". In Arheološka istraživanja u istočnoj Slavoniji i Baranji, Znanstveni skup Vukovar 6 – 9. X. 1981, ed. N. Majnarić-Pandžić, 13–29. Zagreb: Hrvatsko arheološko društvo.

Marković, Z. 1985. "Ražište-tip sopotske kulture". Arheološki vestnik 36, 39–76.

Marković, Z. 1994. "Sjeverna Hrvatska od neolita do brončanog doba. Problem kontinuiteta stanovništva i kultura sjeverne Hrvatske od ranog neolita do početka brončanog doba". Koprivnica: Muzej grada Koprivnice.

Marković, Z. 2012. "Novija razmatranja o nekim aspektima sopotske kulture u sjevernoj Hrvatskoj". Prilozi Instituta za arheologiju u Zagrebu 29, 57–69.

Marković, Z. and K. Botić. 2008. "O neolitičkoj keramici iz Novih Perkovaca kod Đakova". Prilozi Instituta za arheologiju u Zagrebu 25, 15–32.

Marković, Z. and K. Botić. 2014. "Podgorač, Ražište – rezultati arheoloških istraživanja 2013. godine". Annales Instituti Archaeologici X, 63–68.

Marković, Z. and K. Botić. 2016. "Podgorač, Ražište – rezultati arheoloških istraživanja 2015. godine". Annales Instituti Archaeologici XII, 63–70.

Mihaljević, M. 2006. "Istraživanje nalazišta Slavča-Nova Gradiška". In Od Sopota do Lengyela. Prispevki o kamenodobnih in bakrenodobnih kulturah med Savo i Donavo, ed. A. Tomaž, 29–34. Koper: Založba Annales.

Mihaljević, M. 2010. "Lokalitet: Vidovci – Glogovi". Hrvatski arheološki godišnjak 6(2009), 115–116.

Mihaljević, M. 2013. "Sopotska kultura u zapadnoj Slavoniji s posebnim osvrtom na nalazište Slavča-Nova Gradiška". Unpublished PhD dissertation. Zagreb: University of Zagreb.

Miklik-Lozuk, L. 2014. "Kruševica-Njivice". In Darovi zemlje. Neolitik između Save, Drave i Dunava II. Kataloške jedinice, eds. J. Balen, T. Hršak and R. Šošić Klindžić, 55–56. Zagreb: Arheološki muzej u Zagrebu, Filozofski fakultet Sveučilišta u Zagrebu, Muzej Slavonije Osijek.

Milojčić, V. 1943. "Das altere Neolithikum in Serbien". Unpublished PhD dissertation. Vienna: Vienna University.

Milojčić, V. 1949. "Chronologie der Jüngerensteinzeit Mittel-und Südosteuropas". Berlin: Verlag Gebr. Mann GmbH.

Nodilo, H. 2013. "Lokalitet: Kukunjevac – Donja Kućišta (AN 21)". Hrvatski arheološki godišnjak 9 (2012), 175–177.

Nodilo, H. 2014. "Kutina – Dobrovac – Kućište". In Darovi zemlje. Neolitik između Save, Drave i Dunava II. Kataloške jedinice, eds. Balen, T. Hršak and R. Šošić Klindžić, 59–61. Zagreb: Arheološki muzej u Zagrebu, Filozofski fakultet Sveučilišta u Zagrebu, Muzej Slavonije Osijek.

Obelić, B., I. Krajcar Bronić and N. Horvatinčić. 2002. "Rudjer Bošković Institute radiocarbon measurements XV". Radiocarbon 44(2), 601–630.

Obelić, B., M. Krznarić Škrivanko, B. Marijan and I. Krajcar Bronić. 2004. "Radiocarbon dating of Sopot culture sites (Late Neolithic) in Eastern Croatia". Radiocarbon 46(1): 245–258. https://doi.org/10.1017/S0033822200039564

Obelić, B., I. Krajcar Bronić, N. Horvatinčić, J. Barešić and A. Rajtarić. 2011. "Rudjer Bošković Institute radiocarbon measurements XVI". Radiocarbon 53(2), 395–417. https://doi.org/10.1017/S0033822200056642

Rajković, D. 2018. "Eneolitička faza sopotske kulture – kraj neolitika i početak eneolitika na području sjeveroistočne Hrvatske". In Povratak u prošlost. Bakreno doba u sjevernoj Hrvatskoj, eds. J. Balen, I. Miloglav and D. Rajković, 19–23. Zagreb: Archaeological Museum in Zagreb, Faculty of Humanities and Social Sciences of the University of Zagreb, Archaeological Museum Osijek. https://doi.org/10.17234/9789531758185-02

Regenye, J. 2002. "Chronological situation of the Sopot culture in Hungary". A Veszprém Megyei Múzeumok Közleményei 22, 31–42.

Spataro, M., T. Težak-Gregl and M. Burić. 2021. "The chaîne opératoire of Korenovo pottery: hybrid ceramics? Analysis of mixed Starčevo and Korenovo ceramic assemblages from Kapelica-Solarevac and Kaniška Iva (Central Croatia)". Praistorische Zeitschrift 96(2), 382–400. https://doi.org/10.1515/pz-2021-0013

Sraka, M. 2012. "14C calendar chronologies and cultural sequences in 5th millennium BC in Slovenia and neighbouring regions". Documenta Praehistorica 39, 385–412. https://doi.org/10.4312/dp.39.26

Šimić, J. 2000. "Istraživanje neolitičkog lokaliteta Hermanov Vinograd u Osijeku". Histria Antiqua 6, 223–230.

Šimić, J. 2004. "Istraživanje u Čepinu-Ovčara/Tursko groblje u godini 2002. i 2003". Obavijesti Hrvatskog arheološkog društva XXXVI(2), 55–61.

Šimić, J. 2012. "Šetnje slavonskom i baranjskom prapoviješću". Osijek: Filozofski fakultet Sveučilišta Josipa Jurja Strossmayera.

Šošić Klindžić, R., H. Kalafatić, B. Šiljeg, B. and T. Hršak. 2019. "Circles and ceramics through the centuries: Characteristics of Neolithic Sopot culture settlements". Prilozi Instituta za arheologiju u Zagrebu 36, 40–84.

Tasić, N. N., M. Marić, C. Bronk Ramsey, B. Kromer, A. Barclay, A. Bayliss, N. Beavan, B. Gaydarska and A. Whittle. 2016a. "Vinča-Belo Brdo, Serbia: The times of a tell". Germania 93(2015), 1–75.

Tasić, N. N., M. Marić, D. Filipović, K. Penezić, E. Dunbar, P. Reimer, A. Barclay, A. Bayliss, B. Gaydarska and A. Whittle. 2016b. "Interwoven Strands for Refining the Chronology of the Neolithic Tell of Vinča-Belo Brdo, Serbia". Radiocarbon 58(4), 795–831. https://doi.org/10.1017/RDC.2016.56

Težak-Gregl, T. 1993. "Kultura linearnotrakaste keramike u središnjoj Hrvatskoj", Dissertationes et Monographiae 2. Zagreb: Filozofski fakultet.

Whittle, A., A. Bayliss, A. Barclay, B. Gaydarska, E. Banffy, D. Borić, F. Draşovean, J. Jakucs, M. Marić, D. Orton, I. Pantović, W. Schier, N. Tasić and M. Vander Linden. 2016. "A Vinča potscape: formal chronological models for the use and development of Vinča ceramics in south-east Europe". Documenta Praehistorica 43, 1–60. https://doi.org/10.4312/dp.43.1

Zápotocká, M. 2007. "Die Entstehung und Ausbreitung der Kultur mit Stichbandkeramik in Mitteleuropa". In The Lengyel, Polgár and related cultures in the Middle/Late Neolithic in Central Europe, eds. J.K. Kozłowski and P. Raczky, 199–215. Krákow: The Polish Academy of Arts and Sciences Krákow, Eötvös Loránd University Institute of Archaeological Sciences Budapest.

Internet source

Maps for free – Hans Braxmeier, Donaustrasse 13, 89231 Neu-Ulm, mail@braxmeier.de, https://maps-for-free.com/

8.

Pioneers, carpenters, outsiders: radiocarbon dating of early farmers in western Hungary

Krisztián Oross, János Jakucs, Tibor Marton, Erika Gál, Alasdair Whittle

Abstract Archaeological research on Neolithic southern Transdanubia between Lake Balaton and the Drava River has received particular attention over the last 20 years. Besides large-scale excavations of early farming settlements, micro-regional surveys and various bioarchaeological investigations, one of the most significant research objectives has been establishing an absolute chronological framework for the region. Hundreds of AMS radiocarbon measurements have been made during several research projects. *The Times of Their Lives* ERC Advanced Investigator Grant explored radiocarbon chronology as its primary task. A series of research projects funded by the National Research, Development and Innovation Office of Hungary and other institutions have enriched databases with essential data. This paper focuses on the 6th millennium cal BC, particularly on the second half of that period, and thus the consolidation of the Neolithic in the region.

The swift spread of the Neolithic across the Balkan Peninsula reached the southernmost parts of the Carpathian basin during the last centuries of the 7th millennium cal BC. The process did not become frozen entirely afterwards, and a gradual northward shift of the frontier zone could be recorded in eastern Hungary. In contrast, any regional-scale Transdanubian model can only be derived from the general dynamics of the Neolithic dispersal rather than from actual radiocarbon measurements.

Another pivotal point of the regional chronology is the formation of radically different types of settlements after the initial Neolithic and their possible contribution to the neolithisation of central Europe. Despite a series of successful dating programmes, the virtually unlimited variability of late 6th millennium cal BC material culture encourages further research on its spatial and temporal patterns. Radiocarbon dating programmes can also be powerful tools to fix the actual use-time of different pottery styles and manufacturing technologies. At the same time, they provide substantial information on the evolution and density of the regional settlement system.

The third focus of the paper discusses the end of the *Linearbandkeramik* world from a particular perspective. This includes the appearance of a distinct material culture (Sopot) originating in the south and its coexistence with the LBK on a regional level.

Keywords: western Hungary, Neolithic, absolute chronology, radiocarbon dates, 6th millennium cal BC, settlements, material culture

Introduction

Recognition of finds and sites belonging to two major entities in the cultural concept, namely those of the *Linearbandkeramik* culture (LBK) and the Lengyel culture, dates back to the late 19th century in the western areas of modern Hungary. In contrast, ceramic assemblages and sites of the southeast European pattern of the Early Neolithic (Starčevo) were not discovered earlier than the 1970s. Concurrently, the Hungarian distribution of the Sopot culture was also recognised along the Danube and in southwest Transdanubia (Kalicz and Makkay 1972, Kalicz 1980). Those discoveries already enabled the construction of a coherent regional-scale typo-chronological framework for the first millennium of food production (Kalicz 1990; 1991; 1995). The most recent crucial amendment of this system was implemented following the excavation of sites associated with early Vinča- and Ražište-style pottery assemblages in the southernmost part of the region (Jakucs and Voicsek 2015). Nevertheless, increasing datasets revealed the fundamental weaknesses of assigning entire sites and finds assemblages to pure, homogeneous pottery styles.

Parallel to the intensive field research activities of Nándor Kalicz and János Makkay, a new, powerful tool for establishing archaeological chronologies also became available in this region. Thus, radiocarbon dating of Neolithic western Hungary goes back more than a half-century, when the first measurements were carried out in collaboration with the Radiocarbon Dating Laboratory of the German Academy of Sciences in Berlin. A limited number of samples were submitted for dating from various sites, and the first dates were published in the format of uncalibrated dates, such as from Becsehely-Bükkaljai-dűlő and Zalavár (Kohl and Quitta 1963: 301; 1964: 316; Kalicz 1990). After that, the radiocarbon dating of investigated sites remained sporadic, indeed rather exceptional, for decades. Typically one to three measurements were carried out, such as from the Starčevo occupation of Vörs-Máriaasszony-sziget (Kalicz et al. 2002), the LBK occupations of Kustánszeg-Lisztessarok, Pári (Kalicz 1991; Kalicz et al. 2007) and Budapest-Aranyhegyi út (Kalicz 1995), and the Sopot occupations of Ajka and Nemesvámos-Baláca (Regenye 1996: 168).

An increase in new radiocarbon measurements, yielding overwhelmingly AMS dates, occurred at the turn of the millennium and in the following decade due to large-scale preventive excavations before construction works. Field research was mainly related to new motorways, property developments, or other infrastructural projects. Southwest Transdanubia provides an excellent example, as different Neolithic settlements were dated from Becsehely-Bükkaljai-dűlő, Becsehely-Homokos, Petrivente-Újkúti-dűlő, Sormás-Mántai-dűlő and Sormás-Török-földek (Barna 2004; 2012; 2017; Kalicz et al. 2007; 2012). At the same time, the Vienna Environmental Research Accelerator (VERA) carried out some further measurements on samples from research excavations as well; Szentgyörgyvölgy-Pityerdomb was dated with a series of ten measurements (Bánffy 2004: 299–309).

Another important source of radiocarbon dates became the first archaeogenetic research project investigating the region. Radiocarbon dates were primarily used to verify the age of the sampled human remains. Absolute chronological dating proved to be an essential element of the methodology since the sampled materials were heterogeneous. Human bones were collected from assemblages of much earlier excavations alongside skeletons uncovered during new field research programmes, including rescue excavations. Burials from the different periods of the Alsónyék complex, Budakeszi-Tangazdaság, Fajsz-Garadomb, Kóny-Proletár-dűlő II, Lánycsók-Csata-alja, Tolna-Mözs-Községi-Csádés-földek and Szemely-Irtás (referred to as Szemely-Hegyes in some earlier publications) were dated in the course of the ancient DNA projects (Szécsényi-Nagy et al. 2015; Lipson et al. 2017). In many cases, those dates served as the basis of subsequent targeted radiocarbon dating programmes.

The *Times of Their Lives* (ToTL) ERC-funded project marks a pivotal point in regional absolute chronological research. With series of dozens or even hundreds of measurements, it has opened a new horizon for Hungarian research. All dating programmes of the project were carefully planned from the sampling strategy through to the publication of the results. Probability density estimations for the beginning and the end of the use of settlements and burial grounds, as well as date parameters for various activities, were calculated in a Bayesian statistical framework (Bayliss et al. 2016). Based on the successful dating programmes and the experiences of the project, additional series of radiocarbon dates were obtained by further research projects funded by the National Research, Development and Innovation Office of Hungary and other institutions (Figure 1).

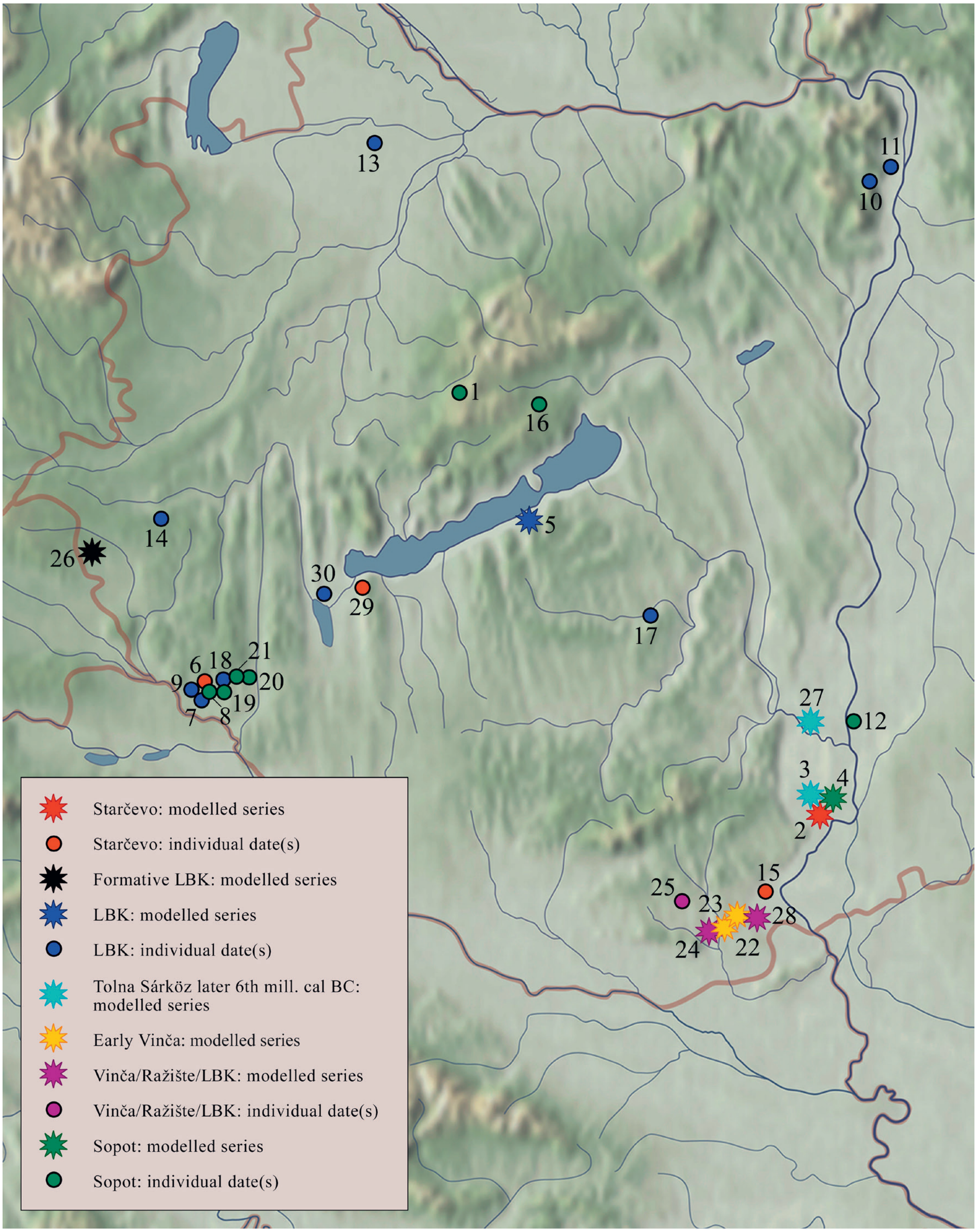

Figure 1. *Radiocarbon dated 6th and earliest 5th millennia cal BC Neolithic sites in western Hungary: 1) Ajka; 2) Alsónyék, Starčevo settlement; 3) Alsónyék, later 6th millennium cal BC settlement; 4) Alsónyék, Sopot burial ground; 5) Balatonszárszó-Kis-erdei-dűlő; 6) Becsehely-Bükkaljai-dűlő, Starčevo settlement; 7) Becsehely-Bükkaljai-dűlő, LBK settlement; 8) Becsehely-Bükkaljai-dűlő, Sopot settlement; 9) Becsehely-Homokos; 10) Budakeszi-Tangazdaság; 11) Budapest-Aranyhegyi út; 12) Fajsz-Garadomb; 13) Kóny-Proletár-dűlő II; 14) Kustánszeg-Lisztessarok; 15) Lánycsók-Csata-alja; 16) Nemesvámos-Baláca; 17) Pári-Altacker; 18) Petrivente-Újkúti-dűlő, LBK; 19) Petrivente-Újkúti-dűlő, Sopot; 20) Sormás-Mántai-dűlő; 21) Sormás-Török-földek; 22) Szederkény-Kukorica-dűlő, eastern unit; 23) Szederkény-Kukorica-dűlő, middle unit; 24) Szederkény-Kukorica-dűlő, western unit; 25) Szemely-Irtás; 26) Szentgyörgyvögy-Pityerdomb; 27) Tolna-Mözs-Községi-Csádés-földek; 28) Versend-Gilencsa; 29) Vörs-Máriaasszony-sziget; 30) Zalavár.*

This paper provides an overview of the current state of absolute chronological research on the neolithisation process and early farming communities in western Hungary, as well as accurate modelling of the consolidation of the food-producing economy in the region. Besides the summary of already published results, two case studies are also presented. The first one successfully demonstrates how a new series of dates can reinforce previous assumptions and contribute to the establishment of a regional-scale chronology. The intention of the second one is to discuss the opportunities afforded by re-modelling already existing datasets by adding new prior information and aspects not previously considered.

The earliest farmers of western Hungary

Based on the informal analysis of new radiocarbon series from various Serbian and Hungarian early Neolithic sites, a gradual shift of the frontier zone towards the north could be determined. The earliest dates went back to c. 6200 cal BC in the Šumadija region of central Serbia south of the Danube, with an early Neolithic occupation in certain parts of the Banat and the Bačka by 6000 cal BC, but many sites did not appear to start earlier than 5800 cal BC. All included Hungarian sites with radiocarbon-dated features lie on the Great Hungarian Plain, that is, in eastern Hungary (Whittle et al. 2002). Later on, again derived from individual radiocarbon dates, László Domboróczki argued for a four-step development for the Great Hungarian Plain during the early 6th millennium cal BC. In his framework, the Neolithic started around 6000 cal BC along the Maros River, while the first food-producing communities were not earlier in the northern Tisza region than the 57th century cal BC (Domboróczki 2010: 159, Figure 11). Small formal models on series dating single sites suggested a similar, slow advance with some pioneer settlements beyond the actual frontier line (Oross and Siklósi 2012).

In Transdanubia, the early Neolithic (Starčevo) occupation of Alsónyék remains the only settlement dated with a formally modelled series of radiocarbon dates (Oross et al. 2016a). Beyond Alsónyék, there is only one radiocarbon date available from the south, from Lánycsók-Csata-alja (Szécsényi-Nagy et al. 2015). From the northernmost areas in central Transdanubia, probably three measurements were carried out on samples from Becsehely-Bükkaljai-dűlő (Kalicz 1990; 2011), and one further radiocarbon date was published from Vörs-Máriaasszony-sziget (Kalicz et al. 2002). The “extreme north” of the Hungarian distribution, such as Gellénháza-Városrét (Simon 1996) and Tihany-Óvár on the northern shore of Lake Balaton (Regenye 2010), are not radiocarbon dated at all.

After the initial Neolithic

Previous radiocarbon chronologies for the early Neolithic of central Europe dated the beginning of the LBK around 5500 cal BC based on about a hundred individual radiocarbon dates from early LBK sites excavated on the territory of the then West Germany and Austria (Stäuble 1995; 2005). Other estimations had set the onset of the LBK between 5700 and 5600 cal BC, or even around 5700 cal BC (Lüning 1991; Gronenborn 1998; 1999). This approach was supported by the assumption that the emergence of the same pattern of material culture must be earlier in the area of origin, that is, in the western Carpathian basin and some adjacent regions. The hypothesis gained support from the earliest radiocarbon dates from the Brunn/Wolfholz 2 settlement in the Vienna basin, associated with a pottery assemblage resembling Starčevo characteristics (Stadler 2005; Stadler and Kotova 2010; 2019: 213–242). The Transdanubian evidence for the period following the southeast European pattern of the initial Neolithic is scarce. The joint formal modelling of Brunn/Wolfholz 2 and Szentgyörgyvölgy-Pityerdomb dated the phenomenon called formative LBK by Hungarian scholars between the 56th and 54th centuries cal BC (Jakucs et al. 2016); radiocarbon-dated assemblages from present-day Hungary are known exclusively from Szentgyörgyvölgy (KO comment ‘t’ missed from the submitted text, small typo)-Pityerdomb (Bánffy 2000; 2004: 299–309; Bánffy and Whittle 2022).

The mid-54th century cal BC and the later 6th millennium settlement of the region

Its final three and half centuries have become the most intensively investigated period of 6th millennium cal BC Transdanubia in the past three decades. The doctoral thesis of Roland Gläser provided a comprehensive survey and a summary of earlier research but already marked the onset of a paradigm shift. Gläser's work presented 637 LBK sites from western Hungary and a meticulous relative chronology based on pottery decoration. His dissertation also pointed out that data on some aspects of the entity, such as architecture, settlement layouts and burial places, well-known from different regions of central Europe, were little known, if at all, from western Hungary (Gläser 1993).

The following two decades definitely brought the golden age of LBK settlement archaeology in Hungary. Research activity started along the M1 motorway that connects Budapest with Vienna, followed by the M7 motorway on the southern shore of Lake Balaton and in southwest Transdanubia, and finally along the M6 motorway between Budapest and Pécs. The road footprints where preventive and salvage excavations were carried out before motorway construction function virtually as three giant sections crossing Transdanubia in different directions.

This type of excavation has proved to be particularly appropriate for the investigation of extended later 6th millennium cal BC settlements. Sites with dozens of timber-framed longhouses, such as Balatonszárszó-Kis-erdei-dűlő on the southern shore of Lake Balaton (Marton 2004; 2008; Oross 2004), Tolna-Mözs-Községi-Csádés-földek in the northernmost part of the Tolna Sárköz (Marton and Oross 2012), Alsónyék in the southern part of the same region (Osztás et al. 2012; Oross et al. 2016b), and Szederkény-Kukorica-dűlő and Versend-Gilencsa in the Southern Baranya Hills (Jakucs and Voicsek 2015; Jakucs et al. 2016; 2018), became the hallmarks of this new era. The uniform central European early Neolithic type architecture was accompanied by constantly altering combinations of material culture, identical with central European LBK pottery styles at Lake Balaton in the north, with growing Vinča influence towards the south and with a predominance of Vinča- and Ražište-style pottery south of the Mecsek Mountains (Jakucs 2020; Oross et al. 2020). The later 6th millennium cal BC settlements are the most accurately dated sites on a regional scale as all three settlement units from Szederkény-Kukorica-dűlő (Jakucs et al. 2016), the adjacent Versend-Gilencsa settlement (Jakucs et al. 2018) and the later 6th millennium cal BC occupation at Alsónyék (Oross et al. 2016b) have been dated and modelled in the ToTL project. The dating programme for the early LBK occupation of Balatonszárszó-Kis-erdei-dűlő has also recently been published (Oross et al. 2020). The only exception is Tolna-Mözs-Községi-Csádés-földek, which remains the single larger evaluated but virtually not radiocarbon-dated settlement so far.

Figure 2. *Aerial view of the Tolna-Mözs-Községi-Csádés-földek settlement from the north-east with the already existing M6 motorway and its typical Tolna Sárköz landscape environment during the small-scale excavation in 2016.*

The Tolna-Mözs-Községi-Csádés-földek site (Figure 2) was excavated in two seasons before the construction of the M6 motorway in 2008 and 2009. Field research was carried out by the Archeosztráda Ltd. and the Institute of Archaeology of the Hungarian Academy of Sciences; the directors of the excavation were Ferenc Redő and István Koós. Within the investigated area, a total of 47 house plans were uncovered; these were the remains of timber-framed longhouses, with so-called long pits flanking the houses both on their eastern and western sides, and proved to be constructions typical of the central European early Neolithic, also referred as the LBK house. Three different clusters of houses could be distinguished, 12 belonging to the southern one and 19 to the middle, while 16 other buildings formed the northern house cluster. They were separated from each other by zones lacking buildings. The distance between the southern and the middle cluster was 90 m, while a 70 m gap could be recognised between the middle and the northern cluster (Figure 3). LBK-style pottery and early Vinča-style characteristics were already recorded in the first assessment of the finds. The southern settlement cluster also revealed a more significant number of fragments resembling late Starčevo-style assemblages (Marton and Oross 2012).

The geomagnetic survey, carried out in collaboration with the Romano-Germanic Commission of the German Archaeological Institute, covered a large area of 79 ha around the excavated surfaces. The surveys were completed both on the western and the eastern side of the already existing motorway in 2011 and 2013. The first evaluation of the geomagnetic data proved the one-time existence of more than 170 Neolithic buildings, including the houses uncovered earlier. The buildings were arranged into 11 house clusters, three of them already recognised in the course of the excavations. The 11 house clusters could be assigned to three different larger settlement parts (Rassmann et al. 2015b). A later comprehensive assessment of the geomagnetic evidence and the excavation record could determine the existence of 186 houses in seven house clusters that formed the three larger settlement parts (Rassmann et al. 2020).

In the framework of the programme *Neolithic communities in the contact zone between the Balkans and central Europe*, further research was carried out in the so-called Tolna Sárköz/Sárvíz Valley micro-region over an area of 3393 ha. This area covers precisely the northern fringes of the Tolna Sárköz, whose largest later 6th millennium cal BC settlement is Tolna-Mözs-Községi-Csádés-földek. The eastern part of the micro-region is located along the Tolna Danube. The largest oxbow of the river on its Hungarian course was separated from the present riverbed by regulation in the 19th century. The western part of the micro-region is located along the Sió/Sárvíz water system and the Völgység stream to the southwest. This territory connects the densely populated Tolna Sárköz region with the internal parts of Transdanubia (Oross et al. 2020).

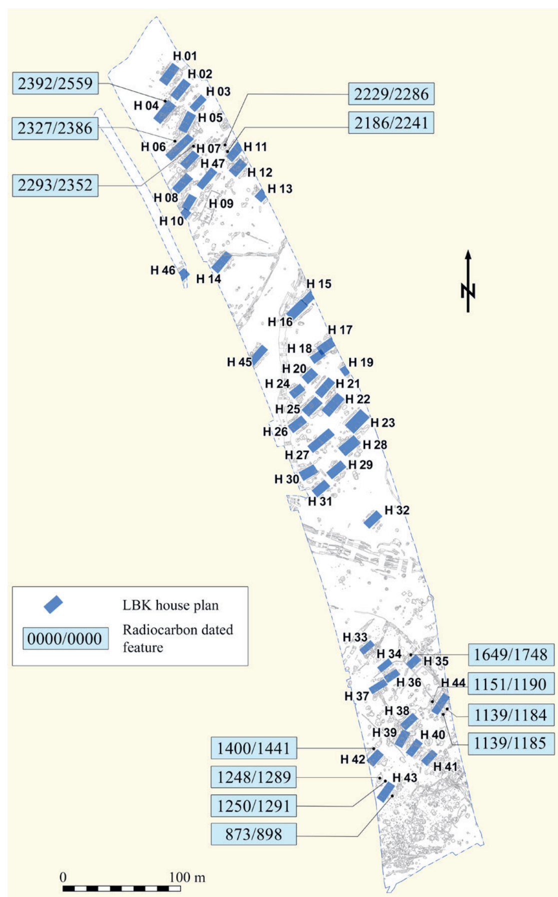

Figure 3. *Overall plan of the excavated part of the later 6th millennium cal BC settlement at Tolna-Mözs-Községi-Csádés-földek with radiocarbon samples and dated features.*

Figure 4. *Pottery from House 44 in the southern excavated house cluster of the later 6th millennium cal BC settlement at Tolna-Mözs-Községi-Csádés-földek: 1–4, 7, 9–10: Feature 1151/1190; 5–6, 8: Feature 1139/1184.*

The NRDIO-funded project *Transforming traditions of material culture. Spatial and temporal patterns in pottery style, production and use during the second half of the 6th millennium cal BC in SE Transdanubia and beyond* was launched in December 2019 focusing on pottery production in the region (Marton et al. 2020). One particular task of the programme is the investigation of the ceramic assemblage from the Tolna-Mözs-Községi-Csádés-földek site. A significant part of the finds consisting of 38,000 objects recovered from the site belongs to the Neolithic. Most of the ceramic material originates from the long pits flanking timber-framed houses and from further pits also closely related to the house units (Figure 4). This statement is valid for all other finds groups in the archaeological record as well.

Regarding stylistic aspects of the pottery, they share certain characteristics of previously defined and canonised style groups of the region (Marton and Oross 2012). Globular-shaped, *Schlickwurf*-decorated storage vessels and large bowls, as well as certain versions of fine-ware biconical bowls are closely related to the late Starčevo ceramic style. Nevertheless, characteristic ornamental painting of late Starčevo sites in south-east Transdanubia (Kalicz 1990; Oross et al. 2016a: 97) is completely absent from Tolna-Mözs-Községi-Csádés-földek. Biconical vessels with a thickening profile at their carination and often with fine vertical or oblique channels on their upper part represent common shapes and ornamental characteristics of early Vinča-style pottery (Lazarovici 1981; Schier 1996; Jakucs 2020). It is worth noting, however, that the black-topped and red-slipped firing and surface treatment technology of the early Vinča ceramic style, that is also frequent in contemporaneous sites in the southernmost part of Transdanubia (Jakucs and Voicsek 2015: 29, Figure 8), is unknown from this assemblage. Fragments and pots decorated with incised lines can be matched with objects from LBK assemblages, primarily with that of early LBK- and evolving later LBK-style ceramics. All these distinct material culture units, which are chronologically and spatially separated in traditional chronological frameworks based on ceramic typology, were recorded side by side, often from the same features, at Tolna-Mözs-Községi-Csádés-földek. Clay figurines and altars show similar patterns, even in statistical assessments.

The ceramic finds of distinct house units in the excavated area show significant variability (Marton and Oross 2012: 232), primarily in the ornaments of the LBK-style pottery. Finds assemblages associated with the house units of the southern excavated house cluster contain early LBK-style sherds. In contrast, pottery from most of the house units in the northern excavated cluster is dominated by sherds belonging to later LBK ceramic styles, among them *Notenkopf*-decorated sherds (Marton and Oross 2012: 232). Some ornaments of the Malo Korenovo-style have also been recognised from the latter area.

From a ceramic technology point of view, the assemblage is uniform over the entire investigated area, but reveals a great variability concerning raw materials. According to macroscopic analyses, chaff tempering was the most frequent one both among fine and coarse ware fragments (Figure 4: 1, 7–8). Coarse ware pottery was often tempered by chaff and gravel, and further by river sediments and calcareous elements (Figure 4: 9). Fine ware vessels were frequently produced from a fine-grained raw material without tempering (Figure 4: 3–5). The surface of the sherds is widely eroded, but the original polished surface can also be observed in patches on some fine ware fragments.

The ceramic assemblage of 1800 sherds, recovered from the long pits of House 44 in the southern house cluster, which is also involved in the current radiocarbon dating programme of the site, provides an excellent example for the stylistic variability discussed above.

Among the vessel shapes associated with coarse ware pottery, globular forms, slight S-profiled vessels, as well as barrel-shaped variants are among the most common ones, typically with vertical and curved *Schlickwurf* decoration on their outer surfaces (Figure 4: 7). Incised decorations and finger incisions on the rim, and furthermore under the rim, are also frequent (Figure 4: 9). Short incisions are typical elements of coarse ware pottery decoration patterns (Figure 4: 8).

Biconical bowls with a wide, open shape and a short upper body (Figure 4: 3) as well as more closed deep bowls with a thickening profile at their carination and with vertical fine chanelling (Figure 4: 5) are unambiguously common in the early Vinča ceramic style. Fragments decorated with incised bands with further dashed incisions on the bands belong to the same category (Figure 4: 10).

The globular storage vessel, probably with a cylindrical neck, decorated with incised spiraloid and meandric bands and with two pairs of vertically perforated handles (Figure 4: 1), represent a widespread early LBK vessel type. The small vessel with funnel-shaped neck uncovered from the long pit of House 44, which is decorated with incised bands of wavy lines and reverse W-shaped supplementary motifs (Figure 4: 2), also shares the characteristics of LBK pottery style, both in terms of its ornamental elements and the position of the elements within the composition.

Parallels for the assemblage from House 44 and the entire southern house cluster are known from different house units of the nearby site at Tolna-Mözs-Szarvas-dűlő, located about 2 km to the south (Oross et al. 2020: 159, Figure 4). Similar observations have been made on the ceramic assemblage of the later 6th millennium cal BC occupation at Alsónyék (Oross et al. 2016b: 126–129). Among the contemporaneous settlements south of the Mecsek Mountains, comparable patterns are recorded from Versend-Gilencsa (Jakucs et al. 2018). Tolna-Mözs-Községi-Csádés-földek was labelled as an LBK settlement in earlier publications along with the later 6th millennium cal BC occupation of the Alsónyék complex. Nevertheless, coeval sites of the Tolna Sárköz region bear a unique combination of material culture which can hardly be identified as LBK in its central European guise. In contrast to the sites of the Southern Baranya Hills micro-region, they are also distinct from typical early Vinča and Ražište assemblages.

Among a wide range of recent investigations on pottery production, fabrics and technologies as well as raw materials, a radiocarbon dating programme also became possible. The primary aim was to determine the date of the establishment of the later 6th millennium cal BC settlement, and further to obtain some dates for the beginnings of the use of later LBK-style pottery. These goals coincide with the ambition to establish a reliable chronology for the excavated part of the Neolithic site.

Grave 1649/1748, a SE–NW oriented, left-crouched body deposited into the western long pit of House 35, was dated prior to this programme in the course of an archaeogenetic project; a clavicle was dated in the CEZA-Laboratory in Mannheim (MAMS-14145). Grave 2392/2559, a SE–NW oriented, left-crouched body deposited into the western long pit of House 04, was dated in the same bioarchaeological project; a tibia was dated in the CEZA-Laboratory in Mannheim (MAMS-14144). Recent sampling concentrated on the southern excavated settlement cluster that yielded the most archaic pottery assemblage in terms of a traditional typo-chronology and on the northern excavated settlement cluster where probably the use of later LBK pottery styles started. Feature 873 (SNR 898), the eastern long pit of House 43 in the southern excavated house cluster, was dated (SUERC-100839) by a sample from an *Ovis aries/Capra hircus* femur with a refitting unfused epiphysis. Feature 1139 (SNR 1184), the eastern long pit of House 44 in the southern excavated house cluster, was dated (Poz-149786) by a sample from a *Sus scrofa/S. domesticus.* radius articulating with its ulna. Another sample from the same eastern long pit of House 44, that means from the same Feature 1139 but from a different context (SNR 1185), was dated (Poz-149785) by a sample from *Bos taurus* articulating thoracic vertebrae. Feature 1151 (SNR 1190), the western long pit of House 44, was dated (SUERC-100840) by a sample from a *Bos taurus* humerus with a refitting unfused epiphysis. Feature 1248 (SNR 1289), a settlement pit, probably the largest preserved part of the one-time western long pit of House 43, was dated (SUERC-100838) by a sample from a *Bos taurus* humerus with a refitting unfused epiphysis. Feature 1250 (SNR 1291), an individual pit, probably part of the one-time western long pit of House 43, was dated (Poz-149784) by a sample from a *Bos taurus* metacarpus articulating with a phalanx. Feature 1400 (SNR 1441), the western long pit of House 42 in the southern excavated house cluster, was dated (SUERC-100835) by a sample from a *Bos taurus* vertebra cervicalis articulating with another vertebra. The same feature and context (1400/1411), from the western long pit of House 42, were dated (Poz-149756) by a sample from an *Ovis aries/Capra hircus* radius articulating with its ulna. Feature 2186 (SNR 2241), the western long pit of House 11 in the northern excavated house cluster, was dated (Poz-149757) by a sample from a *Bos taurus* metacarpus articulating with carpalae. Feature 2229 (SNR 2286), an individual oval settlement pit north-west of House 11, was dated (SUERC-100836) by a sample from a *Bos taurus* humerus with a refitting unfused epiphysis. Feature 2293 (SNR 2352), an individual oval pit in superposition with both the western long pit of House 07 and the eastern long pit of House 06, was dated (SUERC-100837) by a sample from an *Equus caballus* calcaneus refitting with its astragalus. The measurement yielded a mid-7th millennium cal BC date, clearly before the onset of the Neolithic in Transdanubia. Thus, the date was not incorporated into the model. Feature 2327 (SNR 2386), the western long pit of House 06, was dated (Poz-149758) by a sample from a *Bos taurus* radius articulating with its ulna.

The chronological model for the later 6th millennium cal BC settlement at Tolna-Mözs-Községi-Csádés-földek was completed using the program OxCal v4.4.4 (Bronk Ramsey 2009; Reimer et al. 2020). The Neolithic site is dated by 13 results (11 from faunal, and two from human bone samples). As the series consist of a limited number of dates, it was programmed as a single phase model to achieve its objectives.

The model (Figure 5) has a good agreement between the radiocarbon dates and the archaeological prior information (Amodel = 103). The model estimates that the dated activity at Tolna-Mözs-Községi-Csádés-földek began in *5405–5230 cal BC (95% probability; Figure 6; start: Tolna-Mözs-KCSF)*, probably in *5380–5240 cal BC (68% probability)*. The dated occupation lasted for *25–350 years (95% probability; Figure 7; span: Tolna-Mözs-KCSF)*, probably for *45–275 years (68% probability)*. The activity ended in *5210–5025 cal BC (95% probability; Figure 6; end: Tolna-Mözs-KCSF)*, probably in *5205–5115 cal BC (68% probability)*.

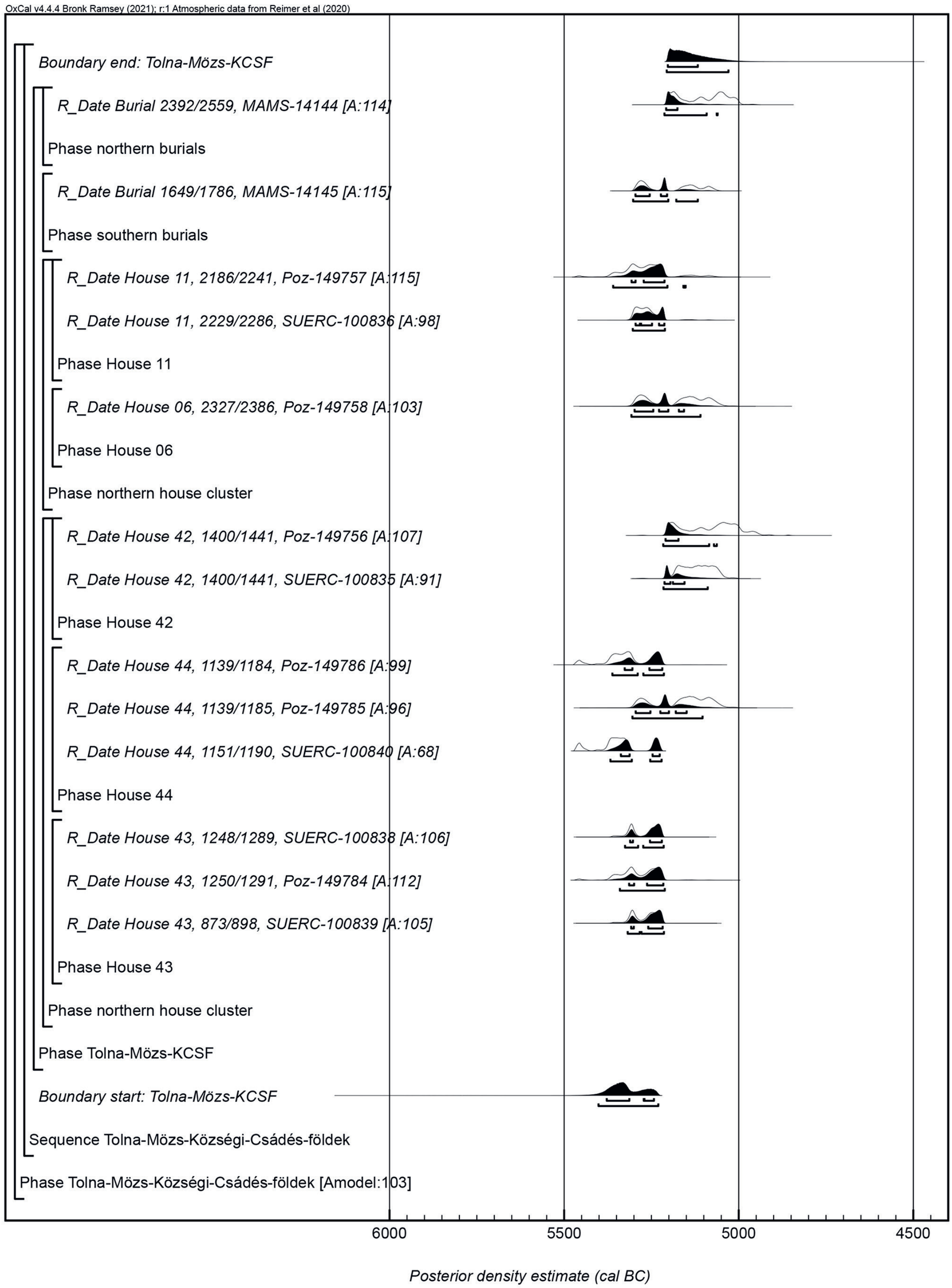

Figure 5. *Probability distributions of radiocarbon dates from the Tolna-Mözs-Községi-Csádés-földek settlement. Each distribution represents the relative probability that an event occurs at a particular time. For each of the dates two distributions have been plotted: one in outline, which is the result of simple radiocarbon calibration, and a solid one, based on the chronological model used. The large square brackets down the left-hand side, along with the OxCal keywords, define the overall model exactly.*

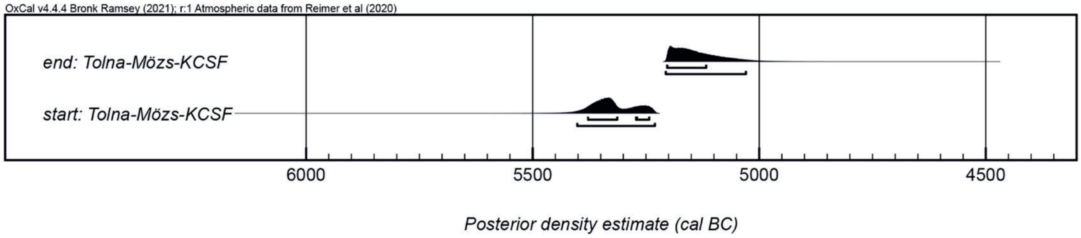

Figure 6. *Key parameters for the start and end of the settlement and burial activity at Tolna-Mözs-Községi-Csádés-földek, derived from the model defined in Figure 5.*

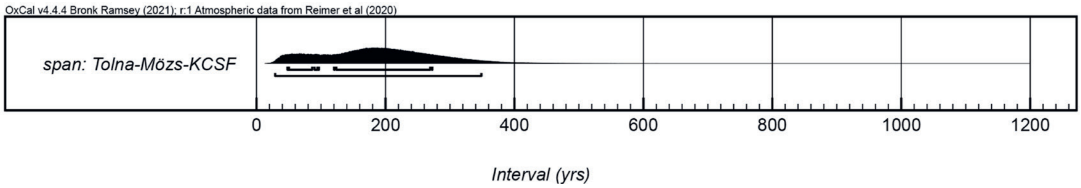

Figure 7. *Probability distributions for the number of years during which the settlement at Tolna-Mözs-Községi-Csádés-földek was used, derived from the model defined in Figure 5.*

The results provide generally wider intervals for the beginning and the end of the dated activities than models based on larger series from later 6th millennium cal BC sites from the region. Nevertheless, the development of the Tolna-Mözs-Községi-Csádés-földek settlement can definitely be compared with those settlements which were established by the mid-54th century cal BC, such as with all three units of Szederkény-Kukorica-dűlő (Jakucs et al. 2016), with the relevant, later 6th millennium cal BC occupation at Alsónyék (Oross et al. 2016b) and with the early LBK settlement part at Balatonszárszó-Kis-erdei-dűlő (Oross et al. 2020).

Re-assessment of the chronology of the Sopot burial ground at Alsónyék

One separate settlement and a burial ground of the Alsónyék complex (Figure 8) in the southernmost part of the Tolna Sárköz region are located about 1.5 km to the east from the core occupation area. The subsequent occupations of the latter can be characterised by Starčevo-style ceramics, the regional variant of later 6th millennium cal BC pottery (i.e. an admixture of LBK- and Vinča-style characteristics) and Lengyel-style material, respectively (Osztás et al. 2012; 2016; Bánffy et al. 2016). In contrast, the spatially separated settlement can be linked to a distinct group of sites along the Danube with Sopot-style material culture. The most spectacular feaures of the excavated area were four ditches, which run roughly parallel across the investigated surface. Besides these short sections of four ditches, ten large, complex pits and a well also relate to a contemporaneous settlement. The burial ground discovered at the same place comprises 18 graves with 20 individuals. The graves covered one of the four diches or were located between them (Oross et al. 2016c).

Geomagnetic surveys cover an area of approximately 30 ha north around the excavated area. The Sopot occupation was also referred to as Alsónyék, Hosszú dűlő, area 7 in some of the studies discussing the geomagnetic survey. The detected geomagnetic anomalies indicate a wide range of archaeological features. Some of them reflect activities different to the Sopot occupation. The existence of two double diches was revealed, marked with the numbers 3, 4, 5 and 6 in the second assessment of the geomagnetic record. Ditches 3 and 4 are equivalent to Ditches 189 and 195 of the excavated area. These two features encircle an area of 4.8 ha. Although their possible northern section could not be identified by the geomagnetic survey, they possibly run north of the investigated area. Several house remains could also be detected; at least four of them in the centre of the territory surrounded by Ditches 189 and 195 may belong to the Sopot settlement. Based on weak geomagnetic contrasts we can also assume a large number of further grave pits of the Sopot burial ground, but their reliable dating based solely on the magnetic data is impossible (Rassmann et al. 2015a: 7–8; 2020: 59–63).

The first study on the absolute chronology of the Sopot burial ground was published as part of the Alsónyék site biography in the ToTL project. In the original absolute chronological model, 12 human bone samples from 11 individuals were dated with 14 results. Three further results from three animal bone samples dated two different features (Oross et al. 2016c).

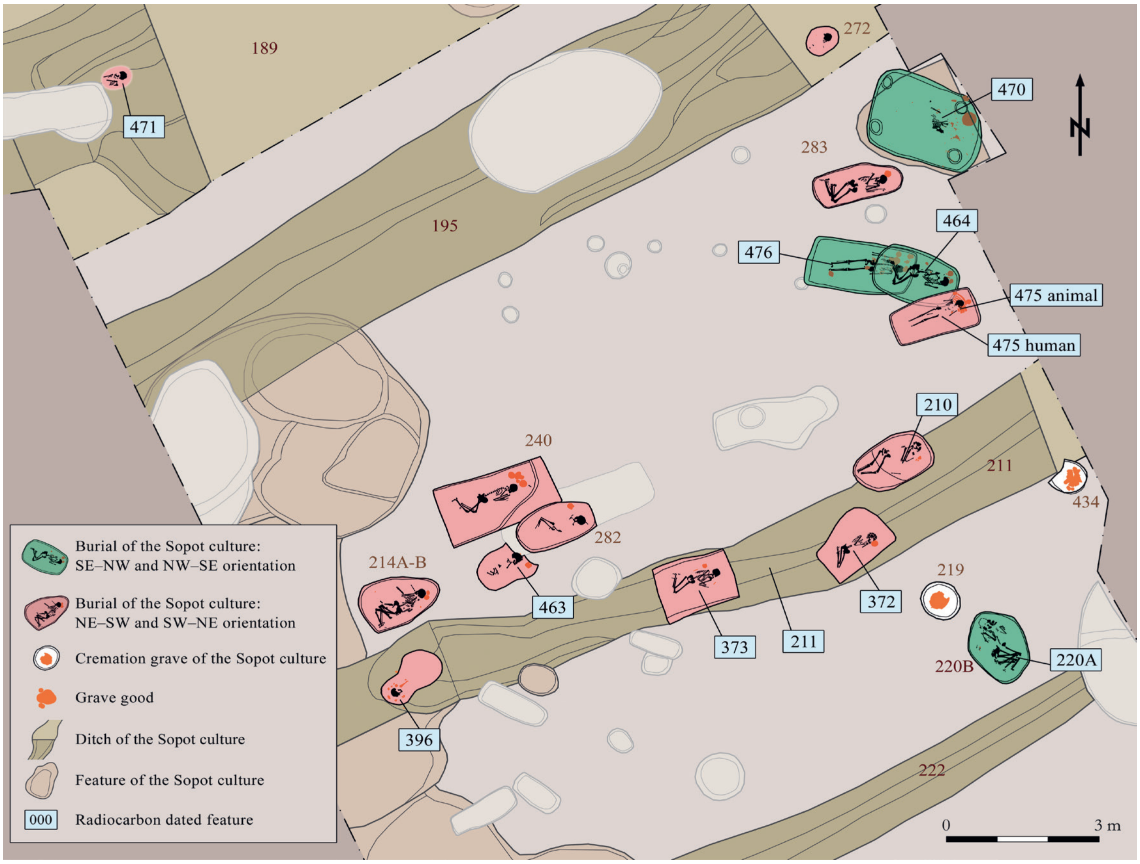

Figure 8. *Overall plan of the Sopot burial ground at Alsónyék with radiocarbon samples and dated features. The two differently oriented groups of burials are marked with distinct colours (modified after Oross et al. 2016c).*

The original model estimates that the dated Sopot burial activity at Alsónyék began in *5200–5005 cal BC (95% probability; Oross et al. 2016c: Figure 8; start: Alsónyék Sopot burials)*, probably in *5095–5020 cal BC (68% probability)*. The burials lasted for *180–470 years (95% probability; Oross et al. 2016c: Figure 7; span: Alsónyék Sopot burials)*, probably for *220–340 years (68% probability)*. The burial activity ended in *4850–4680 cal BC (95% probability; Oross et al. 2016c: Figure 8; end: Alsónyék Sopot burials)*, probably in *4825–4750 cal BC (68% probability)*.

Two main orientation groups can be distinguished among the graves of the burial ground. Four burials, all of them radiocarbon dated, Grave 470, Grave 476, Grave 464 which covered Grave 476 and Grave 220A were southeast–northwest or northwest–southeast oriented. Three of the graves were located between Ditch 211 and Ditch 195, while Grave 220A was uncovered between Ditch 211 and Ditch 222. None of them covered any of the ditches. All other graves were northeast–southwest or southwest–northeast oriented. Some burials were uncovered between the ditches, but a series of graves covered one of them. This observation led to the assumption that the graves with distinct orientation can also reflect a chronological difference. The earlier resolved sequence of the Graves 476, 464 and 475 provided a further reinforcement of this hypothesis. An updated model was created using the individual radiocarbon dates and the experiences of the dating programme from 2016. The two orientation groups were programmed as two subsequent phases where southeast–northwest and northwest–southeast oriented graves represent the earlier, while northeast–southwest and southwest–northeast oriented ones the latter chronological phase. The date parameter for Ditch 211 serves as a *terminus post quem* date for the filling up of the feature.

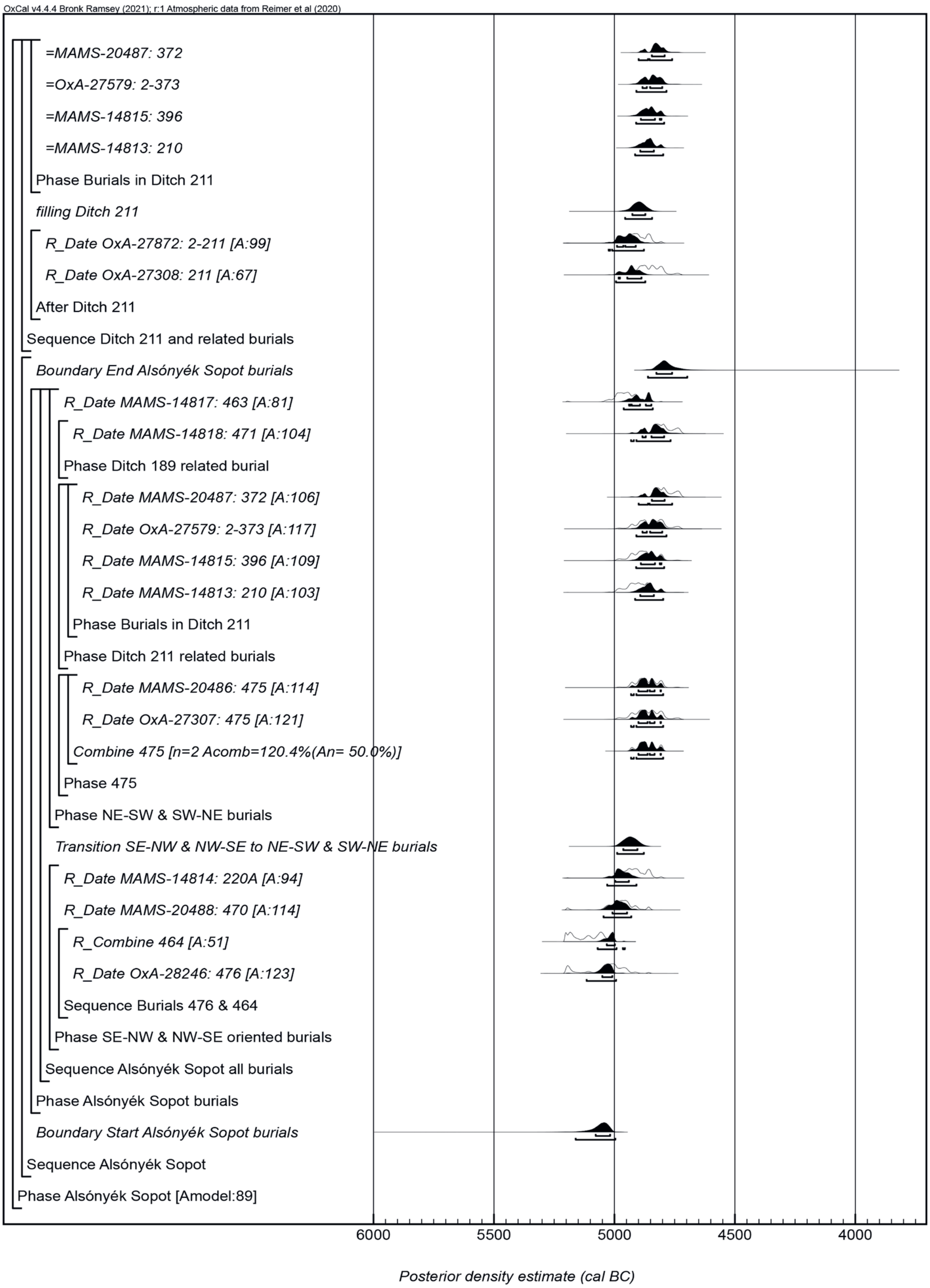

Figure 9. *Probability distributions of radiocarbon dates from the Sopot burial ground at Alsónyék. Each distribution represents the relative probability that an event occurs at a particular time. For each of the dates two distributions have been plotted: one in outline, which is the result of simple radiocarbon calibration, and a solid one, based on the chronological model used. The large square brackets down the left-hand side, along with the OxCal keywords, define the overall model exactly.*

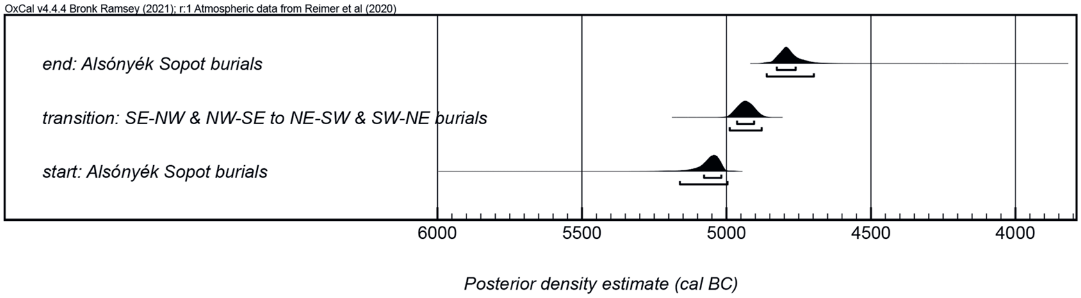

Figure 10. *Key parameters for the start and end of the Sopot burial activity at Alsónyék, and for the transition in the orientation of the graves, derived from the model defined in Figure 9.*

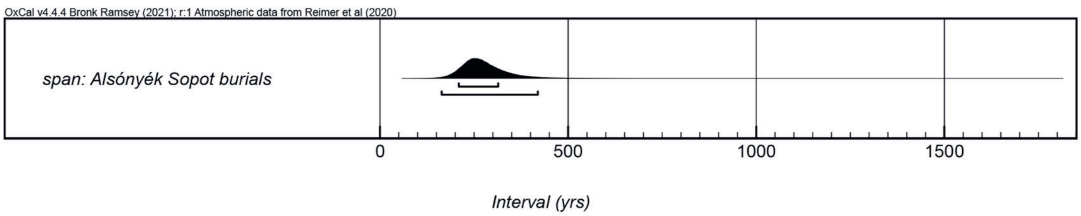

Figure 11. *Probability distributions for the number of years during which the Sopot burial ground at Alsónyék was used, derived from the model defined in Figure 9.*

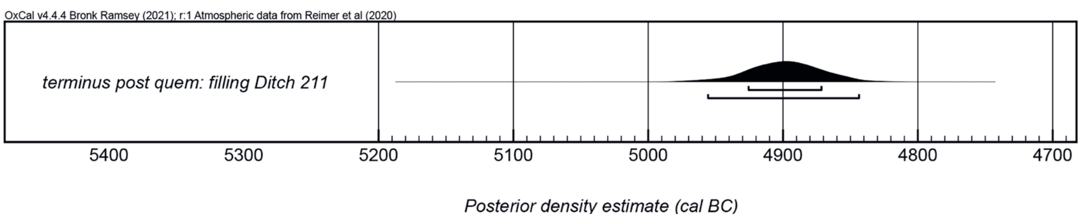

Figure 12. *Probability distributions of the* terminus post quem *for the filling of Ditch 211, derived from the model defined in Figure 9.*

The updated model for the Sopot burial ground at Alsónyék was completed using the program OxCal v4.4.4 (Bronk Ramsey 2009; Reimer et al. 2020). The model (Figure 9) has a good agreement between the radiocarbon dates and the archaeological prior information (Amodel = 89). The updated model estimates that the dated Sopot burial activity at Alsónyék began in *5165–4995 cal BC (95% probability; Figure 10; start: Alsónyék Sopot burials)*, probably in *5080–5015 cal BC (68% probability)*. The burials lasted for *160–420 years (95% probability; Figure 11; span: Alsónyék Sopot burials)*, probably for *205–315 years (68% probability)*. The burial activity ended in *4865–4695 cal BC (95% probability; Figure 10; end: Alsónyék Sopot burials)*, probably in *4830–4760 cal BC (68% probability)*. The transition from the SE–NW and NW–SE oriented burials to NE–SW and SW–NE burials occured in *4990–4875 cal BC (95% probability; Figure 10; transition: SE–NW & NW–SE to NE–SW & SW–NE burials)*, probably in *4965–4905 cal BC (68% probability)*.

The current model provides a *terminus post quem* date for the filling up of Ditch 211. This estimate is *4960–4840 cal BC (95% probability; Figure 12; terminus post quem: filling Ditch 211)*, probably *4930–4870 cal BC (68% probability)*.

Recent modelling of the Sopot radiocarbon series from Alsónyék has been able to narrow down the particularly wide interval for the use of Sopot burial ground at Alsónyék. The estimated coexistence with the later 6th millennium cal BC settlement of the central area was up to 6–9 human generations (Bánffy et al. 2016: 289). The updated model reduces this simultaneous presence by a human generation, which means that the use of the Sopot burial ground did not start before the early 52nd century cal BC, probably before the 51st century cal BC. New results make estimations of the spread and the dynamics of human groups using Sopot material culture along the Danube north of the Drava/Dráva river more plausible.

Towards a precise, regional-scale absolute chronology of 6th and earliest 5th millennia cal BC western Hungary

The radiocarbon dating programme of the earliest Neolithic settlement at Alsónyék resulted in a reliable chronological model for a site permanently occupied over centuries. It has also successfully refuted some earlier assumptions on exclusively small, fragile and briefly inhabited early Neolithic settlements, a concept that became rigid and was repeatedly echoed over time. Thus, the first Neolithic communities were established in the Tolna Sárköz region north of the Mecsek Mountains around 5800 cal BC, probably by the mid-58th century cal BC. Despite this achievement, the formally modelled absolute chronological evidence refers to a single site and cannot be extrapolated to a wider region (Figure 13).

A similar model to that of the Great Hungarian Plain can also be tested in Transdanubia in the future. Despite the limited number of known early 6th millennium cal BC sites, the eastern Baranya area and the Tolna Sárköz were much more densely occupied than all other parts of southern Transdanubia. The settlement system suggests a major route for the dispersal of the Neolithic towards the north along the Danube. The first farmers of southern origin possibly entered Transdanubia in the vicinity of the Danube-Drava/Dráva confluence. One crucial question is whether the Neolithic reached the region south of the Mecsek Mountains before 5800 cal BC. The emergence of farming around 6000 cal BC or between 6000–5800 cal BC seems to be likely there, somewhat parallel to the development of the Tisza/Tisa-Maros/Mureş confluence area in the east. North-west of the Tolna Sárköz, the early 6th millennium cal BC Neolithic was recorded in a limited number of favourable ecological niches such as along the Kapos river and in the Small Balaton area in the westernmost part of the lake. A further shift from south-east Transdanubia could have happened in one or two steps, creating a three- or four-stage system. This tentative model suggests that food-producing communities reached the northern limits of their early 6th millennium cal BC distribution not earlier than about 5700 cal BC.

Our knowledge also remains vague on the development that followed the decline of south-east European pattern early Neolithic communities. Larger-scale excavations have been carried out at only two sites, at Szentgyörgyvölgy-Pityerdomb (Bánffy 2000; 2004), and at Brunn/Wolfholz 2 (Stadler 2005; Stadler and Kotova 2010; 2019), which have been dated with formally modelled radiocarbon series as well. Some further, very limited excavation evidence is known from Zalaegerszeg-Andráshida-Gébárti tó, located in western Transdanubia (Simon 2002). Additional sites are also assigned occasionally to the formative LBK period, predominantly from western Transdanubia and from the Balaton region (Bánffy and Whittle 2022). There is no reason to rule out the possibility that those sites existed between 5500–5350 cal BC. It is worth nothing however, that their finds originate from earlier surface collections or from small-scale excavations without absolute chronological evidence. Recent investigations suggest an enormous complexity concerning the durability of decorative patterns, different fabrics and pottery-making technologies in 6th millennium cal BC western Hungary. Recurrent common occurence and admixture of traits assigned to different pottery styles, labelled even as different archaeological cultures in a traditional framework for the region, reduce their chronological significance. Thus, the solid basis for the assessment of the phenomenon beyond a narrow Pre-Alpine zone of Transdanubia has yet to be established.

There are two possible reasons behind the shortage of observations. Population decline following a rapid growth during the first centuries of the Neolithic is a well known development from many other regions as well (Porcić et al. 2016; Shennan 2018). The northernmost periphery of the south-east European pattern early Neolithic may have been a vulnerable region in this respect. The other explanation is simply the lack of recognition of relevant finds assemblages to date. Typological classification of pottery is particularly challenging when surface collections of 6th millennium cal BC sherds are evaluated.

The mid-54th century cal BC proved to be a pivotal period for the consolidation of the Neolithic in the western Carpathian basin and in southern Transdanubia. As already mentioned, all three settlement units at Szederkény-Kukorica-dűlő started by the mid-54th century cal BC (Jakucs et al. 2016), coeval with the beginnings of the later 6th millennium cal BC settlement at Alsónyék (Oross et al.

2016b). The earliest recorded house units of the Balatonszárszó-Kis-erdei-dűlő site were established about a human generation later in the last third of the 54th century cal BC (Oross et al. 2020). Even the southern excavated house cluster at Tolna-Mözs-Községi-Csádés-földek started not earlier than 5400 cal BC. The regional settlement system regained its visibility during this period. Many major sites were founded, developed to extended settlements in the following centuries and were not abandoned before the earliest 5th millennium cal BC. Moreover, the 54th century cal BC population contributed significantly to the demographic background of the central European neolithisation process (Szécsényi-Nagy et al. 2015; Lipson et al. 2017), that started roughly parallel to the establishment of these sites (Jakucs et al. 2016).

An exponential growth in the number of sites could only be proved about a century later, during the 53rd century cal BC. In this period, some rapid site accumulations resulted possibly in social tensions that led to the split up of the community, as suggested by the chronological model of Versend-Gilencsa (Jakucs et al. 2018). Other small occupations turned into much larger settlements at that time, as at Balatonszárszó-Kis-erdei-dűlő (Oross 2004; 2013).

Another significant process, which can be dated accurately by absolute chronological methods, was the emergence of communities using a distinct material culture called Sopot after its Slavonian roots. They settled down in the region during the 52nd century cal BC, possibly around 5100 cal BC or even one human generation later. Future dating programmes targeting sites such as the earlier excavated Fajsz-Garadomb (Bánffy et al. 2014: 354–357) and the recently discovered burial ground at Dávod (Pap 2019), both on the left bank of the Danube, can contribute to an advanced absolute chronology for the Sopot distribution along the river. The investigation of their long, but often spatially separated, coexistence with the LBK settlements is an exceptional opportunity to get more insight into Neolithic social networks.

Radiocarbon dated longhouse settlements with LBK-style pottery were abandoned around 4900 cal BC in the western Carpathian basin, such as at Alsónyék (Oross et al. 2016b). This date coincides with most of the estimations for the end of the *Linearbandkeramik* world based on data from more westerly areas of central Europe (Lüning 1991; Gronenborn 1998; 1999; Denaire et al. 2017). In contrast to some other regions of the LBK distribution, no signs of social tensions and violence could be recorded by archaeological methods. Nevertheless, the completely synchronous disintegration or transformation of the communities reveals deeper changes in their social system.

The development of the Sopot settlement and burial ground at Alsónyék reflects profound changes around the decline of LBK settlements in Transdanubia. The transition in the orientation of the graves occured in the decades around 4900 cal BC, as well as the filling up of Ditch 211. After centuries of co-existence with the LBK settlement, the group clearly had a different relationship with the Lengyel community which was emerging in the central occupation area by then or shortly after. The possible economic causes and kinship ties behind this transformation remain unknown to date.

The results of recent absolute chronological dating programmes allow the accurate dating of processes and events from the early 6th millennium cal BC to the earliest 5th millennium cal BC. Formal modelling of radiocarbon dates can incorporate and test earlier typochronological beliefs as prior information, which has a particular relevance in a region where the application of advanced statistical methods has little tradition in pottery evaluation. Further objectives can be more precisely determined if the absolute chronological framework has already some well-established, solidly based elements.

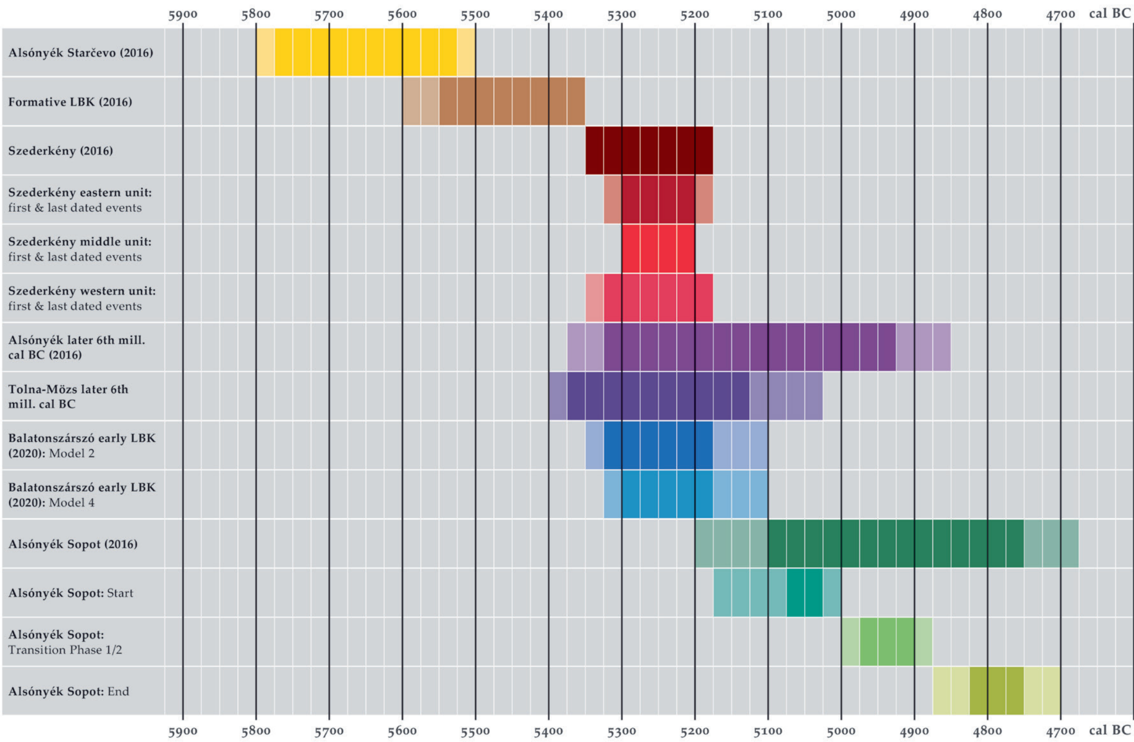

Figure 13. *Current overview of the 6th and earliest 5th millennia cal BC chronology of western Hungary. Intervals are rounded by 25 years, and dark and light colours together represent the 95% probability intervals, while 68% probability intervals are represented by dark colours exclusively.*

Acknowledgements

Grateful thanks are due to National Research, Development and Innovation Office (formerly OTKA) for funding the research projects *Transforming traditions of material culture. Spatial and temporal patterns in pottery style, production and use during the second half of the 6th millennium cal BC in SE Transdanubia and beyond* (*Változó tradíciók. Kerámiastílus, -előállítás és -használat tér- és időbeli mintázatai a Kr. e. 6. évezred második felében a Délkelet-Dunántúlon és a környező régiókban*, grant code: K-19/132663, led by Tibor Marton) and *Neolithic communities in the contact zone between the Balkans and Central Europe in the second half of the sixth millennium BC* (*Újkőkori közösségek a Balkán és Közép-Európa érintkezési övezetében a Kr. e. 6. évezred második felében*, grant code: K 112366, led by Krisztián Oross). Thanks are also due to the European Research Council for funding the *Times of Their Lives* project (Advanced Investigator Grant 295412, 2012–2017, led by Alasdair Whittle and Alex Bayliss). We are indebted to Nóra Mészáros and Zsolt Réti for managing the figures of the contribution.

Lab ID	Context no.	Context description [Sample ID]	Material	$\delta^{13}C_{AMS}$ (‰)	$\delta^{13}C_{IRMS}$ (‰)	$\delta^{15}N$ (‰)	C:N	Radiocarbon age (BP)	Modelled date (95% probability)	References
SUERC-100839	Feature 873 (SNR 898)	Settlement pit, eastern long pit of House 43 in the southern excavated house cluster	Animal bone: sheep/goat; femur, refitting unfused proximal epiphysis		−19.6±0.2	6.8±0.3	3.2	6308±24		unpublished
Poz-149786	Feature 1139 (SNR 1184)	Settlement pit, eastern long pit of House 44 in the southern excavated house cluster	Animal bone: pig; radius, articulating with ulna					6350±40		unpublished
Poz-149785	Feature 1139 (SNR 1185)	Settlement pit, eastern long pit of House 44 in the southern excavated house cluster	Animal bone: cattle; articulating thoracic vertebrae					6220±40		unpublished
SUERC-100840	Feature 1151 (SNR 1190)	Settlement pit, western long pit of House 44 in the southern excavated house cluster	Animal bone: cattle, humerus, refitting unfused epiphysis		−20.3±0.2	6.1±0.3	3.3	6383±24		unpublished
SUERC-100838	Feature 1248 (SNR 1289)	Settlement pit, oval individual pit, probably the largest preserved part of the one-time western long pit of House 43 in the southern excavated house cluster.	Animal bone: cattle; humerus, refitting unfused epiphysis		−20.3±0.2	7.1±0.3	3.2	6319±20		unpublished
Poz-149784	Feature 1250 (SNR 1291)	Settlement pit, smaller individual pit, probably part of the one-time western long pit of House 43 in the southern excavated house cluster.	Animal bone: cattle; metacarpus articulating with phalanx					6320±40		unpublished
SUERC-100835	Feature 1400 (SNR 1441)	Settlement pit, western long pit of House 42 in the southern excavated house cluster.	Animal bone: cattle; articulating vertebrae cervicalis (2)		−20.8±0.2	5.9±0.3	3.3	6178±20		unpublished
Poz-149756	Feature 1400 (SNR 1441)	Settlement pit, western long pit of House 42 in the southern excavated house cluster.	Animal bone: sheep/goat; radius, articulating with ulna					6130±40		unpublished

Lab ID	Context no.	Context description [Sample ID]	Material	$\delta^{13}C_{AMS}$ (‰)	$\delta^{13}C_{IRMS}$ (‰)	$\delta^{15}N$ (‰)	C:N	Radiocarbon age (BP)	Modelled date (95% probability)	References
MAMS-14145	Feature 1649 (SNR 1748)	Grave deposited into the western long pit of House 35 in the southern house cluster. The left-crouched body is SE–NW oriented.	Human bone: clavicle	−22.5			3.3	6233±23	*5305–5115 cal BC*	Szécsényi-Nagy et al., 2015
Poz-149757	Feature 2186 (SNR 2241)	Settlement pit, western long pit of House 11 in the northern excavated house cluster.	Animal bone: cattle; and metacarpus, articulating with carpalae					6300±50		unpublished
SUERC-100836	Feature 2229 (SNR 2286)	Individual oval settlement pit north-west of House 11 in the northern excavated house cluster.	Animal bone: cattle; humerus; refitting unfused epiphysis		−19.9±0.2	7.7±0.3	3.2	6272±23		unpublished
SUERC-100837	Feature 2293 (SNR 2352)	Individual oval pit, in superposition with the western long pit of House 07 and with the eastern long pit of House H06. The two long pits were excavated and documented as one single unit, as Feature 2298 (SNR 2357). All features belong to the northern excavated house cluster.	Animal bone: horse; calcaneus, articulating with astragalus		−22.3±0.2	4.2±0.3	3.1	7481±23		unpublished
Poz-149758	Feature 2327 (SNR 2386)	Settlement pit, western long pit of House 06 in the northern excavated house cluster.	Animal bone: cattle; radius, articulating with ulna					6230±40		unpublished
MAMS-14144	Feature 2392 (SNR 2559)	Grave deposited into the western long pit of House 04 in the northern house cluster. The left-crouched body is SE–NW oriented.	Human bone: tibia	−20.8			3.2	6143±24	*5215–5060 cal BC*	Szécsény-Nagy et al., 2015

Table 1. *Radiocarbon and stable isotopic results from features of the later 6th millennium cal BC Neolithic site at Tolna-Mözs-Községi-Csádés-földek. The results are presented in ascending order by context number.*

References

Barna, J.P. 2004. "Becsehely–Homokos. Előzetes az M7 gyorsforgalmi út 71. sz. lelőhelyén feltárt neolitikus telep kutatásáról (1999–2000)". In ΜΩΜΟΣ 2. Őskoros Kutatók II. Összejövetelének konferenciakötete, eds. E. Gy. Nagy, J. Dani and Zs. Hajdú, 33–44. Debrecen: Debreceni Déri Múzeum.

Barna, J. P. 2012. "Újabb adatok a Délnyugat-Dunántúl középső neolitikuma időrendjéhez". In *ΜΩΜΟΣ 4.* Őskoros Kutatók IV. Összejövetelének konferenciakötete, ed. B. Kolozsi, 171–190. Debrecen: Déri Múzeum Régészeti Tár.

Barna, J. P. 2017. "*The Formation of the Lengyel Culture in South-Western Transdanubia"*. Budapest: Archaeolingua.

Bayliss, A., N. Beavan, D. Hamilton, K. Köhler, É. Á. Nyerges, C. Bronk Ramsey, E. Dunbar, M. Fecher, T. Goslar, B. Kromer, P. Reimer, E. Bánffy, T. Marton, K. Oross, A. Osztás, I. Zalai-Gaál and A. Whittle. 2013[2016]. "Peopling the past: creating a site biography in the Hungarian Neolithic". *Bericht der Römisch-Germanischen Kommission* 94, 23–91.

Bánffy, E. 2000. "The Late Starčevo and the Earliest Linear Pottery Groups in Western Transdanubia". *Documenta Praehistorica* 27, 173–185.

Bánffy, E. 2004. "*The 6th Millennium BC Boundary in Western Transdanubia and its Role in the Central European Neolithic Transition. The Szentgyörgyvölgy-Pityerdomb Settlement"*. Varia Archaeologica Hungarica 15. Budapest: Archaeological Institute of the Hungarian Academy of Sciences.

Bánffy, E., A. Osztás, K. Oross, I. Zalai-Gaál, T. Marton, É. Á. Nyerges, K. Köhler, A, Bayliss, D. Hamilton and A. Whittle, A. 2013[2016]. "The Alsónyék story: towards the history of a persistent place". *Bericht der Römisch-Germanischen Kommission* 94, 283–318.

Bánffy, E. and A. Whittle. 2022. "Szentgyörgyvölgy-Pityerdomb and the formative phase of the LBK revisited". In *Wissenschichten. Festschrift für Wolfram Schier zu seinem 65. Geburtstag,* eds. E. Kaiser, M. Meyer, S. Scharl and S. Suhrbier, 145–161. Internationale Archäologie, Studia honoraria 41. Rahden/Westf.: Verlag Marie Leidorf GmbH.

Bánffy, E., I. Zalai-Gaál, T. Marton, K. Oross, A. Osztás and J. Petrasch. 2014. "Das Sárköz im südungarischen Donaugebiet – ein Korridor zwischen dem Balkan und Mitteleuropa im 6.–5. Jt. v. Chr". In *The Neolithic and Eneolithic in Southeast Europe. New approaches to dating and cultural dynamics in the 6th to 4th millennium BC*, eds. W. Schier and F. Draşovean, 347–368. Prähistorische Archäologie in Südosteuropa 28. Rahden/Westf.: Verlag Marie Leidorf GmbH.

Bronk Ramsey, C. 2009. "Bayesian Analysis of Radiocarbon Dates". *Radiocarbon* 51(1), 337–360.

Denaire, A., P. Lefranc, J. Wahl, C. Bronk Ramsey, E. Dunbar, T. Goslar, A. Bayliss, N. Beavan, P. Bickle and A. Whittle. 2017. "The Cultural project: Formal Chronological Modelling of the Early and Middle Neolithic Sequence in Lower Alsace". *Journal of Archaeological Method and Theory* 24, 1072–1149.

Domboróczki, L. 2010. "Report on the excavation at Tiszaszőlős-Domaháza-puszta and a new model for the spread of the Körös culture". In *Neolithization of the Carpathian Basin: northernmost distribution of the Starčevo/Körös culture*, eds. J. K. Kozłowski and P. Raczky, 137–176. Kraków and Budapest: Polish Academy of Arts and Sciences and Institute of Archaeological Sciences of the Eötvös Loránd University.

Gläser, R. 1993. *"Die Linienbandkeramik in Transdanubien. Beiträge zu ihrer Chronologie und Entstehung"*. Unpublished doctoral thesis. Heidelberg: Heidelberg University.

Gronenborn, D. 1998. "Ältestbandkeramische Kultur, La Hoguette, Limburg, and… What else? – Contemplating the Mesolithic-Neolithic transition in southern Central Europe". *Documenta Praehistorica* 25, 189–202.

Gronenborn, D. 1999. "A Variation on a Basic Theme: The Transition to Farming in Southern Central Europe". *Journal of World Prehistory* 13(2), 123–210.

Jakucs, J. And V. Voicsek. 2015. "The northernmost distribution of the early Vinča culture in the Danube valley: a preliminary study from Szederkény-Kukorica-dűlő (Baranya County, southern Hungary)". *Antaeus* 33, 13–54.

Jakucs, J., K. Oross, E. Bánffy, V. Voicsek, E. Dunbar, P. Reimer, A. Bayliss, P. Marshall and A. Whittle. 2018. "Rows with the neighbours: the short lives of longhouses at the Neolithic site of Versend-Gilencsa". *Antiquity* 92(361), 91–117.

Jakucs, J., E. Bánffy, K. Oross, V. Voicsek, C. Bronk Ramsey, E. Dunbar, K. Kromer, A. Bayliss, D. Hofmann, P. Marshall and A. Whittle A. 2016. "Between the Vinča and *Linearbandkeramik* Worlds: The Diversity of Practices and Identities in the 54th–53rd Centuries cal BC in Southwest Hungary and Beyond". *Journal of World Prehistory* 29(3), 267–336.

Jakucs, J. 2020. "LBK and Vinča in South-East Transdanubia: Comments on merging, interleaving and diversity". *Quaternary International* 560–561, 119–141.

Kalicz, N. 1980. "Becsehely I, Bükkaljai dűlő (Komitat Zala, Kreis Nagykanizsa)". *Mitteilungen des Archäologischen Instituts der Ungarischen Akademie der Wissenschaften* 8–9, 201–203.

Kalicz, N. 1990. "*Frühneolithische Siedlungsfunde aus Südwestungarn*". Inventaria Praehistorica Hungariae 4. Budapest: Magyar Nemzeti Múzeum.

Kalicz, N. 1991. "Die Keszthely-Gruppe der Transdanubischen (Mitteleuropäischen) Linienbandkeramik im Lichte der Ausgrabung in Kustánszeg (Westungarn)". *Communicationes Archaeologicae Hungariae* 1991, 5–32.

Kalicz, N. 1995. "Die älteste transdanubische (mitteleuropäische) Linienbandkeramik. Aspekte zu Ursprung, Chronologie und Beziehungen". *Acta Archaeologica Academiae Scientiarum Hungaricae* 47, 23–59.

Kalicz, N. 2011. "Forschung über die Starčevo-Kultur in Südtransdanubien (Ungarn)". In *Panonski prapovijesni osviti. Zbornik radova posvećenih Korneliji Minichreiter uz 65. obljetnicu života*, eds. K. Botić, S. Kovačević and D. Ložnjak Dizdar, 105–129. Zagreb: Institut za arheologiju.

Kalicz, N., K. T. Biró, and M. Zs. Virág. 2002. "Vörs, Máriaasszony-sziget (Somogy megye)". In *Régészeti kutatások Magyarországon 1999. Archaeological Investigations in Hungary 1999*, eds. E. Marton and J. Kisfaludi, 15–26. Budapest: Kulturális Örökségvédelmi Hivatal and Magyar Nemzeti Múzeum.

Kalicz, N., A. Kreiter, E. Kreiter, Z. M. Tokai, M. Tóth and B. Bajnóczi. 2012. "A neolitikum történeti és kronológiai kérdései Becsehely–Bükkaljai-dűlő lelőhelyen (The Neolithic historical and chronological questions in the Becsehely–Bükkaljai dűlő)". In ΜΩΜΟΣ 4. Őskoros Kutatók IV. Összejövetelének konferenciakötete, ed. B. Kolozsi, 87–170. Debrecen: Déri Múzeum Régészeti Tár.

Kalicz, N., E. Kreiter and Z. M. Tokai. 2007. "Die Rolle der Sopot-Kultur in der Entstehung der Lengyel-Kultur auf Grund der neuen Ausgrabungen in Südwestungarn". In *The Lengyel, Polgár and related cultures in the Middle/Late Neolithic in Central Europe*, eds. J. K. Kozłowski and P. Raczky, 29–47. Kraków: The Polish Academy of Arts and Sciences, Kraków and Eötvös Loránd University Institute of Archaeological Sciences, Budapest.

Kalicz, N. and J. Makkay. 1972. "A neolitikus Sopot–Bicske kultúra". *Archaeologiai Értesítő* 99, 3–13.

Kohl, G. and H. Quitta. 1963. "Berlin-Radiokarbondaten archäologischer Proben I". *Ausgrabungen und Funde* 8, 281–301.

Kohl, G. and H. Quitta. 1964. "Berlin Radiocarbon measurements I". *Radiocarbon* 6, 308–317.

Lazarovici, Gh. 1981. "Die Periodisierung der Vinča-Kultur in Rumänien". *Praehistorische Zeitschrift* 56, 169–196.

Lipson, M., A. Szécsényi-Nagy, S. Mallick, A. Pósa, B. Stégmár, V. Keerl, N. Rohland, K. Stewardson, M. Ferry, M. Michel, J. Oppenheimer, N. Broomandkhoshbacht, E. Harney, S. Nordenfelt, B. Llamas, B. G. Mende, K. Köhler, K. Oross, M. Bondár, T. Marton, A. Osztás, J. Jakucs, T. Paluch, F. Horváth, P. Csengeri, J. Koós, K. Sebők, A. Anders, P. Raczky, J. Regenye, J. P. Barna, Sz. Fábián, G. Serlegi, Z. Toldi, E. Gy. Nagy, J. Dani, E. Molnár, Gy. Pálfi, L. Márk, B. Melegh, Zs. Bánfai, L. Domboróczki, J. Fernández-Eraso, J. A. Mujika-Alustiza, C. Alonso Fernández, J. J. Echevarría, R. Bollongino, J. Orschiedt, K. Schierhold, H. Meller, A. Cooper, J. Burger, E. Bánffy, K. W. Alt, C. Lalueza-Fox, W. Haak and D. Reich. 2017. "Parallel palaeogenomic transects reveal complex genetic history of early European farmers". *Nature* 551(7680), 368–372.

Lüning, J. 1988[1991]. “Frühe Bauern in Mitteleuropa im 6. und 5. Jahrtausend v. Chr“. *Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz* 35, 27–93.

Marton, T. 2004. “Material finds from Balatonszárszó, Neolithic settlement: connections within and without the TLPC territory”. *Antaeus* 27, 81–86.

Marton, T. 2008. “Development of pottery style on the LBK settlement of Balatonszárszó–Kis-erdei-dűlő in Hungary”. *Acta Terrae Septemcastrensis* 7, 197–216.

Marton, T., A. Kreiter, A. Füzesi, L. Gomart, G. Gortva, L. Gucsi, K. Oross, Á. Pető, G. Serlegi, M. Zs. Virág and J. Jakucs. 2020. “Transforming traditions of material culture: Spatial and chronological patterns in ceramic styles, pottery production and pottery consumption in southern Transdanubia and the adjacent regions during the later sixth millennium BC”. *Hungarian Archaeology* 9(1), 1–11.

Marton, T. and K. Oross. 2012. “Siedlungsforschung in linienbandkeramischen Fundorten in Zentral- und Südtransdanubien – Wiege, Peripherie oder beides?“ In *Siedlungsstruktur und Kulturwandel in der Bandkeramik*. Beiträge der Internationalen Tagung “Neue Fragen zur Bandkeramik oder alles beim Alten?!” Leipzig 23. bis 24. September 2010, eds. F. Kreienbrink, M. Cladders, H. Stäuble, T. Tischendorf and S. Wolfram, 220–239. Arbeits- und Forschungsberichte zur sächsischen Bodendenkmalpflege Beiheft 25. Dresden: Landesamt für Archäologie.

Oross, K. 2004. “Das neolithische Dorf von Balatonszárszó. Forschungen zwischen 2000–2002“. *Antaeus* 27, 61–80.

Oross, K. 2013. “*Balatonszárszó-Kis-erdei-dűlő középső neolit településszerkezete és közép-európai párhuzamai*“. Unpublished PhD thesis. Budapest: Eötvos Loránd University.

Oross, K., E. Bánffy, A. Osztás, T. Marton, É. Á. Nyerges, K. Köhler, A. Szécsényi-Nagy, K. W. Alt, K. Somogyi, C. Bronk Ramsey, T. Goslar, B. Kromer and D. Hamilton. 2013[2016]a. “The early days of Neolithic Alsónyék: the Starčevo occupation”. *Bericht der Römisch-Germanischen Kommission* 94, 93–121.

Oross, K., L. J. E. Cramp, G. Gortva, J. Jakucs, K. Lyublyanovics, T. Marton, G. Serlegi, B. Vágvölgyi and A. Whittle. 2020. “‘It’s still the same old story’: the current southern Transdanubian approach to the Neolithisation process of central Europe”. *Quaternary International* 560–561, 154–178.

Oross, K., A. Osztás, T. Marton, É. Á. Nyerges, K. Köhler, Zs. Gallina, K. Somogyi, E. Bánffy, C. Bronk Ramsey, T. Goslar and D. Hamilton. 2013[2016]b. “Longhouse times: dating the Alsónyék LBK settlement”. *Bericht der Römisch-Germanischen Kommission* 94, 123–149.

Oross, K., A. Osztás, T. Marton, K. Köhler, J. G. Ódor, A. Szécsényi-Nagy, E. Bánffy, K. W. Alt, C. Bronk Ramsey, A. Bayliss, D. Hamilton and A. Whittle. 2013[2016]c. “Midlife changes: the Sopot burial ground at Alsónyék”. *Bericht der Römisch-Germainschen Kommission* 94, 151–178.

Oross, K. and Zs. Siklósi. 2012. “Relative and absolute chronology of the Early Neolithic in the Great Hungarian Plain”. In *The First Neolitihic Sites in Central/South-East European Transect. Volume III. The Körös Culture in Eastern Hungary*, eds. A. Anders and Zs. Siklósi, 129–159. BAR International Series 2334.. Oxford: Archaeopress.

Osztás, A., I. Zalai-Gaál and E. Bánffy. 2012. “Alsónyék-Bátaszék: a new chapter in the research of Lengyel culture”. *Documenta Praehistorica* 39, 377–396.

Osztás, A., E. Bánffy, I. Zalai-Gaál, K. Oross, T. Marton and K. Somogyi. 2013[2016]. “Alsónyék-Bátaszék: introduction to a major Neolithic settlement complex in south-east Transdanubia, Hungary”. *Bericht der Römisch-Germanischen Kommission* 94, 7–21.

Pap, E. 2019. “New observations on the neolithic along the left bank of the Danube: Sopot culture burial ground at Dávod”. In *Prehistoric Communities along the Danube*, eds. T. Hršak and M. Dizdar, 25. Zagreb and Osijek: Institute of Archaeology and Archaeological Museum Osijek.

Porčić, M., T. Blagojević and S. Stefanović. 2016. “Demography of the Early Neolithic Population in the Central Balkans: Population Dynamics Reconstruction Using Summed Radiocarbon Probability Distributions”. *PLoS ONE* 11(8), e 0160832.
doi:10.1371/journal.pone.0160832

Rassmann, K., C. Mischka, M. Furholt, R. Ohlrau, K. Radloff, K. Winkelmann, G. Serlegi, T. Marton, A. Osztás, K. Oross and E. Bánffy. 2015a. "Large Scale Geomagnetic Prospection on Neolithic Sites in Hungary I". *Hungarian Archaeology 2015 Spring,* 1–8.

Rassmann, K., C. Mischka, M. Furholt, R. Ohlrau, K. Radloff, K. Winkelmann, G. Serlegi, T. Marton, A. Osztás, K. Oross and E. Bánffy. 2015b. "Large Scale Geomagnetic Prospection on Neolithic Sites in Hungary. Part 2". *Hungarian Archaeology 2015 Summer*, 1–6. http://files.archaeolingua.hu/2015NY/eng_Rassmann_15S.pdf

Rassmann, K., F. Stevens, K. Oross, T. Marton, A. Osztás, G. Serlegi, K. Winkelmann and E. Bánffy. 2020. "Windows onto the landscape: Prospections on the prehistoric sites at Alsónyék, Fajsz-Kovácshalom, Fajsz-Garadomb and Tolna-Mözs in the Sárköz region". In *The Environmental History of the Prehistoric Sárköz Region in Southern Hungary*, ed. E. Bánffy, 11–82. Confinia et horizontes 1. Langenweißbach: Beier und Beran.

Regenye, J. 1996. "The Sopot-Kultur in Transdanubien und ihre südlichen Beziehungen". In *The Vinča Culture, its Role and Cultural Connections*, ed. F. Draşovean, 163–174. Timişoara: Editura Mirton.

Regenye, J. 2010. "What about the other side: Starčevo and LBK settlements north of Lake Balaton". In *Neolithization of the Carpathian Basin: northernmost distribution of the Starčevo/Körös culture*, eds. J. K. Kozłowski and P. Raczky, 53–64. Kraków and Budapest: Polish Academy of Arts and Sciences and Institute of Archaeological Sciences of the Eötvös Loránd University.

Reimer, P. J., W. E. N. Austin, E. Bard, A. Bayliss, P. G. Blackwell, C. Bronk Ramsey, M. Butzin, H. Cheng, R. L. Edwards, M. Friedrich, P. M. Grootes, T. P. Guilderson, I. Hajdas, T. J. Heaton, A. G. Hogg, K. A. Hughen, B. Kromer, S. W. Manning, R. Muscheler, J. G. Palmer, C. Pearson, J. van der Plicht, R. W. Reimer, D. A. Richards, E. M. Scott, J. R. Southon, C. S. M. Turney, L. Wacker, F. Adolphi, U. Büntgen, M. Capano, S. M. Fahrni, A. Fogtmann-Schulz, R. Friedrich, P. Köhler, S. Kudsk, F. Miyake, J. Olsen, F. Reinig, M. Sakamoto, A. Sookdeo and S. Talamo. 2020. "The IntCal20 Northern Hemisphere Radiocarbon Age Calibration Curve (0–55 cal kBP)". *Radiocarbon* 62(4), 725–757.

Shennan, S. 2018. "*The first farmers of Europe. An evolutionary perspective*". Cambridge World Archaeology. Cambridge: Cambridge University Press.

Schier, W. 1996. "The relative and absolute chronology of Vinča: new evidence from the type site". In *The Vinča Culture, its Role and Cultural Connections,* ed. F. Draşovean, 141–162. Timişoara: Editura Mirton.

Simon, K. H. 1996. "Ein neuer Fundort der Starčevo-Kultur bei Gellénháza (Kom. Zala, Ungarn) und seine südlichen Beziehungen". In *The Vinča Culture, its Role and Cultural Connections,* ed. F. Draşovean, 59–92. Timişoara: Editura Mirton.

Simon, K. H. 2002. "Das Fundmaterial der frühesten Phase der transdanubischen Linienbandkeramik auf dem Fundort Zalaegerszeg–Andráshida, Gébárti tó, Arbeitsplatz III". *Antaeus* 25, 189–203.

Stadler, P. 2005. "Settlement of the Early Linear Ceramics Culture at Brunn am Gebirge, Wolfholz site". *Documenta Praehistorica* 32, 269–278.

Stadler, P. and N. Kotova. 2010. "Early Neolithic settlement from Brunn Wolfholz in Lower Austria and the problem of the origin of (Western) LBK". In *Neolithization of the Carpathian Basin: Northernmost Distribution of the Starčevo/Körös Culture,* eds. J. K. Kozłowski, and P. Raczky, 325–348. Kraków–Budapest: Polish Academy of Arts and Sciences and Institute of Archaeological Sciences of the Eötvös Loránd University.

Stadler, P. and N. Kotova. 2019. "*Early Neolithic Settlement Brunn am Gebirge, Wolfholz, in Lower Austria. Volume 1"*. Langenweißbach: Verlag Beier und Beran.

Stäuble, H. 1995. "Radiocarbon dates of the earliest Neolithic in Central Europe". *Radiocarbon* 37(2), 227–237.

Stäuble, H. 2005. "*Häuser und absolute Datierung der ältesten Bandkeramik*". Universitätsforschungen zur Prähistorischen Archäologie 117. Bonn: Habelt.

Szécsényi-Nagy, A., G. Brandt, W. Haak, V. Keerl, J. Jakucs, S. Möller-Rieker, K. Köhler, B. G. Mende, K. Oross, T. Marton, A. Osztás, V. Kiss, M. Fecher, Gy. Pálfi, E. Molnár, K. Sebők, A. Czene, T. Paluch, M. Šlaus, M. Novak, N. Pećina-Šlaus, B. Ősz, V. Voicsek, K. Somogyi, G. Tóth, B. Kromer, E. Bánffy and K. W. Alt. 2015. "Tracing the genetic origin of Europe's first farmers reveals insights into their social organization". *Proceedings of the Royal Society* B 282, 20150339. http://dx.doi.org/10.1098/rspb.2015.0339

Whittle, A., L. Bartosiewicz, D. Borić, P. Pettitt and M. Richards. 2002. "In the beginning: new radiocarbon dates for the early Neolithic in northern Serbia and south-east Hungary". *Antaeus* 25, 63–117.

Contributors

LILY BONGA
Seshat: Global History Databank, Evolution Institute & Seshat Project, University of Oxford Oxford, UK
lilybonga@gmail.com

KATARINA BOTIĆ
Institut za Arheologiju,
Jurjevska ulica 15, 10 000 Zagreb, Hrvatska
kbotic@iarh.hr

JELENA BULATOVIĆ
Department of Historical Studies, University of Gothenburg, SE, 41255 Gothenburg, Sweden
Faculty of Philosophy, University of Belgrade Čika Ljubina 18-20, 11000 Belgrade, Serbia
jelena.bulatovic@gu.se

LJUBO FIDANOSKI
Museum of the City of Skopje, Mito Hadzivasilev bb, 1000 Skopje, North Macedonia
fidanoskilj@yahoo.com

ERIKA GÁL
Institute of Archaeology, Research Centre for the Humanities, Eötvös Loránd Research Network, Centre of Excellence of the Hungarian Academy of Sciences
4 Tóth Kálmán utca, H-1096 Budapest, Hungary
gal_erika@yahoo.com

JÁNOS JAKUCS
Institute of Archaeology, Research Centre for the Humanities, Eötvös Loránd Research Network, Centre of Excellence of the Hungarian Academy of Sciences
4 Tóth Kálmán utca, H-1096 Budapest, Hungary
jakucs86@gmail.com

VELIBOR KATIĆ
Belgrade City Museum
Zmaj Jovina 1, 11000 Belgrade, Serbia
velibor.katic@mgb.org.rs

MIROSLAV MARIĆ
Institute of Balkan Studies, Serbian Academy of Sciences and Arts
Knez Mihailova 35/IV, 11000 Belgrade, Serbia
miroslav.maric@bi.sanu.ac.rs

NEMANJA MARKOVIĆ
Institute of Archaeology
Knez Mihailova 35/IV, 11000 Belgrade, Serbia
nemamarkovic@gmail.com

TIBOR MARTON
Institute of Archaeology, Research Centre for the Humanities, Eötvös Loránd Research Network, Centre of Excellence of the Hungarian Academy of Sciences
4 Tóth Kálmán utca, H-1096 Budapest, Hungary
marton.tibor@btk.mta.hu

GOCE NAUMOV
Goce Delčev University of Štip
Krste Misirkova 10A, 2000 Štip
North Macedonia
gocenaumov@gmail.com

KRISZTIÁN OROSS
Institute of Archaeology, Research Centre for the Humanities, Eötvös Loránd Research Network, Centre of Excellence of the Hungarian Academy of Sciences
4 Tóth Kálmán utca, H-1096 Budapest, Hungary
oross.krisztian@abtk.hu

IVANA PANTOVIĆ
City Museum Vršac
Bulevar Žarka Zrenjanina 20
26300 Vršac, Serbia
arhivana@yahoo.com

AGATHE REINGRUBER
Institut für prähistorische Archäologie
Freie Universität Berlin
Fabeckstrasse 23/25, 14195 Berlin
agathe.reingruber@fu-berlin.de

LAURENS THISSEN
Thissen Archaeological Ceramics Bureau
Amsterdam, Netherlands
lthissen@xs4all.nl

SELENA VITEZOVIĆ
Institute of Archaeology
Kneza Mihaila 35/IV, 11000 Belgrade, Serbia
s.vitezovic@ai.ac.rs

ALASDAIR WHITTLE
Department of Archaeology and Conservation
Cardiff University, John Percival Building
Colum Drive, Cardiff CF10 3EU, Wales, UK
whittle@cardiff.ac.uk

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

903.4"634.7"(4-12)
902.2"634.7"(4-12)

RELATIVELY ABSOLUTE : relative and Absolute Chronologies in the Neolithic of Southeast Europe / edited by Miroslav Marić, Jelena Bulatović and Nemanja Marković ; editor in chief Vojislav G. Pavlović. - Belgrade : Institute for Balkan Studies SASA, 2023
(Belgrade : Birograf). - 160 str. : ilustr. ; 27 cm. - (Special editions / Serbian Academy of Sciences and Arts, Institute for Balkan Studies ; 156)

Tiraž 400. - Str. 1-4: Introduction / Editors. - Contributors: str. 159-160. - Bibliografija uz svaki rad.

ISBN 978-86-7179-122-9

а) Археолошка налазишта -- Југоисточна
Европа -- Неолит -- Зборници б)
Археолошка истраживања -- Југоисточна
Европа -- Неолит -- Зборници

COBISS.SR-ID 110687241